Rotational Water Supply in Command Area

Kisan L. Bidkar, Kailas T. Phalak, Rahul T. Pardeshi

Abstract — Water constitutes one of the prime constraints for increasing food production in our hungry world. So tenuous & delicate is the balance between the demand for water by crops & its supply by precipitation that even short term dry spell often reduce production significantly & prolong drought can cause total crop failure & mass starvation. Irrigation is artificial application of water to agricultural crops, design to permit farms in arid regions & to counterweigh drought in semiarid or semi humid regions.

Rotational water supply in canal commands is seen as an approach to the development of irrigated agriculture with social equity & participation. Responsibility for the operation of canal network, both above & below the outlet as a unified & interrelated task deserves serious consideration. A cadre for Civil Engineering, a new blend of specialization could help deal with whole set of problems related to, 1) Operation, maintenance & management of canal system, 2) Development of Irrigation infrastructure & distribution of water at field level & 3) Scientific water management for agriculture, choice of crops, superior farm system & self management of Chak irrigable.

Index Terms — RWS, Warabandi, Chak, Canal Evapotranspiration

I. Introduction

Water constitutes one of the prime constraints for increasing food production in our hungry world. So tenuous & delicate is the balance between the demand for water by crops & its supply by precipitation that even short term dry spell often reduce production significantly & prolong drought can cause total crop failure & mass starvation [1]. Irrigation is artificial application of water to agricultural crops, design to permit farms in arid regions & to offset drought in semiarid or semi humid regions [4].

The practice of irrigation generally consists of introducing water into the part of soil profile that serves as the root zone, for the subsequent use of crop. A well-managed irrigation system is one that optimize and temporal distribution of water not necessarily to obtain the highest yields or to use the lowest amount of water possible nor always to attain the highest yield per unit amount of water but to maximizes the benefit cost ratio. Although the problem & its solution are site specific in each case, the principle involved into a highly sophisticated operations, involving a simultaneous monitoring & at least partial control of weather, soil & crop variables. Yet progress continues, what with the steepening cost of energy & water, the search of means to increase the efficiency of irrigation & of water utilization through water distribution practices, is becoming all the most urgent.

Water distribution in the command among distributaries, minors as well as distribution among beneficiaries beyond the Government outlet is the most vital part of irrigation. There are different types of water distribution methods. In rotation method the water is delivered at a fixed time on a pre-arranged schedule.

A. Warabandi

Warabandi is system of rotation of water supply according to a fixed scheduled time. The essential elements of Warabandi are the specification of the day & time when a farmer will receive water & the duration of water supply determined on the basis of the size of holding in the outlet command. Thus weekly supply of water on specified days between fixed time intervals is the essence of Warabandi. It would facilitate application of water to an individual field in a stream size which is effective& can be well managed by farmers there by reducing the time & labor required for irrigation. It would help to reduce wastage of water, water disputes, and litigations & at the same time, increase the reliability of water supply particularly to the weaker section of the society & to those situated at the tail end of the command.

B. Crop Coefficient &Crop Curve

In general a crop coefficient is the ratio of actual crop ET at a specific time to potential or reference crop ET at the same time. A plot of the crop coefficient as the function of time is known as a crop curve. The horizontal axis or time scales may take a variety of forms. Often a combination of time scales is used as dimensionless time scale for the period of the growth with a dimensional time scale for the maturation period.

C. Crop Evapo-transpiration

Crop water requirement data are needed for irrigation project planning. Crop water requirement is defined as the depth of water to be needed to meet the water loss through evapo-transpiration (Etc) of a disease free crop, large fields under non-restricting soil conditions growing in including soil water & fertility & achieving full production under the given growing environment [3].

II. Design of Chak

Design of Chak includes fixing of location of outlet & ancillary works viz. field channels, field drains & structures on F.C. & F.D.

Setting of Outlets: Following points considered while locating an outlet. 1. Outlet should be located in its own command. 2. It should be preferably in cutting & not in banking. 3. It should be located on upstream side of fall. 4. Sill of outlet may be fixed at C.B.L. of parent channel at off take point.

Design & construction of "On Farm Works" involved Investigation, Survey, Planning, Design, Construction, and Operation & Testing.

Criteria for Chak Size: Following are the criteria for fixing the Chak sizes:

i. Topographic limits,
ii. Irrigation in Chak must be completed within stipulated flow period in peak rotation,

iii. Number of farmers be limited to maximum 15,
iv. Length of field channel be limited to about 1 Km,
v. Chak should be located in one village area.

III. Socio-Economic Survey

The socio-economic survey conducted before the introduction of the irrigation projects or at any time during their development at different stages & at any length of time. It includes the physical factors, organizational factors, cultural, motivational factors &knowledge factors. Therefore, the location specific issues would be reflected through the components of such surveys.

IV. Land Development Works

The main aim of land development is to convey water efficiently from outlet to turnout i.e. up to the property head. The land must be ready to use this water efficiently & distribute it uniformly on the lands. All natural lands barring few exceptions have uneven surface having grades in the different direction. If water is applied to this natural land, it travels to the low lying area easily by passing the high spot. The distribution is not therefore even, resulting in the poundage of water in depressions & dry areas on elevated portion. This also means interruption of drainage on one hand & acceleration of soil erosion on the other. So for taking RWS program in command, we have to check the suitability of land & see whether there is need of land development work. If the land is not well shaped then the alignment of field channel is quiet difficult & there are some patches which remain un-commanded by the water level in F.C. resulting less irrigated area & thereby less production. The other effects are the non-uniformity of growth & difficulties in farming operations. Land shaping is required to be done to overcome these hazards. It is an asset in dry farming & almost a pre-requisite for efficient modern irrigated farming where RWS programs are taken. Land shaping sometimes called land farming also means reconstruction of land surface either level or with predetermined grades in longitudinal & cross direction.

V. Implementation of Warabandi: Civil Engineering Management Approach

The government outlet aims the correct amount of water at appropriately scheduled intervals on an assured basis to lands of all farmers in the outlet command. An immediate gain is the prevention of inefficiencies of over irrigation arising mainly from the prevalent practice of levying water charges on the basis of crop-acreage rather than on volume of water used, which invariably results in wastage of water & damage to soil [5]. The objective of this is to examine the mechanics of RWS at the farm level & the organization needed for its implementation. On the established canals in Maharashtra the system of water distribution is practiced. According to sanctioned areas the irrigators are supplied water in turn from tail to head as per the schedule prepared & communicated in advance.

A. Preparation of water distribution (RWS) schedule

RWS schedule can be prepared either on the basis of 1) Traditional method of AI/DC or 2) Consumptive needs of crops to be irrigated.

B. Mechanics of RWS

RWS is adopted basically for the Rabi season when there is slight precipitation & in the command area of an irrigation project, the cultivators have to depend 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 those water intensive crops in the Kharif, such as paddy, the branches, the minors & sub minors of the canal distribution system are to be operated on a rational basis.

In the Rabi season, three levels of rotation can be visualized. The first is the rotation of the outlets along a continuous flowing minor & each outlet is opened once a week for a specific time. This is under the assumption that crops grown in the outlet area require a weekly rotation of water. Crops like wheat may require a fortnight & tobacco may require a three week rotation. For those requiring longer intervals, rotation is the one among the farmers below the outlet. The third level of rotation is among the group of farmers within the group below the outlet. The mechanics of RWD (Rotational Water Delivery) at & below the outlet level in the command area have been worked out on the basis of crop water requirements. Day & night irrigation are conducted without interruption in the canal, branches & minors & only outlet are operated.

Though the objectives of the experimental RWD were not compromised, the procedure was far more relaxed. The objectives were: a) to make sure that each farmer obtains a like share of the available water volume per acre based on fixed time to his field, b) to make sure that losses taking place in the field channels are shared equally among the farmers. As regards procedures, no night time irrigation agenda was laid down & only day schedules were followed. Further, time schedules during day were left to the farmers in the sub groups to regulate among themselves without any enforcement being done by the irrigation department. The reasons were obvious, farmers were not used to night irrigation & disciplined rotational method of distribution in fixed turns was unknown. Introduction of RWD in a big way needs familiarization in a painless manner & an experimental measure naturally required a relaxed atmosphere so that ultimate acceptance of RWD was possible.

C. Implementation of Warabandi

For preparation of irrigation schedules at the outlet level & among the outlets the minors or sub minors, a wide range of people & disciplines familiar with soil characteristics, farming practices & crop water requirements have to come together & apply their skills. Once the schedules are worked, a need for water control is obvious. A set of priorities follows. This would include rehabilitation of canals & installation of water control & measurement devices at appropriate locations such as points of diversion to the branches &distributaries. Further, control measures & measuring are required at the outlets which would be simple structures but yet be effective in convincing the farmers of the adequacy of flow.

VI. Case Study – Pus Project

Note on action program for the Pus Projects includes:

a. Diagnostic analysis of the projects,
b. Recommendation of the solution for improvement,
c. Implementation of the recommendations,
d. Monitoring & evaluation

For action program in Maharashtra, the upper Pus Project in Yavatmal Districts of Vidharba region has been selected on the following grounds,

i) it is a representative medium project in that area constructed.

ii) The farmers in the command area are irrigation minded & it is possible to implement the solutions on a reasonable area & show the initial results in a short period. The upper Pus project is a medium irrigation project constructed on river Pus, in Taluka Pusad, District Yavatmal. The project comprises a storage reservoir & pick up weir.

Four representative minors, two on each canal, one been selected for detailed studies & implementing the recommendations. The action program studies on these four selected minors will enable to deal with the following:

i) Problems of water distribution below outlet,
ii) Improvement in water allocating policy,
iii) Improvement in water allocating policy,
iv) Increased in the production,
v) Increased area under irrigation.

VII. Discussion and Conclusions

The original rotation program was designed based on the standard rotation period of 14 days, i.e. 7 days on & 7 days off. The crop water requirement for different crops was calculated according to Modified Penman Method.

Operation Schedule: According to rotation wise water requirement, total water requirement is calculated. However the capacity of minor is only 283 lps Considering 20% losses in the minor due to conveyance, seepage & other losses, only 226 lps water is available in the minor so we can run only 8 outlets in each day as required discharge at each outlet is 28.3 lps approximately 30 lps .Chak-wise time calculated according to the requirement of each farmer & the total time for each outlet is calculated. Operation schedule of minor is prepared by considering the following conditions,

1) The minor should carry full designed discharge,
2) The minor should carry constant discharge during 80% of total flow period,
3) Tail end outlet must open at first. The operation schedule is shown in figure no. 1.

Calculation of Time: First arrange the names of the farmers from tail to end. Then consider the sanctioned area of various crops. The time of irrigation is calculated according to the consumptive use method. Reference evapo-transpiration is calculated by Modified Penman Method given in table no 4 to 7. The crop coefficient for the crops grown in the command area is given in table no. 4. to 7. namely Wheat, Sun flower & Suger-cane. Rotation wise crop coefficient is calculated from Kc Curves. Total water requirement is calculated for each crop in rotation (Etc = ETo x Kc). Correction factors are applied to account for losses in field channel. Correction factors are based on the distance of individual farm holder from outlet. The correction factors are given in table no. 9. The rotation schedule giving exact day, date & time of irrigation for each farmer under each outlet is calculated.

Experience during practical work in command area: Following observations are made by personal opinion of the farmers & experts while working in the command area.

1) At some places, the field channels are not in good conditions.

2) Turnouts are unlined & its positions are not located at certain places.

3) Bed gradient to field channel is not correctly set up at some points causing overflow of the channel,

4) Farmers have broken the field channel in their own farms not using the design turnouts,

Finally the actual time required for each farmer is noted & total time required for each outlet is calculated.

References

[1] Daniel, "Advance in Irrigation", Vol. no. 1 & 2. & Hillel- Academic Press, New York, 1983.
[2] WALMI, "Planning & design of O.F.D. works" Pub. No. 10, 1981.
- Diagnostic Analysis, Pub. No. 11, 1985.
- Operation & Management of Irrigation, Pub. No. 20, 1987.
- Application of Soil Survey in /irrigation, Pub. No. 21, 1987.
- Water Distribution Method, Pub. No. 22, 1987.
[3] Michael, "Irrigation Theory & Practices", Vikas Pub. New Delhi, 1986.
[4] Hansen, "Irrigation, Principles & practices", John Willey & Sons, New York, 1987.
[5] Michael, "Principle of Agricultural Engineering", Vol. II, Jain Brothers, New Delhi, 1986.
[6] CADA- RWS on Girna Canal, CADA, Jalgaon, 1982.
[7] CBIP – Warabandi, Pub. No. 151, New Delhi, 1980.
[8] PWD Hand Book, Chapter No. 25, Govt. of Maharashtra.

Table No. 1 Maximum Velocity in Different Soils

Sr. No.	Type of Soil	Maximum Velocity in m/s
1.	Sandy & Sandy Loam	0.75
2.	Silt	0.90
3.	Sandy Clay Loam	1.00
4.	Clay Loam	1.20
5.	Stiff Clay	1.50

Table No.2 Non Erosive Velocity

Sr. No.	Type of Soil	Non Erosive Velocity in m/s
1.	Silt	0.45
2.	Black Cotton Soil	0.50
3.	Clay Loam	0.65
4.	Soft Murum	0.80
5.	Hard Murum	1.00

Table No.3 Water Table Depth of Crops (Tolerable)

Sensitivity of Crops	Tolerable Water Table Depth (M)	Crops
Sensitive	More than 3	Cotton, G. Nut, Tobacco, S. Flower, Safflower.
Moderately Tolerant	1 to 3	Wheat, Sorghum, Potato, Gram, Linseed, Lentil.
Tolerant	0.5 to 1	Banana.
Highly Tolerant	Less than 0.5	Rice.

Table No.6 Crop Coefficient Values for 20 Days Rotation

Period	Wheat	S.Flower	S.Cane
10/12-29/12	PSS (0.3)	PSS (0.3)	0.62
30/12-18/01	0.56	0.53	PSS (0.75)
19/01-06/02	1.01	0.96	0.65
07/02-28/02	1.19	1.15	0.81
01/03-20/03	1.11	0.74	0.95
21/03-09/04	0.69	-	1.03

PSS – Pre Soaking & Sowing Rotation

Table No. 4 (20 Days Rotation)

ETo of PUSAD & C.W.R. for Rabi (20 Days) ETc – Root Zone / Turn out (80% eff.)								
Rotation Period	ETo mm/day	ETo 20 Days	Wheat Kc	Wheat ETc	Sun Flower Kc	Sun Flower ETc	Sugar Cane Kc	Sugar Cane ETc
10/12-29/12	3.65	73	PSS	75/ 94	PSS	75/ 94	0.62	47/ 59
30/12-18/01	3.80	76	0.56	43/ 54	0.53	40/ 54	0.75	75/ 94
19/01-06/02	4.40	88	1.01	89/ 111	0.96	84/ 105	0.65	57/ 71
07/02-28/02	4.95	99	1.19	118/ 147	1.15	114/ 143	0.81	80/ 100
28/02-18/03	5.35	107	1.11	119/ 149	0.74	79/ 85	0.95	102/ 128
19/03-07/04	6.00	120	0.69	83/ 103	-	-	1.03	124/ 155

Sr. No	O.L.	Time (Days)
1	Tail	3.79
2	L9	3.09
3	R8	1.01
4	L8	1.96
5	R7	0.52
6	L7	7.34
7	R6	0.62
8	L6	5.01
9	R5	5.34
10	L5	5.02
11	R4	0.72
12	L4	4.60
13	R3	1.84
14	L3	4.26
15	R2	1.75
16	L2	2.66
17	L1	2.30

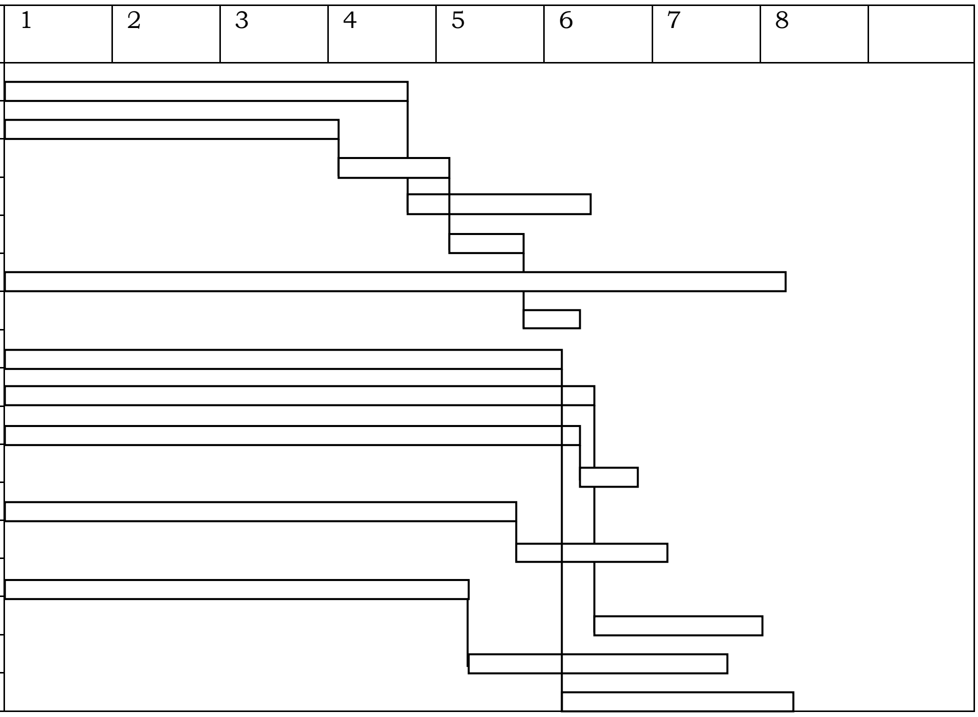

Figure 1. Operation Schedule

Table No. 7 Correction Factor for Discharge

Length in Meter	Correction Factor
0000-0150	1.1
0150-0300	1.2
0300-0450	1.3
0450-0600	1.4
0600-0750	1.5
0750-0900	1.6
0900-1050	1.7
1050-1200	1.8
1200-1350	1.9
1350-1500	2.0

Table No.8 Daily & Rotation wise ETo by Modified Penman Method For Rabi Season

Rotation Period	ETo (mm/day)	ETo in mm (for 14 days)
15/10-28/10	5.1	71
29/10-11/11	4.7	66
12/11-25/11	4.2	59
26/11-09/12	3.9	55
10-12-23/12	3.6	50
24/12-06/01	3.7	52
07/01-20/01	3.9	55
21/01-03/02	4.3	60
04/02-17/02	4.9	69
18/02-04/03	5.0	70

SEASON	RAB										HW											
MONTHS	OCT	NOV		DEC		JAN		FEB		MAR			APR			MAY			JUN			JUL
ROTATION NO.	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12
ROTATION PERIOD	15-10 28-10	29-10 11-11	12-11 25-11	26-11 9-12	10-12 23-12	24-12 6-1	7-1 20-1	21-1 3-2	4-2 17-2	18-2 3-3	4-3 13-3	14-3 23-3	24-3 2-4	3-4 12-4	13-4 22-4	23-4 2-5	3-5 12-5	13-5 22-5	23-5 1-6	2-5 11-6	12-6 21-6	22-6 1-7
1. WHEAT																						
GROWING PERIOD (120 DAYS)			PSS																			
GROWING STAGES WITH DAYS				0 10		1 55			2 15	3 30		4 10										
REQUIREMENT (MM) AT ROOT ZONE (512)			75	16	28	49	64	72	81	69	39	19										
AT OUTLET (854)			120	27	47	80	107	120	135	115	65	32										
WATER ALLOCATION (MM) AT OUTLET (900)			120	60	60	60	120	120	120	120	60	60										
NO. OF HOURS/ Ha.			12	6	6	6	12	12	12	12	6	6										
2. SUN FLOWER																						
GROWING PERIOD (90 DAYS)			PSS																			
GROWING STAGES WITH DAYS				0 10	1 30		2 20	3 30	4 10													
REQUIREMENT (MM) AT ROOT ZONE (370)			75	17	27	45	63	68	50	25												
AT OUTLET (613)			125	28	45	75	105	113	81	41												
WATER ALLOCATION (MM) AT OUTLET (620)			120	60	60	60	100	100	60	60												
NO. OF HOURS/ Ha.			12	6	6	8	10	10	6	6												
3. H.W.G. NUT																						
GROWING PERIOD (120 DAYS)									PSS													
GROWING STAGES WITH DAYS										0 15		1 30			2 20			3 30		4 15		
REQUIREMENT (MM) AT ROOT ZONE (729)									75	18	18	30	46	64	76	87	78	76	75	51	35	
AT OUTLET (1221)									125	31	31	51	51	107	127	145	131	127	125	85	59	
WATER ALLOCATION (MM) AT OUTLET (1260)									120	60	60	60	60	130	130	130	130	130	130	60	60	
NO. OF HOURS/ Ha.									12	6	6	6	6	13	13	13	13	13	13	6	6	
4. SUGAR CANE																						
GROWING PERIOD (365 DAYS)						PSS																
GROWING STAGES WITH DAYS	3 105			4 55			0 30						1 175									
REQUIREMENT (MM) AT ROOT ZONE (1328)	74	62	49	40	33	75	23	35	50	58	46	55	60	70	77	87	80	82	90	72	61	49
AT OUTLET (2217)	124	104	81	67	55	125	39	59	84	97	77	92	100	117	128	145	133	137	151	120	101	81
WATER ALLOCATION (MM) AT OUTLET (2240)	100	100	100	60	60	120	80	80	80	80	80	80	120	120	120	140	140	140	140	100	100	100
NO. OF HOURS/ Ha.	10	10	10	6	6	12	8	8	8	8	8	8	12	12	12	14	14	14	14	10	10	10
5. L. S. COTTON																						
GROWING PERIOD (180 DAYS)	PSS																					
GROWING STAGES WITH DAYS	2 70		3 40			4 20																
REQUIREMENT (MM) AT ROOT ZONE (376)	89	81	67	57	44	38																
AT OUTLET (627)	148	135	112	95	73	64																
WATER ALLOCATION (MM) AT OUTLET (600)	140	140	100	100	60	60																
NO. OF HOURS/ Ha.	14	14	10	10	6	6																

NOTES
1) WATER DELIVERY AT OUT LET
1= CUSECS (28LPS)
2) EFFICIENCY FROM
I) OUTLET TO TURN OUT = 75%
II) TURN OUT TO ROOT ZONE = 80%
3) Q AT TURNOUT = 21 LPS
4) GROWTH STAGES
0= ESTABLISHMENT
1=VEGETATIVE
2=FLOWERING
3= YIELD FORMATION
4= RIPENING
5= PSS = PRE-SOAKING AND SOWING

Figure 2. PUS Project Crop Wise Requirement & Allocation (Based upon Penman Method)

Table No. 9 Daily & Rotation wise ETo by Modified Penman Method For Hot Weather Season

Rotation Period	ETo (mm/day)	ETo in mm (for 14 days)
05/03-14/03	5.0	50
15/03-24/03	5.7	57
25/03-03/04	6.0	60
04/04-13/04	6.8	68
14/04-23/04	7.3	73
24/04-03/05	8.1	81
04/05-13/05	7.3	73
14/05-23/05	7.3	73
04/05-02/06	7.8	78
03/06-12/06	6.2	62

CITE THIS ARTICLE AS :

Kisan L. Bidkar, Kailas T. Phalak, Rahul T. Pardeshi, "Rotational Water Supply in Command Area", *International Journal of Technology and Science*, vol. 5, Issue. 2, pp. 28-33, 2018

AUTHORS' DETAIL

Kisan Bidkar
Associate Professor,
Sandip Institute of Engineering and Management, Nashik, Maharashtra, India
Email: kisan.bidkar@siem.org.in

Kailas Phalak
Associate Professor,
Sandip Institute of Engineering and Management, Nashik, Maharashtra, India
Email: kailas.phalak@siem.org.in

Rahul Pardeshi
Assistant Professor,
Sandip Institute of Engineering and Management, Nashik, Maharashtra, India
Email: rahul.pardeshi@siem.org.in