

ASSESSMENT OF CROP WATER REQUIREMENT AND IRRIGATION SCHEDULING OF DHANSHIRI BASIN

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Abstract

The assessment of crop water requirement and Irrigation Scheduling are the two most important requirements for irrigation development of a basin. In 1948 Food and Agricultural Organization (FAO) studied on crop water requirement and according to FAO the CWR is the need of water to meet Evapo-Transpiration of crops (ET crop). It depends on climate, growth stages of the crops, rooting depth of crops and Soil type. The software CROPWAT 8.0 and CLIMWAT 2.0 are used for the calculation of crop water requirement and Scheduling of Irrigation requirement. The necessary meteorological data are taken CLIMWAT 2.0 for Station Jorhat, Assam-India. The crop water requirements for the different crops of the basin have been calculated by using Cropwat 8.0 software. The irrigation requirement for winter crops is very less due to higher effective rainfall than evapotranspiration. The same is more for Rabi and summer crops due to scanty rainfall. Irrigation scheduling is the best technique of water management. The irrigation scheduling prevents the crop area from water logging.

Key words: CLIMWAT 2.0, CROPWAT, Evapotranspiration, Effective Rainfall, Crop Water Requirement and Irrigation scheduling

1. Introduction

The life line of agriculture is water and its requirements for different crops are different. The irrigation water requirement is based on the correct assessment of crop water requirements. This study work is inspired by Das and Sarma (2018) which calculated the crop water requirements of Kushi basin. Dowod Rasooli Kia (2013) used CROPWAT 8.0 for calculation of crop water requirements. The resource of irrigation development of a basin is water and is very limited in usable condition, since day by day the environment is going on deteriorating by human activities like deforestation, industrialization, automobile, use of pesticide and chemicals, etc. The pollution of environment is a cause of climate change. A study was done by Dr. Falguni Parekh and Kelvin Promodchandra (2013) on Climate Change Impact on Crop Water Requirement. The success of an Irrigation project depends upon the assessment accuracy of irrigation and crop water requirement. Both Irrigation water requirement and crop water requirement were very difficult in early days but now it is made easy due to the redevelopment of many computer aided software on irrigation development. The popular softwares in this field are CLIMWAT 2.0, CROPWAT 8.0, Lingo, Lingdo, etc. the information required to use the software for crop water requirement are climatic data, Soil data and crop data. The information under climate data are average rainfall, maximum & minimum temperature, humidity, sun shine hours and wind velocity which are available from CLIMWAT 2.0 and CROPWAT 8.0. The required soil data are soil name, total available moisture content (TAM), maximum rain infiltration rate, maximum rooting depth, initial soil moisture depletion, etc. The crop information are different for different crops. The required crop data are crop coefficient (K_c), growth stages in days, rooting depth, paddling depth, nursery area, critical depletion (fraction), yield response of crop and crop height. The 90% area of the basin depends on rainfed cultivation and the major crop season is from May to November (winter crop season only) because the irrigation requirement during this season is very less. Recently A study was done on the " Impact of Climate Change on Cropping Pattern in Tropical Sub-humid Watershed by Duku C, Zwart SJ and Hein L (2018). The other seasonal crops are occupying only 15-20 % of the total agricultural area. The farmers of Dhanshiri basin are regularly affected by either draught or from flood. The study on Impact of Flood and River Bank Erosion on Socio-Economic of Golaghat Revenue Circle of Golaghat District by Mili N, Acharjee S and Konwar M (2013). Though both are natural but draught can be compensated cultivating more area for rabi and summer crops if irrigation system is available. The basin has two major crop seasons known as Kharif or

winter season and Rabi season. Another basin in Assam known as Gangadhar basin where cultivation in the same area has been practicing in more than one crop season. The basin has no major surface or Lift irrigation project. The small scale farmers make their own irrigation scheme by installing shallow wells with 5 hp diesel pump set. The system has been running so successfully that the economical condition of the farmers of the basin is better than the farmers of other basin of Assam. Moreover, there is a possibility of failure of river irrigation project due to several reasons. It is mentioned here because the water loss due to seepage, evaporation, canal loss are much more in traditional canal irrigation than small area covering shallow irrigation which are in practice in Gangadhar basin. The scheduling of irrigation in this type of shallow irrigation is very convenient and economical.

Most of the surface water irrigation schemes of Dhanshiri basin are lying abundant basin due to frequent change in river course. From the study of the cropping pattern and irrigation developed by ground water of Gangadhar basin it seems that the Ground water is the most attractive alternative as a source of irrigation in Dhanshiri basin. Since Ground water is very precious, its over exploitation must be controlled by correct estimation of crop water requirements and proper irrigation scheduling. The related subject was studied by Ratna Raju C., et al., (2016)

Crop water requirement is directly related to evaporation from soil surface due to sun light and transpiration through the leaves of plants which is commonly known as evapotranspiration (ET). The most popular technique to estimate ET is 'Kc' approach (Yang F, Zhang Q & R Zhou J, 2014), where the Etc is calculated by using standard agro-meteorological variables and a crop specific coefficient. The value of 'Kc' depends upon atmospheric condition, crop physiology and agricultural practices. If available amount of water is less, the plants will close their pores to reduce evaporation. It hampers their proper growth. The factors that are to be considered for calculation of evapotranspiration are: the radiation from sun, air mean temperature, wind speed, altitude of the area and availability of water.

2. Description of Dhanshiri Basin

The Dhanshiri Basin is named after river 'Dhanshiri. The basin is a major basin in the middle Assam zone. The Dhanshiri River is a south bank tributary of the mighty River Brahmaputra. The basin lies between Latitudes 26°42" N and 25°21" N and Longitudes 94°37" E and 93°10" E as shown in Fig. 1, where the Latitude and Longitude of important Golaghat town are 95.96 E and 26.52 N respectively. The total area of the Dhanshiri basin is 12,240 sq. km. Hilly State Nagaland and Karbi Anglong Autonomous District Council occupy the major part of this area. Out of the total area only 3,502 sq. km falls in the Golaghat District, which is the area under this study. Golaghat District was formed on 15th August'1987. Before that Golaghat was a sub-division of Jorhat District. The river Brahmaputra covers the north side of the District; Nagaland and Karbi Anglong Autonomous District Council in the south side and in the west East Jorhat District.

The basin is situated at about 100.00 m above the mean sea level in Nagaland and the average altitude of the basin in Golaghat District is 60.60 m. The basin topography in the study part is slightly undulating and light to dense forest including National Park Kaziranga. The natural slope of the basin is from south to North and west to east and the resultant slope is southeast.

The reserve forests Kaziranga, Nambor, Dayang and Kaliyoni wild life sanctuary occupy about 1,50,000 hectares out of which Kaziranga wild life sanctuary alone covers about 1,36,000 hectares of area. The basin includes a number of important biodiversity rich areas such areas are Nambar forest Range, part of Dayang and Rengma Reserve forest, Garampani Doigurung Wild Life Sanctuary and the Kaziranga National Park.



Fig. 1: Dhanshiri Basin Map

The basin has two major crop seasons depending on rainfall. The meteorological information of the basin is tabulated in Table – 1. The investigation report for soil of the study area is given in Table – 3. All these information are necessary for running the computer based software as stated earlier.

3. Cropping Pattern of the Basin

The crops which are cultivated in the basin are paddy, jute, oilseeds, maize, millet, vegetables, banana and sugarcane. Paddy and tea are the major agricultural crops at present are grown within the basin. The cropping pattern of Dhanshiri Basin is for two major crop seasons known as Kharif crop season (May to November) and Rabi crop season (December to May) along with a small area for perennial crops. The former one is rainfed and the later one is irrigation fed. The basin is rich in surface and ground water potential. But still the basin is far behind in agricultural development. The existing pattern shows Kharif paddy (Assam Sali different varieties) 115038 ha and Rabi paddy (Assam Ahu and Boro) is only 7759 ha out of total cultivable area 143790 ha (source of cropping pattern information: Assam Agriculture department). This big difference between kharif paddy and Rabi Paddy area is absent of irrigation. During kharif season the water requirement for crops is available naturally but the crops in rabi season are fully irrigation dependent. If water is made available during rabi season the area for rabi paddy may be increased much more than existing kharif paddy area. Considering future irrigation development of the whole basin the rabi crops area for Ahu paddy and boro paddy can be increased in proportion to the existing area to 53530 ha and 42820 ha respectively. With other allied crops the total crops are for kharif crops and rabi crops will be 117038 ha and 125350 ha respectively. Draught is the only problem for rabi season but in kharif season both flood and draught. Draught can be managed by irrigation but flood management is very difficult. Considering this aspect the proposed rabi crops area is more than kharif area. This new cropping pattern the cropping intensity will be raised to 180%. Table – 2 and fig-2 show the future cropping pattern and present Land use map respectively of the Dhanshiri basin.

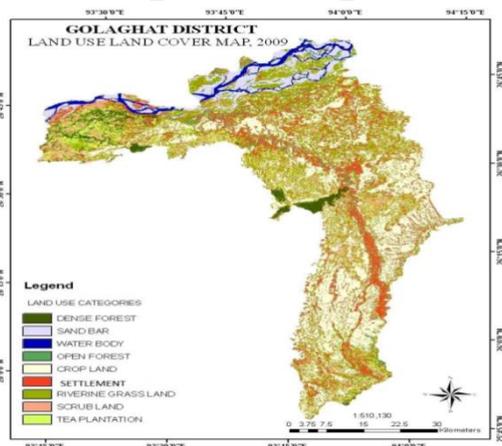


Figure - 2. Land use/land cover map of Dhanshiri Basin

4. Crop Water Requirement and Irrigation Scheduling

To determine crop water requirement of a basin first thing is to select the cropping pattern (cropping pattern considered for the same is given in Table – 2). After selecting the cropping pattern, the next step is to calculate the crop water requirement, irrigation requirement and scheduling of irrigation of the basin. Irrigation scheduling depends upon the irrigation requirement and frequency of application of irrigation water to the crop field which is given in decade. The Climatic information of the basin are given in Table – 1 and Soil information Table – 3. The crop data such as crop coefficient (K_c), crop stages duration, root zone depth for different stages, the allowable soil moisture depletion levels, yield response factor and crop height are preloaded by FAO in the CROPWAT. There are four growth stages of a crop are Initial stage, Development stage, Mid-season and Last season for dry crops and for wet crops Nursery stage is given before Initial stage to meet pre-sowing water requirement. When all these input data are given to the software and command to run CWR the computer will automatically generate the values of crop water requirement and irrigation requirement since effective rainfall data have already shown in Table - 1. Crop wise water requirement per decade and total irrigation requirement (in mm) are shown in Table – 4. In this table for crop K1, watering started from May to October and 1st watering 49.8 mm will be required in 2nd decade of May, 2nd watering 145.4 mm will be in 3rd decade of May and last watering 2.9 mm in 1st decade of October. Total water depth required is 198 mm from sowing to harvesting. All the months are considered for 30 days irrespective of 31 or

28 days to avoid decimal values. After Irrigation requirement next important is Scheduling of irrigation. Scheduling of irrigation means application of water when it is needed with required quantities. For scheduling time and quantity both are very important. If time is not maintained the crops may reach wilting and more water application may cause water logging. To find out the water quantity for irrigation in 1st decade of January let us first go through 1st decade of Table – 5 to find water depth for irrigation of the crops which fall on the 1st decade. January 1st Decade Crops are R1, R3, R5, R6, R7, R8, S1, P1 & P2 and their respective irrigation water depth required from Table – 4 are 16.2, 14.4, 13.0, 14.5, 12.6, 8.6, 11.7, 5.4 and 12.7 and their respective areas in ha are 53530, 243, 9950, 9956, 2213, 1600, 1950, 5832, 62820, 246, 2240 and 2740. Therefore, the water scheduling for January 1st decade (1st January to 10th January) = $16.2 \times 53530 + 14.4 \times 243 + 13.0 \times 2213 + 12.7 \times 2740 = 2502000 \text{ ha.mm} = 2502 \text{ ha m} = 2502 \times 10^4 \text{ m}^3$. Table - 6 is the irrigation scheduling of this study.

5. Result and Conclusion

The assessment of crop water requirement and irrigation requirement for the command area of Dhanshiri basin were done as shown in Table – 4. The crop water requirement of the basin is 5680.6 mm/yr from January to December and net irrigation required is 2035.6 mm/year. These are the summation values of column 5 and column 6 of the same Table. The gross water required for irrigation for one year is 630.72 MCM. So far all the irrigation project of the basin are the lift irrigation scheme from Dhanshiri river and most of the projects are now out of order due to several reasons. The ground water potential of the basin is 930 MCM and water requirement for irrigation is 630 MCM. So it is better to go for Ground water lift irrigation in future.

After calculation of crop water requirement and Irrigation requirement, next part of the study is Irrigation Scheduling. For irrigation scheduling Table – 5 is used. Irrigation scheduling is shown in Table – 6 and column 16 shows the value of water quantities to crop field for irrigation per decade. It is important to mention here that the area of Tea garden of the basin was not included because the Tea industries have their own irrigation system. The net benefit of the study is that at present only 7759 ha area has been cultivated for Rabi crops whereas the available area is 143790 ha in the basin. After the irrigation development of irrigation in the basin the Rabi crop area will be increased to 116350 equals to Kharif crop area. The increased area will raise the irrigation intensity up to 180%.

6. Tables

Table - 1
Climate data of the Basin

Month	Min. Temp	Max. Temp	Humidity	Wind	Sun	Radiation	ETo	Rain	Eff Rain
Unit	°C	°C	%	Km/day	Hours	MJ/m ² /day	mm/day	mm	mm
January	8.6	23.9	80	43	8.1	15.0	2.04	13	12.7
February	10.6	26.2	74	52	7.9	16.9	2.58	32	30.4
March	14.7	30.9	65	61	8.0	19.4	3.59	76	66.8
April	19.1	33.0	65	86	7.0	19.7	4.32	167	122.4
May	22.1	32.5	72	69	5.7	18.6	4.11	168	122.8
June	24.2	32.5	71	61	3.3	15.1	3.58	215	141.0
July	24.8	33.0	78	43	3.2	14.7	3.41	291	154.1
August	24.7	32.9	77	52	3.2	14.3	3.35	224	143.7
September	24.1	32.3	84	43	4.0	14.2	3.19	164	121.0
October	21.3	32.2	80	43	6.5	15.6	3.17	95	179.2
November	15.4	27.1	83	43	7.8	15.1	2.56	10	9.8
December	10.6	24.4	83	43	8.0	14.2	2.02	03	3.0
Av/Total	18.4	29.9	76	53	6.1	16.1	3.16	104.66	83.90
	Average							Total	

Table 2
Cropping pattern of the Basin

Crop	Crop Index	Crop sowing and harvesting time		Area (ha)
		From	To	
Kharif Rice (Sali)	K1	May	November	115038
Kharif Maize	K2	June	October	500
Kharif Vegetable	K3	June	October	850
Rabi paddy (Ahu)	R1	December	April	3570/53530*
Wheat	R2	October	March	243
Oil seeds	R3	October	February	9956
Potato	R4	October	January	2213
Tomato	R5	October	January	1600
Millet	R6	November	February	1950
Pulse (all)	R7	October	January	5832
Rabi Veg.	R8	October	January	5200
Summer Rice (HYV Boro)	S1	February	May	4190/62820*
Fibre crop (Jute)	S2	February	May	246
Sugarcanes	P1	March	February	2240
Banana1	P2	October	September	2740

* Actual area as per present cropping pattern for R1 & S1 are 3570 & 4190 and the proposed area for R1 = 53530 and S1 = 62820 respectively.

Table - 3
Input soil parameters for calculation of crop water requirements
Major soil type (>80%) Red loamy

S. No.	Soil Parameter	Value	Unit
1	Total available moisture	290	Mm/m
2	Maximum rain infiltration rate	40	Mm/day
3	Maximum rooting depth	900	Cm
4	Initial soil moisture depletion (as % TAM)	0	%
5	Initial available soil moisture	290	Mm/m
6	Drainable porosity	12	%
7	Critical depletion for paddle cracking	0.40	Fraction
8	Maximum percolation rate after puddling	3.4	Mm/day
9	Water availability at planting	100	Mm WD
10	Maximum water depth	400	mm

Table – 4

Total Crop water requirement and Irrigation requirement from January to December

Crop	Crop Index	Crop sowing and harvesting time		Area (100m ²)	ET _c (mm)	irrigation required (mm)
		From	To			
1	2	3	4	5	6	7
Kharif paddy (Sali)	K1	May	November	115038	530.7	198.0
Kharif Maize	K2	June	October	500	329.4	00
Kharif Veg.	K3	June	October	850	312.6	00
Rabi Rice (Ahu)	R1	December	April	53530	392.3	433.2
Wheat	R2	October	March	243	202.2	103.2
Oil seeds	R3	October	February	9956	197.9	124.3
Potato	R4	October	January	2213	207.7	125.1
Tomato	R5	October	January	1600	288.2	155.0
Millet	R6	November	February	1950	148.6	79.3
Pulse (all)	R7	October	January	5832	196.7	91.4
Rabi Veg.	R8	October	January	62820	227.9	107.0
Summer Rice (HYV Boro)	S1	February	May		456.8	386.2
Fibre crop (Jute)	S2	February	May	246	302.1	00
Sugarcanes	P1	March	February	2240	1051.2	181.0
Banana1	P2	October	September	2740	836.4	51.9
Total				264958	5680.6/yr	2035.6/yr

Table – 5

Crop wise Irrigation requirement in mm/decade

Month	Decade	W Crops			Rabi Crops								Summer		Perennial	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		K1	K2	K3	R1	R2	R3	R4	R5	R6	R7	R8	S1	S2	P1	P2
Jan	1	X			16.2		14.4	13.0	13.0	14.5	12.6	8.6	11.7	X	5.4	12.7
	2	X			14.5		12.8	13.7	13.8	12.5	11.0	4.3	7.7	X	5.1	10.3
	3	X			17.1		12.8	16.1	12.8	12.1	11.4	0.6	13.1	X	4.6	10.2
Feb	1	X			14.9		3.7	13.7	5.3	7.2	3.5	X	16.3	X	1.7	6.1
	2	X			15.1		00	12.8	9.9	2.0	00	X	20.3	4.2	00	3.8
	3	X			10.2		X	5.3	00	X	X	X	12.5	2.9	4.3	00
Mar	1	X			19.9		X	9.9	X	X	X	X	17.8	0.5	2.0	00
	2	X			20.7	X	X	00	X	X	X	X	18.1	11.0	00	00
	3	X			15.8	X	X	X	X	X	X	X	8.0	169	00	00
April	1	X			8.1	X	X	X	X	X	X	X	2.1	14.5	00	00
	2	X			X	X	X	X	X	X	X	X	00	0.6	00	00
	3	X			X	X	X	X	X	X	X	X	00	00	00	00
May	1	00	00		X	X	X	X	X	X	X	X	X	00	00	00
	2	49.8	00		X	X	X	X	X	X	X	X	X	00	00	00
	3	145.4	00		X	X	X	X	X	X	X	X	X	3.5	00	00
June	1	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	2	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	3	00	00	00	X	X	X	X	X	X	X	X	X		00	00
July	1	00	00	00	X	X	X	X	X	X	X	X	X		00	00

	2	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	3	00	00	00	X	X	X	X	X	X	X	X	X		00	00
Augt	1	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	2	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	3	00	00	00	X	X	X	X	X	X	X	X	X		00	00
Sept	1	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	2	00	00	00	X	X	X	X	X	X	X	X	X		00	00
	3	00	00	00	X	X	X	X	X	X	X	X	X		00	00
Oct	1	2.9	00	00	X	X	X	X	X	X	00	00	X		00	3.7
	2	X		00	X	X	00	X	1.8	X	00	3.7	X		00	17.6
	3	X			X	X	00	X	0.6	X	00	7.2	X		00	19.0
Nov	1	X			00	14.7	00	X	2.0	00	2.7	5.8	X		00	12.2
	2	X			58.4	5.5	00	X	4.8	00	7.7	7.4	X		00	11.1
	3	X			162.7	4.8	6.3	00	11.6	00	12.8	10.7	X		00	14.0
Dec	1	X			17.7	4.3	15.2	4.4	17.3	7.6	17.3	15.3	X		4.4	17.4
	2	X			20.1	2.4	20.2	9.0	20.4	16.4	20.6	18.7	X		8.3	19.7
	3	X			20.9	4.3	19.7	12.7	19.9	16.9	16.8	17.7	X		7.8	18.1
		198	00	00	433.2	103	124	125	155	79.3	91.0	107	386	00	51	181

Table – 6
Irrigation scheduling (m³ per decade)

Month	Decade	W Crops			Rabi Crops								Summer		Perennial		10 ⁴ m ³ / decade
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		K1	K2	K3	R1	R2	R3	R4	R5	R6	R7	R8	S1	S2	P1	P2	
Jan	1	X	X	X	867	0.39	143	28.8	20.8	28.5	73.4	44.7	735	X	12	34.7	2502
	2	X	X	X	776	0.49	127	30.3	22.1	24.4	64.2	22.4	484	X	11	28.2	2020
	3	X	X	X	945	0.54	127	35.6	20.5	23.6	67.3	3.12	823	X	10	28.0	2526
Feb	1	X	X	X	808	0.51	37	30.3	8.5	14.0	20.4	X	1023	X	4	16.7	2552
	2	X	X	X	546	0.97	00	28.3	15.8	39.0	00	X	1275	1.0	00	10.4	2196
	3	X	X	X	1065	1.2	X	11.7	00	X	X	X	785	20.7	10	00	2046
Mar	1	X	X	X	1108	00	X	21.9	X	X	X	X	1118	0.1	5	00	2470
	2	X	X	X	845	X	X	00	X	X	X	X	1137	2.75	00	00	2184
	3	X	X	X	3126	X	X	X	X	X	X	X	503	42.3	00	00	3831
Apr	1	X	X	X	8709	X	X	X	X	X	X	X	132	3.6	00	00	8877
	2	X	X	X	X	X	X	X	X	X	X	X	00	0.2	00	00	0.4
	3	X	X	X	X	X	X	X	X	X	X	X	00	00	00	00	0
May	1	00	00	X	X	X	X	X	X	X	X	X	X	00	00	00	0
	2	5729	00	X	X	X	X	X	X	X	X	X	X	00	00	00	5729
	3	16727	00	X	X	X	X	X	X	X	X	X	X	0.9	00	00	16728
June	1	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	2	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	3	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
July	1	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	2	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	3	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
Augt	1	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	2	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	3	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
Sept	1	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	2	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
	3	00	00	00	X	X	X	X	X	X	X	X	X	X	00	00	0
O	1	334	00	00	X	X	X	X	X	X	00	00	X	X	00	10	688

ct	2	X	X	00	X	X	00	X	2.9	X	00	19.2	X	X	00	.148	321
	3	X	X	X	X	X	00	X	1.0	X	00	37.4	X	X	00	.152	645
	1	X	X	X	00	0.97	00	X	3.2	00	16	30.2	X	X	00	.334	130
Nov	2	X	X	X	947	0.32	00	X	7.7	00	45	38.5	X	X	00	.304	1274
	3	X	X	X	1076	0.29	63	00	18.6	00	75	55.6	X	X	00	.384	788
	1	X	X	X	448	0.27	152	9.7	27.7	14.8	101	79.0	X	X	10	.477	1274
Dec	2	X	X	X	1076	0.15	202	19.9	32.6	32.0	121	97.2	X	X	19	.540	2149
	3	X	X	X	1118	0.27	197	28.1	31.8	33.0	98	92.0	X	X	18	.500	2142
																	63072.4*

* Total water required for irrigation is 63072 Ha .m = 63072 10⁴ m³ = 630.72 MCM.

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