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PERFORMANCE ASSESSMENT OF ARANIAR MEDIUM IRRIGATION PROJECT IN CHITTOOR DISTRICT ACCORDING TO VARIOUS PERFORMANCE INDICES

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ABSTRACT

Enhancing the irrigation systems performance is crucial for making significant progress in addressing India's food security challenges. In this regard, the current study was carried out to evaluate the performance of the Araniar medium irrigation project in the Chittoor district. using various performance indicators. According to the Indian National Committee on Irrigation and Drainage (INCID 2002) New Delhi guidelines. The study found that the Water delivery capacity index of the Araniar project was 0.35. Irrigation intensities in the area varied significantly, with a high intensity of 83.51% obtained in the year 2016-17 and low intensity of 20.39% is obtained in 2010-11. Groundnut exhibited the highest output per hectare at Rs. 48129.84, followed by Paddy and Sugarcane crops with Rs. 38434.93 and Rs. 34671.08 respectively, while Bajra had the lowest output per ha of Rs. 3225.16. A socio-economic survey was conducted in the command area, involving 515 randomly selected farmers. The survey revealed that 57.29% of farmers reported having irrigation water available when needed, while 42.71% reported water scarcity during crucial times. Based on the findings, the study concluded that the Araniar irrigation project faces water scarcity during dry periods. To alleviate this issue, a proposed solution involves implementing a lift irrigation project to transfer water from the Mallemadugu dam to the Araniar project. This would help alleviate the water crisis and ensure water availability during dry spells.

Keywords: Araniar irrigation project, INCID, Mallemadugu dam, Performance assessment, Performance indicators.

Introduction

The Food and Agriculture Organization (FAO, 2017) projected 14% growth in irrigation withdrawals from 1995 to 2025. While, the International Water Management Institute (IWMI) states 17% growth in withdrawals for irrigation (Amarasinghe and Smakhtin 2014). But food production from irrigated land will increase by at least 40% over the same period to meet the food grain needs at a rise in 33% population and to meet trends of better nutrition (Bos *et al.*, 2007). It was estimated that by 2050, as per the Indian National Committee for Irrigation and Drainage (INCID), According to the Ministry of Water Resources (MoWR), approximately 30% of the geographical area

and 16% of the population will encounter severe water scarcity.

Now a day's central and state government gives more importance to construct irrigation projects like Polavaram project, Pattiseema Lift Irrigation Project, Rivers inter linked Programs and other medium size irrigation projects. Before 1956, the total irrigation capacity generated in Andhra Pradesh under major and medium-sized projects was 29.73 lakh acres; To create 34.42 lakh acres of new ayacut in the state by completing the ongoing major and medium irrigation projects government sanctioned 13,139.23 crores during 2019 to the Water Resource Department. The key aim of the irrigation department in State is to

increase the productivity of agriculture per unit water by establishing irrigation potential in the drought prone, upland regions and maintenance of existing projects (WRD, Government A.P).

Irrigation infrastructure projects have received significant funding. However, there is a widespread belief that many irrigation projects fail to meet expectations or achieve their objectives (Gorantiwar and Smout, 2005), creating a large gap between the capacity of irrigation projects created generated and exploited (Phadnis and Kulsrestha, 2011). By identifying issues and exploring avenues for improvement, performance assessment helps enhance the overall efficiency of an irrigation water management system (Cakmak *et al.*, 2004; Elshaiikh *et al.*, 2018; Sekyi-Annan, *et al.*, 2018; Shumye and Meshesha, 2022). On the other hand, a few researchers have conducted studies to evaluate irrigation water

management from the perspective of farmers (Kuscu *et al.*, 2008; Putri, *et al.*, 2022; Rajput, *et al.*, 2017).

Material and Methods

Study Area

The Araniar River also known as ‘Arani’ which flows through the states of Andhra Pradesh and Tamil Nadu. The Araniar medium irrigation project was constructed across the Araniar river near Pichatur village (latitude 13.35 to longitude 79.25), Chittoor District in Andhra Pradesh in the year 1958. It has got 150 sq. miles and 2 sq. miles of free catchment and intercepted respectively; gross capacity of the reservoir is 1.851 TMC. Total ayacut of the irrigation project was 3682.6 ha. Major crops irrigated in the command area are Paddy, Sugarcane, Groundnut and Bajra. The project also provides drinking water to the Nindra and Pichatur mandals through Nindra Rural Water Supply System Fig.1.

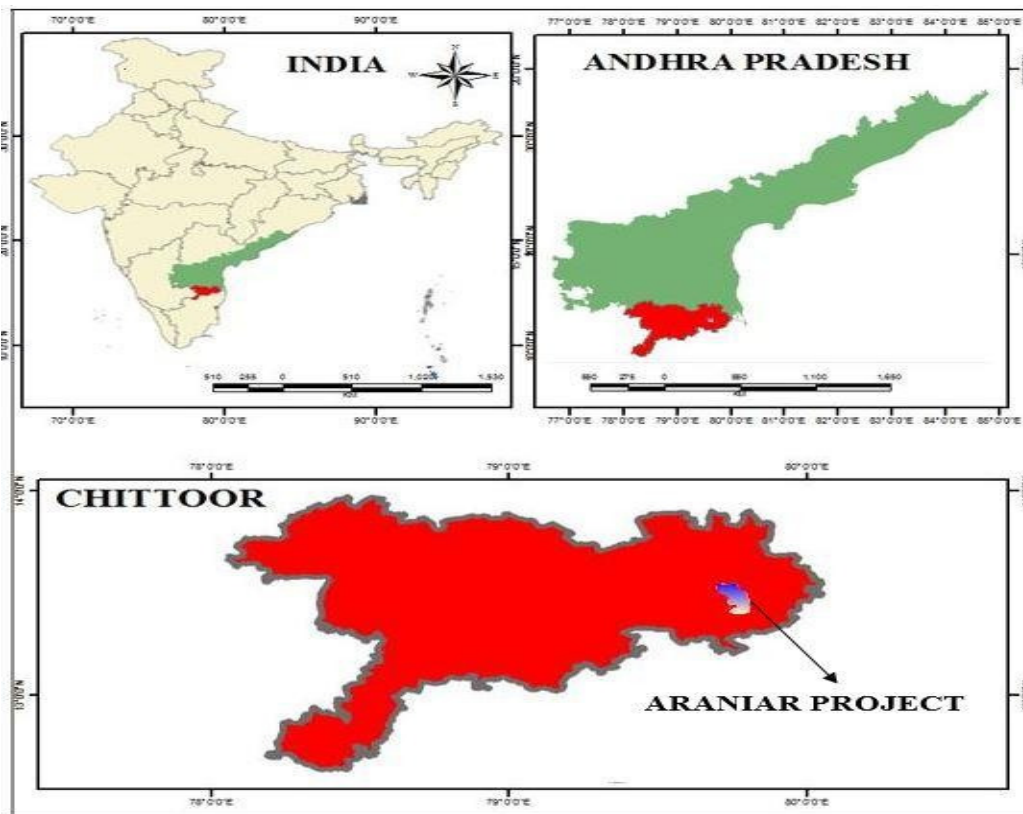


Fig. 1: Location of Araniar medium irrigation project command area

Performance indicators are given as follows

1. System Performance

Water delivery capacity index

It is the ratio of canal capacity to deliver water at system head to peak irrigation water requirement.

By using CROPWAT 8.0 software, the peak irrigation water requirement of the paddy and sugarcane crops were calculated (Parra *et al.*, 2020).

$$\text{Water delivery capacity Index} = \frac{\text{Canal capacity water at system}}{\text{Peak irrigation water requirement}} \dots\dots\dots 1$$

Total annual volume of irrigation water delivery (Mm³/year)

It is the overall amount of water supplied over the year or season to the water users. In this context, water users are the beneficiaries of the irrigation service and these can include single irrigator or groups grouped into water user groups.

Annual irrigation water supply per unit command area (m³/ha)

Total annual volume of water delivered or pumped for irrigation into the system to the command area is the nominal or design area provided with irrigation infrastructure that can be irrigated.

$$\text{Annual irrigation water supply per unit command area} = \frac{\text{Total annual volume of irrigation water inflow (m}^3\text{)}}{\text{Total command area serviced by the system (ha)}} \dots\dots\dots 2$$

Annual irrigation water supply per unit irrigated area (m³/ha)

It is the ratio of total annual volume of water diverted or pumped for irrigation into the system to the total irrigated area cropped during the year (Higginbottom *et al.*, 2021).

$$\text{Annual water supply per unit irrigated area} = \frac{\text{Total annual volume of irrigation water inflow (m}^3\text{)}}{\text{Total annual irrigated crop area (ha)}} \dots\dots\dots 3$$

Intensity of irrigation

Intensity of irrigation (I) is expressed in percentage value. It is defined as percent area irrigated in a particular season with respect to cultivable command area

$$\text{Intensity of Irrigation} = \frac{\text{Total irrigated area}}{\text{Culturable command area}} \times 100 \dots\dots\dots 4$$

2. Agricultural Productivity

For analyzing Agricultural productivity yield details, area sown particulars, market prices and irrigation supply. Paddy, Groundnut and Bajra data was collected from the crop cutting experiments which was conducted by the department of Economics and Statistics (DES) and the market prices were collected from Minimum Support Price (MSP) and Fair and Remunerative Price (FRP) for 2019-2020 season from Economics and statistics (DES) and the Cabinet Committee on Economic Affairs (CCEA), Sugarcane yield data was acquired from farmers response. Irrigation supply details were taken from sub division office of Araniar project, Pichatur. These indicators serve as the foundation for comparing the performance of irrigated agriculture, as they establish a connection

between output and the land area used (Molden *et al.*, 1998; Hakuzimana *et al.*, 2020; Bai *et al.*, 2023).

Output per unit command area (Rs/ha)

$$\text{Output per unit command area} = \frac{\text{Total value of agricultural production (Rs)}}{\text{Total command area (ha)}} \dots\dots\dots 5$$

Output per unit irrigated area (Rs/ha)

$$\text{Output per unit irrigated area} = \frac{\text{Total annual value of agricultural production (Rs)}}{\text{Total annual irrigated crop area (ha)}} \dots\dots\dots 6$$

Output per unit irrigation supply (Rs/m³)

$$\text{Output per unit irrigation supply} = \frac{\text{Total annual value of agricultural production (Rs.)}}{\text{Total annual volume of irrigation of water inflow (m}^3\text{)}} \dots\dots\dots 7$$

3. Financial Indicators

Total O&M cost per unit area (Rs/ha)

$$\text{Total O\&M cost per unit area} = \frac{\text{Total O\&M cost (Rs)}}{\text{The total command area serviced by the system (ha)}} \dots\dots\dots 8$$

Total cost per person employed on water delivery (Rs/person)

It is the ratio of total cost of personnel engaged in irrigation and drainage services in the system to the total number of personnel engaged in the provision of the irrigation and drainage service in the system.

$$\text{Total cost per person employed on water delivery} = \frac{\text{Total cost of personnel engaged in I \& D services (Rs)}}{\text{Total number of personnel engaged in I \& D services (Person)}} \dots\dots\dots 9$$

Revenue collection performance

It is the ratio of total revenue due collection from payment of services by water users during the year to the total revenue due for collection from water users for provision of irrigation and drainage services during the year.

$$\text{Revenue collection performance} = \frac{\text{Total gross revenue collected (Rs)}}{\text{Gross revenue invoiced (Rs)}} \dots\dots\dots 10$$

Staff members for O&M per unit area (Persons/ha)

It is the ratio of total number of persons employed in the provision of the irrigation and drainage service in the system to command area provided with irrigation infrastructure that can be irrigated.

$$\text{Staff members per unit area} = \frac{\text{Total number of persons engaged in I \& D services (Persons)}}{\text{Total command area serviced by the system (ha)}} \dots\dots\dots 11$$

Total O&M cost per unit of water supplied (Rs/m³)

$$\text{Total O \& M cost per unit of water supplied} = \frac{\text{Total O \& M cost (Rs)}}{\text{Total water supplied (m}^3\text{)}} \dots\dots\dots 12$$

4. Environmental Aspects

The water properties such as pH, EC, chloride, and nitrate content are determined by collecting the water samples from the command area (Kavurmacı, et al., 2020; Bello and Adeoye, 2023). The Chemical properties of irrigation water at Araniar Project are furnished in Table 10. The Safe limits for irrigation water qualities were given by Rural water supply and sanitation department are shown in table 1.

5. Socio-economic survey

The main purpose of the Socio-economic survey was to obtain a better understanding of the scenario of farmers, to unpack the needs, issues and problems of Araniar project command area farmers. The primary research questions:

- Availability of irrigation water in required quantity at required time.
- Reasons for not getting the Irrigation water
- Coordination between line departments
- WUA performance

Table 1: Safe limits for irrigation water qualities in the command area

S. No	Properties of irrigation water	Safe limits
1	pH	6.0-8.5
2	EC, dS/m	0.7 -3.0
3	Chloride, mg/l	10-2350
4	Nitrate, mg/l	0.09-33.358

Results and Discussion

1. System Performance

Water delivery capacity index

The peak irrigation water requirement for the third decade of July was found to be 177.7 and 28.6 mm/dec for paddy and sugarcane crops respectively. Therefore, the total peak irrigation water requirement of the crops is 206.3 mm/dec. The total command area of this project in both Kharif and Rabi is 3682.6 ha and the total peak water requirement of the crop was calculated as 7597203.80 m³/dec. The designed discharge of head regulators was 110 cusecs and it was equal to 2691233.13 m³/dec and it was observed as 0.35.

Total annual volume of irrigation water supplied (Mm³/year)

The data of total annual volume of irrigation water supplied from 2010 to 2019 years were collected from Sub-Division office of Araniar project in Pichatur. From Fig.2 it can be concluded that maximum annual

volume of irrigation water of 32.90 Mm³ pertains to the year 2016-17 was observed to be higher than the remaining years which was due to ROVVANU cyclone during the period 01-12-2015 to 03-12-2015 and resulted in highest inflows to the project where as the lowest volume of irrigation water released during 2010-11 is 4.52 Mm³.

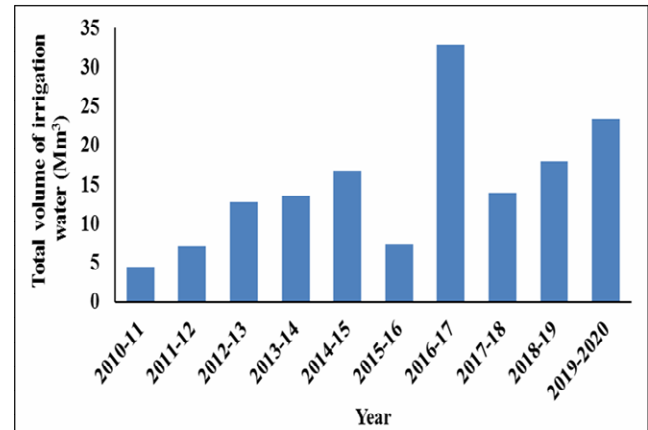


Fig. 2 : Total annual volume of irrigation water supplied

Annual irrigation water supply per unit command area (m³/ha)

Annual irrigation water supply per unit command area in Araniar command area was shown in Fig. 3. It was obtained maximum in 2016-17 with 8934.58 m³/ha. This may be due to the abundant availability of water in the project compared to the remaining years where as minimum in 2010-11 with 1228.06 m³/ha. Phandnis and Kulshrestha (2016) the annual irrigation water supply per unit command area fluctuates based on factors such as water availability, cropping pattern, climate, soil type, system conditions and system management.

Annual irrigation water supply per unit irrigated area (m³/ha)

Annual irrigation water supply per unit irrigated area in the Araniar command area, as shown in Fig.4, reaches a maximum of 10697.87 m³/ha in 2016-17, possibly due to sufficient inflows to the project in that year, and a minimum of 6024.04 m³/ha in 2010-11. If the farmers at the beginning of the irrigation system consume all the water necessary for water-intensive crops, it would result in the farmers located in the middle and tail end receiving insufficient or inadequate amounts of water for their needs.

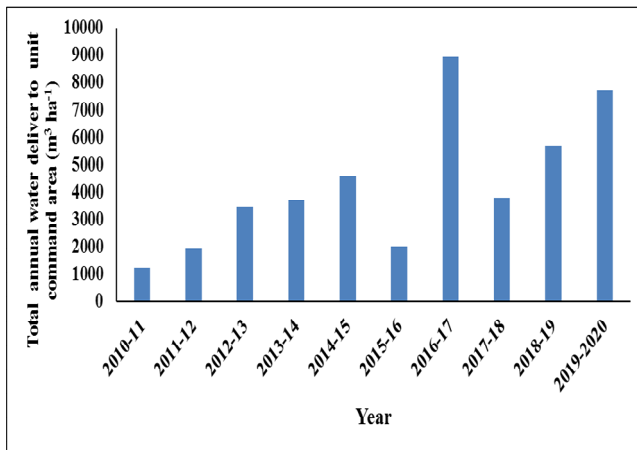


Fig. 3 : Annual irrigation water supply per unit command area

Irrigation Intensity of Araniar Project Area

The high intensity of 83.51 % in 2016- 17 and area benefited by project was 3075.61 ha. The low intensity of 20.39 % was recorded in 2010-11 which may be due to the less availability of water in the project and area which is benefited by project was 751.09 ha. In the research area, there have been significant variations in irrigation intensity.

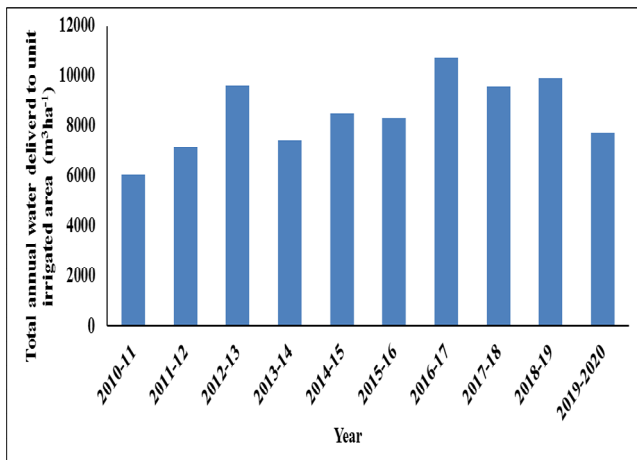


Fig. 4 : Annual irrigation water supply per unit irrigated area

2. Agricultural Productivity

The differences in output values per unit of land can be attributed to changes in the crop pattern and the yield per unit area of cultivated crops. Additional factors that contribute to the variation include the prices of locally and internationally traded staple crops.

Output per unit command area (Rs/ha)

Among all crops Groundnut produced maximum output per ha of Rs. 48129.84 followed by Paddy and Sugarcane of Rs. 38434.93 and Rs. 34671.08 respectively whereas minimum output per ha recorded by Bajra of Rs. 3225.16. Similar results were reported by (Jitendra and Mahesh, 2017).

Output per unit irrigated area (Rs/ha)

Minimum supporting price is more for Groundnut among other crops, the highest output per unit irrigated area is recorded for Groundnut of about Rs. 231086 followed by Sugarcane and Paddy of Rs. 220137.5 and Rs. 102402.3 respectively whereas the lowest output per unit irrigated area is recorded for Bajra of about Rs. 37000 respectively due to the minimum supporting price is very less compared to remaining crops.

Output per unit irrigation supply (Rs/m³)

Crop-by-crop output data that the total sum of output per unit irrigated area was Rs. 458340171. The total amount of water given in 2019-2020 was 23398700 m³. The output per unit of irrigation supply is 19.58 Rs/m³.

3. Financial Aspects

Total O&M Cost Per Unit Area (Rs/ha)

In the Araniar medium irrigation project total 6 people are working as employees those are one executive engineer, one deputy executive engineer, two assistant executive engineer and lusker and one watchman and their salaries are as follows. from 2011-12 to 2019-2020 was furnished in the table 3, In Araniar medium irrigation project the expenditure amount of operation and maintenance from 2011-12 to 2019-2020 was given below in Table 4.

Table 3: Araniar irrigation project employee’s salaries during 2011-2019 period (Rs)

Employee	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Executive engineer	946668	0	884040	0	0	0	1465032	1880160	2230455
Deputy Executive engineer	0	560412	766080	841992	1038312	1091496	1178244	1681884	2039298
Assistant Executive engineer	0	0	392148	420348	552276	614652	665436	701988	812099
O. S	294960	327468	0	0	193524	204384	215928	282684	323562
Lusker	198648	215496	220836	232692	263940	292296	306288	333384	354258
Watchmen	256464	283392	292344	319476	390888	487008	0	0	0
Total salary per month	141395	115564	212954	151209	203245	224153	319244	406675	479973
Total salary per year	1696740	1386768	2555448	1814508	2438940	2689836	3830928	4880100	5759672

(Source: Division office of Araniar project, Tirupati)

The O&M costs related to head works, the main canal, employee salaries and other relevant factors will be prorated and added to the actual O&M cost of the system or sub-system.

Table 4: Amount of expenditure for operation and maintenance

S. No.	Year	Annual operation expenditure (Rs.)	Amount of expenditure in employees salaries (Rs.)	Total (Rs.)
1	2011-12	503632	169674	2200372
2	2012-13	664870	1386768	2051638
3	2013-14	407226	2555448	2962674
4	2014-15	628232	1814508	2442740
5	2015-16	437641	2438940	2876581
6	2016-17	251745	2689836	2941581
7	2017-18	350176	3830928	4181104
8	2018-19	452863	4880100	5332963
9	2019-2020	254583	5759672	6014255

(Source: Division and Sub Division offices of Araniar project, Pichatur & Tirupati)

Table 5: Operation and maintenance cost per unit area

Year	O&M cost per unit area (Rs/ha)
2011-1	598.49
2012-13	558.04
2013-14	805.84
2014-15	664.41
2015-16	782.42
2016-17	800.10
2017-18	1137.28
2018-19	1450.55
2019-20	1635.86

Total Cost Per Person Employed on O&M Works (Rs/Person)

Details of cost per person employed on O&M work is tabulated below in Table 6.

Revenue Collection Performance

Total tax to be collected is of about Rs. 1498546 whereas Rs. 225707 was collected by the revenue department but still Rs. 1272839 has to be collected for better development of Araniar Project. The records emphasize the tax collection is only 15.06 % which shows the revenue collection performance was very low.

Table 6: Cost per person employed on O&M work

S. No.	Year	Total amount of Expenditure (Rs.)	Total cost per person(Rs.)
1	2011-12	2200372	366728.00
2	2012-13	2051638	341939.00
3	2013-14	2962674	493779.00
4	2014-15	2442740	407123.30
5	2015-16	2876581	479430.20
6	2016-17	2941581	490263.50
7	2017-18	4181104	696850.70
8	2018-19	5332963	888827.20
9	2019-20	6014255	1002375.80

No of employees: 6

Table 7: Revenue Taxes collection

Mandal Name	Total Tax to be collect(Rs)	Tax collected (Rs)	Balance Tax tobe Collect (Rs)
Pichatur	684976	110282	574694
Nagalapuram	813570	115425	698145
Total	1498546	225707	1272839

(Source: Mandal revenue offices, Pichatur, Nagalapuram)

Staff member for O&M per unit area (person/ha)

O&M per unit area per ha was of 613.76 ha.

Total O&M cost per unit of water supplied (Rs/cum)

Table 8: Staff member for O&M per unit area shows that total O&M cost per unit water supply was higher in 2019-2020 year, whereas lowest falls in the year 2016-17.

Table 8: Staff member for O&M per unit area

Total command area (ha)	No of persons employed	Unit command area per person (ha)
3682.60	6	613.76

4. Environmental Aspects**Quality of water**

the water was better fit for irrigation and drinking purpose according to the safe limits for irrigation water qualities in the command area shown in Table 10

Table 9 : Total O&M cost per unit water supplied (Rs/m³)

S. No	Year	Amount expenditure (Rs.)	Total water supplied (m ³)	O&M cost per unit of water supplied (Rs/m ³)
1	2011-12	2200372	7093900	0.31
2	2012-13	2051638	12729500	0.16
3	2013-14	2962674	13557800	0.21
4	2014-15	2442740	16820200	0.14
5	2015-16	2876581	7390600	0.38
6	2016-17	2941581	32902500	0.08
7	2017-18	4181104	13931800	0.30
8	2018-19	5332963	20931700	0.25
9	2019-20	6014255	28398700	0.21

(Source Sub Division office of Araniar project, Pichatur)

Table 10 : Chemical properties of irrigation water at Araniar Project

S. No.	Source of water	Reach	pH	EC (dS/m)	Chloride (mg/l)	Nitrate (mg/l)
1	Surface water	Head	7.45	0.65	40	1.2
		Middle	7.22	0.52	40	1.0
		Tail	6.93	0.46	36	0.9
2	Ground water	Middle	7.5	1.15	196	7

Availability of irrigation water in required quantity at required time

220 farmers agreed where as 295 disagreed for availability of irrigation water in required quantity at required time.

Reasons for not getting the Irrigation water

In order to know the farmers response for not getting irrigation water, a questionnaire was designed to elicit specific information on: (i) conveyance system is faulty, (ii) Head reach farmers are not releasing water, (iii) Water is not released when required, and (iv) No problem. among 515 farmers, 245 farmers responded that conveyance system is faulty whereas 110 farmers deeply notified that head reach farmers are not releasing water, it was observed that water was not released when required was responded by 60 farmers

and 100 farmers responded that they have no problem for the designed questionnaire.

Coordination between line departments

The study area about 195 farmers agreed where as 320 people disagreed for coordination in line departments.

WUA performance

The majority of the responses of about 250 are of no response followed by good, poor and very good of 150, 110, 5 responses respectively.

Conclusions

The results showed that the Water delivery capacity index is 0.35, Annual irrigation water supply per unit command area is maximum in 2016-17 with 8934.58 m³/ha whereas minimum in 2010-11 with

1228.06 m³/ha. Annual irrigation water supply per unit irrigated area is maximum in 2016-17 with 10697.87 m³/ha whereas minimum in 2010-11 with 6024.04 m³/ha. Output per unit irrigation water supply is 19.58 Rs/m³.

On observing, it was clearly evident that the operation and maintenance cost is increasing year by year from 2011- 2012 to 2019-2020 mainly ROVVANU cyclone during the in year 2015 damaged three main canal systems in the command area results in higher frequency of repairs on main regulators, canal networks.

Authorship

All authors have made substantial contributions to the conception, design, data collection, analysis, and interpretation of the study. All authors have read and approved the final manuscript.

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Data Availability

The data supporting the findings of this study are available within the article and its supplementary materials.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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