**Computation of Different sectors of Water Demand in the Guntur Channel Command Area, Andhra Pradesh, India (2010-17)**

**Abstract:**

Water is a critical resource for development of other resources. The assessment of available water resources and demand of water for various purposes is of utmost important without which it is difficult to prepare any developmental plan. Guntur channel is selected as study area to determine the availability of canal water and estimate water demand of all sectors of water use in a command area i.e., agricultural water demand of all crops grown in command, domestic water demand and livestock demand were also estimated. The highest irrigation intensity was noticed during the year 2011-12 as 90.62%. Total Agricultural irrigated water demand was highest in year 2011-12 as 96.2 MCM. Three scenarios were proposed in order to check the canal water supply is adequate to meet the demands of different sectors of water use. In existing scenario highest amount of deficit flows (-19.00, -44.93, -76.97 and -21.56) were observed during the year 2013-14 to 2016-17. If the drinking water demand of Guntur Municipality was met from the other source, then there is possibility of commanding entire area by practicing water management technologies.

**Keywords:** Water use, Guntur channel, agricultural, domestic and livestock water demand.

 **Introduction**

Water is the important natural resource essential for crop production. Agriculture plays a vital role in India’s economy. About 54.6% of the population is engaged in agriculture and allied activities (Census, 2011) and it contributes 17.4% of the country’s Gross Value Added. Irrigation is the largest water use sector which accounts or 70% of global water resources. Canals are the major sources of irrigation in the state. Andhra Pradesh has the largest canal irrigation system in the country. Canal irrigation accounts for 36-42% of the net irrigated area of the state. The major canals of Andhra Pradesh are taken from the Krishna, Godavari and Tungabhadra, major canal irrigated areas are in the deltas and coastal regions. About 48.2% of the total area irrigated was through canals, 37.6% by tube and bore wells and the rest through tanks and ponds during the year 2014 (Ground water year book, A.P, 2016). Majority of farmers are dependent on canals.

Climate change affects water resources through its impact on quantity, variability, timing, form, and intensity of precipitation (Adams and Peck, 2008). As water demand increases, issues on water availability and utilization become critical.

It is important to know the availability of water in any command area for better management of water resources. Scarcity and conflict, but also considerable uncertainty, inter-annual variability, and simple lack of reliable data characterize the problems of water resources management. The information on both quantity and quality of surface and groundwater, water demand and supply, reliability, water management technologies can definitely aid in efficient usage of water.

Guntur channel is selected as study area. It is a major irrigation scheme in Guntur district having 10800 ha of ayacut. There is a decreasing inflow into the channel due to upstream water development. There is an uncoordinated development of its own water resources with little regard to the initial plans of *protective irrigation*. It resulted in “spreading scarcity” within major irrigation schemes. The carrying capacity of channel is 600 cusecs to utilise 4 TMC of water. This channel caters the needs of Guntur municipal corporation. Of late, the flows into channel were reduced due to which drinking water needs of Guntur and Mangalgiri constituencies could not able to meet. The main objective of study is to assess the availability of water resources and water demand in different sectors of water use to plan and available water resources effectively in commzand area of Guntur Channel.

**Materials and Methods**

**Study Area**

It is a major irrigation scheme in Guntur district with starting point of channel at upstream of Prakasam barrage. Total length of the channel is 47 km. The command area comprises of seven (7) mandals namely Tadepalli, Mangalgiri, Pedakakani, Guntur, Chebrolu, Vatticherukuru and Parthipadu. The designed discharge of channel is 600 cusecs and amounts to 4 TMC of water for utilization. Water allocated for irrigation and drinking water was 3.815 TMC and 0.185 TMC respectively.



**Fig 1. Location map of study area**

**Canal water releases**

 The data on canal water releases for 12 years was collected from Water resource department, Guntur and analysed for further investigation.

**Arc GIS software**

Geographic Information System (GIS) is a powerful tool used for computerized mapping and spatial analysis. Arc GIS software is used for delineating the command area.

**Crops and Cropping Pattern in study area**

The major crops grown in the study area are paddy, chillies, cotton and pulses. Other crops are also grown but not in significant area. The details of different crops grown in the study area were presented in the Table 1.

**Table 1 Details of planting and harvesting periods of different crops grown in study area**

|  |  |  |
| --- | --- | --- |
| **S. No** | **Name of the Crop**  | **Kharif** |
| **Planting period** | **Harvesting period**  |
| 1 | Paddy | August-1st fortnight | December 1st fortnight |
| 2 | Cotton | July 2nd fortnight | January 1st fortnight |
| 3 | Chillies | July 2nd fortnight | January 1st fortnight |
|  |  **Rabi** |
| 4 | Maize  | November 2nd fortnight  | March 1st fortnight |
| 5 | Green gram | November 2nd fortnight | January 2nd fortnight |
| 6 | Black gram | November 2nd fortnight | February 2nd fortnight |
| 7 | Bengalgram | November 2nd fortnight  | February 2nd fortnight |

**Agricultural water demand**

Agricultural water demand was computed taking into consideration of crop water requirement. It was computed using CROPWAT software. CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO. CROPWAT 8.0 for Windows is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns.

Accordingly, crop evapotranspiration was computed using CROPWAT. The data required for calculating agricultural water demand were ETc of particular crop and area of that crop.

Crop water requirement (m3) = ETc(m) × Area (m2)

The crop water requirement (CWR) was calculated separately for kharif and rabi seasons to assess the demand season-wise. The area under each crop for each season in the command area was collected to estimate the demand

**Domestic water demand**

Domestic water demand was calculated by the formula given below:

 Population of command area × water requirement per day (liters)

**Livestock water demand**

Livestock water demand was calculated by the formula given below:

 Total livestock population in command area × water requirement per day (liters)

**Results and Discussion**

**Available canal water in the command area**

The highest amount of water was released during the year 2011-12 i.e, 169.38 Mm3 (5.98 TMC), where as the actual water allocation to channel was 4.0 TMC. The lowest amount of water was released during 2015-16 i.e., 34.19 Mm3 (1.21 TMC). The volume of water released to Guntur channel during 2005-2016 was given in Fig 2. Most of the years, the water released in the Guntur channel was as per allocation except during 2014-2016. This may be due to less amount of rainfall occurred during the above mentioned years.

 **Fig 2. Volume of water released to Guntur channel during 2005-2016**

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

Daily 35 cusecs of water was delivered to Guntur municipality that amounts to 1.21 TMC. Further 0.185 TMC of water was allotted to drinking water in command area. The drinking water allocations were subtracted to estimate the irrigation water delivery for unit irrigated area. More amount of annual water (13270.88 m3/ha) was delivered per irrigated area during the year 2011-12followed by 2012-13 as (10306.98 m3/ha). The amount of water delivered was low in the year 2015-16 (3444.60 m3/ha). The irrigation water delivery per unit area was presented in the Fig 3.

**Fig 3. Irrigation water delivery per unit irrigated area**

**Irrigation Intensity**

It was estimated by taking into consideration the irrigated area in both the seasons of command area. The irrigation intensity of Guntur channel command area was presented in Table 2. The highest irrigation intensity was noticed during the year 2011-12 as 90.62% followed by 78.62% during 2014-15 and the lowest irrigation intensity was noticed in the year 2016-17. It was due to low canal inflows into the command area. Even though, the flows were less during the year 2015-16, but the cropping intensity was more compared to 2016-17. The area might have been irrigated by the source other than Guntur channel.

**Table 2. Irrigation intensity in command area of Guntur channel**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No** | **Year** | **Irrigated area (ha)** | **Culturable****Command area (ha)** | **Irrigation Intensity (%)** |
| 1 | 2010-11 | 8056.68 | 10800 | 74.5 |
| 2 | 2011-12 | 9787.04 | 10800 | 90.62 |
| 3 | 2012-13 | 7585.82 | 10800 | 70.23 |
| 4 | 2013-14 | 8243.31 | 10800 | 76.32 |
| 5 | 2014-15 | 8491.09 | 10800 | 78.62 |
| 6 | 2015-16 | 8405.66 | 10800 | 77.8 |
| 7 | 2016-17 | 6386.23 | 10800 | 59.13 |

**Agricultural water demand**

 Agricultural water demand was calcualted using CROPWAT software. The weather parameters namely, temperature (min & max), humidity, rainfall, wind speed and sunshine hours were given as input to CROPWAT. Crop evapotranspiration was computed for different crops in the command area of Guntur channel.

**Crop water requirement (CWR)**

The data on climate, rainfall, crop, cropping pattern and soil were provided as input to CROPWAT model. The crop water requirements were estimated for all crops grown in command area of Guntur channel.

 Total Agricultural irrigated water demand was highest in year 2011-12 as 96.2 MCM, whereas lowest demand was observed in the year 2016-17 as 58.96 MCM (Fig 4). It was clear that lowest Kharif unirrigated demand was observed in 2016-17. Maximum rabi unirrigated area was observed in the year 2016-17 (27.09 MCM). Rabi unirrigated demand was higher compared to irrigated demand. Pulses, cotton, chillies were cultivated in more area than registered command area without irrigation in the command area.

**Fig 4. Agricultural water demand in two seasons from 2010-11 to 2016-17**

**Domestic water demand**

The total population of the Guntur channel command area i.e, 33 villages was collected from census report of 2011 as 30,9513. Water requirement per capita in rural areas was taken as 55 lit day**-1** (Ministry of Drinking water and Sanitation, 2014). The total water requirement for the domestic demand per year was analysed as 6.21Mm3 in 2011-12 tabulated in Table 3.

**Table 3. Domestic water demand in the command area of Guntur channel**

|  |  |  |
| --- | --- | --- |
| **S. No** | **Year** | **Domestic water demand (MCM)** |
| 1 | 2010-11 | 6.14 |
| 2 | 2011-12 | 6.21 |
| 3 | 2012-13 | 6.29 |
| 4 | 2013-14 | 6.37 |
| 5 | 2014-15 | 6.45 |
| 6 | 2015-16 | 6.52 |
| 7 | 2016-17 | 6.60 |

The domestic demand gradually increased over a period of time due to increase in population**.**

 **Livestock water demand**

Water requirement for each live stock was taken as 80 lit day-1(Greg, 2007) and the total number of livestock population in the command area were collected from Animal Husbandry Department, Guntur**.** The amount of water required for livestock per year was calculated and tabulated in Table 4.

**Table 4 Livestock water demand of command area of Guntur channel**

|  |  |  |
| --- | --- | --- |
| **S. No** | **Year** | **Livestock water demand (MCM)** |
| 1 | 2010-11 | 0.083 |
| 2 | 2011-12 | 0.079 |
| 3 | 2012-13 | 0.083 |
| 4 | 2013-14 | 0.091 |
| 5 | 2014-15 | 0.100 |
| 6 | 2015-16 | 0.110 |
| 7 | 2016-17 | 0.122 |

The livestock demand was noticed highest in the year 2016 (0.122 MCM), followed by 2015 (0.110 MCM) due to increase in livestock population.

**Water required for Guntur Municipal Corporation**

Guntur channel is the main source of drinking water supply to Guntur Municipal Corporation. According to Water resources department, Guntur daily 35 cusecs water was needed to cater the needs of Guntur Municipality and amounts to 31.25 Mm3/year**.**

**Canal water supply and demand of all sectors in command area of Guntur channel Existing scenario**

Canal water supply versus water demand considering irrigated area, domestic livestock demand and Guntur Municipality for seven years was tabulated in Table 5.

**Table 5 Water supply and demand of all sectors during 2010-2016 of Guntur channel command area.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **Water supply (MCM)** | **Seepage losses (MCM)** | **Effective rainfall (MCM)** | **Water demand of all sectors****(MCM)** | **Deficit/Excess (MCM)** |
| 2010-11 | 106.01 | 8.77 | 24.39 | 106.51 | 15.13 |
| 2011-12 | 169.38 | 11.28 | 20.83 | 133.77 | 45.15 |
| 2012-13 | 117.69 | 10.71 | 22.97 | 102.23 | 27.72 |
| 2013-14 | 103.93 | 10.60 | 18.57 | 130.91 | -19.00 |
| 2014-15 | 82.77 | 9.53 | 11.07 | 129.25 | -44.93 |
| 2015-16 | 34.19 | 3.81 | 18.39 | 125.75 | -76.97 |
| 2016-17 | 79.85 | 7.55 | 3.03 | 96.90 | -21.56 |

**Fig 5. Existing scenario of water supply and demandduring 2010-2016**

There was deficit of water from 2013-14 to 2016-17. From Table 5 it was clear that flows into channel has been decreased from 2012-13 to 2016-17 was depicted in Fig 5. But the area under crops was not reduced in accordance with flows expected during the year 2015-16. This indicates that crops were irrigated with source other than Guntur channel. There was deficit of water from 2013-14 onwards and delivered water was not sufficient and did not meet the demand of all sectors of water use. This was particularly in case of Guntur municipality water demand and planned to meet from krishna river.

 **Second Scenario**

The water supply versus water demand considering irrigated area, domestic and livestock demand was presented in the Table 6 without considering the drinking water need of Guntut municipality.

**Table 6. Water supply versus water demand without considering Guntur municipal water demand.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **Water supply (MCM)** | **Seepage losses (MCM)** | **Effective rainfall (MCM)** | **Water demand of all sectors (MCM)** | **Deficit/Excess** |
| 2010-11 | 106.01 | 8.77 | 24.39 | 75.26 | 46.38 |
| 2011-12 | 169.38 | 11.28 | 20.83 | 102.52 | 76.40 |
| 2012-13 | 117.69 | 10.71 | 22.97 | 70.98 | 58.97 |
| 2013-14 | 103.93 | 10.60 | 18.57 | 99.66 | 12.25 |
| 2014-15 | 82.77 | 9.53 | 11.07 | 98.00 | -13.68 |
| 2015-16 | 34.19 | 3.81 | 18.39 | 94.50 | -45.72 |
| 2016-17 | 79.85 | 7.55 | 3.03 | 65.65 | 9.69 |

The deficit of flows were observed during the years 2014-15 to 2015-16, remaining all the years excess of water available in the command area of Guntur channel (Fig 6). If the drinking water need of Guntur municipality is planned to meet from other source, then there is possibility of commanding entire area even though with low flows by practicing water management technologies.

 **Fig 6. Water supply and demand of all sectors without considering GMC**

**Third Scenario**

Water supply versus irrigated, unirrigated, domestic and livestock demand of command area of Guntur channel was presented in the Table 7

**Table 7 Water supply versus agricultural (irrigated+unirrigated), domestic and**

 **livestock demand**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **Water supply (MCM)** | **Seepage losses (MCM)** | **Effective rainfall (MCM)** | **Water demand of all sectors (MCM)** | **Deficit/Excess (MCM)** |
| 2010-11 | 106.01 | 8.77 | 24.52 | 93.26 | 28.51 |
| 2011-12 | 169.38 | 11.28 | 20.82 | 125.72 | 53.20 |
| 2012-13 | 117.69 | 10.71 | 27.01 | 95.33 | 38.65 |
| 2013-14 | 103.93 | 10.60 | 19.75 | 115.52 | -2.43 |
| 2014-15 | 82.77 | 9.53 | 13.20 | 118.84 | -32.41 |
| 2015-16 | 34.19 | 3.81 | 21.17 | 116.00 | -64.46 |
| 2016-17 | 79.85 | 7.55 | 3.29 | 95.70 | -20.11 |

There was surplus amount of water available in Guntur channel command area during 2010-11 to 2012-13(Fig 7). Due to reduction in canal water flows, there is water deficit was observed in the year 2014-15 to 2016-17.

 **Fig 7. Water supply and total agricultural, domestic and livestock demand**

**Conclusions:**

It was concluded that from the study out of three scenarios proposed existing one was unable to cater the demand of different sectors (irrigated agriculture, domestic, livestock and Guntur Municipality water demand) of water use from 2013-14 to 2016-17. Second scenario excluding Guntur municipality. Excess of water was available in all years except 2014-15 with a deficit of -13.68 MCM and 2015-16 was – 45.72 MCM deficit was noticed. In third scenario also deficit of flows were observed. The comprehensive information on water supply and demand provides an insight about planning of water resources effectively to meet the demand of different sectors of water use in command area of Guntur channel. Canal lining, conjunctive use of surface and ground water, repairs and renovations of irrigation structures and adoption of water management technologies were suggested for sustainable use of water.

**Disclaimer (Artificial intelligence)**

**Option 1:**

**Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript**.

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