Water Demand Analysis for Selected Rural Regions in Visakhapatnam District

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Abstract

To analyse the water demand for rural regions is very important to distribute the public water demand and agricultural water demand. In this contest, rural areas under three reservoir command areas namely Konam, Raiwada and Thandava Reservoir command areas located in Visakhapatnam district are selected. Different methods are used for population forecasting and the results are compared with the available actual population in 2011. Decreasing rate method gives satisfactory results and this method is used to determine the present population in the selected rural regions. Total demand for all three regions is obtained and agricultural demand is about 94 to 96%, domestic water demand is about 2.5 to 3.5 %, water losses is about 1 to 1.5 %, fire and public use demand is around 0.5 %, and industrial and commercial demand is less than 0.5% of the total water demand. Per capita total water demand varies from 1415 to 1817 cubic meters for selected regions.

Keywords: Arithmetical Increase Method, Geometrical Increase Method, Incremental Increase Method, Decreasing Rate Method, Agricultural Water Demand, Public Water Demand

1. Introduction

Water resources engineering are planned and developed either to use or to control ground and surface water flows. A planning strategy for water usage includes researching water quality and demand and considering a project that can meet the anticipated needs of available resources through engineering research and non-structural steps. Water resource development involves planning, designing, building, and operating facilities to control and use water, with the national goal of improving people's quality of life. It should be recognized that the planning and design studies only provide a water development project's conceptual framework[1]. The entire development process also includes the construction, operation, and project management. When planning a water supply system, there is a need to consider overall annual water demand and average flow rates and the differences in these rates. In India, the average annually water availability per person is estimated around 1829 cubic
meters. In present-days, irrigation system consumes around 84% of available water. Modern and residential segments devour around 12 and 4% of available water, respectively\cite{2}. If we considered rural regions only, the percentage is varied.

Sustainable social and economic growth in ecologically vulnerable areas with arid climate, such as Konam, Rairwa and Thandava reservoirs commend areas in Visakhapatnam, largely depends on the accessibility of water and imperishable use of water resources. Nonetheless, under the influence of change in climate and human activity, there is a serious shortage of water supplies and a decline in water production in these river catchment areas, in that context, to recognize the extreme water demand and effective strategies for coping with regional water demand.

2. Methodology and Data

To planning the water supply scheme for a specific region, it is important to know that the amount of water available and the amount of water needed by the public. The first analysis, in fact, is to consider the demand and then the second requirement is to find the source to satisfy that demand. There is no problem if the water available in the sources is higher than the water demanded by the public, if the condition is reversed then the problem of water scarcity comes into picture and more problems will arise due to lack of water. Hence, the objectives of the present study are to find the best method suitable to perform population forecasting in the selected rural regions and to analyse the water demand in the selected rural regions under commanded areas of Konam, Rairwa and Thandava reservoirs.

2.1. Procedure for Estimating the Population in the Present Year

To evaluate the population in the present year we need to consider the previous 5 decades population as the population census will be released for every 10 years. It is possible to assess the present population of a town or city by performing an official enumeration, called a census. Every country's government usually carries out these official surveys at say-about 10 years intervals (called decennial census). Smaller-term surveys are often performed by state or local authorities. Therefore, the water supply schemes developers will first collect all the useful data available from the census department. The data is then used to forecast the future population.

The different methods are available for predicting future population. The specific method to be considered for a certain region greatly depend on the factors debated in those methods, and the choice is left to the designer's direction and intelligence. None of these methods is accurate and they are all based on the laws of probability, and so only approximate estimates can be made for possible future populations. Arithmetical Increase Method, Geometrical Increase Method, Incremental Increase Method and Decreasing Rate Method are considered for present study.
2.2. Procedure to Calculate the Total Water Demand

The annual average daily draft in litres / day required can be worked out by multiplying the likely number of people going to use the facilities provided by the scheme, and each person's annual average daily consumption (for all uses) called per capita demand. Precisely determining the volume of water requested by the population is very difficult, as there are several complex variables impacting water use. Therefore, certain assumptions and empirical formulae are generally used to evaluate this quantity, which can yield precise results. Therefore, the use of a certain process or procedure for a particular case needs to be determined by the designer's intellect and foresight. The various types of water demands can be broken down into the groups below:

1. Domestic water demand.
2. Agricultural water demand.
3. Industrial and commercial water demand.
4. Fire and Public use demand.
5. Water losses.

To measure the overall water demand of a certain sector of the population as accurately as possible, all these requirements must be considered and appropriate preparation made, based on the requirements of those for which the water supply system is to be built. Those demands are outlined below:

Domestic Water Demand

This takes account of the water needed for drinking, cooking, bathing, sanitary purposes, lawn sprinkling and gardening and so on in private buildings. The amount of household water consumption per head shall vary depending on the consumer's living conditions. The water requirement for domestic use is almost constant, through the requirement is slightly more during summer than in winter. With increase in standards of living, the requirement of water for domestic use is gradually increasing[5]. According to IS: 1172-1993, the minimum domestic intake should be taken at 200 lpcd for a town or city with a complete flushing system; however, it can be decreased to 135 lpcd for economically poorer parts and LIG colonies depending on the conditions. The total demand for domestic water is equal to the product of total design population and the domestic consumption per capita.

Domestic water demand can be obtained from the following equation

\[ X = \frac{(P \times Y \times 365)}{1000} \]

Where,

- \( P \) = population in the present year
- \( X \) = demand for water, m³.
- \( Y \) = per capita demand, lpcd (135 for rural).
Three Mandal’s which are under Konam Reservoir Ayacut and four Mandal’s which are under Raivada reservoir are rural areas. Five Mandal’s which are under Thandava reservoir are rural areas and one is an urban area but the population is less than 1 lakh so the water consumption rate is taken as 135 lpcd for all Mandal’s.

**Agricultural Demand**

Agricultural water is the water used to produce food. Water requirement for irrigation is not uniform, maximum demand for irrigation is during winter season when Rabi crops are grown. However, if Kharif crops are grown, irrigation water will be required for the period prior to monsoon. Low rainfall years require more irrigation water then the high rainfall years. Since a storage reservoir protect the area against drought. Some storage should be reserved to meet the irrigation demands during drought period. The water used for agricultural purposes has been analysed based on the delta values of different crops.

Total water required for cultivation = total area cropped × delta of that crop

Any crop requires some quantity of water to achieve its maturity. The total amount of water needed for any crop during its base cycle for its full-fledged nutrition when expressed in water depth (i.e., in 'cm' or 'inches') is called its delta. Those values represent the total water requirement of the crops. Here useful rainfall is balanced by evaporation and percolation losses.

**Commercial and Industrial Water Demand**

Rising population and industrialisation aided by technological advancements have resulted in increased water demand in India. To estimate the water used for the industrial and commercial purpose there is a need to consider various institutions, hospitals, hostels, factories, and industries etc. The water requirement for industrial use is constant throughout the year. However, the growth of industries and power plants, the requirements of water for these are steadily increasing. Paper, petrochemicals, and steel industries are some of the highly water incentive industries. The water use by thermal and nuclear power plants is also very high. Though water required for this purpose is less in rural areas but needs continuous supply. The quantity would undoubtedly differ with the nature of the region and the number and types of commercial establishments and institutions.

**Fire and Public Use Demand.**

Fire generally breaks out in densely populated and industrial areas and can result in serious damage, if not effectively controlled. Therefore, big cities generally keep full fire-fighting squads. Fire-fighting personnel require enough water to throw it at high speeds over the fire. Therefore, a provision should be made in modern water supply systems to combat fires. The amount of water needed to extinguish fires should always be readily available and kept in reservoirs for storage. So, a total of 20 lpcd should be supplied for fire and public use purposes.
Water Required Compensating Losses in Theft and Wastes.

This includes the water lost by leakage due to bad plumbing or faulty meters, water stolen due to illegal water connections, and other losses and waste. These losses should be considered whilst estimating the total requirements. Through careful maintenance and uniform metering, those losses can be reduced. Nevertheless, even in the best managed water works, an amount of 55 lpcd must be counted while calculating total water demand.

2.3 Study Area

The commend areas under three reservoirs are taken for analysis is located mainly in Visakhapatnam district comprises of 9 mandals, one mandal in Vizianagaram district and three mandals in East-Godavari district. All the three reservoirs are in Visakhapatnam district, Andhra Pradesh.

Details of Konam Reservoir

The Konam reservoir project was built across a tributary of Sarada River that is river Bodderu near Konam village (Cheedikada mandal) of Visakhapatnam district. It was built to create a storage capacity of 24.0833 M.cum at FRL in the year 1979. Location co-ordinates are east longitude of 82°-51'-50" and north latitude 17°-58'-30" respectively.[3][4].

Details of Raiwada Reservoir

The Raiwada reservoir was constructed in the year 1983 to create a storage capacity of 101.93 M.cum at FRL in Devarapally mandal across River Sarada. The global location co-ordinates are east longitude 82°-59'-00" and north latitude 18°-00'-30" respectively[3][4].

Details of Thandava Reservoir

The Thandava Reservoir project was built across the river Thandava near Kothagudem village in Kotauratla mandal of Visakhapatnam district. It was built in the year 1974 to create a storage capacity of 140.428 M.cum at FRL. The global location co-ordinates are east longitude 82°-17'-20" and north latitude 17°-17'-50" respectively[3][4].

2.4 Data

The various parameters involved in the computation of population forecasting and estimation of water demand. The data required for these theoretical computations and source of data are presented here.
Table: 1 The Data Required and Source of Data for Theoretical Computations

| Sl.No | The Data Required for Theoretical Computations | Source of Data |
|-------|-----------------------------------------------|----------------|
| 1     | Previous Decades Population Data              | Handbook of Statistics of Vishakhapatnam, East Godavari, and Vizianagaram Districts (Year 2018). |
| 2     | Per capita demand for domestic purpose (135 lpcd for rural). | Code of Basic Requirements for Water Supply, Drainage and Sanitation (IS: 1172-1993) |
| 3     | Delta for each crop                           | Santhosh Kumar Garg, Irrigation Engineering and Hydraulic Structures, Water Resources Engineering (Volume II), Khanna Publishers. |
| 4     | Total area for each crop                      | Handbook of Statistics of Vishakhapatnam, East Godavari, and Vizianagaram Districts. |
| 5     | Water Requirements for institutions, hospitals, hostels, factories, and industries etc. | Code of Basic Requirements for Water Supply, Drainage and Sanitation (IS: 1172-1993) (Year 2018). |
| 6     | No of institutions, hospitals, hostels, factories, and industries etc. | Handbook of Statistics of Vishakhapatnam, East Godavari, and Vizianagaram Districts (Year 2018). |
| 7     | Per capita demand for Fire and Public Use     | Water and Wastewater Engineering Module2: Water Quantity and Intake Details (https://nptel.ac.in/courses/105/104/105104102/#) |
| 8     | Water Required Compensating Losses in Theft and Wastes. | Santhosh Kumar Garg, Water Supply Engineering, Environmental Engineering Volume 1, Khanna Publishers. |

3.0 Results and Discussions

This section contains the results obtained in the present study. This investigation is tracked to obtain the desired objectives. This section includes forecasting of population based on selected three methods and extraction of best method suitable for selected locations.

3.1 Population Forecasting

Theoretical computations of population in 2011 are estimated by Arithmetical Increase Method, Geometrical Increase Method, Incremental Increase Method and Decreasing Rate Method. The theoretical results obtained from various methods for each of the selected Mandal’s and Regions are compared with actual population in 2011. Fig.1 shows the comparison of actual and estimated population by various methods for selected command areas. Geometrical Increase Method gives vary high results compare to other three methods. Arithmetical Increase Method and Incremental Increase Method are given almost same result and that result is higher than the actual one. Decreasing Rate Method gives the satisfactory results comparatively out of all other methods. This method is very close to the actual one. The decreasing rate method is used for forecasting the population in the year 2018. Table No.2 shows the estimation of population in 2018 for selected command areas.
Fig. 1 Comparison of Actual and Estimated Population by Various Methods for Selected Command Areas.
### Table: Estimation of Population in 2018 for Selected Command Areas.

| S. No | Region                  | Name of the Mandal | Population in 2018 |
|-------|-------------------------|--------------------|--------------------|
|       |                         |                    | Mandal Wise        | Region Wise |
| 1     | Konam Command Area.     | Madugula           | 75592              | 194065      |
| 2     |                         | Cheedikada         | 48962              |             |
| 3     |                         | Butchiyyapeta      | 69511              |             |
| 4     | Raiwada Command Area.   | Devarapally        | 61165              |             |
| 5     |                         | K. Kotapadu        | 63501              | 268542      |
| 6     |                         | Chodavaram         | 92890              |             |
| 7     |                         | Vepada             | 50986              |             |
| 8     | Thandava Command Area   | Nathavaram         | 68075              |             |
| 9     |                         | Narsipatnam        | 97762              |             |
| 10    |                         | Kotauratla         | 54042              | 463151      |
| 11    |                         | Kotamanduru        | 49052              |             |
| 12    |                         | Rowthulapudi       | 55647              |             |
| 13    |                         | Tuni               | 138573             |             |

#### 3.2 Total Water Demand

Different types of water demand and their equations are discussed in the previous chapter. There are several factors which influence the amount of water demanded by the public. One of the most important tasks for a water system is to continually meet this demand without interruption. The total demand is calculated by taking various attributes into account for annual year.

**Comparison of Water Demand for Various purposes**

To measure the overall water demand of a certain sector of the population as accurately as possible, all these requirements must be considered and appropriate preparation made, based on the requirements of people for which the water supply system is to be designed. Table No.3 results of water demand for various purposes for selected command areas. Fig.2 shows the percentage of water demand for various purposes for selected command areas. In Konam reservoir command area, agricultural water demand occupies 95.66%, domestic water demand occupies 2.71%, industrial and commercial water demand 0.13%, Fire and Public Use Demand 0.40%, Water losses 1.10%. Per capita total demand is 1817 m$^3$. In Raiwada reservoir command area, agricultural water demand occupies 94.71%, domestic water demand occupies 3.28%, industrial and commercial water demand 0.18%, Fire and Public Use Demand 0.49% and Water losses 1.34%. Per capita total demand is 1500 m$^3$. In Thandava reservoir area, agricultural water demand occupies 94.22%, domestic water demand...
occupies 3.48%, industrial and commercial water demand 0.37%, Fire and Public Use Demand 0.52% and Water losses 1.42%. Per capita total demand is 1415 m$^3$, this is low comparative to other two command area.

Fig: 2 Percentage of Water Demand for Various Purposes for Selected Command Areas
Table: 3 Results of water demand for various purposes for Selected Command Areas.

| S. No | Description                        | Konam Reservoir Ayacut (m³) | Raiwada Reservoir Ayacut (m³) | Thandava Reservoir Ayacut (m³) |
|-------|------------------------------------|-----------------------------|--------------------------------|--------------------------------|
| 1     | Domestic Water Demand              | 9562553                     | 13232407                        | 22821766                        |
| 2     | Agricultural Water Demand          | 337330000                   | 381599500                       | 617431500                       |
| 3     | Industrial and Commercial Water Demand | 443306                  | 726238                         | 2393249                         |
| 4     | Fire and Public Use Demand         | 1416675                     | 1960357                        | 3381002                         |
| 5     | Water losses                       | 3895855                     | 5390981                        | 9297756                         |
| 6     | Total Demand                       | 352648389                   | 402909483                      | 655325273                       |
| 7     | Per capita total demand            | 1817                        | 1500                           | 1415                            |

4.0 Conclusions

The main intention of the present study is to analyse the water demand in the regions belong to Konam, Raiwada and Thandava reservoir. A multipurpose project has uses of water for several purposes. The water stored in the reservoir must be jointly used for these purposes, with proper coordination and compatibility. The work carried out in this regard is summarized along with important conclusions arrived and These are listed below.

- Population forecast obtained from Decreasing Rate Method is close to the actual population in 2011 for all 13 Mandal’s under selected regions and all the three command areas fall under rural areas. All the three regions population is estimated by Decreasing Rate Method.
- Total demand for all three regions is obtained and agricultural demand is about 94 to 96%, domestic water demand is about 2.5 to 3.5 %, water losses is about 1 to 1.5 %, fire and public use demand is around 0.5 %, and industrial and commercial demand is less than 0.5% of the total water demand.
- Per capita total water demand for Konam reservoir commend area is 1817 m³ and this value is close to the average annually water availability per person in India. Per capita total water demand for Raiwada reservoir commend area is 1500 m³. Per capita total demand for Thandava reservoir area is 1415 m³.
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