

Water Resources Development and Management in Sub-Basin using Geospatial Technologies: A Case Study

K.V.Sivakumar Babu, K.Rajasekhara Reddy, K.Sundara Kumar, P.Kasi Vishwanadham

Abstract--- Water resources development and its availability is one of the crucial factors for sustainable development of nation. Planning for water resources development in basin requires careful assessment of the available water resources and reasonable need of the basin in foreseeable future for various purposes such as Irrigation, Drinking, Industries, Hydro power, Recreation, Tourism, Aquatic life, Agro-based industries, Dairy development, and Navigation etc. The water resources development and management should be planned on the basis of hydrologic unit such as sub-basin or watershed as a unit of development for integrated use of water resources together. For planning of integrated use of water, the precise knowledge of Geology, Drainage, Geomorphology, Hydrogeology, Landuse and Landcover, Rainfall, Distribution of soils, Existing cropping pattern and Socio-economic factors are essential need to be studied in detail.

Considering this main aspect an integrated planning of water resources in Prakasam district of Andhra Pradesh in India has been attempted. The primary objective of the study involves the assessment of various water resources available in the sub-basin by using of "Four Waters Concept". The methodology of the four waters Concept revolves around the harvesting of available runoff like Rainwater, Surface Water, Ground Water and In-situ soil moisture. For entire water resources development of an area, the basin shall be decentralized from basin to sub-basin to the lowest possible level units for efficient utilization.

Study also involves the Published literature, Field surveys, Ground water data, Toposheets and Soil Maps, Geological Maps analysis along with satellite data analysis for various seasons by using of the Geo-Spatial tools like ARCGIS, GPS. From the conducted study it can be revealed that available water resources in the sub-basin can be better utilized and managed by modern irrigation methods like drip and sprinkler irrigation and also by building the Water Grid system.

Keywords: Sub-basin, Four Water Concepts, Remote Sensing and GIS, LULC, Runoff

I. INTRODUCTION

Water is a precious element in the universe for human, animals and other species survival, and also for Irrigation, Industrial uses, recreational, environmental activities. In the Arid and Semi-arid regions, the effective management of available water resources in the sub-basin has increased in importance due to limited water availability. In India the per

capita water availability is drastically reducing from 1951 to 2011 as 5177 m^3 to 1545 m^3 as shown in Fig.1

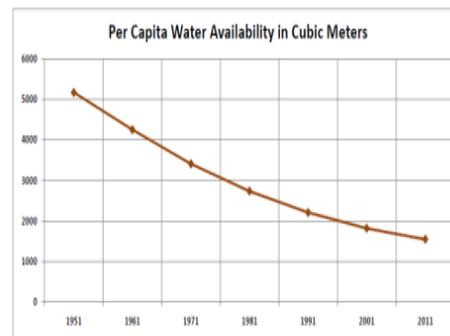


Figure 1 Per capita water availability in India from 1951 - 2011

The present scenario in the sub-basin that the water resources changes with respect to the climate and the water uses increased for the agriculture, domestic and industrial sectors but the water is used for domestic and industrial will not be going to reduce but only increase water productivity in agriculture crops to maintain a sustainable water resource in connection to climate change.

II. STUDY AREA

The Gundlakamma basin lies in Deccan plateau. The basin is arc shaped. The total catchment area of the basin is 8195 km^2 and lies entirely in Andhra Pradesh state. The basin covers parts of the Kurnool, Guntur and Prakasam districts. The study area forms part of river basin, covers an area of 1846 km^2 and falls in Survey of India toposheets 57 M/2, 57 M/3, 57 M/6, 57 M/7, 57 I/14, 57 I/15 and with average elevation of 91m above the Mean Seal Level. The average annual rainfall of the study area is around 895mm and receives rainfall during South west as well as North West monsoon.

The Gundlakamma river is a seasonal river rises near Iskagundam village in Kurnool district at an elevation of 600 m from the Eastern slopes of the Nallamala hills at North latitude $15^\circ 38'$ and East longitude $78^\circ 47'$ and flows in a North-East, East and Southern direction for a total length of 220 km to join the Bay of Bengal. The total area drained by this river is $8,494 \text{ Sq Km}$. The Kandleru is its important left bank tributary. The Cumbum lake is also known as Gundlakamma lake, which irrigates about 11,000 acres of land in Prakasam district. It is the major source for both Irrigation and drinking water purpose. (K.Sai Krishna et al 2018)

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Fig2: Study Area

III. RESEARCH SIGNIFICANCE

The primary motto for this research is in our country most of the states like Andhra Pradesh, Telangana, Tamilnadu and Maharashtra are witnessing the frequent failure of crops due to shortage of water for agriculture resulting debit trap of farmers in turn migration to urban areas in search of livelihood or suicides. Around 11000 farmers committed suicide every year since 2013 due to failure of crops and debit traps.

In the year 2015, Maharashtra topped the list with 4921 suicides followed by Karnataka with 1569, Telangana with 1400, Madhya Pradesh with 1290, Chhattisgarh with 954, Andhra Pradesh with 916 and Tamilnadu with 606. In order to address such crucial social, agricultural and rural employment issues, it is necessary to evolve a comprehensive water network model for meeting the water requirements of growing population in water scarce areas (K. Sai Krishna et al 2018)

IV. OBJECTIVES

1. To study the Sub-basin conditions based on Four Waters concept.
2. To study the watershed conditions, ground conditions, Landuse Land Cover and status of the water resources in the sub-basin.

V. METHODOLOGY

The below given workflow shows the methodology

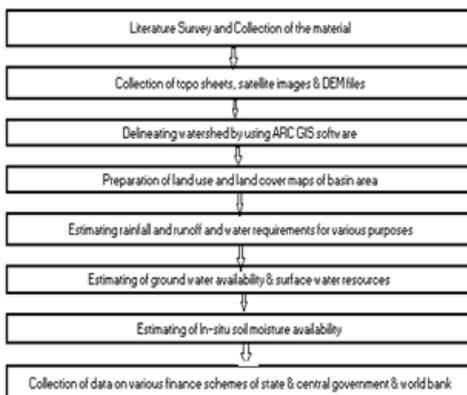


Fig 3: WORKFLOW DIAGRAM

Rainfall data is collected from local sources and IMD for the study area. Surface water sources network of the study area are collected from the toposheets of SOI and local government authorities. Groundwater sources are collected from Groundwater department and local government bodies. Soil data is collected from Agriculture department. Satellite images are used for creating LULC maps by using of ArcGIS software. DEM (Digital Elevation Model) files are created and used in delineating the watershed and identifying various elevation points of study area. Studying of the grid system and how it can apply in the study area. (K.Sai Krishna et al 2018)

VI. DATA COLLECTION

Data related to Rainfall, surface water and Groundwater and also Soil data have been collected from Irrigation department, State Groundwater department Indian Meteorological department, Hyderabad and Horticulture Department of Government of Andhra Pradesh respectively Topo sheets are gathered from Survey of India (Nakshes). DEM files are gathered from the United States Geological Survey (LISS III DEM) and Bhuvan National Remote Sensing Centre (NRSC).

Data regarding plans of Bhagiratha Mission undertaken by Telangana state government, Gujarat water grid and Satya Sai Baba water supply project in Anantapur district of Andhra Pradesh have been collected.

VII. DATA ANALYSIS

VII.1 Water Shed Delineation

First the fill tool is used to seal the imperfections in the digital elevation model. At that point, the stream flow and flow accumulation tools are utilized to decide the course of the stream and assembled water. A shapefile was made to store the pour point and afterwards by utilizing snap pour point to guarantee that point is situated on the higher upstream. Finally, the stream course network was chosen as info raster and pour point as direct information towards getting the yield raster.

VII.2. Land Use/Land Cover (LU/LC) Map

First, the satellite image is geo referenced and to classify the features, training sample manager is used in classification toolbar. Samples are created and stored as signature file in GIS Database. Output raster is arrived by using maximum likelihood classification with the inputs of input raster and signature file (V. M. Chowdary et al)

VII.3. Runoff Estimation by using SCS – CN Method

Soil Conservation Service (SCS) method of United States Department of Agriculture (USDA) is adopted to estimate the run-off for chosen sub basin. The equation for the SCS Curve number is as follows:

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$



Where Q is the runoff in mm, P is average rainfall in mm, Ia is the initial abstraction in mm, and S is the potential maximum retention. To obtain potential maximum retention, the Curve Number (CN) has been taken from SCS National Engineering Handbook, Section 4, 1972. The parameter CN has a range of values between 0 to 100. The curve number is assigned to each portion of watershed according to soil group, land use/land cover features and antecedent moisture conditions. (Engineering Hydrology by K. Subramanyam)

VII.4. Determination of Water requirements

Requirement of water per person is 135 lpd as per IS 1172 – 1963. Population forecasting is done by using the arithmetic increase method and this method is based on the assumption that population increases at a constant rate and then the water requirement is estimated. Census data of 1991, 2001, 2011 is used for estimating population for the selected study area.

The water quantity required for human beings is calculated as follows:

$$\text{Quantity} = \text{Per capita demand} \times \text{Population}$$

Likewise, the cattle needs are calculated based on their population and consumption of water per day. Fire demand is calculated by using the Freeman’s formula with inputs population in thousands. For 1 lakh population, there is need of 35050litres/min. Water requirement for irrigation is arrived assuming that horticulture crops will be encouraged by adopting water conserving irrigation methods like drip irrigation system and allocating 20-25%, 10 %, and 15% for the industrial needs, public use and losses respectively. Crop water requirements are calculated on the basis of average daily pan evaporation (mm/day), spacing of plants by using the following formula.

$$\text{Water requirement under drip irrigation (lpd/Plant)} = A \times B \times C \times D \times E$$

Where, A is open pan evaporation (mm/day),

B is pan factor (0.7),

C is spacing of crops/plant (m²),

D is crop factor (1)

E is wet area (0.3 for widely spaced and 0.7 for closely spaced crops).

VIII. VIII. RESULTS AND DISCUSSIONS

Integrated water resources plan that involves targeting groundwater potential zones and identifying suitable zones for artificial recharge assumes importance and making watershed management simpler and more effective. Formulation of proper management plans requires reliable and up to date information about various factors such as morphologic (size and shape of the watershed, drainage parameters, topography), soil and their characteristics, Land use LandCover (LULC) etc., that effect the behavior of the watershed. (N.Hari et al),

From four waters concept Rainfall data is collected and calculated the surface Runoff and Sub-surface Runoff. From agricultural data calculated the moisture content in the soil. Terrain profile is estimated through DEM (Digital Elevation Model) data files, are gathered and analyzed by using Arc GIS Software. Columns and rows of the raster data are 7200

& 7200 respectively. Spatial extent of this DEM is 170 at top, 150 at bottom, 77.990 at left and 79.990 at right.

Spatial reference of WGS_1984_World_Metacor with datum of D_WGS_1984 is used. Delineated watershed and its details are presented in Figure-3 and Table-1 respectively (K. Sai Krishna et al 2018)



Fig.4 Delineated diagram of Gundlakamma Sub-basin

Depend on the Landuse Land cover (LULC) map, the study area has been classified into five major land use classes viz; built up (9.96%), water bodies (0.002%), forest (32.70%), barren land (18.57%), agriculture land (38.60%) as shown in the Figure - 4. Using LU/LC map, run – off for the Gundlakamma sub – basin is estimated.

Table 1 Details of Gundlakamma sub basin

S.No	Name	Value
1	Area of Sub watershed	1846 Km ²
2	Perimeter of Sub watershed	316 Km
3	Centroid of Sub watershed	79°0'00" Longitude & 15°30'00" Latitude

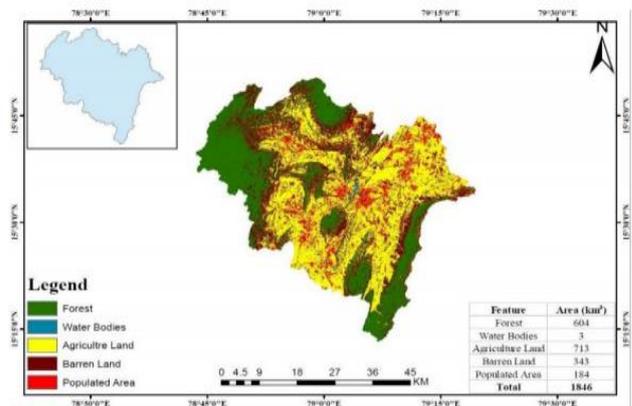


Fig.5 Landuse Land cover map of Gundlakamma sub-basin

Calculation of Runoff using of SCS – CN method, soils of the study area are classified the into four hydrologic soil groups (HSG) to indicate the infiltration rate obtained for plain soil after persistent wetting. The soil classes thus arrived from HSG are A, B, C, D.



Group A has low runoff and great infiltration rate, Group B has modest infiltration rate, Group C has low infiltration rate and Group D has high runoff potential. The area is comprising of black cotton soils which falls under sandy clay loam, accordingly HSG Group C has been taken for determination of curve number and estimation of run – off.

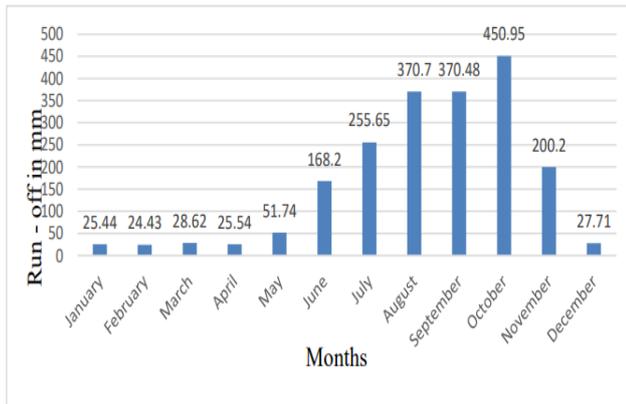


Fig.6 Average monthly runoff for the years 2012-18

Run-off for Forest, Water Bodies, Agriculture Land, Barren Land and Built up Land are 150.85, 694.74, 338.78, 367.04 and 448.25mm respectively and total availability of surface water per year is 54312.05 ha.m or 543120.5 MLD and ground water availability is 20550 ha.m. Total availability of water in the sub basin is 74862.05 ha.m.

Table-2 Run-off and Volume in Gundlakamma Sub-basin

Land Use Cover	Area in m ²	Runoff in mm	Run-off Volume (m ³)
Forest Land	60400000	150.85	91113400
Water Bodies	3000000	694.74	2084220
Agriculture Land	713000000	338.78	241550140
Barren Land	343000000	367.04	125894720
Built Up Land	184000000	448.25	82478000
Total			543120480

IX. CONCLUSIONS

The total Andhra Pradesh Geographical area is 275 lakh hectares out of which waste and degraded lands constituted 115 lakh hectares(42%).The state receives about 24,44,000 lakh cubic meters volume of rainfall through an average annual rainfall of 896 mm. Out of the total volume of 24,44,000 lakh cubic meters(8361 TMC) rainfall received, 10,02,040 lakh cubic meters (3453 TMC) (41%) is lost as Evaporation and Evapotranspiration. 9,77,600 lakh cubic meters(3453 TMC) is lost as surface Run-off, 2,44,40 lakh cubic meters (863TMC) (10%) is retained as soil moisture and 19,960 lakh cubic meters (777 TMC) (9%) is recharged as ground water.

Study area of the Gundlakamma Sub basin is 1846 Km². This has shown that there are five major land use classes viz., Agriculture land, forest, barren land, built – up land and water bodies. Soils are categorized into four hydrologic soil groups. Total run – off of the study area is 54312.05 ha.m, ground water availability is 20550 ha.m. Population projected for 2021, 2031 and 2041 are 3.68, 3.97 and 4.26 lakhs respectively. Water requirement for irrigation is 1643 MLD.The same data is extrapolated for the entire study area.

Various schemes of the state government available for water grid are NTR Sujala Pathakam, Watershed development programme, Water harvesting schemes, Micro irrigation projects. Similarly various schemes available under central government assistance are Rashtriya Krishi Vikas Yojana (RKVY), National Watershed Development Programme for Rain fed Areas (NWDPR), River Valley Project (RVP). The grid will be successful only when it is taken up by state government with the active participation of beneficiaries in conceptualization, installation and operation.

It is suggested to take up such investment-oriented projects on public private partnership mode (K.Sai Krishna et al 2018)

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