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Original Article

Water Resource Distribution and Usage Patterns in the Godavari River Basin, Maharashtra

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Abstract

Water is one of the most vital natural resources, yet its uneven distribution and increasing demand have made its management a pressing concern in India. The Godavari River Basin, the second largest in India, plays a crucial role in Maharashtra's water resource system. Covering about 1,52,811 sq. km within the state. However, changing land use patterns, increasing population pressure, and industrial expansion have significantly altered the water use dynamics in the basin. Agriculture remains the dominant water-consuming sector, followed by domestic and industrial uses, leading to rising stress on available resources. This study highlighting spatial and sectoral variations and emphasizing the urgent need for sustainable water resource management to ensure long-term ecological balance and socioeconomic development in the region. Agricultural and industrial water use suggests a strong positive relationship. Both sectors' water demands rise together, possibly due to shared regional development patterns. clustering serves as a powerful analytical tool to understand spatial and sectoral variations in water use, aiding in data-driven decision-making for efficient and equitable water resource management within the Godavari River basin.

Keywords- *Water resource, water use, regional development*

Introduction

Water is precious resource. It is unevenly distributed on the earth. The use of water is also uneven. So, for the water resource management is necessary. Depleting water resources is one of the major concerns of urban India and it is likely to create a severe crisis in future as our urban population is expected to increase from 377 million in 2011 to 600 million by 2031 (Amarasinghe 2004). Despite being rich in surface water resources, water scarcity is being recognized as an important problem facing India. Currently, India is home to about 18% of the world's population and accounts for about 2.4% of the world's geographical area. India consumes 4% of the total water resources. As an important economic resource, water is essential for all forms of livelihood activities, agriculture, animal husbandry and most of the industrial production processes (Merrett 1997; Kay et al. 1997). Rivers and lakes are dying, and groundwater levels are dropping due to the overexploitation of surface and groundwater by farmers, city dwellers, and industries. Furthermore, the limited available water is highly polluted (TERI 2021). The per capita water availability has declined by almost 75%, from Maharashtra State is geographically divided into 5 river basins, namely Godavari, Krishna, Tapi, Narmada, West flowing rivers in Konkan. A river basin is natural unit within the territorial limits of which all activities that are taking place are interdependent. The River Godavari originates near Trimbakeshwar in Nashik district in Sahyadri hill ranges. It further flows down to Andhra Pradesh after having flowed through Ahmednagar, Chh. Sambhajinagar, Nanded districts and joins the Bay of Bengal near Rajahmundry. The total geographical area of this basin is 3,12,812 Sq. Km. of which 1,52,811 Sq. Km. fall within Maharashtra.

The Godavari is the second largest basin and accounts for nearly 9.5% of the total geographical area of the country. It extends over states of Maharashtra (48.7%), Nagpur is the most important urban centre in the basin. Other important towns are Nasik, Aurangabad, Warangal, Rajahmundry, Akola, Amravati, and Ahmednagar.

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The Godavari basin is emerging a new industrial zone in Maharashtra. Agro-industries are developing in the basin. Agriculture sector is expanding its area. The use of water is changing constantly due to increasing population and increasing urban centre.

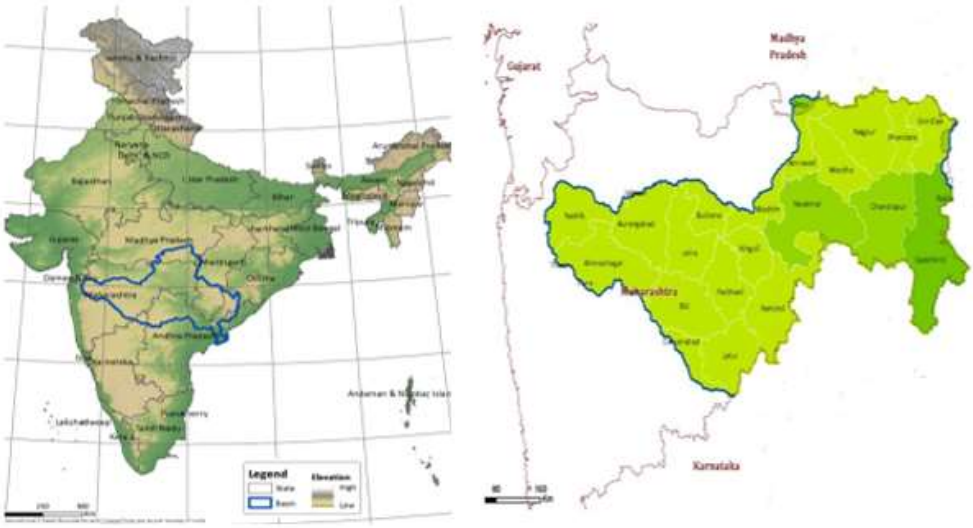
Objective

1. To analysis relationships between different water use sectors
2. To classify basins based on their water characteristic using cluster analysis.

Study area

Godavari river basin is extended 73°24' to 83°4' E to 16°19' to 22°34' N. The basin covered 48 percent area of the Maharashtra state. The basin is bounded on the north by the Mahadeo Hills, the Satmala Hills, on the north-west by the Ajanta Range, on the west by the North Sahyadri range of the Western Ghats, on the east and south east by the Eastern Ghats and on the south by the Balaghat Range. The Godavari basin has a tropical climate.The weather in the basin is cold from mid-October to mid-February and the wetsren and the north-eastern part being colder than the rest of the basin. The weather is comparatively hotter in the westernmost parts of the basin in comparison to the Central, northern and eastern region. Annual rainfall of the basin varies from 755 mm to 1531 mm. The average annual rainfall in the basin is 1096

.92 mm. It is found that the rainfall varies temporally and spatially across the basin. In Godavari the high rainfall zone in the Western Ghats the annual rainfall varies from 1000 to 3000 mm in this reach. There is a belt some distance east of the Western Ghats experiencing less than 600 mm annual rainfall. Annual maximum temperature varies from 31 C to 33.5 C The Godavari is the biggest of the east-flowing rivers of the peninsular India and the second largest river draining in India. Godavari river originates near Trimbakeshwar near disrtict Nashik, northeast of Mumbai in the state of Maharashtra at an elevation of 1067 m and flows for a length of about 1465 km, in a generally south-east direction before joining the Bay of Bengal. It flows through the Eastern Ghats and emerges out of Polavaram into the plains.



Data source and Methodology

The present research paper is based on secondary data which is published in integrated state water plan 2024.
Data is tabulated in different sector like Total Available Water, Domestic Use, Industrial Use, Irrigation
Use. Karl Persons correlation analysis is used for the study of analysis the relationship in different sectors. While data standardized using Z-Score to remove unit differences. K-Means Clustering (K = 5) Euclidean distance used as similarity measure. 27 sub basins grouped on the basis of their water use similarity. The Elbow Method graph (K vs SSE) was used to confirm that K=5 gives optimal separation with minimal within-cluster error.

Result and Discussion

Table No. 1

Total available water and its use

Sr. No.	Name of Basin / Sub Basin	Total available water (MCUM)	Use of Water in different sector in (MCUM)		
			Domestic	Industrial	Irrigation
1	Upper Godavari	8,349	855	209	7648
2	Pravara				

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3	Mula				
4	Middle Godavari	6,481	219	21	2452
5	Dudhna	873	70	2	853
6	Purna	2,765	124	8	2127
7(a)	Sudha	110	3	0	50
7(b)	Swarna	29	1	0	5
8	Manjara	1,226	119	17	1152
9	Terna	502	41	4	668
10	Lendi	359	35	1	342
11	Manar	482	49	1	680
12	Kayadhu	7,484	309	51	4696
13	Penganga				
14	Pus				
15	Arunawati				
16	Bembla	502	32	0	772
17	Wardha	3,764	145	225	1851
18	Venna	1,614	70	89	812
19	Erai	265	34	143	44
20	Andhari	1,222	35	0	839
21	Nag	508	20	8	61
22	Kolar	382	9	0	202
23	Kanhan	1,486	12	16	413
24	Pench	725	199	63	423
25	Wainganga	5,560	108	199	3535
26	Bagh	959	14	3	480
27	Gadhavi	524	5	0	466

Source: integrated state water plan 2024.

Table No. 2

Relationships between different water use sectors

Sr. No.	Relation	Coefficient r	N	T Statistic	DF	P- Value
1	Total vs Domestic	0.815615375	23	51.16301665	21	1
2	Total vs Industrial	0.513163533	23	14.62871279	21	1
3	Total vs Irrigation	0.916966635	23	10.53245436	21	1

The correlation values(r) show that irrigation sector has strongest use with total water use. Domestic sector has shown a strong use of water while industrial use is moderately related. The t value confirm that the correlations are statistically significant. The correlation analysis between total water use and its sectoral uses revels that irrigation shows the highest positive correlation indicating that irrigation largely determines the total water use pattern in the Godavari basin. Domestic use also exhibits a strong positive relation while industrial use has moderate correlation. The computed t-statistics with 21 degrees of freedom confirm that these correlations are statistically significant. Thus, irrigation emerges as the dominant water use sector influencing overall water consumption across the sub basin.

Each cluster represents a distinct pattern of water utilization among Godavari River basins Cluster 1- High water available and multi sector usage - Contains basin like upper Godavari, Middle Godavri, Wainganga etc these basins show high total water and irrigation potential, along with moderate domestic and industrial use represent major agricultural and resources rich sub basin. Cluster 2- Medium Irrigation Dominant basin – Moderate total water but irrigation is the main component. Domestic and industrial use is relatively low represent semi developed agricultural region. Cluster 3 Low total water and minimal use - includes smaller tributaries with low total discharge and very low sectoral usages represent dry or less developed catchments possibly dependent on rainfall and seasonal flow.

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River Basin	Z Total	Z Domestic	Z Industrial	Z Irrigation	Dist_C1	Dist_C2	Dist_C3	Dist_C4	Dist_C5	Cluster Assigned	SSE Cluster
1	2.787656	4.534446	2.46278	3.826799	6.9641	5.445666	0	7.943391	4.974099	3	0
2	-0.71804	-0.55267	-0.57492	-0.66499	1.371425	4.049019	8.220263	0.305604	3.967796	4	0.093394
3	-0.71804	-0.55267	-0.57492	-0.66499	1.371425	4.049019	8.220263	0.305604	3.967796	4	0.093394
4	2.003317	0.750342	-0.26969	0.775105	2.516742	2.934775	5.631512	3.065443	0.773176	5	0.597801
5	-0.35147	-0.13619	-0.54555	-0.16401	0.950105	3.623255	7.526455	0.455575	3.272547	4	0.210291
6	0.442977	0.185106	-0.45564	0.554227	1.244362	3.088137	6.592675	1.557003	2.172065	1	1.548437
7	-0.67185	-0.53483	-0.57492	-0.63563	1.333539	4.012141	8.173541	0.250353	3.911076	4	0.062692
8	-0.70556	-0.54673	-0.57492	-0.66206	1.362557	4.040594	8.209759	0.293715	3.954592	4	0.08627
9	-0.20325	0.155357	-0.32783	0.011594	0.701075	3.306853	7.1039	0.85105	2.947301	1	0.491511
10	-0.50725	-0.30873	-0.51675	-0.27267	1.031171	3.723439	7.745733	0.23231	3.506333	4	0.053965
11	-0.5673	-0.34443	-0.56035	-0.46413	1.143573	3.8565	7.912705	0.106529	3.667594	4	0.011413
12	-0.51565	-0.26113	-0.56035	-0.26562	1.05295	3.754474	7.732552	0.266525	3.497792	4	0.071196
13	2.424474	1.255829	0.166339	2.093042	3.618043	3.072925	4.354552	4.322913	0.773176	5	0.597801
14	-0.71804	-0.55267	-0.57492	-0.66499	1.371425	4.049019	8.220263	0.305604	3.967796	4	0.093394
15	-0.71804	-0.55267	-0.57492	-0.66499	1.371425	4.049019	8.220263	0.305604	3.967796	4	0.093394
16	-0.50725	-0.36225	-0.57492	-0.21159	1.095752	3.759613	7.769555	0.266219	3.505999	4	0.070873
17	0.562455	0.310053	2.695331	0.422125	2.622595	0.659202	5.76176	3.703635	3.301151	2	0.434545
18	-0.04033	-0.13619	0.715647	-0.18509	0.452955	2.45344	6.995129	1.406716	3.104622	1	0.205195
19	-0.60677	-0.35035	1.503507	-0.63915	1.405034	2.671696	7.499915	2.052549	4.067641	1	1.97412
20	-0.20493	-0.34443	-0.45564	-0.17224	0.927826	3.515659	7.568761	0.447546	3.233109	4	0.200366
21	-0.50473	-0.43365	-0.45564	-0.62917	1.144416	3.824245	7.994537	0.184593	3.731104	4	0.034074
22	-0.55764	-0.49913	-0.57492	-0.54636	1.244665	3.915334	8.054521	0.114663	3.76553	4	0.013145
23	-0.09407	-0.45125	-0.34237	-0.42243	0.954905	3.485543	7.706255	0.474254	3.332554	4	0.224945
24	-0.41361	0.631345	0.340752	-0.41636	0.655925	3.063714	6.927595	1.339662	3.260709	1	0.430241
25	1.616591	0.059909	2.317436	1.411165	3.065165	0.659202	5.194395	4.064659	2.613716	2	0.434545
26	-0.31536	-0.46935	-0.53131	-0.35305	1.092705	3.712493	7.832933	0.223962	3.484505	4	0.050159
27	-0.49501	-0.52293	-0.57492	-0.3913	1.195645	3.840155	7.961962	0.11941	3.631706	4	0.014259

Cluster 4 Industrial and Domestic Emerging basin – comparatively smaller in total water but industrial and domestic shares are higher proportionally represent urban influenced or industrializing basin.

Cluster 5 Balanced use basins- shows moderate water in all four-sector indicating balanced management represent transitional zones between high and low water use basins.

The k means cluster analysis successfully classified the 27 Godavari sub basin into five distinct water use categories this classification highlights spatial disparities in water availability and utilization and helps in Identifying high demand vs low resource basins Guiding integrated water resource management strategies Supporting policy decision for sustainable water planning

Conclusion

The correlation analysis indicates that irrigation use has the strongest and most significant association with total water use, confirming that agriculture remains the dominant water-consuming sector across the basin. Domestic use also shows a strong positive relationship, while industrial use exhibits a moderate correlation, reflecting its localized influence in specific sub-basins. The statistical validation through t-tests further confirms the reliability of these relationships Together, these findings highlight the dominance of irrigation in shaping overall water consumption, as well as the regional disparities in water availability and use among sub-basins. The classification provides a valuable framework for integrated water resource management, enabling planners to identify high-demand versus low-resource areas, prioritize equitable distribution, and support sustainable water planning across the Godavari basin.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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