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Ground Water Management in Godavari Basin

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Abstract:- The Godavari River is rising in Western Ghat near Nashik and running for a length of 1445 Km. to join the sea. Godavari is the largest river in South India, flowing through six states and joining to bay of Bangal. It has 49% catchment area in Maharashtra with 30 Sub-basins. Out of these, 3 sub-basins are lying in Nashik Region, 9 Sub-basins are in Marathwada Region, and 18 Sub-basins are in Vidharbha Region. As per the availability of surface water the category of Sub-basins in Nashik and Vidharbha Region is classified as Normal as it is having more than 3000 Cum. of Water per Hectare. However the Sub-basins in Marathwada Region are in highly deficit category, as it is having the water of only 1181 Cum. per Hectare. Nearly 92% area of the state is occupied by the hard rock including 82% of basalt and 10% of Metamorphic rocks. Maharashtra state is having total 807 nos. of water sheds with 12249 Mcum. Ground Water available. Out of these net 3752 Mcum. Of Ground Water is available for future use. It is estimated that about 271719 of additional wells can be taken up in the state under Godavari Basins.

Keywords: Ground Water, Surface Water, Rocks Classification

I. INTRODUCTION

The Godavari river is the largest river in Southern India. The river originates at RL. 1067 mt. near Trimbakeshwar (19^0 55' 47" N and 73^0 31' 22" E) in Brahmagiri ranges in the Sahyadri hills named as western Ghat in Nashik District and meets sea at Bay of Bengal in Andhra Pradesh State. Total length of the Godavari River is 1445 km out of which length within Maharashtra state is 694 km. Godavari Basin extends over states of Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh, and Orissa in addition to smaller parts in Madhya Pradesh, Karnataka and union territory of Podduchery. The basin has the total drainage area of 3,12,800 Sq.km. The basin has a length of about 995 km and width of about 583 and occupies nearly 9.5% of the total geographical area of the country and is the largest river basin in the peninsular India. The Godavari river basin covers the drainage area of 1,52,587 sq.km. i.e. about 49% of the total Godavari catchment area in Maharashtra State. The basin is bounded by the western Ghats on the west side with Satmala hills, Ajantha ranges and Mahadev hills on the north, low hill ranges in the south along with eastern Ghats in the east.

II. OBJECTIVE

1. To study the salient features of Godavari basin
2. To study the Geo-hydrology of Godavari basin
3. To study the Ground Water availability in Godavari basin

III. METHODOLOGY

Only secondary data like books, research paper reports of water commission, GWP and ISWP are used for the present research paper.

IV. STATE WISE COVERAGE

The catchment area of the entire Godavari basin covers six states. The Sate wise area is given below.

Table No. 1 State wise Percentage of Catchment Area

Sr. No.	State	C.A. in Sq. Km	Percent %
1	Maharashtra	152587	49
2	Madhya Pradesh	26168	8
3	Chhattisgarh	39087	13
4	Orissa	17752	6
5	Karnataka	4406	1
6	Telangana (old AP)	72800	23
	Total	312800	100

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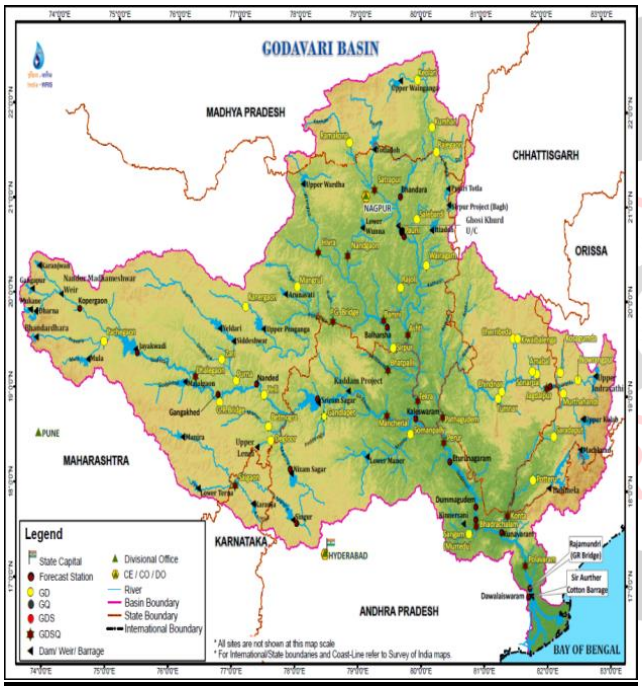
Source: GoM (2017), "Integrated State Water Plan For Godavari Basin of Maharashtra", WRD, Volume No. 1 Page No. 107

The above table explains the state wise catchment area in Godavari basin in each state along with its percentage. It is clear from the above table that Maharashtra is having maximum (49 per cent) catchment area in Godavari basin and the Karanataka state having the minimum (only1 per cent) catchment area in Godavari basin.

Fig. 1. Map of Godavari Basin

Region	Culti. Area (Ha)	Surface Water		Cum/ Ha (5/3)	Category
		Avail.	Allotted		
Nashik	1773471	5773	5837	3292	N
Marathawada	4427526	7046	5229	1181	HD
Vidharbha	4640247	25788	17957	3870	N
Total Regions	10841244	38607	29023	2677	D



Source: www.mapsofindia.com (Godavari Basins)

VI. PARTS OF THE BASIN

The entire Godavari basin is divided in to three regional parts, along with thirty sub-basins named from the name of the rivers of tributaries joining to the main Godavari river as below.

Table No.2 Sub basin wise Population

Regional Name	Sub basin	Drainage Area (Ha)	Population (2011)
Nashik	3 Nos	2191200	8713424
Maharthwada	9 Nos	5187800	13336178
Vidarbha	18 Nos	7879700	17227900
Godavari Basin	30 Nos	15258700	39277502

Source: GoM (2017), "Integrated State Water Plan For Godavari Basin of Maharashtra", WRD, Volume No. 1 Page No. 137-156

VII. SURFACE WATER AVAILABILITY

The yield calculated above for various dependability, is the surface water available on the ground in the number of sub basins. The yield at 75% dependability is generally considered for the design of the projects. But, whole quantity of surface of water available cannot be use in the respective sub basins for the interstate rivers like Godavari. And hence the tribunal has put some restrictions on the use of available surface water. Accordingly, the Godavari Water Disputes Tribunal (GWDT) has allowed the following sub basin wise water use in the Godavari basin.

From the above table, if the region wise classification of the basins is done, it is seen that,

1) Nashik Region : Nashik region is lying in Average or Normal category as the value of water allotted is 3292 CuM/Ha which is more than the normal value of 3000 CuM/Ha.

2) Marathwada Region : Marathwada region is in highly deficit category as the value of the water available / allotted is only 1181 CuM/Ha i.e. less than <1500 CuM/Ha.

3) Vidarbha Region : Vidarbha region is lying in Average or Normal category as the value of water allotted is 3870 CuM/Ha which is above Normal value of 3000 CuM/H.

Even the value of water available / allotted to Nashik and Vidarbha Region is more than 500 CuM/Capita/year, may face the scarcity conditions. But, the Marathwada Region having only 320 CuM/Ha/year of water is classified under acute or absolute scarcity as the value is less than 500 CuM/Capita; This shows that, to bring the Marathwada region out of the scarcity condition additional water will have to be transferred to this region from other surplus basins.

VIII. CLASSIFICATION OF SUB-BASINS

Maharashtra Water and Irrigation Commission (1995) has prescribed the norms of classification of basins /sub basins on the basis of surface water availability per hectare on cultivable land. Accordingly, the sub basins of the Godavari basin are classified as shown in the table given below.

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Table No. 4 Percentage wise Drainage Area

Sr. No.	Category	Drainage Area In sqkm	Percentage
1	Highly Deficit (0-1500)	42322	27.8 %
2	Deficit (1501-3000)	57207	37.5 %
3	Normal (3001-8000)	47674	31.2 %
4	Surplus (8001-12000)	5384	3.5 %
5	Abundant (Above 12000)	--	--
6	Total	152587	100 %

From the table No. 4, the overall region wise classification is as below.

1) Nashik Region: 3 nos. Sub Basins are in normal category.

2) Marathwada Region: 7 nos. Sub basins are in highly deficit category.
2 nos. Sub Basins are in deficit category.

3) Vidarbha Region: 1 no. Sub basin is highly deficit category.
7 nos. Sub basins are in deficit category.
7 nos. Sub basins are in average category.
3 nos. Sub basins are in Surplus category.

Total 30 nos. Sub basins.

From the above analysis it is seen that, the Marathwada region is under highly deficit or deficit category and requires more water to increase the irrigation of this area.

IX. GEOLOGY AND HYDRO-GEOLOGY OF BASINS

Maharashtra state comprises mainly of the six basins, as Godavari, Krishna, Tapi, WFR of Kokan, Narmada and Mahanadi. The Godavari basin is 68 % underlain by the Deccan Trap formation. The Godavari and Krishna basin comprises of a series of basaltic lava flows of 6 to 100 m individual thickness. The Deccan trap exhibits step-like topography. Individual flows are generally separated by thin beds of red bole. Red bole and Green bole range in thickness between 0.5 to 1m in Godavari basin and 0.2 to 1m in Krishna basin, having fine graines and brick red and green in colour respectively, ferruginous and clayey in nature and indicate presence of vesicular or zeolitictrappean unit underneath. Generally, it serves as marker horizon. Red bole or Green bole acts as a marker horizon between two basaltic flows. Alluvium is found on both sides of the Godavari River and its tributaries mainly in the parts of Upper Godavari, Mula, Middle Godavari, Lendi, Dudhna, Purna, Wardha, Erai, Andhari, Venna, Kolar, Kanhan and Wainganga sub-basins ranging in depth from 2 to 23 m and comprises brownish clay with intercalations of gravel and kankar.

X. GROUNDWATER POTENTIAL ZONES

Lineaments, faults and shear-zones are promising locations for occurrence of groundwater. The pattern and intensity of fracture determine whether the groundwater occurs under unconfined conditions or under confined conditions. When fractures are vertical unconfined condition is likely to exist, but if the fractures are inclined with little inter-connections between them, then confined condition is likely to prevail in individual inclined joints. The groundwater worthy area is further sub integrated divided into three groundwater potential zones based upon hydro-geological conditions of the area and yield from the wells. These zones are i) Moderate to good potential zone ii) Poor to Moderate Potential Zone and iii) Poor Potential Zone.

XI. AQUIFER GEOMETRY AND AQUIFER SYSTEMS

Konkan West flowing river basin is a part of Deccan-Trap groundwater province in basaltic lava-flows where the aquifers are mostly inconsistent with complex hydrogeological system. Groundwater occurs under unconfined, semi-confined and confined aquifer conditions. In local shallow alluvium, groundwater occurs under unconfined condition.

1) Unconfined Aquifer

This category extends upto a depth of 15 m to 25 m mostly in dug well and varies in thickness from 2 m to 10 m. It occupies plain areas and shows signs of weathering, jointing and fracturing of basalt flows and other rock types. The groundwater potential in this gradually sloping terrain mostly gets concentrated towards its valley.

2) Semi-Confined Aquifer

This category comprises of deeper dug-wells and dug-cum-bore-wells and shallow bore- wells. These aquifers are

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found to have connectivity with water table aquifer and occur between the depths varying from 25 m to 50 m. The piezometric-head in the wells / tapping these aquifers is generally much above the water-level in the nearby wells which tap the unconfined aquifers.

3) Confined Aquifer

This aquifer is tapped at depths below 50 to 80 m and more mostly through shallow and deep bore wells. The recharge to this aquifer is through major shear-zones, fracture zones, intersecting several flows or in a few cases through exposed-portion of the formation in the recharge area.

4) Multi Layered Aquifer

Exploratory bore wells are drilled by Central Groundwater Board and drinking water bore wells are drilled by Groundwater Survey and Development Agency, Maharashtra in Deccan Trap area. In deep bore wells deeper aquifer is encountered a depth of 60 to 100 meters. On the basis of lithology of bore wells it is observed that the flow units consist of vesicular and non vesicular units. The vesicular unit is a pervious and act as an aquifer whereas the non-vesicular unit (hard compact massive trap) is impervious and act as non-aquifer. The alternate pervious and impervious layers at deeper level, the bore well when drilled under this geological condition, water may encounter in pervious zone (aquifer).

XII. GROUND WATER RECHARGE & DISCHARGE

The major contribution to the groundwater recharge takes place from direct precipitation. Percolation from surface water bodies, influent seepage from streams, return flow from surface water and groundwater irrigation are the indirect agents of groundwater recharge. The soil conservation and water spreading techniques will have the necessary impact on the groundwater recharge. The recharge to groundwater body is affected by a) heavy concentration of rainfall in short period of time, b) thin soil cover and poor permeability of the formation and c) steep topographic gradient and vegetation cover.

As per the observations in Maharashtra State, the recharge components are rainfall 67%, canal seepage 2%, return flow from surface irrigation 12%, return flow from GW irrigation 14%, tank & ponds 1% and water conservation structures 4%. The recharge from surface and GW irrigation accounts for 26% of the total recharge.

Discharge of groundwater takes place through extraction of water from irrigation, domestic and other wells, effluent seepage from the major rivers, natural spring and evapotranspiration. The streams are effluent near their origin and further away down side they become influent.

XIII. AQUIFER PARAMETERS OF WATER BEARING FORMATIONS

The parameters of aquifers and the yield characteristics of wells are assessed by means of various aquifer performance tests in hydro geological surveys. The principle objective is to determine quantum of groundwater that can be safely withdrawn perennially from the aquifer.

In West flowing river basin the groundwater in the area in basaltic flow occurs under unconfined, semi confined and confined conditions. The sp. yield of the massive basalt is poor and thus significant fluctuation in water levels are observed in the area. This also results in shallow water level conditions from August to November. The sp. capacity of dug well tapping the massive basalt ranges 2.03mts to 55lpm/m of drawdown whereas in moderately jointed massive basalt it ranges from 32.54 to 97.61lpm/m of drawdown. The sp. capacity of weathered basalt ranges from 110 to 130.16lpm/m of drawdown. In vesicular basalt the sp. capacity ranges from 15 to 39.04 lpm/m of drawdown.

XIV. YIELD OF DUG WELLS AND BORE WELLS

Dug wells are used both for domestic and irrigation purposes and rarely for industrial use. Yield of the groundwater structures varies depending upon the geological formations, their location with respect to physiography, diameter, depth etc. In basaltic area, generally the vesicular part of the flow, if saturated gives better yield. Thus, the yield depends upon the saturated thickness of vesicular basalt encountered in the well. Occasionally fractured zones are also encountered which gives relatively better yield. The dug wells located in the topographic lows and morphological depression, yield comparatively more water.

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The unconfined aquifer is being developed by large diameter dug wells (1.5 to 15 min dia and 4 to 30 m deep) dug-cum bore wells (up to 60 m deep) with high capacity centrifugal pumps (5-10 HP). The inventory of bore wells shows the depth of casing provided was from 3 to 22m below ground level for depth of bore wells ranging between 25 to 90m below ground level.

For Krishna basin, the unconfined aquifer is being developed by large diameter dug wells (1.5 to 8 m in dia and 7 to 20 m deep) dug-cum bore wells (up to 60 m deep) with high capacity centrifugal pumps (5-10 HP). The inventory of bore wells shows the depth of casing provided was from 3 to 22m below ground level for depth of bore wells ranging between 25 to 90m below ground level.

In Godavari and Krishna basin Average optimum yield of dug wells in Trap ranged between 0.42 m3/hr and 384m3/hr and alluvium ranged from 1.26 to 300m3/day. The data showed wide variation in yield of bore wells between 0.5 to 43.08m3/day in Deccan Trap and 28.80 to 54.03m3/day in Gondwanas. For Tapi basin, the yield of dug wells tapping upper phreatic aquifer ranges between 21-337 m3 per day which have 5-15m below ground level depth range borewells drilled down to 60-150m depth, tapping weathered and vesicular basalt are found to yield 1.8-52 m3 per da, and the groundwater in alluvium occurs under water table semi confined and confined conditions. The dug well is deep ranging from 10-50m below ground level in depth with yield varying from 120-200 m3/day in winter and from 50-100 m3/day in summer.

XV. PARTICIPATORY GROUND WATER MANAGEMENT

Nearly 92% area of the state is occupied by the hard rock including Basalt (82%) and Metamorphic rocks (10%) These rocks have poor ground water yielding (specific yield ranges from 1 to 3%) capacity. Thus, restricting the groundwater availability as per the report on Dynamic Groundwater Resources of Maharashtra as on 2013-14 the annually replenish-able groundwater resources of the State is 31, 5 BCM against which the groundwater extraction in the state is 56% of the annually replenish-able groundwater resource, Though, the state groundwater extraction figure is 56%, However, in around, one fourth part of the state, the stage of groundwater extraction is nearly or more than 100%.

As per the report on Dynamic Groundwater Resources of Maharashtra as on 2013-14, out of the total 1531 watersheds of the State, 74 are categorized as Over Exploited (OE), 04 Critical (CR), 111 Semi critical (SC), 04 poor groundwater quality and rest 1338 are Safe. Groundwater being the common pool resource needs to be managed through participatory approach. Groundwater Survey and Development Agency (GSDA) has implemented the pilot projects on Aquifer based Participatory Ground water management in 52 villages from Satara, Jalna, Beed, Buldhana, Aurangabad district. GSDA is also implementing Aquifer based Participatory Ground water management in 102 villages from Amravati, Buldhana, Aurangabad, Jalgaon, Ahemadnagar, Pune and Satara. Results from these projects show that the Groundwater can be very well managed by Participatory approach. It is also learnt that Demand side interventions are more beneficial and contributing than the supply side interventions. Thus, there should be a proper mixture of supply and demand side interventions in implementation.

XVI. GROUND WATER AVAILABILITY

The ground water is one of the most important natural resources on the earth. It plays important role in maintenance of economy, environment and standard of living of any society in the state. In the absence of immediate availability of surface water sources, a large population depends upon ground water. It is equally important in river basin management. It has been the primary source of water supply for domestic, agricultural and industrial purposes. It is the single largest and most readily available source of irrigation and large irrigation (above 50%) is depending on the ground water. In Maharashtra, a rapid growth of population and the consequent increase in irrigated agriculture, drinking water supplies and industrial needs have focused the attention of concerned to developed new water sources.The ground water assessment is carried out in the state by the Groundwater Survey of Development Agency (GSDA) in the year 2011-12. The information is compiled as water shed wise recharge annual gross groundwater draft and

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ground water availability for use of various purposes like driving irrigation and industry.

As per this assessment, given in the table below, total annual ground water recharge is 17494 mm and net annual ground water availability (70%) is 12249 mm. Annual gross ground water draft from irrigation wells, domestic wells and bore wells is 8496 mm. The allocation for domestic and industrial water supply needs to be kept reserved, based on projected population of the year 2025.

Table No. 5 Ground Water Assessment

Sub Basins	No. of water sheds	Net Recharge G.W.		Draft in	Future use in Mcum. (Col. 5-6)	No. of addl. Wells for Irri.
		100%	70%			
1	2	3	4	5	6	7
Nashik Region	101	2704	1893	2126	-233	889
Marathawada	279	6797	4758	3621	1137	79887
Vidharbha	427	7996	5598	2749	2849	190943
Total	807	17498	12249	8496	3753	271719

Source: GoM (2018), "Integrated State Water Plan For Godavari Basin of Maharashtra", WRD, Volume No. 1 Page No. 204

XVII. TOTAL WATER AVAILABILITY (Sw + Gw)

The surface water availability is worked out on the basis of the restricted use of water allowed by the Godavari Water Disputes Tribunal (GWDT). Similarly, though the 100% use of ground water is permitted by the tribunal, the State Water Board (SWB) has recommended only 70% of ground water for actual use leaving 30% to be allowed for ecological purposes. Thus, the total water available will be allotted surface water and ground water.

Table No. 6 Total Water (sw + gw) Available

Region	Cultivable area in Ha	Water Allotted (Mcum)	GW 70% of avail.	Total water MCum	Water. Cum/ha	Category
1	2	3	4	5	6	7
Nashik	1773471	5837	1893	7730	4359	Normal
Marathwada	4427526	5229	4758	9987	2256	Deficit
Vidarbha	4640247	17957	5598	23555	5076	Normal
Total	10841244	29023	12249	41271	3807	Normal

Source: GoM (2018), "Integrated State Water Plan For Maharashtra", WRD, Volume No. 1 Page No. 156

From the above table, it is seen that, if the surface and ground water is considered together for deciding the category of basins, then Nashik and Vidarbha basins are coming under normal category. The classification of Marathwada is however, in deficit category only. These shows that, by considering the ground water the Marathwada I not having Satisfactory or Normal category of available water. Moreover, it is very uncertain to get the expected ground water in Marathwada region as the hard or impervious black rock is about 82% below surface of ground in this region. And hence, there are no hopes of getting good replenishment of water in the wells dug in the Marathwada region. So no one can depend on ground water as guaranteed source in Marathwada. And hence, the surface water can only be the assured source of water in Marathwada region.

XVIII. RECOMMENDATIONS

In order to manage the groundwater resource in long term it is needed to focus and strongly implement following holistic Schemes in regular manner. Then only water scarcity can be managed successfully.

1) Groundwater shall be treated as social commodity and its use for drinking and irrigation purpose be done efficiently based on availability. Groundwater survey and development shall be done watershed wise and not on administrative region wise.

2) Groundwater use shall be regulated to control over exploitation. Detailed geological investigations shall be done before undertaking artificial groundwater recharge measures.

3) Water shall be managed in holistic manner.

4) There shall be a long term Village scale aquifer mapping, delineation and participatory groundwater management scheme from the Government to resolve the upcoming water issues. Since the Demand side management interventions are more beneficial than the supply side (Water conservation and Groundwater recharge) interventions. More stress shall be given on demand side interventions.

5) Groundwater monitoring network shall be made distributive, and on real time basis so as to provide real time water balance to the farmers/stake holders. This will be useful in planning water resources in the state.

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6) The Maharashtra Groundwater (Development and Management) Act, 2009 shall be implemented actively in the state, so as to regulate the over extraction of groundwater.

7) Drought-prone areas shall be made less vulnerable through soil moisture conservation measures, water harvesting practices, development of the groundwater potential including recharging.

8) As far as possible, new industries and residential habitations shall be settled in non-irrigated area.

9) Percolation tanks, check dams are constructed in that part of the state where groundwater is deeper.

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