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Status and Stages of Groundwater Resources in the Malaprabha River Basin, Karnataka; A Spatial Analysis

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ABSTRACT
Groundwater is the most precious natural resource of the earth and is of great importance in every facet of human life. It is the main source of fresh water and is most widely distributed resource on the earth. The entire river basin lies in a semi-arid type of climate, spread in the hilly, Northern dry, and Northern Transition Zones of the Agro-Climatic Zones of Karnataka State, and it is very warm during the summer and the annual normal rainfall of the basin area is over 759 mm spread over 50 days, which receives monsoon rainfall as much as our nation with slight variations. In this study area the growing of agriculture practices with technological advances, the more quantity of water requirement for the irrigation and the groundwater extraction has been is more and more. The excessive use of the groundwater purposes in some areas of the basin area has affected the groundwater depth. Hence, the present study is an attempt to make an analysis the status of groundwater resources in the environs of the Malaprabha River Basin, which includes an appraisal of the present scenario, stages of development, status, prospects and its utilisation and fluctuations of ground water and by proposing suitable tactics in view of prevailing government policies and programmes for proper utilisation of groundwater in the study area.
Key words; Groundwater, Agro-Climatic Zones, Draft, Irrigation and Monsoon

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INTRODUCTION

Groundwater is the most indispensable and precious natural resource, which is replenished annually by the precipitation. In our country a large section of population in dependent on untreated groundwater which is generally believed to be free from contamination and thus considered safe for drinking purpose. The groundwater level fluctuation is controlled by recharge and draft of groundwater and the diverse influences on groundwater levels include meteorology, tidal phenomena, urbanization, earthquakes and external loads stress and strain in water level due to groundwater recharge, discharge and intensity of rainfall are reflected in groundwater level fluctuation with time [1]. The mean annual rainfall over India is about 105 cm and exceeds the global average rainfall of 70cm. Even then, 80% of the Indian territories fall under semi-arid conditions. This is because of spatial and temporal distribution of rainfall, overall variabilities of monsoon, topographic variations, prevailing semi-arid to arid climatic conditions and varied nature of hydrogeology [3]. Due to the prevailing different climatic conditions of our nation, tube wells have become the largest single source of irrigation, because livelihood of more than two-third of its population depends on agriculture. More than 90 percent of the rural population and nearly 30 percent of urban population also depend on ground water for meeting their drinking and domestic water requirements. The excessive draft of groundwater and less recharge has depleted this natural resource. For fulfill the increasing demands of water. So, there is need to appraise the status of groundwater in different climatic conditional areas of the nation. The lowering of groundwater levels has resulted in reduction in individual well yield, growth in population, failure of bore wells, drying up dug wells and increase in power consumption [2, 6-8].

Groundwater is often developed without proper understanding of its occurrence in time and space and is, therefore, threatened by over-exploitation and contamination. For that reason, groundwater management is the key to combat the emerging problem of water security. Knowledge of water table depth is a crucial element in many hydrological investigations, including agriculture salinity management, landfill characterization, chemical seepage movement, and water supply studies [4]. Hence, the present study is an attempt to make a spatial analysis of the status of groundwater resources in the talukas of the Malaprabha

River Basin, which includes an appraisal of the present scenario, stages of development, status, prospects and its utilisation and fluctuations of ground water and by proposing suitable water conservation measures for proper utilisation of groundwater in the study area.
The present study has been carry out with the following objectives:

- To analysis the status, prospects and its utilization and fluctuations of groundwater resources (taluka-wise) in the light of rainfall in the talukas of the basin area
- To study the spatial pattern of groundwater and their area in the environs of the river basin and
- To suggest appropriate strategies in the light of water conservation measures **for** proper utilization of groundwater in the environs of the Malaprabha river basin.

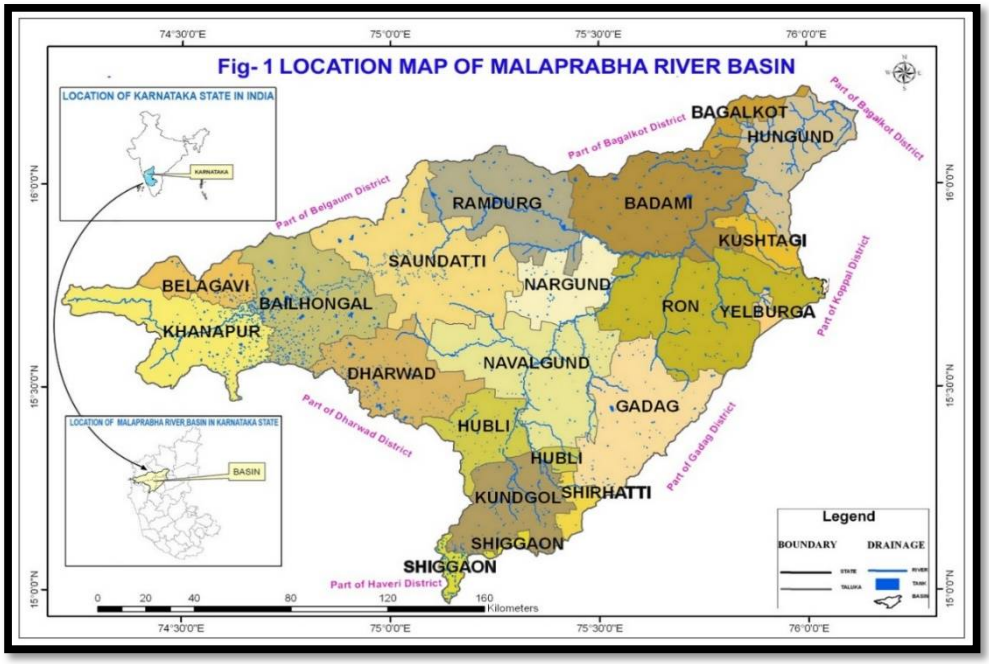
MATERIAL AND METHODS

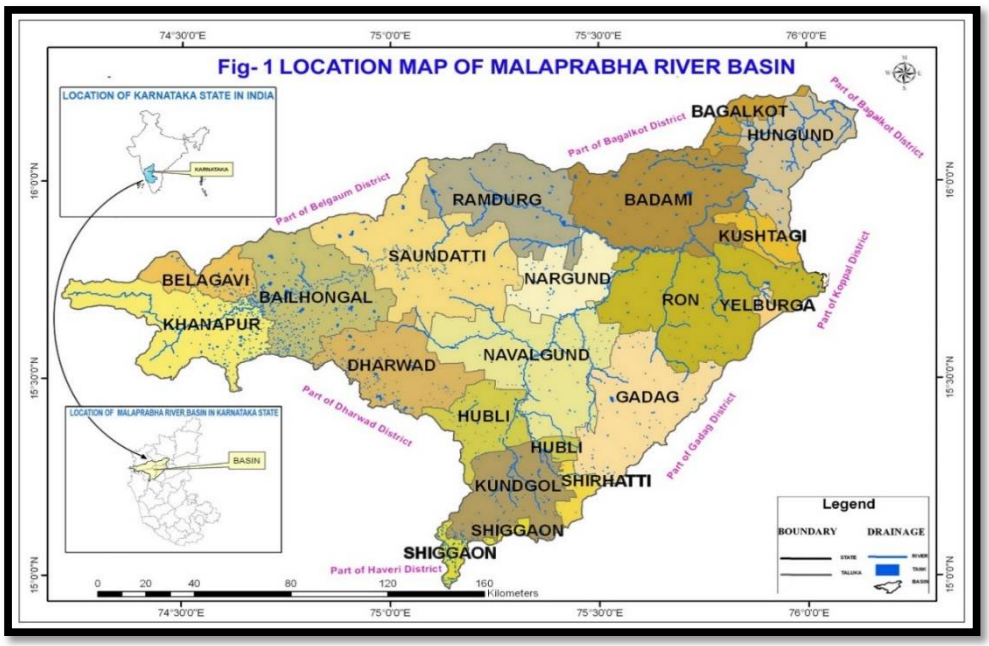
The study has been focused on the status of groundwater and its utilisation and stages of development. The study is based on secondary data collected from the district wise Reports of Belagavi, Gadag, Bagalakot and Dharwad published by Central Ground Water Board, Bangalore and required Rainfall Data collected from DES, Rainfall Division, Bangalore, Karnataka State. The Directorate, Department of Economic and Statistics, Bangalore, District Statistical Offices of Belgaum, Dharwad, Gadag & Bagalkot districts; besides this, data were also collected from various government offices and websites. Presently, the taluka has been considered the smallest unit of analysis. To achieve the objectives mentioned above, relevant statistical tools and methods of quantitative analysis have been employed. At last, the results were presented with suitable diagrams and figures.

Study Area:

The Malaprabha River Basin of Karnataka State is approximately triangular and located in the extreme western part of the Krishna basin. It lies between 15^0 05^{l} 02^{ll} to 16^0 20^{l} 19^{ll} N. latitudes and 74^0 05^{l} 43^{ll} to 76^0 05^{l} 33^{ll} E. longitudes, covering an area of 11549 sq. km, out of which 3880 sq. km are in Belgaum (33.59%), 1950 sq. km in Bagalkot (16.89%), 2739 sq. km in Dharwad (23.72%), 2657 sq. km in Gadag, 220 sq. km in Koppal, and 103 sq. km [Fig. 1]. Topographically, the Malaprabha river basin presents two important divisions, viz., the Western Ghats and the typical eastern part of the Deccan/Karnataka plateau, with distinct characteristics. The plateau has two natural subdivisions, the Semi-Malnad and the Northern Maidan, which include the northern upland, or the Deccan trap, of the state [Fig. 2]. An exhumed structure with superimposed drainage is also responsible for the sharp relief in the Kaladgi sandstones, in which Ghataprabha forms a waterfall near Gokak and the Malaprabha forms a gorge near Saundatti [5]. The river Malaprabha is the most important right-bank tributary of the river Krishna. The Benni Hall, Hire Hall, and others are the principal tributaries of the Malaprabha River [Fig. 3].

The entire river basin experiences a semi-arid type of climate, spread in the hilly, Northern dry, and Northern Transition zones of the agro-Climatic Zones of Karnataka State, and it is very warm during the summer, especially in April and May, with temperatures ranging between 35^0 and 40°C in the eastern part of the river basin. The annual normal rainfall of the Malaprabha basin area is over 759 mm spread over 50 days, which receives monsoon rainfall as much as our nation with slight variations. Deep black cotton soils are ubiquitous in the basin area. Jowar, besides other drought-resistant inferior small millet crops, is traditionally the predominant crop. Geographically, deep black cotton soils, Unpredictable monsoonal rainfall, droughts, and famines are part of the lives of people in the study region. The present study is a natural region that occupies 6.02% of the Karnataka state. As per the 2011 census, the population of the Malaprabha River Basin is 3.38 million (5.53% of the state's total population), of which 77.66% are rural and 22.34% are urban. The dominance of rural populations makes the regional economy mainly agrarian. The basin's 68.37% of the workforce (61.75% of males and 79.55% of females), however, is still dependent on agriculture and its allied activities for their livelihood. The economic development and prosperity of the masses depend mainly on agriculture.





RESULTS AND DISCUSSION

The advantage of groundwater as a resource to meet the ever-changing needs in domestic, agricultural and industrial front need not be overemphasized. It has become a valuable commodity as it plays a significant role in the economy of the nation. It also sustains the flow in our rivers and plays an important role in maintaining the fragile ecosystems. The groundwater dependence of agrarian states like Karnataka is high. Recent studies indicate that 26 percent of the area of Karnataka state is under over exploited category and number of blocks is under critical category. In view of the growing concerns of sustainability of groundwater sources, immediate attention is required to augment groundwater resources in stressed areas. Irrigated agriculture in the state is putting additional stress on the groundwater system and proper management of the resources. Management of this valuable resource is determined by its accessibility and utilizibility in terms of quantity and quality in any area.

Rainfall of the MRB:

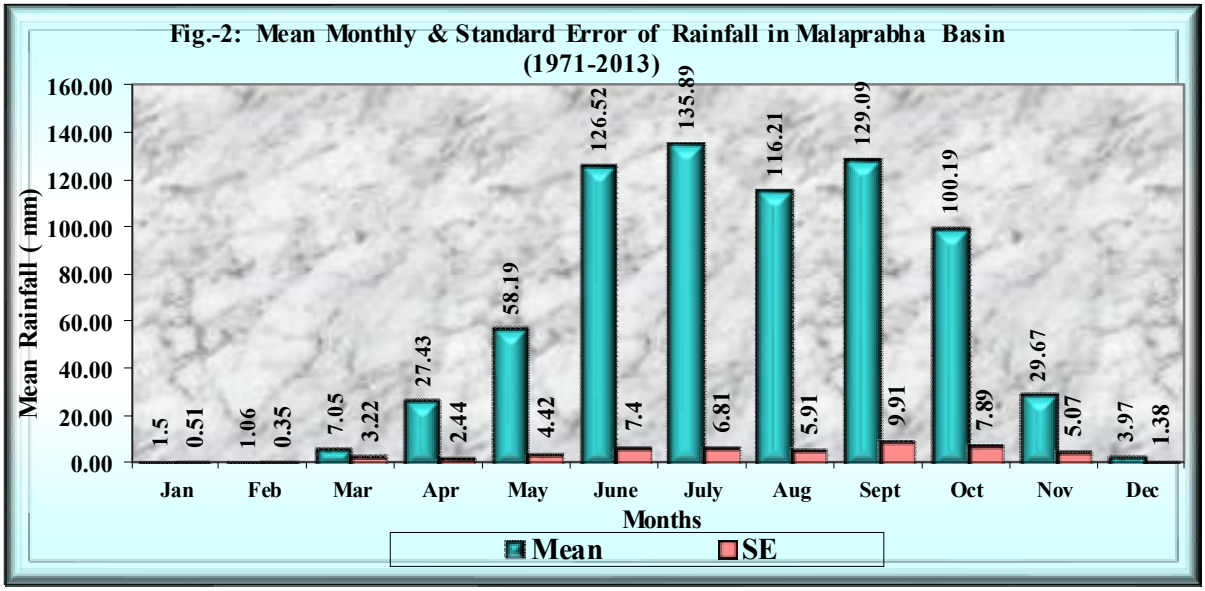
The average monthly, seasonal, and annual rainfall characteristics over the long term for 58 rain gauge stations in the Malaprabha river basin area are presented in Table 1 and Fig. 2. The observations and inferences from these are discussed as follows:

Table-1 Mean Monthly, Seasonal and Annual Rainfall Statistics (SD, SE & CV) of Malaprabha River Basin from 1971 to 2013

Months	Min	Max	Mean	SD	SE	CV	% contribution to
January	0.00	15.24	1.50	3.37	0.51	225.29	0.20
February	0.00	13.36	1.06	2.31	0.35	217.00	0.15
March	0.00	138.23	7.05	21.13	3.22	299.54	0.95
April	0.03	71.54	27.43	15.99	2.44	58.31	3.73
May	4.50	124.20	58.19	29.01	4.42	49.86	7.90
June	54.39	303.82	126.52	48.49	7.40	38.33	17.17
July	42.88	244.79	135.89	44.66	6.81	32.87	18.44
August	33.63	206.77	116.21	38.73	5.91	33.33	15.78
September	33.39	289.88	129.09	65.01	9.91	50.36	17.53
October	17.11	224.34	100.19	51.75	7.89	51.66	13.60
November	0.00	121.22	29.67	33.24	5.07	112.02	4.03
December	0.00	37.80	3.97	9.07	1.38	228.48	0.54
Seasons;							
Cold (Jan-Feb)	0.00	15.2	2.56	8.04	0.34	318.32	0.35
Hot (Mar-May)	35.6	205.8	92.67	51.58	2.18	55.78	12.58
S-W (Jun-Sep)	244.7	822.2	507.71	494.30	20.91	97.58	68.91
N-E (Oct-Dec)	30.9	280.7	133.83	73.70	3.12	55.09	18.16
Annual	**451.22**	**1052.58**	**736.77**	**504.41**	**21.33**	**68.59**	**100.0**

Source: Computed from Rainfall Data collected from DES, Rainfall Division, Bangalore, Karnataka State.

The average annual normal rainfall was 736.77 mm in the river basin from 1971 to 2013, with a standard deviation of 504.41 mm. The coefficient of variation of annual rainfall is 68.59 percent, indicating that it is highly variable. The variation in rainfall is found in every month, with the intensity of rainfall gradually increasing from March to July and suddenly decreasing from August to September. Rainfall during July is the highest (135.89 mm) and contributes 18.44% of annual rainfall (736.77 mm), followed by September (17.53%), June (17.17%), August (15.78%), and October (13.60%). Thus, the high intensity trends are noticed in the months of July and September, and these months get the highest rainfall, which reaches its maximum peak and also starts to decrease from December onwards. Least amounts of rainfall are observed during the month of February (1.06 mm), followed by January (1.50 mm), which contribute only 0.15 and 0.20 % to the annual rainfall, respectively [Fig. 2]. The coefficient of variation is highest in March (299.54%), followed by December (228.48%) and January (225.29%), and the least during July (32.87%) and August (33.33%). The contribution of the seasonal rainfall to the annual rainfall is highest during the monsoon period (68.91%), followed by the post-monsoon period (18.16%), the pre-monsoon period (12.58%), and the winter period (0.35%) in decreasing order. A non-significant relationship between SD and CV has been observed during the months of highest rainfall (July and September).



Groundwater Scenario:

Water table generally follows the topography of the area and is at greater depths in the water divides and topographic highs, but becomes shallower in the valleys and topographic lows and therefore, groundwater moves down and follows the gradient from the higher to lower elevations, that is, from recharge area to discharge area. Therefore, locally direction of flow from higher elevations is towards the rivers. Overall, the general flow direction of groundwater in the Malaprabha river basin generally towards east. Main rock formations in the talukas of Malaprabha river basin are the Granite, Gneiss, Basalt, Med sediment and Schist, the secondary structures like joints, fissures and fault present in them. At higher depths groundwater occurs under unconfined to semi-confined conditions in fractures and joints as well as formation contacts, its movement is controlled by the interconnectivity and geometry of the structurally week zones called lineaments. In the study area the ground water is developed through dug wells and dug cum bore wells up to 20 to 25 meter depth.

Groundwater Resources:

Groundwater is dynamic and replenishable precious natural resources and is an essential component of the environs and economy of the study area. Sustainability of groundwater resources depend mainly two factors viz. Annual groundwater recharge and annual groundwater draft. The sole source of the groundwater in river basin is recharge by the annual rainfall and recharge takes place through applied irrigation and canal seepages in addition to rainfall. The resources estimation and categorization is carried out as per the recommendations of GEM-97. The dynamic resources estimated of the study area as follows;

Table-1a Groundwater Resources in Malaprabha River Bain, 2012-13

Sl. No	Particulars	Total
1	Annual Groundwater Recharge (HAM)	89918
2	Provision for Natural Discharge (HAM)	8921
3	Net Groundwater Availability (HAM)	80997
4	Total Draft (HAM)	82624
5	Groundwater Availability for Future Irrigation (HAM)	18890
6	Stage of Development	96%

Sources: District wise Reports of Belagavi, Gadag, Bagalakot and Dharwad by CGWB, Bangalore

As per the GEM-97, Table-1 depicts that, the dynamic groundwater resources estimation carried out by the CGWB Bangalore, in the talukas of river basin in 2012-13; the annual Net Groundwater availability is 80997 HAM. The existing groundwater draft for all uses (Irrigation, Domestic and Industrial) is 82624 HAM. The net groundwater availability of future irrigation development after allocating for domestic and industrial uses till 2025 is 18890 HAM. The Stage of Development in the study area is 96% in the talukas of Malaprabha river basin. The taluka wise dynamics of groundwater resources, status of utilization and stages of groundwater development in the Malaprabha river basin is shown in Table-2. Table-3 and Fig.3.

Table-2 Ground Water Resources in the Talukas of MRB, 201

Taluka with its Geographical Area	Geographical Area	Recharge from Rainfall During Monsoon Season	Recharge from Other Sources During Monsoon Season	Recharge from Rainfall During Non-Monsoon Season	Recharge from Other Sources During Non-Monsoon Season	Total Annual Ground Water Recharge	Provision for Natural Discharge
Khanapur	1729.56	8696	2372	999	668	12735	2035
Bailhongal	1122.33	4631	2205	934	1258	9028	547
Saundatti	1581.46	3771	2859	1274	1941	9845	667
Ramadurga	1215.42	2465	2638	780	2097	7980	572
Badami	1394.20	830	965	1346	6170	354	3029
Hunagund	1353.58	3369	517	1818	1787	7491	426
Naragund	435.62	520	1634	316	648	3118	263
Ron	1290.91	2786	1927	1029	1664	7406	582
Gadag	1097.51	2702	1049	1086	991	5828	480
Dharwad	1117.88	3952	401	1622	407	6382	1282
Hubli	737.07	2268	599	906	240	4013	860
Navalgund	1082.18	1680	2265	1486	1244	6675	489
Kundagol	648.59	1906	94	1095	152	3247	364
Total	**14806.31**	**41775**	**19390**	**14310**	**14443**	**89918**	**8921**

Sources: District wise Reports of Belagavi, Gadag, Bagalakot and Dharwad by CGWB, Bangalore

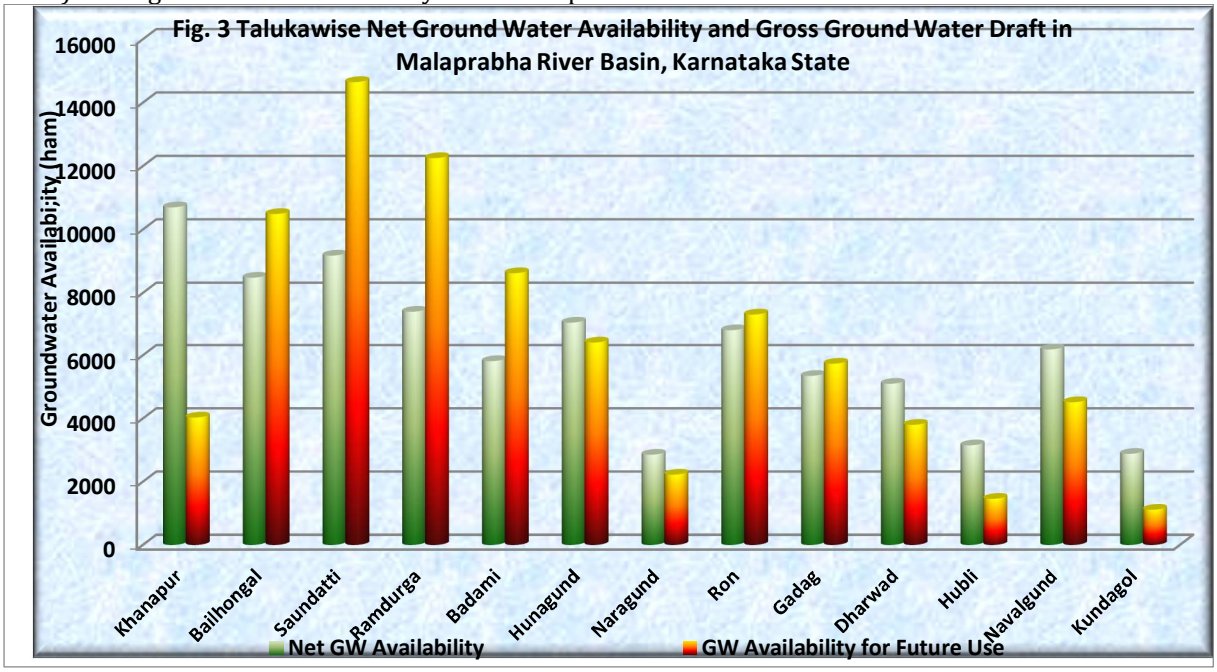
Table-3 Ground Water Resources in the Talukas of MRB, 2013

Taluka	Net Annual G. W Availability	Existing Gross G.W. Draft For Irrigation	Existing Gross G. W. Draft For Domestic & Industrial Water	Existing Gross G.W. Draft For All Uses	Provision for Domestic & Industrial Requirements Supply	Net G.W. Availability For Future Irrigation Development	Existing Stage of Development
Khanapur	10700	3584	449	4033	547	6570	38
Bailhongal	8481	9696	793	10489	844	1826	124
Saundatti	9178	13641	1010	14651	1169	172	160
Ramadurga	7408	11329	924	12253	941	240	165
Badami	5816	7494	1130	8624	1147	54	148
Hunagund	7065	5580	824	6404	917	1334	91
Naragund	2855	2102	122	2224	224	793	78
Ron	6824	6832	488	7320	664	1306	107
Gadag	5348	5237	498	5735	588	943	107
Dharwad	5100	3214	587	3801	723	1163	75
Hubli	3153	1156	304	1460	459	1537	46
Navalgund	6186	3878	638	4516	1252	1252	73
Kundagol	2883	802	312	1114	382	1700	39
Total	**80997**	**74545**	**8079**	**82624**	**9857**	**18890**	**96**

Sources: District wise Reports of Belagavi, Gadag, Bagalakot and Dharwad by CGWB, Bangalore

The spatial distribution of Groundwater in the talukas of Malaprabha river basin is presented in the Table-2, Table-3 and Fig.3 for orderly analysis; the talukas are classified in to three groups based on net ground

water availability. It reveals that, the high quantity (more than 8000 HAM) of net ground water availability is in Khanapur (10700), Saundatti (9178) and Bailhongal (8481) talukas of the river basin. The Ramdurga (7408), Hunagund (7065), Ron (6824), Navalgund (6168), Badami (5816) Gadag (5348) and Dharwad (5100) talukas have witnessed medium quantity (4000 to 8000 HAM) of net ground water availability, but Hubli (3153) Kundagol (2883) and Naragund (2855) talukas are observed low quantity (less than 4000 HAM) of net ground water availability in the Malaprabha river basin.



Stages of Groundwater Development:

On the bases of the stage of groundwater development mentioned in Table-3**,** to explain the present status, the areas falling in different stage of development in the Malaprabha river basin is grouped into four categories, namely very high, high, medium and low. It reveals that the stage of development is the lowest (less than 50%) in Hubli (46%), Kundagol (39%) and Khanapur (38%) talukas, whereas the moderate (50-100%) stage of development is observed in Hunagund (91%), Naragund (78%), Dharwad (75%) and Navalgund (73%) talukas of the river basin. The highest stage of development is noticed in Badami (148%) and followed by Bailhongal (124%), Ron (107%) and Gadag (107%) talukas and very high stage of development is noticed in Ramadurga (165%) and Saundatti (160%) talukas of the basin.

Status of Ground Water Prospects:

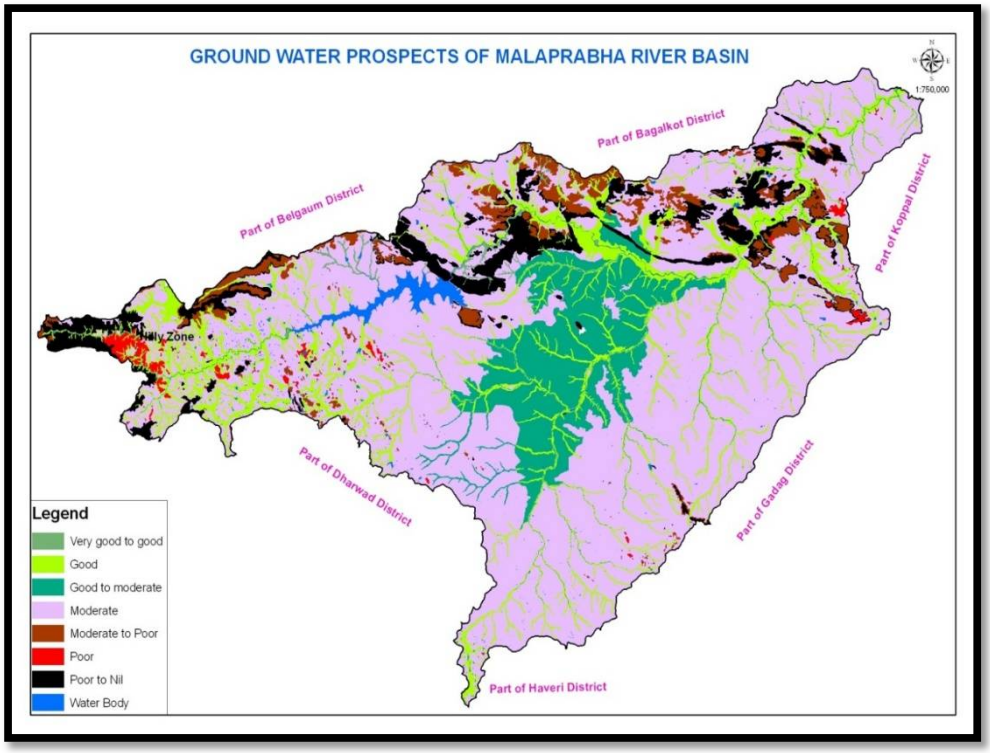
The occurrence and movement of groundwater in hard rock terrains are controlled by number of factors such as lithology, structure, landforms, thickness of weathered mantle, soil type, land cover and land use, recharge through rainfall etc. Except rainfall data other aspects have been generated by using satellite data, qualitatively on regional scale. Such information derived from satellite data when integrated with adequate hydrological and collateral data, will be use full in the delineation of groundwater prospects zones. It is well understood that there exist a close relationship between landform, lithology, structure and groundwater resources. Information on landform is one of the important aspects for land and water resources management. Apart from landform, the geological information like rock type and structures also play an important role in identifying the ground water potential zones. Based on the hydro-geomorphic units of the river basin, groundwater prospects map is prepared. The varying status of groundwater prospects of the river basin are given in the Table-4 and portrayed in Fig-4. Out of the total area of the river basin, the moderate status of the groundwater prospects represents the highest share i.e. about 7025.26 sq.km (60.81%), which represents the highest share in the basin. it is followed by Good (13.49%) and Good to Moderate (10.44%) status of prospects with the share of area is about 1558.89 sq.km and 1205.75 sq.km of the basin's area respectively. The remaining basin's area is under Poor to Nil is about 845.26 sq.km (7.32%), Moderate to Poor is about 549.27 sq.km (4.75%) and Poor status of prospects with the share of 92.32 sq.km (0.80%) of the river basin area.

Table-4 Status of Groundwater Prospects in MRB, 2012-13

Sl. No.	Ground Water Prospects	Area (Sq Km)	Area (In %)
1	Very Good to Good	49.52	0.43
2	Good	1558.89	13.49
3	Good to Moderate	1205.75	10.44
4	Moderate	7025.26	60.81
5	Moderate to Poor	549.27	4.75
6	Poor	92.32	0.80
7	Poor to Nil	845.26	7.32
8	Water Body	226.16	1.96
Total		**11552.42**	100.00

Sources: District wise Reports of Belagavi, Gadag, Bagalakot and Dharwad by CGWB, Bangalore

Fig. 4: Ground Water prospects of malaprabha river basin



Status of Groundwater Utilization:

Taluka wise areas falling in various categories of status of groundwater utilization in the Malaprabha river basin are also presented in Table-5; it reveals that, in the entire study area, six talukas namely Khanapur (100%), Kundagol (100%), Hubli (80%), Dharwad (50%), Naragund (40%) and Ron (39%) talukas area is in the Safe (S) category. The Navalgund (60%), Dharwad (50%), Hunagund (38%) and Saundatti (29%) talukas have area under Semi Critical category. The Badami (99%), Ramadurga (90%), Bailhongal (85%), Saundatti (70%), Ron (60%), Gadag (55%), Hunagund (52%) and Naragund (40%) talukas have area under Over Exploited (OE) status of groundwater utilization.

Fluctuations of Ground Water:

It is clear from the Table-5 that, there is high variation in the fluctuations of groundwater level in dry land areas compare to irrigated areas of the talukas of Malaprabha river basin. In 2012-13, dry land areas of Bailhongal, Ron, Dharwad, and Hubli talukas showed a high (more than 20 meters) level of groundwater fluctuations. It is followed by the dry land areas of Khanapur, Ramadurga, Badami and Gadag talukas depicts the medium (15-20meters) level of groundwater fluctuations. The low (less than 15 meters) level of fluctuations is noticed only in the dry land areas of Saundatti, Hunagund, Kundagol, Navalgund and Naragund talukas of the river basin. But the picture entirely reversed in the irrigated areas of talukas of

the Malaprabha river basin. Except irrigated areas of Khanapur and Hunagund talukas, the remaining irrigated areas of the talukas showed the low level of groundwater fluctuations in the river basin. The study reveals that, the higher the water level, lower will be the efficiency of groundwater and vice-versa.

Table-5 Ground Water Resources in the Talukas of Malaprabha River Basin, 2013

S. No.	Taluka	Existing Stage of Ground Water Status				Fluctuations of Ground Water Level			
		Safe	Semi Critical	Critical	Over Exploited	In Irrigated Areas		In Dry land Areas	
						Min	Max	Min	Max
1	Khanapur	100	0	0	0	3.75	10.95	11.00	19.00
2	Bailhongal	10	5	0	85	4.90	9.35	10.50	22.90
3	Saundatti	1	29	0	70	1.40	9.20	3.35	14.75
4	Ramadurga	10	0	0	90	0.40	4.10	12.20	15.75
5	Badami	1	0	0	99	2.73	8.91	3.66	18.40
6	Hunagund	10	38	0	52	3.24	13.07	7.86	10.55
7	Naragund	40	20	0	40	4.20	4.35	--	--
8	Ron	39	1	0	60	5.10	5.10	20.10	20.10
9	Gadag	25	20	0	55	--	--	2.48	16.03
10	Dharwad	50	50	0	0	--	--	4.28	25.06
11	Hubli	80	20	0	0	6.40	7.95	8.30	22.30
12	Navalgund	25	60	0	15	4.25	7.00	10.63	11.60
13	Kundagol	100	0	0	0	--	--	7.63	14.06
	Total	**26**	**17**	**0**	**57**	**2.80**	**6.15**	**7.85**	**16.19**

Sources: District wise Reports of Belagavi, Gadag, Bagalakot and Dharwad by CGWB, Bangalore [3]

CONCLUSION

The study reveals that the variation in rainfall is found in every month, with the intensity of rainfall gradually increasing from March to July and suddenly decreasing from August to September month of the year. The existing groundwater draft for all uses such as Irrigation, Domestic and Industrial is 82624 HAM. The net groundwater availability of future irrigation development after allocating for domestic and industrial uses till 2025 is 18890 HAM. The Stage of Development in the study area is 96% in the talukas of Malaprabha river basin It discloses that, the high quantity of net ground water availability is in Khanapur (10700) followed by Saundatti (9178) and Bailhongal (8481) talukas and low quantity of net ground water availability is in Naragund (2855) taluka in the Malaprabha river basin.

The study reveals that, there is high variation in the fluctuations of groundwater level in dry land areas compare to irrigated areas of the talukas of river basin. In 2012-13, dry land areas of Bailhongal, Ron, Dharwad, and Hubli talukas showed a high (more than 20 meters) and the low (less than 15 meters) level of fluctuations is noticed only in the dry land areas of Saundatti, Hunagund, Kundagol, Navalgund and Naragund talukas of the river basin. But the picture entirely reversed in the irrigated areas of talukas of the Malaprabha river basin. Except irrigated areas of Khanapur and Hunagund talukas, the remaining irrigated areas of the talukas showed the low level of groundwater fluctuations in the river basin. The study reveals that, the higher the water level, lower will be the efficiency of groundwater and vice-versa. The status of groundwater utilization tells that, Khanapur, Kundagol, Hubli, Dharwad, Naragund and Ron talukas area is in the Safe (S) category, Navalgund, Dharwad, Hunagund and Saundatti talukas have area under Semi Critical category and Badami, Ramadurga, Bailhongal, Saundatti, Ron, Gadag, Hunagund and Naragund talukas have area under Over Exploited (OE) status of groundwater utilization in the Malaprabha river basin. These Over Exploited talukas are needed water conservation measures very urgently to overcome from the water crises in upcoming days.

Considering the prevailing scenario of the groundwater resources, the following suggestions are made to overcome from the water crises in the light of sustainable development of the basin area. There is more groundwater storage than the surface water and reliable sources of water supply. Hence surface runoff need to be conserved to increase groundwater. It is necessary to construct check dam and sub-surface dykes at appropriate places across the streams and tributaries in the basin areas. A comprehensive programme should be framed to harvest the rainwater and proper bunds should be built to enhance the groundwater resources. Conserving of tanks is utmost importance, Check dams, surface tanks, subsurface dykes are to be made to enhance and recharge sub surface flows and augment the groundwater resources in the basin areas.

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