

# Geospatial Analysis of Ground Water Exploitation and Agriculture Situation of Chamarajanagara District, Karnataka, India

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## ABSTRACT

Chamarajanagara district is located in the extreme south of the Deccan plateau region of Karnataka. District groundwater availability mainly depends on weathered and fractured hard rocks and the amount of rainfall. Since surface water resources are limited throughout the district, groundwater has been the next alternative option. On account of reckless use of groundwater, there are other serious consequences looming at large in the district. To understand the ground reality, the present study examines the Groundwater overdraft for agricultural purposes and resultant groundwater level change between 2001 and 2016. Secondly, the utilization of groundwater for agriculture is examined at the taluk/block level. Thirdly, spatial and temporal variability of groundwater level has been mapped in GIS platform. Understanding the ground reality is one of the major objectives of this study.

**Keywords:** Hard rocks; Rainfall; Spatial; Temporal Variability; Overdraft; GIS.

## INTRODUCTION

The water that is found underground in spaces and cracks in soil, rocks, sand, and Gravels called Groundwater. Groundwater is the water that seeps through rocks and soil and is stored below the ground (Suhag 2016). Groundwater is non-exhaustive resources, which is received from the surface of the earth, drop by drop, collected and stored inside the rocks, it is a long process. The water stored underground in aquifers provides a base flow supplying water to streams and lakes during the dry season in semi-arid and arid regions and it's also a major source of liquid freshwater on Earth's surface apart from lakes, rivers, and Ice caps.

Human races and many ecosystems depend on groundwater to sustain their life. Wetlands, streams, and lakes of the aquatic ecosystem and phreatophyte (xerophytes) vegetation of semi-arid and arid regions of terrestrial ecosystems depend on groundwater for long term sustainability on the surface of the earth. But once this precious water getting empty, it will take hundreds of years to rejuvenate the groundwater. India extracts about 245 Billion Cubic Metre (BCM) of groundwater per year for both Irrigation and other uses. The over-exploitation and contamination of

groundwater continue to threaten the long-term sustainability of our precious water resources, in spite the best efforts made by various agencies (Nagaraju et al. 2017). A continuous withdrawal of fresh water for irrigation and salinization caused by poor agricultural management is distracting the natural aquifer system found beneath the ground.

## BACKGROUND OF THE STUDY

According to Central Groundwater Board, Government of India, the number of over-exploited and critical units are higher in Karnataka with other states like Haryana, Punjab, Rajasthan, and Tamil Nadu. As per this assessment taluks (Units) of Chamarajanagar was also listed in Critical and Over Exploited Units. Since 1994 taluks of Chamarajanagar listed in Over exploited, Critical, and Semi critical taluks of Karnataka state. These assessments indicate the overdraft of groundwater for irrigation purposes in the district. Section 7 of the Indian Easement Act of 1882 "A landowner has the right to appropriate water which is below land and no action will be taken against the owner even if it intercepts, abstracts or diverts water which remains under the land of another", thus groundwater can be

utilized without any permission from government agencies. Recently Central and State governments are regularizing the electric power supply to irrigation borewells/ tubewells and through electric power supply corporations and department of mines and geology are checking the excessive digging of borewells/tubewells in farmlands. This area needs to be addressed instantly and areas of groundwater table decline should be identified at the micro-level.

## STUDY AREA

Chamarajanagara district is coming under the southern dry zone of the Agro-climatic zones of Karnataka. The district is situated in the extreme south in the Deccan peninsula of Karnataka state. The district lies between  $76^{\circ}24'$  and  $77^{\circ}43'$  east longitudes and  $11^{\circ}32'$  and  $12^{\circ}16'$  north latitudes and covering an area of  $5676 \text{ km}^2$  (Fig. 1). The Highest mean monthly maximum temperature of  $34^{\circ}\text{C}$  recorded in May and the lowest recorded in the month December with a mean monthly minimum temperature of  $16^{\circ}\text{C}$ .

## Geology

The study area is located in hard rock terrain consists of peninsular gneiss and Charnockites. The

availability of groundwater depends on weathering and fractures in the rock system. The occurrence, origin and distribution of groundwater are controlled by the nature of rock formation, Geological structure, Geomorphological and Hydrometeorological conditions (Basavarajappa et al. 2015). About 64 percent of the total geographical area belongs to Band Gneissic complex and 33% of the area is under Charnockites. These rocks control the availability and development of groundwater. The limited thickness in weathered and fractured zones of above-stated rock systems are limiting the groundwater recharge.

## Relief and drainage

Chamarajanagara district is undulating tableland situated in the southern tip of Karnataka plateau, where the Eastern Ghats and the Western Ghats ranges converge and formed a group of hills called the Niligiri hills. The northern part of the district having an elevation between 500 to 800m with considerably flat tableland. The southern part with an elevation ranges between 900 to 1200 meters. Along the course of the Cauvery river in the western part having an elevation between 200 and 450m. Generally, the gradient is towards the south and southeastern direction, where river Cauvery flows

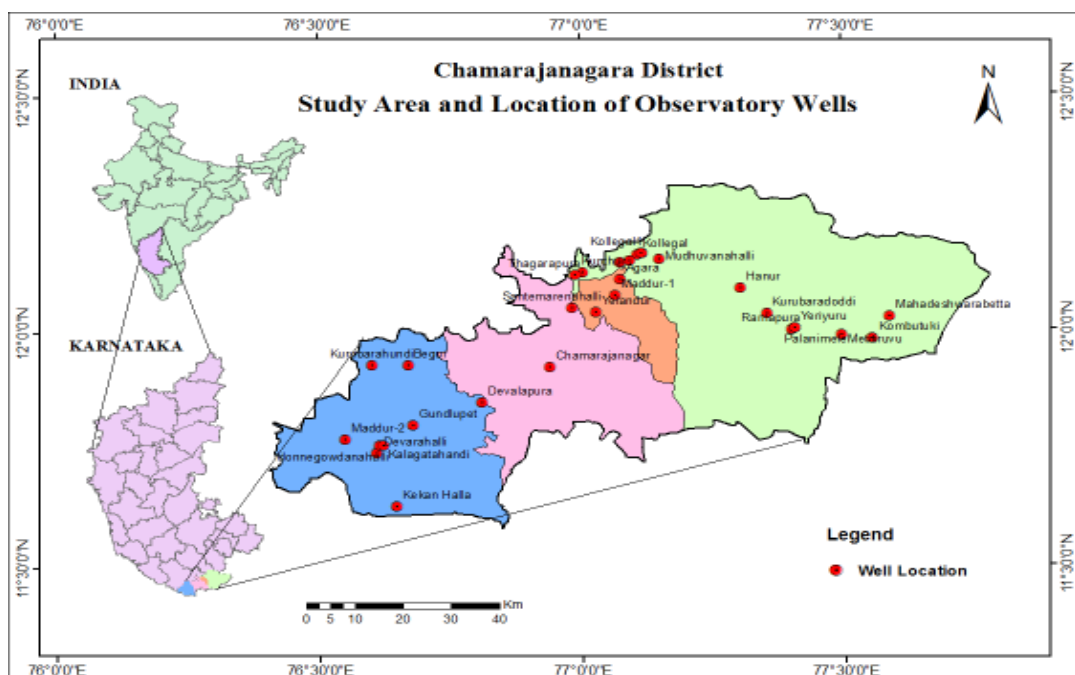


Figure 1. Study area and location of observatory wells

towards the eastern direction with tributaries, comprises mainly Kabini, Suvarnavathi, Chikkahole, Gundal, Palar and Mayor River.

### **Rainfall**

The entire district falls in the southern dry agro-climatic region of Karnataka and according to Thornthwaite (1889–1963) climatic classification semi-arid (dry) and semi-arid (moist) regions receiving an annual average rainfall of 500 -700 and 750 – 850 mm respectively. Thus study area is receives an annual average rainfall of 700 mm from both southwestern and northern monsoon winds, climatically the region is having semi-arid (dry) conditions and in some patches of forest land in hilly areas falls in semi-arid(moist). The pre-monsoon rainfall also contributes significantly and shares about 24 to 30 percent of rainfall in total annual rainfall. Both Southwest monsoon and northeastern monsoon contribute equally to total district rainfall. Since the district is situated in the rain shadow region of Western Ghats, the district receives less rainfall compared to the western face of Western Ghats during the southwest monsoon period. Because of this reason climatic induced drought is a common phenomenon in the district.

### **MATERIALS AND METHODOLOGY**

The Data of Groundwater level is collected from the Central Groundwater Board and Water Resources Information System (WRIS), Government of India. Collected data sets were analyzed and mapped using ArcGIS software package. The spatial variability of Groundwater level maps was generated for the period between 2001 and 2016. Observatory wells location map is generated with the help of Indian topographical Maps and Census of India (2011) Village Maps. Secondary data related to Groundwater utilization was procured from different Government agencies. Block-wise different source of irrigation and ground water-based irrigation data was used to analyze the groundwater exploitation and its impact on groundwater table changes. Socio-Economic survey reports of Karnataka state and Census of India data were utilized in the present analysis.

### **RESULTS AND DISCUSSION**

#### **Agriculture situation of the region**

Agriculture of Chamarajanagara district is mainly reliant on rainfall, More than 70 percent of the people are depending on agriculture for livelihood. The district comes under the southern dry agro-ecological zone and is mainly composed of hard rock which limits groundwater recharge (Sharif 2011). People are dependent on rain-fed and Groundwater facilitated agriculture only. Chamarajanagar is a chronic drought area in the absence of any type of perennial water source (Harish 2011). Principal crops are Cereals such as Maize, Jowar, Ragi and Paddy and Pulses like Horsegram, Blackgram, Greengram and Cowpea. Groundnut, Sunflower and Castor are major oilseed crops, Cotton and sugarcane are the commercial crops, and in this Paddy and Sugarcane crops were growing using irrigation facilities. About 68 percent of the working population is involved in agricultural activities. This indicates the importance of agriculture in the socio-economic conditions of this region.

#### **Trend of ground water situation from 2001 to 2016**

As stated in the introduction part, agriculture is the principal occupation of large people in the study area and rainfall is the chief source of water for rainfed agriculture. Open dug wells are traditional means of water resources along with tanks in southern Deccan plateaus states. Ground water-based irrigation was accelerated after the 1980s. Shallow dug wells are the main sources of irrigation in Chamarajanagar, Yalandur and Kollegal taluks before the arrival of borewells/Tubwells. Table 1 shows that in 2001 share of groundwater to the total irrigated area is 63.43% and it increased to 76.60 in 2016. The area under Groundwater based irrigation is increasing in the district since 2001.

Among the taluks, Gundlupet taluk utilizes the maximum extent, the share of groundwater to total irrigated area is 98% in 2001 and it raised to 100% in 2016. Chamarjanagar taluk also utilizes groundwater at a rate of 58% in 2001 and it's increased to 88% during 2016. The share of groundwater to the total irrigated area is 50 to 60%

Table 1. Taluks/block wise irrigated area under groundwater (ha)

Taluks/Blocks	2001			2006			2011			2016		
	Total Irrigated	Share of Groundwater	%	Total Irrigated	Share of Groundwater	%	Total Irrigated	Share of Groundwater	%	Total Irrigated	Share of Groundwater	%
Chamarajanagara	18423	10763	58.42	16741	15150	90.50	19302	16336	84.63	13012	11494	88.33
Gundlupet	8659	8529	98.50	8374	8374	100.00	13307	13307	100.00	10920	10920	100.00
Kollegal	21437	13573	63.32	22249	14122	63.47	32308	19054	58.98	14921	8644	57.93
Yelandur	8643	3395	39.28	11363	6541	57.56	8437	2062	24.44	5751	3110	54.08
Total	57162	36260	63.43	58727	44187	75.24	73354	50759	69.20	44604	34168	76.60

in Kollegal and Yalandur taluks. Overall Gundlupet and Chamarajanagar Taluks are pumping water for irrigation excessively since 2001. Improved technology and adaptation of this technology in the pumping of water from below the ground has created many hydrological imbalances in both surface water and groundwater table.

### Spatial and temporal variation of groundwater level

Table 1 illustrates the groundwater exploitation for irrigation based crop growing in Chamarajanagara district. Spatial Variation of groundwater level was mapped at the five-year intervals and the same has been mapped. Table 2 shows the average groundwater depth for 2001, 2006, 2011 and 2016. The average depth ranges between 7 to 12.9 meter below ground level (mbgl) in the Chamrajanagara district (Figure 2). The spatial variation map of the groundwater level depicts the decline of the water table from 2001 to 2016. Figure 3 shows the spatial

Table 2. Taluk wise annual average depth (mbgl)

	2001	2006	2011	2016
Chamarajanagar	9.04	10.94	18.21	25.09
Gundlupet	9.17	9.62	9.39	11.4
Kollegal	5.22	5.51	7.83	7.28
Yalandur	4.81	4.60	4.90	8.19
District Average	7.06	7.66	10.08	12.99

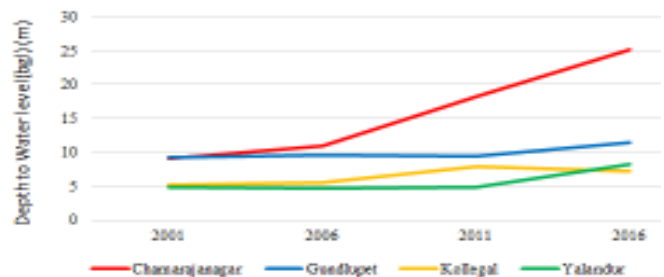


Figure 2. Taluk/block wise variations of average depth to water level (mbgl)

and temporal change in the groundwater table. Area of shallow water level is declining and area of the deeper level is increasing over time. The area of deeper water level is increasing in Gundlupet taluk, shallow water level zone has almost vanished. Gradually moderate water level zone is occupying

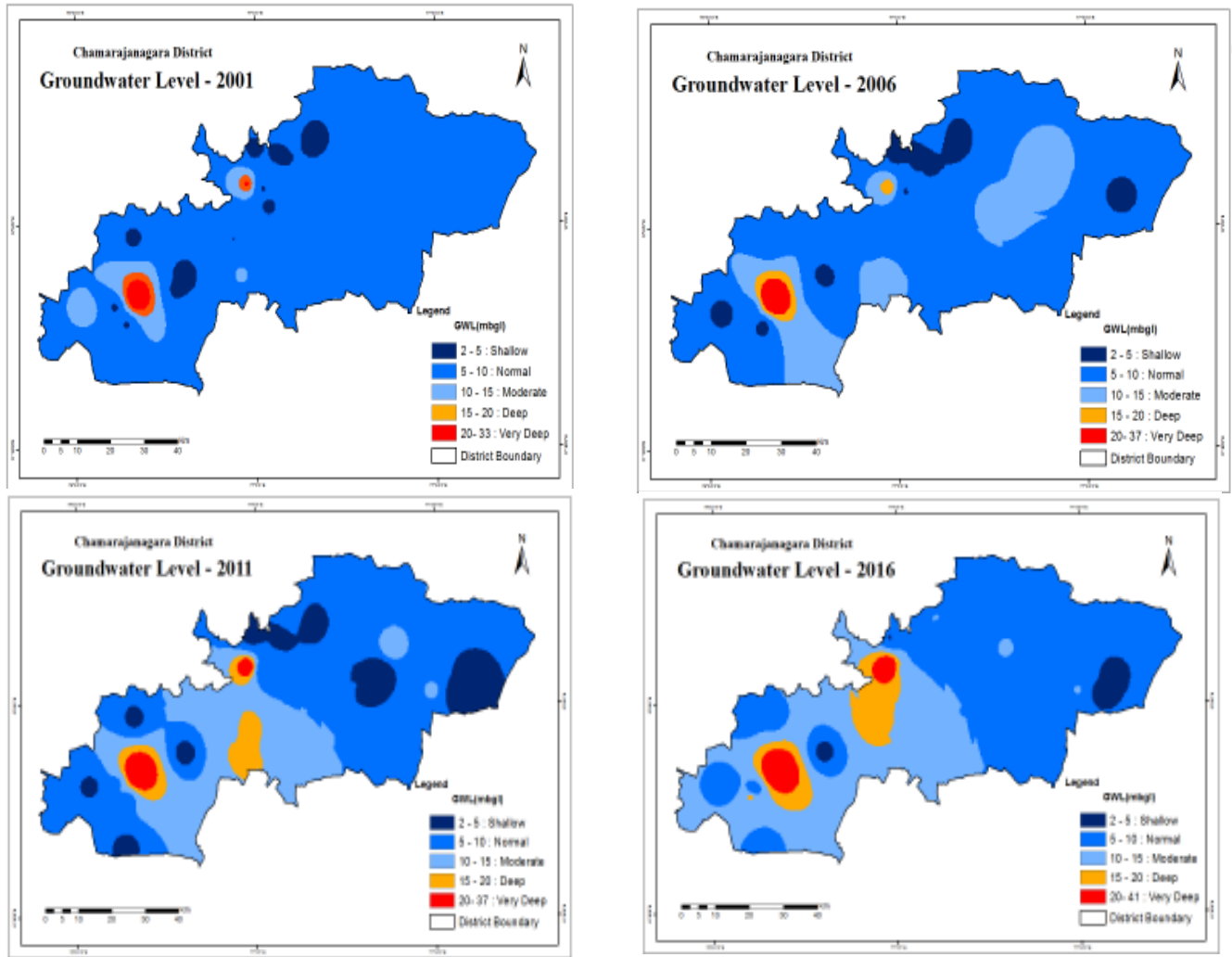


Figure 3. Groundwater level in 2001 to 2026 in Chamaranagar district

the areas of shallow water level in Kollegala and Yalandur taluks.

A groundwater table is defined as the locus of all points in a saturated soil-water system at which the pore water pressure is atmospheric (Gray and Mahapatra 1965). The groundwater level is 9 mbgl in 2001 and it's increased to 25 mbgl in Chamaranagara taluk. It is a clear indication of the overutilization of groundwater. Nearly 15-meter changes observed in chamaranagara taluk, depth to below ground level goes deeper further 15 meters. All the taluks are showing the declining trend of the groundwater table. Yalandur and Kollegal taluks groundwater depth ranges between 4 to 8 mbgl and the water level goes deeper nearly 4 meters from 2001 to 2016. Internal Spatial variation maps show that area of shallow water level zone is decreasing drastically and alarmingly area of deeper water level

zone is increasing. It's a clear sign of overdraft of precious groundwater.

Groundwater overdraft, a form of 'over-exploitation', occurs when extraction exceeds both natural and induced aquifer recharge over a long period (Pophare et al. 2014). Excessive use of groundwater has many adverse effects on the earth's surface. As groundwater levels decrease, the amount of water also will reduce in streams, rivers, and tanks. Declining underground water level affects the flow of streams on the surface during dry seasons, during rainy seasons again these streams are flowing with rainy water, whereas during summer or dry periods these streams and other surface water bodies are largely depending on underground. It is very much evident in the study area which is situated in the Semi-arid (dry) climatic region. Initially, groundwater based irrigation allows farmers to change cropping patterns and improve the individual

farm income and safeguard against drought. But crystalline rocks hold low shallow water storage, which is emptying in a short period where natural recharge is not competing with groundwater withdrawal. Intensive irrigated agriculture substantially modifies the hydrological cycle and often has major environmental impacts (Foster et al. 2018). Excessive use of groundwater also created saline soil in red and loamy areas of semi-arid regions in the Chamarajanagar district. The declining groundwater table limits the availability of water for plants and reduces growth. It will result in the lowering of crop yields, these phenomena further pushing the people of study area towards socio-economic backwardness. Table 4 reveals the change in the occupation structure of Chamarajanagara district between 2001 and 2011. The share of cultivators to total workers is 27.7% and agricultural labors accounts are 43% in 2001. This composition of occupation structure is changed in 2011, the share of cultivators reduced 23.5%, for ten years about 4% cultivators changed their occupation, and share of agricultural labors increased to 44.49%. Change analysis revealed that, reduction in farm income and continuous drought conditions are pushing the farmers to change their occupation.

## CONCLUSIONS

The present research paper revealed that the groundwater table is getting deeper and deeper. Groundwater based irrigation system has resulted in the spatial change of groundwater depth in Chamarajanagara district. Excessive pumping of groundwater through borewells/ Tubewells is altering the water table below the ground. On this background, groundwater cannot be used as our wish. The share of groundwater to the total irrigated area is 70%, this scenario is not conducive to the areas of semi-arid and arid regions. To prevent over-utilization of groundwater, the crops which require minimum water for its entire life span should grow and the promotion of these crops has to be done by the government at the micro-level. Watershed development programs can be implemented effectively. Increasing of vegetative cover, the construction of check dams, rejuvenate the stream paths, maximum utilization of rainwater for

cultivation and growing of land suitable crops were epitome measurements in checking the groundwater overdraft in Chamarajanagara district.

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**Conflict of interest:** We declare that there are no conflicts of interest.

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