Groundwater utilization and its environmental sustainability in coastal aquifers of Dakshina Kannada District, Karnataka, India

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Abstract. Water is one among the foremost precious of natural resources. In many regions of the world, the pressures of economic development are creating a surface water scarcity. Study of groundwater sustainability– like to remind people that most of the world's available freshwater is stored underground. The best institutional set up for any country depends on its system of government, its climatic and hydrological context and its social and economic circumstances. Groundwater resources to meet current and future beneficial uses without causing unacceptable environmental or socioeconomic consequences. The methods that promote the wise use of groundwater supplies, is need to determine strategies that promote groundwater sustainability. Groundwater users have not generally had to pay anything like "full economic cost" for groundwater use, nor have groundwater polluters had to pay for clean-up of their contamination. Thus, this study aims to determine the strategies that promote ground-water sustainability and groundwater resources to meet present and future beneficial uses without causing un-desirable environmental or socioeconomic consequences.

1 Introduction

Freshwater found in the pore spaces of soil and the fissures of rock formations beneath the surface of the earth is known as groundwater. When a rock or unconsolidated deposit can provide a useable amount of water, it is referred to as an aquifer. Only 3% of the water on Earth is fresh; the remainder is saline, or oceanic. 30.1% of the freshwater on Earth is groundwater, 0.3% is surface water, 0.9% is other minor storage, and 68.7% is permanently stored in icecaps and glaciers. "The study uses numerical simulation to examine how shallow, coastal unconfined aquifers respond to predicted overdraft conditions and the impact of climate change." [1, 2].

There are significant issues with groundwater management in India as a result of overuse of groundwater and the need for irrigation in large canal commands. "Depletion of water tables, saltwater encroachment, drying of aquifers, groundwater pollution, water logging and salinity, etc. is major consequences of overexploitation and intensive irrigation" [3]. Groundwater in coastal area is of major alarm due to the fact that > 60% of the world population lives within 30 km of shoreline and about 20% of the population of India lives in the coastal regions. Seawater ingression is a major problem in most of the coastal aquifers.

This occurs when the balance between freshwater and saltwater is upset for a variety of reasons, including land reclamation, climate change, overdraft, and rising sea levels. "A good understanding of the coastal dynamics and detailed knowledge of the variability of their parameters is essential to carry out studies on coastal aquifers" [4].

2 Study area

Mangalore is an officially known as Mangaluru, located next to the Arabian Sea in the southwest region of Karnataka. The district receives almost 3800 mm of rainfall a year, and its total size is 834 square kilometers. extending between 12˚30'00" & 13˚11'00" north latitude and 74˚35'00" & 75˚33'30" east longitude. Mangalore town is the district headquarters. Administratively, the taluk is having several villages viz. Ganjimata, Moodbidri, Belvai and Mulki. Population of the district (2011 census) 4,84,785 in the city and 6,19,664 in metropolitan. The primary occupation of the people in the district is agriculture. Twenty-eight percent of the entire geographical area is made up of the net sown area. Paddy, arecanut, coconut, cashew nut, rubber, and vegetables are the main crops. Various water sources irrigate roughly 57% of the net planted area. About 75% of the irrigated area is watered by groundwater, with the remainder coming from surface water sources.

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3 Materials and methods

Identified the groundwater aquifer of the coastal area in and around part of Mangalore (groundwater stressed areas) to determine the characteristic of groundwater as well as to study the depletion of depth of the water table of both dug well and bore well. Reconnaissance survey of the study area was conducted using depth of the groundwater table fluctuation vs. rainfall data (from 2010 to 2019) based on the climatic conditions of the area.

4 Results and discussion

Before presenting the data on groundwater quality, we introduce key parameters analyzed in this study, as summarized in Tables 1-6 and Figs.1-6. Each parameter offers insights into various aspects of water quality: Table 1 and Fig. 1 present pH levels, indicating the acidity or alkalinity of the water. Table 2 and Fig. 2 focus on dissolved oxygen (DO) levels, which are critical for supporting aquatic life and reflect the water's overall health. Chloride concentrations, provided in Table 3 and Fig. 3, help identify potential contamination sources of chloride. Table 4 and Fig. 4 displays turbidity values, which measure water clarity and can signal the presence of suspended particles. Table 5 and Fig. 5 illustrate total hardness, reflecting the water's mineral content, such as calcium and magnesium, which affects both household and agricultural uses. Lastly, Table 6 and Fig. 6 present of total solids of soil. By examining these parameters across multiple groundwater sampling points, we aim to provide a comprehensive assessment of water quality in the study area, detailed in the following tables and figures and the recapitulation is in Figs.7 and 8 which explain the static water level for dug wells and bore well.

Table 1. Results of pH.

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	7	6.5	Desired Limit: 6.5 - 8.5 Water will have an impact on the mucosal membrane and water supply system if it exceeds this threshold. Permissible Limit: No Relaxation
Belvai	7	6.5	
Ganjimata	7	6.5	
Moodabidri	7	6.5	

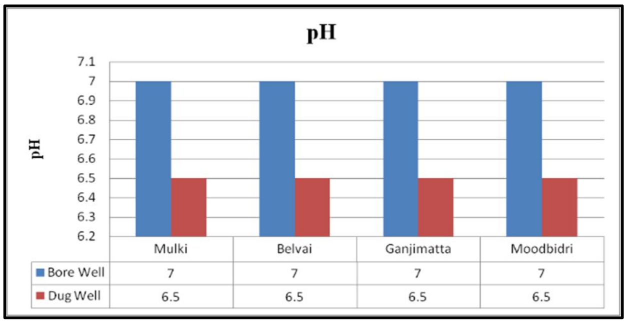

Fig. 1. Graphical representation of pH

Table 2. Results of chloride (mg/l).

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	22.68	19.85	Desired Limit: 250 mg/l Taste, corrosion, and palatability are impacted beyond this range. Permissible Limit: 1000mg/l
Belvai	8.50	19.85	
Ganjimata	14.18	3.40	
Moodabidri	2.83	5.67	

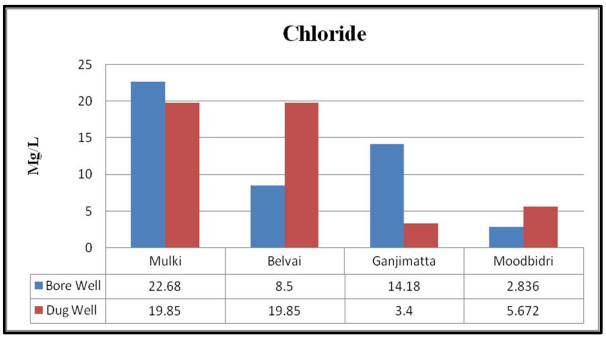

Fig. 2. Graphical representation of chloride

Table 3. Results of turbidity (NTU).

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	4.4	8.4	Desired Limit: 5 NTU Above 5, consumers acceptance decreases Permissible Limit: 10 NTU
Belvai	4.6	6.1	
Ganjimata	9.3	8	
Moodabidri	4	6.2	

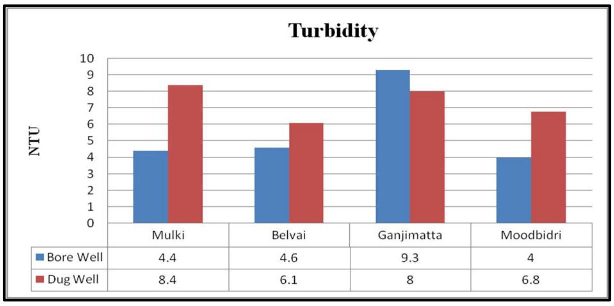

Fig. 3. Graphical representation of turbidity

Table 4. Results of dissolved oxygen (mg/l).

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	4.72	3.94	Desired Limit: 5 – 7 mg/l @ 25ºC
Belvai	3.94	6.10	
Ganjimata	8.07	6.40	
Moodabidri	6.2	5.71	

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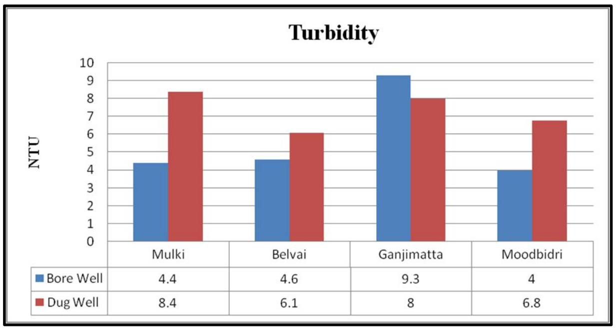

Fig. 4. Graphical representation of dissolved oxygen (mg/l).

Table 5. Results of total hardness (mg/l).

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	132	64	Desired Limit: 300 mg/l Beyond encrustation in water supply structure and adverse effect on domestic uses. Permissible Limit: 600 mg/l
Belvai	84	60	
Ganjimata	72	44	
Moodabidri	56	36	

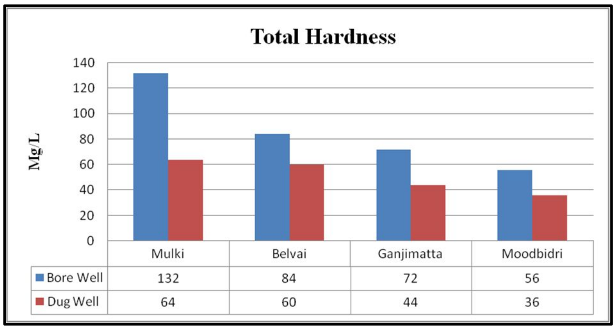

Fig. 5. Graphical representation of hardness

Table 6. Results of total solids (mg/l).

	Bore Well	Dug Well	BIS: 10500 – 2012
Mulki	340	540	Desired Limit: 500 mg/l Beyond this palatability decreases and may cause gastro intestinal irritation Permissible Limit: 2000 mg/l
Belvai	230	320	
Ganjimata	164	210	
Moodabidri	150	196	

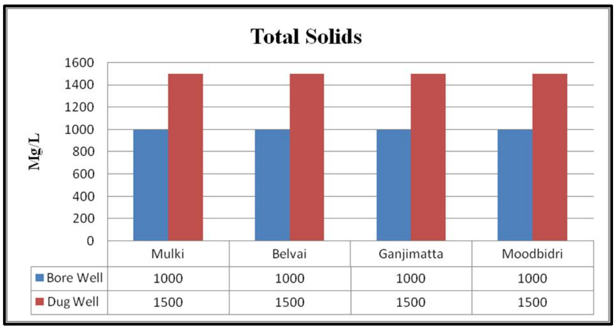

Fig. 6. Graphical representation of total soids

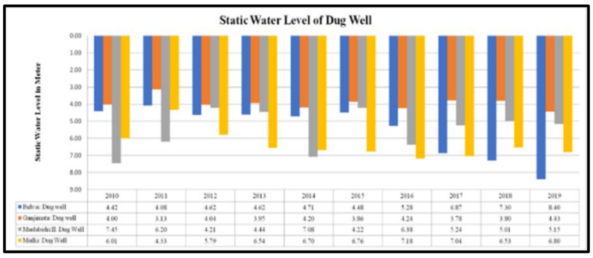

Fig. 7. Static water level of dug well (in M**)**

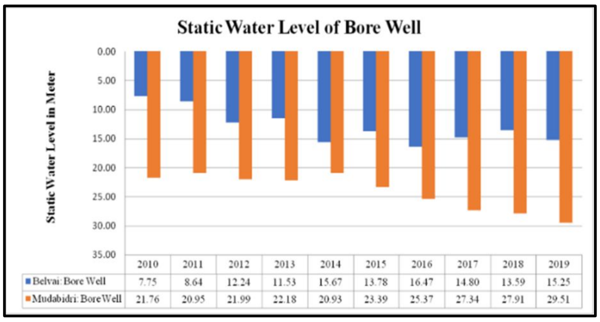

Fig. 8. Static water level of bore well (in M).

4.1 Geological information of the Moodabidri area using GIS and Rainfall data

The following series of images provides insights into the study area's characteristics based on various geospatial and hydrological parameters. Figure 9 displays an administrative map that outlines the area boundaries, while Fig.10 shows population distribution, and Fig. 11 presents rainfall data in the region. Fig.12 provides a land use map depicting different types of land utilization, followed by Fig.13, which illustrates soil type distribution. Fig.14 showcases land suitability for irrigation, and Fig.15 displays groundwater availability. Fig.16 contains a rock type map, giving details about the geological composition of the area.

Subsequently, comparative analyses between rainfall and groundwater depth are shown in Figs.17 and 18, representing data from dug well and bore well, respectively. Figs. 19 and 20 illustrate graphical representations of the static water level in dug well and bore well. Together, these images offer a comprehensive view of the geospatial and hydrological conditions in the study area.

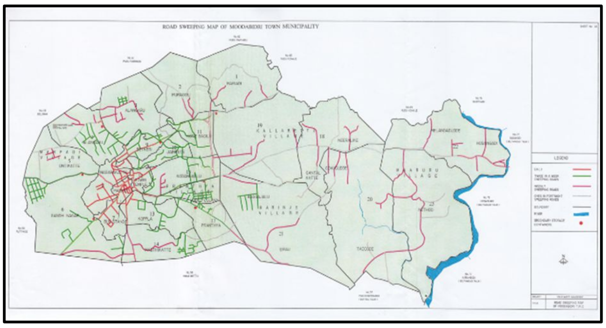

Fig. 9. Administrative boundary of Moodabidri

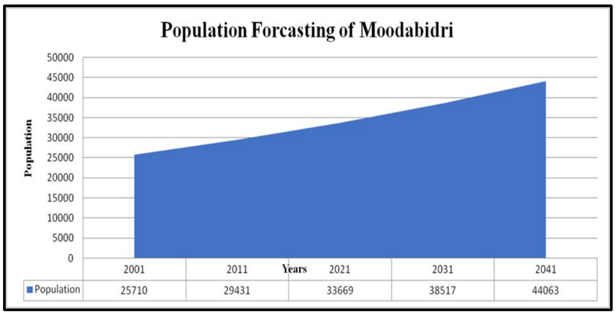

Fig. 10. Population forecasting of Moodabidri using geometrical progression method

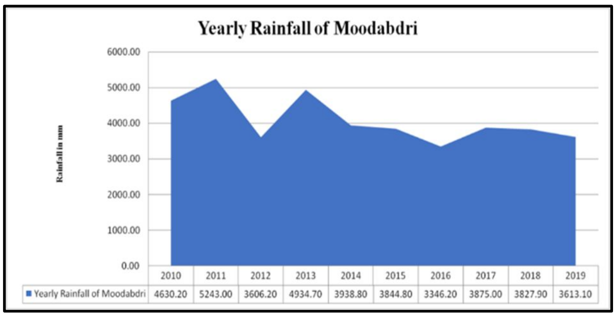

Fig. 11. Graphical representation of yearly rainfall of Moodabidri (from 2010 to 2019 data)

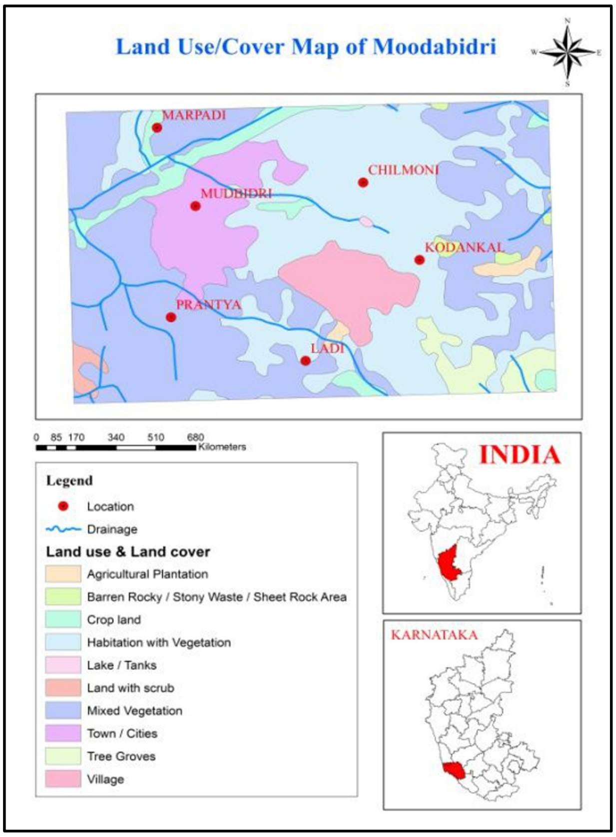

Fig. 12. Land use/cover map of Moodabidri

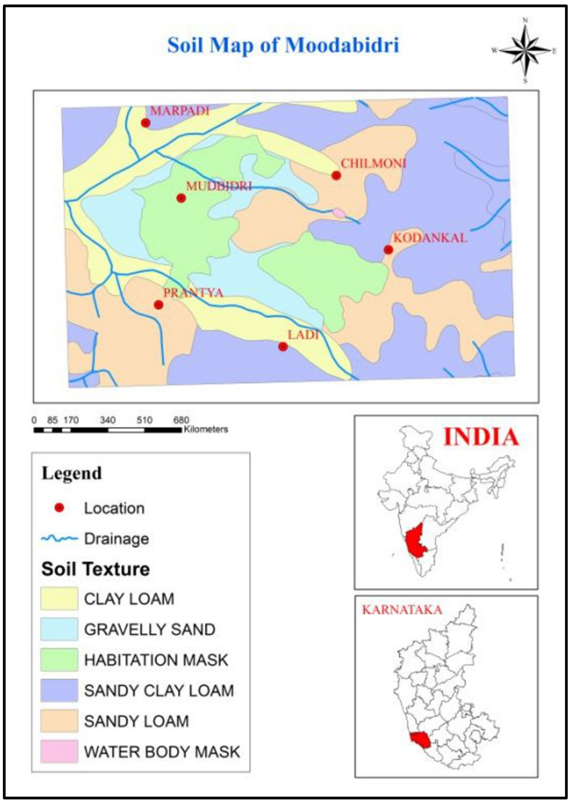

Fig. 13. Soil Map of Moodabidri

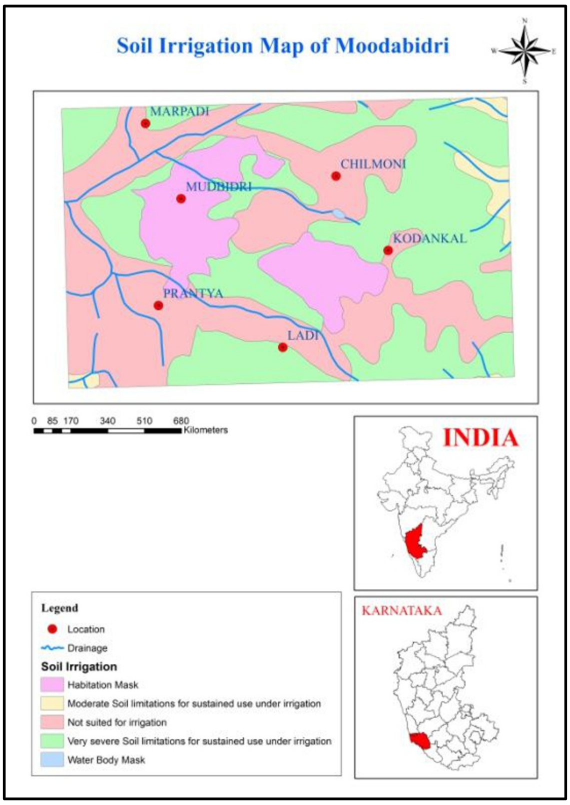

Fig. 14. Soil irrigation map of Moodabidri

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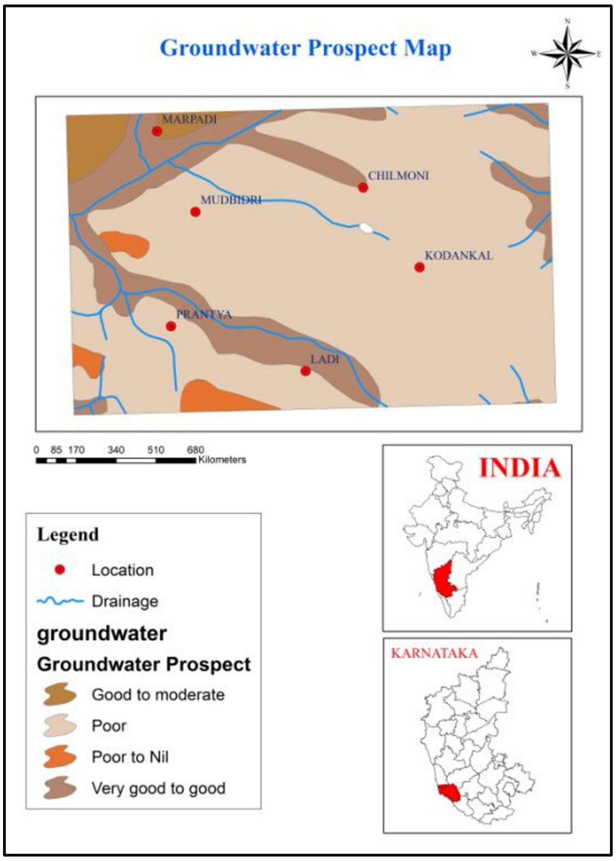

Fig. 15. Groundwater prospectus map of Moodabidri

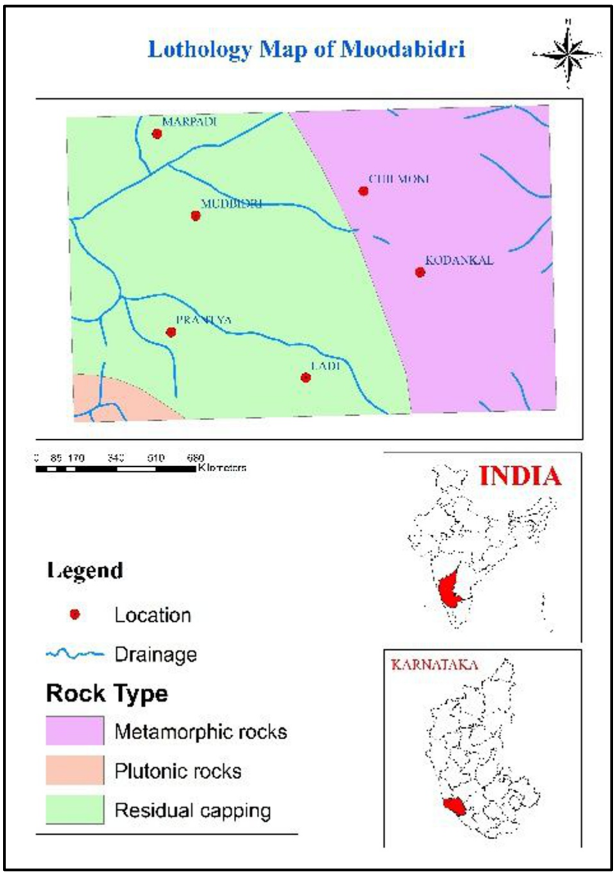

Fig. 16. Lithology map of Moodabidri

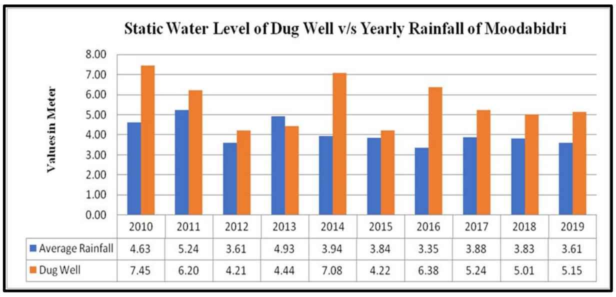

Fig. 17. Graphical representation of Moodabidri rainfall v/s dug well static water level.

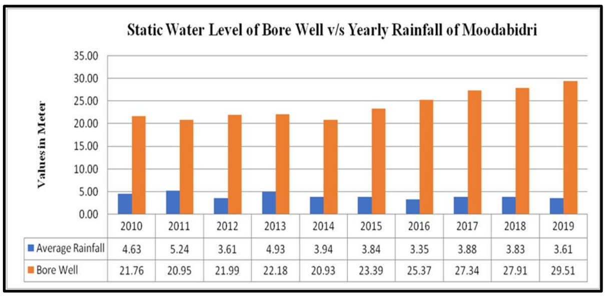

Fig. 18. Graphical representation of Moodabidri rainfall v/s bore well static water level.

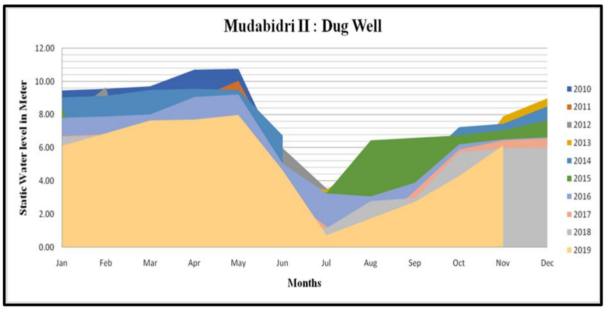

Fig. 19. Graphical representation of dug well static water level

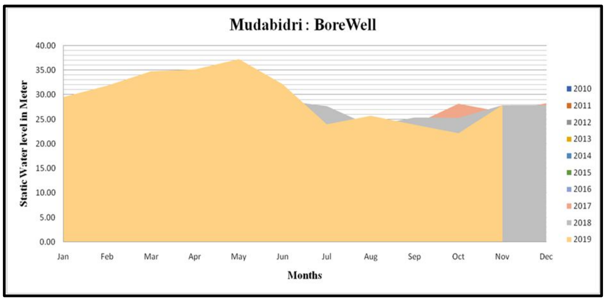

Fig. 20. Graphical representation of bore well static water level

According to the results, rainfall variability linked to climate change causes notable variations in water levels in the study area's bore and dug wells. The demand for water has increased over the past few decades due to urbanization and population development. The yearly rainfall in Moodabidri town has been steadily declining over the past few decades, as illustrated in Fig. 11. At the same time, the statistics (Figs. 17 and 18) show that the water levels in both the bore and dug wells in Moodabidri are declining.

The over exploitation and utilization of water demand is increased from past decades due to increased population and urban sprawling in the study area

4.2 Geological and Geophysical Investigation of Moodabidri.

Moodabidri is a town situated in the coastal district Dakshina Kannada of Karnataka state falls along the west coast of peninsular India and is separated from the rest of peninsula by towering high Western Ghats.

Temperature, density, porosity, water content, water quality, and mineral composition all affect a rock's resistivity values. The direction of electrode distribution and the composition of the top layer in the hardrock region also affect the formation resistivity value.

These techniques are predicated on the idea that the electrical resistivity of loose, unconsolidated, or partially consolidated surficial materials, such as soil loss, alluvium sand, clay, and other byproducts of rock weathering and erosion, differs from that of the bed rock on which they are deposited. The electrical resistance of the rock decreases as it becomes more porous or jointed and fissured. Therefore, undamaged metamorphic and igneous rocks are generally more resistant than sedimentary rocks.

A signal stacking resistivity meter was used up to 3.8-4 m depth as only for the geological structural requirement in the circular shaft, primarily to measure bed rock depth and subsurface formations by studying the variations in their electrical properties. Because of the regulated depth of inquiry and excellent resistivity contrasts across the lithological units, this technology gained significant traction in subsurface exploration [5].

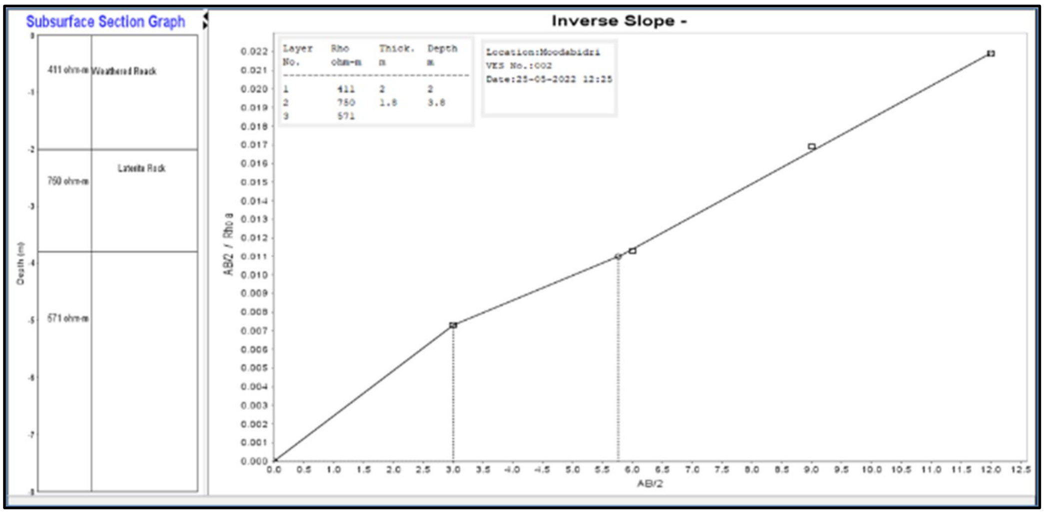

Fig. 21. Interpretation geological formation using resistivity meter

5 Conclusion

The water level of both dug well and bore well of the experimented study area showing drastic water level fluctuations with respect to rainfall data as well as rainfall seasonal variation. In detail regular study on characterization of coastal aquifer in both quality and quantity is need of the day for sustainable development in the present scenario of urban sprawling and climate change. Also, the improvement in the modern technology and methods is the need of the day for the substantial implementation of groundwater augmentation in the coastal aquifer.

Thus, the water conservation and harvesting are essential for sustainable water management in the study area. The need for groundwater augmentation and characterization highlights the urgency of implementing mandatory regulations for effective water conservation and harvesting, especially for coastal aquifers.

Authors are likes to extend their gratitude to the Department of Civil Engineering, MITE for provided state-of-art Environmental Engineering laboratory and also, express the thanks to KSCST, GoK for the student project sponsorship and we express our sincere thanks to District Ground Water Office, Dakshina Kannada, GoK.

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