GEO-EYE

ORIGINAL ARTICLE

Premonsoon Groundwater Trend Analysis for Hunsur taluk of Karnataka, India using GIS

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OPEN ACCESS

Received: 19-03-2025
Accepted: 10-10-2025
Published: 15.10.2025

Citation: Manjunatha MC, Prabhavathi MC. (2025). Premonsoon Groundwater Trend Analysis for Hunsur taluk of Karnataka, India using GIS. Geo-Eye. 14(1): 5-9. https://doi.org/10.53989/bu.ge.v14.i1.25.6

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Funding: None

Competing Interests: None

Published By Bangalore University, Bengaluru, Karnataka

ISSN
Print: 2347-4246
Electronic: XXXX-XXXX

Abstract

Groundwater plays an important part in the hydrologic cycle, providing sources for industrial, household, and agriculture applications throughout the country. The study focuses on groundwater trend mapping and its variance over several recorded years using a GIS platform. 6 observations well points data were collected for the pre-monsoon season (Jan-May) throughout a 16 year period (2003 - 2019). Pre-monsoon groundwater level measurements were collected to avoid the seasonal recharges caused by rainfall in the present investigation. ArcGIS's Inverse Distance Weighted (IDW) tool was used to delineate groundwater levels with their various depths, and contours of identical values were then produced. The study's findings underline the importance of appropriate groundwater monitoring during extreme summer conditions and effective planning of future demands and supply, particularly for rural farmers.

Keywords: Premonsoon; Groundwater trends; Hunsur taluk; GIS; IDW

1 Introduction

Groundwater is a vital natural resource that sustains wetlands, rivers, streams, and human habitats [1]. Groundwater is a key supply for residential water, particularly in rural India, and its use requires adequate design. Overexploitation of groundwater, growing industrialization, urbanization, mining, automobile industries, climate change, and other human pressures all pose ongoing threats to groundwater resources [2]. Heavy rainstorm discharge and droughts are the two most crucial extremes of climate change, as measured by both short and long-term effects on underground water supply. Hydrometeorology, geomorphology, geologic structures, and rock types had altered groundwater conditions, indicating atmospheric anomalies in the hydrologic cycle, putting pressure on aquifer recharge-withdrawal equilibrium. Seasonal variations in precipitation and Land Surface Temperature (LST) have naturally impacted aquifers in numerous states, causing water scarcity difficulties in many areas of the country. Excessive use of aquifer water has the potential to lower water levels across a large area [3].

Nearly 65% of our country's total geographic area is covered in hard rock formations with low porosity and permeability [4]. India is the world's largest user of groundwater, with an estimated 230 km^2 consumed [5,6]. Groundwater levels fluctuate due to a variety of hydrologic phenomena, the majority of which are caused by human influences [7]. Resource planning and development at the local level can lead to an increase in groundwater levels [8]. The GIS methodology has grown as a highly compelling method for hydrologic modeling, resource mapping, and delineation of spatio-temporal variation in groundwater levels using statistical data [9,10]. Even basic GIS software tools produce effective results in tracking spatio-temporal trends in groundwater levels, which generate substantial evapo-transpiration due to the temperature range of 35^0 to 37^0c in Hunsur taluk. The present study aims to outline the subsurface water mapping and its fluctuation for more than 15 years using simple GIS tool.

2 Methodology

Site Description: Hunsur taluk covers 895.79 km^2 and has elevations ranging from 680mts to 774mts above MSL, making it cold and wet during winter and rainy season (Figure 1) [11]. It consists of 4 hoblies, 30 grama panchayaths, 192 inhabited villages and 21 uninhabited villages [12]. The watershed is predominantly agricultural, with crops, dispersed vegetation, and inadequate soil cover accounting for most of the land [12]. The soil types are red sandy soil, red loamy soil, and deep black soil with different thicknesses up to 6 feet [13]. Variation in rainfall causes periodic droughts and excessive groundwater use, which defines the research area. The Lakshman Theertha River, a sub-basin of Cauvery River, flows from south-west to north-east across the study area, supplying water for agricultural and irrigation activities.

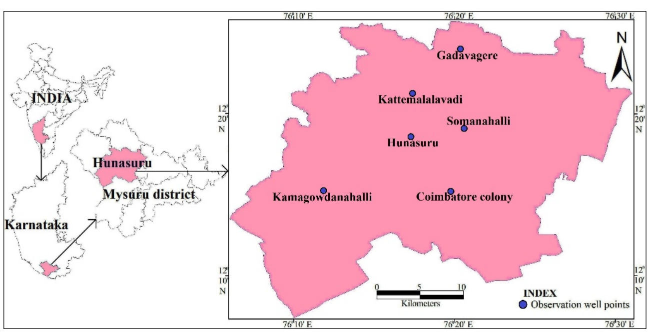

Fig. 1. Location and Observation well points map of Hunsur taluk

Data and Analysis: Survey of India (SoI) toposheets (1:50,000) are efficiently used to extract Hunsur's taluk boundary. Six observations well stations of groundwater level data from 2003 to 2019 were obtained from the District Groundwater Board (DGWB), Mysuru (Table 1) [14], and trend maps were constructed using IDW tool in ArcGIS v10 (Figures 2 and 4) [15]. Trend maps of groundwater (m bgl) levels from 2003 to 2019 were extracted during the pre-monsoon season and evaluated for short-term (2003-2007, 2007-2011, 2011-2015 & 2015-2019) and long-term fluctuations (2003 - 2019) (Tables 3 and 4). Only the pre-monsoon (Jan to May) data of groundwater levels were studied for the present study, since these depict the actual representation without considerable influence of seasonal recharges owing to precipitation [1].

3 Results and Analysis

Groundwater Trend Analysis

Groundwater supplies are predominantly used as fresh water and are being consumed at a faster rate due to demographic growth, increased demands for industrial, mining, and other megastructure constructions, which are directly causing a continuous fall in the water table. Modern agricultural methods, geographical characteristics, meteorological factors, precipitation regime, basic human forces directly putting stress on aquifer recharge-withdrawal equilibrium, and rapid depletion in groundwater levels all have a significant negative impact on future economic imbalance. Accurate spatio-temporal estimates of groundwater variations are critical for future water management and implementation strategies. Along NNE directions, many types of linear dykes, faults, minor shears, and fractures can be encountered, which aids in the natural recharge of groundwater [16]. 6 bore wells were used as observation stations to analyze groundwater table fluctuations from January to May (pre-monsoon season) over a 16-year period (2003-2019). Gadavagere (6.26) and Somanahalli (31.66) have shallow and deeper water levels, measured in meters below ground level (m, bgl) (Table 1). Groundwater levels were declining in the central regions since 2015 and are decreasing in the southern region as of 2019 (Figure 2). Overuse of surface water and loss of greenery contributed to the decline in groundwater levels around the Coimbatore colony observation station. Line graphs of groundwater table data revealed groundwater trend analyses during a 16-year period (2003-19) (Figure 3 & Table 2).

The long-term fluctuation map of 2003 to 2019 shows inclination trends in water depth across an area of 197.95 km^2, while roughly 700 km^2 falls under declination trends (Table 4). Heavier rainfall recorded in Kodagu district in August 2018 may have contributed to an increase in water levels in the central part of the study area in 2019. More water-intensive crops, such as paddy, tobacco and sugarcane, should be avoided in critical and over-exploited areas [12]. Percolation ponds and nalah bunds are the most effective Artificial Recharge Structures (ARS) for aquifers recharge in minimizing groundwater decline areas.

Table 1. Observation well points data (mts) of average Pre-monsoon-wise Groundwater Levels

Sl. No	Location	Latitude	Longitude	2003	2007	2011	2015	2019
1.	Hunsur	12.3128	76.2884	8.49	8.30	7.26	8.28	8.57
2.	Coimbatore colony	12.2548	76.3287	10.20	10.02	10.32	17.46	24.56
3.	Gadavagere	12.3991	76.3392	9.19	8.98	7.78	6.26	6.30
4.	Kamagowdanahalli	12.2566	76.1995	12.77	11.99	11.59	11.61	12.65
5.	Kattemalalavadi	12.3532	76.2905	10.37	10.35	9.62	8.20	9.95
6.	Somanahalli	12.3207	76.3413	19.99	18.70	14.23	31.66	25.98

Table 2. Area under different Groundwater depth zones (meters) in various years

Sl. No	Depth of Groundwater Levels	2003	2007	2011	2015	2019
1.	26 - 32	0	0	0	13.12	0
2.	18 – 26	8.70	2.96	0	90.98	251.13
3.	10 – 18	849.69	842.50	654.10	724.55	602.49
4.	6 – 10	37.40	50.33	241.70	67.15	42.17

Table 3. Area under different Groundwater Depth fluctuation in various years

Fluctuation in depth to water levels (m, bgl)	Area (km^2)				Trend of fluctuation
	2003-07	2007-11	2011-15	2015-19	
>3	0	23.22	0	19.00	
1.51 – 3.0	0	233.96	0.18	26.28	Inclination
0.01 – 1.5	8	629.47	32.49	152.67	
-1.50 – 0	0	9.13	163.86	497.04	Declination
<-1.51	0	0	699.26	200.80	

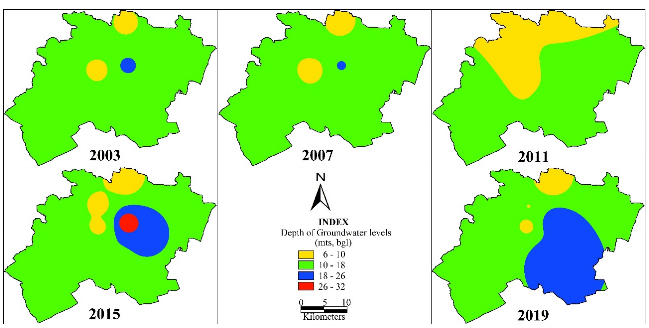

Fig. 2. Depth of Pre-monsoon GW levels (meters) map in various years of Hunsur taluk

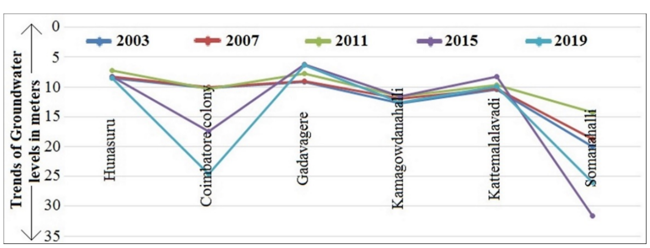

Fig. 3. Line graph depicting the Groundwater trends for various years of Hunsur taluk

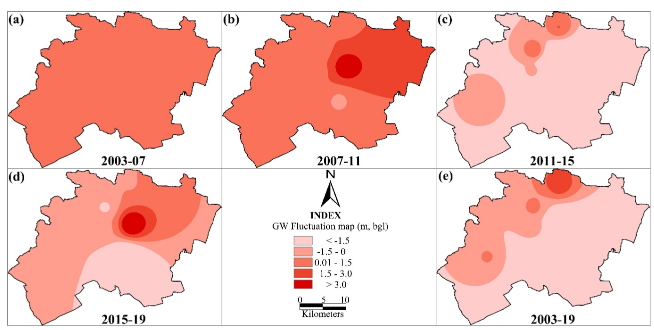

Fig. 4. Premonsoon GW level fluctuations for various years (a) to (d) and Long-term Premonsoon GW level fluctuation for Hunsur taluk (e)

Table 4. Area under Long-term fluctuation from 2003 to 2019

Fluctuation in depth to water levels (m, bgl)	Area (km^2)	Trends in fluctuation
3.0 >	0	
1.51 – 3.0	23.17	Inclination
0.01 – 1.50	36.64	
-1.51 – 0	277.96	Declination
<-1.5	558.02	

4 Discussion

Demand for water sources is quickly increasing each year, particularly in the domains of agriculture, industries, manufacturing industries, mining, automobile industries, residential, and others, which may have an impact on the adequate supply process. The trends in groundwater levels during the pre-monsoon season (Jan-May) during a 16-year period (2003-2019) were investigated using GIS-generated maps (Figures 2 and 4). Overexploitation of groundwater had been observed near Somanahalli (2015) and Coimbatore colony (2019). Figure 3 shows line graphs of groundwater trend analyses over a 16-year period (2003-19). The GIS-based approach to water resources study produces reliable data that are critical in prediction, validation and scientific decision for making policies[17]. Pre-monsoon groundwater level data were collected in order to eliminate seasonal recharges caused by rainfall in the present investigations. The long-term fluctuation map from 2003 to 2019 covers an area of 197.95 km^2 and demonstrates inclination patterns in water depth (Table 4). The deeper zones of groundwater levels in Hunsur were refilled by the flash flood of Cauvery River in August 2018. Individual well yield decreased when groundwater levels fell, bore wells failed, dug wells dried up, and power usage skyrocketed by the usage of electric vehicles.[18]

5 Conclusion

The use of GIS techniques to investigate groundwater trend analysis produce significant and meaningful results in the form of simple maps. The water table varies greatly between 6.26 m (Gadavagere) to 31.66 m (Somanahalli) due to the undulating geography. The findings of this study will undoubtedly meet the water needs of rural village farmers and aid in the implementation of appropriate agricultural production practices for Hunsur taluk. A scientific periodic to periodic management using even a simple tool of GIS software will undoubtedly solve future water sources challenges. Accurate and appropriate analysis of groundwater monitoring over a longer period will undoubtedly address the environmental and socio-economic demands of water supplies.

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