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Research Article

VARIABILITY ANALYSIS OF GROUNDWATER DEPTH: A CASE STUDY OF SONIPAT DISTRICT IN HARYANA, INDIA

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Abstract: In Northern India, particularly in Haryana, the pressure on groundwater has mounted many folds resulting decline in groundwater level. The objective of the study was to analyze variability in groundwater table during two decades *i.e.* 1993-2013. For this purpose, groundwater depth data of 123 monitoring wells was obtained from Groundwater Cell, Rohtak. Inverse Distance Weighted (IDW) interpolation method using Arc GIS software version 10.1was applied to obtain predicted values. A decline in average groundwater depth from 6.62 meters in 1993 to 7.89 meters in 2013 was noticed. Average seasonal fluctuation in groundwater table is varied from 0.7 meters to 1.5 meters during 1993 to 2013. The maximum area of Sonipat district *i.e.*, about 1724.44 sq. km was recorded under seasonal fluctuation of 1 to 3 meters rise during June 1993 October 1993 but the maximum area of Sonipat district *i.e.*, 1209.26 sq. km area under seasonal fluctuation of 0 to 1 meters during June 2013 to October 2013. Long term fluctuation trends in groundwater table during 1993 to 2013 revealed that there was a decline in groundwater table in four blocks out of seven blocks of the study area. The maximum fall in groundwater table was observed in Ganaur block Ganaur block expand near the bank of Yamuna River so that land of Ganaur block is a store house of fresh water. Due to fresh water withdrawal of groundwater in Ganaur block is high. There was 0.06 meter per annum decline in groundwater table in the entire Sonipat district during 1993 to 2013 in all seven blocks of the Sonipat district.

Keywords: *Variability Analysis, Inverse Distance Weighted (IDW) Interpolation, Sonipat, Haryana*

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Introduction

After the onset of green revolution in Haryana, the High Yielding Varieties (HYV) of seeds are required more amount of water for irrigation. The annual rainfall of the state is low and uneven with a long hot summer season and high rate of evaporation. The same conditions also exist in Sonipat district. The normal annual rainfall of the district for the period 1901-1980 is 567 mm [2].Yamuna river flows along the eastern boundary of Sonipat district. It is a perennial river but it remains dry in stretches from Tajewala to Delhi because of Hathni Kund Barrage which is origin of two important canals, the Western Yamuna Canal and Eastern Yamuna Canal. After Tajewala, the main channel of river Yamuna is almost dry and behaves like seasonal river. Thus, the absence of perennial rivers or streams as well as uneven and erratic rainfall makes availability of fresh water a matter of concern. The demand for irrigation water is always high. Advances in technology have resulted in an enormous increase in extraction of groundwater, thereby disturbing natural groundwater balance. Rapid urbanization coupled with enhanced groundwater extraction for irrigation, has adversely affected the groundwater resources of the study area. Thus, the question of groundwater availability is important and demands a scientific action plan to ensure water security in the study area (Sonipat district). Objective of the study was to analyze variability in the depth to groundwater table of the Sonipat district during the last two decades *i.e.* 1993-2013.

Study Area

The study area is geographically located between 28^{0}48' 15"North to 29^0 17' 10" North latitudes and 76^0 28' 40"East to 77^0 12' 45" East longitudes. Sonipat district has a sub-tropical continental monsoon climate. The district lies in the central part of the state and having temperature regimes of hot semi-arid regions [1]. The soil of this district are sandy to clay loam textured [6]. It is predominantly an agricultural district. About 70 percent of people are engaged in different agricultural pursuits. It is situated in the heart of green revolution belt of the state. Wheat, rice, sugarcane, barley, maize and mustard are the main crops of the district [4]. The total geographical area is 2, 13,000 hectares, out of which 1, 71,000 hectares area is cultivable. Net sown area is nearly 80.27 percent of the total area. The area sown more than once is 1, 47,000 hectares bringing the total cropped area (gross sown area) to 3, 16,000 hectares. The district has a high irrigation intensity of 187 percent. The net irrigated area by canals is 91,000 hectares and net irrigated area by tube wells is 78,000 hectares [7]. Sonipat district is a part of the Indo-Gangetic plain. It has almost a plain topography with general slope from north to south. A natural depression exists in north and northwest of Gohana. The maximum elevation of the plain is 235 meters above mean sea level. As per the physiographic regions, the study area can be divided into three regions namely: active floodplain, abandoned floodplain of recent past and upland plain. The study area has not much geological diversity. Sonipat district is dominated by Quaternary to Recent age deposits of Indo-Gengatic plains. It is almost covered by alluvial deposits of clay, loam, silt and sand brought down by Yamuna River during quaternary to recent age. High-grade silica sand left behind by the change in the course of the Yamuna River is found (Geological Survey of India, 2012).

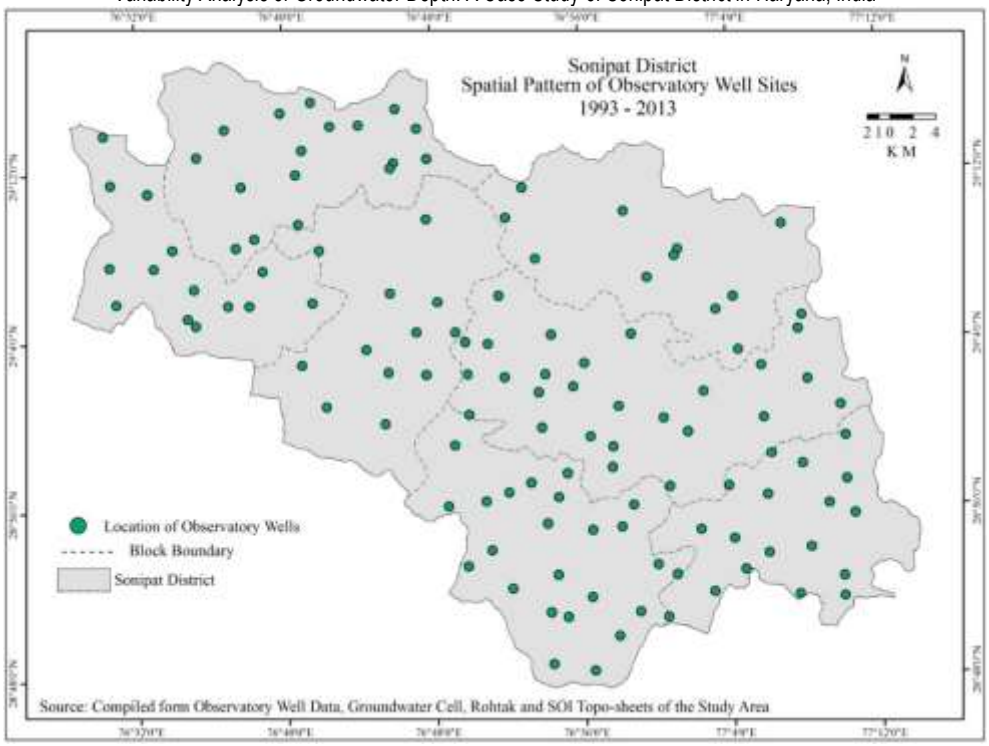

Fig-1 Point location map of 123 observations well sites in Sonipat district, Haryana

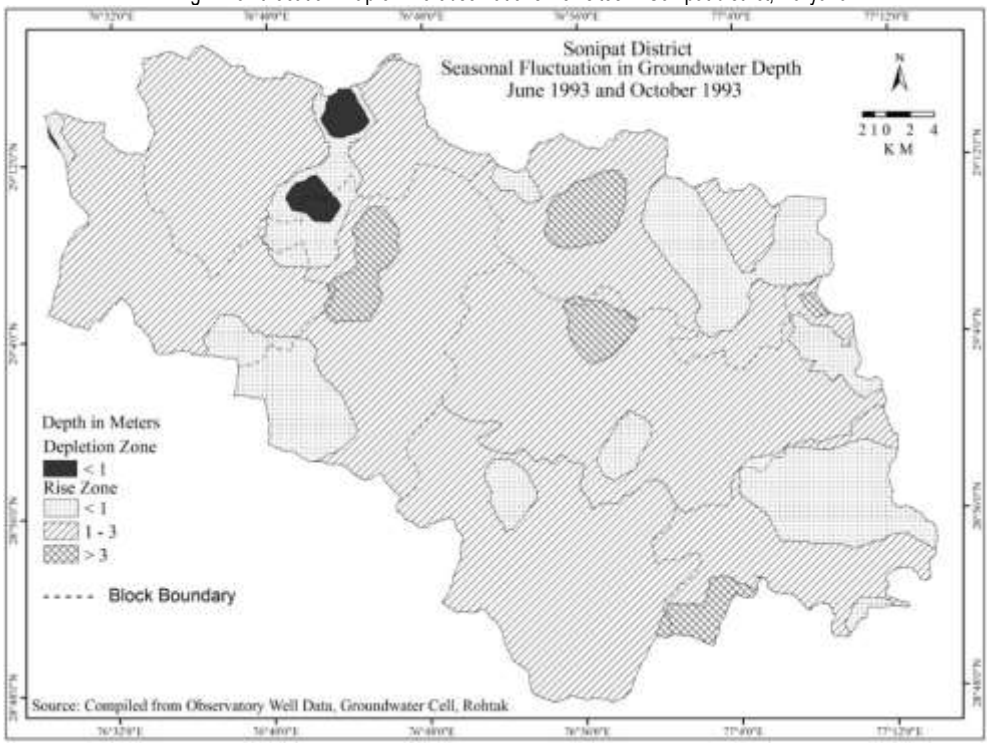

Fig-2 Spatial pattern of seasonal fluctuation in groundwater depth during pre-monsoon to post – monsoon period in 1993.

Table-1 *Block-wise average depth to groundwater table (meters) for pre-monsoon*

Blocks	1993	1998	2003	2008	2013
Kathura	2.96	3.01	4.43	2.89	4.08
Mundlana	4.81	3.87	5.60	5.11	5.11
Ganaur	8.96	7.68	10.84	13.69	16.95
Gohana	5.40	3.17	5.92	5.26	5.30
Sonipat	8.99	7.02	11.23	10.05	7.67
Kharkhoda	6.01	3.50	4.73	4.14	4.81
Rai	9.19	8.03	11.75	12.46	11.29
District Average	6.62	5.18	7.79	7.66	7.89

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

Table-2 *Block-wise average depth to groundwater table (meters) for post-monsoon period (October) during 1993 to 2013.*

Blocks	1993	1998	2003	2008	2013
Kathura	2.6	2.43	3.42	2.48	2.2
Mundlana	3.35	2.95	4.71	3.19	3.78
Ganaur	7.15	7.24	10.46	13.34	16.88
Gohana	3.49	2.33	5.27	4.00	2.88
Sonipat	7.16	6.49	10.71	9.51	6.01
Kharkhoda	4.21	1.72	3.39	2.97	3.39
Rai	8.02	6.92	11.66	12.24	10.79
District Average	5.14	4.3	7.09	6.82	6.56

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

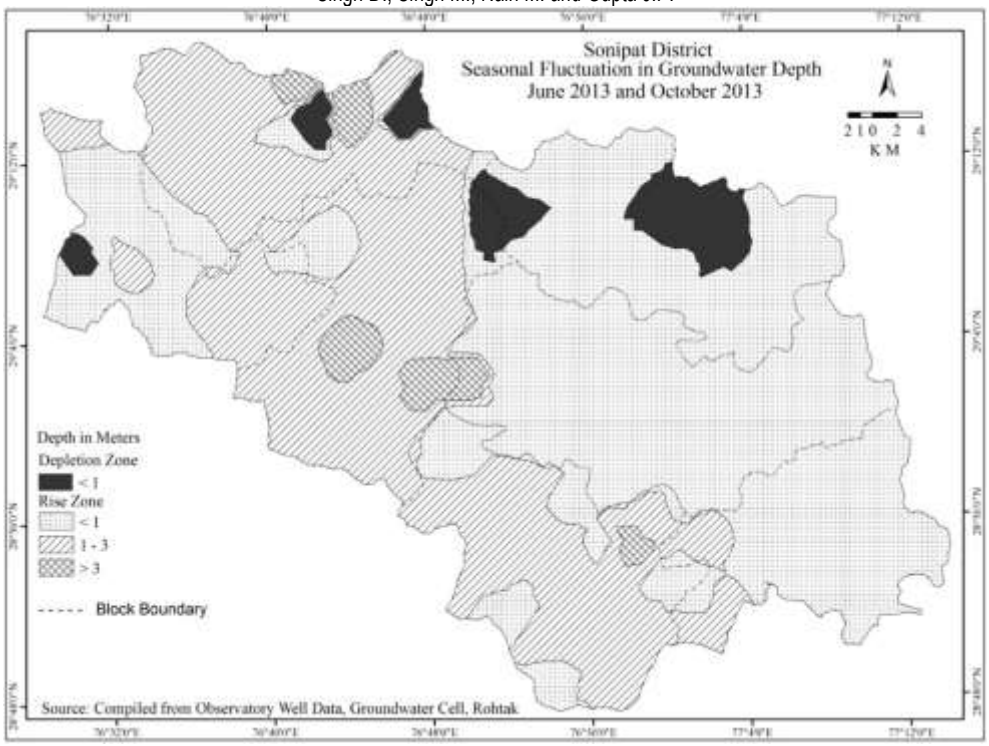

Fig-3 Spatial pattern of seasonal fluctuation in groundwater depth during pre-monsoon to post-monsoon period in 2013.

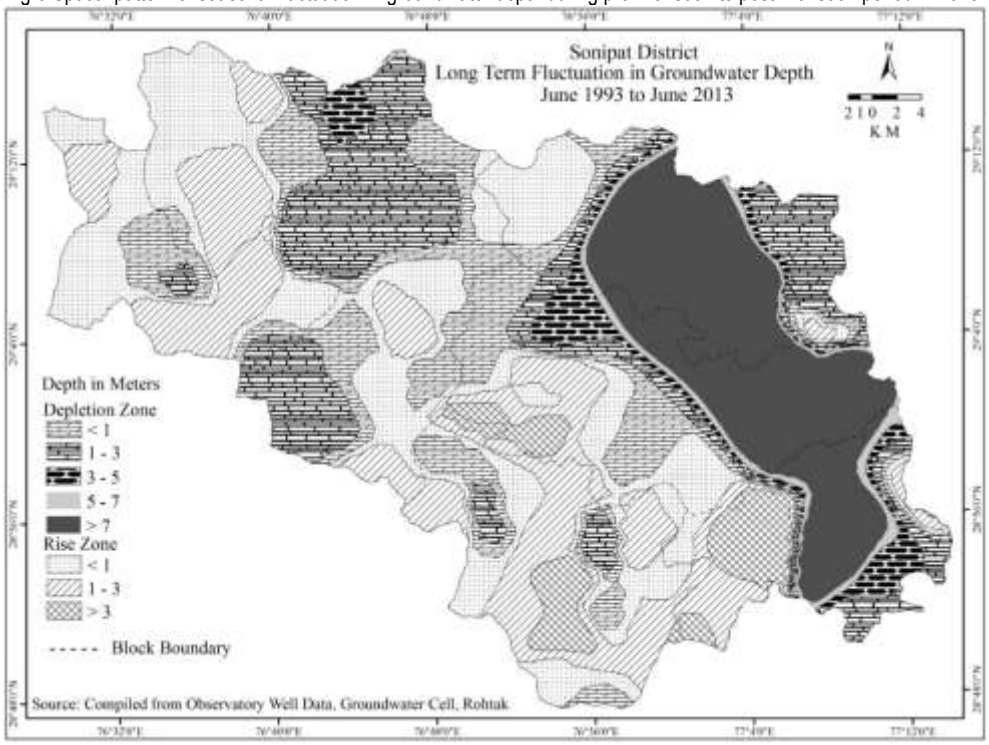

Fig-4 Spatial pattern of long term fluctuation in groundwater depth for pre-monsoon period during 1993-2013.

Data Sources and Methodology

The study was done through secondary data. The Survey of India (SOI) topo sheets on 1:50,000 scales were used to prepare the base map and boundary demarcation. The study area covers the Survey of India (SOI) toposheets no. H43Q8, H43Q11, H43Q12, H43Q15, H43Q16, H43R4, H43W9, H43W13, and H43X1. The groundwater depth data of 123 monitoring wells from seven blocks of Sonipat district from 1993 – 2013 was obtained [3]. The maximum numbers of monitoring wells (27 wells) are found in Sonipat block. It is followed by Kharkhoda block (25 wells), Mundlana block (17 wells) and Ganaur block (17 well). The minimum monitoring wells are found in Ganaur block (11 wells). It is followed by Gohana block (12 wells) and Kathura block (14 wells). [Fig-1] shows the block wise location of monitoring wells in Sonipat district. As per Groundwater Cell, Rohtak, each monitoring well represents the circle area of approximately 25 km radius. Toposheets of the study area were registered in Arc GIS 10.1 environment using map projection of WGS 1984 and UTM Zone 43N.

Table-3 *Block-wise seasonal fluctuation (pre-monsoon and post-monsoon) in groundwater table (in meters).*

Block	1993	1998	2003	2008	2013
Kathura	1.5	0.5	1.0	0.5	0.8
Mundlana	1.5	0.9	0.9	1.9	1.3
Ganaur	1.8	0.4	0.4	0.3	0.07
Gohana	1.9	0.8	0.6	1.3	2.4
Sonipat	1.8	0.5	0.5	0.5	1.7
Kharkhoda	1.8	1.8	1.3	1.2	1.4
Rai	1.2	1.2	0.1	0.2	0.5
District Average	1.5	0.9	0.7	0.8	1.3

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell.

Table-4 *Block-wise area under seasonal fluctuation in groundwater table*.

Zones	Depth in meters	June 1993 – Oct 1993		June 2013 – Oct 2013		Blocks	Blocks
		Area (km²)	Area (%)	Area (km²)	Area (%)	(June 1993 – Oct 1993)	(June 2013 – Oct 2013)
Depletion Zone	0 – 1	22.89	1.01	113.83	5.04	Mundlana, Gohana	Kathura, Mundlana, Gohana, Ganaur
Rise Zone	0 – 1	398.62	17.66	1209.26	53.57	Parts of all blocks	Parts of all blocks
	1 – 3	1724.44	76.40	861.64	38.17	Parts of all blocks	Kathura, Mundlana, Gohana, Kharkhoda, Rai
	3 and Above	111.27	4.93	72.49	3.21	Gohana, Ganaur, Sonipat, Rai	Gohana, Mundlana, Sonipat, Kharkhoda

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

Table-5 *Block-wise decadal fluctuation in groundwater table (meters) for the pre-monsoon period during 1993 to 2013.*

Blocks	1993-2003	Average per annum	2003-2013	Average per annum	1993-2013	Average per annum
Kathura	-1.47	-0.15	0.35	0.04	-1.12	-0.06
Mundlana	-0.79	-0.08	0.49	0.05	-0.3	-0.02
Ganaur	-1.88	-0.19	-6.11	-0.61	-7.99	-0.40
Gohana	-0.52	-0.05	0.62	0.06	0.1	0.01
Sonipat	-2.24	-0.22	3.56	0.36	1.32	0.07
Kharkhoda	1.28	0.13	-0.08	-0.01	1.2	0.06
Rai	-2.56	-0.26	0.46	0.05	-2.1	-0.11
District Average	-1.17	-0.12	-0.1	-0.01	-1.27	-0.06

+ Value shows Rise, – Values shows Fall in Groundwater Table.

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

Table-6 *Block-wise decadal fluctuation in groundwater table (meters) for the post-monsoon period during 1993 to 2013.*

Blocks	1993-2003	Average per annum	2003-2013	Average per annum	1993-2013	Average per annum
Kathura	-0.82	-0.08	1.22	0.12	0.4	0.04
Mundlana	-1.36	-0.14	0.93	0.09	-0.43	-0.04
Ganaur	-3.31	-0.33	-6.42	-0.64	-9.73	-0.97
Gohana	-1.78	-0.18	2.39	0.24	0.61	0.06
Sonipat	-3.55	-0.36	4.7	0.47	1.15	0.12
Kharkhoda	0.82	0.08	0	0	0.82	0.08
Rai	-3.64	-0.36	0.87	0.09	-2.77	-0.28
District Average	-1.95	-0.20	0.53	0.05	-1.42	-0.14

+ Values shows Rise, – Values shows Fall in Groundwater Table.

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

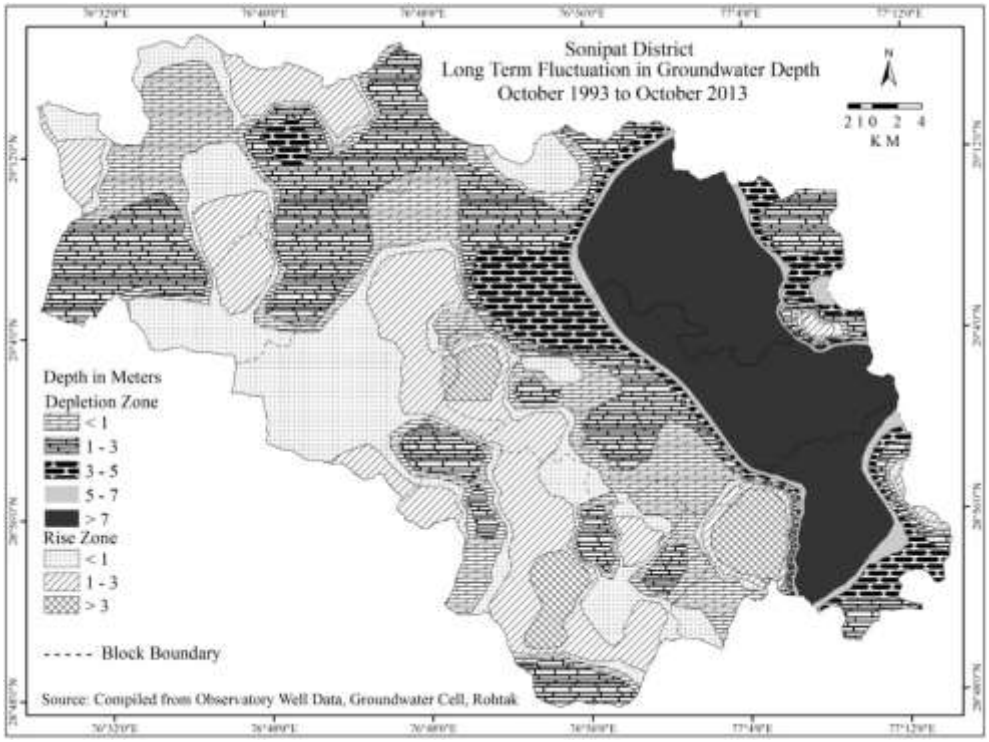

Fig-5 Spatial pattern of long term fluctuation in groundwater depth for post – monsoon period during 1993 – 2013.

Thereafter, the toposheets were mosaiced in Erdas Imagine 9.0. Boundary map of Sonipat district was extracted from mosaiced images of topo sheets in Arc GIS 10.1. Boundary of each block was demarcated as per the Groundwater Cell, Department of Agriculture, Rohtak. The well locations map of 123 observation sites was digitized from toposheets [Fig-1]. The pre and post monsoon data of groundwater depth, seasonal fluctuation and longterm fluctuation of groundwater were attached to well locations map in the form of the attribute table. Maps of spatial pattern of seasonal and longterm fluctuations in groundwater table during 1993 and 2013 were prepared to analyze the extent of changes during the period under study and also find out the spatio-temporal variation in fluctuations of groundwater table spatial interpolation method defines the continuous pattern of data on surface.

Table-7 *Area under various categories of pre and post monsoon long term fluctuation in groundwater depth*.

Zones	Depth in meters	June 1993 – June 2013		Oct. 1993 - Oct. 2013		Blocks during June 1993 – June 2013	Blocks during Oct 1993 – Oct 2013
		Area (km²)	Area (%)	Area (km²)	Area (%)		
Depletion Zone	0 – 1	332.04	14.71	340.21	15.07	Parts of all blocks	Parts of all blocks
	1 – 3	379.23	16.80	504.51	22.35	Parts of all blocks	Parts of all blocks
	3 – 5	95.38	4.23	156.55	6.94	Mundlana, Ganaur, Sonipat, Rai	Mundlana, Ganaur, Sonipat, Rai
	5 – 7	39.27	1.74	45.47	2.01	Ganaur, Sonipat, Rai	Ganaur, Sonipat, Rai
	7 and Above	381.13	16.88	407.32	18.05	Ganaur, Sonipat, Rai	Ganaur, Sonipat, Rai
	Total	1227.05	54.36	1454.06	64.42		
Rise Zone	0 – 1	511.46	22.66	383.59	16.99	Parts of all blocks	Parts of all blocks
	1 – 3	413.22	18.31	339.27	15.03	Parts of all blocks	Parts of all Blocks except Ganaur Block
	3 and Above	105.49	4.67	80.30	3.56	Sonipat, Kharkhoda, Rai	Sonipat, Kharkhoda, Rai
	Total	1030.17	45.64	803.16	35.58		

Source: Calculated by researcher from Observatory Well Data, Groundwater Cell, Rohtak

For given data of some point, this method predicts the values of other unknown points and creates a continuous spatial pattern of given data [5]. To determine the accuracy of interpolation, all three algorithms (Inverse Distance Weighted, Spline and Kriging) have been used in the Arc GIS software. Inverse Distance Weighted (IDW) method was applied to create a continuous surface pattern from the set of 123 sample measurements. IDW was chosen because it predicts the most approximate spatial pattern of unknown values of groundwater depth data as compared with groundwater depth data of 123 wells after categorization of fluctuation. The area under each groundwater fluctuations zones were calculated with the help of Calculate Geometry tool in the attribute table. Change in the area of seasonal fluctuation and long term fluctuation in groundwater table for the year 1993 (June and October) and 2013(June and October) was analyzed and presented by tables.

Results and Discussion

Depth to Groundwater Table

The block wise pre-monsoon groundwater table at five years' interval (below ground level) of the study area during 1993 – 2013 is presented in [Table-1]. It is evident that fluctuations in groundwater table in the study area are not unique. From June 1993 to June 1998, the groundwater table has risen in the district. After 1998, groundwater table has sharply declined. The block wise groundwater table for post-monsoon period at a five years' interval (below ground level) of the study area during 1993 – 2013 period (October) is presented in [Table-2]. From October 1993 to October 1998, there is rise in groundwater table but noticed a sharp declined thereafter. The maximum depth to groundwater is in Ganaur block *i.e.*, 16.88 meters (below ground level) during 2013 but minimum in Kharkhoda block *i.e.*, 1.72 meters in 1998.

Seasonal Fluctuation in Groundwater Table

Block-wise seasonal fluctuation in groundwater table for both the pre-monsoon and the post-monsoon period from 1993 to 2013 is presented in [Table-3]. The groundwater table shows rising trend in all the blocks. In 1993, all the blocks in the district experienced a positive fluctuation in groundwater table during the pre-monsoon to the post-monsoon period. Ganaur block witnessed subtle (0.07 meters) fluctuation in the groundwater table in 2013 whereas Gohana block recorded maximum fluctuation of the groundwater table of all time since 1993.

Spatial Pattern of Seasonal Fluctuation in Groundwater Table

[Fig-2] represented the spatial pattern of seasonal fluctuation in groundwater depth during June 1993 and October 1993 and spatial pattern of seasonal fluctuation in groundwater depth during June 2013 and October 2013 is shown in [Fig-3]. The output results of seasonal fluctuation are shown in [Table-4]. In large part (76.40 percent) of the study area, *i.e.*, 1724.44 sq. km, the seasonal fluctuation in groundwater table was recorded between 1 to 3 meters range during June 1993 and October 1993. The results reveal that there is considerable change in the area as well as in the extent of net groundwater recharge in the seasonal fluctuations held during 1993 and 2013. In a large part of the study area, *i.e.*, 1209.26 sq. km, the seasonal fluctuation in groundwater table is 0 to 1 meter. It covers 53.57 percent area in the district. This shows that over twenty years, the over-exploitation of groundwater is increased to such an extent that rainfall during the monsoon season could no longer replenish the groundwater level. Thus, there is a great need for artificial recharge in such parts of the district.

Long Term Fluctuation in Groundwater Table

The block-wise long term decadal fluctuation in groundwater table for the pre-monsoon period during June 1993 to June 2013 has been worked out [Table-5]. During first decade, *i.e.*, June 1993 to June 2003, out of seven blocks, six blocks experienced a fall in the groundwater table. During June 1993 to June 2003, maximum fall in groundwater table is 2.56 meters in Rai block followed by Sonipat block (2.24 meters), Ganaur block (1.88 meters) and Kathura block (1.47 meters) respectively. However, during the same period, Kharkhoda block experienced a rise in the groundwater table. The rise in groundwater table in Kharkhoda block was 1.28 meters. The average fall in groundwater table in the entire district during this period was 1.17 meters. It is evident that there was 0.12 meters per annum decline in groundwater table in the entire district during June 1993 to June 2003. During last decade, *i.e.*, June 2003 to June 2013, Ganaur and Kharkhoda blocks experienced a fall in the groundwater table. The maximum fall in groundwater table is 6.11 meters in Ganaur block followed by Kharkhoda block (0.08 meters). During the same period, Sonipat block experienced the maximum rise in the groundwater table. The rise in groundwater table in Sonipat block was 3.56 meters. However, the average fall in groundwater table is 0.1 meter. There was 0.01 meter per annum decline in groundwater table in the entire district during June 2003 to June 2013. In comparison to the fluctuation in groundwater table during June 1993 to June 2003, there was a sharp change in groundwater table during June 2003 to June 2013. The long term fluctuation in groundwater table during June 1993 to June 2013 revealed that there was a decline in groundwater table in four blocks of the study area. The maximum fall in groundwater table is in Ganaur block (7.99 meters). At the same time, groundwater table increased in Sonipat block (1.32 meters). However, the average fall in groundwater table in the entire district during 1993 to 2013 is 1.27 meters. The annual decline in groundwater table in the entire district is 0.06 meter during June 1993 to June 2013. [Table-6] represents the block-wise decadal fluctuation in groundwater table for the post-monsoon period, *i.e.,* October 1993 to October 2013. Even in the post-monsoon period, the trend of fluctuation in groundwater table is similar to the pre-monsoon period. In the first decade, *i.e.*, October 1993 to October 2003, out of seven blocks, six blocks experienced a fall in the groundwater table. During October 1993 to October 2003, the fall of 3.64 meters in the groundwater table in Rai block. However, during the same period Kharkhoda block experienced a rise in the groundwater table. The rise in groundwater table in Kharkhoda block was 0.82 meters. The average fall in groundwater table in the entire district during the same period was 1.95 meters. It is evident that there was 0.20 meters per annum decline in groundwater table in the entire district during October 1993 to October 2003. During October 2003 to October 2013, out of seven blocks, only Ganaur block experienced a fall in the groundwater table. The fall in groundwater table in Ganaur block was 6.42 meters. During the same period, Sonipat block experienced the maximum rise in the groundwater table. The rise in groundwater table in Sonipat block was 4.7 meters. Kharkhoda block showed no change in the groundwater table during October 1993 to October 2013. However, the average rise of groundwater table in the entire district during this period was 0.53 meters. There was 0.05 meters per annum rise in groundwater table in the entire district

during October 2003 to October 2013. The long term fluctuation in groundwater table during October 1993 to October 2013 revealed that there was a decline in groundwater table in three blocks of the study area. The maximum fall in groundwater table was observed in Ganaur block which was 9.73 meters. It was followed by Rai block (2.77 meters) and Mundlana block (0.43 meters). At the same time, the maximum rise in groundwater table was observed in Sonipat block (1.15 meters). It was followed by Kharkhoda block (0.82 meters), Gohana block (0.61 meters) and Kathura block (0.4 meters).

Spatial Pattern of Long Term Fluctuation in Groundwater Table

Spatial pattern of long term fluctuation in groundwater table was identified in the study area for pre-monsoon [Fig-4] as well as post-monsoon [Fig-5]. The area under various categories of pre and post monsoon long term fluctuation in groundwater table along with names of blocks is shown in [Table-7]. There was a decline in groundwater in 1227.05 sq. km area that accounts 54.36 percent of the total area of the district. Out of this, 381.13 sq. km (16.88 percent) area in which groundwater table had declined more than 7 meters in Ganaur, Sonipat and Rai blocks. The area under 5 – 7 meters decline in groundwater table was noticed in about 39.27 sq. km (1.74 percent) area of the district in Ganaur, Sonipat, and Rai blocks. In 95.38 sq. km area, the long term fluctuation in groundwater table of 3 – 5 meters decline). It covered 4.23 percent area of the district. This change has occurred in Mundlana, Ganaur, Sonipat and Rai blocks. The area under 1 – 3 meters decline in groundwater table was noticed in about 379.23 sq. km which constitutes about 16.80 percent area of the district. In an area about 332.04 sq. km, accounting to 14.71 percent where 0-1 meter decline in groundwater table during June 1993 to June 2013. However, there was a rise in groundwater table in 45.63 percent area of the district during June 1993 to June 2013. Out of this, about 105.49 sq. km (4.67 percent area of the study area) area witnessed more than 3 meters rise in Sonipat, Kharkhoda and Rai blocks. In about 413.22 sq. km area (18.31 percent area of the study area) groundwater is in 1 – 3 meters. Area under 0 – 1-meter rise in groundwater table is about 511.46 sq. km (22.66 percent area). The trend of fluctuation in groundwater table for post-monsoon period was not found to be very different from the pre-monsoon period. There was a decline in groundwater table in 1454.06 sq. km area. It accounts 64.42 percent of the area of the district. Out of this, 407.32 sq. km area in which groundwater table has declined by more than 7 meters was noticed in Ganaur, Sonipat and Rai blocks. It accounts 18.05 percent area of the study area. The area under 5 – 7 meters depletion zone of groundwater table was noticed about 45.47 sq. km (2.01 percent) area of the district in Ganaur, Sonipat, and Rai blocks. In 156.55 sq. km (6.94 percent) area, the decline in groundwater table was noticed between 3 – 5 meters range in Mundlana, Ganaur, and Sonipat and Rai blocks. The area under 1–3 meter decline zone was noticed in about 504.51 sq. km (22.35 percent) area of the district. In an area about 340.21 sq. km (15.07 percent) of the study area shows 0–1 meter's decline in groundwater table was recorded during the same period. However, there was a rise in groundwater table in 803.16 sq. km (35.58 percent) area as well during October 1993 to October 2013. Out of this, about 80.30 sq. km (3.56 percent) area witnessed more than 3 meters rise in groundwater table in Sonipat, Kharkhoda and Rai blocks. In about 339.27 sq. km (15.03 percent) area groundwater table has risen between 1 – 3 meters. Area under 0-1 meter rise in groundwater table was noticed in about 383.59 sq. km (16.99 percent) of the district. Just as the pre-monsoon long term fluctuation in groundwater table, the post-monsoon long term fluctuation in groundwater table demarcates the same pattern.

Conclusion

The variability analysis has highlighted the situation of groundwater availability since 1993 to 2013 in Sonipat district of Haryana. The results revealed that the average depth to groundwater table declined from 6.62 meters below ground level in 1993 to 7.89 meters in 2013. It indicates over-exploitation of the groundwater in the study area. During the period under study, maximum seasonal fluctuation in groundwater table was recorded in the year 2013. The long term fluctuation from June 1993 to June 2003 revealed that out of seven blocks, six blocks experienced a fall in the groundwater table. About 76.40 percent area of the district noticed a seasonal fluctuation in groundwater table between 1 to 3 meters during pre to post monsoon season in 1993. The long term fluctuations revealed that 54.36 percent area of the district showed a decline in groundwater table during June 1993 to June 2013. At the same time, about 45.63 percent area of the district observed arise in groundwater table.

Application of research: Variability analysis of groundwater depth using remote sensing and GIS can help in monitoring and conserving groundwater resources in Sonipat district.

Research Category: Groundwater analysis

Abbreviations: GIS: Geographic Information System, IDW: Inverse Distance Weighted

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Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Sonipat District in Haryana

Cultivar / Variety / Breed name: Nil

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
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