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Assessment of Groundwater Depth: A Case Study of Sonepat District of Haryana, India

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ABSTRACT:-

Groundwater is a valuable, dynamic, renewable natural resource and one of the most essential in our life. Due to population explosion, demand for groundwater has increased over years. Overexploitation of this resource is threatening our ecosystems and even the life of future generations. The present study aims to assess the groundwater depth from 1993 to 2013 in Sonepat district of Haryana. For this purpose, time series data was obtained from Groundwater Cell, Department of Agriculture, Rohtak. Groundwater depth data of 123 monitoring wells was analyzed for the year 1993, 1998, 2003, 2008 and 2013. Inverse Distance Weight (IDW) method using Arc GIS was applied to obtain suitable results. A decline in average groundwater depth from 6.62 meters below ground level in 1993 to 7.89 meters below ground level in 2013 was reported. The analysis further reveals that the area under normal groundwater depth zone has declined during last twenty years. During the same period, the area under deep and very deep groundwater depth zone has increased. Groundwater prospective zones during successive five years were also compared and critical areas with substantial fall in groundwater levels were identified. A small part covering about 0.42 per cent of district area was identified to be in critical condition. The depletion in this part has exceeded 20 meters in a period of twenty years.

Keywords: Groundwater, GIS, Depletion, Substantial, Inverse Distance Weight (IDW).

INTRODUCTION

Water occurs everywhere on the earth surface, sub-surface and atmosphere. Population explosion has led to increase in demand for water in almost every sphere of life. The demand for groundwater has increased over years. Overexploitation and unchecked pollution of this vital resource is threatening our ecosystems and even the life of future generations. Therefore, the extreme scarcity of water resources along with its ever increasing demand and uneven distribution have given rise to an urgent need for accurate and efficient management of this resource. Groundwater has been examined by many scholars (**Jasrotia et al., 2012; Saxena, 2012; Sinha et al., 2012; Gontia and Patil, 2011; Rekha et al., 2011; Nag, 2005; Colten, 1998; Al-Saleh, 1992**) in India and abroad. A number of studies on groundwater depth have been reported. Despite recent industrial development, Sonepat district is primarily an agricultural district of Haryana. After the onset of green revolution in the Haryana, the High Yielding Varieties (HYVs)

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of the seeds required good quality of fertilizers and more amount of water for irrigation. Due to the low, uneven and erratic rainfall, availability of fresh water is always a matter of concern. The demand for irrigation water is always high. Groundwater extraction without proper recharge and leaching of pollutants from pesticides and fertilizers into the aquifers has polluted groundwater supplies (Goyal and Chaudhary, 2010). Rapid urbanization coupled with enhanced groundwater extraction for irrigation, have adversely affected the groundwater resources of the region. The objective of the present study is to understand the existing status and spatio-temporal change associated with groundwater depth in the study area.

STUDY AREA

The study area comprises Sonepat district. Sonepat district is geographically located between 28° 48′ 15″ to 29° 17′ 10″ North latitudes and 76° 28′ 40″ to 77° 12′ 45″ East longitudes (Figure 1). The total area of Sonepat district is 2,257.22 sq. km. The district comes under the National Capital Region (NCR). According to the Census of India, 2011 total population of Sonepat district was 14,50,001. Population growth rate of the district was 13.5 per cent during 2001-11. The density of Sonepat district is 683 persons per sq. km during census 2011. Seven Community Development Blocks of Mundlana, Kathura, Gohana, Ganaur, Sonepat, Kharkhoda and Rai have been set up in the district for the development of rural areas (Figure 1). Sonepat 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 (Rathee et al., 2009). The district is a continuous part of the Haryana-Punjab Plain. The cropping intensity of the district is 169 per cent. The major cropping system under the existing farming systems is primarily rice-wheat cropping with buffalo. Out of the total geographical area, about 8,500 hectares area is under forest cover. Approximately 32,000 hectares area put to non-agricultural uses like as built-up area etc. About 7,000 hectares area of the district is under the barren and uncultivable land. There is completely absence in the current fallow land in the district during 2011-12. The net area sown of the district is 1,69,000 hectares and area sown more than once is 1,47,000 hectares (Statistical Abstract of Haryana, 2012 – 2013).

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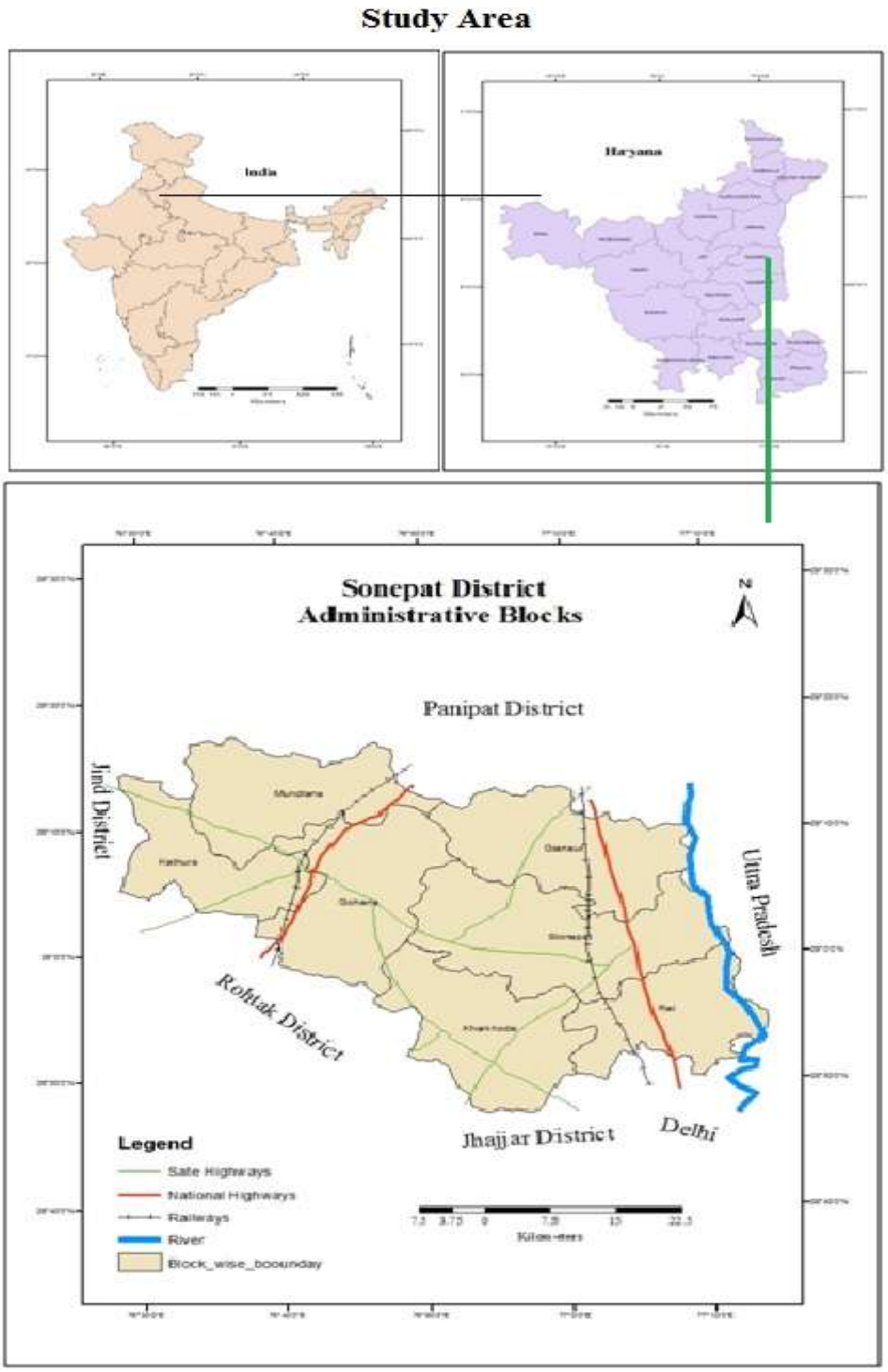

Figure 1

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DATA SOURCES AND METHODOLOGY

The study is carried out on Sonepat district of Haryana, India. The study is done through secondary data. Survey of India (SOI) topographical sheet on 1:50,000 scale was used to prepare the base map and preparation of point map of well location. The study area falls in the Survey of India (SOI) topo-sheets no. 53C, 53D, 53G and 53H. The groundwater depth data of 123 monitoring wells of Sonepat district from 1993 – 2013 was obtained from Groundwater Cell, Department of Agriculture, Rohtak. The well location map of 123 observation sites established by Groundwater Cell, Rohtak has also been digitized from topo-sheets of the study area (Figure 2). The data of groundwater depth have been attached with well location map in form of attribute table. Spatio-temporal maps of groundwater depth were prepared using Arc GIS 10.1. Inverse Distance Weight (IDW) method was applied to obtain suitable results and to find out the spatial pattern of groundwater depth. Spatial distribution maps of groundwater depth were also classified into various groundwater depth zones. Criteria for delimiting groundwater depth zones as per Indian Standard are given in Table 1. Area under each groundwater depth zones was calculated with the help of Calculate Geometry tool in Arc GIS. To find out the spatio-temporal variation in groundwater depth during 1993 to 2013, Overlay method of Arc Toolbox was used.

Table 1. Criteria for delimiting groundwater depth zones.

Groundwater depth range (m bgl)	0 – 3	3 – 10	10 – 20	20 – 30	30 – 50
Groundwater depth zones	Shallow	Normal	Moderate	Deep	Very Deep

Source: Groundwater Cell Rohtak, 2014.

RESULTS AND DISCUSSION

Depth to groundwater table

The block wise depth to groundwater table (below ground level) of the study area during 1993 – 2013 shows in Table 2 for pre-monsoon period. From June 1993 to June 1998, the groundwater table has risen in the district. After 1998, groundwater table has sharply declined. However, in 2003 the average depth to groundwater table has reached 7.79 meters. After 2003 there is a slight rise in groundwater table and it reached at 7.66 meters. Again the groundwater level has fallen and it was 7.89 meters below ground level in 2013. Similarly, this trend is observed in all blocks except in Kathura block. The maximum depth to groundwater table was 16.95 meters found in the Ganaur block in 2013. In Kathura block, the groundwater depth was observed minimum among all the blocks during last two decades.

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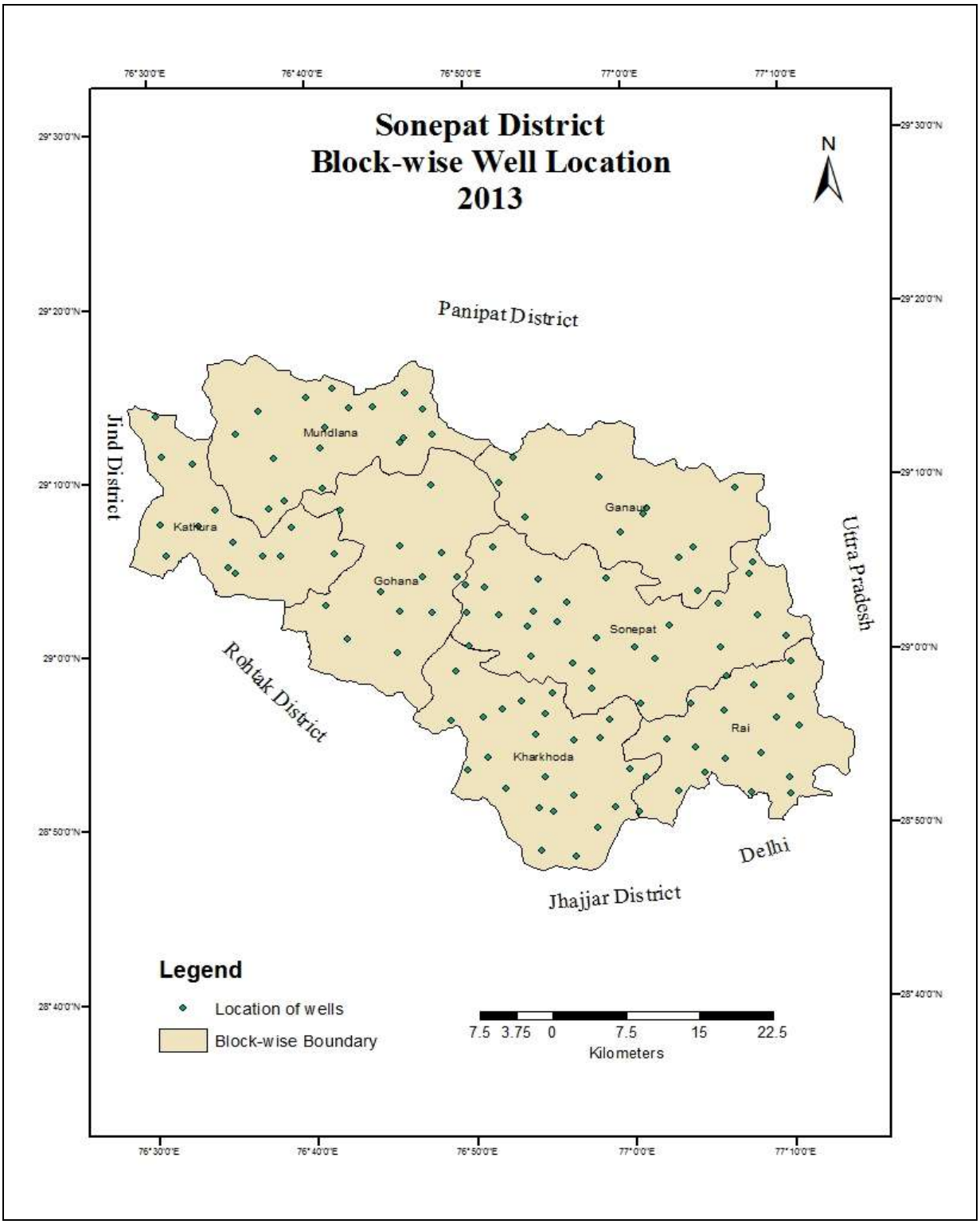

Figure 2

Table 2. Block-wise average depth to groundwater table (meters) during June 1993 to 2013.

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
Sonepat	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**

Spatial distributions of groundwater depth at intervals of five years during 1993 to 2013 are depicted in Figure 3. The areas calculated in various groundwater depth zones from these maps are presented in Table 3. The area under normal groundwater depth zone in 1993 was 77.6 per cent of the study area whereas; it was only 61.9 per cent during 2013. Area under moderate groundwater depth zone during 1993 was 21.1 per cent of the total area. But in 2013, it remained only 18.0 per cent of the study area.

Table 3. Area under different groundwater depth zones during 1993 to 2013.

Ground - water Depth Zone	1993		1998		2003		2008		2013	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Shallow	29.52	1.3	439.68	19.5	38.65	1.7	253.76	11.2	134.41	5.9
Normal	1752.58	77.6	1461.68	64.8	1550.29	68.7	1334.79	59.1	1396.02	61.9
Moderate	475.12	21.1	355.86	15.7	623.26	27.6	534.11	23.7	405.34	18.0
Deep	0	0	0	0	45.02	2.0	134.56	6.0	310.00	13.7
Very Deep	0	0	0	0	0	0	0	0	11.45	0.5

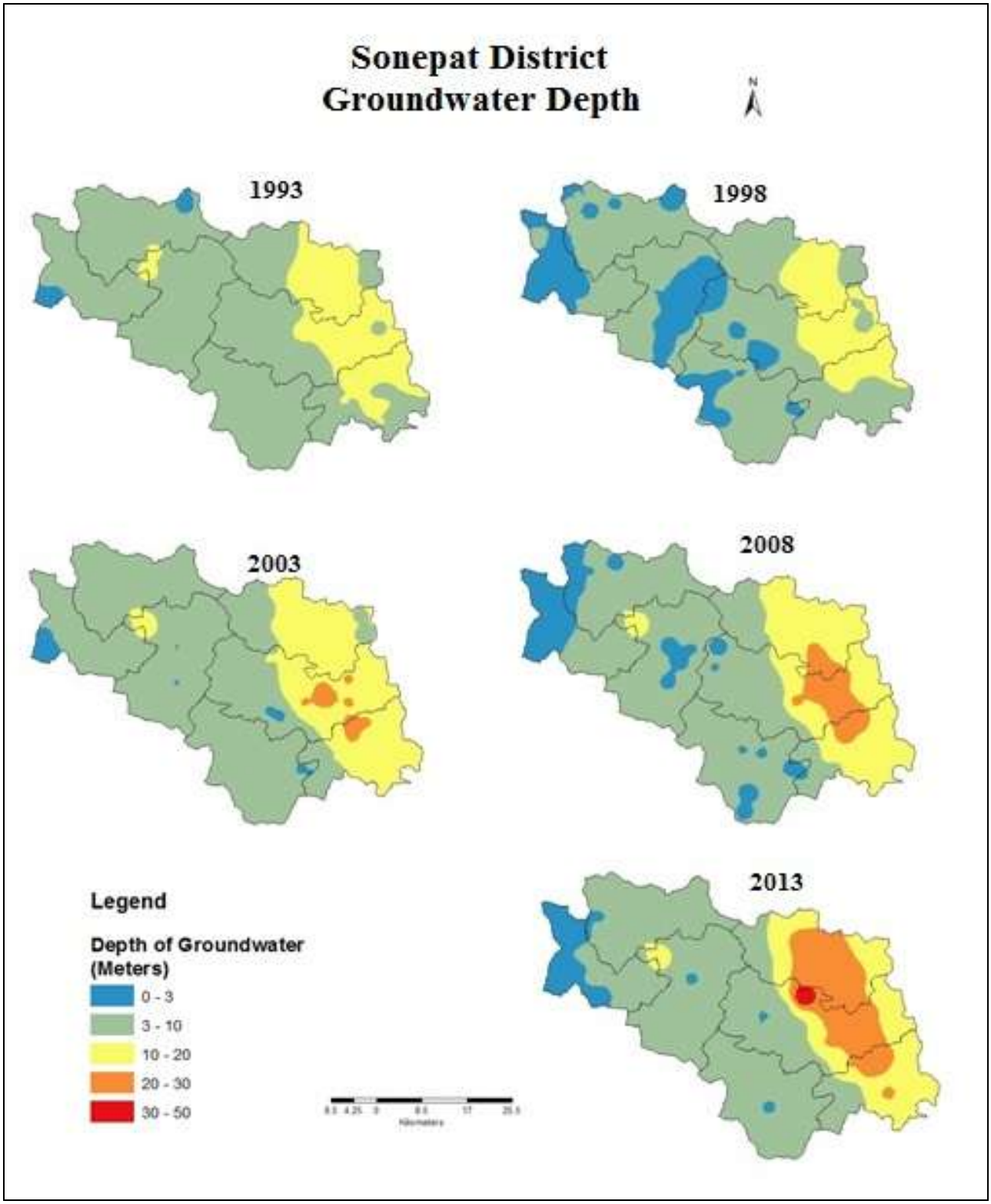
Sonepat District
Groundwater Depth
N
1993
1998
2003
2008
2013
Legend
Depth of Groundwater
(Meters)
0 - 3
3 - 10
10 - 20
20 - 30
30 - 50

Figure 3

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Area under deep groundwater depth zone has increased. There was no part of the district which was under the deep groundwater depth zone during 1993 whereas it was 13.7 per cent during 2013. Area under shallow groundwater depth zone has also increased during the same period. It was 1.3 per cent during 1993 whereas; it was 5.9 per cent during 2013. Area in very deep groundwater depth zone was increased and reached up to 0.5 per cent of the study area during 2013. The analysis of data clearly indicates that groundwater in Sonepat district is overexploited and there is no significant improvement observed during last 20 years.

Spatio-temporal variation in groundwater depth (1993 – 2013)

The change detection analysis map of 1993 and 2013 (Figure 4) was obtained by carrying out overlay operation in Arc GIS on Analysis tools. Figure 4 shows the block-wise classification of the district into zones of various categories which represented the spatial-variation in groundwater depth from 1993 to 2013. The cross map divided the district into four main categories of spatio-temporal change i.e. no change, semi-moderate change, moderate change and critical change (Table 4). About 69.81 per cent of the total area of the district falling under the part of all blocks depicted no change in groundwater levels. A major part of all blocks constituting about 28.36 per cent of total area showed a semi-moderate change. Moderate change in groundwater depth was observed in about 1.41 per cent of the district area falling in Ganaur and Sonepat blocks. A small part which is 9.49 sq. km (about 0.42 per cent of district area) was identified to be in critical condition in southern part of Ganaur block and northern part of Sonepat block with decline in groundwater levels from 3-10 meters range in 1993 to 30-50 meters range in 2013. The depletion in this part has exceeded 20 meters in a period of twenty years.

CONCLUSION

The present research work has highlighted the existing situation of groundwater availability since 1993 to 2013 in Sonepat district of Haryana. An attempt has been made to study the spatio-temporal change in groundwater depth. The result reveals that the average depth to groundwater table was found to be declining from 6.62 meters below ground level in 1993 to 7.89 meters below ground level in 2013. The analysis further reveals that the area under normal groundwater prospective zone has decreased during last twenty years. The area under normal groundwater prospective zone in 1993 was 77.64 per cent whereas during 2013, it was decreased to 61.85 per cent. It shows that the discharge of groundwater is more than recharge in the district.

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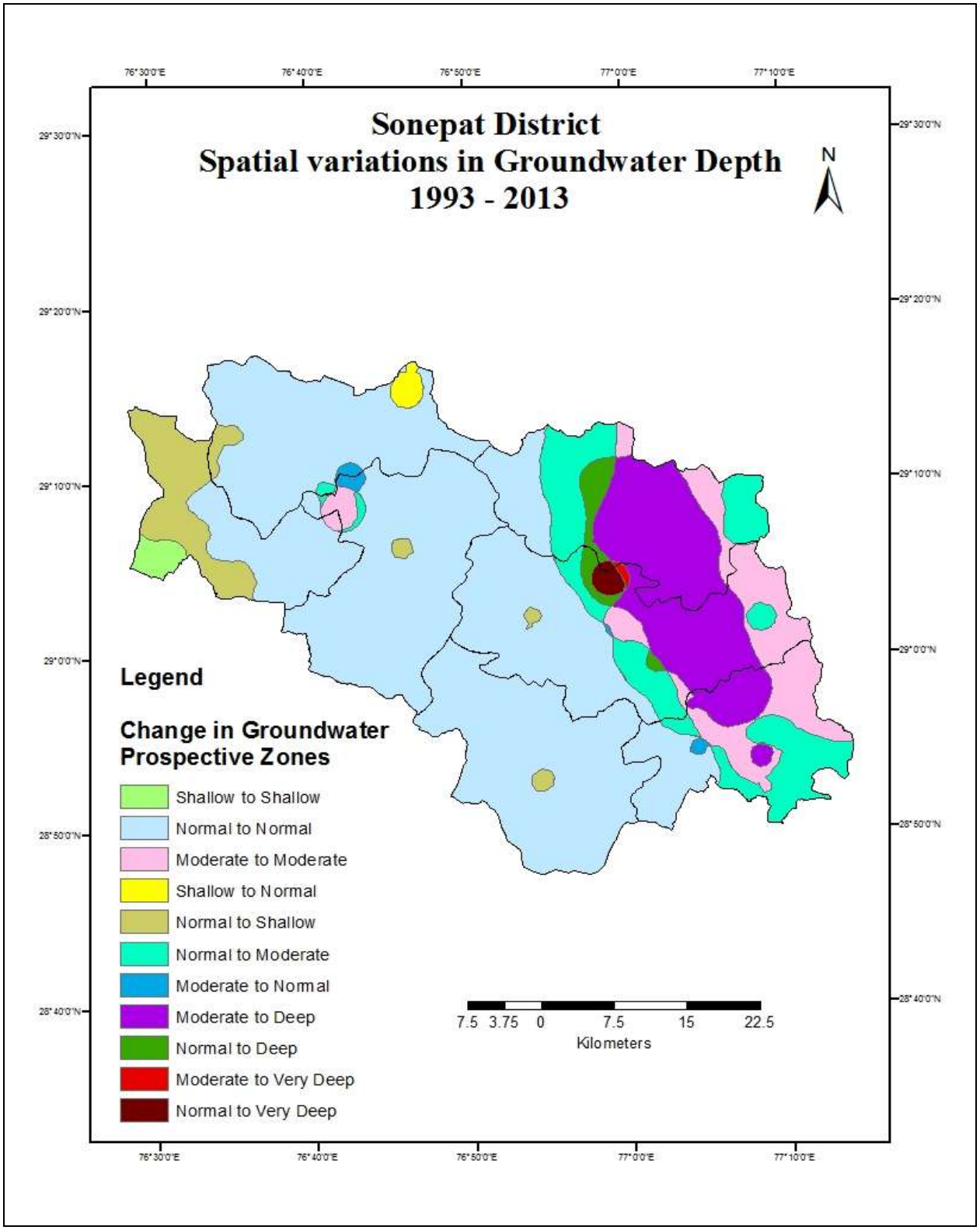

Figure 4

Table 4. Spatio – temporal change in groundwater depth (1993 – 2013).

Sr. No	Change Class	Range of Depth (m)		Status of Groundwater depth		Area		Blocks
		1993	2013	1993	2013	km^2	%	
1	No Change	0-3	0-3	Shallow	Shallow	17.76	0.79	Parts of all blocks
		3-10	3-10	Normal	Normal	1374.67	60.90	
		10-20	10-20	Moderate	Moderate	183.31	8.12	
		Total area under no change				**1575.74**	**69.81**	
2	Semi-Moderate Change	0-3	3-10	Shallow	Normal	11.74	0.52	Parts of all blocks
		3-10	0-3	Normal	Shallow	116.62	5.17	
		3-10	10-20	Normal	Moderate	222.04	9.83	
		10-20	3-10	Moderate	Normal	9.67	0.43	
		10-20	20-30	Moderate	Deep	280.02	12.41	
		Total area under semi-moderate change				**640.09**	**28.36**	
3	Moderate Change	3-10	20-30	Normal	Deep	29.95	1.32	Ganaur, Sonepat
		10-20	30-50	Moderate	Very Deep	1.95	0.09	
		Total area under moderate change				**31.90**	**1.41**	
4	Critical Change	3-10	30-50	Normal	Very Deep	9.49	0.42	Ganaur, Sonepat
		Total area under critical change				**9.49**	**0.42**	

To solve the declining trend of groundwater levels in the district, the following strategies can be adopted: (1) change in present crops sequence; (2) awareness among farmers about crop-water requirements through farmer's educational program; (3) judicious use of surface and groundwater; (4) use of water harvesting technique; (5) Renovation of water bodies like 'Johar' etc; (6) sprinkle irrigation system; (7) artificial recharge of groundwater; (8) agro-forestry along with inter crops. So, government efforts should be directed towards providing required quantity water to the people. However, the efforts should involve both government and the people of the study area to solve this problem.

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