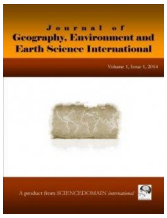

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GIS Approach Based Spatio-Temporal Change Analysis of Ground Water Resource: A Case Study from East Burdwan District of West Bengal, India

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The present paper tries to highlight the Spatio-temporal changing pattern and fluctuation pattern of ground water of Bhatar Block. Above 80% local people of the block are connected with agricultural activity and winter cultivation of the region mostly depends on ground water resource and small part of winter cultivation depends on surface water resource. The depletion rate of ground water resource during study period is very important. A clear warning of unsustainable changes of ground water resource in the area is identified in the present work. The changes of cropping pattern and ever-increasing demand in domestic sector are leading to depletion of ground water resource. Experience gathered during field visit and information collected from local people is that most of the hand pumps remain waterless from the month of December. Though the block recorded an overall decrease of ground water resources, but its level varies spatially from one part of the block to another. The deteriorating ground water trends advocate that water resource management must be taken acutely prior to diminishing water levels. In the final part, an appropriate plan for ground water resource management and encouragement for alternative crop cultivation are recommended.

Keywords: Piezometric station; SWID; tank rejuvenation; water level fluctuation.

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1. INTRODUCTION

Groundwater is the water existing below the surface of the earth in soil pore spaces and in the cracks of rock stratum [1,2]. Upper level of an underground surface in which the soil or rocks are everlastingly saturated with water is called water table [3].

In the words of Palanichamy [4] the water table is the initial occurrence of groundwater. Extraction of underground water exceeding usual replenishment creates pressure in the aquifers causing depletion of water table [5]. When groundwater is pumped at a higher rate than it is recharged, drawdown occurs [6]. Various parts of the globe people are mining ground water from underground rapidly than the aquifers are refilled by recharge [7]. Due to extreme withdrawal, groundwater stores are depleted in the surrounding area of the well [8]. Ground water depths give decisive hydrological details regarding discharge, renew and storage in an aquifer [9]. Ground water is extensively distributed beneath the earth surface which is the chief source of usable fresh water [10].

India is the biggest groundwater consumer in the globe [11]. Groundwater has been playing an important function in the protection of India's economy, environment and living standard [12]. Ground water exhaustion is concentrated mainly in thickly inhabited and economically prolific regions and the consequences will be harsh for the poor people [13]. When the pace of water extraction exceeds the net renew, mining of ground water occurs which may affect in a variety of major problems including fast reduction of ground water resources [14].

Observing water level fluctuation and depletion data on seasonal basis can recognize previous signs of changes in the groundwater level and assist to realize how to preserve it [15]. In West Bengal most of the rural people depend on the ground water [16]. With the growing use of ground water for cultivation, domestic and industrial purposes, the yearly withdrawal of groundwater is increasing compare to net recharge from natural supply [1,17]. As ground water is being extracted from underground storage ground water level is diminishing [18].

Groundwater is the largely oppressed resource in West Bengal mainly in farming sector with High Yielding Varieties (HYV) seeds, where there was no restriction for pumping of groundwater. In spite of containing huge underground water reserve, utilization of ground water in East Burdwan district shot up to such point that 80's decade initially observed the signal of diminution of groundwater level in a few blocks of Eastern Burdwan district where pre-monsoon water level fallen under the pumping limit and domestic tube wells went dried up. The seasonal fluctuation of ground water in pre- monsoon and post monsoon period are in great measures liable for varied land use pattern.

The ground water level of Bhatar block from the surface extended from 7.4 meter (1985) to over 20 meter (2016). Boro paddy cultivated land is growing enormously and farming of boro paddy of the area is exclusively dependent on ground water resource, which triggers the issue rapidly. Consequently the office of district magistrate has declared it as a dark block regarding ground water resource availability. Though the block recorded an overall decrease of ground water resources, but its level varies spatially from one part of the block to another. The present paper tries to highlight the Spatio-temporal changing pattern and fluctuation pattern of ground water of Bhatar Block. The supply of groundwater is not limitless and, so, its use should be suitably premeditated basis on the understanding of the groundwater system behavior to make sure its sustainable use [19].

In the concluding part, a suitable plan for ground water resource management and encouragement for alternative crop cultivation are recommended.

1.1 Study Area

Bhatar is one of the very agro- rich block of Eastern Burdwan district. Not only in present eastern Burdwan district, but it was famous for boro paddy cultivation in previous integrated Burdwan district. The block located at the central part of the district between 23^0 22′N to 23^0 30 ′N latitude and 87^0 44′E to 88^0 03′ 30″E longitude (Fig. 1). The block surrounded by Mongalkot police station in north, Katwa P.S in north-east. The Southern boundary of the area includes Galsi, Burdwan and Monteswar P.S. and in the western side the Ausgarm P.S is located. Total area of the block is 414.40 sq km. It has 107 moujas which are categorized into 14

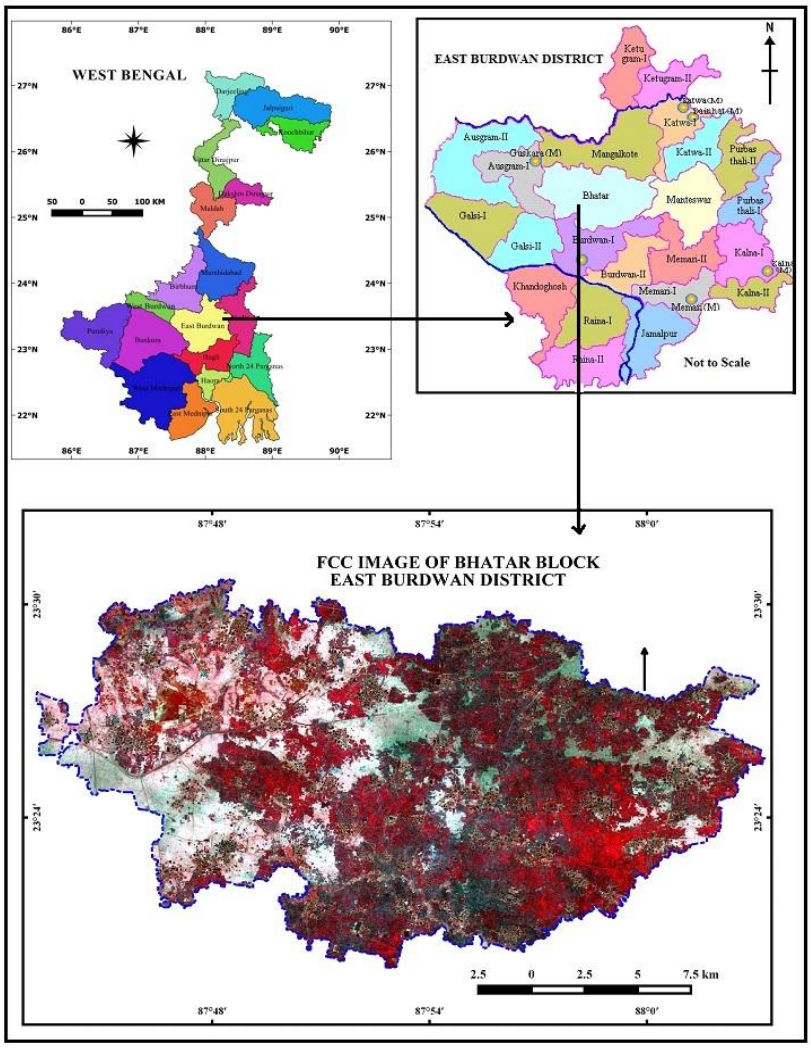

Fig. 1. Location map of the study area

Gram panchayat (GP). The Tropic of Cancer ($23^0$30´N) locates on the northern frontier of the study area. Bhatar Block had a total population of 263064 (2011).

2. OBJECTIVES

The main objectives of the study are;

i. To study the Spatio-temporal changing pattern of groundwater resource in the block in between the time period 1985-2016
ii. To show the spatial pattern of ground water depth in pre and post-monsoon season.
iii. To give some suitable plans for ground water resource management.

3. DATA BASE AND METHODOLOGY

In the first step of the study, necessary literature review has been done to address the issues of ground water depletion appropriately. Numbers of Topographical maps (73M/15, 79A/3, 73M/14, 73M/11) have been collected from SOI (Survey of India), Kolkata office. For understanding the nature of oscillation of ground water resource between pre-monsoon and post-monsoon season ground water level data has been collected from East Burdwan State Water Investigation Directorate (SWID) office for the period of 32 years during 1985 to 2016. Water level data have been collected from 16 piezometric stations of the block and these centers are uniformly distributed over the block. Based on the raw data average water level depth

and water level fluctuation between pre-monsoon and post-monsoon season were calculated. For making of current ground water fluctuation map an outline map collected from Burdwan fishery department have imported into raster. Then georeferencing has been done with the help of Survey of India topographical maps of the study area. The groundwater data were studied for their long - term mould, and GIS mapping charts were made to understand the dynamics of the groundwater level. The maps showing spatial pattern of seasonal fluctuation were made by interpolation method using QGIS 2.18 open source software.

4. RESULTS AND DISCUSSION

4.1 Spatial Distribution of Ground Water

Pre-monsoon and post-monsoon groundwater level data were assembled from SWID, East Burdwan district for 16 piezometric point (Fig. 2) pertaining 31 years of data (1985-2016). Table 1 shows the pre-monsoon depth, post-monsoon depth, water level fluctuation and position of each piezometric tube of the Bhatar block. It is assumed that if the ground water level depth from the surface is low, indicates good ground water condition. When depth is high it is assumed that ground water condition is bad.

The difference between post and pre-monsoon water level depth affected by both rainfall and amount of water drafted.

Spatial pattern of ground water depth is expressed in the following table (Table 2). The seasonal variation of ground water in dry and wet season is in great measures liable for various land use pattern. The water level swings between the wet and dry season, actually corresponds with the phases of infiltration and capillary process correspondingly.

The deepest water levels are usually limited to the north and north-east part of the area, while the shallow ground water levels are found in areas of south and south west part of the block (Figs. 3 and 4).

In the northern side of the study area the depth of ground water label found varies from 22m to 29.8m in the month of April (dry season). This zone covers 213.09 km^2 (51.35%) of total geographical area of the region. In the dry season about 67.17 km^2 (16.15%) area confirms a depth of less than 16m, 67.53km^2 (16.27%) lies between 16-19m, above 16.20% (67.21 km^2) within 19-22m.

The zone of very deep ground water level in the month of April is found over Mahata, northern part of Sahebganj-2, northern part of Sahebganj-1, most of Eruar GP, western part of Nityanandapur and north-west of Bhatar GP. In contrast the zone of shallow water level is established only over Banpass and western part of Mahachanda Grampanchayat.

Whole area of Bhatar block is divided into four zones to explain spatial pattern of water level in the month of November (Fig. 4). In the post monsoon season 27 % (111.89 km^2) area of the block lies within a depth of less than 16m, 59.10 km^2 (14.21%) within 16-19m,128.26 km^2 (30.84%) within 19-22m while remaining 28% area within 22-26.6m depth.

Very deep ground water zone in post monsoon season (>22m) is found over Mahata, Eruar, northern part of Sahebganj-2, northern part of Bhatar GP, north east of Bamunara and over small part of Amarun-2 and Barabelun-1 GP. The zone of shallow ground water level in post monsoon period is found over Banpass GP, over the southern part of Sahebganj-1, Mahachanda, southern part of Mahachanda GP. Medium depth of ground water level is observed on eastern part of the block and over a narrow belt extending from west to east of the block.

4.2 Spatio-Temporal Change of Ground-water

Data of Ground water level of Bhatar Block is available since 1985 and picture of regular decline of ground water resource of the region is found from the collected data (Table 1). Whole of the Bhatar Block experienced a negative change in water level depth in pre and post monsoon season. The decline, however, varies spatially from one part of the block to another. It is seen that while the deepest ground water level was 14.9m in April 1985 found in Sripur mouja as low as 29.8m in 2016 in the same season and it is found in Kaluttak F.P School. In pre-monsoon season lowest depth of ground water level in 1985 was recorded over Parhat Mouja and it was only 5m from the surface, but in 2016 it increased to 11m. In 1985, 50% stations recorded above 10m depth of ground water level but in 2016, 100% stations recorded above 10m depth which indicate unsustainable condition of the region.

Table 1. Spatio-temporal pattern of ground water resource

Name of P. Tube Site.	Longitude (x)	Latitude (y)	Ground water level(m), 1985			Ground water level(m), 2016		
			April	Nov	Fluctuation(m)	April	Nov	Fluctuation(m)
B. D. O. Campus	23°24'14"	87°55'17"	8.64	3.9	4.74	21.74	20.00	1.74
Orgram High School	23°26'08"	87°45'49"	10.48	5.5	4.98	23.48	17.4	6.08
Kubajpur F.P. School	23°21'52"	87°58'46"	8.96	7.59	1.37	21.76	18	3.76
Kulnagar F.P. School	23°24'11"	87°56'27"	8.5	2.38	6.12	21.83	20.05	1.78
Barabelun Bus Stand	23°24'33"	87°58'55"	11.65	5.35	6.3	24.39	22.35	2.04
Amarun F.P. School	23°21'32"	87°56'52"	9.75	4.1	5.65	19.42	17.2	2.22
Parhat F.P. School	23°22'00"	88°01'20"	5.3	2.6	2.7	10.95	6.85	4.1
Salanda F.P. School	23°27'5.9"	87°59'52"	9.1	2.7	6.4	22.08	21.05	1.03
Balgona G.P. Office	23°27'23"	87°56'58"	10.7	4.96	5.74	22.91	20.4	2.51
Karjona High School	23°21'22"	87°53'25"	10	4.5	5.5	17.73	14.65	3.08
Kaluttak F.P. School	23°26'53"	87°54'17"	11.6	5.2	6.4	29.8	26.5	3.3
Sripur F.P. School	23°27'52"	87°55'17"	14.9	11.35	3.55	27.85	26.6	1.25
Gramdihi Samity	23°24'46"	87°47'19"	9.1	3.11	5.99	15.1	11.35	3.75
Nutangram F.P. School	23°23'59"	87°53'44"	10.27	5.76	4.51	19.3	18.01	1.29
Ratanpur F.P. School	23°24'42"	87°50'38"	8.95	4.89	4.06	15.75	14.2	1.55
Salkuni F.P. School	23°26'54"	87°47'51"	10.15	6.1	4.05	22.45	20.85	1.6

Source: SWID, East Burdwan District

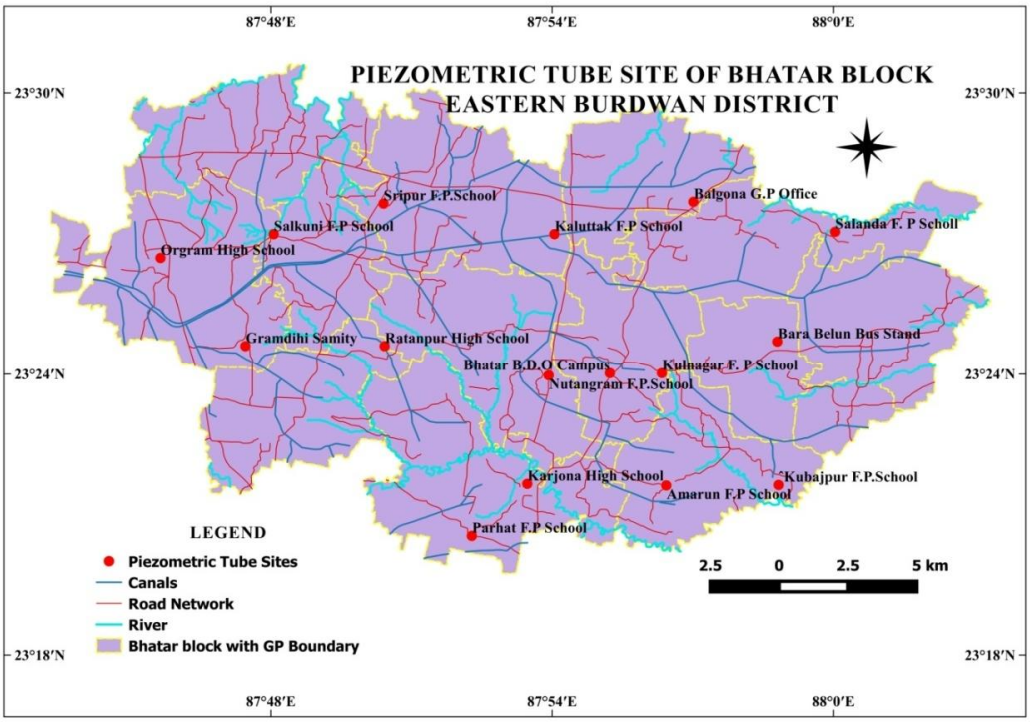

Fig. 2. Piezometric stations of Bhatar block

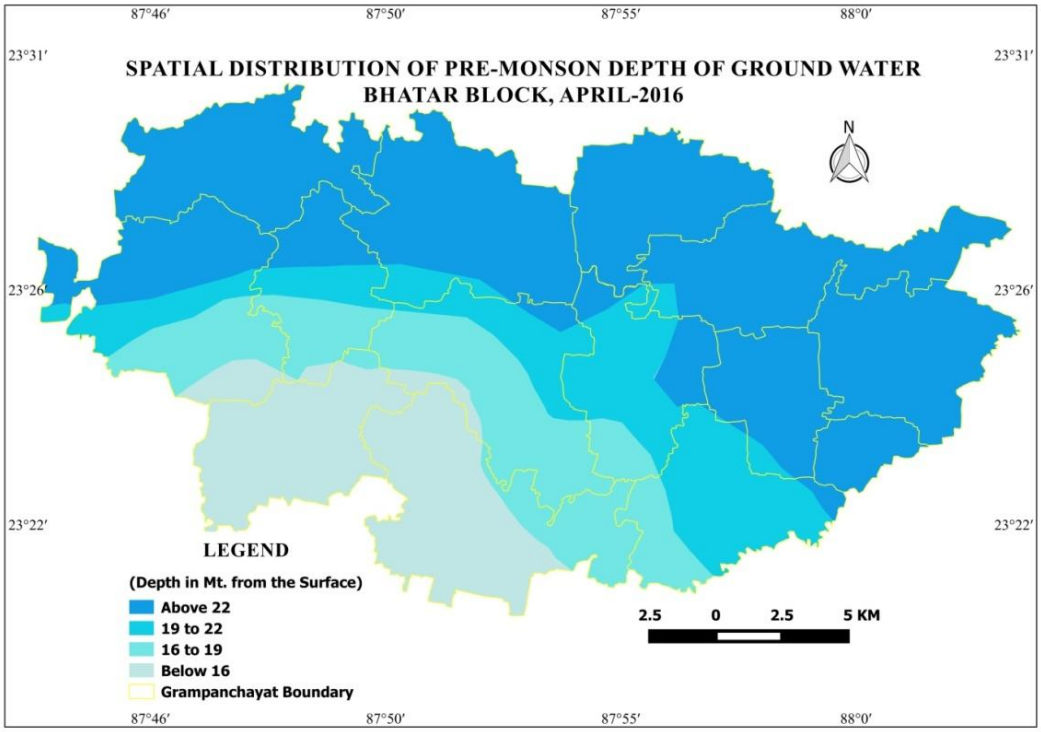

Fig. 3. Distribution of pre-monsoon depth of ground water

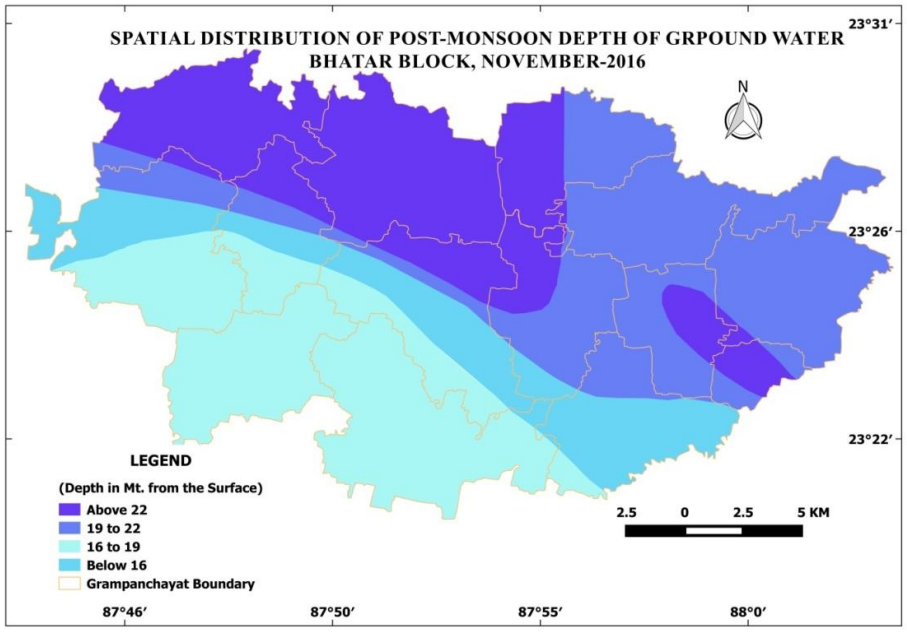

Fig. 4. Distribution of post-monsoon depth of ground water

Table 2. Distribution of ground water resource

Spatial distribution of ground water of Bhatar block				
Depth of ground water (m)	Coverage of underground water			
	Pre-monsoon season		Post-monsoon season	
	Area in sq.km	Area in %	Area in sq.km	Area in %
<16	67.17	16.15	111.89	26.90
16-19	67.53	16.27	59.10	14.21
19-22	67.21	16.20	128.25	30.84
>22	213.09	51.35	116.70	28.06

Source: SWID, Burdwan and researcher's calculation

The declining trend of ground water is found in post monsoon season (November) also. The lowest depth of ground water level was recorded in Kulnagar mouja(2.38m) in 1985, but in 2016 it increase to 20.05m. Highest depth in the month of November 1985 was 11.35m (Sripur) and in 2016 it reached to 26.6m. It is invented from Table 1 that problem is more serious in northern part of the block.

4.3 Fluctuation of Ground Water

Water levels are being computed four times a year generally in January, April, August and November. In the present study two extreme months i.e. April and November have been considered and water level data collection started in the year 1985 by SWID, govt. of West Bengal. The water level fluctuation is calculated by subtracting the value of pre and post monsoon (April and November) water level depth. It is very significant factor for planning sustainable development of water resource as well as for agricultural development. Table 1 shows the maximum fluctuation in 2016 seen over the Orgram mouja and the value is over 6m followed by 4.1m on Parhat mouja. Fluctuations range between 3m and 6m are the characteristics of Orgram, Parhat, Kubajpur, Gramdihi, Kaluttak and Karjona Mouja. High level fluctuation may be originated by excess withdrawal of groundwater over these mentioned areas.

5. CONCLUSION

The water level fluctuation between pre-monsoon and post-monsoon season implies the influence of both water resource withdrawal and nature of rainfall. The increase of ground water depth in

post monsoon season was initiated due to intense usage in irrigation for different crops and withdrawal for domestic uses. Maximum depletion of ground water is being observed in pre-monsoon season in Bhatar Block. The threat comes generally from the cropping pattern change, mainly due to significant expansion of rabi and boro paddy cultivated land. We know Bhatar is situated in tropical climate zone; hence negligible rainfall occurs in winter season. Ground water is the important source of irrigation of this region in winter season.

The deteriorating ground water trends advocate that water resource management must be taken acutely prior to diminishing water levels. In this condition, some proper measures must be adopted so that the water resource of the block stays sustainable in the long term. With increasing water crisis, tank rejuvenation may be implemented, which can reduce pressure on ground water resource of the region [6].

During field visit local peoples are suggested to use tank water for rabi and boro cultivation to reduce stress on ground water resource and some tips were given to local farmers of the block about cropping pattern change. Alternative cropping methods can be adopted in suitable land of the region. They were advised to initiate dry farming especially in elevated western area of the block where water resource is in more vulnerable condition. Considering the imminent crisis of water resource depletion, everybody should do their part to use less groundwater whenever possible. The greatest way to approach the issue of groundwater diminution and to discover a way out is to think on both an individual and government level.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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