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A Groundwater Assessment Study in Haringhata Block, West Bengal for Realizing Sustainable Water Supplies

KEYWORDS: Groundwater Estimation Committee, Stage, Groundwater, Haringhata Block.

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ABSTRACT *A quantitative groundwater assessment study was carried out in Haringhata Block, Nadia district, West Bengal for the sustainable utilization of vulnerable groundwater resource of the area. The groundwater resources were evaluated based on Groundwater Resource Estimation Committee norms. The total groundwater recharge was estimated from rainfall using infiltration factor method and recharge of groundwater from irrigated fields was estimated using the norms recommended by the Groundwater Estimation Committee. The net annual groundwater draft was estimated based on the number and type of wells and unit draft. Using the annual net groundwater draft and annual utilizable groundwater resources, the stage of groundwater development was determined for the block. The net annual groundwater draft of the study area was estimated as 174 MCM whereas the total groundwater recharge was estimated as 103.52 MCM considering two major recharge sources to groundwater i.e., rainfall and return flow of irrigation. The stage of groundwater development of the block was estimated as 167%, i.e. more than 100% which indicates the area as an overexploited zone.*

Introduction

Water plays a key role in all socio-economic development and for maintaining healthy ecosystems. According to UN (United Nations) estimates, the total amount of water on earth is about 1400 million km^3, which is enough to cover the earth with a layer that is 3000 meters deep. However, the general notion about the earth as a blue planet is elusive. In reality, only 2.5% of the total global water is fresh, of which less than 1% is readily accessible for direct human consumption in the form of lakes, rivers, reservoirs and shallow groundwater (Kuylenstierna et al., 1997a). Recent research reveals that well irrigation has overtaken surface-water irrigation as the main supplier of water for India's agriculture. In the last two decades, for instance, the groundwater irrigated areas in India increased by 105%, whereas the surface-water irrigated areas rose by only 28% (IWMI, 2001). But the indiscriminate use of this vital natural resource has resulted fast falling of groundwater table in many parts of India. With this background, a quantitative groundwater assessment study was carried out in Haringhata Block, Nadia district, West Bengal for the sustainable utilization of vulnerable groundwater resource of the area. As the main occupation of the local people is agriculture, the water scarcity problem greatly hampers the socio-economic condition in the area. The block is mainly irrigated through extraction of ground water. There are 3477 shallow tube wells, 42 Deep Tube wells run by the Department of Agri-irrigation, Govt. of West Bengal. There are also 3 Nos. of River Lift Irrigation, which cannot ensure proper quantity of water at required time due to the capricious nature of the rainfall in India. Therefore, groundwater becomes an inevitable source of water supply in the study area. However, the unrestricted excessive pumping of groundwater has resulted in groundwater lowering problem in the area in past few years. In addition to that, the area has an arsenic contamination problem. The detrimental health effect has greatly increased in recent years because of increased use of tube wells. The water delivered by them contains high arsenic level. Therefore, there is an urgent need to develop management strategies for the sustainable utilization of groundwater resources in the study area. However, for planning of proper groundwater utilization, it is necessary to estimate the total groundwater recharge and the actual volume of water available annually for utilization. In the present study, a water balance approach has been taken up to evaluate the different components of groundwater recharge in the block and to suggest the safe volume of groundwater withdrawal in the area.

Study Area Description

Haringhata Block, study area of this present study, is located in extreme south of Nadia district of West Bengal. The geographical extent of Haringhata Block lies within a latitude of $22^0 54'$ N to $23^0 2'$ N and longitude of $88^0 30'$ E to $88^0 41'$ E which covers an area of about 170.32 Sq. Km. The location of the study area is shown in Fig. 1. The block comprises of 10 *Gram Panchayats* (GP). The block is bound by Chakdah block in the north and the west. South and east part of the block is bounded by North 24Parganas District. A small river system which is locally known as Jamuna is flowing through the block. The soil of the block is mostly clay loamy type. The climate of the block is characterized by oppressively hot summer, high humidity and high rainfall during the monsoon. Winter starts from the middle of November which continues up to the end of February. During the monsoon from June to September about 71% of annual rainfall occurs. The rainiest month is August. The mean annual rainfall is about 1400 mm. Average elevation of the block is 10 m from mean sea level.

Figure 1. Location map of the study area.

Estimation of Groundwater Balance
In the present study, the groundwater resources were evaluated based on the GEC recommendations (Central Groundwater Board, 1997). The computations of various parameters which are involved in groundwater resource estimation were described in the following sections.

3.1 Groundwater Recharge from Rainfall using Infiltration Factor Method
Groundwater recharge into a basin from rainfall is estimated from the known values of average annual rainfall over that basin and its infiltration characteristics of the soils of the basin. Groundwater recharge assessment based on rainfall infiltration factor was estimated using the following formula:

R= f * A* P ……..1

Where, R = annual recharge, ha-cm, f = rainfall infiltration factor, A = area occupied by the particular soil unit, ha, P = annual rainfall, cm.

Monthly rainfall data collected for the period of 2004-2008 from the rainguage station monitored by B.C.K.V., Mohanpur, Nadia were used to quantify the average annual rainfall of the block. The estimated average annual rainfall for the study area is 140 cm.

The soil map for the Haringhata Block was delineated from soil map of Nadia district obtained from the National Bureau of Soil Survey and Landuse Planning (NBSS&LUP), Nagpur. The soil map for the study area reveals two main soil classes' viz., clay loam and sandy clay loam. It is apparent from Fig. 2 that the majority of the study area is dominated by clay loam. Sandy clay loam soil covers relatively small area.

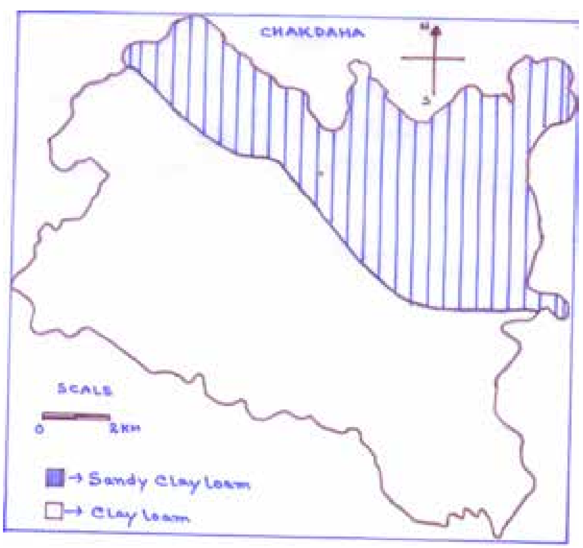

Figure 2. Soil map of the study area

Infiltration rates assigned to different types of soil units and the area covered by each soil unit are given in Table 1. The groundwater recharge amounts are also tabulated in Table 1. The infiltration factors of the different soil units were taken from Groundwater Estimation Committee (GEC 1984) norms which suggests rainfall infiltration factors for alluvial areas with higher clay content ranges from 10- 20% of rainfall . As the soil units present in the study area predominantly contains loamy type with higher clay content the rainfall infiltration factors were taken closer to upper limit of the range suggested by GEC. Thus total groundwater recharge from rainfall using infiltration factor method is estimated as 4088 ha-m or 40.88 MCM.

Table 1. Estimation of groundwater recharge by infiltration factor method

	Column 1	Column 2	Column 3	Column 1 X Column 2 X Column 3
Soil Type	Corresponding Area (ha)	Average Annual Rainfall (m)	Rainfall Infiltration Factor	Recharge (ha-m)
Clay Loam	10417.74	0.14	0.17	247942.1
Sandy Clay Loam	6385.068	0.14	0.18	160903.7
Total				408845.8

3.2. Groundwater Recharge due to Return Flow of Irrigation
Recharge from irrigated fields including losses in field channels was estimated using the GEC 1984 norms recommended by the. In the resent study recharge due to return flow of irrigation was computed taking the seepage factor as 35% as per GEC norms. The details of various crops grown in the study area i.e., the area under each crop and water requirement of each crop were collected from the office of Agriculture Development Officer (A.D.O.), Haringhata Block. The total water required for irrigation purpose was estimated by multiplying the area under each crop and corresponding water requirement for the crop. The details of various crops grown in the study area i.e., the type of crop, the area under each crop and water requirement of each crop collected from the office of Agriculture Development Officer (A.D.O.), Haringhata Block are presented in Table 2.

Recharge due to return flow of irrigation was computed taking the seepage factor as 35% as per GEC norms and was equal to 17896.25 × 0.35 = 6264 ha m = 62.64 MCM.

Table 2. Details of various crops grown under irrigation and total irrigation requirement of the Block

Crop season	Type of crop	Crop area(ha)	Irrigation Requirement (m)	Total volume of water required for irrigation (ha-m)
Kharif	Paddy	6500	1	6500
Kharif	Pulses	15	0.25	3.75
Kharif	Jute	1000	0.45	450
Rabi	Oil seeds	3100	0.42	1302
Rabi	vegetables	3300	0.4	1320
Rabi	wheat	1881	0.5	940.5
Summer	paddy	6150	1.2	7380
Total irrigation water requirement annually				17896.25

3.3 Estimation of Total Groundwater Recharge
Total amount of groundwater recharge from both the sources was estimated as 104.59 MCM. The groundwater recharge from other sources i.e. from seepage from canal/streams, minor irrigation tanks and ponds is neglected due to unavailability of the data.

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As per GEC norms, annual utilizable groundwater resources is 85% of total annual groundwater resources = 104.59 x 0.85 = 88.9 MCM.

3.4 Estimation of Total Groundwater Draft

Knowing annual groundwater draft is essential to assess the status of a basin in terms of categorization and for proposing suitable water harvesting structures. Estimation of groundwater draft requires the number and type of wells, unit draft, number of operating hours and number of days of operation. The details of the type of well, their number which are present in the study area and number of operating days were collected from the office of the Assistant Engineer (Agri-Irrigation), Kalyani, Nadia. The unit draft of those wells was taken as per GEC norms. The details of well and the annual draft of the block is presented in Table 3.

Table 3. Details of well and annual draft of the study area

Name of Sources	Structures	Number	Average Discharge (m^3/s)	Operating Hours/day	Total Draft (Mm^3)
Groundwater	Shallow (private +Govt.)	3477	0.006	12	225.3096
	Govt. Deep Tube-well	42	0.044	14	23.2848
Total groundwater draft					248.5944

Thus the gross annual groundwater draft was worked out to be 248.59 MCM. The net annual groundwater draft was estimated at 70% of the gross annual draft as recommended by GEC. Net annual groundwater draft = 248.59 × 0.70 = 174 MCM. Therefore net annual groundwater draft = 174 MCM.

4. Estimation of Stage of Groundwater Development

The groundwater assessment unit was categorized into different categories – safe, semi critical, critical and over-exploited – based on groundwater resources available and groundwater draft. The various categories are: *safe* – groundwater development is <70%; *semi critical* – groundwater development is 70–90%; *critical* – groundwater development is 90–100%; *overexploited* – groundwater development is >100%. The category of the Haringhata Block was evaluated by following the methodology suggested by GEC.

The stage of groundwater development was calculated using the formula:

$$\frac{\text{Annual net groundwater draft}}{\text{Annual utilizable groundwater resources}} \times 100 \quad \ldots\ldots 2$$

$$= \frac{174}{88.9} \times 100 = 195.72$$

The stage of groundwater development of the block considering only two sources of recharge is 195.72%, i.e. more than 100% which indicates the area as an overexploited zone. If other sources of recharge were taken into consideration then the amount of total recharge could have increased by some amount decreasing the ratio as represented by Eqn. 2. However, the stage of groundwater development will vary between critical to over-exploited range for the study area.

5. Conclusions

A quantitative groundwater assessment study was carried out in Haringhata Block, Nadia district, West Bengal for the sustainable utilization of vulnerable groundwater resource of the area. The present study aimed at estimating the different components of groundwater recharge and the average annual dynamic exploitable/utilizable groundwater reserve to critically analyze the groundwater scenario in this area. The total groundwater recharge from rainfall infiltration factor method is estimated as 40.88 MCM. The amount of recharge due to return flow of irrigation was computed taking the seepage factor as 35% as per GEC norms 62.64 MCM. The net annual groundwater draft of the study area was estimated as 174 MCM which is more than the total groundwater recharge from the two major source of recharge i.e., rainfall and return flow of irrigation. The stage of groundwater development of the block considering only two sources of recharge is 195.72 %, i.e. more than 100% which indicates the area as an overexploited zone. If other sources of recharge were taken into consideration then the amount of total recharge could have increased by some amount decreasing the ratio as represented by stage of groundwater development. Nonetheless, the stage of groundwater development will vary between critical to over-exploited range for the study area. Therefore, the present study suggests to improve the groundwater recharge by any suitable means in the study area and to limit the indiscriminate use of this vital and vulnerable resource by taking suitable and sustainable management policies.

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