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RESEARCH PAPER

Study on Estimation of Nadia District's Ground Water Recharge

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ABSTRACT

The Nadia district is known for its rice cultivation. Either less land must be used for *boro* agriculture, or artificial ground water replenishment must be encouraged. Using the annual net groundwater draught and the annual utilisable groundwater resources, the stage of groundwater development for the block was determined. The total groundwater recharge, which accounts for two major sources of groundwater recharge, namely rainfall and irrigation return flow, was estimated to be 873.79 MCM. The net annual groundwater draught of the study region was calculated to be 1265.76 million cubic metres (MCM). The projected groundwater development stage for the block was 144.90%, which is greater than 100%, and denotes an overexploited area.

HIGHLIGHTS

- Ground water is being used as the major source of irrigation water in most of the district of West Bengal.
- Withdrawals of ground water excess to the amount of water get recharged under natural process during the period of monsoon (June/Jul-Sept/Oct).
- The situation is sometime so alarming that the state concerned department become compels to declare some region as black zone to check the excessive withdrawal of ground water.

Keywords: Ground water, artificial, draft, recharge, overexploite

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 2008). But the indiscriminate use of this vital natural resource has resulted fast falling of groundwater table in many parts of India. Ground water plays a key role in meeting the water needs of various user-sectors in India. As per the report, the annual replenish able Ground Water Resource for the entire country is 433 billion cubic metre (BCM), Net Annual Ground Water Availability is estimated as 399 billion cubic metre whereas the Annual ground water draft for irrigation, Domestic & Industrial was 231 billion cubic metre and their Stage of Ground Water Development for the Country as a whole is 58% (Ghosh and Biswas 2016). With this background, a quantitative groundwater assessment study was carried out in 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, he water scarcity problem greatly hampers the socio-economic condition in the area. There are 29640 nos. 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

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time due to the capricious nature of the rainfall in India (Chowdhury 2016). Therefore, groundwater becomes an inevitable source of water supply in the study area. According to reports, drinking water with arsenic contamination (>0.05 mg/L), which is much higher than the WHO permissible limit of 0.01 mg/L, is severely affecting 79 Administrative Blocks in the State in 8 different districts (Malda, Murshidabad, Nadia, North 24 Praganas, South 24 Praganas, Howrah, Hooghly, and Bardhaman) (Rahman *et al.* 2014). With the foregoing in mind, the current study is being conducted to assess the ground water recharge of the Nadia district in order to determine the stage of ground water development and to determine the safest method of ground water exploitation.

MATERIALS AND METHODS

Demographic Profile

The district is divided into four administrative divisions: Kalyani, Tehatta, Krishnagar Sadar, and Ranaghat. Nadia is ranked seventh in terms of population, eleventh in terms of area, and fifth in terms of population density. Block wise geographical data has been shown in the table.

Table 1: Block wise geographical area

Name of the block	Geographical area (ha)
Karimpur-I	28155.07
Karimpur-II	17032.4
Tehatta-I	13089.5
Tehatta-II	26699.83
Kaliganj	15638.62
Nakashipara	27133.71
Chapra	12436.68
Krishnaganj	9245.53
Krishnanagar-I	35448.51
Krishnanagar-II	32092.44
Nabadwip	24955.43
Santipur	17247.22
Hanskhali	21415.83
Ranaghat-I	22437.76
Ranaghat-II	30597.12
Chakdaha	15159.94
Haringhata	24628.78

Collection of Data

The Agricultural Meteorology and Physics Department, B.C.K.V., Mohanpur, Nadia, provided monthly meteorological data for the year's 2012-2021. It was found that the average annual rainfall of the study area is 1330.22 mm

Ground Water Recharge Assessment

Bhattacharjee (1954) conducted a study at U.P. Irrigation Recharge Institute, Roorke, based on the analysis of water table elevation, pump age and rainfall data with the following equation (Bhattacharjee 1954)

$$P = 3.47\,(R - 38)^{2/5} \qquad ...(1)$$

Where, P = Rainfall penetration in cm R = Annual rainfall in cm

In order to determine the recharge as a function of yearly precipitation, Chaturvedi (1973) constructed an empirical relationship based on the variations in water levels and rainfall amounts in the Ganga-Yamuna doab (when rainfall exceeds 40 cms) (Chaturvedi 1973);

$$Rp = 2.0\,(R - 15)^{2/5} \qquad ...(2)$$

Where, Rp = Recharge in inch R = Rainfall in inch.

Datta and Das (1973) stated that;

$$P = 0.4\,R.e^{-0.046} \qquad ...(3)$$

Where, P, R and C denote the rainfall penetration in cm, annual rainfall in cm and average clay percentage in the top soil respectively (C = 17.78% for Nadia) (Datta and Das 1973).

Ground water level fluctuation method According to GEC1984 technique, the recharge was calculated using the following formula—

$$R_{wtf} = h \times S_y \times A \qquad ...(4)$$

Where R is the recharge of ground water during the monsoon in MCM, h is the rise in water level during the monsoon in metres, S_y is the formation's specific yield value, and A is the area the formation occupies in square kilometres. The regions where the slope is greater than 20% were disregarded while calculating the area (A). The recharge figures for each block were then obtained. The Nadia district experienced an average water table fluctuation of 2.47 meters (GEC, 1984). Due to the district's affiliation with the New Alluvial Zone, the specific yield values for Nadia were taken to be 0.11 (NAZ). Nadia's entire recharging area was 3927 square kilometres.

Total Groundwater Draft Estimation

When determining a basin's categorization status and recommending suitable water harvesting infrastructure, knowledge about the yearly groundwater draught is essential. Information on the type of well, the number of wells in the study zone, and the number of operating days was provided by the office of the Assistant Engineer (Agri-Irrigation), Kalyani, Nadia. The unit draught of the wells was determined using GEC (Ground Water Estimation Committee) criteria (Chowdhury 2016).

Estimation of Stage of Groundwater Development

Depending on the amount of groundwater resources available and the groundwater draught, the groundwater assessment unit was divided into four separate categories: safe, semi-critical, critical, and overexploited. Safe: groundwater development is less than 70%; semi- critical: groundwater development is between 70% and 90%; critical: groundwater development is between 90% and 100%; overexploited: groundwater development is greater than 100%. The GEC-recommended technique was used to examine the Nadia category (GWREM 1997):

$$\frac{\text{Annual Net Ground Water Draft}}{\text{Annual Ground Water Recharge}} \times 100 \qquad ...(5)$$

RESULTS AND DISCUSSION

Estimation of Recharge due to Rainfall

Total average rainfall of the Nadia District per year = 1330.22 mm = 133.02 cm. The estimated recharges due to rainfall taking the average of different methods are tabulated in Table 2.

Table 2: Estimation of recharge due to rainfall

Formula	Annual rainfall		Annual recharge	
	cm	inch	inch	cm
Bhattacharjee (1954)	133.02	—	—	21.45
Chaturvedi (1973)	133.02	52.37	8.512	21.62
Datta and Das (1973)	133.02	—	—	23.5
GEC 1984 methodology	133.02			27.17

Average annual recharge = 23.44 cm = 0.234 m

Table 3: Block wise volume of ground recharge

Name of the block	Geographical area (ha)	Volume of Recharge in million cubic metre (MCM)
Karimpur-I	28155.07	65.88286
Karimpur-II	17032.4	39.85582
Tehatta-I	13089.5	30.62943
Tehatta-II	26699.83	62.4776
Kaliganj	15638.62	36.59437
Nakashipara	27133.71	63.49288
Chapra	12436.68	29.10183
Krishnaganj	9245.53	21.63454
Krishnanagar-I	35448.51	82.94951
Krishnanagar-II	32092.44	75.09631
Nabadwip	24955.43	58.39571
Santipur	17247.22	40.35849
Hanskhali	21415.83	50.11304
Ranaghat-I	22437.76	52.50436
Ranaghat-II	30597.12	71.59726
Chakdaha	15159.94	35.47426
Haringhata	24628.78	57.63135
Total amount of Recharge		873.79

Total ground water draft

Total annual ground water draft have been calculated and tabulated in the Table 3 following the CGWB (Central Ground Water Board) recommendation.

Table 4: Total annual ground water draft

Name of the sources	Structures	Number	Average Discharge (m^3/sec)	Average Operating hours /day	Total annual draft in million cubic metre (MCM)
Ground Water	Tube well	29640	0.025	13	1265.76

Stage of ground water development

The following calculation has been made using Eq.5 to determine the stage of ground water development: (1265.80/873.80) × 100 % = 144.90%. The district's groundwater development stage, when taking recharge sources into account, is 144.86%, or more than 100%, indicating that the land is overexploited. The quantity of overall recharge may have grown slightly, lowering the ratio, had additional sources of recharge been taken into account. For the research area, the level of groundwater development will range from critical to overexploit.

CONCLUSION

In order to critically assess the groundwater scenario in this area, the current study intended to estimate the various groundwater recharge components and the average annual dynamic exploitable/ utilizable groundwater reserve. Estimates place the total groundwater recharge from precipitation as 873.79 MCM. The research area's projected net annual ground-water draw, which exceeds total groundwater recharge, is 1265.76 MCM. The block's groundwater development stage is 144.90%, or more than 100%, when only two sources of recharge are taken into account, indicating that the land is overexploited. The amount of total recharge may have grown slightly, decreasing the ratio as represented by stage of groundwater development, if alternative sources of recharge were taken into account. However, for the research area, the groundwater development stage will range from critical to overexploit. Therefore, the current study advises improving groundwater recharge in the study region using any appropriate methods and limiting indiscriminate use of this precious and vulnerable resource by implementing appropriate and sustainable management practices. In addition to providing irrigation water, the phased construction of rainwater harvesting facilities may also be very helpful in supplying domestic water for most of the blocks in this district, which is in desperate need of water due to the alarming level of arsenic contamination of the ground water. The structures and erections for schools, universities, and workplaces may be employed in roof top water collection. Another option to lessen the need for irrigation water is to choose crops that demand as little water as possible and implement appropriate water application techniques.

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