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ASSESSMENT AND MANAGEMENT OF WATER RESOURCES : A CASE STUDY OF SHAHABGANJ BLOCK, CHAKIA TAHSIL, VARANASI DISTRICT. UTTAR PRADESH, INDIA

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ABSTRACT : The study area is better endowed with ground water resources as compared to surface water resources but the rate of utilization is considerably higher at present in the case of the latter. The main source of surface water-supply is from the reservoirs built on the Karamnsa river whereas the fine and medium sand aquifers in the underlying alluvium form the main source of the ground water-supply. A study of the water quality shows that it is suitable both for domestic and agricultural purposes. On the basis of the assessment, present utilization and the available potential, the most suitable methods for the development of the water resources have been suggested.

Introduction

The Shahabganj Block (83° 14' E to 83° 21' E longitude aud 24° 58'N to 25° 10'N latitude) is situated in the Middle Ganga Plain and covers an area of 15,806 hectares on either side of the Karamnasa river. It occupies the north-eastern part of the Chakia Tahsil in south-eastern Varanasi District, Uttar Pradesh. The northern boundary is demarcated by the Chandauali block (Chandauli Tahsil) and the southern by the Naugarh block (Chakia Tahsil) whereas the eastern and the western boundaries are demarcated by the Bihar state and the Chakia block (Chakia Tahsil) respectively. The block (Shahabganj) is well connected by road with the district headquarters (Varanasi city) as well as with the Chakia tahsil headquarters (Chakia town) and the Chandauli tahsil headquarters (Chandauli town).

As regards the land use in the area, it is mainly under agriculture since 83·62% (13,217 ha in 1978-79) of the total area is under cultivation. The area is well endowed with irrigation facilities as the net irrigated area (13,086 ha) is 82% of the total area. Further, the gross irrigated area (13,946 ha) is 63·24% of the gross sown area (22,054 ha).

The area under study often witnesses drought conditions and hence has been included under the the ' drought prone area programme' of the Uttar Pradesh Government. The area is covered mainly by the alluvial deposits, with a small part in the south coming under the rocks of the Vindhyan system. The area is well endowed with surface and ground water resources. The main source of surface water-supply is from a chain of reservoirs built on the Karamnasa river. This has also helped to regulate the discharge of the river which is very much seasonal in nature. The ground water resources are being tapped from the various types of wells like tube-wells, pumping-sets and masonary wells.

It may be mentioned at the outset that the assessment of the water resources in the area is mainly tentative in nature since the data available at present is not exact or complete in itself, for instance, the data as regards surface runoff and ground water recharge from rainfall, and rate of seepage from irrigation water.

Relief and Drainage

The study area falls in the micro-region termed the 'Chakia-Chunar Plain' in the scheme of regional division of India (Singh, R. L., 1971, p 246). This may further be divided into (i) the alluvial flat, and (ii) the foot hills (rocky tract). The former occupies the central and the northern part of the block and is formed of clay, silt, sand and occasional kankar nodules, whereas the latter occupies the southern part and is formed of the upper Vindhyan rocks, mainly sandstone. The general slope of the ground is towards the north. The general elevation of the ground is about 100 metres above mean sea level. Several hillocks are found along the southern border of the block with elevations between 210 and 260 metres above mean sea level.

The alluvial tract is topographically almost featureless and is subjected to only minor fluvial action. On the other hand the rocky tract is somewhat undulating and forms the northern fringe of the Vindhyan plateau. It is devoid of any conspicuous soil cover and hence presents a barren appearance.

The block is drained by the Karamnasa river which flows through a narrow and shallow valley in the area. The river discharge exhibits marked seasonal variations. Thus, the river is often heavily flooded during the rainy season whereas it is reduced to complete insignificance during the rest of the year. The river has no tributaries in this block.

Climate

The study area comes under the subtropical monsoon type of climate (Cwg). The summers (March to middle June) are fairly hot and the temperature rises up to 47°c. The rainy season (middle June to September) brings about 86.35% of the average annual rainfall (103.30 cm). The winter season (October to end of February) often brings spells of shivering cold. The average temperature in the season is 30°C. However, the average annual maximum and minimum temperatures are 41°C and 5°C respectively.

Geology

The different rock formations found in the study area are shown below:

Upper Pleistocene to Recent	Newer alluvium	Sand, Silt, Clay
Middle to Upper Pleistocene	Older alluvium	Clay with Kankar, fine to course grained sand
	Unconformity	
Pre-Cambrian	Upper Vindhyan (Kaimur Series) Sandstone	

The alluvium forms the main aquifer and covers about 80% of the area of the block. It consists of sand, silt, clay, kankar and their mixtures in varying proportions. The thickness of the alluvium in the area increases from south to north, the maximum being 67 m.

The rocks of the Upper Vindhyan system cover about 1/5th of the area of the block. They extend beneath the alluvium towards the north and mainly comprise of sandstone which displays different shades of colours from yellow to reddish brown. It is fine to medium grained. It is largely fractured and highly jointed in nature. The joints are mainly vertical. The sandstones often exhibit current bedding–an indication that they were deposited under shallow water with rapidly changing physical conditions of deposition.

Occurrence of Ground Water

Ground water occurs both in the unconsolidated alluvial deposits and in the joints and fractures of the consolidated sandstones. However, the latter is not regarded as a good source of water-supply

Table I : Hydrological data of Block Shahabganj

Sl. no.	Well no.	Village	Depth to water table from the ground Surface (m) 1977 Max.	1977 Min.	1977 Range of fluct-uation	1978 Max.	1978 Min.	1978 Range of fluct-uation
1.	S-1	Shahabganj	9.08	4.23	4.85	9.80	4.52	5.28
2.	S-2	Mubarakpur	5.90	3.18	2.72	8.16	2.72	5.44
3.	S-3	Ilia	5.10	1.42	3.68	4.00	1.72	2.28
4.	S-4	Ven	3.25	0.96	2.29	2.90	1.42	1.48
5.	S-5	Gandhinagar	9.00	3.36	5.64	8.63	3.87	4.76
6.	S-6	Naudiha	8.60	1.42	7.18	6.40	4.90	1.50
7.	S-7	Khileh	9.18	4.26	4.92	6.70	3.62	3.08
		Average fluctuation			4.46			3.06

Two years average fluctuation = 3.93 m.

Source : G. W. I. O., Varanasi (unpublished).

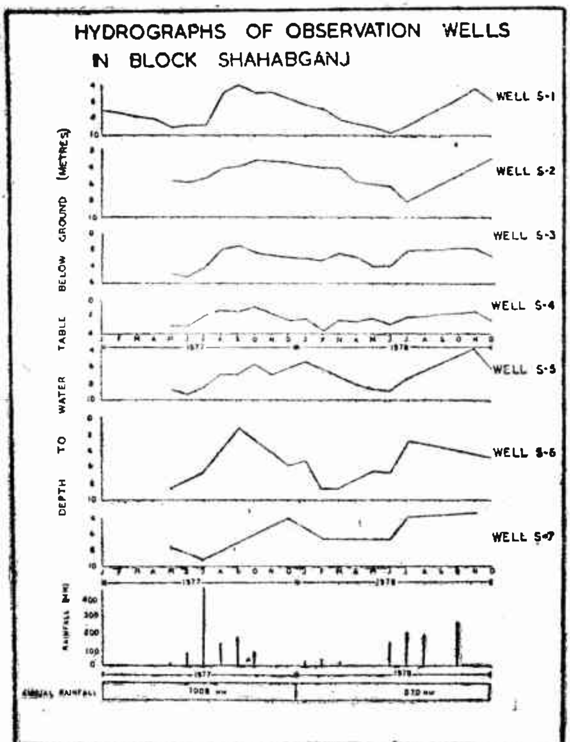

Fig 1

on account of the comparatively smaller storage capacity and also due to the high cost of well construction. In the former, the fine and medium sand strata, especially the well assorted ones form excellent aquifers.

The position of the water table in the study area is being measured from a net-work of well hydrograph stations (Table I) There is great seasonal variation in the position of the water table (Fig 1). It is noted that the ground water table occuers at com-paritively shallow depths and shows a fluctuation of about 4 metres.

Sources of water

1. Surface Water :- In the study area, the main source of surface water is from three interconnected storage reservoirs, that is, Bhainsora (uppermost), Naugarh, and Moosakhand (lowermost) on the Karamnasa river. Out of these, the Moosakhand dam and just below it, the Latifshah weir, are located in the study area. The water from these reservoirs is supplied through a network of canals all of which take off from the Latifshah weir (Fig.2). However, most of the local surface runoff, in the absence of

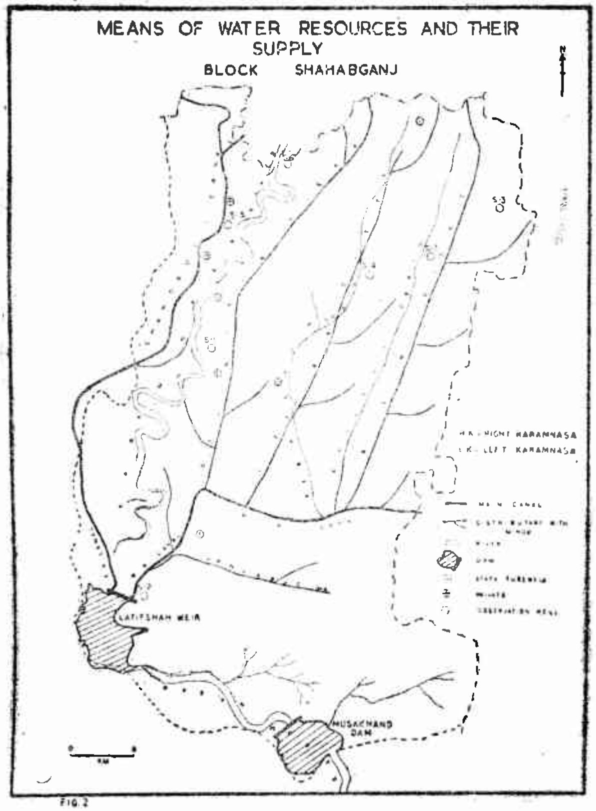

FIG 2

any significant storage in the area, reaches the Karamnasa river and finds its utilization only further downstream. A small proportion of the river water is also directly utilized in the area through a chain of 6 electric pumping sets fixed on the river.

2. **Ground Water :—** The fine and the medium sand aquifer in the alluvium forms the main source of ground water in the study area. The avarage depth for the water table below the ground is 8m. The ground water is being pumped out by the the different types of works (Table III). The masonary wells, lead all the others as regards the total number, followed in that order by pump-set masonary wells with persian wheel, private tube-wells and state tube wells. However, as regards the average discharge of a work, state tube-well is the most important, followed in that order by private tube-well, pumping-set, masonary well with persian wheel and masonary well. It may be pointed out here that of an average depth of 100m of a state tube-well, the total thickness of the aquifers average 47·5m (Fig· 3). The state tube-well, private tube-well, pumpset and masonary well with persian wheel are mainly used for supplying water for irrigation whereas the masonary well is mainly used for domestic water-supply.

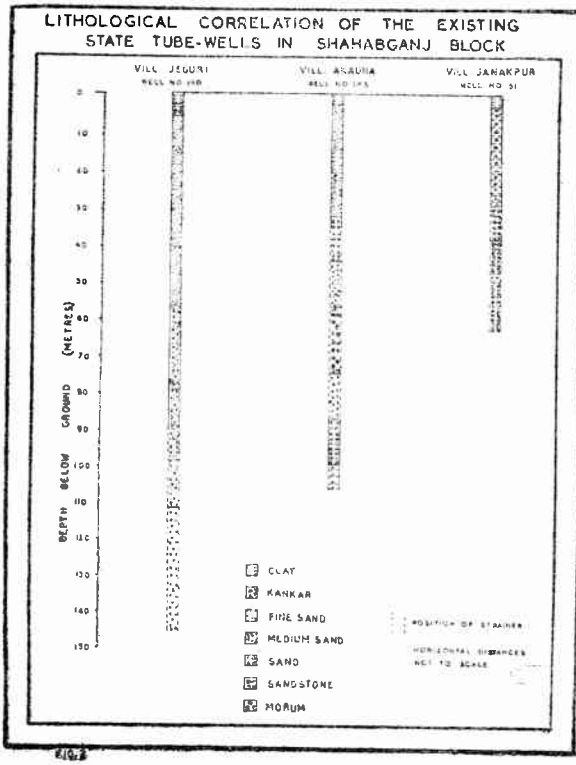

FIG 3

Assessment of water resources generated in the Shahabganj Block

1. **Surface Water :** The surface water in the area results from local rainfall and can, therefore, be computed from the water balance method by finding out the water surplus, as shown below for a normal year

Rainfall (P)	= 113.9 cm
Actual evapotranspiration (AE)	= 103 cm
Therefore, annual water surplus	= (P – AE)
	= (113.9 - 103)
	= 10.9 cm
Volume of water surplus	Area x Depth

$$= 15806 \times \frac{10.9}{100} \text{ hm}$$

$$\frac{15806 \times 10.9}{100 \times 100} \text{ mcm}$$

$$= 17.13 \text{ mcm}$$

Table II : Discharge of water for irrigation from canals in Shahabganj Block in 1978-79

Sl. No.	Name of Canals	Discharge at inlet in the block (cumec)	Discharge at outlet from the block (cumec)	Discharge utilization in block (cumec)
1.	Right Karamnasa main canal	1.8687	0	1.8687
2.	Govindpur distributary	0,2265	0	0.2265
3.	Lehra distributary	0,2265	0	0.2265
4.	Ben distributary	0.2265	0	0.2265
5.	Kurwa minor	0.1416	0	0.1416
6.	Sapra minor	0.0849	0	0.08849
	Total	2.7747	0	2.7747

Source : U. P. Govt. Irrigation Deptt., Varanasi (unpublished).

Table III : Ground water pumped by different types of work in Shahabganj Block (1978-79)

Sl. No.	Types of work	No. of Works	Rate of pumpage per work (m c m)	Total pumpage (m c m)
1.	State Tube-well	3	0.142	0.426
2.	Private Tube-well	41	0.022	0.902
3.	Pumpset	181	0.014	2.534
4.	Masonary well with persian wheel	108	0.0092	0.9936
5.	Masonary well	916	0.0052	5.038
	Grand Total	-	-	9.8936

Source : U. P. Govt. Distt. Statistical Office, Varanasi (unpublished).

Out of this surplus, the proportion of surface runoff and ground water recharge have been fixed at 20% and 80% respectively on the basis of the average conditions prevailing in the area.

Therefore, the volume of average surface runoff and ground water recharge amount to 3.45 and 13.78 mcm respectively. However the runoff, in the absence of any significant storage in the area, reaches the Karamnasa river and finds its utilization only further downstream.

2. Ground water :— This comprises of : (1) ground water recharge in the area (2) ground water in storage in the area.

(1) **Ground water recharge in the area :—** It results from influent seepage from (i) rainfall (ii) canals and (iii) irrigated fields.

(i) **Recharge due to influent seepage from rainfall :—** The Uttar Pradesh Government Ground Water Investigation Organisation (henceforth written as G. W. I. O.) has established 7 well hydrograph stations in the block where water levels are being observed at monthly intervals since the inception of the stations. The ground water recharge due to influent seepage from rainfall in the area has been computed from two different methods, as shown below for the year 1978-79.

(a) **Water table method–**

Recharge= Area (h) x specific yield (%)* x average water table rise (m)

$$= \frac{15806 \times 2 \times 3.93}{100 \times 100} \text{mcm}$$

$= 12.42$ mcm.

(*A figure of 2% for the specific yield value in the area has been computed by taking into account the work of the G. W. I. O.)

(b) **Water balance method–**

Recharge= 80% of water surplus.

The water surplus, as calculated earlier, comes to 17.23 (mcm)

Therefore, recharge= $17{\cdot}23 \times \frac{80}{100}$

$= 13.78$ mcm.

(ii) **Recharge due to influent seepage from canals–** This has been computed by fixing the average rate of seepage as 1·83 cumec per million sq. metre of wetted area, by taking into account the average conditions prevailing in the area.

Therefore, recharge in 1978–79 =

Average number of canal running days x average wetted perimeter (m) x length of canal (km) x average rate of seepage

(a) For branch canals :

$$\frac{122 \times 14.33 \times 20 \times 1000 \times 1.83 \times 0.0864}{10^6} \text{mcm}$$

(∵ 1 cumec – day = 0.0864 mcm)

= 5·53 mcm

(b) For distributaries :

$$\frac{122 \times 4.57 \times 119 \times 1000 \times 1.83 \times 0.0864}{10^6}$$

= 10.49 mcm

Table IV

Chemical analysis of water samples from wells in block Shahabganj

Chemical constitutents and quality	Shahabganj	Mubarakpur	Iliya	Naudiha
T.D.S. (PPm)	298	664	548	238
E.C. (in micromhos/cm)	447·42	958·71	838·92	372·85
pH Value	7·8	7·5	7·8	7·5
Cl	5·68	85·2	65·3	14·2
HCO_3	283·04	303·5	292·8	195
SO_4	9·06	13·6	100·0	18·9
Si + + +	8·39	9·3	12·19	7·46
Fe + + +	12·60	15·4	12·60	8·4
Ca + +	32·85	85·7	71·42	21·4
Mg + +	12·0	13·2	14·4	7·2
Na +	11·04	55·2	39·10	18·6
S.A.R.	0·42	1·46	1·10	0 89
S.I.	–23·40	–18·98	–20·59	–22·64
S.G.	C_2S_1	C_3S_1	C_3S_1	C_2S_1
Result	Good	Moderate	Moderate	Good

S.A.R. = Sodium adsorption ratio
S.I. = Salt Index
S.G. = Salinity group

Source: Tech. Memo. No. 25, Drought Prone Area Programme, Uttar Pradesh Goverment, Lucknow, 1978 (unpblished),

Therefore, total seepage = (a) + (b)
= 5.53 + 10.49
= 16.02 mcm

(iii) **Recharge due to influent seepage from irrigated fields :** It has been computed by fixing the average rate of seepage as 35% of the total water applied to the field, by taking into account the average conditions prevailing in the area. The total discharge of water for irrigation from the different canals comes to 2.7747 cumec (Table II).

Therefore, recharge in 1978-79 = Average number of canal running days x volume of water released for irrigation x average rate of seepage

$$= \frac{122 \times 2.7747 \times 0.0864 \times 35}{100} \text{ mcm}$$

= 10.24 (mcm)

Therefore, total recharge from all the sources
= (i)* + (ii) + (iii)
= 13.10 + 16.02 + 10.24
= 39.36 mcm

(*The average of the two values (12.42 and 13.78) has been taken here.)

2. **Ground water in storage in the area :** This has been computed by taking into account the thickness, the area, the porosity and the specific yield of the aquifers.

In the present case :

Average thickness of aquifers = 47.5 m
Average porosity of aquifers = 30 per cent.
Aaea under aqifers = 15,806 ha

Therefore, ground water in storage = Volume of saturated aquifers x porosity

$$= 47.5 \times 15806 \times \frac{30}{100}$$

= 225235.5 hm
= 2252.36 mcm

The amount of stored ground water available for development will be given by applying the specific yield factor, that is, 2 per cent.

Therefore, available stored ground water = ground water in storage x specific yield

$$= 2252.36 \times \frac{2}{100}$$

= 45.05 mcm

Assessment of water resources generated outside the Shahabganj block

1. **Surface water :** — The surface water resources of the study area, generated outside the area, are in the form of discharge in the Karmanasa river. A portion of this discharge is utilized in the area by means of canals taking off from the Latifshah weir. As given earlier (Table II), the total river discharge utilized in the area in 1978-79 comes to 2·7747 cumec.

Therefore, the surface water utilized = Average number of canal running days × volume of water released for irrigation

= 122 × 2.7747 × 0.864 mcm
= 29.25 mcm

Then, the total surface water potential = surface water generated in the area + surface water generated outside the area

= 3.45 + 29.25
= 32. 70 mcm

2. **Ground water :**— The ground water resources of the study area, generated outside the area, are in the form of ground water inflow which ultimately passes out of the area as ground water outflow. The direction of movement approximately conforms to the surface drainage, that is, from south to north. The ground water inflow may be taken to be equal to the outflow since little, if any, of the former is being utilized in the area. Therefore, the total ground water available for development that is, ground water potential = renewable ground water + stored ground water

= 39·36 + 42.05
= 84.41 mcm

Utilization of water resources

1. **Surface water :**—As pointed out earlier the surface runoff from local rainfall is not

being utilized in the study area. However, the surface water being utilized in the area is from the diversion of a portion of the water of the Karamnasa river by canals taking off from the Latifshah weir situated at the south-western corner of the block (Fig. 2). As given earlier (Table II), the total water thus utilized in the area comes to 29·25 mcm in 1978-79.

2. Ground water:— As shown in Table III the total ground water utilized in 1978-79 comes to 9·89 mcm.

Quality of water

As a resource, the quality of ground water is as significant as its quantity. The water quality is assessed from a study of its chemical, physical and bacteriological characteristics and its suitability for domestic, agricultural and other purposes is determined. For this study, water samples from a total of 4 dug wells were collected and analysed by standard laboratory methods. The results of the analysis are presented in Table IV. It becomes obvious from this table that the quality of water in the area is suitable for dvmestic, agricultural and other purposes.

Prospects of future development of resources

Almost all of the water available from the Karamnasa river for the block is already being utilized in the block. As regards the surface water from local rainfall the same has not so far been utilized in the area in the absence of adequate storage facilities.

In view of the foregoing coniderations, any further development of the water resources in the area will have to be from an increased exploitation of the ground water potential of the area since only 11.73% of the potential (84.41mcm) has so far been utilised.

There is a definite possibility of increasing the ground water potential of the area since the ground water of the area has not been fully explored. Further, there are good prospects of converting the existing open wells into dug cum bore wells. Moreover, large diameter open wells with infiltration galleries may be constructed, especially in the rocky part of the area.

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