punjab geographer

A JOURNAL OF THE ASSOCIATION OF PUNJAB GEOGRAPHERS, INDIA

VOLUME 6 OCTOBER 2010

ASSESSMENT AND DEMAND OF WATER RESOURCES IN REWARI DISTRICT OF HARYANA

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Abstract

Water has emerged as an exceedingly important resource and its increasing demand in agriculture, domestic and industrial uses ranks it a resource of strategic importance. Its adequate and continuous supply is the most important input in agriculture and has made a significant contribution in providing stability to food grain production and self–sufficiency to societies. This resource can be optimally used and sustained only when quantity of water is assessed at micro level. In the present study an attempt has been made to assess the availability and demand of water resources at block level during kharif and rabi season in Rewari district of Haryana during 2004-08. The average depth of available water during the study period in the district was observed to be 453 mm, out of which rainfall, canal and groundwater contributed about 56.7%, 37.2% and 6.1%, respectively. The available water within the district is not adequate to meet the total crop water demand during rabi season however water is surplus for the kharif season crops. The average seasonal crop water demand of the district was estimated to be about 212 mm for kharif season and 254 mm for the rabi season. The annual water demand exceeded average annual available water in the district by 1831 ha-m. The above findings point towards the fact that, there is a need for scientific and rational conservation and utilization of water resources in the district which is possible through interventions like design of suitable recharge structures that would commensurate with the rate of draft and can bridge the gap between water availability and demand.

Introduction

The earth's population has quadrupled in the last 100 years and water use has grown by a factor of seven. Unfortunately, water is increasingly becoming scarce in many parts of the world. Moreover, rapid industrial development, urbanization and increase in agricultural production have led to water shortages. An increasing gap between water supply and demand poses a threat to poverty reduction, ecological sustainability and future economic growth (Kumar and Seethapathi, 2002; Kumar et al. 2002; Goyal, 2003; Sethi et al. 2008; Aggarwal et al. 2009a & b). The balance between water supply and demand in a sustainable manner, under natural climate variability as well as long-term climate change, is crucial to local viability and vitality (Morehouse, 2000; Pawar and Tiwari, 1997). In India, the livelihood of more than two-thirds of the population depends on agriculture. In recent decades, population growth and changes to more profitable crops have boosted water demand. Traditional canal irrigation has been widely replaced by more assured groundwater irrigation with subsidies from the government (Ambast et al. 2006; Shah et al. 1998). Intensive withdrawals of groundwater in excess of natural recharge over the years have affected the environment causing a continual fluctuation in the potentiometric levels (Balukraya, 2000). Due to excessive mining of aquifers in fresh groundwater areas of Punjab and Haryana, groundwater table depths started falling at a rate of 2–3 m annually. As a result, the groundwater dropped to depths that were inaccessible in 5% and 15% of the irrigated areas (Aggarwal et al. 2009a & b; Tanwar, 1998). Further, the groundwater boom has triggered groundwater level declines with severe consequences such as wells running dry, increasing costs for drilling and pumping, higher vulnerability to droughts and salinity ingress (Chatterji et al. 2009).

Haryana being mostly arid or semi-arid is in a disadvantageous position with regard to quantity of water. Estimates indicate that the groundwater has registered an average decline of about 35 cm per year in depth (Chatterjee and Purohit, 2009). On an average, the state receives 545 mm of rainfall annually, as compared to the environmental demand of 1500 mm. Further, a growing population, consumption driven growth, climate change, non-recycling of used water and poor conservation habits are widening the gap between demand and supply of water. Moreover, farmers have abandoned traditional crops that required less water and switched to paddy, lured by frequent price hikes. Widespread aquifer depletion and water scarcity are the vital symptoms of an imminent crisis. The shortage of water resources for agricultural, industrial and domestic purposes has become more striking. The scarcity of water particularly during crop growth stages is well pronounced and it has a significant bearing on the agriculture of the state. For the existing cropping pattern and a total cropped area of about 6.2 million ha, the gross annual irrigation water requirement of Haryana has been estimated at 46 BCM. In the backdrop of above cited preamble, facts and issues, the present study is aimed to assess the block-wise availability and demand of water resources in Rewari district of Haryana so as to estimate the gap in demand and supply of water resources in the region.

Study Area

Rewari district of Haryana state lies between 27° 46' to 28° 28' North latitudes and 76° 15'to 76° 51' East longitudes. Total geographical area of the district is 1509 km2. The district has been divided into five development blocks viz. Bawal, Jatusana, Khol, Nahar and Rewari for the purpose of administration (Fig. 1). The elevation of land in the district varies from 232 m above mean sea level in the north to 262 m in south. The slope of the area is towards the north. Sahibi is the major river of the district. It is an ephemeral river and rises from Mewat hills in the state of Rajasthan. There are various other small nalas also which carry rain water from the hills during monsoon season. The climate of district can be classified as tropical steppe, semi-arid and hot which is mainly dry with very hot summer and cold winter except during monsoon period. The mean minimum and maximum temperature in the district ranges from 5.6° C to 41° C during January and June respectively. The normal monsoon and annual rainfall of the district is 489 mm and 553 mm, respectively, which is unevenly distributed over the area and spreads over just 23 days during the year. Generally, rainfall in the district increases from southwest to northeast. Soils of the district are light

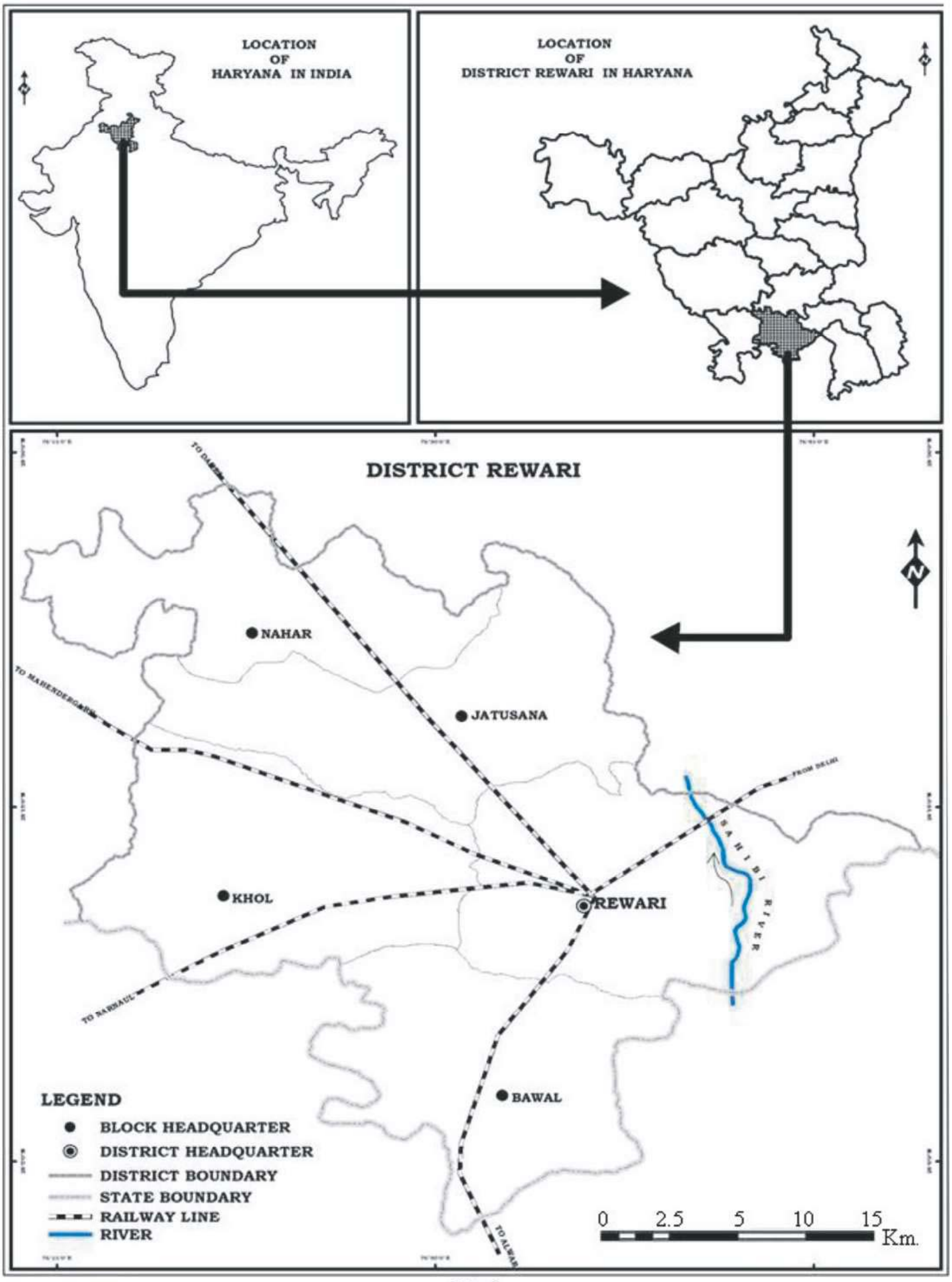

LOCATION
OF
HARYANA IN INDIA
LOCATION
OF
DISTRICT REWARI IN HARYANA
DISTRICT REWARI
TO DADRI
NAHAR
JATUSANA
TO MAHENDERGARH
FROM DELHI
SAHIBI RIVER
KHOL
REWARI
TO NARNAUL
BAWAL
TO ALWAR
LEGEND
BLOCK HEADQUARTER
DISTRICT HEADQUARTER
DISTRICT BOUNDARY
STATE BOUNDARY
RAILWAY LINE
RIVER
0 2.5 5 10 15
Km.

Fig. 1

coloured, medium textured and calcareous. Most of the area of the district is fit for cultivation. Therefore, the agriculture forms the backbone of the district. The total irrigated area in district is 143000 ha and majorily irrigated by shallow and deep tube wells (District Statistical Officer, Rewari). Jawaharlal Nehru canal forms the canal drainage pattern with a network of distributaries and minors supplying surface water in the district.

Materials and Methods

Adoption of sound analytical techniques in any scientific investigation is necessary for proper interpretation because they act as foundation stones of the study. In order to meet and achieve the proposed set of objectives of the present study the following sections present a brief overview of the adopted methodologies.

Assessment of Available Water Resources and Demand of Water

The seasonal (*Kharif* and *Rabi*) and annual available water resource in each block of Rewari district was computed by adding the available groundwater, canal water and rainfall recharge. The demand of water was computed in the from of crop water requirement (evapotranspiration) for major crops grown in the district. The data pertaining to the present study were collected from secondary sources both in published and unpublished format.

Assessment of Groundwater Recharge Due to Fluctuations in Water Table

The data pertaining to water table for the period 2004-08 in the district for pre and post-monsoon period were obtained from Groundwater Cell, Department of Agriculture, Narnaul (Mohindergarh). This method takes into account the specific yield, the mean water table rise and the area of the aquifer. Mathematically it is calculated as:

$$R = A x Y x NS \qquad (1)$$

where, R= Recharge (ha-m),
A = Area of aquifer (hectare),
Y = Specific yield of the hydrogeological unit and
NS = Fluctuations in groundwater table during pre and post-monsoon periods (m).

Based on Ground Water Resources Estimation Committee (GWREC, 1997) norms, specific yield for district was assumed as 6% because the district broadly forms a part of Indo-Gangatic alluvial plain of the Yamuna basin. Moreover, 75% recharge due to groundwater fluctuations is accounted during *kharif* season while remaining 25% recharge for the *rab*i season.

Assessment of Recharge from Canal Seepage

The data regarding wetted perimeter, wetted area and daily canal water release were obtained from Irrigation Department of the district for the period 2004-2008 and on the basis of daily discharges, season-wise discharges were computed. Recharge from canal seepage (R_s) depends upon the size and cross-section of the canal, depth of flow, characteristics of soils in the bed, sites and location and level of drains on either side of the canal. It is calculated as:

$$R_s = WP \times WA \times NCR \times SF \qquad (2)$$

Where, R_s = Recharge from canal seepage (ha-m),
WP = Total wetted perimeter (m),
WA = Wetted area (m),
NCR = Number of canal running days (94 days for *Kharif* and 92 days for *Rabi* season) and
SF = Seepage factor.

Daily seepage rate for unlined canals in normal soil (sandy loam) was considered as 20 ha-m/day/10^6 m^2 of wetted area of canal and for lined canals it is 6 ha-m/day/10^6 m^2 of wetted area of canal (CGWB, 2005; Chatterji et al. 2009;Chatterjee and Purohit, 2009; Kumar et al. 2002).

Assessment of Recharge from Rainfall

The daily rainfall data (2004-2008) for different blocks of the district was obtained from the office of the District Revenue officer, Rewari. The rainfall pattern in the district is erratic and non-uniformly distributed. Moreover, rainfall contributes towards surface runoff, groundwater recharge, deep percolation and other losses. For the computation of rainfall recharge, 50 per cent of the total rainfall was taken as effective rainfall which contributes to crop water requirement (Gaur, 2001; Mathur and Jain, 1981). The amount of rainfall recharge was calculated by multiplying the 50 % amount of rainfall (meter) with the area (hectare) of the respective block.

Estimation of Crop Water Requirement (Evapotranspiration)

For calculating crop water requirement, data on total area for major *kharif* and *rabi* crops (2004-2008) for the study area were collected from Department of Agriculture, Rewari, Haryana. The main crops grown in study area are jowar, bajra, cotton, paddy and sugarcane during *kharif* season and wheat, barley, gram and oilseeds during *rabi* season. Pan evaporation data were collected for the study period (2004-2008) from Haryana Agricultural University Regional Station located at Bawal. Month-wise crop coefficient and crop growth days for different crops were used as suggested (Jalota and Arora, 2002). The evapotranspiration was estimated by using the following equation:

$$ET = k \times E_p \quad (3)$$

where, ET = Evapotranspiration

k = Crop coefficient, and

E_p = Pan evaporation

Further, crop-wise evapotranspiration was estimated using area and growing period (days) under each crop.

Variation in Supply and Demand of Water Resources

Block-wise estimation of the deficit/ excess of water resources was obtained by taking the difference between the available water resources i.e. canal water, rainfall, groundwater and evapotranspiration demand depending upon prevailing cropping pattern and climatic condition for *kharif* and *rabi* seasons.

Results and Discussion

Assessment of the Available Water Resource

The total available water resource in each block was computed from the available canal water, rainfall and groundwater resource of respective block and the results are presented in Table 1. The available water resource for irrigation in the Rewari district was 68442 ha-m, out of which 50732 ha-m (74%) in *kharif* season and 17710 ha-m (26%) in *rabi* season. The average depth of available water in the district was observed to be 453 mm, out of which rainfall, canal and groundwater contributed about about 56.7%, 37.2% and 6.1%, respectively. It was also revealed from the Table 1 that water availability was in descending order in blocks of Bawal (733 mm), Rewari (506 mm), Jatusana (358 mm), Khol (333 mm) and Nahar (307 mm). The maximum annual average water availability was observed in Bawal block (22957 ha-m) while the least was observed in the Nahar block (8230 ha-m) (Table 1). The maximum annual availability of water in Bawal block of Rewari district may be due to a very good network of canals in comparison to other blocks of the district. Moreover, a good amount of rainfall received by this block during the study period 2004-

2008 also contributed to maximum availability of water. Further, it was also revealed from the analysis that tube well density and cropping intensity was least in this block (16.2 tube wells/km2 and 136%, respectively). The analysis also revealed that rain water availability was maximum in the Rewari block during 2004-08 period. The average annual effective rainfall was calculated as 257 mm. The average canal water availability in the district ranged from 17-403 mm in different blocks (Table 1). Bawal block received maximum canal water supply during the study period in both the seasons. The maximum rainwater availability for crop evapotranspiration during *kharif* and *rabi* seasons was observed to be 403 mm and 57 mm in the year 2008 and 2007, respectively. Khol block evidenced negative groundwater recharge and it is mostly attributed to very less amount of rainfall in the block. During the study period Khol block experienced only 298 mm of average rainfall in comparison to 619 mm and 594 mm average rainfall received by Rewari and Bawal blocks respectively.

Cropping Pattern and Crop Water Requirement

Block-wise analysis of cropping pattern and evapotranspiration of different crops was carried out for the Rewari district for the period 2004 to 2008 and the average water evapotranspiration requirements of different crops during *kharif* and *rab*i season are presented in Table 2 and 3, respectively. Bajra was the major crop during *kharif* season occupying nearly 91% of the total cropped area followed by cotton (6%). In *rabi* season, the average area under oilseeds was 58% followed by wheat (40%). The area under bajra varied from 50379 ha (2004) to 64060 ha (2007) in *kharif* season during the study period, whereas in *rabi* season area under oilseeds varied from 64048 ha (2007) to 74727 ha (2005). During the *kharif* season area under bajra crop increased and area under cotton crop decreased during 2004-08 period. However, during *rabi* season area under wheat and oilseeds did not reported any definite trend. The total cultivated area in the district showed a increasing trend as it increased from 177386 ha (2004) to 183421 ha (2008).

The average annual crop water demand in the Rewari district was observed to be about 70273 ha-m out of which 32000 ha-m (46%) was in the *kharif* season and 38273 ha-m (54%) in the *rabi* season (Table 2-3). The analysis also revealed that Rewari block has the maximum crop water requirement whereas Bawal block has the minimum crop water requirement. Further, the average seasonal crop water requirement of the district was estimated to be about 212 mm for *kharif* season and 254 mm for the *rabi* season. Table 2 reveals that the maximum crop water demand was 338 mm in *kharif* season for the Rewari block whereas minimum crop water requirement of 136 mm was estimated for Jatusana block. Similarly for *rabi* season the maximum crop water requirement of 273 mm and minimum crop water requirement of 225 mm was reported by Nahar and Bawal blocks respectively during the study period (Table 3). Bajra and cotton are the crops which require the maximum amount of water during the *kharif* season whereas water requirement of wheat and oilseeds crop is maximum during the *rabi* season. Crop water requirement was almost fulfilled by rainfall during the *kharif* season. However, irrigation is used as a supplemental source during the dry spell. But in the *rabi* season to meet the crop water requirement groundwater and canal water is the only source of irrigation for the farmers in the area.

Table 1
Rewari District: Block-wise Average Assessment of Available Water Resources (2004-08)

Blocks	*Kharif* (ha-m)			*Rabi* (ha-m)			Annual water available (ha-m)	Area of block (ha)	Annual rain water depth (mm)	Annual canal water depth (mm)	Annual groundwater depth (mm)	Depth of available water (mm)
	Rainfall	Canal water	Ground Water	Rainfall	Canal water	Ground Water						
Rewari	8894	2389	1194	1082	2338	398	16296	32213	310	147	49	506
Bawal	8384	6386	764	918	6250	255	22957	31329	297	403	33	733
Jatusana	7554	663	1249	808	649	416	11338	31679	264	41	53	358
Khol	3778	3207	-781	538	3139	-260	9620	28927	149	219	-33	333
Nahar	6111	230	711	716	225	237	8230	26782	255	17	35	307
Total	**34720**	**12875**	**3137**	**4063**	**12601**	**1046**	**68442**	**150930**	**254**	**169**	**28**	**453**

Source: Compiled by Authors

Table 2
Rewari District: Block-wise Water Requirement of Kharif Crops (2004-08)

Blocks	Water Requirement (ha-m)					Total ET (ha-m)	Depth of required water (mm)
	Paddy	Bajra	Jowar	Cotton	Sugarcane		
Rewari	5689	4774	139	271	7	10880	338
Bawal	92	3506	255	715	5	4573	146
Jatusana	0.00	3502	116	677	5	4299	136
Khol	7	4042	103	842	0	4994	173
Nahar	471	4958	64	1759	2	7254	271
Total	**6259**	**20781**	**677**	**4264**	**18**	**32000**	**212**

Source: Compiled by Authors

Table 3
Rewari District: Block-wise Water Requirement of Rabi Crops (2004-08)

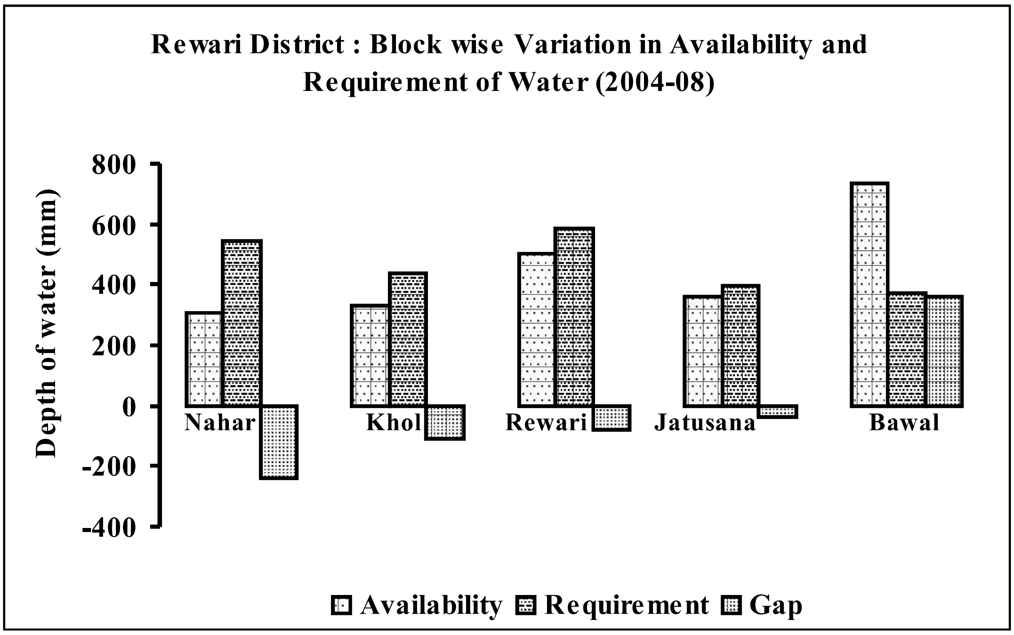
Blocks	Water Requirement (ha-m)				Total ET (ha-m)	Depth of required water (mm)
	Wheat	Gram	Barley	Oilseeds		
Rewari	3115	88	88	4619	7910	246
Bawal	2100	17	55	4880	7053	225
Jatusana	3408	7	109	4753	8277	261
Khol	2698	11	85	4933	7728	267
Nahar	2318	11	43	4934	7305	273
Total	**13640**	**135**	**380**	**24119**	**38273**	**254**

Source: Compiled by Authors

Variation in Water Availability and Water Demand

The analysis revealed that the annual water requirement exceeded average annual available water in the district by 1831 ha-m. A deficit of about 20563 ha-m water was observed during the *rabi* season in the district. Moreover, a surplus of about 18282 ha-m water was experienced during the *kharif* season in the district during 2004-08 period. The availability of surplus water during *kharif* season is attributed to short duration crops of jowar and bajra. Block-wise variation in water availability and its requirement has been presented in figure 2. Negative signs on the figure indicate the water deficit whereas positive sign indicate water surplus to crop water requirements. The analysis shows that maximum and minimum annual water deficit of 236 mm and 39 mm is recorded by Nahar and Jatusana blocks, respectively. However, Bawal block evidenced a water surplus of about 361 mm and it is presumably attributed to good canal network, less tube well density, low cropping intensity and higher amounts of annual rainfall.

The block-wise variation in availability of water for irrigation and crop evapotranspiration requirement of water for *kharif* and *rabi* season of Rewari district has been presented in Fig. 3 and 4. It is revealed from figure 3 that Rewari block experienced a



Source: Compiled by Authors

Fig. 2

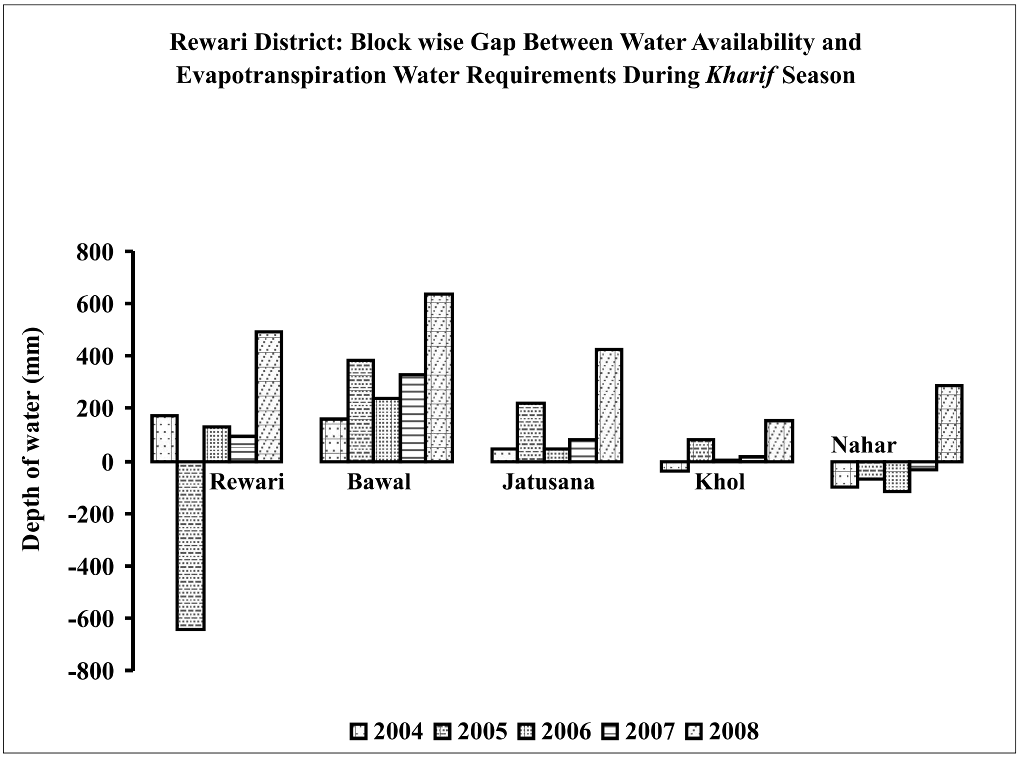


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Fig. 3

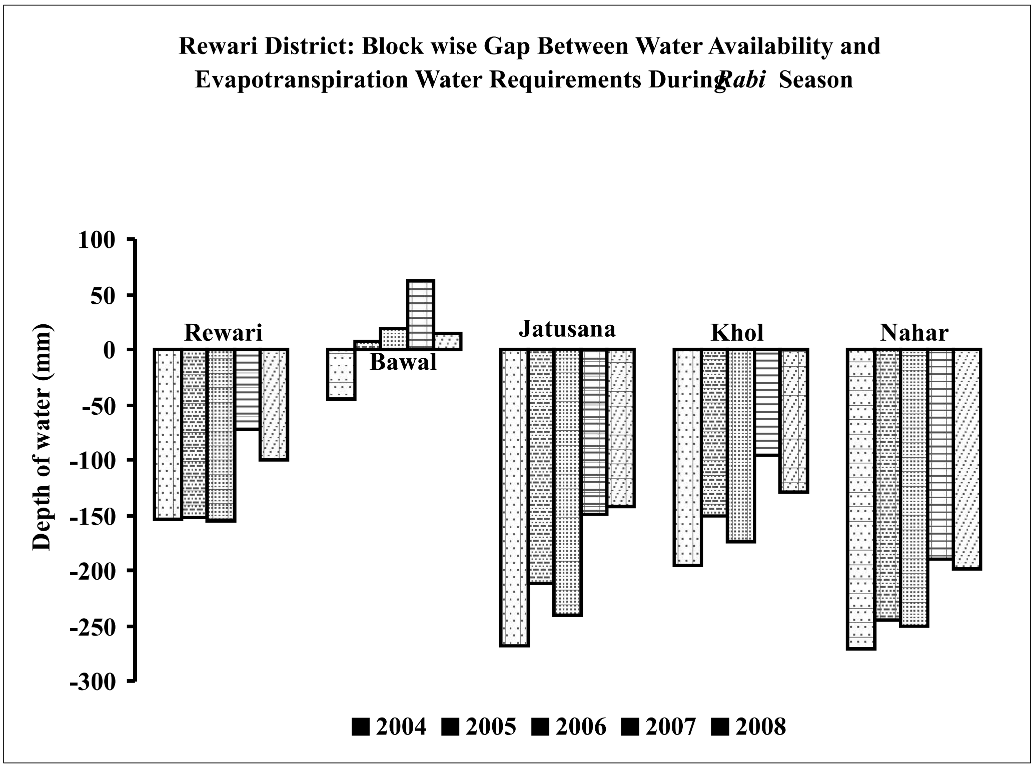

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Fig. 4

deficit of about 643 mm during 2005. Bawal and Jatusana block experienced a water surplus during the entire study period (2004-2008). It was also observed that kharif season experienced a water surplus in all the blocks of the district during the year 2008. It is attributed to normal monsoon season during the year. Moreover, *rabi* season demonstrated a water deficit in all the blocks of the district during the study period except the Bawal block. However, Bawal block also evidenced a water deficit of 45 mm during the year 2004 (Fig. 4).

Conclusions and Recommendations

The study presents a systematic account of water availability in five blocks of Rewari district in Haryana on the basis of groundwater, canal seepage and rainfall during 2004-2008. The demand of water resources in the district has been estimated on the basis of crop water requirement. Bajra is the major *kharif* crop in the district and it occupied more than 90% of the total cropped area whereas oilseeds and wheat are the major *rabi* crops and occupying about 58% and 40% of the total cropped area respectively. The analysis revealed that Bawal block has the maximum annual average water availability (22957 ha-m) whereas Nahar block has the minimum water availability (8230 ha-m). The average depth of available water in the district was observed to be 453 mm, out of which rainfall, canal and groundwater contributed about 56.7%, 37.2% and 6.1%, respectively. The average seasonal crop water demand of the district was estimated to be about 212 mm for *kharif* season and 254 mm for the *rabi* season. The study also demonstrated that Rewari block has the maximum crop water requirement (18790 ha-m) whereas Bawal block has the minimum water requirement (11626 ha-m). However, on an average a surplus of about 18282 ha-m water was experienced during the *kharif* season in the district during 2004-2008. The annual water demand exceeded average annual availability of water in the district by 1831 ha-m. The analysis showed that maximum and minimum annual water deficit of 236 mm and 39 mm was observed in Nahar and Jatusana blocks, respectively. A deficit of about 20563 ha-m water was observed during the *rabi* season in the study area. In *rabi* season all the blocks of the district demonstrated a water deficit during the study period except the Bawal block. However, Bawal block also evidenced a water deficit of 45 mm during the year 2004.

The analysis of the present study indicates that the district is gradually shifting towards overexploitation of water resources. Therefore, in view of the rapidly changing demographic profile and land utilization pattern an appropriate water resource development plan for the district is urgently required to eliminate the prevailing imbalance of water resources. If preventive measures are not taken up to rationalize the demand with water availability, the district will be devoid of water in the near future. Denying the land owners the ownership rights of groundwater, levying a cess on its extraction, separation of agricultural and non agricultural feeders for supplying power in villages, location specific recharge structures to replenish fast depleting water resource would provide the district with a buffer. Periodic assessment of groundwater resources should be given top priority on the behalf of water resource managers. Groundwater regulatory measures need to be imposed in severely over-exploited areas through pro-active approach. Aravli hills which is acting as a recharge zone in the district should be protected as groundwater sanctuary. Moreover, check dams need to be raised at the outlet of streams and other hydrogeologically sensitive areas to harvest the rainwater. It is worthwhile to mention here that contaminated rainwater to be avoided for rainwater harvesting. Improved irrigation practices (sprinkler and drips) should be followed in order to reduce burden on water. Village ponds need to be revived with community effort to ensure that ground water gets replenished. Better water management at the individual levels is the need of the hour. Cropping pattern in the area should be changed by growing low water consuming crops namely, mustard and gram during the *rabi* season. For effective outcome of these management strategies, stakeholders should be actively involved in the implementation process. Mass awareness and mass mobilization of the people on the various facets of groundwater management in the Rewari district is therefore an utmost necessity. There should be holistic management approach for the entire water resources of the district in broader perspective of technical, ecological, social and economical considerations. However, to ensure a pragmatic and enduring solution for the persisting problem of water resources in the district, systematic and well structured research activities need to be carried out prior to any intervention.

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