Research Paper Engineering

Assessment of Ground Water Recharge by Water Harvesting Structures Using Remote Sensing and GIS. A Study of Jamka Village

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ABSTRACT

Though groundwater is an important source of irrigation in India, its availability is non-uniform in space and time. In Saurashtra region of Gujarat state, problem of groundwater depletion has arisen due to high withdrawal than rate of replenishment of groundwater. This also resulted in seawater intrusion in coastal areas at very high rate. The water harvesting and groundwater recharge activities played an important role in increasing the groundwater resource and also improved the quality of groundwater and decreased the rate of seawater intrusion in the region. In present study, groundwater recharge created through water harvesting structures in Jamka microwatershed had been estimated and efficient utilization of groundwater available in study area was suggested using remote sensing and GIS.

Keywords : ground water, Remote sensing, GIS, Water harvesting structure.

INTRODUCTION

Groundwater is the largest available source of fresh water lying beneath the ground it has become crucial not only for targeting of groundwater potential zones, but also monitoring and conserving this important resource. Besides targeting groundwater potential zones it is also important to quantify natural as well as artificial groundwater recharge in the region. Keeping this in view the present study attempts to quantify groundwater recharge in Saurashtra region areas using an integrated approach of remote sensing and GIS. It is true that satellite alone cannot provide information regarding aquifers, the geophysical and drilling data have to be consulted for acquiring subsurface information and decision file shall be created through overlay by GIS technique.

STUDY AREA

The study area is Jamka micro watershed 5G1C4, Tal. and Dist. Junagadh, Saurashtra region of Gujarat. It is located between 21o18'49.64" N to 21o21'49.03" N latitude and 70o30'31.85" E to 70o33'19.42" E longitude and falls under Survey of India Toposheet number 41K/11. It covers 1275 ha of land.

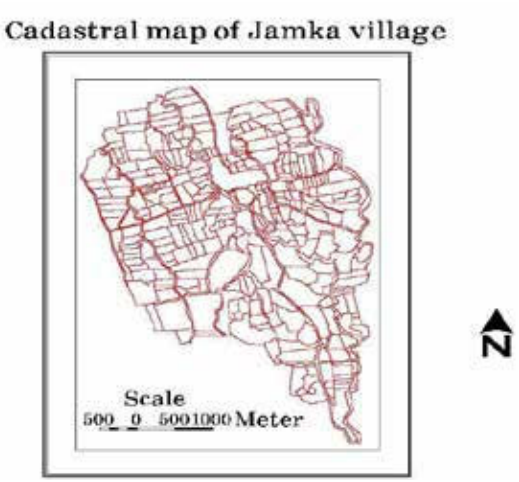

Fig. Jamka micro watershed

DATA SET USED

1. Map of India (Scale 1:15, 00,000), Gujarat (Scale 1:37, 50,000) and Watershed map of Gujarat (Scale 1:37, 50, 000).
2. Cadastral map of Jamka village (Scale 1:4000)
3. Satellite image of IRS 1D, PAN + LISS III merged data (November 2002) of study area.
4. Satellite images of IRS P6 of sensor LISS III (26 Nov 2009), AWiFS (13 January 2010) digital data and images from Google Earth.

METHODOLOGY

1. Visual interpretation
2. Ground truth and data collection
3. Preparation of thematic maps
4. Groundwater recharges estimation using empirical formulae

Chaturvedi formula (1936) $Rg=2(P-15)^{0.4}$ Where, Rg is net recharge, in inches, P is annual rainfall, in inches

U.P.I.R.I. Formula (1954) It is given by Uttar Pradesh Irrigation Research Institute, Roorkee (1954) as follows (Kumar, 1996), $Rg = 1.35 (P-14)^{0.5}$

Krishna Rao formula (1970) He gave the following empirical relationship for Karnataka state (Kumar, 1996). Rr=K(P-X) where, Rr is groundwater recharge, mm, P is precipitation, mm and K is recharge coefficient

Bhattacharjee formula (1954) by(Annual report of AICRP on groundwater utilization, 2006-07), $R=3.47(P-38)^{0.4}$ where, R is groundwater recharge, cm and P is precipitation, cm

5. Estimation of artificial groundwater recharge from water harvesting structures

The water harvesting structures existing in watershed were identified using merged images of LISS III and PAN of IRS 1D. Then areas under submergence in these structures were identified. Taking the average depth of storage from ground truth information of the study area the volume of water stored in the structures was estimated. From this volume of impounding evaporation losses in study area deducted.

Volumes of water formula;

Vs=C*As*H

where, Vs is volume of impounding of water in structures (ha m), As is water spread area in ha, H is average depth of storage, and C is storage coefficient.

6. Total groundwater recharge

After estimating groundwater recharge through various sources. Total groundwater recharge in the study area through various sources is calculated by using following general equation for recharge;

R = Rr + Ri + Rg + Rsi + Rt + Rc + Rp

where, Rr is recharge from rainfall, Ri is recharge from return flow of irrigation water, Rgi is groundwater inflow in the area, Rs is influent seepage from rivers, Rt is seepage from tanks and ponds and Rc is seepage from canals and Rp is groundwater draft (Anonymous, 2008b).

7. Groundwater recharges estimation using water table fluctuation method

Groundwater recharge was estimated using water table fluctuation method. Two years (2009 and 2010) water table fluctuation data of the study area were used for groundwater recharge estimation using following formula;

Rg=Aw*ΔL*Sy ---(1)

where Rg is groundwater recharge, Aw is area of watershed (m2), Sy is specific yield and ΔL is water table difference (m)

RESULT AND DISCUSSION

Estimation of natural groundwater recharge through rainfall

The recharge percentages with these empirical formulae were estimated at 15.99, 15.04, 15.71, 12.20 and 14.60 per cent respectively. The recharge percentage with respect to rainfall with all these empirical approaches varies 12 per cent to 16 per cent with an average of 14.71 per cent.

Assessment of artificial groundwater recharge

The water harvesting structures were identified with the help of Google earth map of the study area i.e. Jamka micro watershed and same structures were located in PAN+LISS III image of November 2002 for study area. The total numbers of recharge structures present in the study area are 51 but only 27 recharge structures were identified through satellite image. Total volume of impounding of water in these structures was estimated 55.64 ha m. The evaporation loss in the study area for the month of July to December was found 145.2 mm. So evaporation and other losses in the study area was estimated as 5.54 ha m. Using volume of impounding after subtracting evaporation and other losses from volume of water impounded as 50.12 ha m recharge volume was estimated assuming recharge three times that of volume of impounding. Total volume of recharge was found 150.37 ha m in the study area.

Estimation of total groundwater recharge

After estimating groundwater recharge through various sources.. Total groundwater recharge in the study area was estimated as 407.12 ha m.

Recharge through rainfall (R_r)	239.92
Recharge through return flow of irri. water (R_i)	16.83
Influent seepage from structures (R_s)	150.37
Total Recharge (ha m):	407.12

Estimation of groundwater recharges using water table fluctuation data

The groundwater recharge for the two years 2009 and 2010 was computed using Eq. 1.By using this method recharge percentage with respect to rainfall estimated for the year 2009 and 2010 as 27.13 and 20.77 per cent respectively. Total recharge volume for year 2009 and 2010 were 377.49 and 373.56 ha m respectively.

Comparison between groundwater recharge estimated through water table fluctuation method and total groundwater recharge

Total groundwater recharge through rainfall and water harvesting structures in the study area was found 407.12 ha m. While, recharge estimated through water table fluctuation method was estimated as 377.49 ha m for year 2009 which indicates difference in recharge volume of 29.63 ha m. Recharge through rainfall and seepage from structures is more than that of recharge estimated from water table fluctuation.

CONCLUSION

1. The natural groundwater recharge through rainfall in the study area was found varying from 12 to 16 per cent of annual rainfall.
2. Remote sensing and GIS technique used to determine water spread area of 51 water harvesting structures and used for estimation of total groundwater recharge from water harvesting structures and found as 150.37 ha m.
3. The total groundwater recharge through rainfall, water harvesting structures and return flow of irrigation water in the study area was estimated as 407.12 ha m.
4. The groundwater recharge estimated using water table fluctuation data was found less than the recharge estimated through rainfall and storage structures. This indicates the groundwater outflow from microwatershed.
5. Groundwater recharge estimated from rainfall and water harvesting structures was 407.12 ha m which can irrigate 422.05 ha of wheat crop by applying 627 mm water with 65 per cent application efficiency.

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