Ground water balance study in the command area of Sanand branch canal, Gujarat, India using GEC 1997 and Geoinformatics Technology

Daksha Katariya[1], Prof. P.K. Shah [2], Dr. Indra Prakash [3], Khalid Mehammud [4]

[1] *PG Student, Water Resources Management, L.D.Collage of Engineering, Gujarat, India*
[2] *Prof. P.K. Shah, Water Resources Management, L.D.Collage of Engineering, Gujarat, India*
[3] *Dr. Indra Prakash, BISAG, Gandhinagar, India*
[4] *Khalid Mehammud BISAG, Gandhinagar, India*

ABSTRACT

The study aims to analyze the changes that occurred in ground water condition after the construction of Narmada branch canal in the Sanand area. Ground water balance study carried out using GEC 1997 method in GIS environment indicated that ground water draft is decreased from 6316 Ha m to 2289.6 from 2001 to 2010, mainly due to less utilization of ground water after canal irrigation. This trend will continue in future if ground water is exploited systematically as per the water balance analysis.

Keyword: - *Canal, Sanand, water balance equation, GEC 1997*

1. INTRODUCTION

Canal irrigation in India is the requirement of present day due to inadequate and erratic rainfall in conjunction of groundwater. Quantification of ground water is a basic need for efficient ground water resource development. Water resources are limited, moreover rapidly expanding urban, industrial and agricultural water requirement, ground water utilization is of much importance.

The aim of this study is to assess and analyze the changes in ground water for Sanand taluka using Geoinformatics technology after the construction of canal. Analysis of the data has been carried out for the period 2001 to 2010.

2. STUDY AREA

Sanand is a Taluka of Ahmedabad district. It is located at 22.98°N 72.38°E. It has an average elevation of 38 meters (124 feet). Annual rainfall varies from 319.44 mm to 1262.5 mm from 2000 to 2010 in study area. More than 70 per cent of the annual rainfall occurs during the monsoon season from July to September. More than 90% is agriculture land in Sanand. Most of Sanand is a fertile plain having Fine Loamy soil. At present land use pattern in the area is changing due to fast industrial development.

The Sanand Branch Canal is 28.170 Km long, passes through Kadi Taluka of Mehsana District and Sanand Taluka of Ahmedabad District. Sanand Branch Canal crosses Irana-Indroda drain at Ch. 3.259 Km. It emanates from Narmada Main Canal at Ch. 258.632. There are Paddy, Cotton, Juvar, Pulses, Wheat, Vegetables, Gram, and Linseed Crops generally being shown in the command area of this canal. The general slope of command is flat. There are 8 No's of falls with total 17.087 m drop depth of all falls, constructed on the canal to traverse the geography.

The canal was constructed during the period 1998 to 2004 and fully operated since 2005. It is capable of running discharged at head 31.387 cumecs and at tail 8.074 cumecs. There are 18 no's of bridges, 5 no's of Nalah crossing and no river crossing locate at the canal for passing through the region.

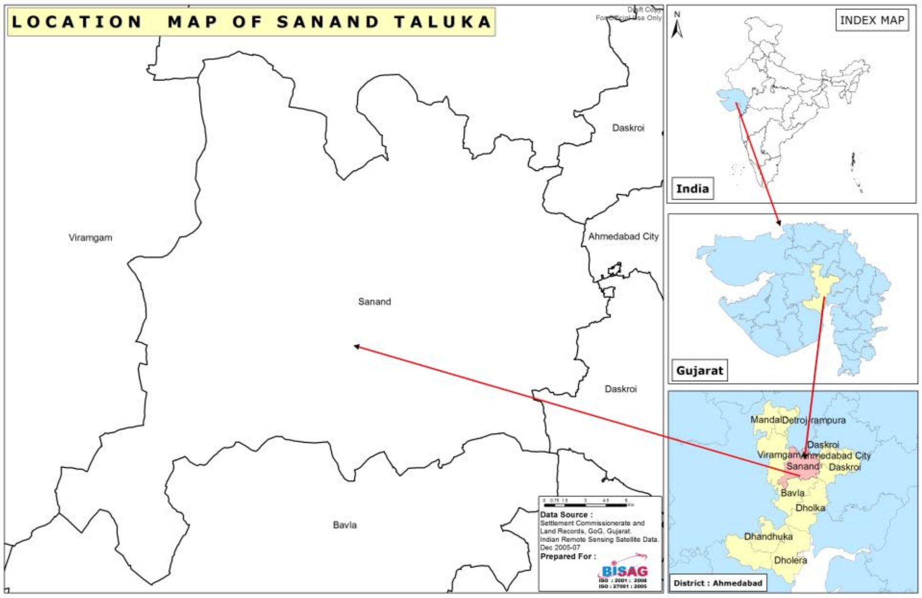

Fig -1: Study Area Location map

3. DATA COLLECTION

Ground water and rainfall data has been collected from various government agencies such as State Water Data Center, Gujarat and Groundwater investigation unit1, Ahmedabad. In the present analysis data of one exploratory well located at Latitude: 22°55'49", Longitude: 72°26'52" have been used. Top elevation of this well is at RL: 32.85 m.

Table -1: Ground water levels

Sr. No.	Time	Water Level (m)	Reduced Water Level (m)
1	May 01	9.90	22.95
2	Oct 01	8.50	24.35
3	May 04	10.65	22.2
4	Oct 04	7.00	25.85
5	May 09	4.95	27.9
6	Oct 09	3.90	28.95
7	May 11	4.10	28.75
8	Oct 11	2.40	30.45

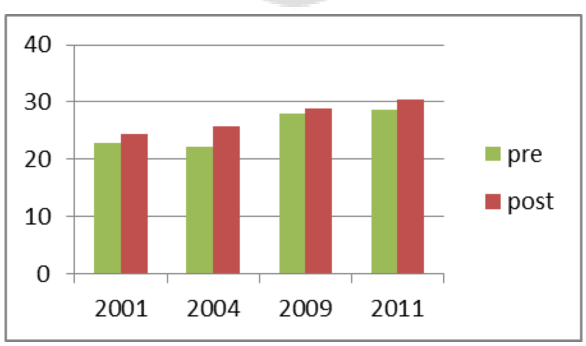

Fig -2: Pre-post Groundwater Levels

Rain fall data has been obtained for the period 1999 to 2010 of Sanand Taluka. Average annual rainfall varies from 319.44 mm to 1262.5 mm.

Table -1: average annual rainfall

Sr. No.	Year	Avg. annual rain (mm)
1	1999	745
2	2000	534
3	2001	530
4	2002	319.44
5	2003	739.4
6	2004	1051.6
7	2005	1073
8	2006	878.5
9	2007	913.5
10	2008	860.5
11	2009	363.5
12	2010	1262.5

4. METHODOLOGY

Ground water analysis is carried out using ground water balance equation which is as follow:

Input -Output = Storage Change

In the above equation, the terms input and output are used in the general sense, referring to all components of ground water balance. Hence input refers to recharge from rainfall and other sources and output refers to ground water draft. Above equation holds good for any period of year and hence it can be applied to the year as a whole or to different seasons separately. Considering the various inflow and outflow components in a given study area, the groundwater balance equation can be formulated as:

$$Rr + Rc + Rt + Si + Ig = Tp + Se + Og + DS$$

Where,

Rr = recharge from rainfall
Rc = recharge from canal seepage
Rt = recharge from tanks
Si = influent seepage from rivers
Ig = inflow from other basins
Tp = draft from groundwater
Se = effluent seepage to rivers
Og = outflow to other basins
DS = change in groundwater storage

At present, the methodology recommended by "Ground Water Estimation Committee" in 1997 (GEC1997) is being used to ground water balance equation.

5. GEC 1997 METHOD

Basic Equation

Inflow-Outflow=Change in Storage

Inflow Components

- Rainfall Recharge
- Recharge From canals
- Recharge From Tanks & Ponds
- Recharge From Water Conservation Structures

Outflow Components

- Gross Draft

5.1 CALCULATION STEPS

1) Estimation of Recharge Due To Rainfall:

i) Rainfall infiltration factor method

RRF = Area × NMR × RFIF

Where,

RRF = Recharge due to rainfall
Area = Total area of the subunit
NMR = Normal Monsoon Rainfall
RFIF = Rainfall infiltration Factor

ii) Water level fluctuation method

$\Delta S = h \times Sy \times A$

Where,

ΔS = Change in storage
h = Rise in water level in the monsoon season
Sy = Specified yield
A = Area of sub unit

For the year 2001:

h1 = 9.90 & h2 = 8.50
Sandy soil with Alluvial plain, so Sy = 16%

$\Delta S = h \times Sy \times A$

Where,

h = 9.90 – 8.50 = 1.40 m
Sy = 0.16
A = 80007.402 Ha

$\Delta S = 1.40 \times 0.16 \times 80007.402$
= **17921.66 Ha m**…………………2001

For the year 2010:

h1 = 4.10 & h2 = 2.40
Sandy soil with Alluvial plain, so Sy = 16%

$\Delta S = h \times Sy \times A$

Where,

h = 4.10 – 2.40 = 1.70 m
Sy = 0.16
A = 80007.402 Ha

$\Delta S = 1.70 \times 0.16 \times 80007.402$
= **21762.013 Ha m**………………2010

2) Estimation of Recharge Due To Canal

Rc = WA × Days × SF

Where,

Rc = recharge due to canal segment in Ha m
WA=Wetted Area in Million Sq. m
SF = Seepage Factor in Ha m/Million Sq. m/day

WA= WP × L

Where,

WA =Wetted Area in Million Sq. m
WP =Wetted perimeter
L = Length of Canal Segment in Km

$$WP = \frac{2 \times ASD}{Sin\theta} + BW$$

Where,

WP=Wetted perimeter in m

ASD = Average Supply Depth in m = 0.6 × FSD

θ = Side slope of the canal in Degrees

BW = Bed width of the canal in m

Canal reach Name – Sanand Branch Canal
Reach Type – lined
Lithology – Sandy Soil
Length – 28.170 km
Full Supply Depth – 3.70 m
Bed Width – 6 m
Slope – 45°
Running Days – 100 days
Canal Seepage Factor = 20% (25 Ha m/day/million sq. m)
= 5 Ha m/day/million sq. m

ASD = Average Supply Depth in m
= 0.6 × FSD = 2.22 m

$$WP = \frac{2 \times ASD}{Sin\theta} + BW$$
$$= (2 \times 2.22 \div \sin 45) + 6$$
= 12.279 m

WA = WP × L
= 12.279 × 228170
= 35987.6 sq. m = 0. 346 million sq. m

Rc = WA× Days × SF
= 0.346 × 100× 5
= **173 Ha m**……….……..………..2010

3) Estimation of Ground Water Draft:

GGWD = ∑ no × unit draft

Where,

GGWD = Gross Ground Water Draft in any season

No = Number of Abstraction Structures

Unit Draft = Draft For one abstraction structure

Unit Draft= Draft per day × No of days the structures are in use

Total No of Abstraction Structures = 2862
Daily draft = 40 m3/day
No of days = 200

Unit Draft = Draft per day × No of days the structures are in use
= 40 × 200 = 8000 m3

GGWD = ∑ no × unit draft
= 2862 × 8000
= 22896000 m3
= **2289.6 Ha m**……………..2010

5.2 TOTAL GROUND WATER RECHARGE

$TGWR = R_{RF} + R_C$

Where,

TGWR = Total Ground Water Recharge

R_{RF} = Recharge due to Rainfall

R_C = Recharge due to Canals

5.3 STORAGE CHANGE

$\Delta S = TGWR - GGWD$

Where,

TGWR = Total Ground Water Recharge

GGWD = Gross Ground Water Draft in any season

6. ANALYSIS OF DATA

For 2001:

Gross Ground Water Draft in 2010 = 6316 Ha m
(Source: CGWB)

Total Ground Water Recharge:

$TGWR = R_{RF} + R_C$

= 17921.66 + 0 = 17921.66 Ha m

Storage change:

$\Delta S = TGWR - GGWD$

= 17921.66 – 6316 = **11605.66 Ha m**

For 2010:

Total Ground Water Recharge:

$TGWR = R_{RF} + R_C$

= 21762.013 + 173 = 21935.013 Ha m

Storage change:

$\Delta S = TGWR - GGWD$

= 21762.013 – 2289.6 = **19645.413 Ha m**

7. RESULTS AND CONCLUSIONS

Ground water balance study has been carried out for the study area using GEC 1997 method in GIS environment. Analysis of the data and results indicated that ground water draft is decreased from 6316 Ha m to 2289.6 from 2001 to 2010, mainly due to less utilization of ground water after canal irrigation. This has resulted in the increse of storage of ground water from 11605.66 Ha m to 19645.413 Ha m during the study period. This trend will continue in future and thus improve the quality of ground water in this area. It is suggested that exploitation of groundwater in future in Sanand area should be carried out as per the water balance analysis.

8. REFERENCE

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