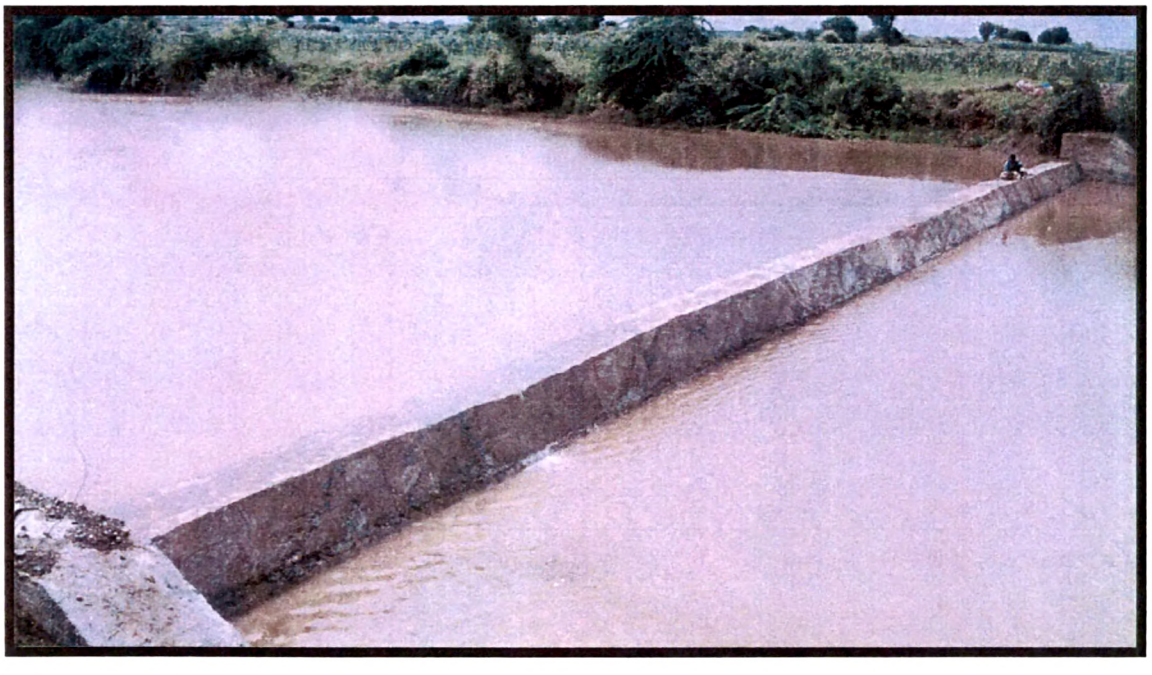
Chapter - 6

Impact of Checkdams on Ground Water Regime



6 IMPACT OF CHECKDAMS ON GROUND WATER REGIME IN VARIOUS TALUKAS OF RAJKOT DISTRICT

6.1 GROUND WATER ASSESSMENT AND DATA ANALYSIS

In order to study the impact of the check dams constructed between years 2000 to 2006 on the ground water recharge in Rajkot district, comparative study of following parameters for the years 1997, 2002 and 2006 has been taken up on the basis of the detailed ground water assessment studies that have been carried out in Rajkot district. The aspects which have been studied in detail taluka wise are the following:

- Total geographical area (Km^2)
- Hilly area having >20% slopes (Km^2)
- Saline area (Km^2)
- Net suitable area (Km^2)
- Normal monsoon rainfall (mm) (for years 1961 to 2006) (IMD)
- Average monsoon rainfall (mm) (for years 1991 to 2006)
- Normalization factor (NF)
- Average rainfall (mm)
- Average water level fluctuation data
- Specific yield (2% is considered for this study as per "Report ground water resources estimation committee - 1997", Ministry of Water Resources, Government of India. Para No. 5.9.1)
- Rain water harvesting structures like check dams, village ponds & percolation tanks which are not silted and are functional only considered

- Area under irrigation, details of lined and unlined canals & number of days running, storage of water in reservoir of Major, Medium & Minor irrigation projects for calculation of seepage & contribution to ground water recharge
- Flood prone areas and numbers of days for which area remains flooded
- Number of wells with electric motors up to 7.5 HP & yield is considered as 0.01 Mm^3/year
- Number of wells with electric motors 7.5 to 15 HP & yield is considered as 0.012 Mm^3/year
- Number of wells with electric motors 15 to 30 HP & yield is considered as 0.015 Mm^3/year
- Number of wells with electric motors more than 30 HP & yield is considered as 0.02 Mm^3/year
- Number of wells with diesel sets & yield is considered as 0.01 Mm^3/year
- From surface and ground water used for irrigation, 35 % volume is considered as ground water recharge as per "Report ground water resources estimation committee - 1997", Ministry of Water Resources, Government of India (Para No: 5.9.4).

6.1.1 Typical analysis of ground water estimation of Gondal taluka

Detailed analysis of ground water estimation with a view to study the impact of check dams of all talukas are carried out. However, the detailed analysis only for Gondal taluka of Rajkot district for the year 1997, 2002 and 2006 have been narrated as under:

(A) Ground Water Recharge and Draft calculation of Gondal Taluka of Rajkot District. (Year 1997)

(1) Change in ground water storage due to Water table fluctuation (WTF).

Net suitable area x water table fluctuation x specific yield

= 1193 x 5.33 x 0.02

= **127.17 Mm^3.** .....(I)

(2) Recharge through surface water irrigation

= Area irrigated x depth of water x 0.35 seepage

There are four surface water irrigation schemes & data of all schemes are given in Chapter-IV for all talukas.

(I) Recharge through surface water irrigation:

Minor irrigation schemes: Area irrigated 212 ha, Depth of water 0.38 m

(a) Monsoon Recharge:

$= \frac{212 \times 0.38 \times 10^4 \times 0.35}{10^6} = 0.28\ Mm^3.$

Vachhapari irrigation scheme - Area 260 ha & depth of water 0.38 m

$= \frac{260 \times 10^4 \times 0.38 \times 0.35}{10^6} = 0.0.34\ Mm^3$

Total monsoon irrigation recharge = 0.28 + 0.34 = 0.62 Mm^3

(b) Non-monsoon recharge:

Gondali irrigation scheme - Area 40 ha & depth of water 0.65 m

$= \frac{40 \times 10^4 \times 0.65 \times 0.35}{10^6} = 0.09\ Mm^3$

Vachhapari irrigation scheme - Area 235 ha & depth of water 1.15 m

$= \frac{235 \times 10^4 \times 1.15 \times 0.35}{10^6} = 0.94\ Mm^3$

Chhapaewadi irrigation scheme - Area 395 ha & depth of water 0.70 m

$= \underline{395 \times 10^4 \times 0.70 \times 0.35} = 0.97\ Mm^3$

Total non-monsoon irrigation recharge = 0.09 + 0.94 + 0.97 = 2.00 Mm^3

(3) Recharge through ground water irrigation

The details of electric driven & diesel driven pumpsets fitted on wells in all talukas are given in Chapter IV.

The draft for various capacity pumps fitted on wells are taken as per field tests carried out and average draft is taken. (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State, Narmada, Water Resources, Water Supply & Kalpasar Department, Government of Gujarat") Monsoon draft is considered 20% & Non monsoon draft 80%.

Power of pumps fitted on wells	Total Nos	Draft/No (Mm^3/year)	Total draft (Mm^3)	Monsoon Draft (Mm^3)	Non-monsoon Draft (Mm^3)
Up to 7.5 HP	4670	0.01	46.70	9.34	37.36
7.5 HP to 15 HP	474	0.012	5.68	1.14	4.54
15 HP to 30 HP	-	-	-	-	-
30 HP to above	-	-	-	-	-
Diesel sets	4738	0.006	28.43	5.69	22.74
		Total	80.80	16.15	64.64

Recharge from ground water irrigation:

(a) Monsoon recharge = 100% of Monsoon draft = 16.15 Mm^3

(b) Non-monsoon Recharge = 15 % of draft (depth in well 10 to 25 m)
= 0.15 x 64.64 = 9.72 Mm^3

(4) Recharge through seepage from water structures

(a) Losses from Canals

2.5 cumecs/ Mm^2 – Un-lined canal {As per Water Account of RIC}

0.3 cumecs/ Mm^2 –Lined canal

(1) Monsoon seepage:

Vachhapari irrigation scheme - wetted area = 0.009 Mm^2 (unlined)

Canal running days = 20 days

Seepage = $\frac{0.009 \times 20 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.04 Mm^3

(2) Non-monsoon seepage:

Gondali irrigation scheme - wetted area = 0.008 Mm^2 (unlined)

Canal running days = 60 days

Seepage = $\frac{0.008 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.10 Mm^3

Chhaparwadi-I irrigation scheme - wetted area =0.053 (Unlined)

Canal running days = 60 days

Seepage = $\frac{0.053 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.69 Mm^3

Total non-monsoon seepage = 0.10 + 0.69 = 0.79 Mm^3

(b) Seepage from surface water bodies like check dams, percolation tanks etc. (44 cm/year) (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State, Narmada, Water Resources, Water Supply & Kalpasar Department, Government of Gujarat")

Details of structures and water spread area are given in Data collection sheets.

Description	Total Nos. of structures	Water spread area (Mm^2)	Seepage (m)	Monsoon seepage only (Mm^3)
Ponds	00	0.000	0.44	0.00
Percolation tanks	88	0.030	0.44	1.16
Checkdams	49	0.030	0.44	0.64
			Total	1.80 Mm^3

(c) Seepage from flood prone area

Area details are given in Data collection chapter for all talukas.

Yearly flood area = 74.76 km^2 (As per Rajkot District Panchayat record)

Days of flooding = 15 days (Monsoon).

Seepage per year = 0.44 m

Total seepage = $\frac{74.76 \times 15 \times 0.44}{365} = 1.35\ Mm^3$

Recharge from seepage depends on rainfall normalization factor (NF).

NF = $\frac{\text{Normal Monsoon rainfall (Year 1963 to 2002)}}{\text{Average Monsoon rainfall (Year 1991 to 1997)}} = \frac{571.8}{678.0} = 0.84$

X = (Seepage from canal losses + Seepage from tanks + Seepage from flood prone area). =0.04 + 1.80 + 1.35 = 3.19 Mm^3

Actual effect on recharge through seepage = X – (X) **x** (NF)

= 3.19 – (3.19 x 0.84) = **2.68 Mm^3** ..... **(II).**

Ground water seepage (Y) = Ground water draft (monsoon) x 0.25

= 16.15 x 0.25 = 4.03 Mm^3.

Actual recharge = Draft – (Y) x (NF)
= 16.15 – 4.03 x 0.84 = **12.76 Mm^3** ..... **(III)**

Actual monsoon recharge = (I) + (II) + (III).

= 127.17 + 0.45 + 12.76 = 139.78 Mm^3 = Say 140.00 Mm^3

Total recharge = Monsoon recharge + Non-monsoon recharge.

= 140.00 + (2.00 + 9.70 + 0.79) = 152.49 Mm^3.

(B) Ground Water Recharge and Draft calculation of Gondal Taluka of Rajkot District. (Year 2002)

(1) Change in ground water storage due to Water table fluctuation (WTF).

Net suitable area x water table fluctuation x specific yield

= 1193 x 4.12 x 0.02

= **98.30 Mm^3.** .....(I)

(2) Recharge through surface water irrigation

= Area irrigated x depth of water x 0.35 seepage

There are surface water irrigation schemes & data of all schemes are given in Chapter-IV for all talukas.

(I) Recharge through surface water irrigation

Minor irrigation schemes: Area irrigated 1405 ha, Depth of water 0.38 m

(a) Monsoon Recharge

$$= \frac{1405 \times 0.38 \times 10^4 \times 0.35}{10^6} = 1.86 \text{ Mm}^3.$$

(b) Non-monsoon recharge

Bhadar irrigation scheme - Area 250 ha & depth of water 1.4 m

$$= \frac{250 \times 10^4 \times 1.4 \times 0.35}{10^6} = 0.12 \text{ Mm}^3$$

Moj irrigation scheme - Area 2055 ha & depth of water 0.50 m

$$= \frac{2055 \times 10^4 \times 0.50 \times 0.35}{10^6} = 3.59 \text{ Mm}^3$$

Venu-II irrigation scheme - Area 1250 ha & depth of water 0.50 m

$$= \frac{1250 \times 10^4 \times 0.5 \times 0.35}{10^6} = 2.18 \text{ Mm}^3$$

Total non-monsoon irrigation recharge = 0.12 +3.59+2.18 = 5.89 Mm^3

(3) Recharge through ground water irrigation

The details of electric driven & diesel driven pumpsets fitted on wells in all talukas are given in Chapter IV.

The draft for various capacity pumps fitted on wells are taken as per field tests carried out and average draft is taken. (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State,

Narmada, Water Resources, Water Supply & Kalpasar Department, Government of Gujarat") Monsoon draft is considered 20% & Non monsoon draft 80%.

Power of pumps fitted on wells	Total Nos	Draft/No (Mm^3/year)	Total draft (Mm^3)	Monsoon Draft (Mm^3)	Non-monsoon Draft (Mm^3)
Up to 7.5 HP	6272	0.01	62.72	12.54	50.18
7.5 HP to 15 HP	581	0.012	6.97	1.39	5.58
15 HP to 30 HP	49	0.015	0.73	0.147	0.583
30 HP to above	4	0.020	0.08	0.016	0.064
Diesel sets	3529	0.01	35.29	7.05	28.32
		Total	105.79	21.15	84.63

Recharge from ground water irrigation:

(a) Monsoon recharge = 100% of Monsoon draft = 21.15 Mm^3

(b) Non-monsoon Recharge = 15 % of draft (depth in well 10 to 25 m)
= 0.15 x 84.63 = 10.69 Mm^3

(4) Recharge through seepage from water structures

(a) Losses from Canals

2.5 cumecs/ Mm^2 – Un-lined canal {As per Water Account of RIC}

0.3 cumecs/ Mm^2 –Lined canal

(1) Monsoon seepage:

Vachhapari irrigation scheme - wetted area = 0.009 Mm^2 (unlined)

Canal running days = 20 days

$$\text{Seepage} = \frac{0.009 \times 20 \times 60 \times 60 \times 24 \times 2.5}{10^6} = 0.04 \ Mm^3$$

(2) Non-monsoon seepage:

Gondali irrigation scheme - wetted area =0.008 Mm^2 (unlined)

Canal running days = 60 days

$$\text{Seepage} = \frac{0.008 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6} = 0.10 \ Mm^3$$

Vachhapari irrigation scheme - wetted area = 0.009 Mm^2 (unlined)

Canal running days = 60 days

Seepage = $\frac{0.009 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.125 Mm^3

Chhaparwadi-I irrigation scheme - wetted area = 0.053 (Unlined)

Canal running days = 60 days

Seepage = $\frac{0.053 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.69 Mm^3

Total non-monsoon seepage = 0.10 + 0.12 + 0.69 = 0.91 Mm^3

(b) Seepage from surface water bodies like check dams, percolation tanks etc. (44 cm/year) (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State, Narmada, Water Resources, Water Supply & Kalpasar Department, Government of Gujarat")

Details of structures and water spread area are given in Data collection sheets.

Description	Total Nos. of structures	Water spread area (Mm^2)	Seepage (m)	Monsoon seepage only (Mm^3)
Ponds	80	0.010	0.44	0.35
Percolation tanks	110	0.020	0.44	0.96
Checkdams	357	0.030	0.44	4.71
			Total	6.02 Mm^3

(c) Seepage from flood prone area

Area details are given in Data collection chapter for all talukas.

Yearly flood area = 74.76 km^2 (As per Rajkot District Panchayat record)

Days of flooding = 15 days (Monsoon).

Seepage per year = 0.44 m

Total seepage = $\frac{74.76 \times 15 \times 0.44}{365}$ = 1.35 Mm^3

Recharge from seepage depends on rainfall normalization factor (NF).

NF = Normal Monsoon rainfall (Year 1963 to 2002) = 561.5 = 1.48
Average Monsoon rainfall (Year 1998 to 2002) 444.8

The rainfall of 1998 to 2002 is less than average rainfall. Therefore, there is negative effect on ground water (GW) recharge (Monsoon).

X = (Seepage from canal losses + Seepage from tanks + Seepage from flood prone area). =0.04 + 6.02 + 1.35 = 7.39 Mm^3

Actual effect on recharge through seepage = X – (X) **x** (NF)

= 7.39 – (7.39 x 1.48) = **(-) 3.55 Mm^3 ..... (II).**

Ground water seepage (Y) = Ground water draft (monsoon) x 0.25

= 21.15 x 0.25 = 5.28 Mm^3.

Actual recharge = Draft – (Y) x (NF)
= 21.15 – 5.28 x 1.20 = **14.81 Mm^3** ..... **(III)**

Actual monsoon recharge = (I) + (II) + (III).

= 98.30 - 3.55 + 14.81 = 109.56 Mm^3 = Say 110.00 Mm^3

Total recharge = Monsoon recharge + Non-monsoon recharge.

= 110.00 + (5.89+10.69 +0.91) = 127.49 Mm^3.

(C) Ground Water Recharge and Draft calculation of Gondal Taluka of Rajkot District. (Year 2006)

(1) Change in ground water storage due to Water table fluctuation (WTF).

Net suitable area x water table fluctuation x specific yield

= 1193 x 8.23 x 0.02

= **196.36 Mm^3.** .....(I)

(2) Recharge through surface water irrigation

= Area irrigated x depth of water x 0.35 seepage

There are four surface water irrigation schemes & data of all schemes are given in Chapter-IV for all talukas.

(II) Recharge through surface water irrigation

Minor irrigation schemes: Area irrigated 1405 ha, Depth of water 0.38 m

(a) Monsoon Recharge

$= \frac{1405 \times 0.38 \times 10^4 \times 0.35}{10^6} = 1.86\ Mm^3.$

Bhadar irrigation scheme - Area 718.6 ha & depth of water 0.50 m

$= \frac{718.6 \times 10^4 \times 0.50 \times 0.35}{10^6} = 1.26\ Mm^3$

Chhaparwadi irrigation scheme - Area 557 ha & depth of water 0.50 m

$= \frac{557 \times 10^4 \times 0.50 \times 0.35}{10^6} = 0.97\ Mm^3$

Total monsoon irrigation recharge = 1.38 + 1.26 + 0.97 = 3.61 Mm^3

(b) Non-monsoon recharge

Chhaparwadi irrigation scheme - Area 553 ha & depth of water 0.56 m

$= \frac{553 \times 10^4 \times 0.56 \times 0.35}{10^6} = 1.08\ Mm^3$

(3) Recharge through ground water irrigation

The details of electric driven & diesel driven pumpsets fitted on wells in all talukas are given in Chapter IV.

The draft for various capacity pumps fitted on wells are taken as per field tests carried out and average draft is taken. (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State, Narmada, Water Resources, Water Supply & Kalpasar Department,

Government of Gujarat") Monsoon draft is considered 20% & Non monsoon draft 80%.

Power of pumps fitted on wells	Total Nos	Draft/No (Mm^3/year)	Total draft (Mm^3)	Monsoon Draft (Mm^3)	Non-monsoon Draft (Mm^3)
Up to 7.5 HP	2278	0.01	22.78	4.56	18.22
7.5 HP to 15 HP	339	0.012	4.07	0.81	3.25
15 HP to 30 HP	4	0.015	0.06	0.01	0.05
30 HP to above	0	-	-	-	-
Diesel sets	3516	0.01	35.26	7.05	28.21
		Total	**62.17**	**12.43**	**49.73**

Recharge from ground water irrigation:

(a) Monsoon recharge = 100% of Monsoon draft = 12.43 Mm^3

(b) Non-monsoon Recharge = 15 % of draft (depth in well 10 to 25 m)
= 0.15 x 49.73 = 7.43 Mm^3

(4) Recharge through seepage from water structures

(c) Losses from Canals

2.5 cumecs/ Mm^2 – Un-lined canal {As per Water Account of RIC}

0.3 cumecs/ Mm^2 –Lined canal

(1) Monsoon seepage:

Gondali irrigation scheme - wetted area = 0.008 Mm^2 (unlined)

Canal running days = 23 days

$$\text{Seepage} = \frac{0.008 \times 23 \times 60 \times 60 \times 24 \times 2.5}{10^6} = 0.04 \ Mm^3$$

Vachhapari irrigation scheme - wetted area = 0.009 Mm^2 (unlined)

Canal running days = 20 days

$$\text{Seepage} = \frac{0.009 \times 20 \times 60 \times 60 \times 24 \times 2.5}{10^6} = 0.04 \ Mm^3$$

Chhaparwadi irrigation scheme - wetted area = 0.053 Mm^2 (unlined)

Canal running days = 98 days

$$\text{Seepage} = \frac{0.053 \times 98 \times 60 \times 60 \times 24 \times 2.5}{10^6} = 0.34 \ Mm^3$$

Total monsoon seepage = 0.04 + 0.04 + 0.34 = 0.42 Mm^3

(2) Non-monsoon seepage:

Gondali irrigation scheme - wetted area = 0.008 Mm^2 (unlined)

Canal running days = 76 days

Seepage = $\frac{0.008 \times 76 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.13 Mm^3

Vachhapari irrigation scheme - wetted area = 0.009 Mm^2 (unlined)

Canal running days = 60 days

Seepage = $\frac{0.009 \times 60 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 0.12 Mm^3

Chhaparwadi-I irrigation scheme - wetted area =0.053 (Unlined)

Canal running days = 98 days

Seepage = $\frac{0.053 \times 98 \times 60 \times 60 \times 24 \times 2.5}{10^6}$ = 1.12 Mm^3

Total non-monsoon seepage = 0.13 + 0.12 + 1.12 = 1.37 Mm^3

(d) Seepage from surface water bodies like check dams, percolation tanks etc. (44 cm/year) (As per "Report of Estimation of Ground Water Resources & Irrigation Potential in Gujarat State, Narmada, Water Resources, Water Supply & Kalpasar Department, Government of Gujarat")

Details of structures and water spread area are given in Data collection sheets.

Description	Total Nos. of structures	Water spread area (Mm^2)	Seepage (m)	Monsoon seepage only (Mm^3)
Ponds	80	0.010	0.44	0.35
Percolation tanks	110	0.020	0.44	0.96
Checkdams	521	0.030	0.44	6.89
			Total	8.20 Mm^3

(c) Seepage from flood prone area

Area details are given in Data collection chapter for all talukas.

Yearly flood area = 74.76 km^2 (As per Rajkot District Panchayat record)

Days of flooding = 15 days (Monsoon).

Seepage per year = 0.44 m

Total seepage = $\frac{74.76 \times 15 \times 0.44}{365} = 1.35\ Mm^3$

Recharge from seepage depends on rainfall normalization factor (NF).

NF = $\frac{\text{Normal Monsoon rainfall (Year 1963 to 2002)}}{\text{Average Monsoon rainfall (Year 2003 to 2006)}} = \frac{566}{628} = 0.90$

X = (Seepage from canal losses + Seepage from tanks + Seepage from flood prone area). =0.42 + 8.20 + 1.35 = 9.97 Mm^3

Actual effect on recharge through seepage = X – (X) **x** (NF)

= 9.97 – (9.97 x 0.90) = 1.00 Mm^3 ..... (II).

Ground water seepage (Y) = Ground water draft (monsoon) x 0.25

= 12.43 x 0.25 = 3.10 Mm^3.

Actual recharge = Draft – (Y) x (NF)

= 12.43 – 3.10 x 0.90 = 9.64 Mm^3 ..... (III)

Actual monsoon recharge = (I) + (II) + (III).

= 196.36 + 1.00 + 9.64 = 207.00 Mm^3

Total recharge = Monsoon recharge + Non-monsoon recharge.

= 207.00 + (1.37 + 7.46 + 1.16) = 216.99 Mm^3 = Say 217 Mm^3

Abstract of the above results is presented in Table 6.1

Table 6.1 Abstract of the study of Gondal taluka

Sr. No.	Details	1991-97	1998-2002	2003-06
1	Average rainfall (mm)	678	445	628
2	Check dams	49	357	522
3	Av. water table fluctuation (m)	5.33	4.12	8.23
4	Monsoon recharge (Mm^3)	140.00	110.00	207.00
5	Gross recharge (Mm^3)	152.49	127.49	217.00
6	Total draft (Mm^3)	80.80	105.77	62.17

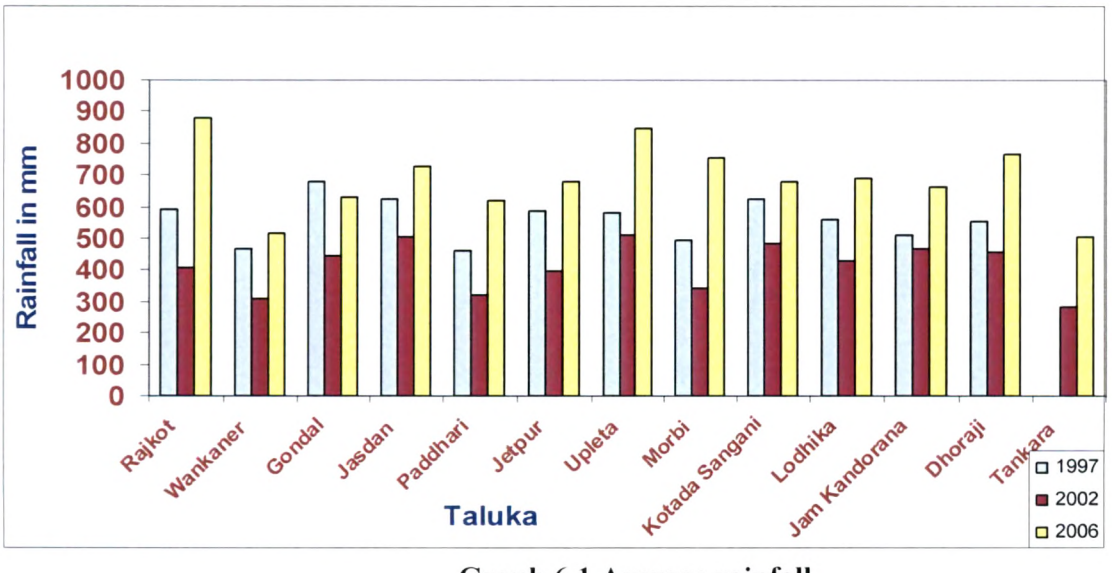
Similarly the study for all 13 talukas individually carried out by using the basic data as tabulated in Chapter-4, Data Collection.

6.1.2 Analysis to compare rainfall data of all talukas for three different years scenario

The data of average rainfall in these three different years scenario of period of the 13 talukas has been calculated, which are as under (Table 6.2 Graph 6.1):

Table 6.2 Talukawise average rainfall of three different years scenario (mm)

Sr. No.	Taluka	Av 1991-1997	Av 1998-2002	Av 2003-2006	% of 1997
1	Rajkot	595	406	882	148
2	Wankaner	465	310	514	110
3	Gondal	678	445	628	92
4	Jasdan	624	505	730	117
5	Paddhari	460	320	618	134
6	Jetpur	588	399	679	115
7	Upleta	583	512	850	140
8	Morbi	496	340	754	152
9	Kotada Sangani	625	483	681	109
10	Lodhika	558	428	692	124
11	Jam Kandorana	509	467	663	130
12	Dhoraji	556	459	764	137
13	Tankara	Part of Morbi	282	507	
Rajkot District Average		561	422	705	
% age with respect with year 1997		-	**75 %**	**125 %**	



Graph 6.1 Average rainfall

As seen from the above, average rainfall for the year 2002 is 25 % lower compared to year 1997 & average rainfall for the year 2006 is 25% higher than year 1997.

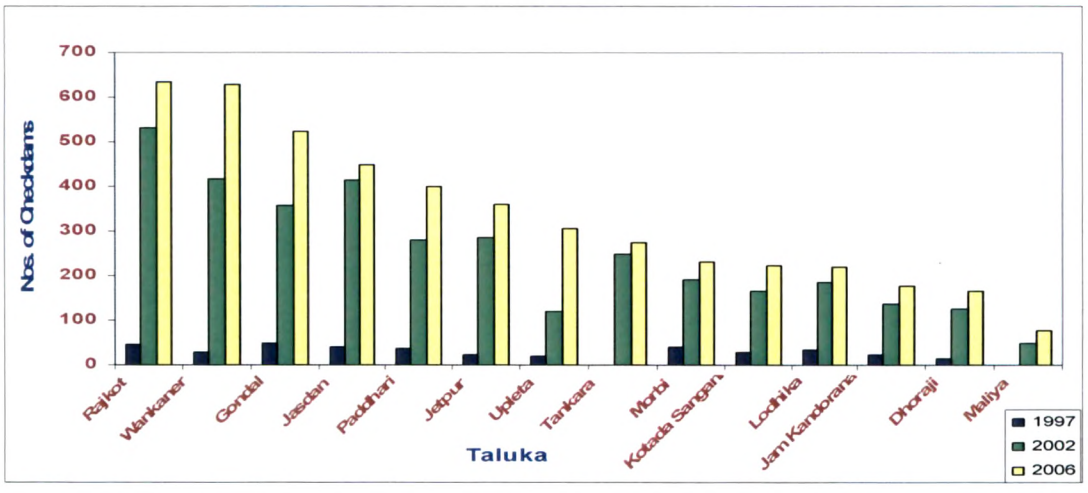
6.1.3 Check dams

The government implemented the scheme "Sardar Patel Sahbhagi Jal Sanchay Yojana" for construction of check dams under public participation and the contribution of government was 60 % cost. There was overwhelming response from the public. In Rajkot district, the scheme was successfully implemented in majority of talukas.

The details of the check dams constructed in 14 talukas of Rajkot district during the period years 1991-97, 1998-2002 & 2003-2006 are as under (Table 6.3 & Graph 6.2):

Table 6.3 Details of check dams (nos)

Sr. No.	Taluka	Year 1997	Year 2002	Year 2006
1	Rajkot	47	532	634
2	Wankaner	29	417	630
3	Gondal	49	357	522
4	Jasdan	39	414	450
5	Paddhari	38	280	399
6	Jetpur	23	287	361
7	Upleta	19	120	307
8	Tankara	-	248	275
9	Morbi	39	191	231
10	Kotada Sangani	28	166	222
11	Lodhika	35	185	219
12	Jam Kandorana	24	138	178
13	Dhoraji	14	125	165
14	Maliya	0	50	77
Total		**308**	**2561 (830%)**	**3406 (1105%)**
Source: BISAG, Gandhinagar				



Graph 6.2 Check dams constructed in various talukas

As seen from the above upto the year 1997, solid concrete / masonry check dams of 384 having average storage capacity of 10000 m^3 to 30000 m^3 were constructed in Rajkot District. After the draught year 2000, Rajkot district farmers realized the benefits of check dam scheme and the scheme took momentum.

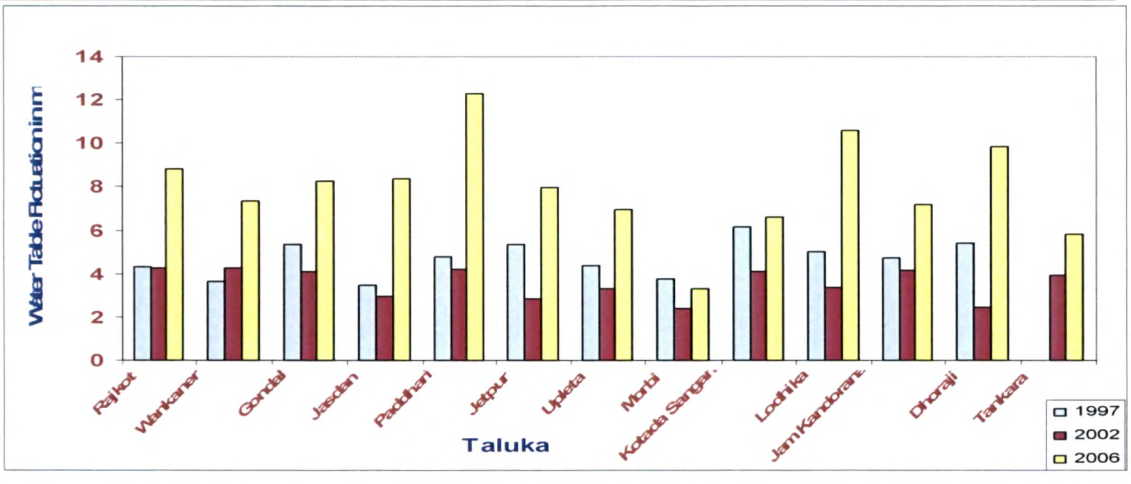
6.1.4 Water Table Fluctuation (WTF)

Monitoring of more than 4000 observation wells / tubewells / piezometers was done for observing the fluctuation in the ground water table as well as the quality of ground water twice in a year i.e. pre monsoon (May) and post monsoon (October). It is being carried out by the GWRDC since 1970. The data collected year wise is analyzed to know the fluctuation in water level to know the impact of rainfall and recharge thereof by using the formula as under (Table 6.4 & Graph 6.3):

Table 6.4 Average rise (m) in water level (WTF)

Sr. No.	Taluka	Av. From Year 1991 to Year 1997	Av. From Year 1998 to Year 2002	Av. From Year 2003 to Year 2006
1	Rajkot	4.31	4.29	8.81
2	Wankaner	3.62	4.25	7.33
3	Gondal	5.33	4.12	8.23
4	Jasdan	3.46	2.97	8.37

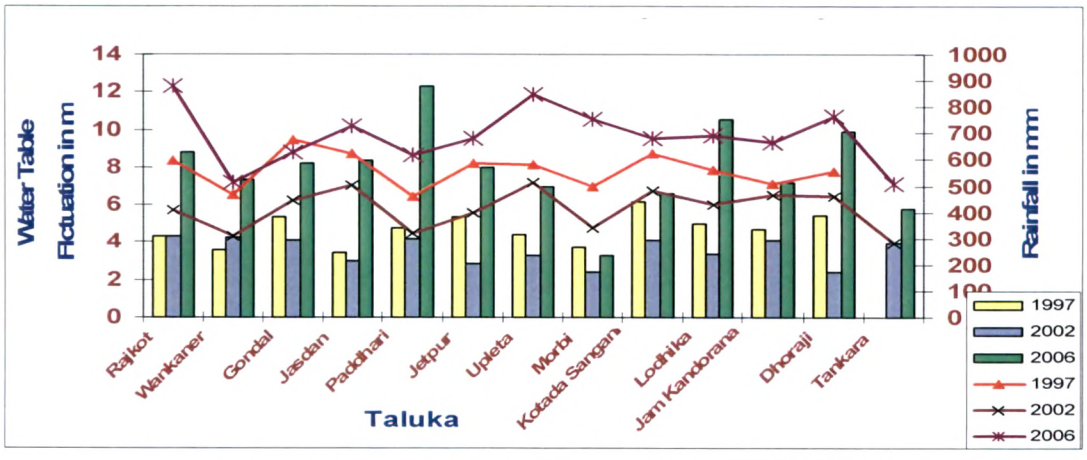
Sr. No.	Taluka	Av. From Year 1991 to Year 1997	Av. From Year 1998 to Year 2002	Av. From Year 2003 to Year 2006
5	Paddhari	4.80	4.19	12.3
6	Jetpur	5.35	2.84	7.98
7	Upleta	4.4	3.29	6.94
8	Morbi	3.73	2.39	3.29
9	Kotada Sangani	6.14	4.09	6.60
10	Lodhika	5.00	3.37	10.59
11	Jam Kandorana	4.70	4.14	7.17
12	Dhoraji	5.43	2.45	9.87
13	Tankara	Part of Morbi	3.94	5.79
	Average	**4.69**	**3.56**	**7.94**
	(%) age		**76**	**170**



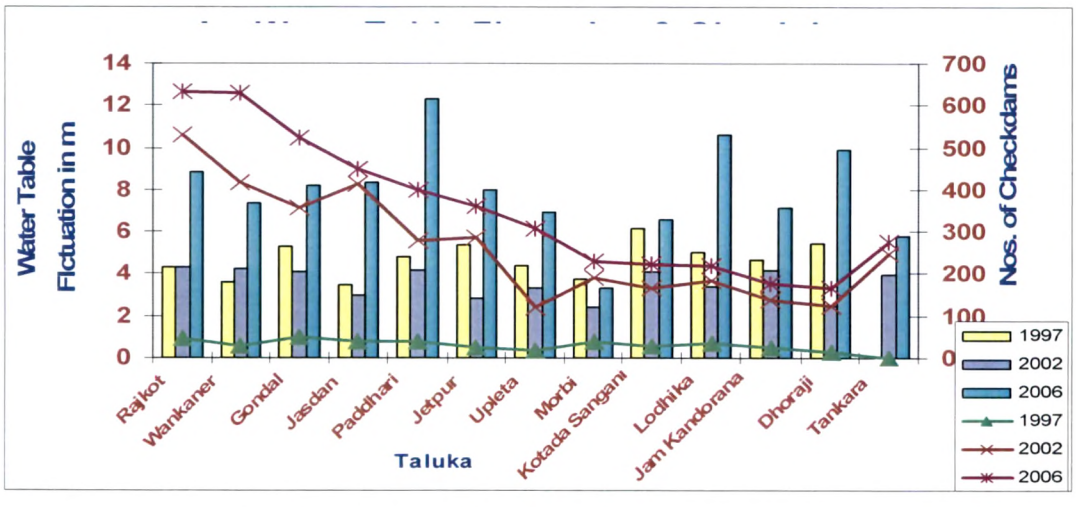
Graph 6.3 Water table fluctuation

As seen from the above, the average water table rise in year 2006 is nearly 70% higher in comparison to that of year 1997. The average rainfall of Rajkot district in the year 2006 is 705 mm in comparison to that 561 mm of year that in 1997. Thus there is 25% increase in rainfall in the year 2006 as compared to year 1997. However, because of construction of the check dams in Rajkot district, the water table rise in the year 2006 is increased substantially than the year 1997. Analysis shows that there is considerable improvement in water table in the year 2006 as compared to that in year 1997 (Graph 6.4 & Graph 6.5). Gondal taluka the rainfall in year 1997 is 678 mm where as in year 2006 it is

628 mm (92%). Even though the WTF of year 2006 is 8.23 m (154%), higher than 5.33 m in year 1997.



Graph 6.4 Water table fluctuation & average rainfall



Graph 6.5 Water table fluctuation & check dams

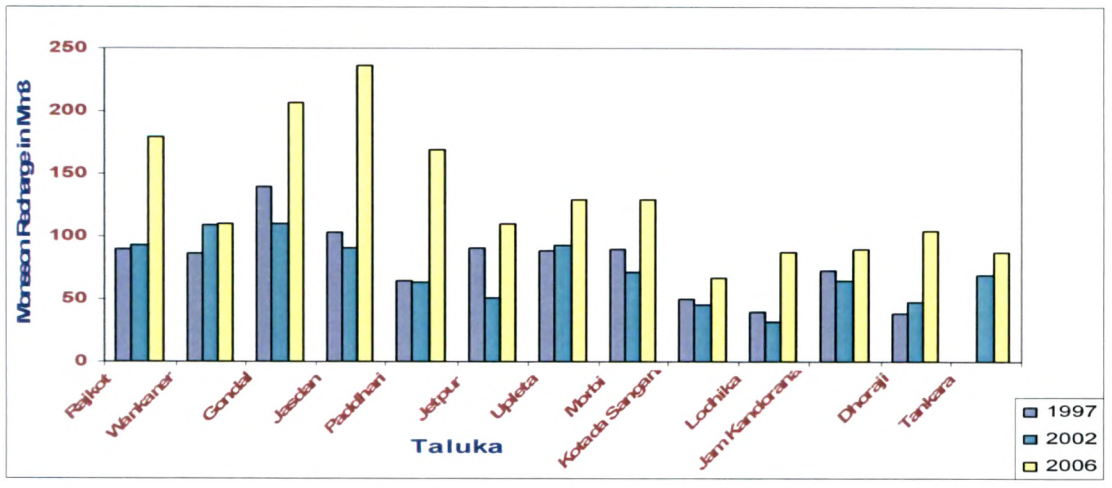
6.1.5 Monsoon recharge

In Gujarat State, the rainfall pattern is almost same i.e. the monsoon period is between months June to September every year. During the monsoon season, the ground water recharge takes place by direct infiltration seepage through water bodies/seepage through surface water & ground water irrigation/canal losses seepage and flood, etc. The monsoon recharge for each component has been calculated in which the main monsoon recharge as because

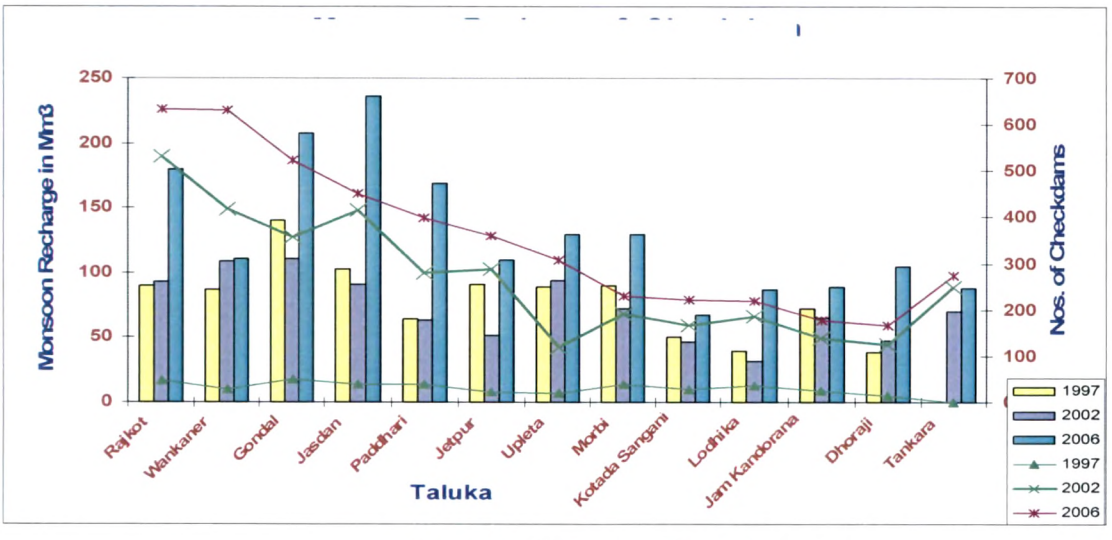
of water table fluctuation (WTF). The data are presented in Table 6.5 and Graphs 6.6, 6.7, 6.8 & 6.9.

Table 6.5 Analysis of talukawise monsoon ground water recharge (Mm^3)

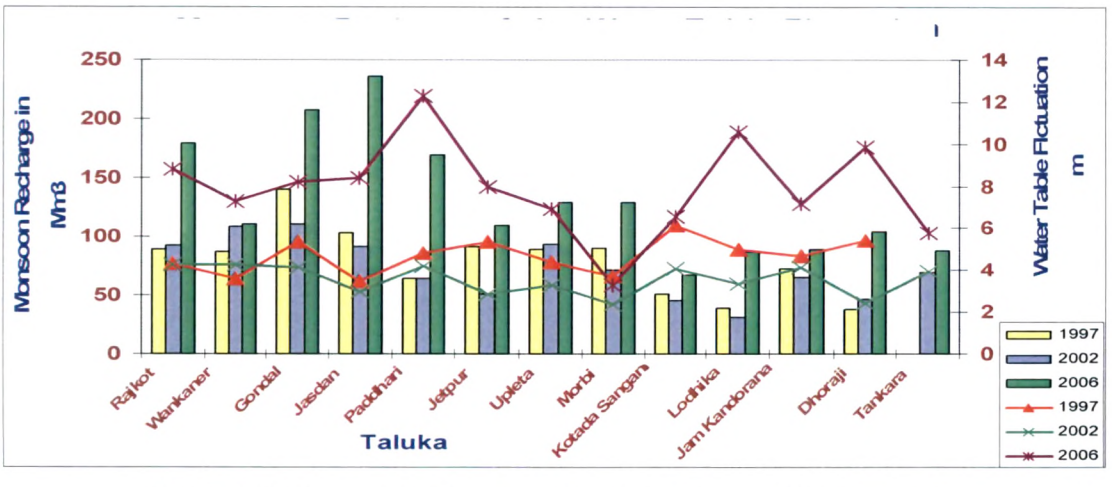
Sr. No.	**Taluka**	**1997**	**2002**	**2006**	**% 1997**	**% rainfall**
1	Rajkot	89.67	92.71	179.58	200	148
2	Wankaner	86.57	108.88	110.64	128	110
3	Gondal	140.00	110.00	207.00	150	92
4	Jasdan	102.91	91.16	235.88	229	117
5	Paddhari	64.58	63.72	169.39	262	134
6	Jetpur	90.88	51.52	109.98	121	115
7	Upleta	89.13	93.54	129.43	145	140
8	Morbi	90.05	72.09	128.98	143	152
9	Kotada Sangani	50.55	45.97	67.37	133	109
10	Lodhika	39.39	31.78	87.17	221	124
11	Jam Kandorana	72.41	65.22	89.32	123	130
12	Dhoraji	38.35	47.25	104.67	273	137
13	Tankara	Part of Morbi	69.70	87.95		
	Total	954.49	943.54	1710.36		
	(%) age		98.00	179.00		



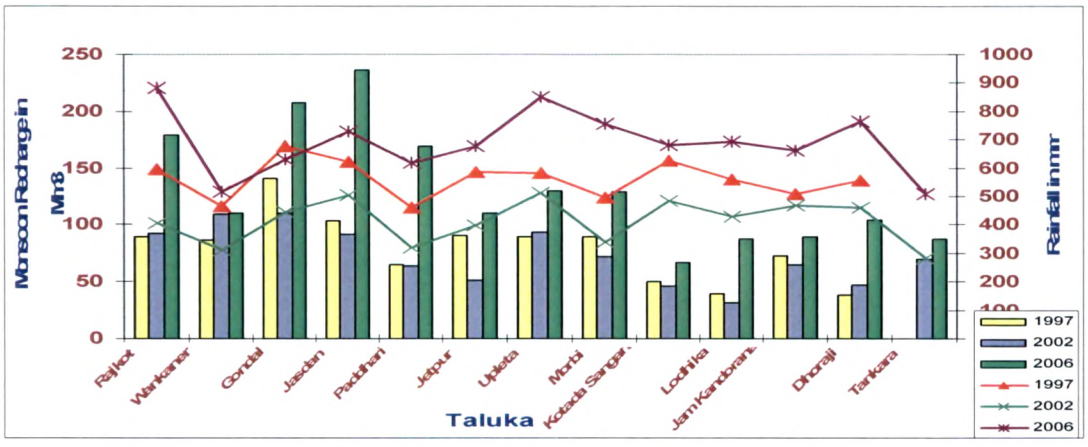
Graph 6.6 Monsoon recharge



Graph 6.7 Recharge & check dams



Graph 6.8 Monsoon recharge & average water table fluctuation



Graph 6.9 Monsoon recharge and average rainfall

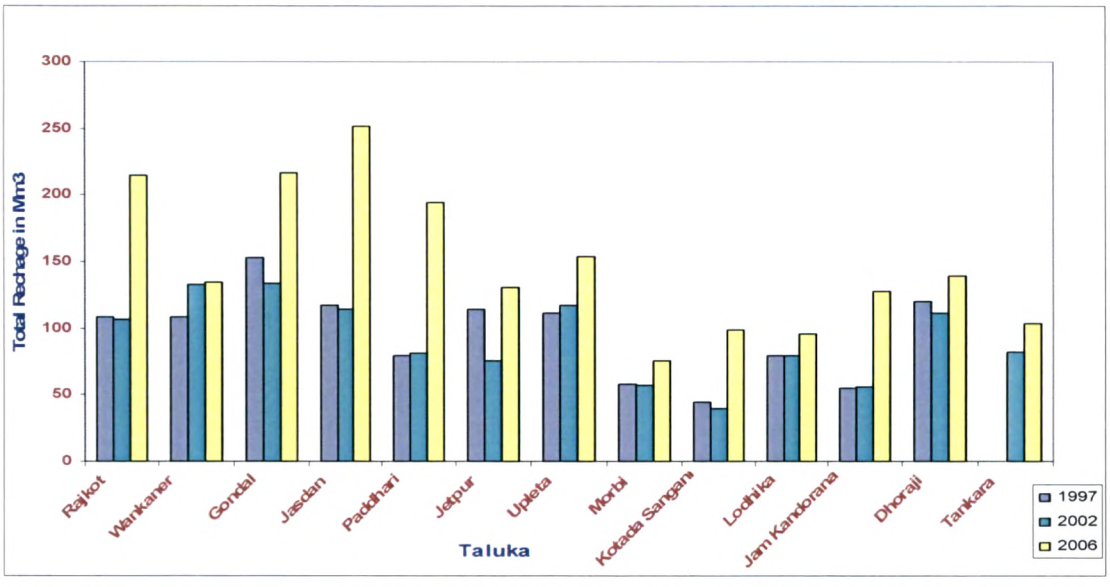
As seen from the above table, even though the average rainfall in year 2002 was less than year 1997 but because of 3510 nos. of checkdams were constructed in Rajkot district upto year 2002, the monsoon recharge of Rajkot district in the year 2002 is 944.17 Mm^3, which is slightly less than that of year 1997, which is 954.76 Mm^3. The year 2006 was extremely better than that of year 1997. However, because of 4670 nos. of checkdams were constructed in Rajkot district upto year 2006, the monsoon recharge in year 2006 is 1707.55 Mm^3 against that in year 1997 which is 954.76 Mm^3. Hence about 78% additional ground water recharge has taken place in the year 2006 compared to that of year 1997. The average rainfall of year 2006 is 705 mm. whereas in year 1997, it was 561 mm. The average rainfall of year 2006 is 26 % more than year 1997, but the monsoon recharge is 78 % more in the year 2006 than that in the year 1997. The monsoon recharge in alluvial soil & canal irrigation's talukas like Jetpur, Jam Kandorana and Upleta the impact of check dam is less compare to rock strata talukas.

6.1.6 Total Ground Water Recharge

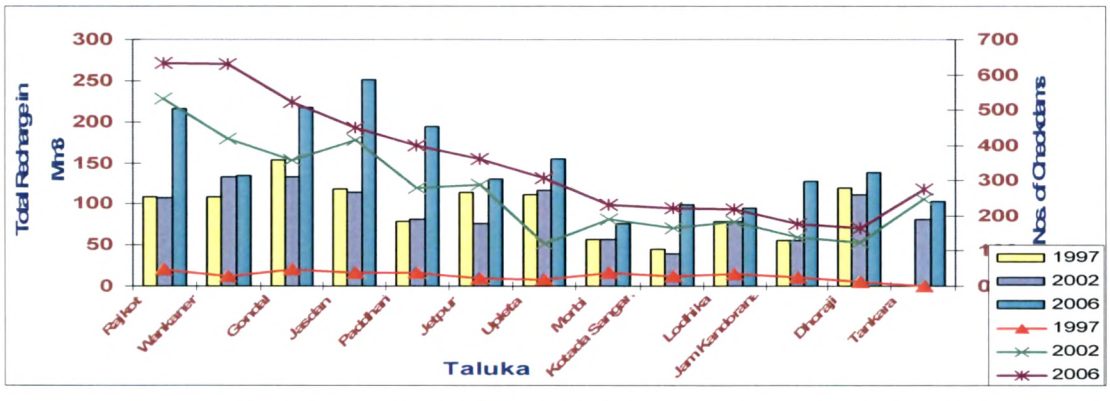
The total ground water recharge mainly covers monsoon recharge, non-monsoon recharge and potential recharge. Rajkot district is falling in semi arid region. The water availability of surface irrigation is not sufficient for rabi & hot season crops. However, through wells and tubewells, the ground water is used for rabi and kharif seasons even through the ground water availability in these seasons is less. Therefore, the non-monsoon recharge in Rajkot district is lower compared to the monsoon recharge. There is no over irrigation and high intensive water crop in Rajkot district. Hence, there is little scope for water logging or flooding. Therefore, the potential recharge in Rajkot district is very meager. The talukawise total ground water recharge results are presented in Table 6.6 and Graphs 6.10, 6.11, 6.12, 6.13,6.14. Gondal taluka total ground water recharge of year 2006 is 142% of year 1997, where as rainfall of year 2006 is 92% of year 1997.

Table 6.6 Analysis of talukawise total ground water recharge (Mm^3)

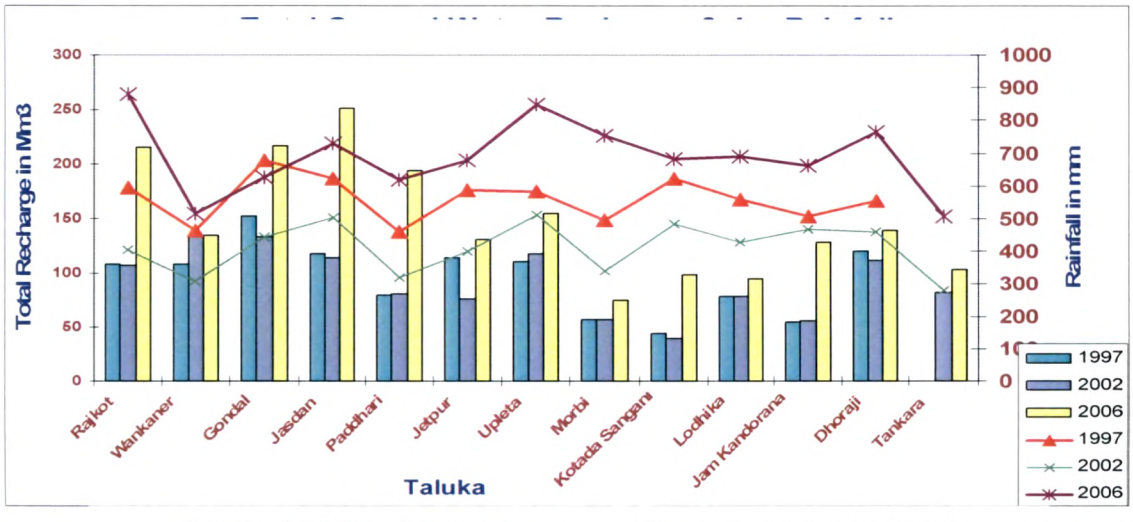
Sr. No.	District	1997	2002	2006	% with 1997	% rainfall
1	Rajkot	108.09	106.91	215.27	199	148
2	Wankaner	108.05	133.03	134.80	125	110
3	Gondal	152.49	127.49	217.00	142	92
4	Jasdan	117.50	114.30	251.67	214	117
5	Paddhari	79.37	81.45	194.16	244	134
6	Jetpur	113.92	75.72	130.51	115	115
7	Upleta	111.14	117.39	154.35	139	140
8	Kotada Sangani	57.60	57.14	75.37	131	109
9	Lodhika	44.17	39.59	98.76	224	124
10	Jam Kandorana	79.08	79.08	95.68	212	130
11	Dhoraji	55.35	55.89	128.05	231	137
12	Morbi	120.05	111.41	138.92	116	152
13	Tankara	Part of Morbi	81.80	103.08		
	Total	1146.81	1181.20	1937.62		
	(%) age		103	169		



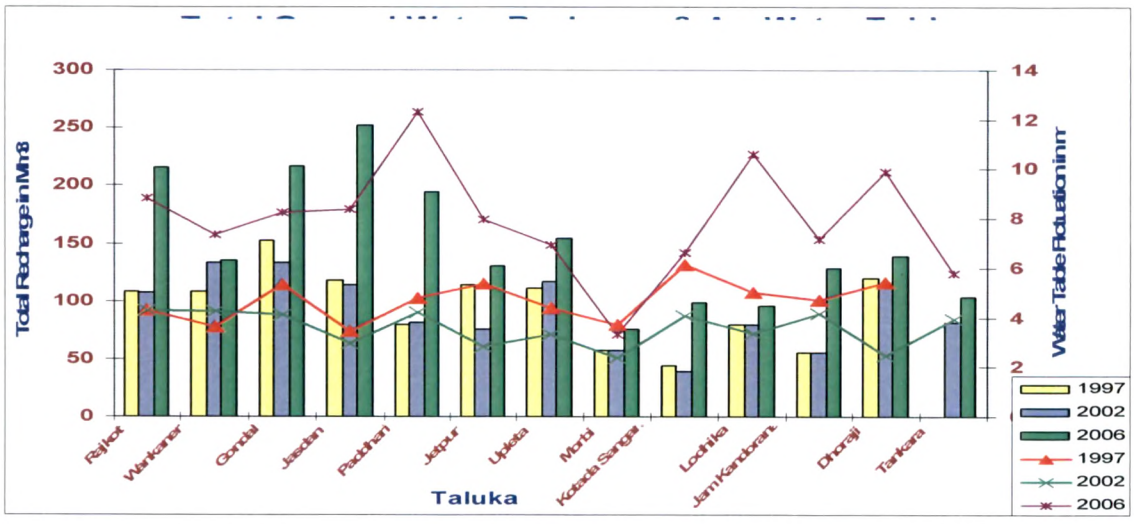
Graph 6.10 Total ground Water recharge



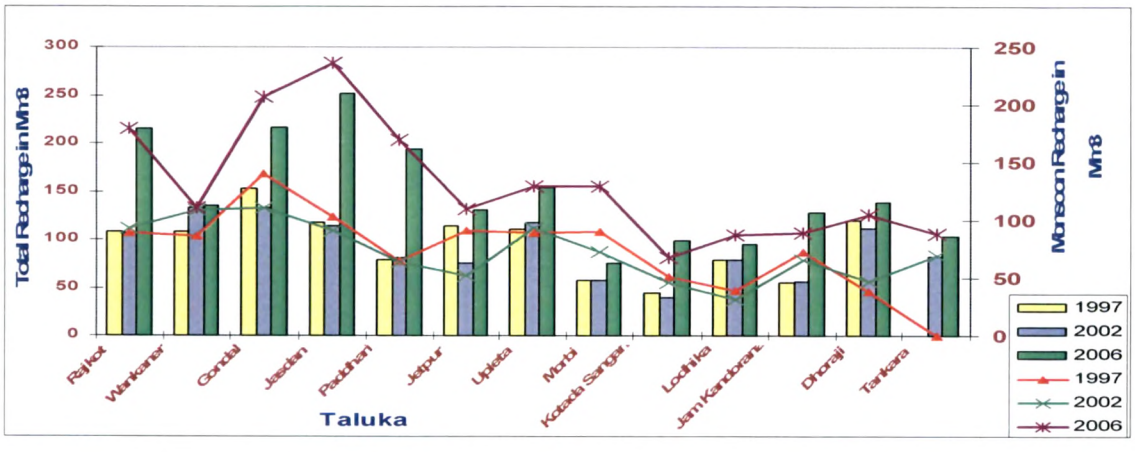
Graph 6.11 Total ground water recharge & check dams



Graph 6.12 Total ground water recharge & average rainfall



Graph 6.13 Total ground water recharge & average water table



Graph 6.14 Total ground water recharge & monsoon recharge

As seen from the above results, the average rainfall in the year 2002 is less than in the year 1997, but due to 3510 nos. of checkdams constructed upto year 2002, the yearly total ground water recharge in the year 2002 is 1187 Mm^3 which is slightly higher than 1147 Mm^3 of the year 1997. The average rainfall of the year 2006 is 705 mm which is 26 % above the average rainfall 561 mm for the year 1997. The ground water irrigation duty in Rajkot district is 245 ha/ Mm^3. Therefore, by additional 700 Mm^3, ground water recharge in the year 2006, the additional 1.70 lakh ha ground water irrigation potential is created.

6.1.7 Total ground water draft

In Rajkot District, the ground water irrigation is much larger compared to surface water irrigation. The ground water is available mainly up to 30 to 40 m depth of fractured and weathered basalts trap. The farmers have dug wells and dug-cum-bore wells. Deep tubewells have been constructed in sandstone formation. Earlier the farmers were using diesel pump sets to get the water from wells, but thereafter the wells have been converted into electric driven pumpsets, by which the ground water availability is increased because of more ground water recharge. The total ground water draft for the talukas and the total draft, non-monsoon draft and monsoon draft are calculated and results are as under (Tables 6.7, 6.8, 6.9 and Graphs 6.15, 6.16, 6.17, 6.18, 6.19):

Table 6.7 Analysis of talukawise total draft (Mm^3)

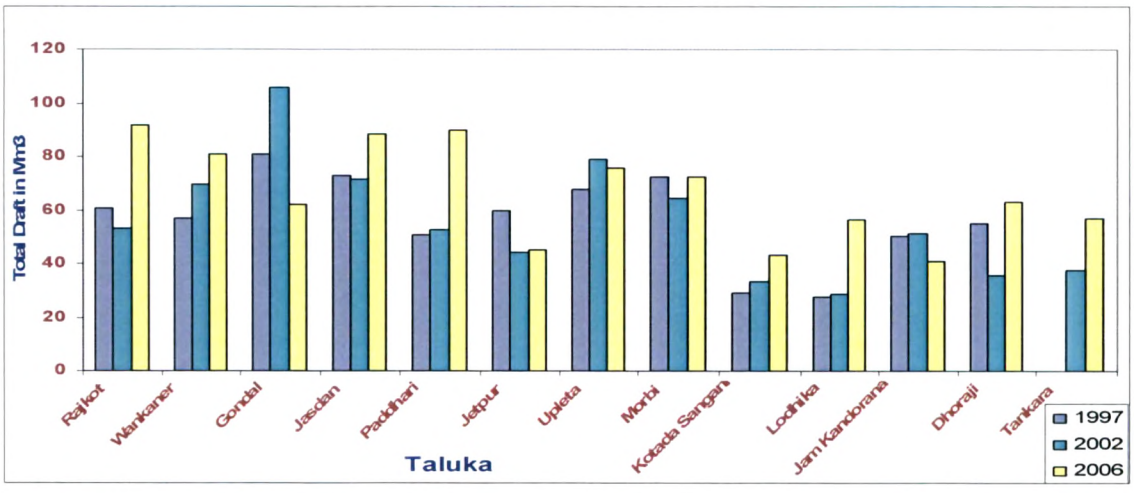
Sr. No.	District	1997	2002	2006
1	Rajkot	60.62	53.01	91.70
2	Wankaner	57.00	69.72	80.92
3	Gondal	80.80	105.79	62.17
4	Jasdan	73.07	71.31	88.59
5	Paddhari	50.97	52.59	89.80
6	Jetpur	59.57	44.21	45.21
7	Upleta	67.72	78.91	75.71
8	Morbi	72.62	64.34	72.33
9	Kotada Sangani	29.15	33.26	43.25
10	Lodhika	27.63	28.5	56.57
11	Jam Kandorana	50.53	51.2	40.72
12	Dhoraji	55.26	35.93	63.04
13	Tankara	Part of Morbi	37.77	57.07
	Total	684.94	726.54	867.08
	(%) age		106	127

Table 6.8 Analysis of talukawise non monsoon draft (Mm^3)

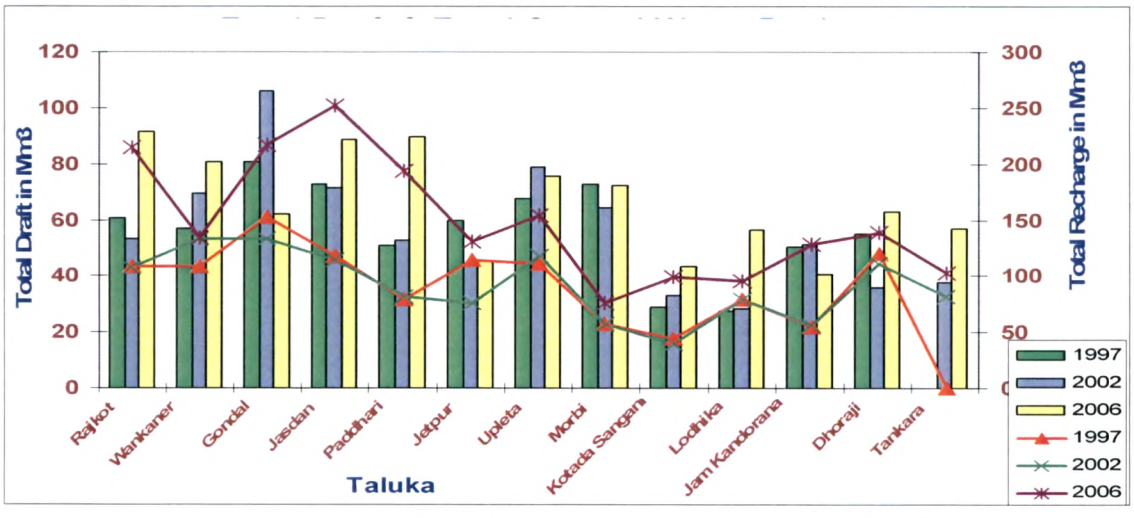
Sr. No.	District	1997	2002	2006
1	Rajkot	48.49	42.41	73.36
2	Wankaner	45.6	55.78	64.73
3	Gondal	64.64	84.63	49.73
4	Jasdan	58.46	57.04	70.87
5	Paddhari	40.78	42.07	71.84
6	Jetpur	47.66	35.37	36.17
7	Upleta	54.17	63.13	60.57
8	Morbi	58.1	51.47	57.86
9	Kotada Sangani	23.32	26.61	34.6
10	Lodhika	22.1	22.8	45.26
11	Jam Kandorana	40.43	40.96	32.58
12	Dhoraji	44.21	28.75	50.43
13	Tankara	Part of Morbi	30.21	45.66
	Total	547.96	581.23	693.66
	(%) age		106	127

Table 6.9 Analysis of talukawise monsoon (kharif) draft (Mm^3)

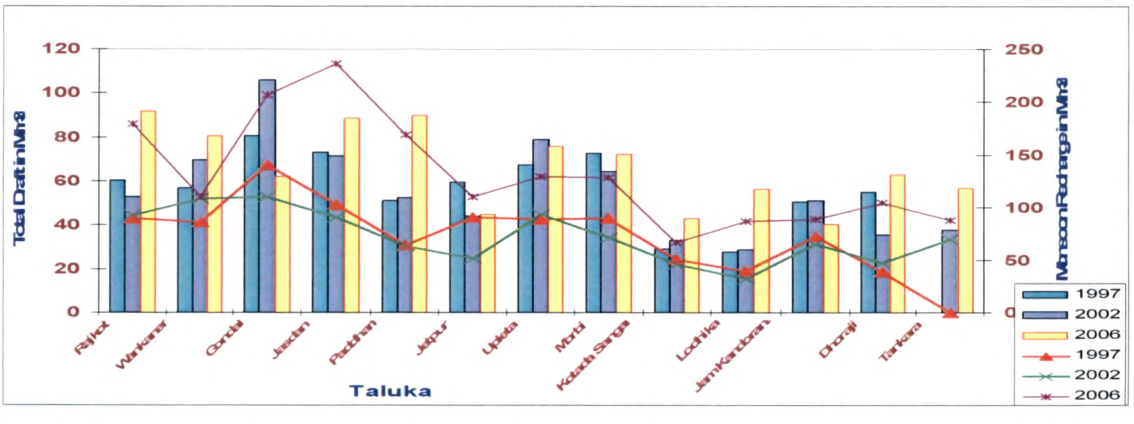
Sr. No.	District	1997	2002	2006
1	Rajkot	12.12	10.6	18.34
2	Wankaner	11.4	13.94	16.18
3	Gondal	16.15	21.15	12.43
4	Jasdan	14.61	14.26	17.72
5	Paddhari	10.19	10.52	17.96
6	Jetpur	11.91	8.84	9.04
7	Upleta	13.54	15.78	15.14
8	Morbi	14.52	12,87	14,47
9	Kotada Sangani	5.83	6.65	8.65
10	Lodhika	5.53	5.7	11.31
11	Jam Kandorana	10.11	10.24	8.14
12	Dhoraji	11.05	7.19	12.61
13	Tankara	-	7.55	11.46
	Total :	136.96	145.29	173.45
	(%) age		106	127



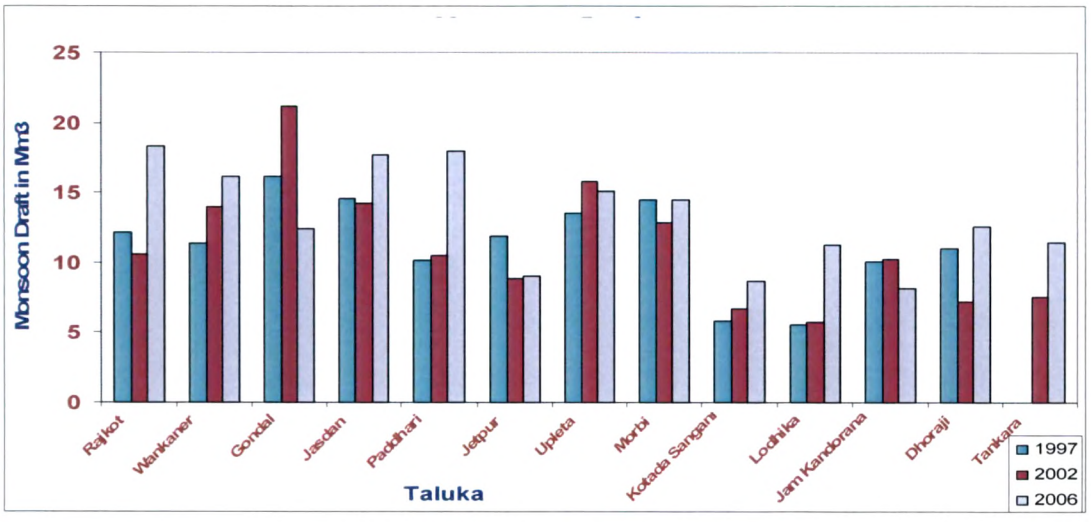
Graph 6.15 Total draft



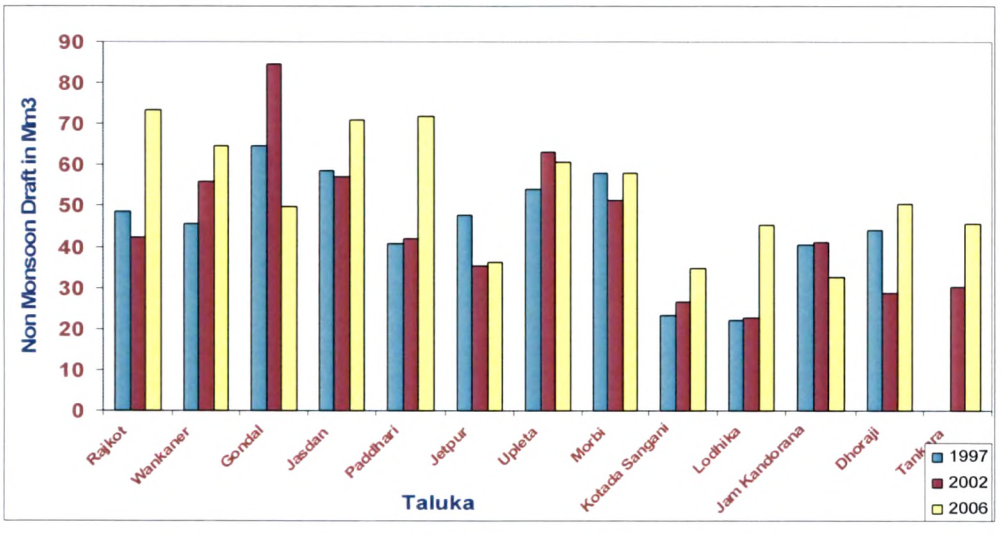
Graph 6.16 Total draft & Total ground water recharge



Graph 6.17 Total draft & Monsoon recharge



Graph 6.18 Monsoon draft



Graph 6.19 Non-monsoon draft

The gross recharge in the year 2006 is 1937 Mm^3 whereas the gross recharge in the year 1997 is 1147 Mm^3 (68 % more in the year 2006). But in case of ground water utilization, proportionately it is in the year 1997. Thus the draft is comparatively higher than in the year 2006. The total draft in year 1997 is 684 Mm^3 and in the year 2006 it is 867 Mm^3 which is 27% higher, but the gross recharge in the year 2006 is 68 % higher than in the year 1997. Even though there is less rainfall in year 2002 compared to the year 1997, total draft in the year 2002 is 726 Mm^3 and in year 1997 it is 684 Mm^3 whereas the gross

recharge in the year 1997 is 1147 Mm^3 and in the year 2002 the total recharge is 1187 Mm^3. This trend indicates that the gross recharge and the total draft, both for the year 1997 and year 2002 are more or less similar, even though, the year 2002 was the water scarcity year.

6.2 IMPACT OF CHECKDAMS IN GROUNDWATER QUALITY OF VARIOUS TALUKAS OF RAJKOT DISTRICT

6.2.1 General

In Gujarat State, the ground water quality is deteriorating due to excessive withdrawal. The main problem in ground water quality is excessive salinity, excessive fluoride and excessive nitrate. The table 6.10 shows ground water quality problems in various districts:

Table 6.10 Details of villages having salinity problem in Gujarat State

Sr. No.	District	Nos. of villages having excessive			Total
		Fluoride	Salinity	Nitrates	
1	Ahmedabad	173	107	9	289
2	Junagadh	48	49	2	99
3	Rajkot	15	50	2	67
4	Surendranagar	41	26	1	68
5	Amreli	70	8	65	143
6	Bhavnagar	75	25	115	215
7	Jamnagar	11	47	23	81
8	Gandhinagar	20	0	0	20
9	Sabarkantha	310	28	95	433
10	Banaskantha	386	78	52	516
11	Kachchh	4	13	0	17
12	Mehsana	447	132	8	587

Sr. No.	District	Nos. of villages having excessive			Total
		Fluoride	Salinity	Nitrates	
13	Baroda	261	105	46	412
14	Kheda	178	205	98	481
15	Bharuch	26	116	35	177
16	Surat	23	34	22	79
17	Panchmahals	311	38	54	403
18	Valsad	14	11	8	33
19	Dang	0	0	0	0
	Total :	2413	1071	635	4120
Source: GWSSB					

As seen from the above, in Rajkot District, the problematic villages include:

Fluoride excessive: 15 villages

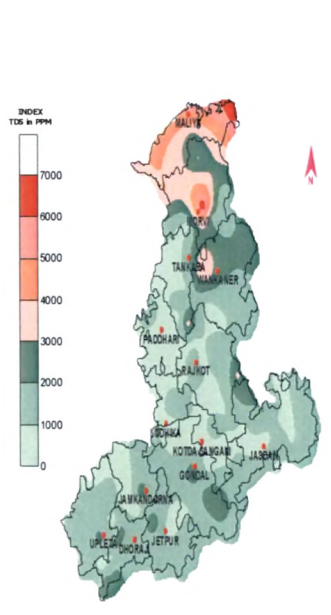
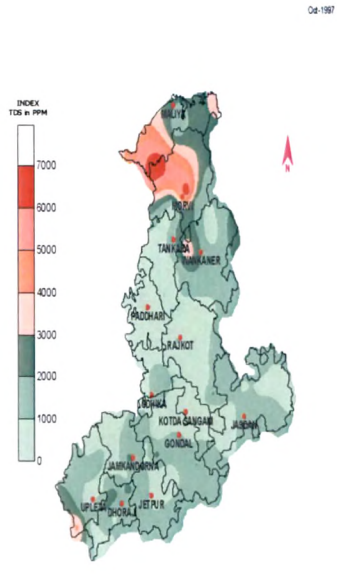
Salinity excessive: 50 villages

Nitrate excessive: 2 villages

Total: 67 villages

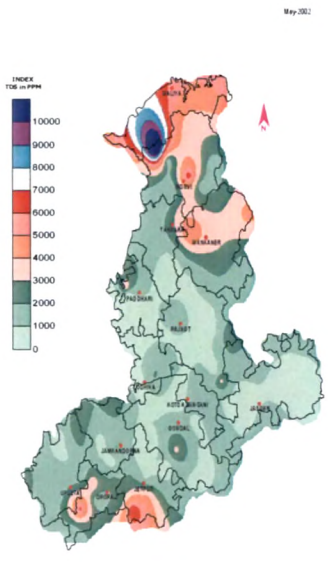
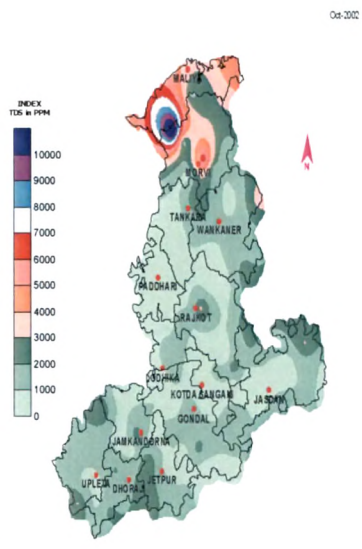
6.2.2 Total dissolved salts

Contour map showing variations in total dissolved salts (ppm) in Rajkot district

Contour map May 1997	*Contour map October 1997*
	

Graph 6.20

May 1997	October 1997
The Total Dissolved Salts contour map for May 1997 indicates a variation in the TDS contents between 1000 and 2000 ppm in most of the area and between 2000 and 3000 ppm in scattered parts of the district and between 3000 ppm and 7000 ppm in the extreme northern part of the district comprising of Maliya taluka. Except for the higher TDS values in Maliya taluka, which is inherently saline, the TDS values are observed to vary between 1000 to 2000 ppm in general and above 2000 ppm in scattered parts.	The Total Dissolved Salts contour map for October 1997 indicates a variation in the TDS contents between 1000 and 2000 ppm in most of the area and between 2000 and 3000 ppm in very few patches in scattered parts of the district and between 3000 ppm and 7000 ppm in the extreme northern part of the district comprising Maliya taluka. Except for the higher TDS values in Maliya taluka, which is inherently saline, the TDS values are observed to vary between 1000 to 2000 ppm in general and above 2000 ppm in scattered parts.

Contour map showing variations in total dissolved salts (ppm) in Rajkot district	
Contour map May 2002	***Contour map October 2002***
	
Graph 6.21	
May 2002	**October 2002**
The Total Dissolved Salts contour map for May 2002 indicates a variation in the TDS contents between 1000 and 2000 ppm in most of the area and between 2000 and 3000 ppm in scattered parts of the district and between 3000 ppm and 7000 ppm in the extreme northern part of the district comprising of Maliya, Morbi and Wankaner talukas and small patches in Dhoraji, Jetpur and Upleta talukas. Except for the higher TDS values in these areas, the TDS values are observed to vary between 1000 to 2000 ppm in general and above 2000 ppm in scattered parts.	The Total Dissolved Salts contour map for October 2002 indicates a variation in the TDS contents between 1000 and 2000 ppm in most of the area and between 2000 and 3000 ppm in very few patches in scattered parts of the district and between 3000 ppm and 7000 ppm in the extreme northern part of the district comprising Maliya taluka. Except for the higher TDS values in Maliya taluka, which is inherently saline, the TDS values are observed to vary between 1000 to 2000 ppm in general and above 2000 ppm in scattered parts.

6.2.3 Impact of ground water recharge on ground water quality

The ground water quality before 2000 in most of the observation wells were not fit for domestic water supply. The data of improving the quality in the observation wells are collected from GWSSB. Water quality in the year 2003, 2004, 2005 and 2006 was observed at total 28 observation wells in different talukas. The ground water samples were collected to analyse the parameters included total dissolved salts, chloride, fluoride, nitrate etc. The details are presented in tables 6.11, 6.12, 6.13 & 6.14.

Table 6.11 Chemical analysis data of the water samples collected by GWSSB

JULY – 2003

Sr. No.	Village	Taluka	Location of the observation well	SWL (m)	Ground water quality				
					TDS (PPM)	Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)
1	Mahika	Wankaner	Behind Prathmik Shala	6	866	200	480	53.6	0.1
2	Sartanpar	Wankaner	Near Water Supply Tank	7	1344	400	600	1.77	0.6
3	Pipali	Morbi	In Gupteshwar Mahadev Temple	6	2300	1120	600	35.44	0.2
4	Luntavadar	Morbi	Near Bank of Talav	0.01	368	24	160	1.77	0.2
5	Jasapar	Maliya	LHS of road to Village Moti Brar	5.5	1404	400	480	70.88	0.2
6	Khirai	Maliya	RHS of road to Highway	2.5	920	280	360	8.86	0.3
7	Lajai	Tankara	Near Water Supply Tank	2	490	100	200	1.77	0.1
8	Mitana	Tankara	On Left Bank of Mitanio Vonkla	2.5	556	100	320	0	0.2
9	Gauridad	Rajkot	LHS of road to Rajkot	5.5	1334	320	560	35.44	0.2
10	Kasturba Dham	Rajkot	RHS of road to Sradar	14	1080	160	600	79.74	0.2
11	Nyara	Paddhari	500 mts West of Village	1.3	970	240	440	17.72	0.2
12	Khamta	Paddhari	Opp. To Khamta Bus Stand on Highway	6.5	926	140	480	14.18	0.1
13	Atkot	Jasdan	Rhs on Highway to Rajkot	15	366	40	280	1.77	0.2
14	Hingolgadh	Jasdan	500 mts North of Village	4.5	622	80	400	36.44	0.2
15	Mekha Timbi	Upleta	Nera Khandeshwar Mahadev Temple	12.9	934	220	520	70.88	1
16	Arni	Upleta	500 Mts. From Village on way ti Sajadiyali	4.8	742	100	440	35.44	0
17	Supedi	Dhoraji	Near Hotet Shiv	14.2	3156	1000	1360	17.72	0.1
18	Jamnavad	Dhoraji	GSFC Well near Bridge	7.5	840	200	360	35.44	0.2
19	Jetalsar	Jetpur	Opp. Amardip Farm	10.1	866	180	660	14.18	0.1
20	Virpur	Jetpur	LHS of Metal road to Mevasa	1.5	402	60	280	35.44	0.1
21	Khajurda	Jam Kandorana	Right side of road to Kandorana	5.5	540	60	360	35.44	0.1
22	Dholidhar	Jam Kandorana	Left side to Village Khandorna	3.6	842	140	480	70.88	0.2
23	Dahiya	Gonadal	In Village Padar Near road to Gondal	3.9	884	200	480	35.44	0.1
24	Moviya	Gonadal	Near Village Panchayat & Smashan	5.1	506	180	480	35.44	0.1
25	Bhadva	Kotda Sanghani	LHS of road to Sharda	2.9	534	80	320	35.44	0.2
26	Nani Menghni	Kotda Sanghani	LHS of road to Navi Meghani	7.95	384	120	520	17.72	0.1
27	Pardi	Lodhika	Opp overhead Tank	4.1	650	160	180	17.72	0.2
28	Khirsara	Lodhika	In the Village	4.4	1294	240	600	70.88	0.1

Source : GWSSB

Table 6.12 Chemical analysis data of the water samples collected by GWSSB

May - 2004

Sr. No.	Village	Taluka	Location of the observation well	SWL (m)	Ground water quality				
					TDS (PPM)	Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)
1	Mahika	Wankaner	Behind Prathmik Shala	9.5	1972	292	600	0	0
2	Sartanpar	Wankaner	Near Water Supply Tank	8.7	1180	260	480	14.13	0.8
3	Pipali	Morbi	In Gupteshwar Mahadev Temple	10	4168	440	560	26.53	0.2
4	Luntavadar	Morbi	Near Bank of Talav	4.07	426	300	200	0.39	0.2
5	Jasapar	Maliya	LHS of road to Village Moti Brar	5.2	804	360	280	0	0.8
6	Khirai	Maliya	RHS of road to Highway	3	2520	538	480	0	1.2
7	Lajai	Tankara	Near Water Supply Tank	11.5	6274	260	2240	17.72	0
8	Mitana	Tankara	On Left Bank of Mitanio Vonkla	6.1	778	380	400	17.72	0.2
9	Gauridad	Rajkot	LHS of road to Rajkot	15	1074	252	600	17.72	0.2
10	Kasturba Dham	Rajkot	RHS of road to Sradar	17	1400	280	600	35.44	0.2
11	Nyara	Paddhari	500 mts West of Village	5.8	1360	120	560	1.77	0.1
12	Khamta	Paddhari	Opp. To Khamta Bus Stand on Highway	9.8	860	200	480	17.72	0.2
13	Atkot	Jasdan	Rhs on Highway to Rajkot	9.5	1190	160	560	14.18	0.1
14	Hingolgadh	Jasdan	500 mts North of Village	7	960	240	400	0	0.1
15	Mekha Timbi	Upleta	Nera Khandeshwar Mahadev Temple	16.8	1084	280	520	35.44	0.6
16	Arni	Upleta	500 Mts. From Village on way ti Sajadiyali	8	1643	240	560	70.83	0
17	Supedi	Dhoraji	Near Hotet Shiv	12.05	4474	160	1640	35.44	0.4
18	Jamnavad	Dhoraji	GSFC Well near Bridge	14.05	1864	280	920	1.77	0.4
19	Jetalsar	Jetpur	Opp. Amardip Farm	15.3	834	360	520	1.77	0.4
20	Virpur	Jetpur	LHS of Metal road to Mevasa	3.25	1632	400	480	53.16	0
21	Khajurda	Jam Kandorana	Right side of road to Kandorana	8.4	1104	160	520	25.44	0
22	Dholidhar	Jam Kandorana	Left side to Village Khandorna	10	1990	200	320	79.74	0
23	Dahiya	Gonadal	In Village Padar Near road to Gondal	11.06	1072	240	600	53.16	0
24	Moviya	Gonadal	Near Village Panchayat & Smashan	6	860	200	620	14.18	0
25	Bhadva	Kotda Sanghani	LHS of road to Sharda	4.3	1248	240	600	14.18	0
26	Nani Menghni	Kotda Sanghani	LHS of road to Navi Meghani	13	890	280	620	7.99	0
27	Pardi	Lodhika	Opp overhead Tank	7.3	1042	240	400	7.99	0
28	Khirsara	Lodhika	In the Village	8.5	1080	250	600	17.72	0

Source : GWSSB

Table 6.13 Chemical analysis data of the water samples collected by GWSSB

May - 2005

Sr. No.	Village	Taluka	Location of the observation well	SWL (m)	Ground water quality				
					TDS (PPM)	Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)
1	Mahika	Wankaner	Behind Prathmik Shala	7.5	1584	200	600	1.77	0.4
2	Sartanpar	Wankaner	Near Water Supply Tank	7.3	1134	240	480	35.44	1.5
3	Pipali	Morbi	In Gupteshwar Mahadev Temple	10.2	3038	320	600	35.44	1
4	Luntavadar	Morbi	Near Bank of Talav	4.9	892	400	220	0	0
5	Jasapar	Maliya	LHS of road to Village Moti Brar	5.6	1020	260	240	17.72	1.5
6	Khirai	Maliya	RHS of road to Highway	3.1	1734	560	200	0	0.4
7	Lajai	Tankara	Near Water Supply Tank	15	4390	180	1360	17.72	0.2
8	Mitana	Tankara	On Left Bank of Mitanio Vonkla	6.9	586	240	260	14.11	0.2
9	Gauridad	Rajkot	LHS of road to Rajkot	14.8	458	240	140	10.63	0.2

Sr. No.	Village	Taluka	Location of the Observation Well	SWL In Mt	Ground Water Quality				
					Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)	Cl (PPM)
10	Kasturba Dham	Rajkot	RHS of road to Sradar	15.2	944	320	520	35.44	0.1
11	Nyara	Paddhari	500 mts West of Village	8.8	1598	220	480	35.44	0.2
12	Khamta	Paddhari	Opp. To Khamta Bus Stand on Highway	9	788	280	420	70.88	0.2
13	Atkot	Jasdan	Rhs on Highway to Rajkot	10.5	4700	200	1800	17.71	0.4
14	Hingolgadh	Jasdan	500 mts North of Village	9	858	240	200	1.77	0.4
15	Mekha Timbi	Upleta	Nera Khandeshwar Mahadev Temple	13.5	720	260	320	35.44	0
16	Ami	Upleta	500 Mts. From Village on way ti Sajadiyali	9.2	1204	200	480	1.77	0.2
17	Supedi	Dhoraji	Near Hotet Shiv	13.2	4142	320	1280	1.77	0.4
18	Jamnavad	Dhoraji	GSFC Well near Bridge	15.6	3832	180	1000	17.71	0
19	Jetalsar	Jetpur	Opp. Amardip Farm	14.2	838	400	420	5.32	0
20	Virpur	Jetpur	LHS of Metal road to Mevasa	6.4	2058	320	780	35.44	0
21	Khajurda	Jam Kandorana	Right side of road to Kandorana	9.6	966	220	400	5.32	0
22	Dholidhar	Jam Kandorana	Left side to Village Khandorna	12	3918	220	1520	17.72	0
23	Dahiya	Gonadal	In Village Padar Near road to Gondal	212.5	736	220	340	14.18	0
24	Moviya	Gonadal	Near Village Panchayat & Smashan	6.1	1626	400	800	14.18	0.4
25	Bhadva	Kotda Sanghani	LHS of road to Sharda	9.6	1510	300	700	14.18	0
26	Nani Menghni	Kotda Sanghani	LHS of road to Navi Meghani	15.5	922	320	540	10.63	0
27	Pardi	Lodhika	Opp overhead Tank	8.1	948	520	400	5.32	0.2
28	Khirsara	Lodhika	In the Village	12	1818	160	460	17.71	0

Source : G.W.S.& S.B

Table 6.14 Chemical analysis data of the water samples collected by GWSSB

May - 2006

Sr. No.	Village	Taluka	Location of the observation well	SWL (m)	Ground water quality				
					TDS (PPM)	Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)
1	Mahika	Wankaner	Behind Prathmik Shala	9.5	1460	400	440	17.72	1.2
2	Sartanpar	Wankaner	Near Water Supply Tank	6.4	1290	160	400	70.88	1.4
3	Pipali	Morbi	In Gupteshwar Mahadev Temple	8	2740	280	1000	8.6	0.2
4	Luntavadar	Morbi	Near Bank of Talav	4.6	510	200	280	0	0.4
5	Jasapar	Maliya	LHS of road to Village Moti Brar	4.8	2840	480	1080	17.72	0.1
6	Khirai	Maliya	RHS of road to Highway	2.8	974	320	240	14.18	1.4
7	Lajai	Tankara	Near Water Supply Tank	13	2540	160	800	3.54	0.1
8	Mitana	Tankara	On Left Bank of Mitanio Vonkla	6.3	500	200	240	14.18	0.1
9	Gauridad	Rajkot	LHS of road to Rajkot	13.5	620	160	200	1.77	0.1
10	Kasturba Dham	Rajkot	RHS of road to Sradar	15	1310	200	600	3.14	0.1
11	Nyara	Paddhari	500 mts West of Village	8.2	460	160	240	8.86	0.2
12	Khamta	Paddhari	Opp. To Khamta Bus Stand on Highway	8.5	590	280	200	0.89	1.2
13	Atkot	Jasdan	Rhs on Highway to Rajkot	11	1580	400	400	70.88	1.4

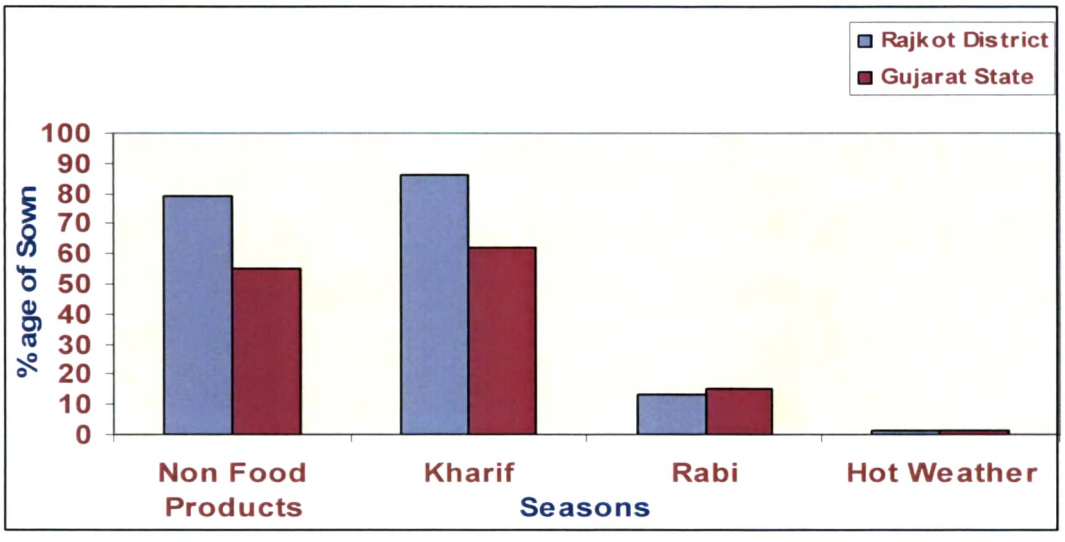
Sr. No.	Village	Taluka	Location of the observation well	SWL (m)	Ground water quality				
					TDS (PPM)	Cl (PPM)	HDs (PPM)	NO^3 (PPM)	F (PPM)
14	Hingolgadh	Jasdan	500 mts North of Village	7	1780	200	720	0.89	0.1
15	Mekha Timbi	Upleta	Nera Khandeshwar Mahadev Temple	11.8	2008	640	640	0.89	0.2
16	Arni	Upleta	500 Mts. From Village on way ti Sajadiyali	9	530	600	200	1.77	0.2
17	Supedi	Dhoraji	Near Hotet Shiv	12..3	5410	240	1760	17.72	0.4
18	Jamnavad	Dhoraji	GSFC Well near Bridge	14.3	1200	280	320	17.72	0.4
19	Jetalsar	Jetpur	Opp. Amardip Farm	14	1814	260	680	70.88	0.2
20	Virpur	Jetpur	LHS of Metal road to Mevasa	6.3	700	240	200	17.72	0.4
21	Khajurda	Jam Kandorana	Right side of road to Kandorana	10	520	120	280	70.88	0.2
22	Dholidhar	Jam Kandorana	Left side to Village Khandorna	11	2478	280	1160	88.6	0.2
23	Dahiya	Gonadal	In Village Padar Near road to Gondal	12	1640	200	600	17.72	0.2
24	Moviya	Gonadal	Near Village Panchayat & Smashan	6.6	2270	600	720	53.16	0.2
25	Bhadva	Kotda Sanghani	LHS of road to Sharda	9	2136	120	800	17.72	0.4
26	Nani Menghni	Kotda Sanghani	LHS of road to Navi Meghani	13.5	780	280	400	17.72	0.2
27	Pardi	Lodhika	Opp overhead Tank	6.8	830	120	300	14.18	0.2
28	Khirsara	Lodhika	In the Village	10	860	240	200	17.72	0.2
Source : G.W.S.& S.B									

The ground water quality analysis has been done by Gujarat Water Supply & Sewerage Board (GWSSB) is available for the recent years also. It reveals that the ground water quality has improved upto the requirement of drinking water in most of the samples collected from all the talukas.

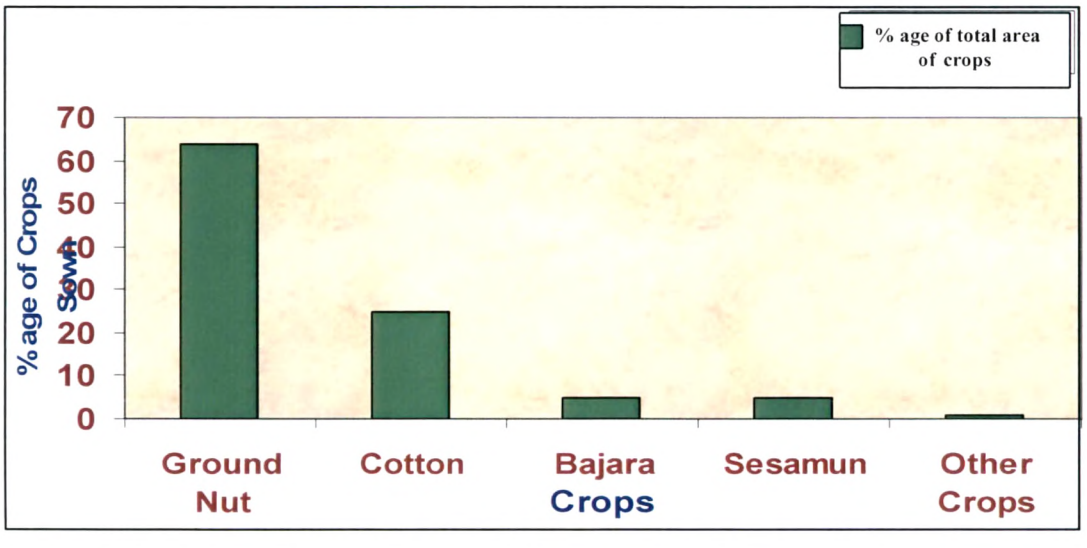
6.3 IMPACT OF CHECK DAMS ON CROPPING PATTERN & AGRICULTURAL PRODUCTION IN RAJKOT DISTRICT

6.3.1 Cropping pattern in Rajkot district

Rajkot is the largest district in geographical and cultivated areas in Saurashtra region. The cropping pattern in Rajkot district in comparison to Gujarat State is depicted in Graph 6.22. The kharif season cropping pattern in Rajkot district is shown in Graph 6.23.



Graph 6.22 Cropping pattern of Rajkot district in comparison to Gujarat State



Graph 6.23 Cropping pattern in kharif season in Rajkot district

Among the kharif crops, cotton and castor are the long duration crops of about 6 months and tur of 5 months, while others are of 3-4 month duration. All the rabi and summer season crops are grown totally with irrigation, while the long duration crops require irrigation even in good monsoon season for better output.

6.3.2 Water availability and crop production in Rajkot district

Because of variable quantum and distribution of rainfall, the availability of water for irrigation in Rajkot District is highly inadequate even to protect kharif crops. Monthly and total rainfall (1991 to 2003) of Rajkot district varies widely in distribution and quantity. Rainfall obtained in Rajkot district is uneven during the good rainfall period during July-August in Gujarat state, it is not received uniformly in Rajkot district. Irrigation to the existing crops for cultivation and protection to existing rabi and hot weather is meager through surface resources and whatever irrigation is done in Rajkot district, it is through ground water resources.

For normal growth of any crop, there is a need of adequate moisture in soil profile to meet the evapo-transpiration demand as dictated by climate. Rainfall of 25 mm / week or 100 mm / month is sufficient not only for survival but also for normal yields. During 3rd, 2nd and 1st week of June, August and September, respectively, in which rainfall exceeds 100 mm / week callusing runoff to replenish surface storages. Similarly monthly rainfall, during the months of September and October receive less than 100 mm rainfall except for the years 1997, 1998 and 2005 in September. The variations in rainfall also influence yields with CV% of 50, 80, 63 and 46 for bajra, juwar, groundnut and cotton crops, respectively, which are fairly high values.

Ground water is the main source of water for irrigation in Rajkot district. The groundnut and cotton are the principal kharif crops receiving irrigation, which is mainly due to long crop period and the overall return from a unit area. The coverage of area in rabi season is mainly by wheat, cumin, isabgul, garlic, onion, gram, vegetables, etc. and groundnut and bajra in hot - weather season depending on ground water availability.

In Rajkot district, during the years 2000 to 2006, more than 4000 check dams have been constructed with people's participation. Because of storage of rainwater in these check dams, there has been a substantial increase in gross recharge through these years relative to year 1997 (Table 6.15).

Table 6.15 Increase in ground water table in Rajkot district			
Details	**1997**	**2002**	**2006**
Average rainfall (mm)	561	414	705
Total Ground Water Recharge (Mm^3)	1147	1182	1937

As seen from the above data, the total ground water recharge in the year 2006 increased to 790 Mm^3 in compared to that in the year 1997. The ground water duty in Rajkot district is 245 ha/Mm^3. Hence, the possibility of additional ground water irrigation potential of 1.70 lakh ha which stands created in the year 2006 due to the constructed check dams. Table 6.16 presents area, production and yield of crops in various years.

Table 6.16 Area, production & yield of crops from year 1998-99 to 2004-05 for groundnut and cotton

Sr. No.	Year	Area ('00 ha)	Production ('00 tons)	Yield (ton / ha)
GROUNDNUT				
1	1998-1999	4133	5148	1.25
2	1999-2000	4090	270	0.07
3	2000-2001	3748	218	0.06
4	2001-2002	3919	4958	1.27
5	2002-2003	4191	530	0.13
	Average	**4016**	**2225**	**0.56**
1	2003-2004	3707	8583	2.32
2	2004-2005	4202	3307	0.79
	Average	**3955**	**5945**	**1.56**
Source: Agriculture University, Junagadh				

Sr. No.	Year	Area ('00 ha)	Production ('00 tons)	Yield (tons / ha)
COTTON				
1	1998-1999	1612	6105	3.79
2	1999-2000	1510	2357	1.56
3	2000-2001	1777	691	0.39
4	2001-2002	1831	2112	1.15
5	2002-2003	1720	690	0.4
	Average	**1690**	**2391**	**1.46**
1	2003-2004	1681	10118	6.02
2	2004-2005	2028	10683	5.27
	Average	**1855**	**10401**	**5.65**
Source: Agriculture University, Junagadh				

The main kharif crops in Rajkot district are groundnut (64 %) & cotton (25 %). The overall production & yield of Kharif crops in Rajkot district increased in the year 2003 to year 2005 due to assured ground water irrigation available to farmers because of storage of water in checkdams. Hence there is positive impact of check dams on crop production.