SOCIO-ECONOMIC IMPACT OF COASTAL SALINITY PREVENTION STRUCTURE

REPORT-2014

COASTAL SALINITY PREVENTION CELL
Kharash Vistarotthan Yojana

Submitted to
COASTAL SALINITY PREVENTION CELL
AHMEDABAD

ACT
IMPROVING THE QUALITY OF DEVELOPMENT DELIVERY

Prepared by
ARID COMMUNITIES AND TECHNOLOGIES
BHUJ-KACHCHH

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1. INTRODUCTION

1.1 BACKGROUND

The coastal areas of Saurashtra region of Gujarat have a very fragile resource base that affects agriculture as well as other activities. The basic problem that concerns water in coastal areas is that due to sea water ingress and migration of seawater towards land, sweet aquifers turn saline. This phenomenon also causes reduction in the availability of quality drinking and irrigation water. The main causes for salinity ingress can be attributed to heavy withdrawals of ground water from coastal plain aquifers, seawater ingress, tidal water ingress, insufficient recharge and poor land and water management.

In order to mitigate salinity, the Salinity Ingress Prevention Circle (SIPC) set up by the Government of Gujarat under the Irrigation Department has invested in building structures like tidal regulators, bandharas, check dams, spreading channels and reservoirs for recharging ground water and controlling salinity and thereby improving water availability and quality of coastal aquifers. This study attempts to analyse the socio-economic impact of the various salinity control initiatives carried out by the department. The list of structures along with the villages that have been studied for this purpose is given in the following page.

1.2 APPROACH AND METHODOLOGY

Socio-economic impact of coastal salinity prevention structures has been analysed with reference to change in the following parameters:

a) Assets, income and investments
b) Fodder, livestock and milk production
c) Groundwater availability and quality
d) Agriculture
e) Situation of women

Each of these parameters has been examined on the basis of information collected through primary surveys and Focus Group Discussions (FGDs) in the villages falling under the 21 schemes selected for this study. (Table 1.1) A stratified random sample of 20 households covering big, small and marginal farmers as well as people undertaking different occupations in the village was chosen from each village. In addition, information was collected on impact at overall village level as well as separately through FGDs with Self-Help Groups of women to understand socio-economic impact of the structures on women's lives.

In addition to social engineering assessment, impact of schemes had also been assessed from changes in groundwater quality and water level fluctuation point of view with the help of observation data by SIPC. Status of landuse around TR structures has studied with the help of available satellite images. Since procedure for procurement of current year satellite data from respective department is lengthy procedure and therefore, data used for such analysis those freely available on internet.

Table 1.1 List of Coastal salinity prevention structures

S. No.	Name of scheme	Taluka	District	Compl. Yr.	Beneficiary villages	Site location	Villages
1	Garibpura R. R	Ghogha	Bhavnagar	2003	Garibpura and Bhankhale	Garibpura	2
2	Gopnath Bandhara	Talaja	Bhavnagar	2011	Amla, Gadula and Mahdevpura	Amla	3
3	Nikol Bandhara	Mahuva	Bhavnagar	2001	Nikol, Naip, Vaghnagar, Sathra, Mahuva, Bhadrod	Nikol	6
4	Samadhiyala Bandhara	Rajula	Amreli	2000	Samadhiyala, Patwa, Padhiyaka, Dolia, Vangar	Samidhiyala	5
5	Vasoj T. R.	Una	Gir Somnath	1984	Vasoj, Naliamandvi	Vasoj	2
6	Barda Bandhara	Kodinar	Gir Somnath	1985	Math, Chuhan ni Khan, Barda (Kodinar), Kanjotar, Dhamnej, Rakhej (sutrapada)	Barada	6
7	Muldwarka T. R.	Kodinar	Gir Somnath	1986	Muldwarka,Chhara,Panadar,Damli, Pipali, Madh	Muldwarka	6
8	Vadodara Zala T. R.	Sutrapada	Gir Somnath	1982	V.Zala, Prashnawada, Lothwa, Barula, Singsar, Thordi, Dahmlej, Sara		8
9	Somnath T. R.	Veraval	Gir Somnath	2010	Patan, Lati, Kajli, Badalpara		4
10	Sheel Bandhara	Mangrol	Junagadh	1987	Sheel, Sangawada, Jhariyawada		3
11	Sabli Netravati Canal, 7.30km	Mangrol	Junagadh	1996	Diwasa, Sangawada, Jhariyawada, Bamanwada, Ajak, Mekhadi		4
12	Ozat Madhuvanti Canal, 24.15km	Porbandar	Porbandar	2010	Pata, Chingariya, Gorsar (partial),Mocha (Partial) , Balej, Untada, Ratia		7
13	Karli T. R.	Porbandar	Porbandar	1993	Chhya, Rangahvav, Ratanpar, Odadar, Tukda(gosa), pipalia, Vanala(virpur), Mokar, Bapodar		9
14	Barda Sagar	Porbandar	Porbandar	1987	Rinavada, Modhvada, Kinderkheda, Keshav, Palkahda, Srinagar, Kuchadi, Baradiya, Kantela, Bharvada	Rinavada	10
15	Karlicreek Kindricreek canal	Porbandar	Porbandar	2009	Ratdi, Jhavar, Srinagar, Bokhira		8
16	Medhacreek T. R.	Porbandar	Porbandar	1993	Miyani, Gandhvi, Premsar, Tankaria, Raval, Vadala, Bhavpara, Ambarama, Chaslana, Gangadi	Miyani	6
17	Bhogaat T. R.	Kalyanpur	Jamnagar	1998	Bhogat, Goinji, Bhatvadiya		3
18	Sarmatkhara Beraja Bandhara	Jamnagar	Jamnagar	2002	Sarmat, Vasai, Dhicahda, Khara Beraja	Sarmata	4
19	Khijadiya Stepwell to Jambuda Bandhara canal, 7.35km	Jamnagar	Jamnagar	2010	Khijadiya , Jambuda, Dhuvav	Khijadiya	2
20	Balambha Bandhara	Jodiya	Jamnagar	2005	Balmbha, Kesiya, Mansar(hirapar)	Balambha	3
21	Khiri T. R.	Jodiya	Jamnagar	1998	Khiri	Khiri	1

Total villages: 100; total structures: 21

2. SOCIO-ECONOMIC IMPACT IN BHAVNAGAR DISTRICT

There are three schemes selected for assessment such as (01) Garibpura RR; (02) Gopnath Bandhara and (03) Nikol Bandhara of Ghogha, Talaja and Mahuva taluka respectively. Fig. 2.1 shows location of structures and villages those considered for the assessment.

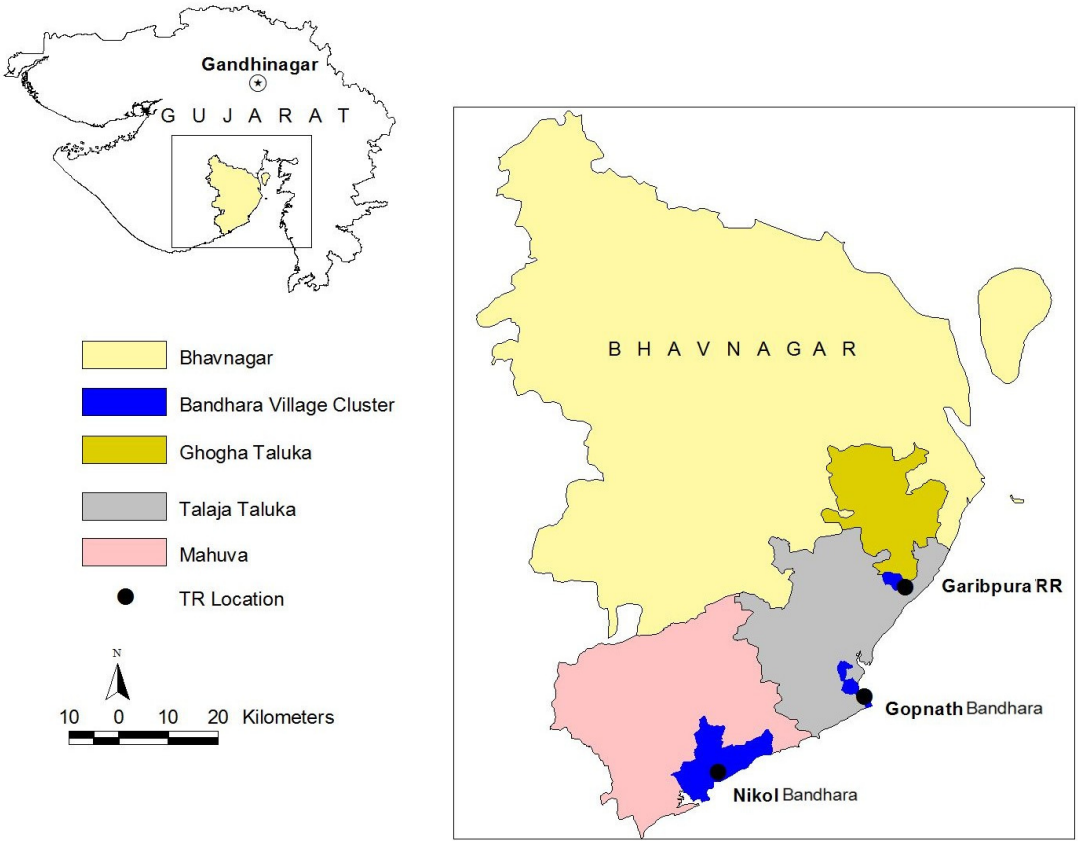


Fig 2.1: Location of Salinity Prevention Structures in Bhavnagar District

2.1 GARIBPURA Recharge Reservoir

Plate No. 2.1 Field Photograph Showing Overflow of Garibpura RR

Socio economic impact in surrounding villages of Garibpura RR has been judged through various parameters. Major socio economic parameter considered were, increase in assets, investments, increased securities in livelihood sectors such as impact on fodder availability etc.

Besides socio economic angle changes in groundwater quality and water level behaviour have also studied with the help of secondary data. Following is a description of impact due to Garibpura RR in its surrounding area.

2.1.1 ASSETS, INCOME AND INVESTMENTS

In Bhavnagar district, the impact of salinity prevention structures on asset ownership, incomes and investments is quite significant in villages under the Garibpura RR scheme. Here, the most common assets acquired by families after the scheme include mobile telephone, vehicle and tractor as can be seen from Fig 2.2.

Another impact of the construction of the recharge reservoir has been introduction of new sources of income which did not exist before the scheme. In the case of Garibpura, several households have reported income from selling milk, fodder and manure which can be attributed to the increase in the number of milch animals (discussed later in this section). In addition, opportunities for daily wage employment and business have also increased (Fig. 2.3, A).

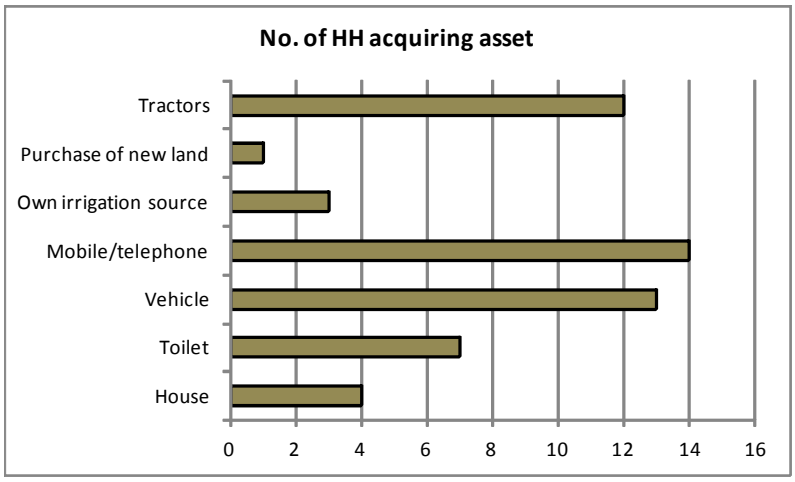
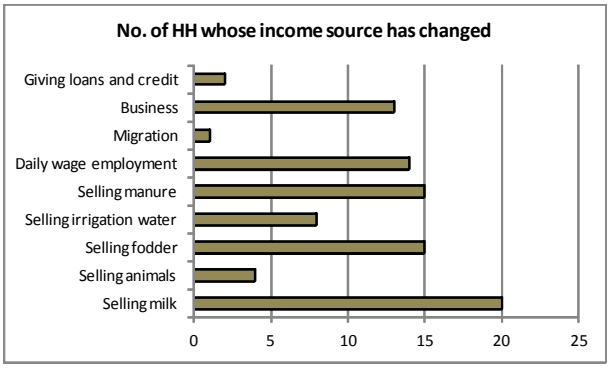
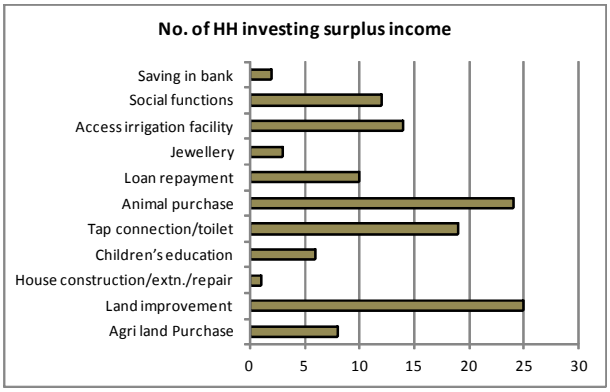


Fig 2.2: Impact on assets in Garibpura

Most of the families have invested the additional income to improve their agricultural land, purchase an animal or for getting a tap connection/toilet in their house as can be seen from Fig 2.3.



(A)



(B)

Fig 2.3: (A) Impact on income source and (B) Investment of surplus income in Garibpura

2.1.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Improved agriculture has in turn led to better availability of both green and dry fodder as well as manure (cow dung), as can be seen from Table 2.1. This has resulted in many households taking up selling of fodder and manure for additional income as has been seen previously.

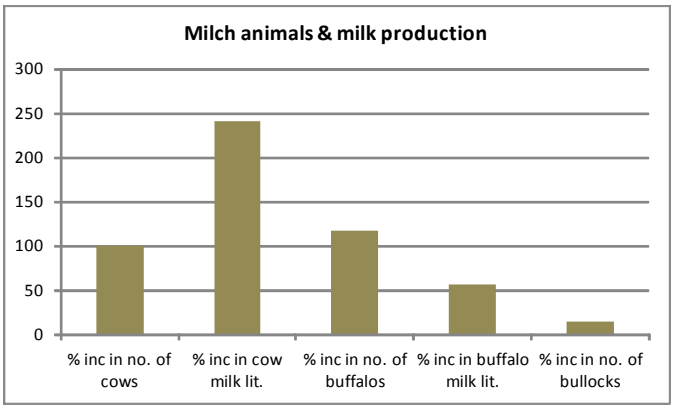


Fig 2.4: Impact on milch animals and milk production in Garibpura

Table 2.1: Impact on fodder availability due to agriculture, Garibpura RR

Impact	Quantity
Increase in Green Fodder (%)	360
Increase in Dry Fodder (%)	91
Increase in Cow dung (%)	630

Fig. 2.4 highlights the impact of the scheme on livestock and milk production in Garibpura. The benefits of increased fodder availability are most evident in villages under this scheme where both the number of cows and buffaloes and their milk production has shown very significant increase post the scheme. Due to improved agriculture, the number of bullocks used for ploughing during cultivation has also shown an increase in the area.

2.1.3 IMPACT ON GROUNDWATER

Impact on groundwater has studied from two different methods viz., (01) People's observation and (02) analysis of well observation data of SIPC, GoG. As per people point of view there is very little or no improvement in groundwater levels has been experienced by surveyed households in villages after the Garibpura RR scheme. While a mere 3 per cent of the households have reported improvement in water tables, 38 per cent have noticed no change and an even more significant 44 per cent of the households have reported water tables going down by upto 25 feet (Fig. 2.5).

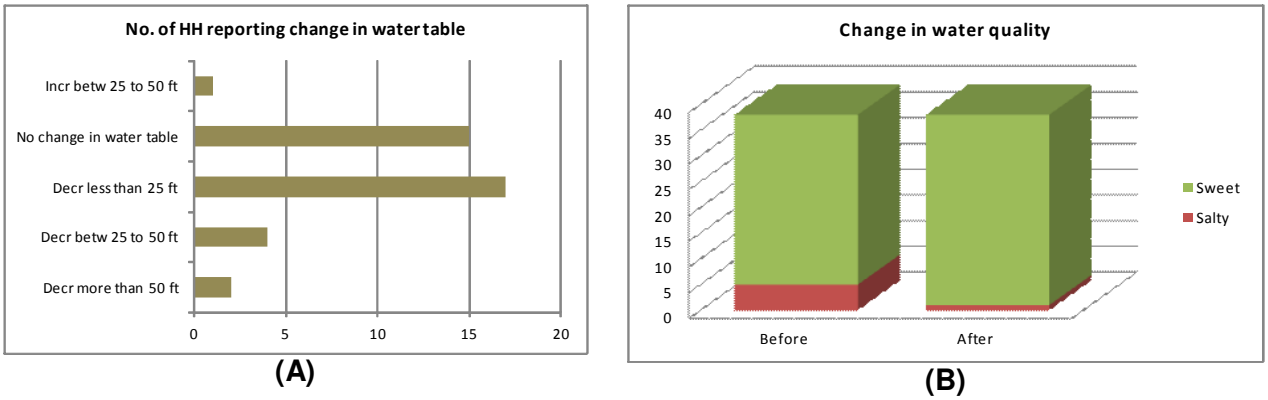


Fig. 2.5 People's Perspective on Groundwater (A) Water Level and (B) Water Quality

In terms of water quality, a perceptible difference has been noticed before and after the construction of the recharge reservoir. The number of households reporting availability of sweet water after the scheme has gone up by about 12 per cent - from 33 to 37 households while water salinity has also marginally decreased as can be seen from Fig. 2.5

In addition to people's concern, impact on groundwater has also been assessed based on available pre and post construction well monitoring data of SIPC. The main aspects have studied were changes in water level and concentration of Total Dissolved Solids (TDS). However the data were made available for only one well and from 2003 to 2011. Geology in nearby village namely Garibpura is igneous type rock called basalt. The mainly weathered basalt exist in this area.

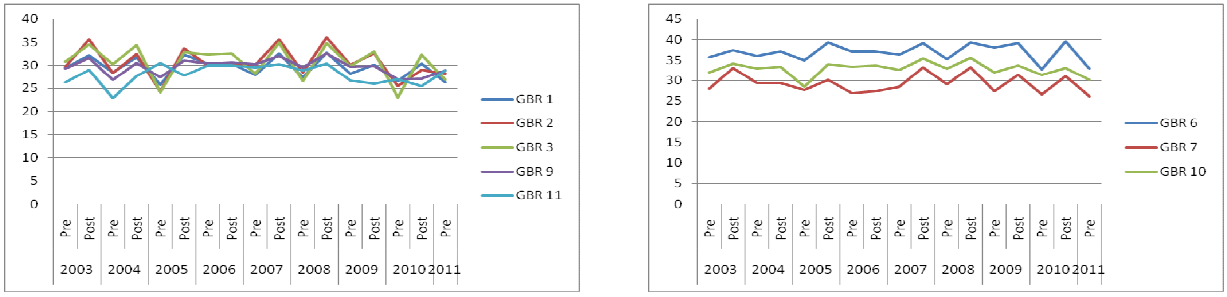
Plate No. 2.2 Field Photograph Showing Seepage Water Flow from Garibpura RR

Table 2.2 (A) : Pre and Post Monsoon Changes and Groundwater Levels and Quality in Observation Well of Garibpura

OW		GBR 1	GBR 2	GBR 3	GBR 9	GBR 11	GBR 4	GBR 5	GBR 6	GBR 7	GBR 10
Village		Bhakhal					Garibpura				
RL (M)		33.96	37.63	36.03	33.17	31.22	39.16	38.28	42.86	38.89	37.71
2003	Pre	29.36	29.68	30.73	29.27	26.22	31.46	32.18	35.76	27.89	32.11
	Post	32.16	35.68	34.53	31.57	29.02	35.06	34.78	37.46	32.99	34.21
2004	Pre	28.46	28.38	30.29	26.77	22.82	30.26	32.48	36.06	29.39	33.01
	Post	31.76	32.48	34.33	30.47	27.62	31.16	34.28	37.06	29.39	33.51
2005	Pre	25.66	24.18	24.03	27.37	30.52	29.56	30.48	34.86	27.69	28.51
	Post	32.30	33.70	32.90	31.10	27.80	30.90	34.40	39.20	30.10	34.10
2006	Pre	30.46	29.98	32.33	30.37	29.92	29.96	33.38	37.06	26.79	33.41
	Post	30.46	30.38	32.63	30.67	29.92	30.36	33.78	37.16	27.39	33.71
2007	Pre	27.86	30.18	28.23	30.17	29.62	28.76	32.08	36.36	28.39	32.61
	Post	32.66	35.68	34.93	32.07	30.22	33.56	35.88	39.06	33.19	35.41
2008	Pre	27.36	28.48	26.53	29.47	28.92	30.66	32.68	35.16	29.09	33.01
	Post	32.76	36.08	34.83	32.57	30.32	34.16	35.78	39.26	33.19	35.61
2009	Pre	28.16	30.08	29.83	29.67	26.72	30.06	32.48	38.06	27.39	32.11
	Post	30.06	32.58	33.03	29.87	25.92	33.06	35.28	39.06	31.39	33.71
2010	Pre	26.56	25.36	22.93	26.97	26.92		29.58	32.76	26.59	31.51
	Post	30.46	28.98	32.33	27.07	25.42	30.96	34.58	39.56	31.09	33.11
2011	Pre	26.16	28.18	26.83	28.87	28.82	26.56	28.08	32.86	26.09	30.16

Changes in groundwater in nearby area of Garibpura Bandhara have understood through computing hydrographs for reduced water levels, TDS and chloride concentrations. (Fig no. 2.6 and 2.7) Hydrographs clearly point following

- Reduced water levels is gradually decreases in case of observation wells of Bhakhal village while it remains maintain in case of Garibpura village
- Total dissolved solids in ground water shows maximum value remains below than 1000 ppm in almost all the years.
- In case of Bhakhal village the TDS value the minimum TDS concentrations in all the Bandharas were ranges from 300 to 600 ppm while in case of Garibpura village is 400 to 600 ppm
- The maximum value is gradually increases in both the villages and they range from 500 to 800 in case of Bhakhal village and are 400 to 1000 in case of Garibpura village.
- Interestingly the Bhakhal village shows both depleting trends in water level as well as groundwater quality.



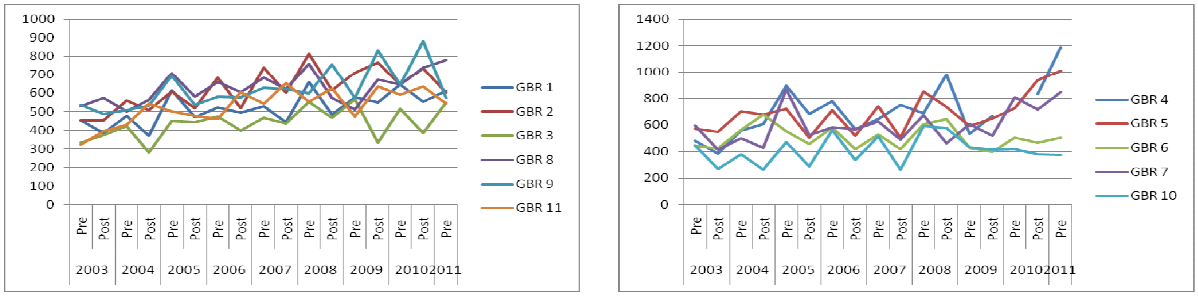
(A) (B)

Source: SIPC, 2003 - 2011

Figure 2.6: Well Hydrograph Showing Changes in Reduced water levels in Observation Well of Garibpura RR (A) Village Bhakhal and (B) Village Garibpura

Table 2.2 (B): Pre and Post Monsoon Changes and Total Dissolved Solids (PPM) in Observation Wells of Garibpura

TDS (PPM)												
Village		Bhakhal						Garibpura				
OW		GBR 1	GBR 2	GBR 3	GBR 8	GBR 9	GBR 11	GBR 4	GBR 5	GBR 6	GBR 7	GBR 10
2003	Pre	452	452	333	530	536	321	482	571	440	595	446
	Post	386	453	373	572	486	393	386	546	419	413	266
2004	Pre	478	558	422	501	507	427	558	701	564	501	376
	Post	371	506	282	563	531	544	608	678	678	429	262
2005	Pre	615	609	450	706	695	501	894	723	553	866	473
	Post	470	516	444	581	535	477	685	503	457	522	287
2006	Pre	524	684	473	661	581	461	780	712	581	581	564
	Post	495	516	400	604	577	604	570	516	414	569	332
2007	Pre	530	740	467	684	627	541	644	740	530	627	513
	Post	444	600	437	620	620	653	751	502	418	490	261
2008	Pre	660	815	552	758	598	552	689	852	604	672	593
	Post	485	614	467	572	756	627	981	737	645	461	577
2009	Pre	577	710	566	510	572	473	534	590	424	608	430
	Post	550	768	333	672	832	634	672	646	397	518	410
2010	Pre	645	645	516	645	645	591		726	506	806	419
	Post	553	737	385	740	884	637	836	938	463	716	379
2011	Pre	613	601	548	780	571	542	1190	1012	506	845	375



(A) (B)

Source: SIPC, 2003-2011

Figure 2.7: Well Hydrograph Showing Changes in Concentrations in TDS and Cl in Observation Well of (A) Village Bhakhal and (B) Village Garibpura

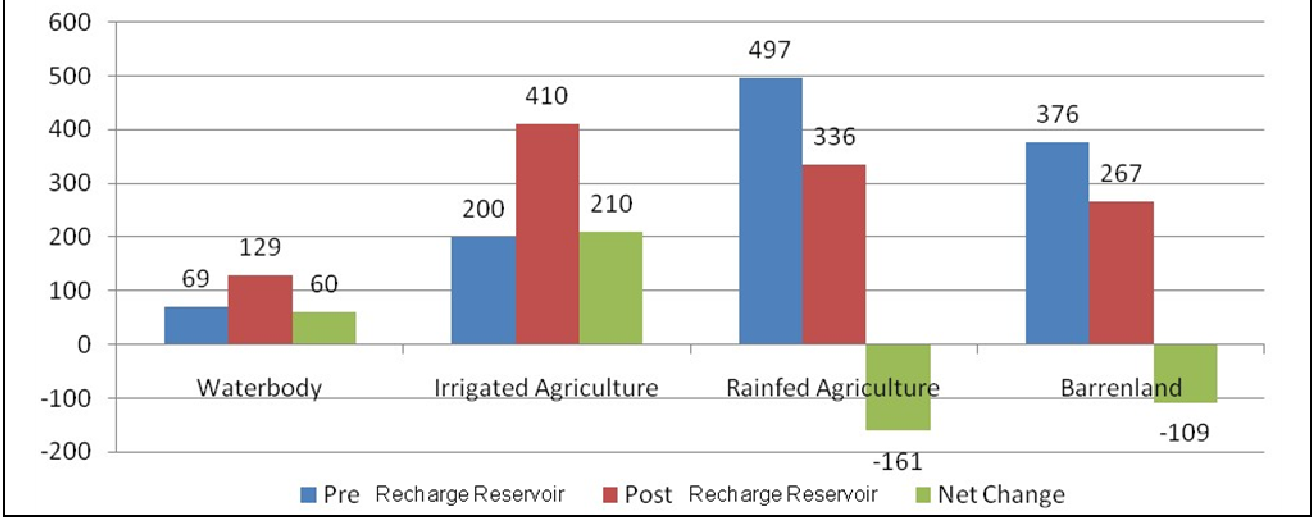
2.1.4 LANDUSE PATTERN

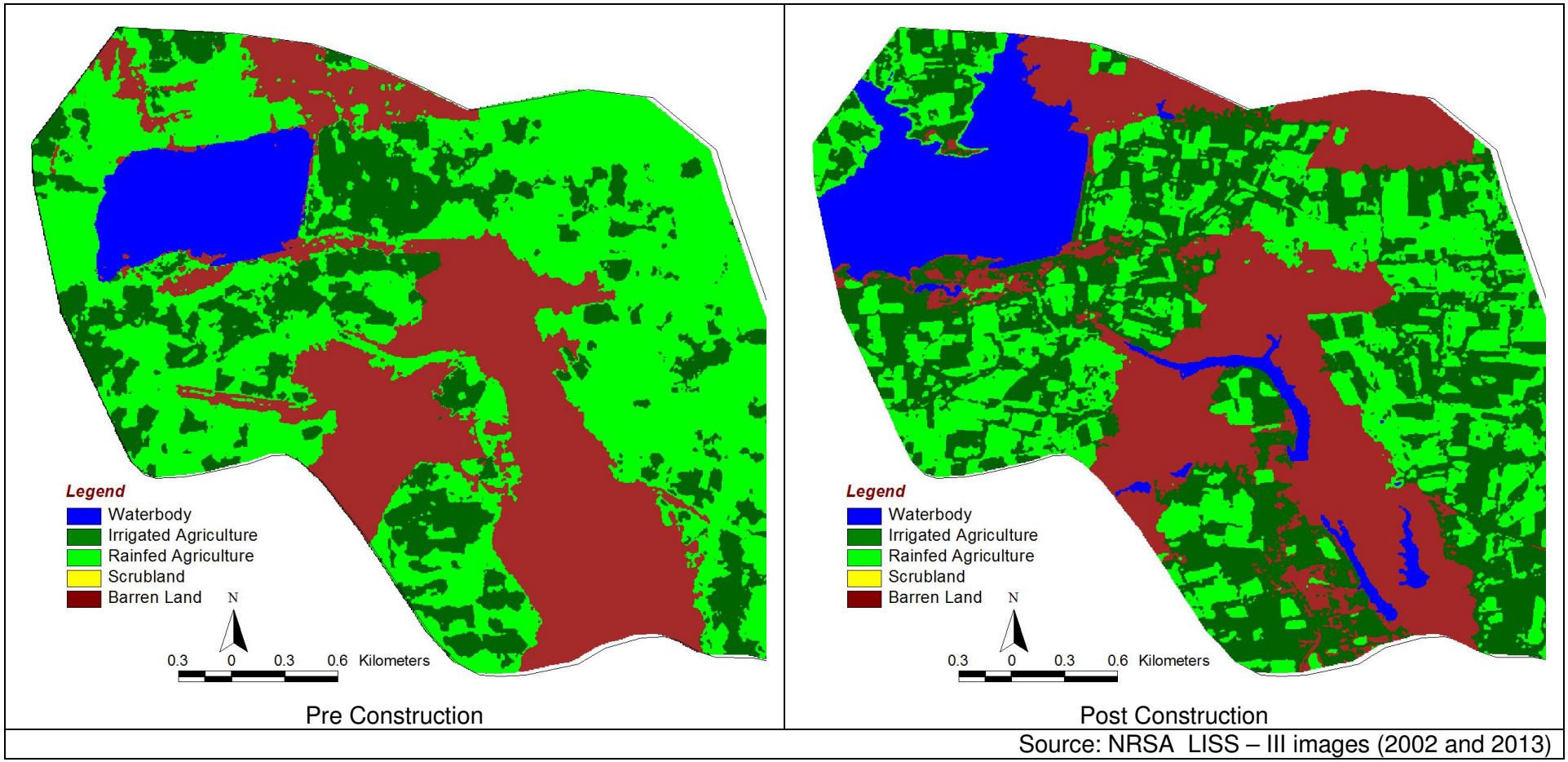
Land use pattern around Garibpura recharge reservoir has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years, 2002 Pre recharge reservoir construction and 2013 post recharge reservoir construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table2.3)

Changes in land use pattern clearly shows about double increased in irrigated areas i.e. 200 Ha Pre recharge reservoir construction to 410 Ha post recharge reservoir construction period. In case of rainfed agriculture and barren land area about 161 ha and 109 Ha areas have decrease. Decrease in rainfed area indicates that much of the area has converted in irrigated areas.

Table 2.3 Pre & Post Construction Changes in Landuse Pattern around Garibpura RR

Land use	Changes in Land use Area (Ha)		
	Pre RR	Post RR	Net Changes
Water body	69	129	60
Irrigated Agriculture	200	410	210
Rain fed Agriculture	497	336	-161
Barren land	376	267	-109
Total	**1142**	**1142**	**0**





Source: NRSA LISS – III images (2002 and 2013)

Fig. 2.8 Landuse Pattern around Garibpura RR Area,

2.2 GOPNATH BANDHARA

2.2.1 ASSETS, INCOME AND INVESTMENTS

Very little impact on assets and income sources is seen in villages under the Gopnath bandhara with most of the surveyed households reporting no asset acquisition or change in income source post the construction of the bandhara (Fig. 2.9 (A) and 2.9 (B)). In a few cases where new income sources like selling of milk and fodder have been reported, the surplus income generated has been mostly used for accessing irrigation facilities (Fig 2.9, (C)).

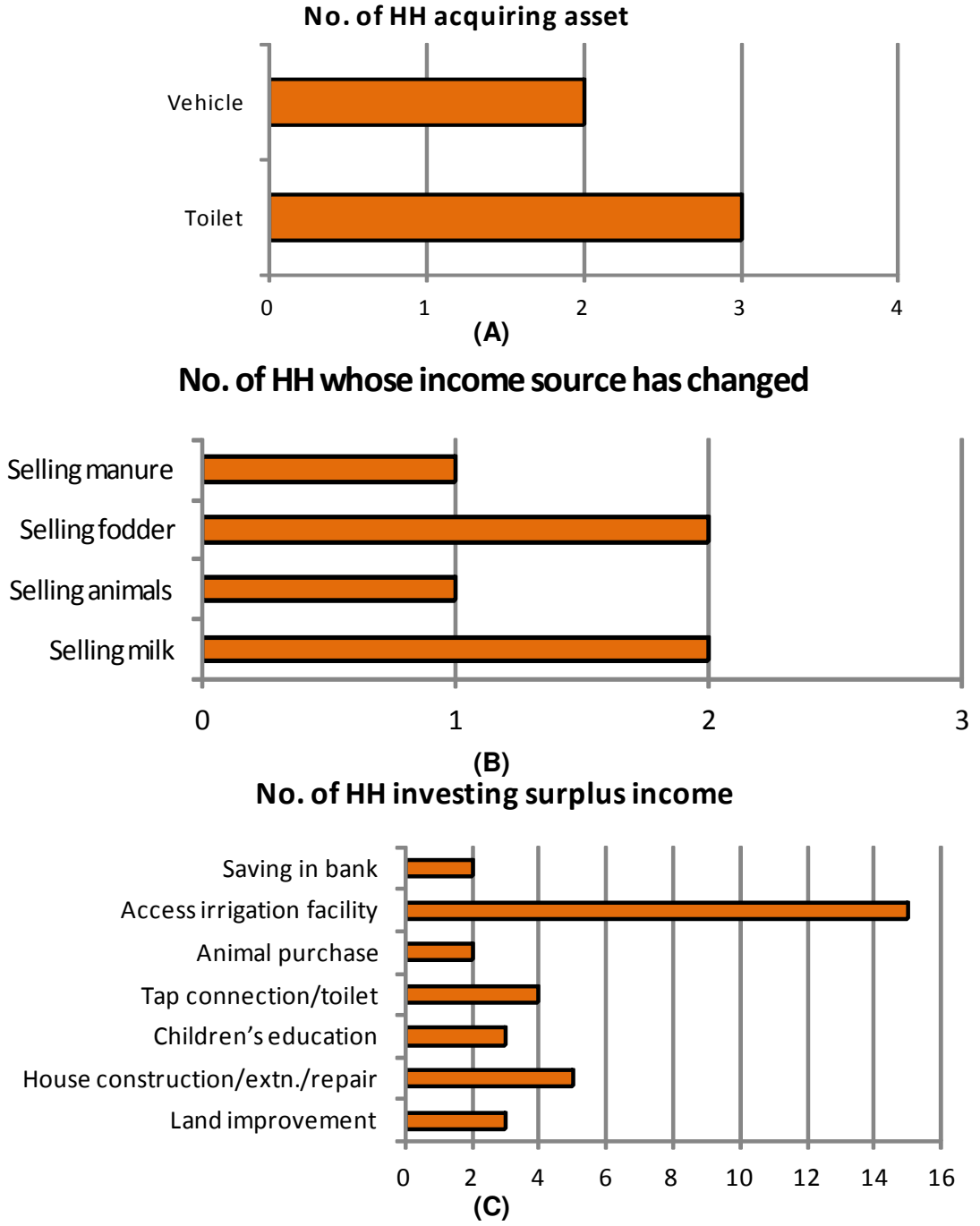


Fig 2.9 (a) Impact on assets; (B) Impact on income source; (c) Investment of surplus income In Gopnath Bandhara

2.2.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Despite significant improvement in availability of green and dry fodder (Table 2.4), people seem to be disinclined to keep milch animals. In fact, there has been a drastic reduction in the number of buffaloes in the affected villages of Gopnath bandhara as can be seen from Fig. 2.10.

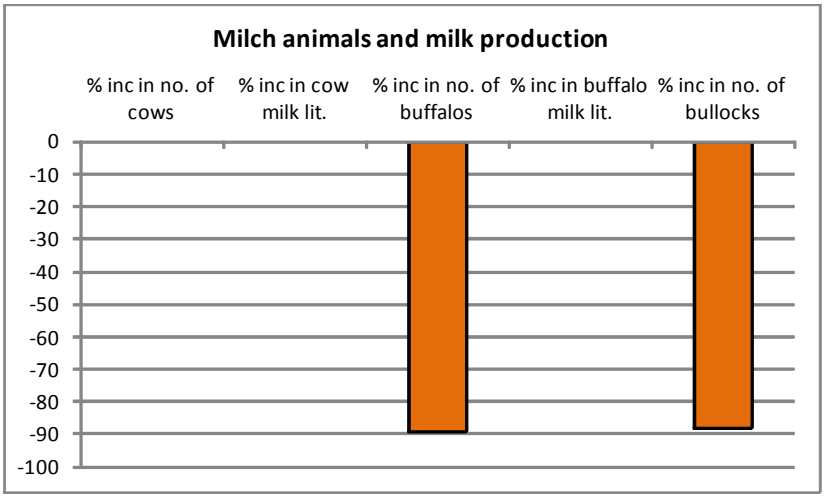


Fig. 2.10: Impact on milch animals and milk production in Gopnath

Table 2.4: Impact on fodder availability due to agriculture, Gaopnath Bandhara

Impact	Quantity
Increase in Green Fodder (%)	78
Increase in Dry Fodder (%)	52
Increase in Cow dung (%)	18

A declining trend is also seen in the case of bullocks used for agriculture which points to either a possible downturn in agriculture as an occupation in these villages or greater farm mechanisation

2.2.3 GROUNDWATER AVAILABILITY AND QUALITY

Impact on groundwater has studied from two different methods viz., (01) People's observation and (02) analysis of well observation data of SIPC, GoG. While largely there has been no change in the water table in the affected villages post construction of the Gopnath bandhara, three households have reported increase in water table by upto 25 feet as shown by Fig. 2.11.

Plate No. 2.3 Field Photograph of Gopnath Bandhara

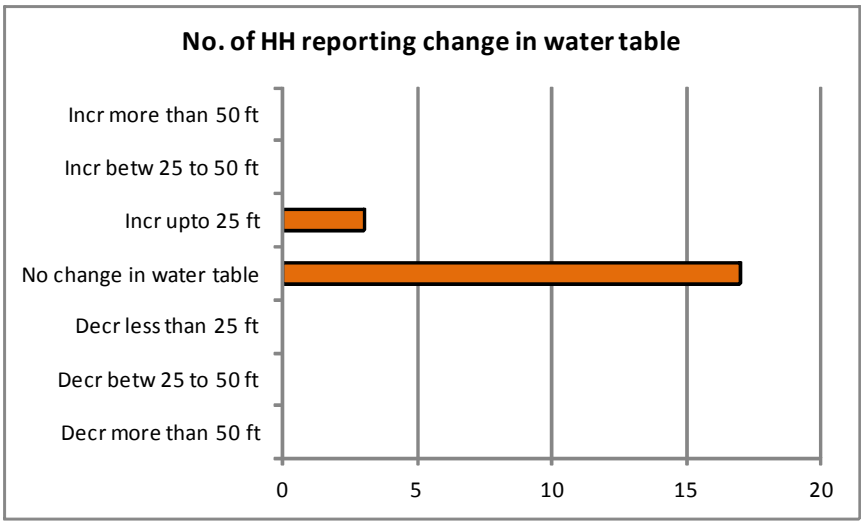


Fig 2.11: People's Point of View on Change in water table in Gopnath

In addition to people's concern, impact on groundwater has also been assessed based on available pre and post construction well monitoring data of SIPC. The main aspects have studied were changes in water level and concentration of Total Dissolved Solids (TDS). However the data were made available for only one well and from 1988 to 2011. It is important note here that groundwater data from year 2005 to 2010 were note made available for the analysis.

Records of two monitoring wells were available those established by SIPC for analysis viz., Observation well BUS-136 and BUS-137 located in village Amla of Taluka. SIPC monitors both the wells since 1988. Geologically the area shows rock formations of Tertiary age and Milliolitic limestone is a dominant aquifer system in this area. Table 2.5 shows the monitoring records of observation wells.

Plate no. 2.4 Consultations With Farmer Near Gopnath Bandhara

Changes in water levels and groundwater quality have been evaluated based on hydrographs prepared for reduced water levels, TDS and chloride concentrations. (Fig no. 2.12 and 2.13) Hydrographs clearly point following

- Water level depth is gradually increases in both the observation wells however, in case of well no BUS-136 there was sudden increase in water table depth during year 1988 to 2003 than onward the rise in water table has increased constantly. Whereas a constant increase in water level observed in well no BUS – 137.
- In case of water quality concentration of Total dissolved solids in well no BUS – 136 remains above than 1500 ppm during most of the pre monsoon season whereas in post monsoon the concentration value goes below than 1500 ppm during post monsoon seasons of year 2001 and 2002. Whereas the TDS concentration is gradually increases in well no BUS – 137
- Hydrograph for chloride concentration also shows similar trends as TDS concentration.

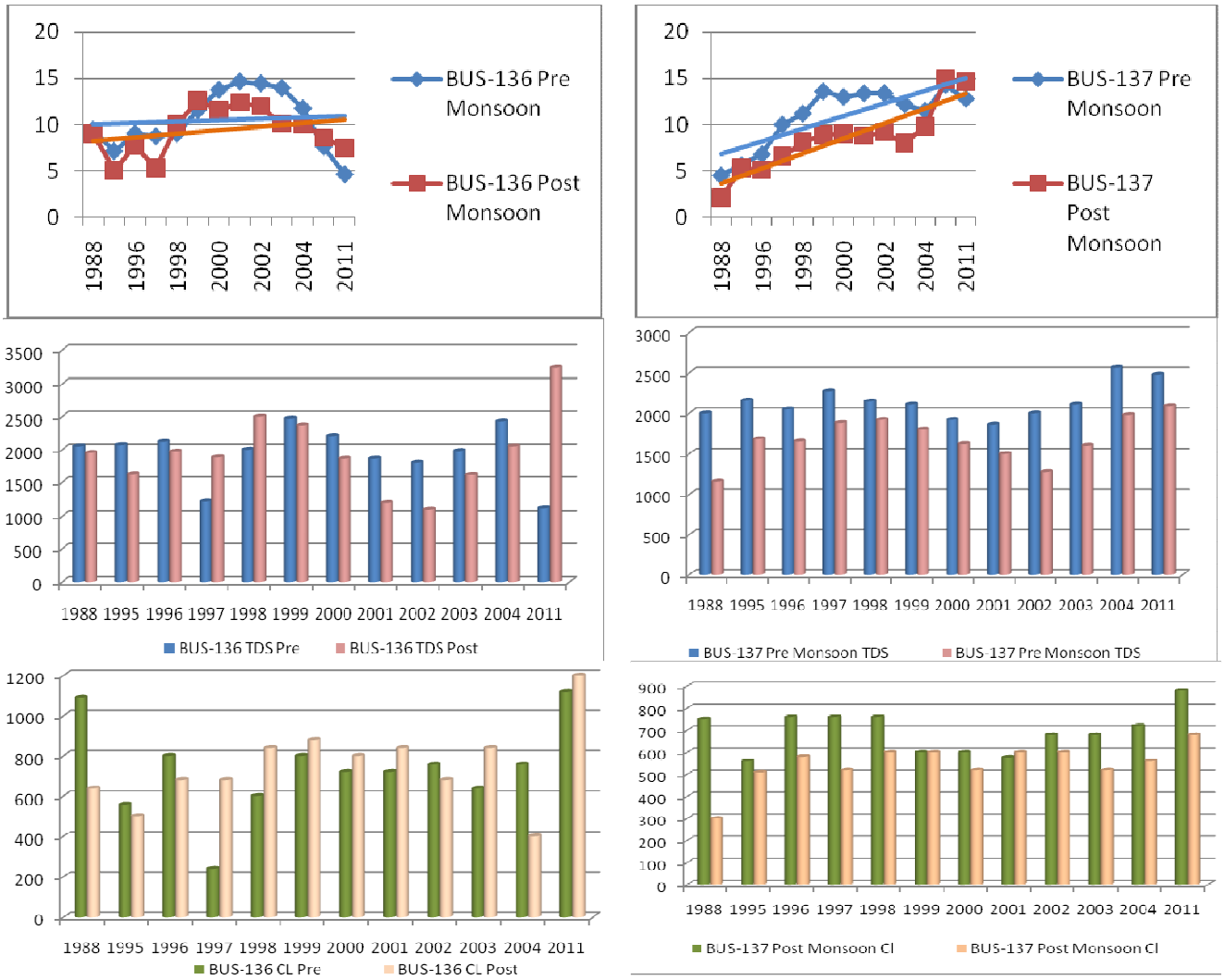


Fig.2.12 Well Hydrograph Showing Changing Trends in (A) RWL and (B) TDS and (C) Chloride Concentrations in Well No. BUS 136 and BUS-137 of Vill. Amla, Tal. Talaja near Gopanath Bandhara

Table 2.5: Pre and Post Monsoon Changes and Groundwater Levels and Quality in Observation Wells BUS-136 and BUS-137 of Gopnath, Vill Amla-Tal. Talaja

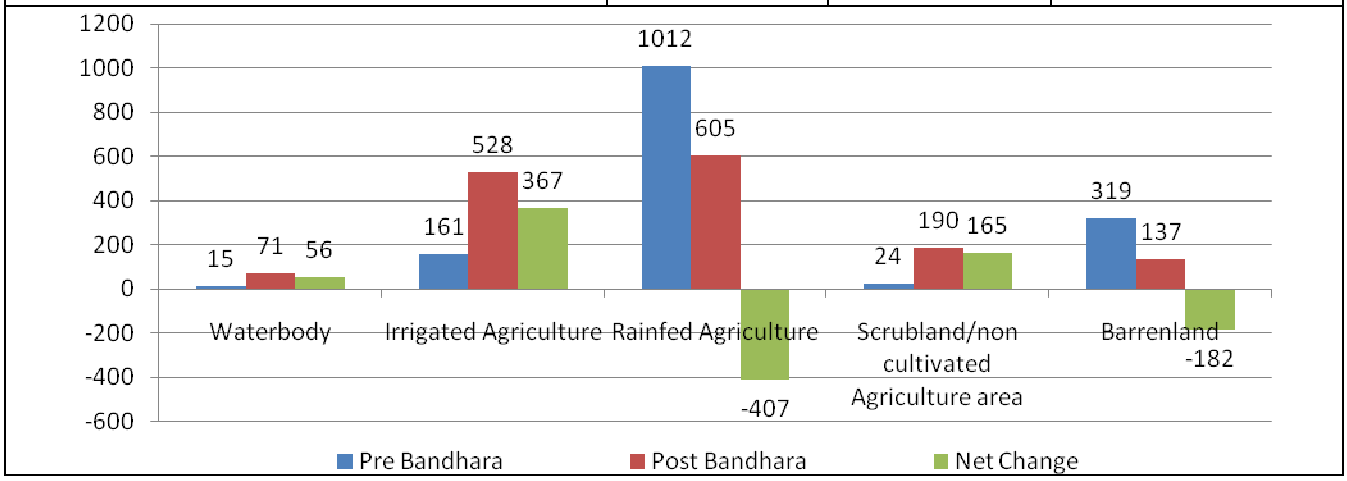
Year	Observation Well BUS-136						Observation Well BUS-137					
	Pre Monsoon (May)			Post Monsoon (October)			Pre Monsoon (May)			Post Monsoon (October)		
	WL	TDS	Cl	WL	TDS	Cl	WL	TDS	Cl	WL	TDS	Cl
1988	9.5	2050	1090	9.0	1950	640	4.5	2000	750	2.10	1150	300
1995	7.2	2070	560	5.1	1630	500	5.6	2160	560	5.30	1680	510
1996	9.1	2120	800	7.8	1970	680	6.8	2050	760	5.10	1650	580
1997	8.8	1220	240	5.4	1880	680	10.0	2270	760	6.60	1880	520
1998	9.1	2000	600	10.1	2500	840	11.2	2150	760	8.10	1920	600
1999	11.6	2470	800	12.6	2370	880	13.6	2110	600	8.90	1800	600
2000	13.8	2200	720	11.6	1860	800	13.0	1920	600	9.00	1620	520
2001	14.7	1860	720	12.4	1200	840	13.4	1860	576	8.80	1500	600
2002	14.5	1800	760	12.0	1100	680	13.4	2000	680	9.20	1280	600
2003	14.0	1980	640	10.1	1620	840	12.2	2110	680	8.00	1600	520
2004	11.8	2430	760	10.0	2050	400	11.5	2560	720	9.80	1980	560
2009	7.7	3980	---	8.6	3360	---	14.3	2860	---	14.9	2170	---
2011	4.7	1120	1120	7.5	3230	1200	12.8	2480	880	14.6	2090	680

2.2.4 LANDUSE PATTERN

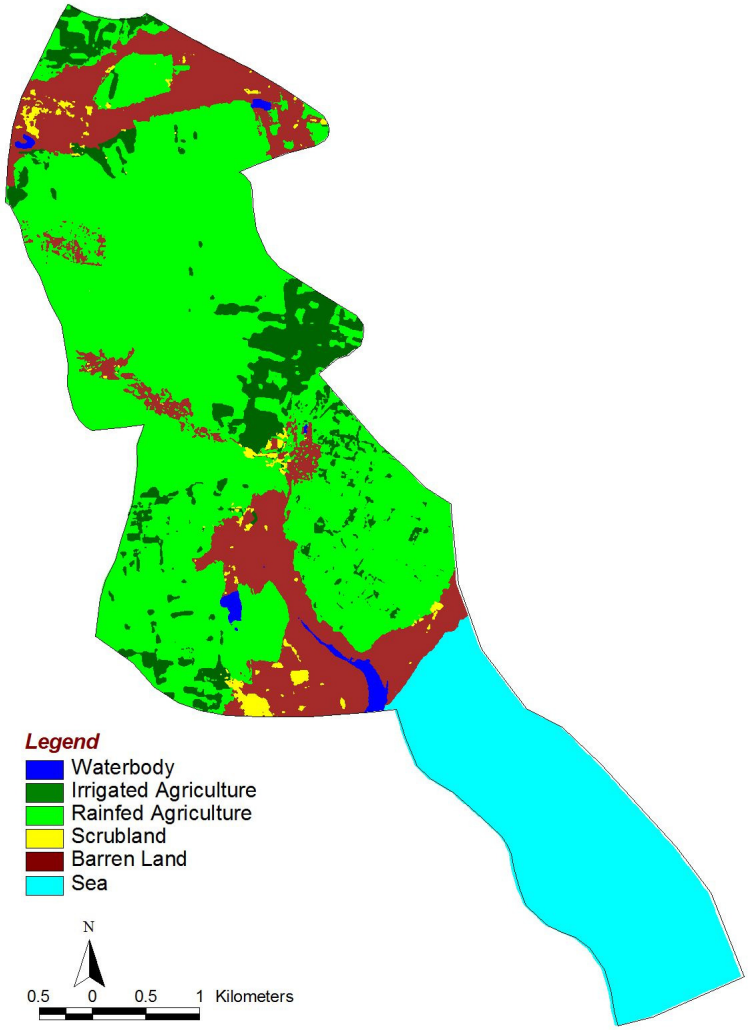
Land use pattern around Gopinath Bandhar has been studied with the help of remote sensing data. To understand land use pattern LISS – III image of the years 2008 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table2.6) Table 2.6 and fig 2.13 shows pre and post construction changes in land use pattern around Bandhara, it is very clearly shows significant increase in irrigated areas from 161 Ha (pre construction) to 528 Ha (post construction). The Table 2.6 also shows decrease of about 407 ha of rainfed area. Increase scrubland areas due to vegetative growth and decrease in barren land areas also shows impact of storage of water in Bandhara.

Table 2.6 Landuse Pattern around Gopnath Bandhara

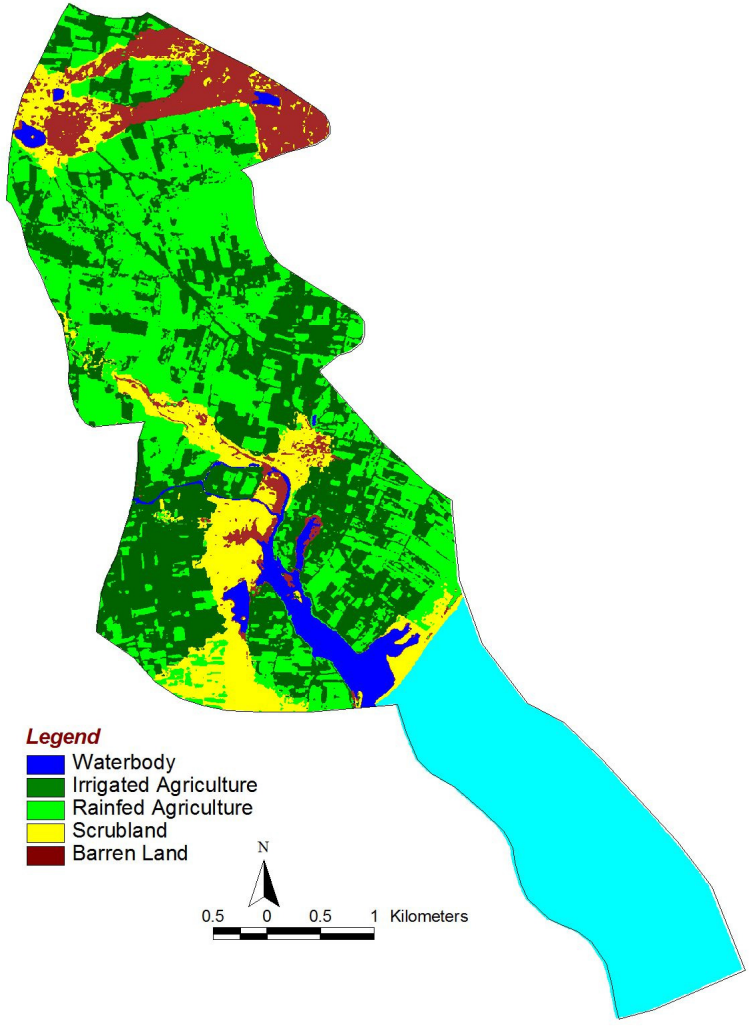
Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	15	71	56
Irrigated Agriculture	161	528	367
Rain fed Agriculture	1012	605	-407
Scrubland/non cultivated Agriculture area	24	190	165
Barren land	319	137	-182
Total	**1531**	**1531**	0



Land use pattern analysis of satellite images of Pre and post construction phases of Bandhara shows significant increase in irrigated areas from 161 Ha (in year 2008) to 528 Ha during year 2013. While it shows decrease in rainfed areas that clearly shows rainfed areas now turned in irrigated areas. One another important change has noticed is decrease in barren land from 319 Ha to 137 Ha and vis a vis increase of scrubland from only 24 Ha to 190 Ha during year 2013.



Pre Constructon



Post Construction

Source: NRSA LISS – III images (2008 and 2013)

Fig. 2.13 Landuse Pattern around Gopnath Bandhara Area

2.3 NIKOL BANDHARA

2.3.1 ASSETS, INCOME AND INVESTMENTS

In villages benefiting from the Nikol bandhara, the impact on assets has been moderate – not as low as in the case of Gopnath while at the same time, not as significant as in villages benefiting from the Garibpura tidal regulator. The asset acquired post the scheme by most households is a vehicle, followed by mobile telephone and own irrigation source (Fig. 2.14).

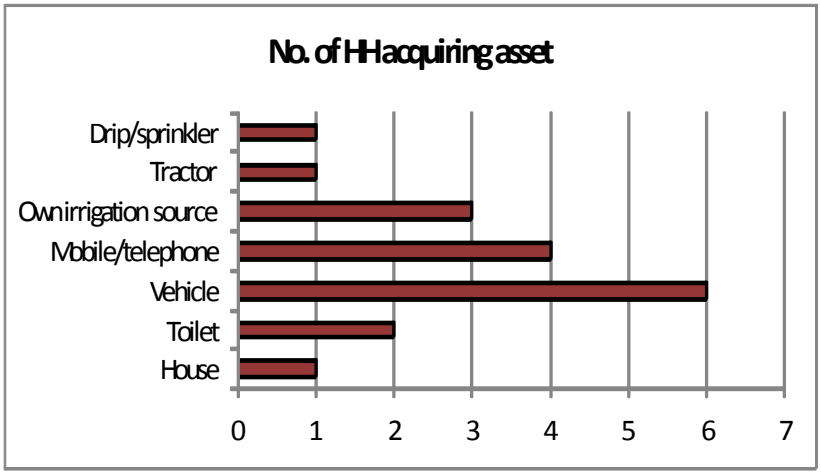


Fig. 2.14: Impact on assets in Nikol

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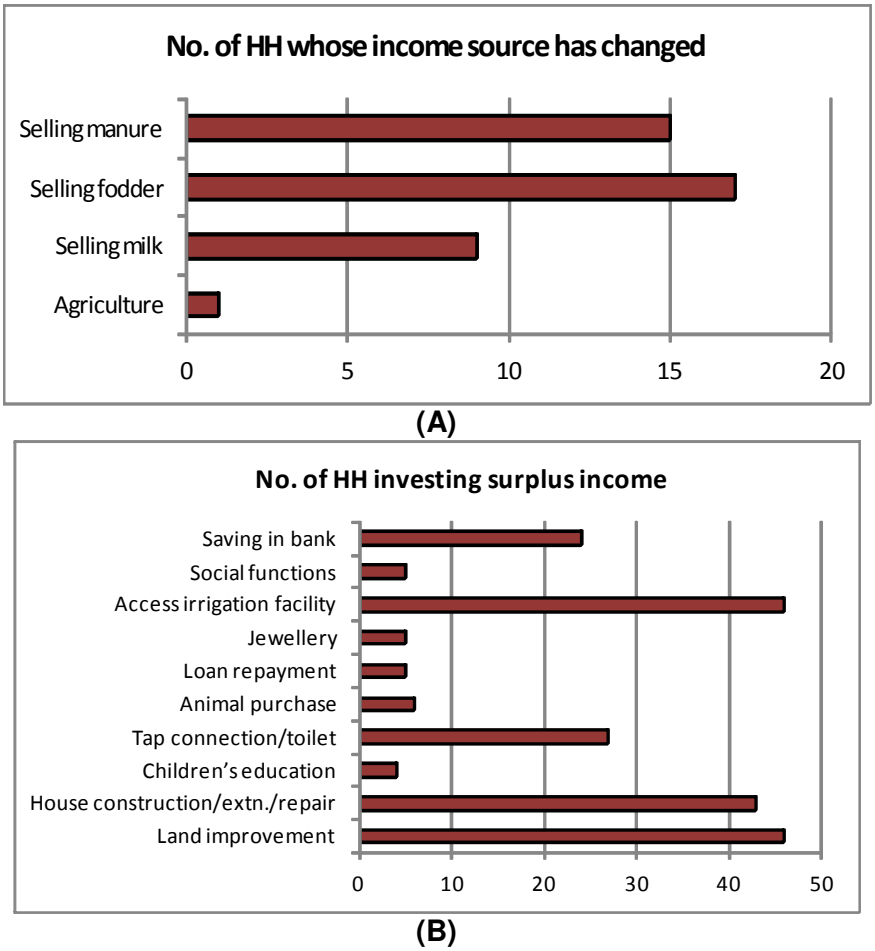


Fig. 2.15: Impact on income source (A) and Investment of surplus income (B) in Nikol

2.3.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Selling fodder, manure and milk has become the new additional source of income for many families as shown by Fig. 2.15 A. The surplus income gained from these activities has been largely invested in improving agricultural land, ensuring irrigation facilities and undertaking renovation/extension of the house (Fig. 2.15 B). A few families have also used the surplus to install a tap connection/toilet in their house or have kept it away as savings in a bank

Like in the case of assets and income, the impact on fodder availability in Nikol has also been moderate as shown in table 2.7 below

Table 2.7: Impact on fodder availability due to agriculture, Nikol Bandhara

Impact	Quantity
Increase in Green Fodder (%)	31
Increase in Dry Fodder (%)	14
Increase in Cow dung (%)	28

Though the actual number of milch animals seems to have declined in villages affected by the Nikol scheme, overall milk production has improved possibly on account of better fodder availability in the area. The fact that the number of bullocks has also come down drastically can be an indicator of increasing use of mechanised tools for cultivation (Fig. 2.16).

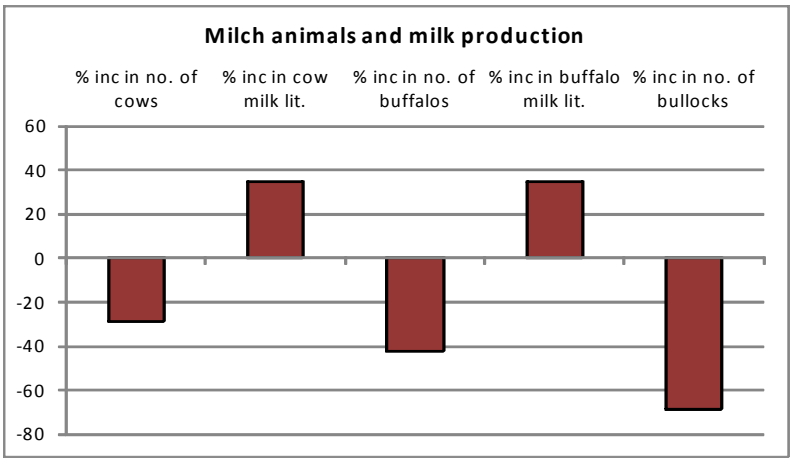


Fig. 2.16 Impact on milch animals and milk production in Nikol

2.3.3 GROUNDWATER AVAILABILITY AND QUALITY

Plate no. 2.5 Discussions with Farmer Residing Near Nikol Bandhara

Even though no change in water table has been reported by the majority of surveyed households (Fig. 2.17), about 30 families have experienced rise in water table by up to 25 feet post the construction of the Nikol bandhara.

However, in terms of change in water quality, villages affected by the Nikol bandhara have witnessed the most significant impact where all 87 of the surveyed households have reported getting sweet water after the scheme even though most of these households were receiving salty water before the scheme as evident from Fig. 2.17.

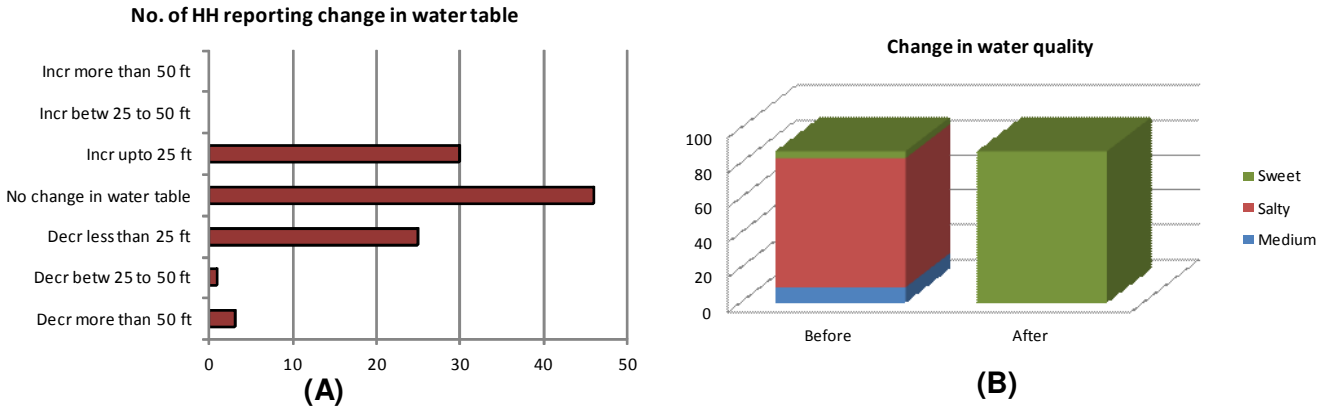


Fig. 2.17 People's Perspective on Groundwater (A) Water Level and (B) Water Quality

In addition to people's concern, impact on groundwater has also been assessed based on available pre and post construction well monitoring data of SIPC. The main aspects have studied were changes in water level and concentration of Total Dissolved Solids (TDS).

There are twenty six monitoring wells spreads over villages viz., Vaghnagar, Nikol, Naip Sathara, and Mahuva, established by SIPC to monitor impact of Bandhara on groundwater, To understand the impact hydrograph of selected wells were drawn whose data have maintain consistency. SIPC monitors all six wells since 1988 to 2004 and in 2011. (Table 2.8 and 2.9) Geology of this area is of recent and tertiary age. The major aquifer are alluvium, milliolite and limestone exist in this area. Hydrographs for reduced water levels and TDS concentrations have computed to understand changes in groundwater. (Fig no. 2.18 and 2.19)

Village wise well hydrographs of reduced water level shows constant rise in water levels in almost all the wells of villages Vaghnagar, Sathara and Naip while that of village Nikol shows balance trend in water level. The rising trend of water level clearly shows gradually the overall water level has increased and now it has risen above AMSL in all these three village that were below AMSL between 4 to 6 m.

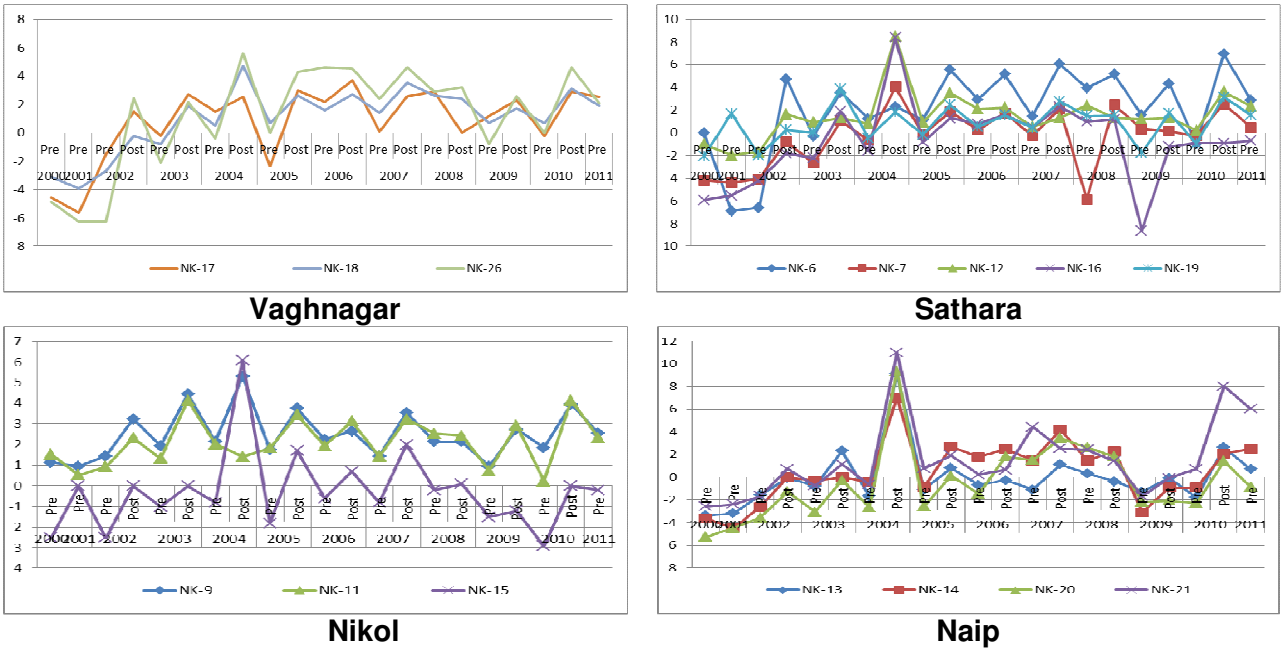


Fig 2.18 Well Hydrograph Showing Pre and Post Monsoon Water Level Fluctuation in Observations Wells in Surrounding Villages

Table 2.8 Pre and Post Monsoon Records of Static Water Levels (M) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011)

VILLAGE		Vaghnagar								
OBS WELL		NK-1	NK-2	NK-3	NK-4	NK-5	NK-17	NK-18	NK-25	NK-26
R.L.(M)		9.75	12.21	12.01	8.11	7.08	5.18	6.19	7.20	8.18
2000	Pre	-1.15	-0.63	0.71	-2.89	-1.72	-4.52	-3.11	1.3	-4.87
2001	Pre	-1.15	0.01	-0.49	-1.09	-	-5.62	-3.91	-	-6.27
2002	Pre	0.25	0.81	0.81	-0.79	-	-1.52	-2.71	1.90	-6.23
	Post	-	-	-	-	-	1.48	-0.21	-	2.43
2003	Pre	1.05	1.11	-	-0.79	-	-0.22	-0.81	1.5	-2.12
	Post	-	5.71	3.41	1.61	-	2.68	1.89	-	2.18
2004	Pre	1.45	1.51	1.81	-0.49	-3.22	1.48	0.49	2.80	-0.42
	Post	8.10	10.10	9.50	6.30	8.10	2.50	4.70	4.30	5.60
2005	Pre	1.35	1.31	1.71	-0.69	-3.12	-2.32	0.69	1.70	-0.02
	Post	3.05	4.11	4.11	1.21	0.88	2.98	2.59	3.80	4.28
2006	Pre	3.25	4.45	2.01	6.11	-1.52	2.18	1.59	2.30	4.58
	Post	-	-	8.11	6.31	-0.12	3.68	2.69	-	4.48
2007	Pre	1.65	-	1.71	-0.49	-2.12	0.08	1.39	1.60	2.38
	Post	-	-	-	-	1.88	2.58	3.49	-	4.58
2008	Pre	-	-	-	-	-0.72	2.88	2.59	-	2.88
	Post	-	-	-	-	-0.52	-	2.39	-	3.18
2009	Pre	0.95	-	1.31	1031	-2.42	1.18	0.69	1.40	-0.82
	Post	1.85	6.01	2.41	1.01	-1.52	2.28	1.69	2.6	2.58
2010	Pre	0.95	-	3.71	-0.79	-2.72	-0.22	0.69	0.4	-0.02
	Post	1.05	-	4.21	1.31	-2.72	2.88	3.09	3.8	4.58
2011	Pre	4.45	4.21	2.11	0.11	-1.02	2.53	1.89	0.60	2.08

Table 2.8 Pre and Post Monsoon Records of Static Water Levels (M) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011) Contd…

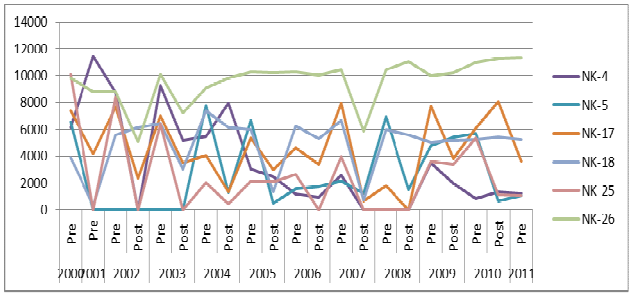
VILLAGE		Sathara					Nikol					
OBS WELL		NK-6	NK-7	NK-12	NK-16	NK-19	NK-8	NK-9	NK-10	NK-11	NK-15	NK-22
R.L.(M)		**7.52**	**4.93**	**8.31**	**8.38**	**4.03**	**10.35**	**8.53**	**4.56**	**4.52**	**6.79**	**5.96**
2000	Pre	-	-4.17	-0.99	-5.92	-2.07	2.85	1.13	0.75	1.52	-2.51	-1.54
2001	Pre	-6.88	-4.37	-1.99	-5.52	1.68	0.55	0.93	0.75	0.52	-	-
2002	Pre	-6.58	-4.07	-1.69	-4.22	-1.97	4.05	1.43	1.05	0.92	-2.51	-0.44
	Post	4.72	-0.77	1.61	-1.82	0.23	-	3.23	-	2.32	-	-
2003	Pre	-0.28	-2.67	0.91	-2.22	0.03	Filled	1.93	-	1.32	-1.01	0.76
	Post	3.53	1.03	1.31	1.88	3.83	-	4.43	-	4.12	-	-
2004	Pre	1.22	-0.67	0.81	-1.62	-0.47	2.15	2.13	-	2.02	-0.81	0.66
	Post	2.30	4.00	8.50	8.40	1.80	6.90	5.30	Filled	1.40	6.10	N.A.
2005	Pre	1.12	-0.17	0.91	-0.82	-0.17	1.85	1.73	-	1.82	-1.81	0.16
	Post	5.52	1.83	3.51	1.28	2.43	4.25	3.73	-	3.42	1.69	-
2006	Pre	2.92	0.23	2.11	0.78	0.53	2.75	2.23	-	1.92	-0.61	-
	Post	5.12	1.73	2.21	1.58	1.53	2.95	2.63	-	3.12	0.69	-
2007	Pre	1.42	-0.27	0.51	0.48	0.43	2.25	1.43	-	1.42	-0.81	-
	Post	6.02	2.13	1.31	2.28	2.73	4.35	3.53	-	3.22	1.99	-
2008	Pre	3.92	-5.87	2.41	0.98	1.49	3.15	2.13	-	2.52	-0.21	-
	Post	5.12	2.43	1.31	1.18	1.53	2.85	2.13	-	2.42	0.09	-
2009	Pre	1.52	0.33	1.21	-8.62	-1.79	2.05	0.93	-	0.72	-1.51	-
	Post	4.32	0.13	1.31	-1.22	1.73	3.05	2.73	-	2.92	-1.21	-
2010	Pre	-0.98	-0.27	0.21	-0.92	-0.97	2.05	1.83	-	0.22	-2.91	-
	Post	6.92	2.53	3.61	-0.92	3.13	5.05	3.93	-	4.12	-0.01	-
2011	Pre	2.82	0.43	2.31	-0.72	1.53	2.75	2.53	-	2.32	-0.21	-

Table 2.8 Pre and Post Monsoon Records of Static Water Levels (M) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011) Contd…

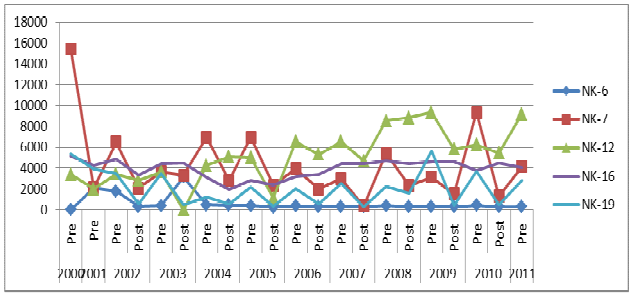
Reduced Water Levels (M)							
VILLAGE		Naip				Mahuva	
OBS WELL		NK-13	NK-14	NK-20	NK-21	NK-23	NK-24
R.L.(M)		8.52	7.99	7.93	11.43	8.92	8.70
2000	Pre	-3.38	-3.61	-5.27	-2.57	-14.18	-21.5
2001	Pre	-3.18	-4.51	-4.47	-2.37	-	-
2002	Pre	-1.58	-2.61	-3.57	-1.67	-15.58	-
	Post	-0.08	-	-1.27	0.73	-13.58	-
2003	Pre	-0.78	-0.31	-3.07	-0.77	-1518	-18.4
	Post	2.32	-	-0.27	1.13	-11.63	-12.3
2004	Pre	-1.68	-0.41	-2.67	-0.67	-12.18	-6.10
	Post	9.10	7.00	9.40	11.00	16.60	24.00
2005	Pre	-1.08	-0.91	-2.57	0.77	-10.78	-8.00
	Post	0.82	2.69	0.13	1.93	-5.08	-4.90
2006	Pre	-0.68	1.79	-1.47	0.23	-6.08	-5.90
	Post	-0.28	2.49	1.83	0.63	-1.58	0.70
2007	Pre	-1.08	1.49	1.53	4.43	-6.08	-14.10
	Post	1.12	4.19	3.43	2.53	2.42	3.20
2008	Pre	0.32	1.49	2.63	2.43	-3.43	-12.10
	Post	-0.38	2.29	1.83	1.43	-1.58	-3.50
2009	Pre	-1.28	-3.11	-2.17	-1.67	-5.18	-23.3
	Post	-0.08	-0.91	-2.07	-0.07	-3.48	-5.80
2010	Pre	-1.78	-0.91	-2.27	0.73	-6.98	-11.4
	Post	2.62	2.09	1.43	8.03	-1.78	-1.60
2011	Pre	0.72	2.49	-0.87	6.03	-4.48	-15.80

Well hydrograph for water levels in observation wells already shown increasing trend in water level has its impact on TDS concentration also. Village wise analysis of well hydrograph for TDS concentrations shows following changes in groundwater quality

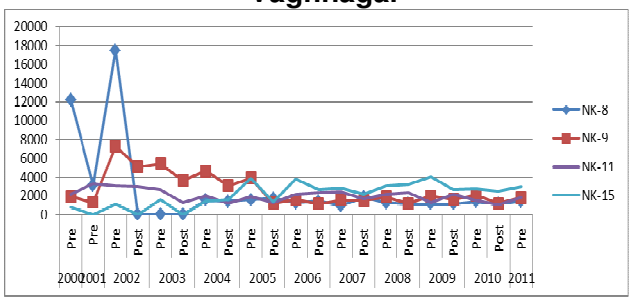
- The well hydrographs of Vaghnagar village shows constant reduction in concentrations of total dissolved solids except one well i.e. NK 25. Otherwise all wells shows reduction of TDS concentration limits from 6000 – 8000 to 4000 – 6000 ppm.
- In case of village Sathara the concentrations shows minor increasing trend from year 2000 to 2011 in majority of wells. However well no. NK 6 and NK 19 have TDS concentrations comparatively less than other wells. (Fib 2.19)
- The observation wells of Nikol village shows almost balance fluctuation except one well i.e. NK 8. It is important to notice that water levels in Nikol also behave as similar to water quality
- Water quality changes in wells of Naip village shows different behaviour such as wells NK 14 and Nk 21 shows gradual but marginal increase in TDS concentrations while well no. N 20 shows very high fluctuation in different year i.e. during year 2007 and 08 the TDS concentration were less than 2000 ppm and again it increased abruptly from year 2009 and further it is going down from post monsoon season of year 2010.



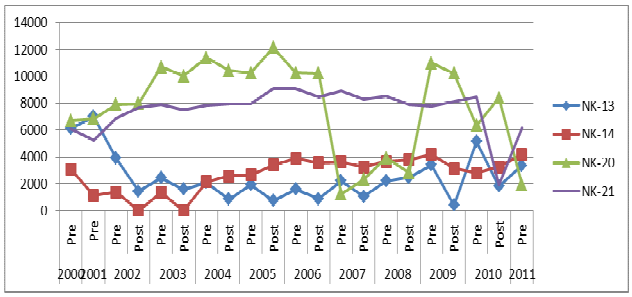
Vaghnagar



Sathara



Nikol



Naip

Fig 2.19 Well Hydrograph Showing Pre and Post Monsoon Changes in Concentration of Total Dissolved Solids and Chloride in Observations Wells of Surrounding Villages

Table 2.9 Pre and Post Monsoon Records of Concentration of Total Dissolved Solids (PPM) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011)

VILLAGE		Vaghnagar								
OBS WELL		NK-1	NK-2	NK-3	NK-4	NK-5	NK-17	NK-18	NK-25	NK-26
2000	Pre	757	7456	3261	6173	6523	7396	3902	10134	9843
2001	Pre	782	7340	3790	11491	-	4166	357	-	8783
2002	Pre	2737	19510	8620	8736	-	7688	5591	8387	8783
	Post	-	-	-	-	-	2383	6147	-	5080
2003	Pre	5833	16666	-	9285	-	7023	6428	6369	10118
	Post	-	320	401	5206	-	3512	3072	-	7213
2004	Pre	9114	18277	5696	5468	7804	4044	7405	2051	9114
	Post	6820	12288	4301	7987	1290	1352	6144	442	9830
2005	Pre	14240	12531	4557	3019	6664	5354	5981	2164	10253
	Post	4800	7808	4288	2496	525	3008	1344	2112	10240
2006	Pre	3873	6949	6152	1196	1595	4614	6266	2677	10253
	Post	-	-	690	941	1756	3387	5331	-	10035
2007	Pre	9523	-	3274	2619	2143	7976	6666	3971	10468
	Post	-	-	-	-	1254	690	753	-	5896
2008	Pre	-	-	-	-	6949	1823	5981	-	10424
	Post	-	-	-	-	1504	-	5595	-	11059
2009	Pre	5174	-	3853	3523	4788	7761	5009	3633	10017
	Post	4672	1792	2560	1984	5440	3840	5184	3392	10240
2010	Pre	2697	-	5614	826	5724	6109	5229	5339	11008
	Post	2045	-	6618	1324	692	8061	5414	1131	11309
2011	Pre	983	8602	1659	1229	1044	3625	5222	1044	11366

Table 2.9 Pre and Post Monsoon Records of Concentration of Total Dissolved Solids (PPM) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011) contd…

VILLAGE		Sathara					Nikol					
OBS WELL		NK-6	NK-7	NK-12	NK-16	NK-19	NK-8	NK-9	NK-10	NK-11	NK-15	NK-22
2000	Pre	-	15434	3378	5125	5358	12236	1922	5708	2155	815	5824
2001	Pre	2106	2106	2024	4285	3928	3128	1309	5119	3274	-	-
2002	Pre	1805	6465	3436	4834	3494	17472	7280	1631	3087	1107	6523
	Post	339	2070	2822	3324	564	-	5080	-	2948	-	-
2003	Pre	423	3631	3631	4404	3512	-	5416	-	2619	1607	12678
	Post	3136	3324	-	4516	502	-	3630	-	1254	-	-
2004	Pre	467	6949	4272	3133	1253	1538	4671	-	1994	1481	7462
	Post	455	2826	5100	1966	559	1413	3072	-	1167	1597	-
2005	Pre	399	6949	5012	2791	2184	1596	3873	-	1937	3873	3816
	Post	282	2386	1146	2368	326	1760	1216	-	1248	1344	-
2006	Pre	376	3930	6550	3190	1994	1253	1595	-	2164	3816	-
	Post	289	2007	5331	3387	610	1443	1129	-	2321	2696	-
2007	Pre	328	2976	6547	4404	2559	952	1548	-	2381	2857	-
	Post	295	364	4704	4392	301	1882	1505	-	1693	2195	-
2008	Pre	399	5411	8544	4728	2221	1253	1880	-	2164	3076	-
	Post	319	2346	8844	4452	1564	1143	1203	-	2346	3249	-
2009	Pre	341	3137	9357	4678	5669	1156	1981	-	1266	4018	-
	Post	307	1536	5824	4672	422	1158	1613	-	2176	2688	-
2010	Pre	440	9357	6271	3798	3686	1376	2092	-	1541	2752	-
	Post	307	1324	5475	4514	493	1143	1203	-	1083	2527	-
2011	Pre	307	4170	9216	4055	2826	1413	1843	-	1843	2949	-

Table 2.9 Pre and Post Monsoon Records of Concentration of Total Dissolved Solids (PPM) in Observation Wells Around Nikol Bandhara (Source: SIPC, 2000 to 2011) contd…

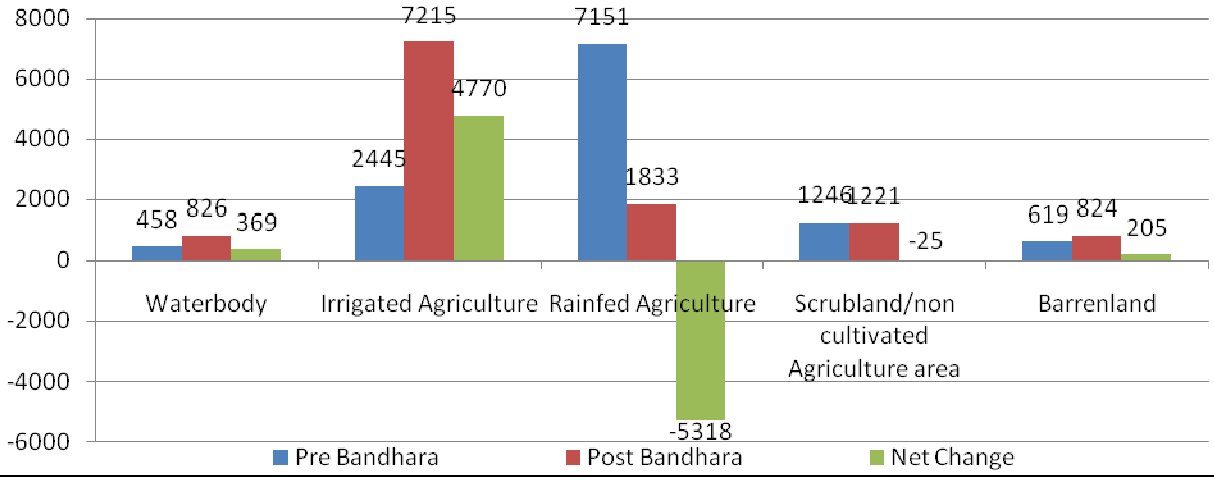
VILLAGE		Naip				Mahuva	
OBS WELL		NK-13	NK-14	NK-20	NK-21	NK-23	NK-24
2000	Pre	6115	3087	6698	6115	11881	10426
2001	Pre	7023	1131	6845	5238	-	-
2002	Pre	3902	1398	7921	6872	13686	-
	Post	1443	-	7965	7652	14426	-
2003	Pre	2440	1369	10714	7916	-	-
	Post	1599	-	10035	7526	13171	6272
2004	Pre	2108	2164	11392	7860	13102	6835
	Post	860	2580	10445	7987	12902	6144
2005	Pre	1937	2677	10253	7974	5696	11962
	Post	730	3392	12160	9088	12160	10240
2006	Pre	1595	3873	10253	9113	12531	6380
	Post	878	3575	10223	8467	5394	10223
2007	Pre	2202	3639	1250	8928	10118	5475
	Post	1066	3261	2321	8279	3638	3700
2008	Pre	2221	3645	3930	8544	10253	4956
	Post	2467	3790	2828	7881	5475	4211
2009	Pre	3412	4183	11008	7816	10017	5724
	Post	409	3136	10240	8128	9600	6528
2010	Pre	5163	2807	6330	8476	9577	6605
	Post	1805	3249	8400	1924	2767	6131
2011	Pre	3379	4178	1966	6144	11059	6144

2.3.4 LANDUSE PATTERN

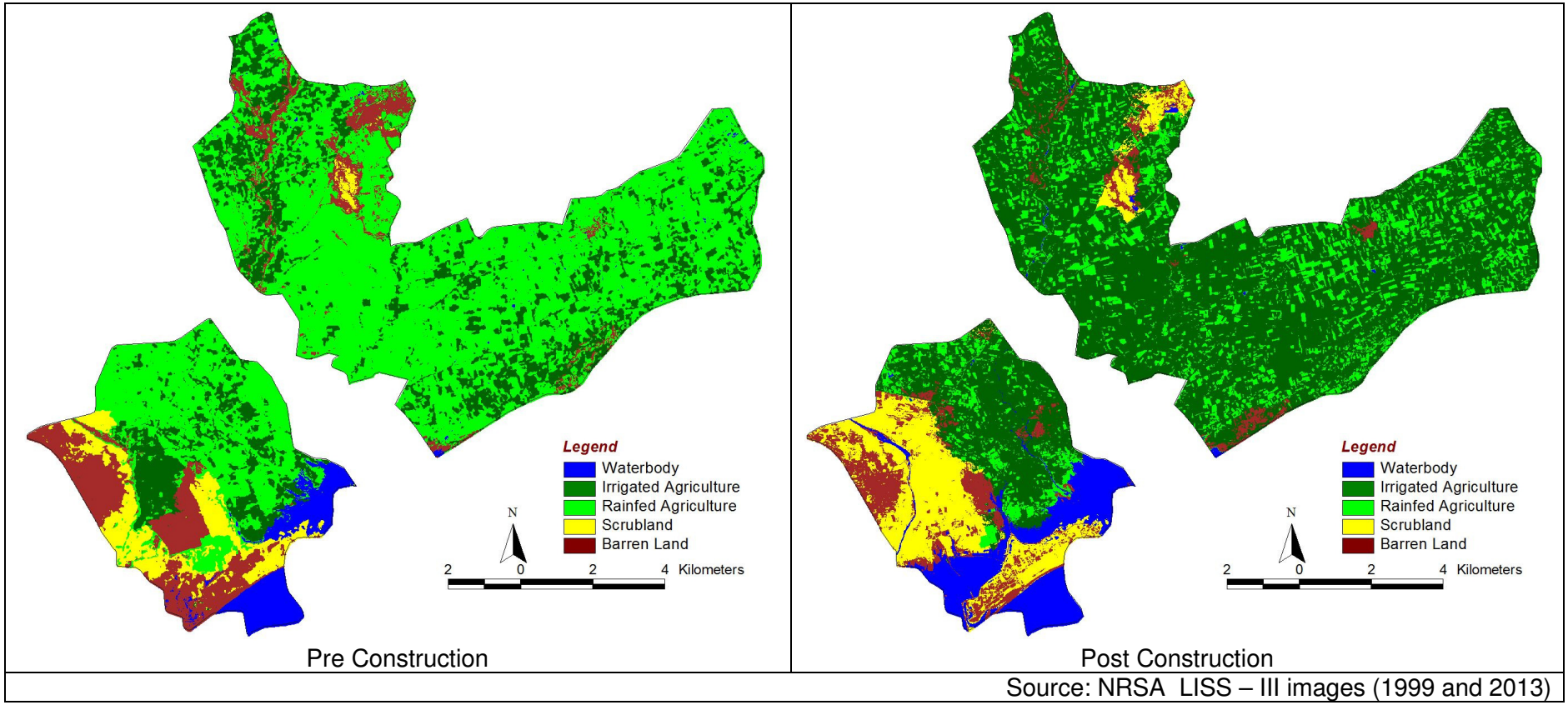
Landuse pattern around Nikol Bandhara has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1999 Pre Bandhara construction and 2013 post Bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table2.10)

Table 2.10 Landuse Pattern around Nikol Bandhara

Land use	Changes in Landuse Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	458	826	369
Irrigated Agriculture	2445	7215	4770
Rain fed Agriculture	7151	1833	-5318
Scrubland/non cultivated Agriculture	1246	1221	-25
Barren land	619	824	205
Total	**11919**	**11919**	0



Satellite image analysis of pre and post construction phase shows very high increase in irrigation areas (almost three times more). It is important to notice that in case of this Bandhara it shows very high increase in compare to rest of the Bandharas of Bhavnagar district. Similarly it also shows very high decrease in rainfed areas from 7151 Ha to 1833 Ha after construction.

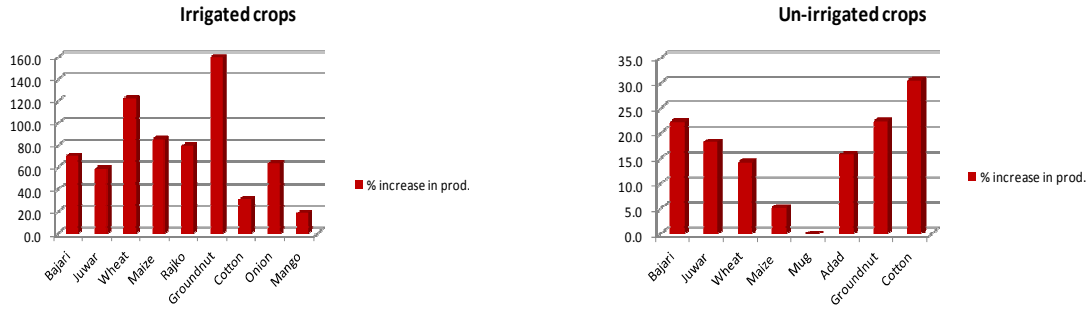


Source: NRSA LISS – III images (1999 and 2013)

Fig. 2.20 Land use Pattern around Nikol Bandhara Area

2.4 AGRICULTURE

The area under agriculture has increased in villages benefiting from the Garibpura RR scheme where there has been a 27 per cent increase in area under irrigated crops and a 97 per cent increase in area under un-irrigated crops. However, this trend is not seen in the other two Bandharas of Bhavnagar district in the case of either irrigated or un-irrigated crops. Also, at the overall district level, no change in area under food grains, oil seeds, cash crops or vegetables can be seen.



(A) **(B)**

Fig. 2.21: Percentage Increase in Area under Irrigated (A) and Un-irrigated Crops (B)

Table 2.11: Impact on agriculture production – irrigated crops

Sr. Nr.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	1082	1844	70.4
2	Juwar	856	1357	58.5
3	Wheat	1208	2688	122.5
4	Maize	605	1122	85.5
5	Rajko	328	590	79.9
6	Groundnut	1293	3360	159.9
7	Cotton	12067	15816	31.1
8	Onion	550	900	63.6
9	Mango	134	159	18.7

Even as the area under cultivation may not have shown much rise, better water availability post the schemes has resulted in improved crop production as can be seen in Tables 2.11 and 2.12. In case of irrigated crops, production increases ranging from 19 per cent for mango to 160 per cent for groundnut can be seen. For un-irrigated crops, this increase has been more modest, varying from 5 per cent for maize to 31 per cent for cotton. Interestingly, availability of irrigation post the schemes has resulted in a change in the cropping pattern with the introduction of a cash crop (mango) which was not seen in the pre-scheme scenario.

Table 2.12: Impact on agriculture production – un-irrigated crops

Sr. No.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	3763	4602	22.3
2	Juwar	2581	3051	18.2
3	Wheat	35	40	14.3
4	Maize	290	305	5.2
5	Mug	99	99	0.0
6	Adad	19	22	15.8
7	Groundnut	592	725	22.5
8	Cotton	998	1303	30.6

2.5 SITUATION OF WOMEN

Availability of potable water within the village as a result of the bandharas has benefited women by reducing the drudgery of fetching water from outside their village. It has also resulted in significant savings of time for womenfolk, who claim that they are now able to give more time to their housework, family and children and are keen to explore livelihood options for themselves. Women also reported that improved availability of water for agriculture has led to increase in agriculture productivity and number of days of employment and a decrease in out-migration from the village in search of work. Besides, there is now better availability of water for animals.

Becoming part of a SHG has helped women to start saving, which has increased their confidence levels. Some of them have also become members of the Pani samitis in the village. This has helped improve their awareness levels and decision making abilities, and they are now increasingly exercising their choice in selection and rearing of milch animals in the family.

3. SOCIO-ECONOMIC IMPACT IN AMRELI DISTRICT

There is only one Bandhara – Samadhiyala has selected for the impact assessment study Fig 3.1 shows location of Bandhara along with the villages where, survey has held.

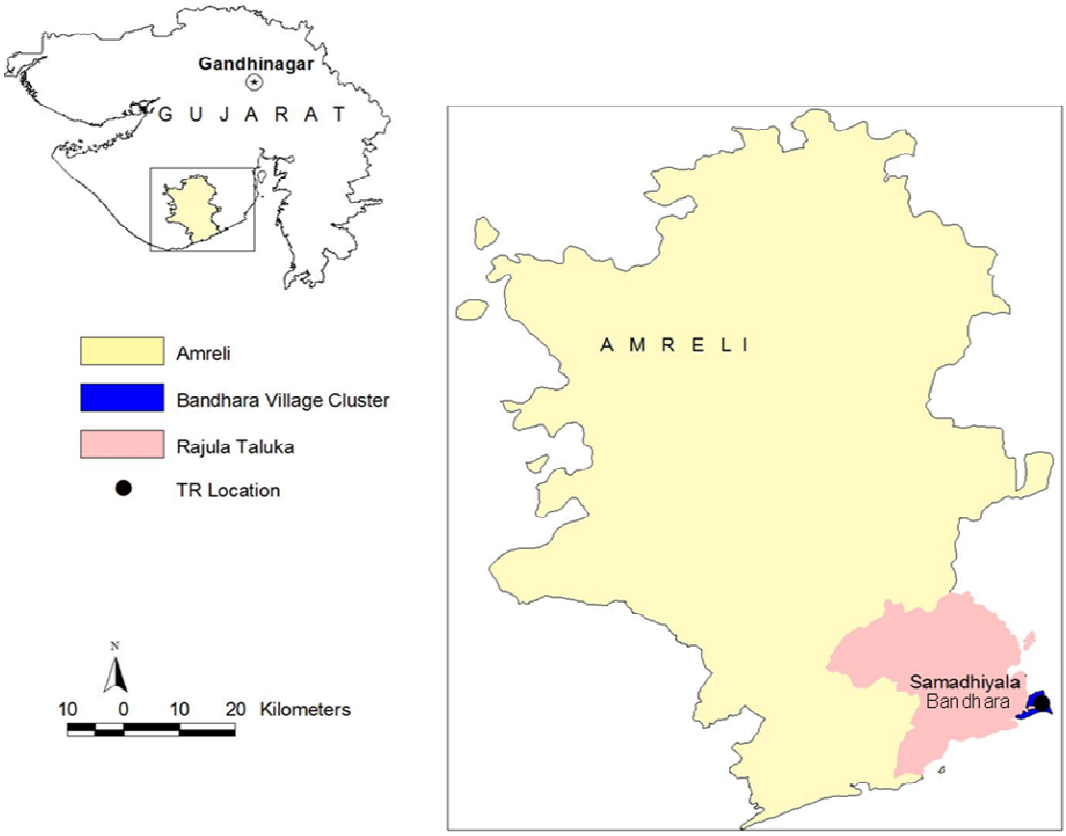


Fig. 3.1 Location of Samadhiyala Bandhara, Rajula – Amreli District

3.1 ASSETS, INCOME AND INVESTMENTS

The impact of Amreli district's Samadhiyala bandhara on assets is similar to that seen in Bhavnagar district where overall ownership of low-value assets such as mobile telephone and vehicle has increased more than high value assets like tractors, house construction or own irrigation source.

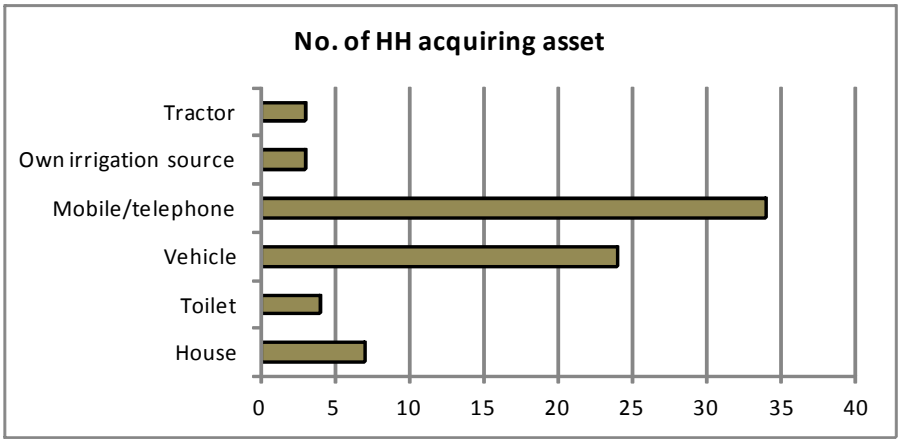


Fig. 3.2: Impact on assets in Samadhiyala

In terms of impact on income source, an overwhelming majority of surveyed households has reported additional new income from selling milk as can be seen from Fig. 3.3 A. This additional income is being invested by households on renovation/extension of house, purchase of animals as well as for ensuring irrigation facilities as can be seen from Fig. 3.3 B.

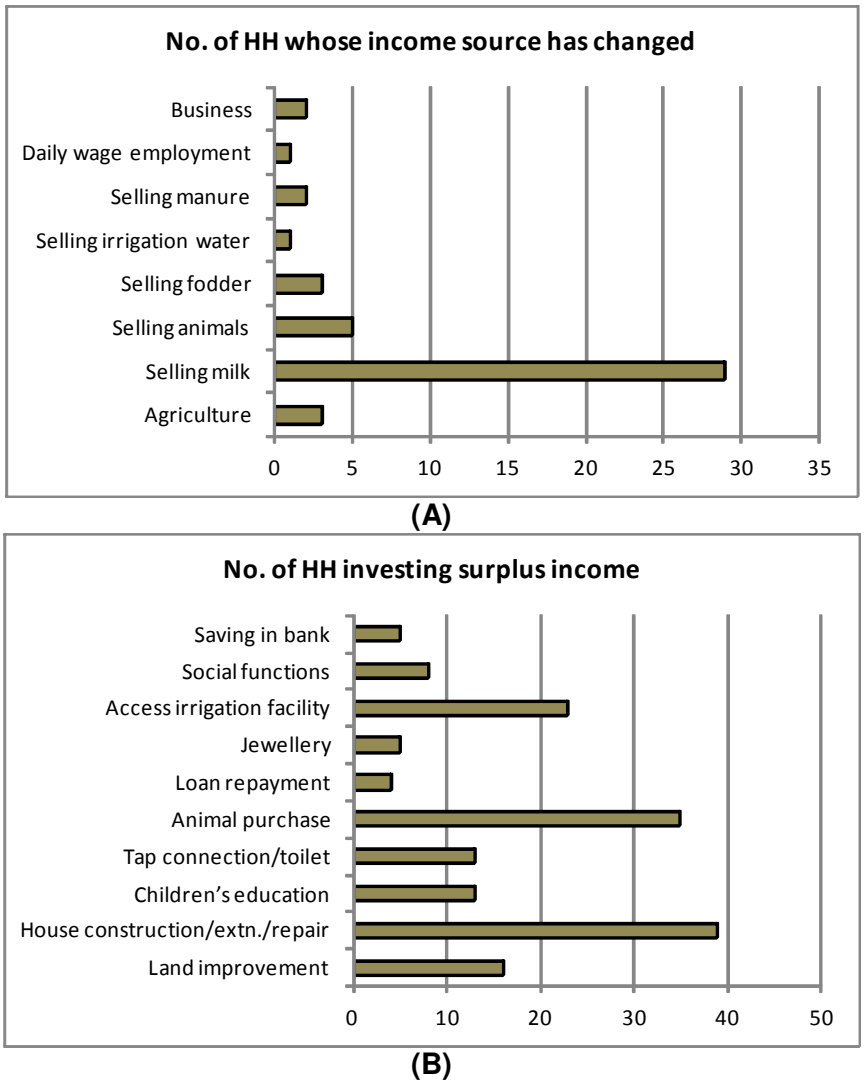


Fig. 3.3: Impact on Income Source (A) and Investment of surplus Income (B) in Samadhiyala

3.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 3.1: Impact on fodder availability due to agriculture, Samadhiyala Bandhara

Impact	Quantity
Increase in Green Fodder (%)	108
Increase in Dry Fodder (%)	53
Increase in Cow dung (%)	127

Availability of fodder has improved in villages benefiting from the Samadhiyala bandhara where output of green fodder has more than doubled and that of dry fodder has gone up by more than 50 per cent as can be seen from Table 3.1. Similarly, availability of manure (cow dung) has also increased by 127 per cent.

Improved fodder availability post the scheme has not only encouraged people to keep more milch and dwarf animals but also increased milk production. While the number of cows and buffaloes has gone up by between 116 to 230 per cent, milk production from these animals has improved by over

150 per cent as can be seen from Fig. 3.4. Also, with improved prospects in agriculture, a strong demand for dwarf animals such as bullocks can also be noticed.

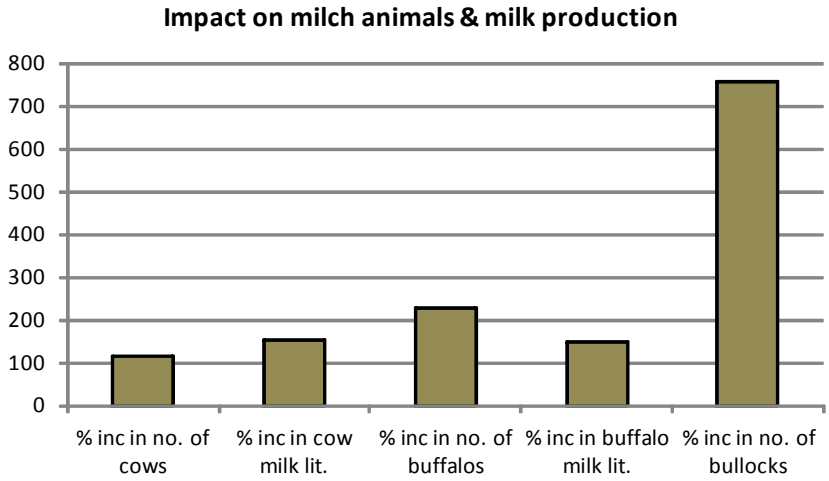


Fig 3.4: Impact on Milch Animals and Milk Production in Samadhiyala

3.3 GROUNDWATER AVAILABILITY AND QUALITY

Impact on groundwater due to bandhara has assessed through two methods such as people's observations and by computing hydrographs of reduced water levels, concentrations of TDS and Chlorides in groundwater. SIPC is monitoring groundwater through observation wells in surrounding villages of Bandhara, records of such wells have used to prepare hydrograph of respective monitoring parameter. Following are brief account of impact of Samadhiyala bandhara assessed through these methods

Plate No. 3.1 Waste Weir of Samadhiyala Bandhara

Even as most households have experienced no change in water table post the construction of the bandhara, 10 families (12 per cent of sample households) have reported an increase in water table by upto 25 feet while a few families have even reported water tables improving by up to 50 feet (Fig. 3. 5). While use of bore wells for irrigation could be a strong factor for a significant number of households reporting no change in water table, the contribution of the bandhara in helping recharge underground water levels to some extent cannot be ignored. In terms of improvement in water quality, a significant improvement is noticeable where the percentage of households getting salty water has reduced from 90 per cent before the construction of the Samadhiyala bandhara to 53 per cent afterwards. Similarly, from a mere 5 per cent of households receiving sweet water before the scheme, this proportion has gone up to 38 per cent (Fig. 3.5).

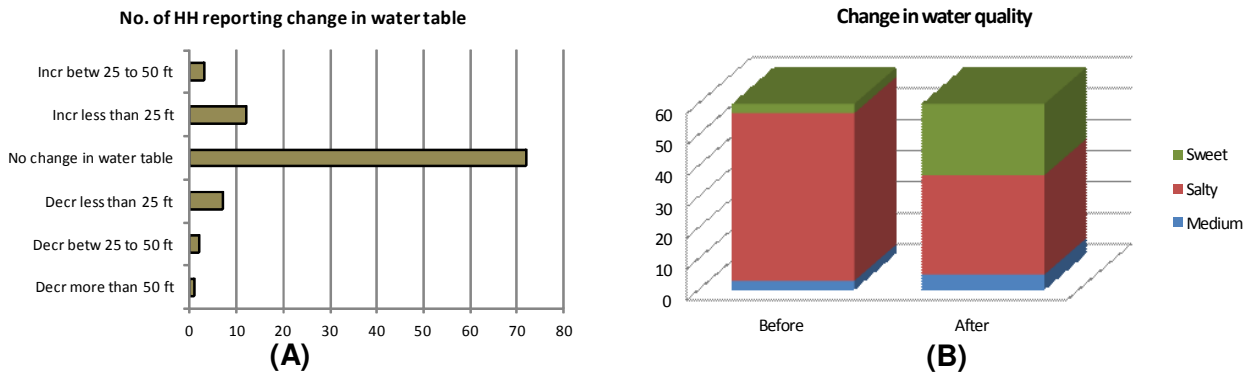


Fig. 3.5 People's View on Changes in Groundwater Levels (A) and Quality (B) Before and After Bandhara Construction

There are observations wells in four villages viz., Patva, Doliya, Padiyarka, and Samdhiyala of Rajula Taluka. SIPC's monitoring data since pre monsoon season of year 2000 to pre monsoon season of year 2011 have been used to understand changes in groundwater levels and groundwater quality due to Samadhiyala TR. Table 3.2 and 3.4 along with Fig.3.7 and 3.8 shows summarized impact of on groundwater levels and quality while table 3.5, 3.6 and 3.7 show the monitoring data.

Table 3.2 Observed Impact on Water Level

Village	Impact on Water Level
Patva	The Hydrographs of all wells shows rising trend in water levels those were below up to 4 m AMSL during year 2000 now all the wells have it above AMSL in some cases it is even above 6 m than AMSL. OW no SAM 1, 4, 5, and 6 shows almost average 10 m rise from year 2000 to year 2011
Doliya	There is only one observation well, hydrograph shows two pattern in fluctuation i.e. before year 2005 it was remained below AMSL just less than 0 m while it is rising from AMSL from post monsoon season of year 2009
Padiyarka	In Padiyarka village both the observation wells shows vary significant rise in reduced water level from 6 (OW SAM 10) and 8 (OW SAM 11) in year 2000 to just near to 2 m during year 201. Net average rise in these wells is about 9 m.
Samadhiyala	All the observation wells of Samadhiyala village were below AMSL in year 2000 now all are just above AMSL during pre monsoon season of year 2011. The well hydrograph very clearly shows after post monsoon season of year 2005 all the wells have water level above AMSL.

Table 3.3 Observed Impact on Water Quality

Village	Impact on Water Quality	
	TDS	Salinity Cl:HCO3 Ratio
Patva	SAM 13 and SAM 2 increase in TDS while remaining wells shows gradual decrease in TDS concentration even though average TDS concentration is till between 4000 to 6000 ppm	In case of Salinity status out of total observation wells 7 were of injurious salinity category and three were showing some contamination in year 2000 while in year 2011 the groundwater in four wells become moderately saline while three are still of very high degree salinity
Doliya	Gradually TDS concentration is increasing from year 2000 to 2011. The well was having concentration less than 1500 ppm in year 2000 now it is more than 3000 ppm	In case of Doliya the well during pre monsoon of year 2011 shows some contamination that was have almost no salinity during pre monsoon of year 2000
Padiyarka	One well SAM 10 shows increase in TDS while SAM 11 shows reduction in salinity	During 2000, one well in each category i.e. injurious and very high degree of salinity category that is now both the well are in injurious category
Samadhiyala	The trend of hydrograph for TDS shows almost balance condition however the TDS value is very high in almost all the groundwater except SAM 20.	All six wells were showing very high degree of salinity during 2000 but during 2011 groundwater in one well is found of injurious category

Table 3.4 Pre and Post Monsoon Water Levels in Observations Wells of Samadhiyala Bandhara (Source: SIPC, 2000-2011)

VILLAGE		Patva										Doliya	Padhiyarka		Samadhiyala						
OBS WELL		SAM-1	SAM-2	SAM-3	SAM-4	SAM-5	SAM-6	SAM-7	SAM-8	SAM-12	SAM-13	SAM-9	SAM-10	SAM-11	SAM-14	SAM-15	SAM-16	SAM-17	SAM-18	SAM-19	SAM-20
R.L.(M)		4.77	5.36	5.39	7.77	8.37	8.31	5.22	6.23	5.68	5.88	6.46	7.4	6.79	6.08	6.62	6.58	7.68	6.08	7.5	5.68
2000	Pre	-1.03	-2.24	-4.01	-0.73	-0.03	-2.63	-4.68	-5.77	-1.32	-0.88	-5.54	-5.80	-7.21	-4.52	-3.98	-3.32	-2.02	-2.02	-0.50	-1.22
2001	Pre	0.27	-1.24	-2.81	-1.33	-1.93	-0.79	-4.48	-4.27	-	-0.52	-7.74	-6.5	-5.21	-	-4.78	-3.22	-1.82	-2.02	-0.20	-2.52
2002	Pre	-0.13	-1.94	-2.81	-1.53	-2.13	-2.59	-3.78	-2.37	-2.32	-0.22	-8.14	-5.6	-6.01	-3.52	-2.88	-2.72	-1.52	-2.22	0.00	-0.52
	Post	2.07	1.16	-0.31	2.47	5.27	-	-	-	3.08	2.98	-	-3.90	-2.81	-1.62	-1.88	-3.22	-	-3.22	1.80	1.08
2003	Pre	-0.87	1.06	-1.71	0.17	2.07	-0.69	-4.08	-1.57	0.78	2.38	-5.84	-4.4	-4.81	-2.12	-2.18	-2.32	-1.42	-2.12	-0.5	0.08
	Post	2.27	2.96	-0.21	2.77	3.57	2.71	-	-	1.08	4.98	-	-2.2	-2.21	-1.02	-0.28	0.18	0.78	-0.42	4.00	4.88
2004	Pre	1.17	-0.14	-1.51	0.07	1.97	-0.89	-2.28	-2.57	0.08	2.86	-5.54	-3.5	-4.31	-2.42	-1.66	-3.02	-2.32	-1.42	-0.10	1.68
	Post	1.77	1.16	-0.31	2.47	2.37	2.51	-	-	1.68	3.48	-	-2.40	-2.31	-0.72	0.02	-0.42	0.28	-0.42	1.3	2.78
2005	Pre	1.17	-0.64	-1.41	-0.23	-0.03	-1.29	-2.78	-2.27	0.08	1.28	-7.54	-3.20	-3.51	-2.02	-1.58	-1.42	0.18	-1.22	0.30	2.68
	Post	3.37	2.96	1.48	4.37	5.97	6.01	-	-	2.98	4.58	-	0.80	1.29	2.08	3.42	3.78	3.88	2.98	4.20	3.68
2006	Pre	1.97	1.56	0.09	2.57	3.37	2.71	0.22	3.53	1.78	2.08	-0.34	-0.20	-0.01	-0.22	0.92	1.38	1.78	0.78	2.10	3.68
	Post	2.67	2.26	0.69	3.97	6.37	6.01	-	-	2.28	3.88	-	0.60	1.39	1.08	2.32	2.63	2.78	1.68	3.30	-
2007	Pre	1.27	1.66	-0.21	2.77	5.17	2.71	0.02	2.03	1.38	3.28	-0.54	-0.40	0.09	0.48	0.82	1.38	1.68	0.48	1.60	4.68
	Post	3.77	2.96	1.49	4.77	6.37	6.21	-	-	2.98	4.88	-	4.40	-	4.78	5.22	5.28	6.58	4.58	6.00	4.68
2008	Pre	2.57	2.06	0.49	2.97	4.57	3.41	2.12	3.03	1.78	3.78	-0.04	2.40	2.89	2.08	2.32	2.18	3.18	1.96	3.60	-
	Post	2.77	2.16	0.59	4.17	4.87	-	-	-	2.68	4.28	-	2.80	-	3.08	2.62	2.48	3.48	2.56	3.80	-
2009	Pre	1.17	0.46	0.39	0.67	1.17	0.81	0.22	-	0.88	2.78	0.16	0.90	1.29	0.88	0.92	1.48	2.28	0.68	2.00	-
	Post	2.47	1.46	0.69	3.87	4.27	3.81	-	-	1.98	3.78	-	2.60	2.69	2.18	2.42	2.28	2.68	1.68	2.90	-
2010	Pre	-0.73	-0.04	-1.71	0.87	0.87	0.61	-6.98	1.83	1.16	2.98	2.06	0.90	1.09	0.88	0.72	10.8	1.38	1.68	1.90	2.18
	Post	3.17	2.16	0.69	3.57	5.97	6.81	0.82	-	3.78	4.18	-	2.90	3.39	3.38	2.82	2.48	3.08	1.88	3.60	4.88
2011	Pre	0.21	1.46	-0.61	-0.13	1.07	-1.29	-3.78	2.23	2.68	2.98	-	1.40	1.49	0.58	0.62	0.38	2.48	0.18	2.00	-

Table 3.5 Pre and Post Monsoon TDS Concentrations in Observations Wells of Samadhiyala Bandhara (Source: SIPC, 2000-2011)

VILLAGE		Patva										Doliya	Padhiyarka		Samadhiyala						
OBS WELL		SAM-1	SAM-2	SAM-3	SAM-4	SAM-5	SAM-6	SAM-7	SAM-8	SAM-12	SAM-13	SAM-9	SAM-10	SAM-11	SAM-14	SAM-15	SAM-16	SAM-17	SAM-18	SAM-19	SAM-20
2000	Pre	6406	5824	4193	4834	7047	2097	5183	2388	5824	5358	1223	4019	6523	7571	7862	6232	9959	5067	7862	6872
2001	Pre	5952	7023	4345	5714	2619	2738	6071	4166	-	4226	1309	4047	7857	-	7976	7738	9404	2083	6309	5714
2002	Pre	9493	6290	5125	7164	3261	2737	7921	6931	7105	7746	1340	4601	8503	2155	8095	7047	10250	1223	5126	6406
	Post	10788	7025	5582	8655	10725	-	-	-	4579	4704	-	4328	2258	314	8781	7965	-	5268	508	6397
2003	Pre	12499	3928	5833	7142	4404	4404	3155	2619	2857	5952	1309	5357	6547	9523	7857	6954	7500	5059	13094	6607
	Post	11315	2596	5857	3594	1997	2463	-	-	5724	8320	-	3328	4925	8852	6856	6922	6922	7588	5658	3727
2004	Pre	8829	6038	6152	4443	4500	3418	3873	3247	7633	9683	1937	5463	4386	9114	8544	7177	7405	5126	10822	6038
	Post	9920	4736	4224	3392	4544	3456	-	-	7680	9600	-	5568	4032	9600	352	8320	7232	7552	9600	5376
2005	Pre	11962	5924	3816	3816	5183	5411	9683	2734	7804	6266	1367	6380	5240	8544	9114	7974	7405	2508	11392	7974
	Post	7837	3068	4831	1828	2742	2807	-	-	5614	1893	-	4700	2154	1371	3656	7834	8095	535	10445	5875
2006	Pre	8145	2677	3702	2962	1310	2108	3475	1994	3076	11962	1424	5696	1367	9398	8544	6835	9114	1994	11392	7462
	Post	8209	2510	3596	2442	1425	1425	-	-	3935	11532	-	3616	1492	10176	2510	7462	9226	882	10854	-
2007	Pre	8928	2857	2559	2262	1548	1667	3988	2857	7142	12499	1488	9523	2500	9523	7976	6250	8928	4226	11666	5119
	Post	2481	2742	3133	2281	2481	2676	-	-	6593	3133	-	7442	-	718	477	1567	1958	457	2872	1567
2008	Pre	8088	2962	2620	1595	1481	2905	3532	4614	5183	10253	2991	2648	11392	9683	7519	6835	9114	3475	8772	-
	Post	8242	3790	2707	1985	2888	-	-	-	5114	9806	-	9144	-	3188	3128	6678	7580	1504	10287	-
2009	Pre	9027	4899	3908	3082	3137	4954	3688	-	5174	11008	3523	8036	1651	7485	7430	6680	6605	6495	10733	-
	Post	8909	4485	3748	3318	3256	4178	-	-	4977	11121	-	7373	1167	9830	2273	5837	5530	1106	10445	-
2010	Pre	8328	5125	4776	3844	2388	4019	1456	1922	4892	11706	3320	7571	1223	10134	8154	7047	9318	11182	9377	2097
	Post	2321	5896	4328	3512	3136	5519	3324	-	5770	8467	-	8969	1619	1254	11059	7434	6768	11059	1966	1290
2011	Pre	6076	7821	4813	3790	4632	2467	1684	4813	3730	11430	-	9144	3249	10348	7821	8422	7219	3850	9626	-

Table 3.6 Pre and Post Monsoon Chloride Carbonate Ratio in Observations Wells of Samadhiyala Bandhara (Source: SIPC, 2000-2011)

VILLAGE		Patva										Doliya	Padhiyarka		Samadhiyala						
OBS WELL		SAM-1	SAM-2	SAM-3	SAM-4	SAM-5	SAM-6	SAM-7	SAM-8	SAM-12	SAM-13	SAM-9	SAM-10	SAM-11	SAM-14	SAM-15	SAM-16	SAM-17	SAM-18	SAM-19	SAM-20
2000	Pre	12.07	16.31	6.32	10.5	41.67	2.03	22.58	1.09	6.31	2.65	0.23	6.24	38.13	22.75	96.03	28.33	27.31	10.71	40.64	7.70
2001	Pre	8.08	14.78	5.46	5.10	3.84	5.44	21.12	3.50	-	11.72	0.26	9.38	43.22	-	30.81	42.36	30.33	2.81	23.99	4.72
2002	Pre	14.15	16.88	5.94	33.83	9.19	2.79	22.33	8.13	7.02	24.83	0.28	5.25	39.47	4.8	48.96	16.1	46.05	1.26	12.25	5.12
	Post	16.57	29.79	17.3	43	122.4	-	-	-	9.72	3.00	-	8.64	3.25	0.49	104.5	40.59	-	21.5	1.12	7.51
2003	Pre	29.82	9.50	18.18	22.79	21.33	21.05	2.33	2.56	2.87	6.45	0.23	9.91	37.66	64.11	79.24	25.07	33.03	1056	43.26	6.45
	Post	29.46	1.55	18.33	3.32	2.99	3.17	-	-	7.42	10.81	-	18.36	8.62	92.99	19.76	22.05	73.58	94.14	10.46	3.42
2004	Pre	15.84	16.05	12.75	9.84	6.73	2.48	2.67	2.54	12.00	7.83	0.56	7.35	8.35	6.43	42.6	42.84	24.36	12.74	39.46	3.85
	Post	19.82	11.11	10.63	3.10	24.2	3.98	-	-	12.31	11.47	-	7.99	14.22	50.57	0.82	35.52	34.92	41.49	78.1	12.07
2005	Pre	16.75	14.67	5.63	3.82	13.84	15.33	44.98	1.92	11.52	5.18	0.25	10.7	11.81	22.77	27.21	19.34	26.04	6.27	31.16	14.03
	Post	13.5	5.12	10.56	0.56	6.54	6.05	-	-	8.57	1.72	-	13.22	2.75	1.97	15.24	55.21	98.86	1.12	101.7	14.57
2006	Pre	12.14	2.62	4.13	2.07	0.80	0.82	1.46	1.19	3.53	5.42	0.23	9.48	0.83	30.51	30.19	20.39	44.8	7.5	34.65	19.15
	Post	13.14	3.59	4.75	1.42	1.53	1.46	-	-	5.2	22.37	-	26.98	1.45	29.75	7.52	30.22	24.03	1.66	61.67	-
2007	Pre	17.89	6.62	4.73	1.23	4.93	2.60	2.09	0.98	8.26	20.07	0.75	12.81	6.76	70.98	72.23	28.54	45.82	22.04	64.85	12.79
	Post	3.76	5.64	3.22	2.17	1.41	5.23	-	-	8.92	9.78	-	40.2	-	1.78	1.21	4.65	5.63	3.96	7.52	5.64
2008	Pre	11.89	3.99	1.99	0.73	1.25	4.11	2.20	5.51	5.52	17.32	5.82	6.05	9.49	27.91	25.50	21.54	23.71	13.12	21.59	-
	Post	11.61	10.77	2.09	1.18	1.9	-	-	-	5.29	18.14	-	9.51	-	20.52	17.08	40.49	42.80	6.43	117.3	-
2009	Pre	12.64	9.05	3.27	3.01	3.37	9.12	2.05	-	2.68	13.32	1.68	4.42	3.08	19.09	14.46	11.13	13.24	45.07	56.27	-
	Post	8.9	11.27	3.92	4.26	4.40	10.38	-	-	3.18	11.78	-	6.96	1.82	53.06	5.87	3.48	38.31	3.05	100.3	-
2010	Pre	9.75	10.55	5.13	5.77	4.84	2.40	1.66	1.42	2.49	10.81	1.62	3.77	1.25	36.78	27.19	22.26	31.03	34.70	61.55	0.82
	Post	2.88	13.15	5.88	5.07	3.91	2.31	7.04	-	5.34	11.27	-	10.98	2.98	2.82	18.35	21.11	11.28	23.17	4.93	1.67
2011	Pre	3.23	24.36	3.47	5.13	8.91	3.90	1.82	2.76	2.46	11.70	-	6.60	8.02	29.27	20.89	17.39	25.35	9.26	19.50	-

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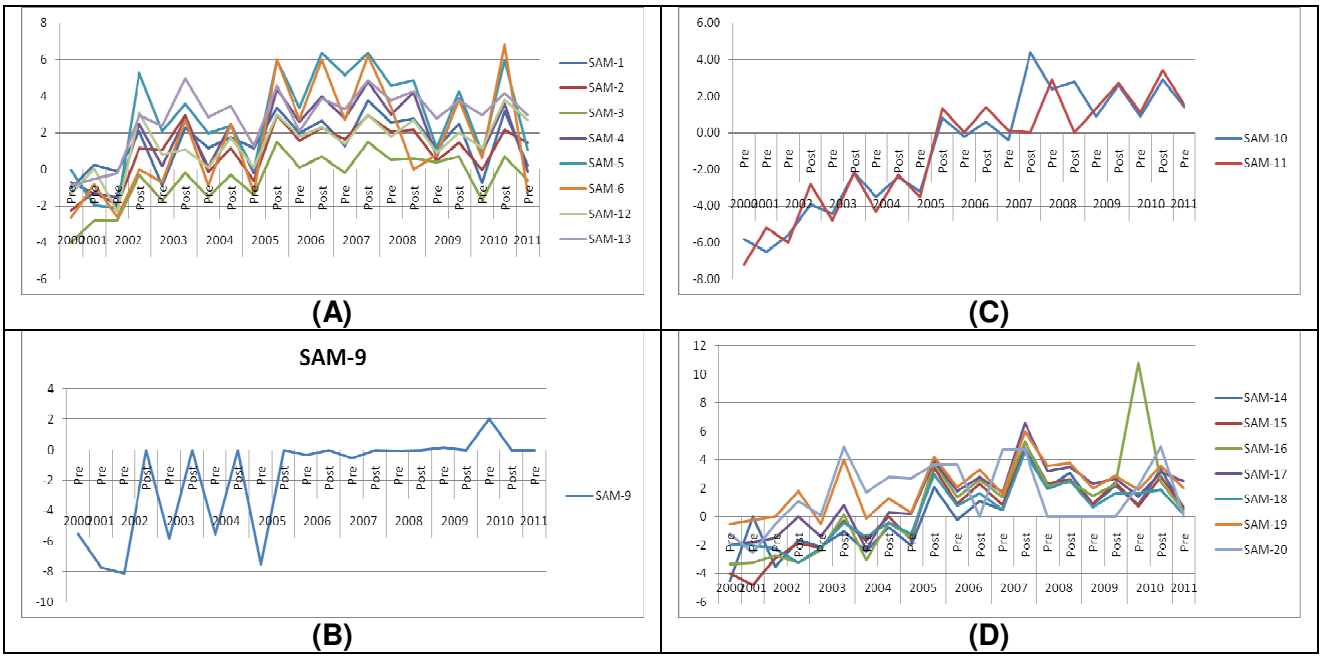


Fig.3.6 Pre and Post Monsoon Hydrograph Showing Water Table Fluctuation in Observations Wells Surrounding Samadhiyala Bandhara (A)Patva; (B)Doliya; (C), Padiyarka; and (D) Samadhiyala

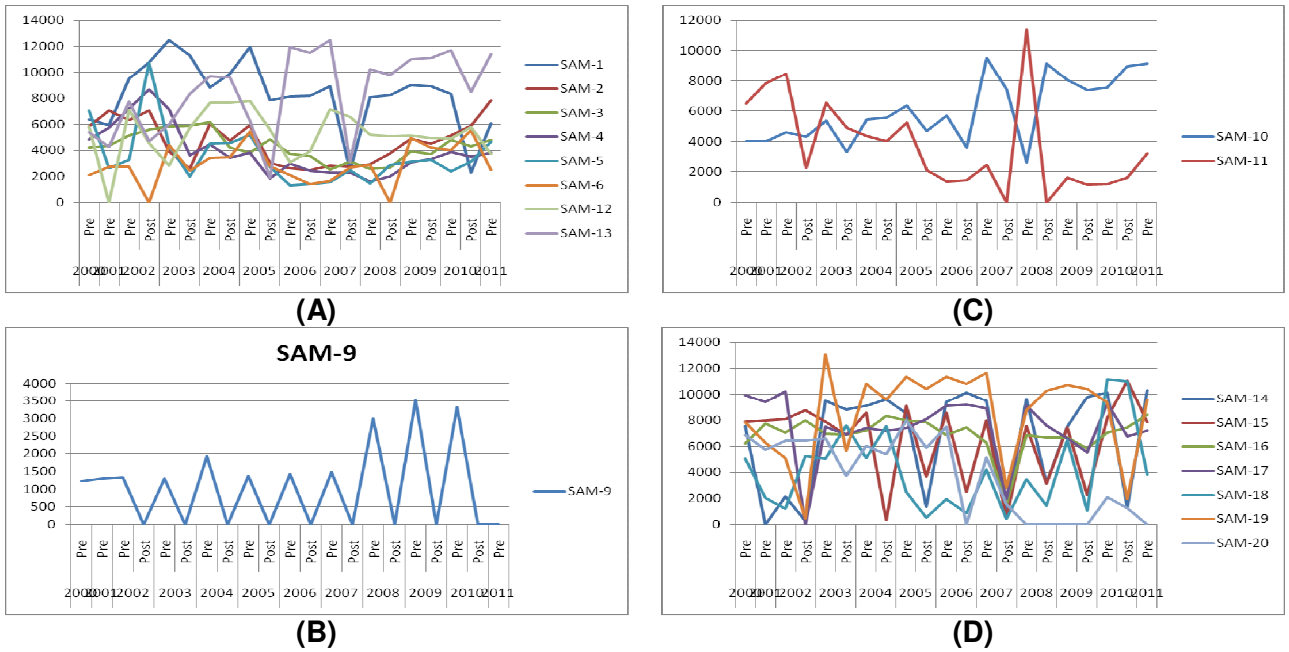


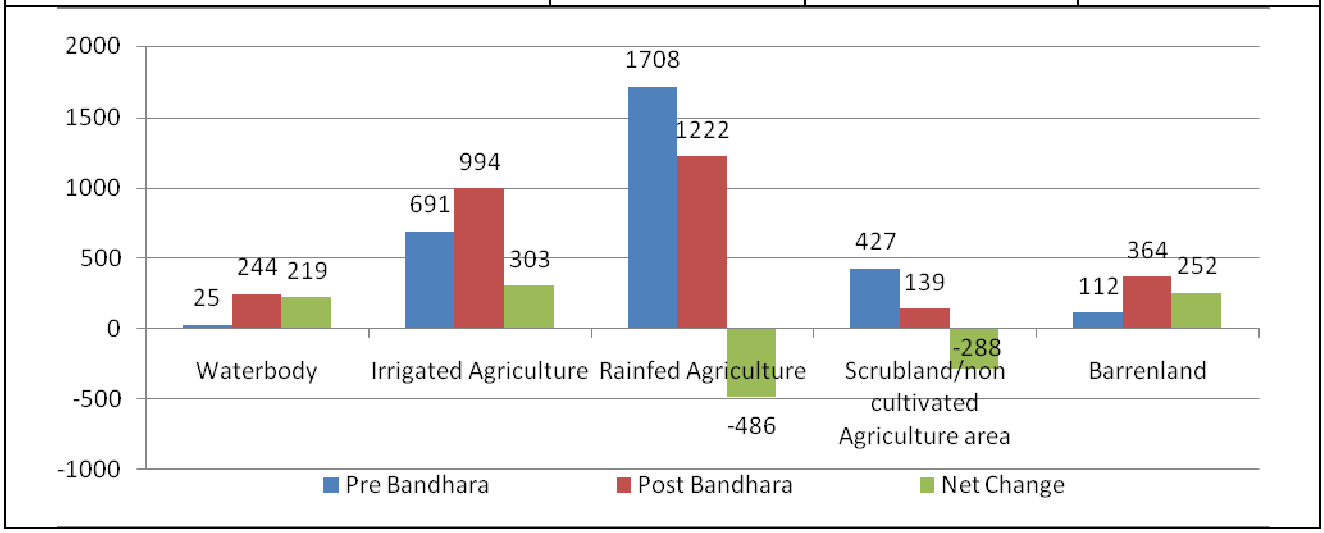
Fig.3.7 Well Hydrograph Showing Pre and Post Monsoon Changes in Concentration of Total Dissolved Solids in Observations Wells Surrounding Samadhiyala Bandhara (A)Patva; (B)Doliya; (C), Padiyarka; and (D) Samadhiyala

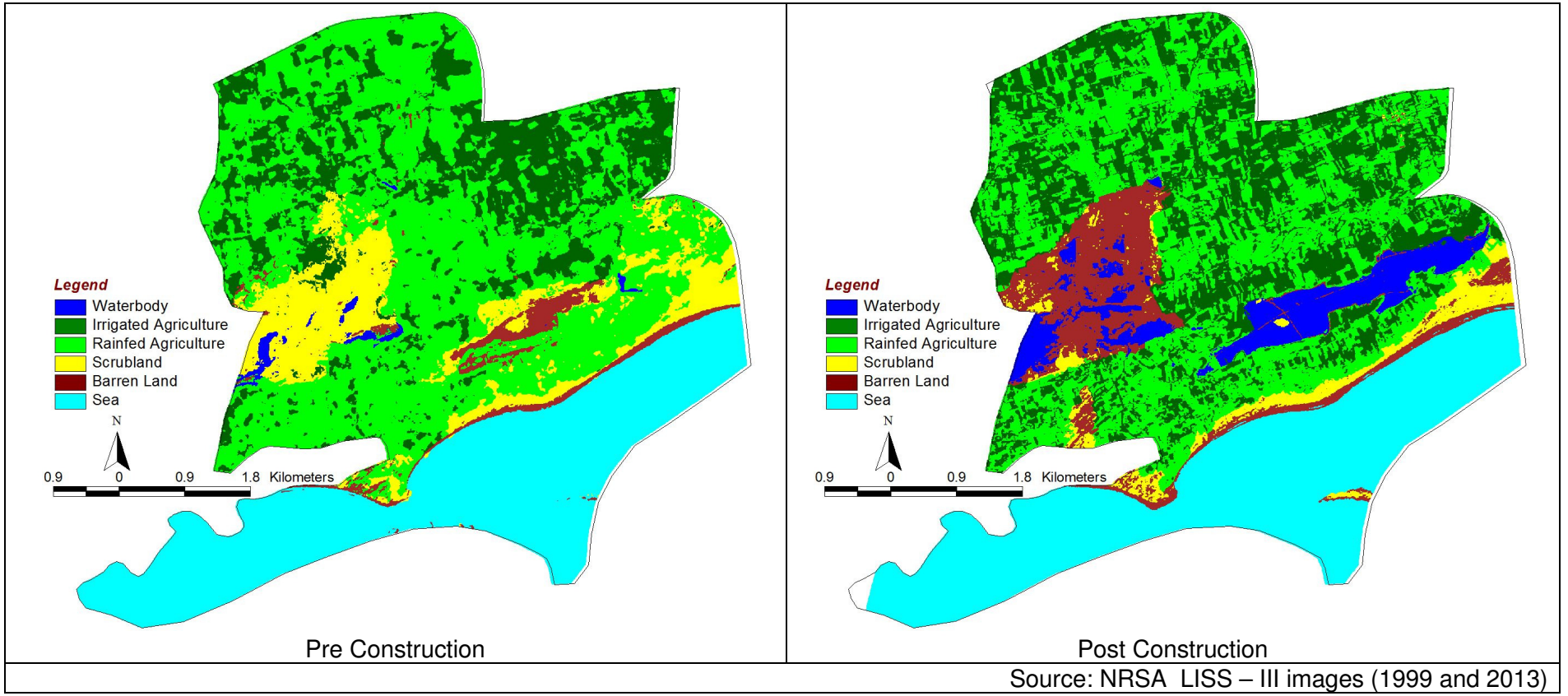
3.4 LANDUSE PATTERN

Land use pattern around Samadhiyala Tidal regulator has been studied with the help of remote sensing data. To understand land use pattern LISS – III image of the years 1999 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 3.7)

Table 3.7 Landuse Pattern around Samadhiyala Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	25	244	219
Irrigated Agriculture	691	994	303
Rain fed Agriculture	1708	1222	-486
Scrubland/non cultivated Agriculture	427	139	-288
Barren land	112	364	252
Total	**2964**	**2964**	0





Pre Construction

Post Construction

Source: NRSA LISS – III images (1999 and 2013)

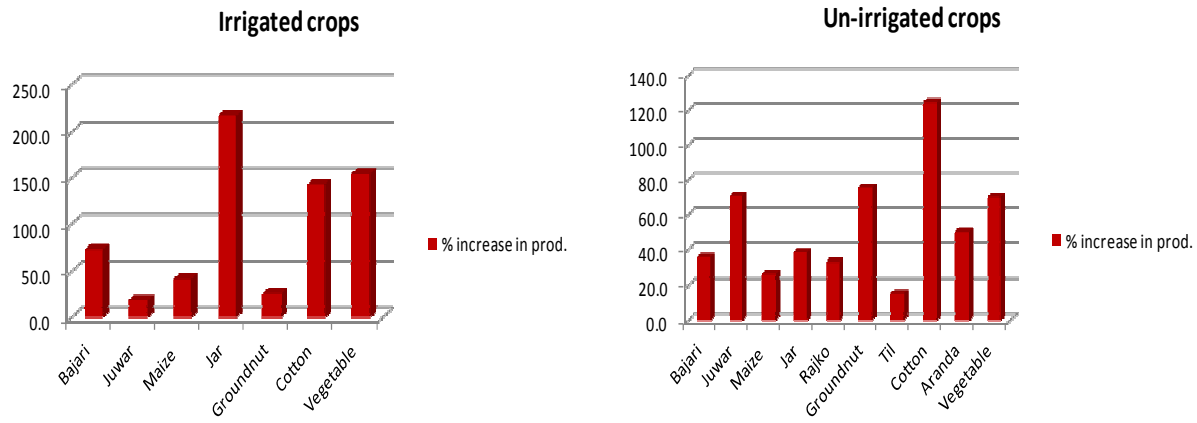
Fig. 3.8 Landuse Pattern around Samadhiyala Bandhara Area

3.5 AGRICULTURE

As in the case of Bhavnagar, there is no change in the area under irrigated and un-irrigated crops in the surveyed villages of Amreli district post the construction of the Samadhiyala bandhara. This holds true for food grains, oil seeds, cash crops as well as vegetables. However, in terms of crop production, irrigated crops have shown an increase of 19 per cent for Juwar and 218 per cent in the case of Jar before and after the bandhara as shown in Table 3.8 and figure 3.9. Un-irrigated crops which have shown significant improvements in production post the bandhara include cotton, groundnut, juwar and vegetables in that order (Table 3.9). That improved irrigation as a result of the bandhara has had a greater impact on productivity of irrigated crops as compared to un-irrigated crops can be clearly seen in the difference between the levels of increase of production of bajri, maize, jar, cotton and vegetables.

Table 3.8: Impact on agriculture production – irrigated crops

Sr.No.	Major Crop	Production in mun		% increase in production
		Before Scheme	After Scheme	
1	Bajari	465	809	74.0
2	Juwar	585	695	18.8
3	Maize	398	565	42.0
4	Jar	55	175	218.2
5	Groundnut	581	732	26.0
6	Cotton	530	1290	143.4
7	Vegetable	324	825	154.6



(A) (B)

Fig. 3.9: Percentage increase in area under irrigated and un-irrigated crops

Table 3.9: Impact on agriculture production – un-irrigated crops

Sr.No.	Major Crop	Production in mun		% increase in production
		Before Scheme	After Scheme	
1	Bajari	1527.5	2072	35.6
2	Juwar	290	495	70.7
3	Maize	330	418	26.7
4	Jar	1205	1667	38.3
5	Rajko	30	40	33.3
6	Groundnut	2371	4164	75.6
7	Til	26	30	15.4
8	Cotton	3374	7580	124.7
9	Aranda	20	30	50.0
10	Vegetable	50	85	70.0

3.6 SITUATION OF WOMEN

Women have benefited from significant savings of time in collection of drinking water since construction of the Samadhiyala bandhara has ensured availability of potable water within the village. This has helped them spend more time with family and give greater attention to their children's education. Also, due to improved availability of water for agriculture, agriculture productivity has increased and horticulture has been encouraged. Migration from the village has come down since people can now find work in the village itself.

About 15 per cent of the women surveyed in Amreli district said that they had started growing their vegetables at home while more than 100 women of Dolia village had started practicing horticulture post the construction of the bandhara. Becoming part of a SHG has helped women to start saving, which has increased their confidence levels. They have now started taking loans for livelihood activities and going to the market to sell fruits and vegetables which has enhanced their incomes.

4. SOCIO-ECONOMIC IMPACT IN JUNAGADH DISTRICT

There are seven structures of Junagadh district have selected for socio-economic impact such as (01) Vasoj tidal regulator; (02) Barda bandhara; (03) Muldwarka tidal regulator; (04) Vadodara Zala tidal regulator; (05) Somnath tidal regulator; (06) Sheel bandhara and (07) Sabli Netravati canal. Fig. 4.1 shows location maps of bandharas

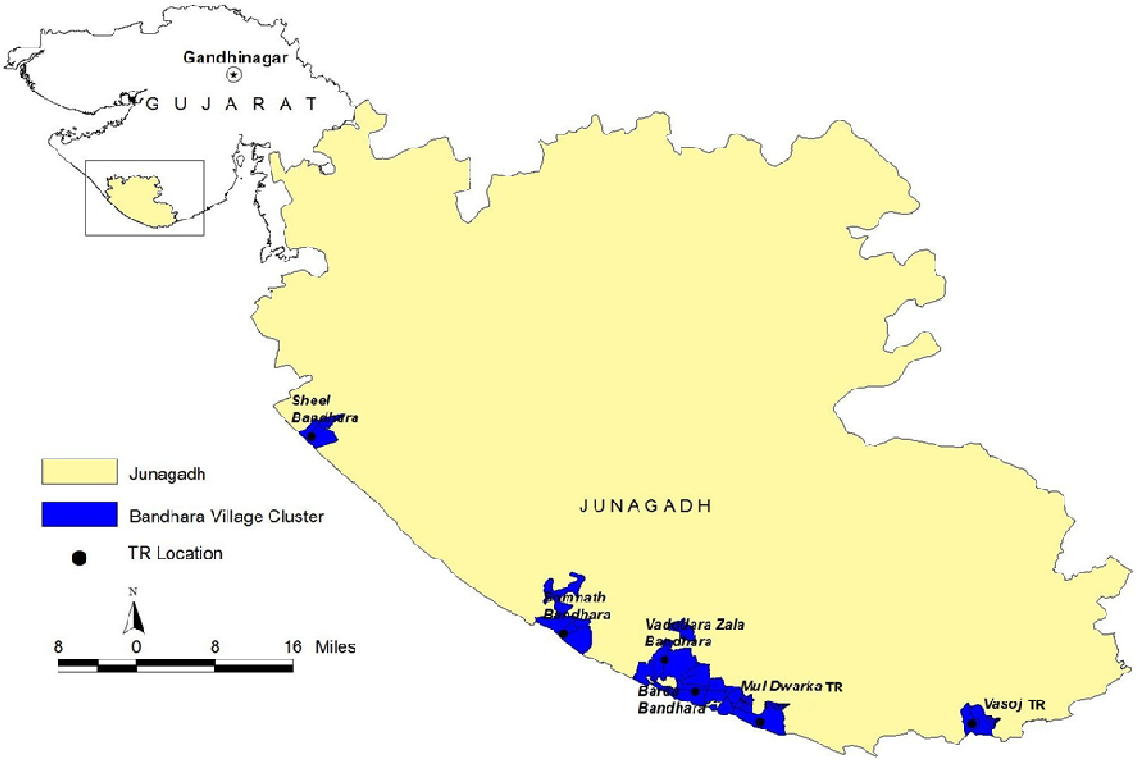


Fig 4.1: Location of Salinity Prevention Structures in Junagadh District

4.1 VASOJ TIDAL REGULATOR

4.1.1 ASSETS, INCOME AND INVESTMENTS

While most families benefiting from the Vasoj tidal regulator have acquired mobile telephones after the scheme, a lesser number of families have also been able to acquire a more important asset in the form of a house (Fig. 4.2).

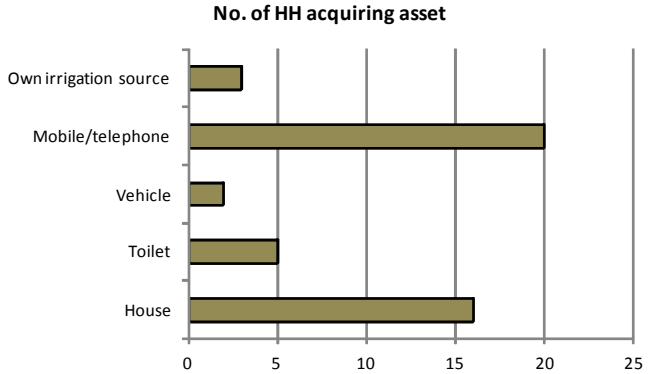


Fig. 4.2: Impact on assets in Vasoj

Animal husbandry seems to have become a popular occupation in villages affected by the scheme since a large number of families have reported selling of milk as a new source of income (Fig 4.3 A). Some of them have set up a business while others have benefited from better daily wage employment prospects post the tidal regulator. While the additional income has been used by most families for consumptive purpose like attending/organising social functions, a good number of households have used it for children's education, animal purchase or as savings in a bank (Fig. 4.3 B).

Plate No. 4.1 Desilting Activities in Vasoj Tidal Regulator

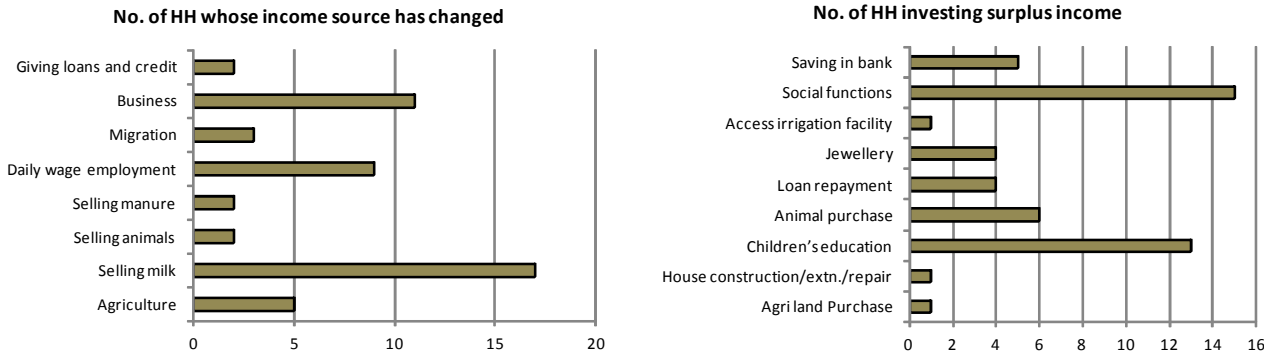


Fig 4.3 Impact on Income Source (A) and Investment of Surplus Income (B) in Vasoj

4.1.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 4.1: Impact on fodder availability due to agriculture, in Vasoj

Impact	Quantity
Increase in Green Fodder (%)	73
Increase in Dry Fodder (%)	66
Increase in Cow dung (%)	50

Green fodder availability has increased by 73 per cent while dry fodder availability has increased by 66 per cent in villages serviced by the Vasoj TR scheme while manure availability has also shown a marked increase as can be seen from Table 4.1.

4.1.3 LIVESTOCK AND MILK PRODUCTION

Across Junagadh district, while the number of cows and buffaloes has increased to the greatest extent in villages under the Vasoj TR scheme, this has somehow not been able to translate into a corresponding increase in milk production from these animals. However, due to improved agriculture, the number of bullocks has seen a rise of 40 per cent.

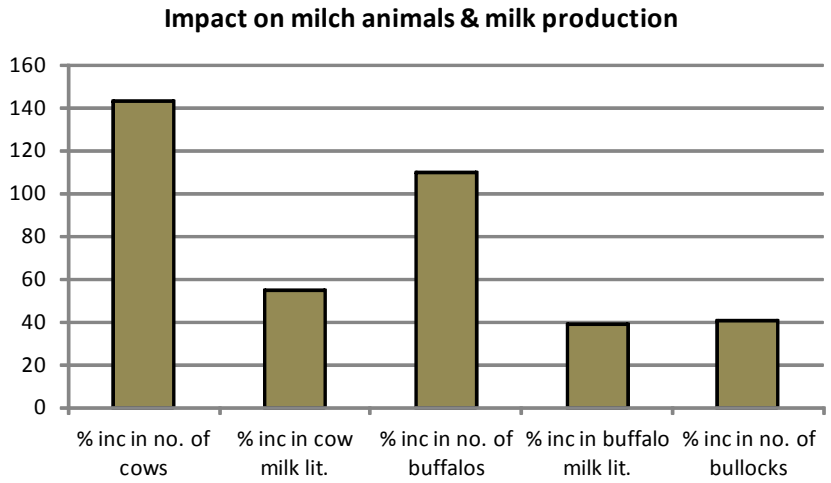


Fig 4.4 Impact on milch animals and milk production in Vasoj

4.1.4 GROUNDWATER AVAILABILITY AND QUALITY

The Vasoj TR scheme has had a limited impact on the local water table with most of the surveyed households either reporting groundwater levels declining by upto 25 feet or no change in the water levels post the scheme as seen from Fig. 4.5 A.

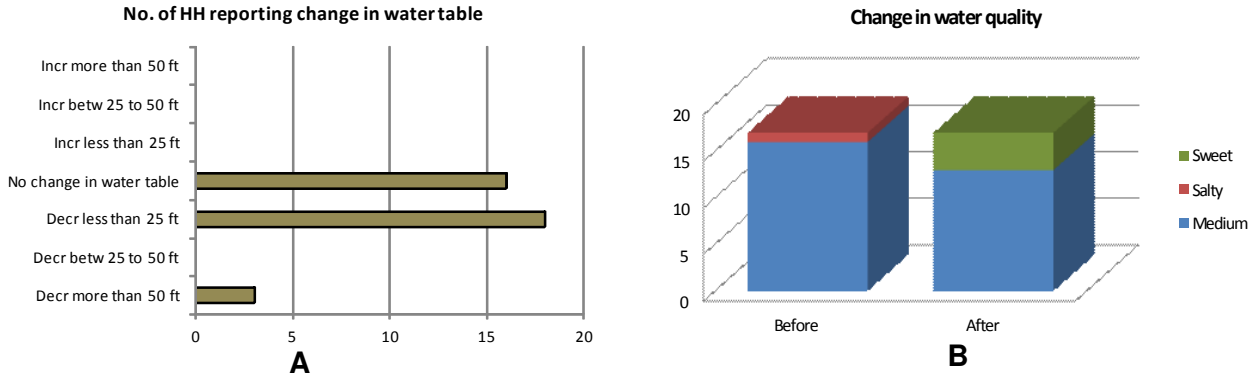


Fig. 4.5: People's View on Change in Water Table (A) and Water Quality in Vasoj

However, that water quality has improved post the construction of the Vasoj TR scheme is evident from the fact that while none of the surveyed households were receiving sweet water before the scheme, at least a fourth of the families are now getting sweet water and the incidence of salt in water has completely diminished as seen from Fig. 4.5 B. Changes in groundwater table and quality have also been assessed with the help of two monitoring wells established by SIPC. Both the wells (S – 351 and S – 352) are located in village Vasoj of Taluka Una. SIPC monitors both these wells since 1987. (Table 4.2)

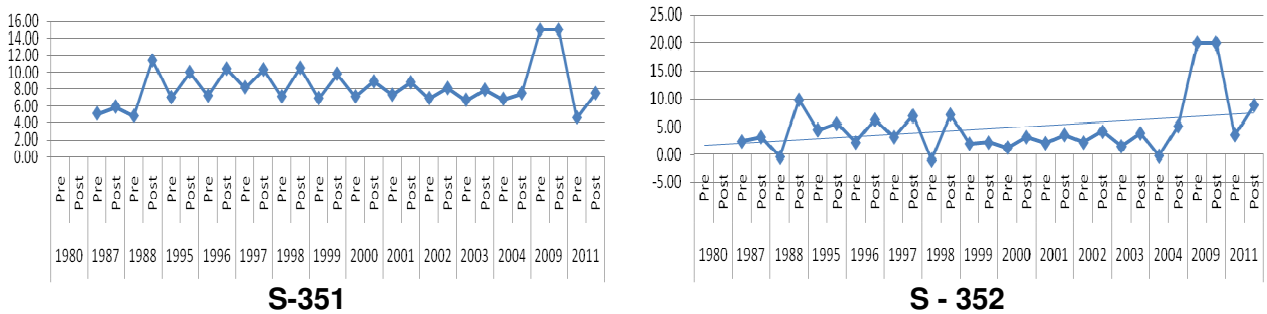
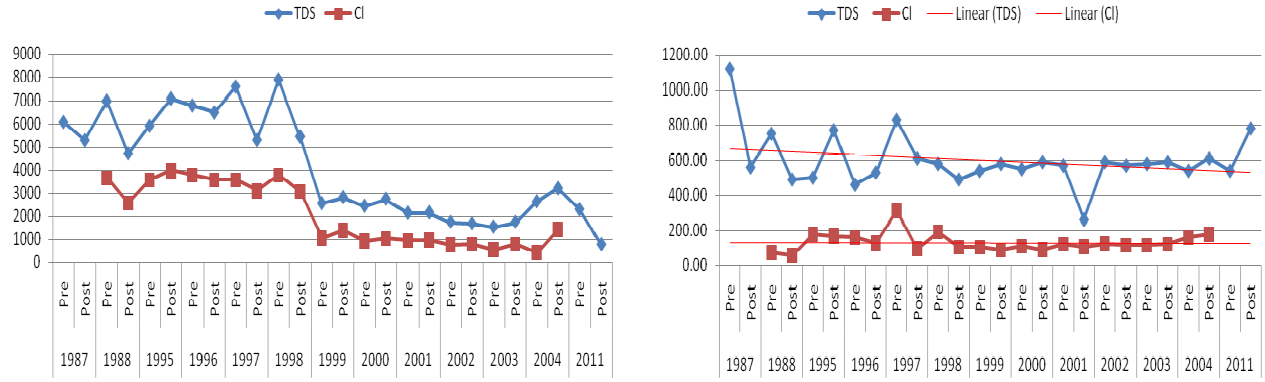


Fig 4.6 Well Hydrographs Showing Pre and Post Monsoon Fluctuation in RWL in Monitoring Wells of Vasoj TR

Table 4.2: Pre and Post Monsoon Changes and Groundwater Levels and Quality in Observation Wells of Vasoj TR

Year	WL (M)				TDS (PPM)				Chloride (PPM)			
	S – 351		S - 352		S – 351		S - 352		S – 351		S - 352	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1988	10.20	3.60	20.40	10.10	6980	4720	750	490	3680	2600	72	56
1995	8.00	5.00	15.50	14.40	5910	7080	500	770	3600	4000	176	168
1996	7.80	4.60	17.80	13.70	6790	6490	460	530	3800	3600	160	128
1997	6.80	4.70	16.80	13.00	7580	5300	830	610	3600	3120	312	96
1998	7.90	4.50	20.90	12.80	7880	5450	580	490	3800	3100	192	104
1999	8.10	5.20	18.00	17.80	2560	2820	540	580	1080	1400	104	88
2000	7.90	6.10	18.70	16.80	2450	2750	550	590	950	1050	110	90
2001	7.70	6.20	17.90	16.40	2150	2170	570	260	970	980	120	105
2002	8.10	6.90	17.80	15.80	1750	1680	590	570	780	810	125	115
2003	8.30	7.10	18.50	16.10	1540	1750	580	590	570	810	115	120
2004	8.20	7.50	20.20	14.80	2640	3210	540	610	440	1450	160	180
2011	10.4	7.50	16.4	11.1	2300	780	540	780				

Almost similar behaviour in water level fluctuation has been shown by both the observation wells. Overall water level in this area has increased. As far as TDS and Chloride concentrations there is significant change after year 1999 in observation well no. S – 351. The TDS vaules in this well has reduced from more than 7000 ppm to less than 1000 ppm. Whereas in case of well no S – 352 the change is gradually showing decrease in TDS and Chloride values in groundwater, however, in this case the maximum TDS was also within potable limit i.e. less than 1500 ppm. (Fig 4.7) Both the hydrographs for Water quality clearly shows parallel relationship between TDS and Cl concentration.



S-351 **S - 352**

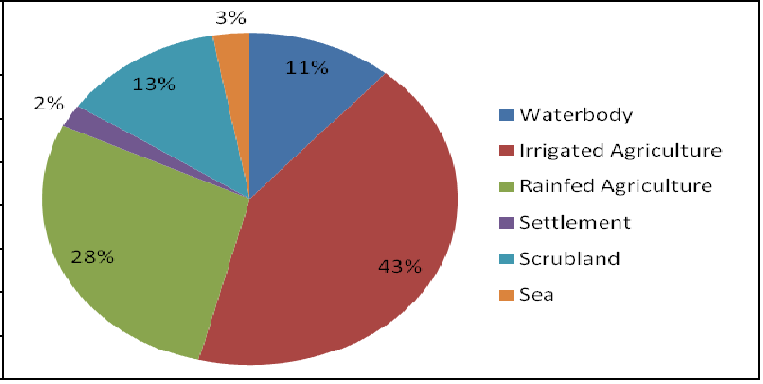
Fig 4.7 Well Hydrographs Showing Pre and Post Monsoon Fluctuation in TDS and Chloride Concentrations in Monitoring Wells of Vasoj TR

4.1.5 LANDUSE

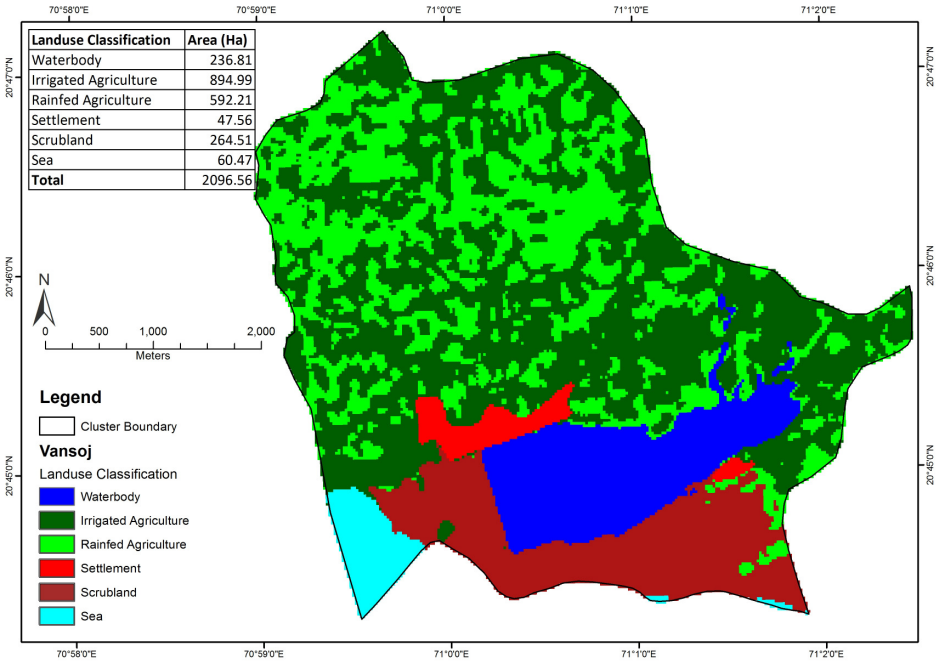
Landuse pattern around Vasoj TR has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the year 2008 of post monsoon season has downloaded from web site ***bhuvan****.nrsc.gov.in* Ideally there need to analyse landuse from pre and post construction period but procurement of recent data was not possible due to shortage of time and therefore, in present assessment only status of land use has studied.

Table 4.3 Landuse Pattern around Vasoj TR

Landuse	Area (Ha)
Water body	237
Irrigated Agriculture	895
Rainfed Agriculture	592
Settlement	48
Barren lands	265
Sea	60
Total	**2097**



Out of total analysed land area (2097 Ha) about 71 % area is categorized as agriculture land where all other areas such as water bodies, settlements, barren land and sea occupies about 16 percentages of total area is occupied by sea in surrounding area of Vasoj TR. It is important to clarify that, pre and post TR construction changes in landuse pattern especially in irrigated agriculture areas was not possible to compute due to non availability of pre construction remote sensing data. (Table 4.3, Fig. 4.8)



Source:LISS-III, Bhuvan.nrsc.gov.in

Fig. 4.8 Landuse Pattern around Vasoj TR Area, (Year 2008)

4.2 BARDA BANDHARA

4.2.1 ASSETS, INCOME AND INVESTMENTS

Following the trend in other schemes, many households have acquired mobile telephones in villages benefiting from the Barda bandhara. However, construction of toilet has been the most significant asset addition posts the scheme here as evident from Fig. 4.9.

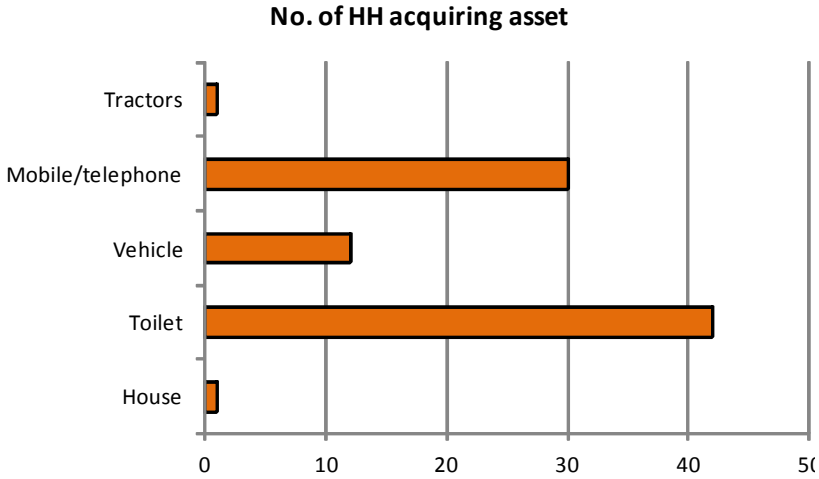


Fig. 4.9 Impact on assets in Barda

That animal husbandry has got a boost due to the Barda bandhara can be seen from Fig. 4.10 A where selling milk and animals are the predominant sources of additional income for households post the construction of the scheme, followed by income from business. The additional income generated has been invested by most families on getting a toilet/tap connection in their house, while others have invested the money on agriculture by purchasing more cultivable land, undertaking land improvement and getting irrigation for their land (Fig. 4.10 B).

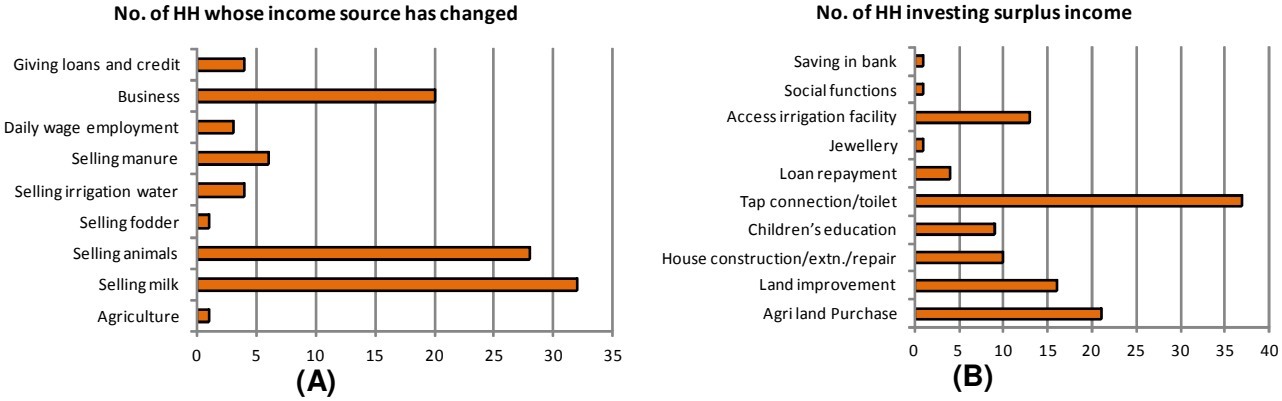


Fig 4.10 Impact on Income Source (A) and Investment of Surplus Income (B) in Barda

4.2.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 4.4: Impact on fodder availability due to agriculture, Barda Bandhara

Impact	Quantity
Increase in Green Fodder (%)	131
Increase in Dry Fodder (%)	-3
Increase in Cow dung (%)	2

Villages affected by the Barda bandhara account for the maximum increase in green fodder availability among all schemes of Junagadh district (Table 4.4). This has had a positive bearing on milch animal population as well.

Except for dwarf animals (bullocks), a significant increase can be seen, both in the number of milch animals and milk production from cows and buffaloes (Fig. 4.11). This can be attributed directly to better availability of green fodder in the villages under Barda bandhara.

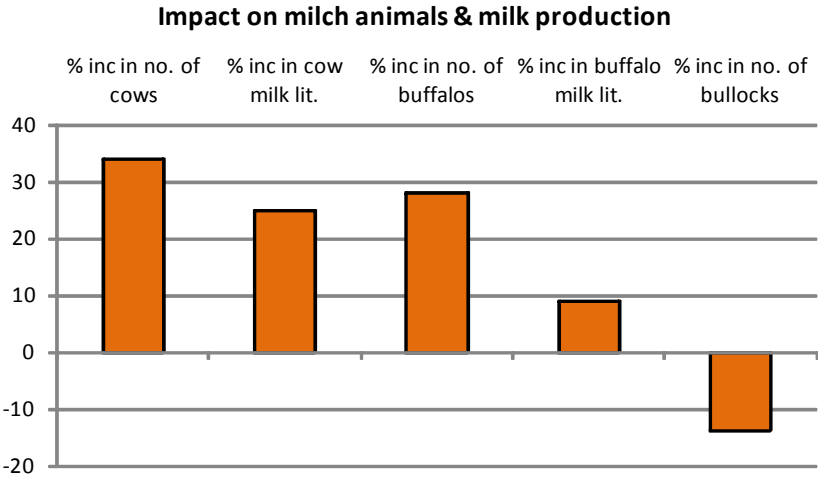


Fig. 4.11: Impact on milch animals and milk production in Barda

4.2.3 GROUNDWATER AVAILABILITY AND QUALITY

Overall, the situation of groundwater in villages falling under the Barda bandhara has improved with 58 per cent of the surveyed households (nearly 70 families) reporting that the height of the groundwater table has increased by upto 25 feet as can be seen from Fig. 4.12 A.

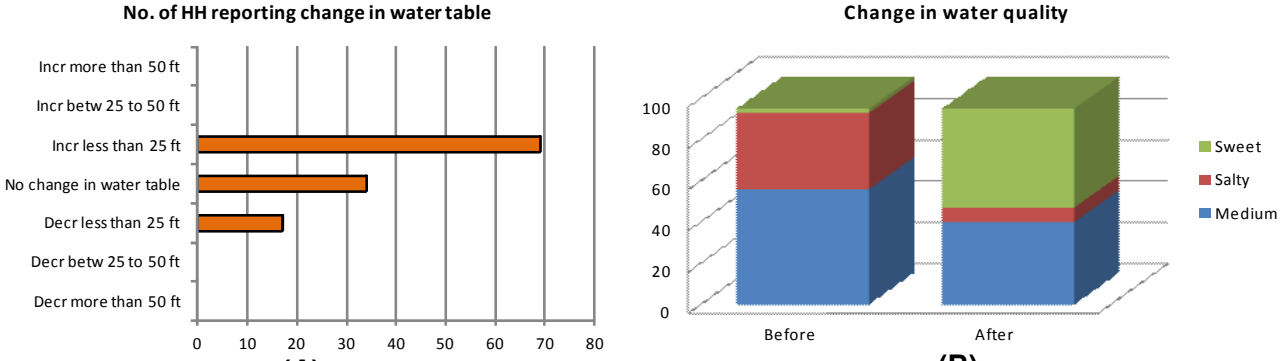


Fig 4.12 People's View on Change in water Table (A) Water Quality (B) in Barda

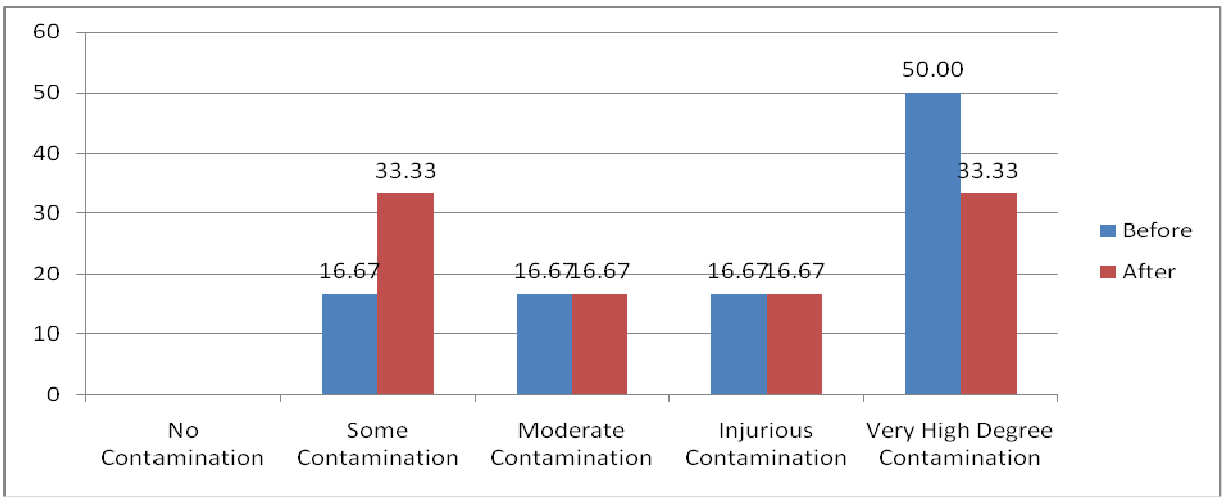
A drastic change can be seen in water quality – not merely in terms of the 32 per cent reduction in the incidence of salty water but more significantly, owing to the 48 per cent increase in households receiving sweet water post the scheme (Fig. 4.12 B)

In addition to above analysis data collected by SIPC from various observations located in different villages around bandhara were also analysed to understand changes in ground water levels and quality in different villages. Table 4.5 shows changing trends in water level and TDS concentrations along with quantitative analysis of salinity status during before and after construction of Barda bandhara in area.

Table 4.5 Village Wise Impact on Groundwater levels and Quality during Before and After Construction

Village	Impact on Groundwater	
	RWL	**TDS Concentrations**
Barda	All observation wells shows gradual rise in water level. Before construction the water levels were below 4 m than AMSL while during year 2011 one well (BBU 11) shows water level just reaching to AMSL and another well (HLC 168) has WL just below sea level.	During 1995 to 2005 the fluctuation ranges were more in compare to later years. Initially the TDS concentration in BBU 11 was more than 3500 ppm but during year 2011 all the well have TDS concentration just near to 3000 ppm
Rakhej	Similar to Barda OW of Rakhej village also show rising trend in water level	Up to year 2004 TDS values have gradually increased from 2000 to 6000 ppm but than after it has reduced up to less than 2000 ppm
Kanjotar	Both well shows almost balance behaviour since before construction time	TDS value constantly decreases from 4000 ppm in year 1984 to less than 2000 ppm in year 2010
Dhamlej	Water level shows gradual decreasing trend	Gradual decreasing trend in TDS from >4000 ppm in year 1984 to < 2000 ppm
Muldwarka	The wells shows balance and straight trend but the seasonal fluctuation is more in compare to other wells especially in case of OW no BBU 7	Both the wells shows increasing trends in TDS concentrations
Cho.Khan	Initially the water level show decreasing trend but since year 2005 it is gradually increasing	Both wells shows different behaviour in fluctuation but overall TDS have decreased from before construction stage
Math		Sudden decrease in TDS from year 2004

Quantitative analysis of Chloride Carbonate ration clearly shows that before construction about 50 % of groundwater had vary degree of contamination that has reduced up to 33.33 %. In case of some contamination category the percentages of groundwater have increased from 16.67 % (before condition) to 33.33 % in after condition. While no change has been seen in case of moderate and injurious contamination categories.



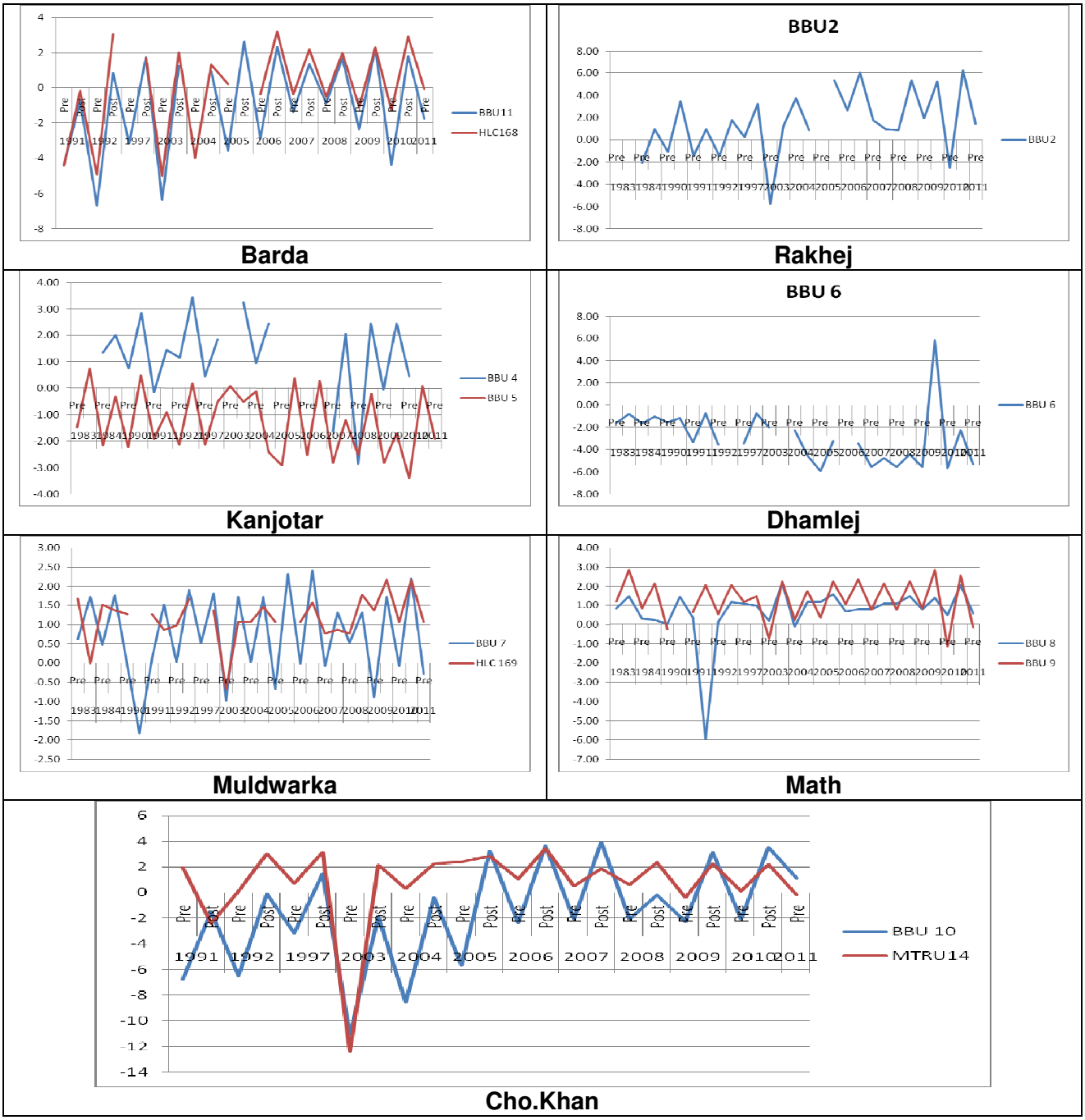


Fig. 4.13 Village Wise Well Hydrographs of Observation Wells Showing Changing Trends in Water Levels around Barda Bandhara, Gir Somnath

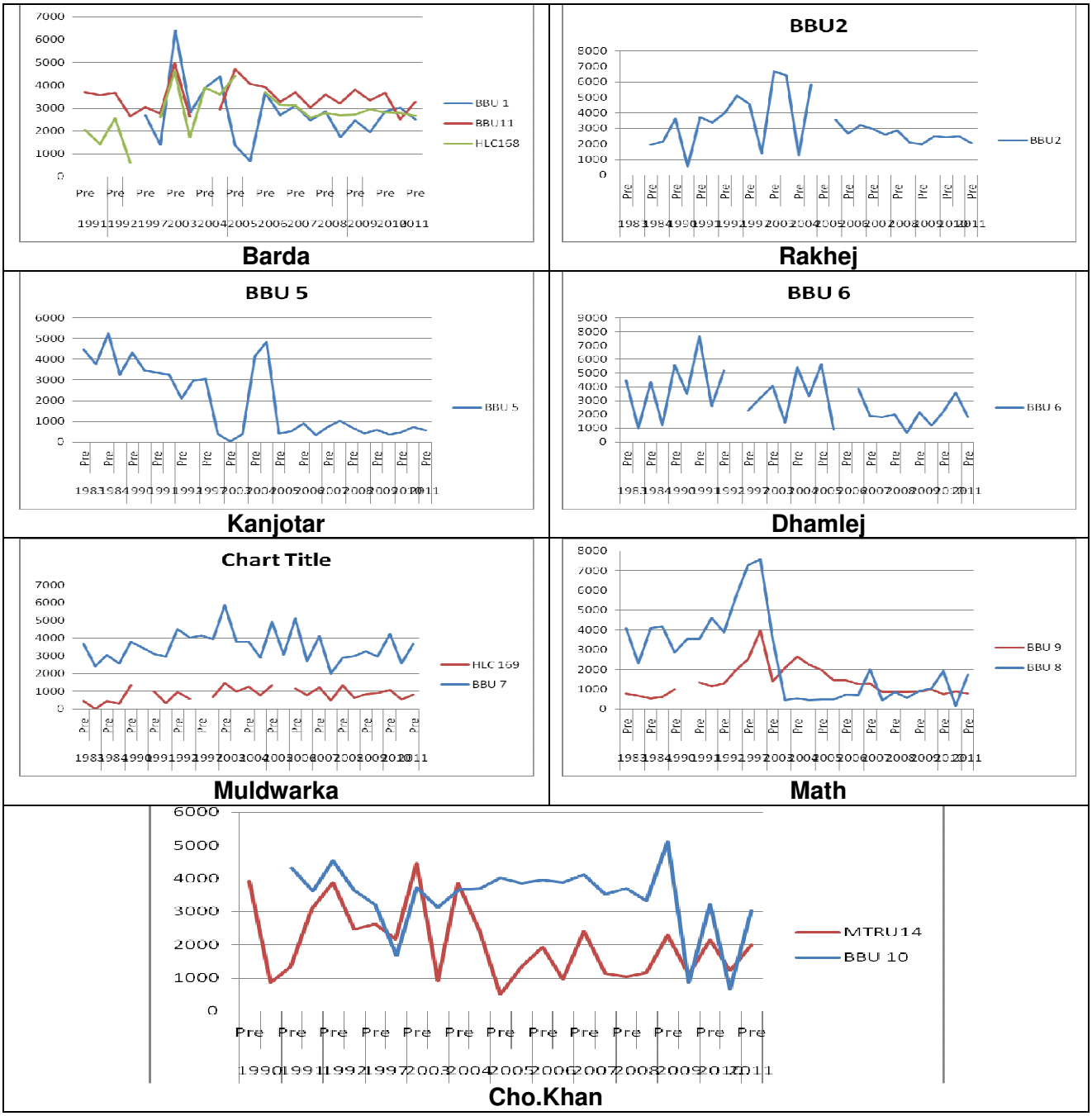


Fig. 4.14 Village Wise Well Hydrographs of Observation Wells Showing Changing Trends in TDS Values around Barda Bandhara, Gir Somnath

Table 4.6: Pre and Post Monsoon Changes and Groundwater Levels in Observation Wells of Barda Bandhara (Source: SIPC, 1988-2011)

VILLAGE		Barda			Rakhej	Kanjotar			Dhamlej
OB.WELL		BBU 1	BBU11	HLC168	BBU2	BBU 3	BBU 4	BBU 5	BBU 6
RL(m)		6.81	5.63	5.01	7.26	6.83	5.45	3.89	1.47
1983	Pre	1.81		-0.19	-1.44	1.03	1.75	-1.46	-1.58
	Post			3.51		4.93		0.74	-0.78
1984	Pre			-1.34	-2.04	-0.07	1.35	-2.16	-1.63
	Post	3.21		2.76	0.96	3.33	2.01	-0.31	-1.03
1990	Pre			-4.79	-1.04	-1.07	0.75	-2.21	-1.53
	Post				3.46	3.63	2.85	0.49	-1.18
1991	Pre		-4.37	-4.39	-1.44	0.03	-0.15	-1.91	-3.33
	Post		-0.77	-0.19	0.96	2.33	1.45	-0.91	-0.73
1992	Pre		-6.67	-4.89	-1.44	0.13	1.15	-2.11	-3.53
	Post		0.83	3.05	1.76	3.33	3.45	0.19	
1997	Pre	0.71	-3.17		0.26		0.45	-2.11	-3.43
	Post	4.51	1.73	1.71	3.26		1.85	-0.51	-0.73
2003	Pre	2.31	-6.37	-4.99	-5.74			0.09	-2.03
	Post	4.51	1.23	2.01	1.26		3.25	-0.51	
2004	Pre	3.01		-3.99	3.76	-6.17	0.95	-0.11	-2.23
	Post	3.21	0.93	1.31	0.86		2.45	-2.41	-4.53
2005	Pre	1.21	-3.57	0.21				-2.91	-5.93
	Post	4.81	2.63		5.36			0.39	-3.23
2006	Pre	1.61	-2.87	-0.39	2.66	0.03	0.25	-2.51	
	Post	4.81	2.33	3.21	6.06	2.63		0.29	-3.43
2007	Pre	1.01	-1.37	-0.39	1.76	-0.87	-1.65	-2.81	-5.53
	Post	4.01	1.33	2.21	0.96	1.83	2.05	-1.21	-4.73
2008	Pre	0.31	-0.87	-0.49	0.86	1.03	-2.85	-2.51	-5.53
	Post	3.31	1.66	2	5.36	2.03	2.45	-0.21	-4.43
2009	Pre	-1.39	-2.37	-1.09	1.96	-1.47	-0.05	-2.81	-5.53
	Post	4.31	2.23	2.31	5.26	1.43	2.45	-1.71	5.83
2010	Pre	1.71	-4.37	-1.29	-2.54	-1.37	0.45	-3.41	-5.63
	Post	4.71	1.8	2.91	6.26	2.13		0.09	-2.23
2011	Pre	1.21	-1.77	-0.09	1.46	-1.07	0.35	-1.91	-5.33

Table 4.6: Pre and Post Monsoon Changes and Groundwater Levels in Observation Wells of Barda Bandhara (Source: SIPC, 1988-2011) Contd…

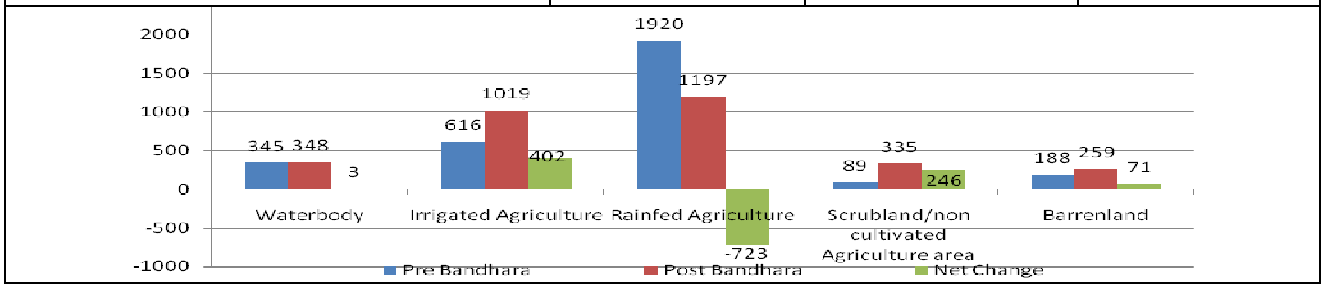
VILLAGE		Muldwarka			Math		C.KHAN	
OB.WELL		BBU 7	HLC 169	MTRU 13	BBU 8	BBU 9	BBU 10	MTRU14
RL(m)		4.02	5.07	3.18	3.19	5.26	5.91	4.61
1983	Pre	0.62	1.67		0.84	1.21		
	Post	1.72	1.87		1.49	2.86		
1984	Pre	0.47	1.52		0.31	0.86		
	Post	1.77	1.37		0.24	2.16		
1990	Pre	-0.08	1.27	0.48	0.04	-0.24		-3.49
	Post	-1.82		1.98	1.45			2.41
1991	Pre	0.12	1.27	-0.82	0.35	0.66	-6.76	1.91
	Post	1.52	0.87	0.98	-5.95	2.06	-1.49	-2.41
1992	Pre	0.02	0.97	0.68	0.15	0.56	-6.49	0.11
	Post	1.92	1.67	1.18	1.19	2.06	-0.09	3.01
1997	Pre	0.52		-0.52	1.09	1.16	-3.19	0.71
	Post	1.82	1.37	0.58	0.99	1.46	1.41	3.11
2003	Pre	-0.98	-0.67	-3.82	0.19	-0.74	-11.09	-12.39
	Post	1.72	1.07		2.19	2.26	-1.89	2.11
2004	Pre	0.02	1.07		-0.11	0.26	-8.59	0.31
	Post	1.72	1.47		1.19	1.76	-0.39	2.21
2005	Pre	-0.68	1.07		1.19	0.36	-5.69	2.39
	Post	2.32		-0.32	1.59	2.26	3.21	2.81
2006	Pre	-0.02	1.07		0.69	1.06	-2.39	1.01
	Post	2.42	1.57	1.18	0.79	2.36	3.61	3.41
2007	Pre	-0.08	0.77	-1.12	0.79	0.76	-2.09	0.51
	Post	1.32	0.87	-0.32	1.09	2.16	3.91	1.81
2008	Pre	0.52	0.77	-0.52	1.09	0.76	-2.09	0.61
	Post	1.32	1.77	0.68	1.49	2.26	-0.19	2.31
2009	Pre	-0.88	1.37	-0.4	0.79	0.86	-2.29	-0.39
	Post	1.72	2.17	-0.12	1.39	2.86	3.11	2.21
2010	Pre	-0.08	1.07	-0.82	0.49	-1.14	-2.09	0.11
	Post	2.22	2.17	0.18	2.09	2.56	3.5	2.19
2011	Pre	-0.28	1.07	-1.12	0.59	-0.14	1.1	-0.19

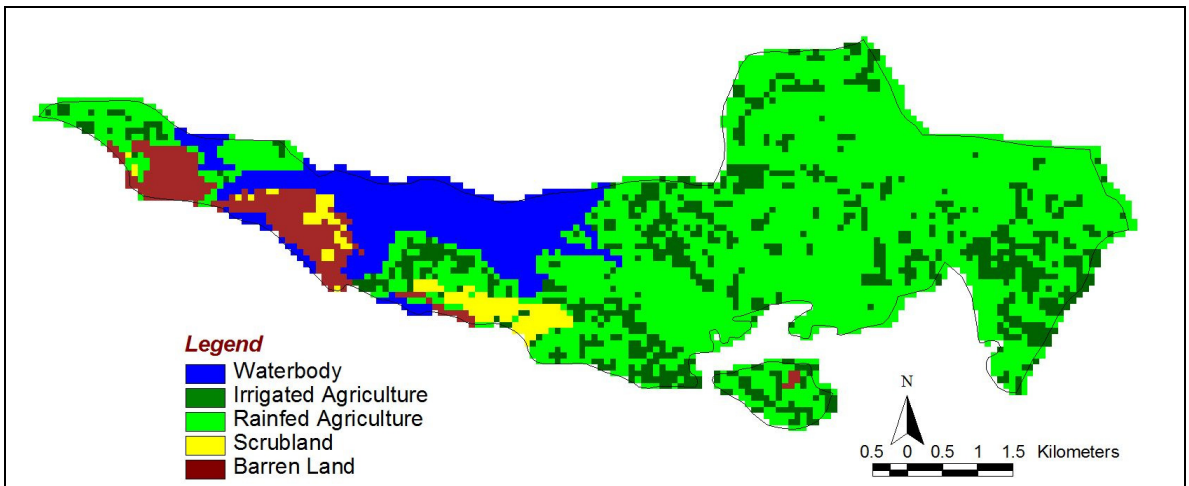
4.2.4 LANDUSE

Landuse pattern around Barda Bandhara has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1988 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed. (Table 4.7) The remote sensing data analysis clearly shows significant rise in irrigated area from 616 Ha before construction of Bandhara to 1019 Ha areas. It is also important to notice that there is a slight increase (about 71 Ha area) of barren land that may be on account of increase in soil salinity due to evaporation leaded by capillary action during summer season. (Fig. 4.13)

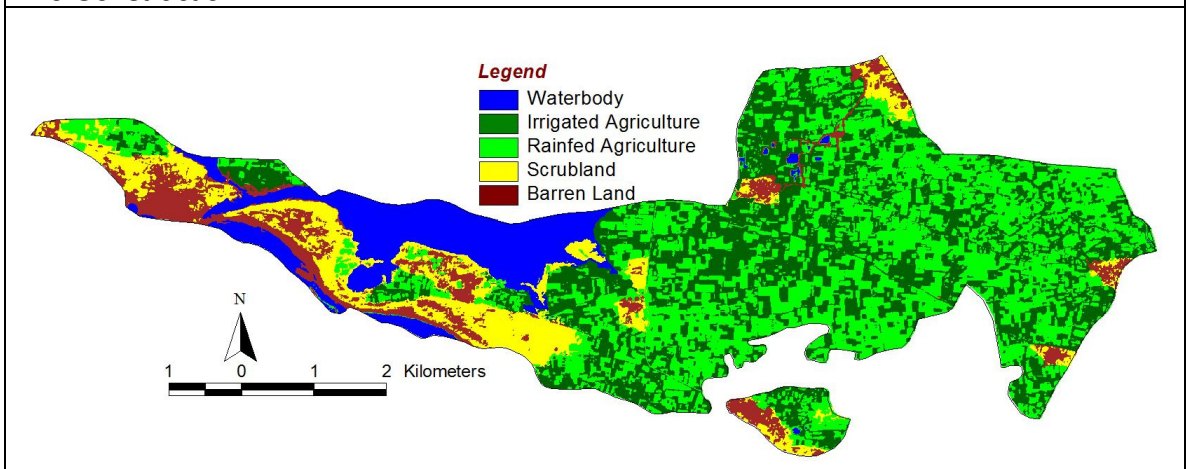
Table 4.7 Landuse Pattern around Barda Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	345	348	3
Irrigated Agriculture	616	1019	402
Rain fed Agriculture	1920	1197	-723
Scrubland/non cultivated Agriculture	89	335	246
Barren land	188	259	71
Total	**3159**	**3159**	0





Pre Construction



Post Construction

Source: NRSA LISS – III images (1988 and 2013)

Fig. 4.15 Landuse Pattern around Barda Bandhara Area

4.3 MULDWARKA TIDAL REGULATOR

4.3.1 ASSETS, INCOME AND INVESTMENTS

The most common assets acquired by families post construction of the Muldwarka tidal regulator include mobile telephone and vehicle. Interestingly, 27 per cent of surveyed households also reported constructing toilets after the scheme (Fig. 4.16).

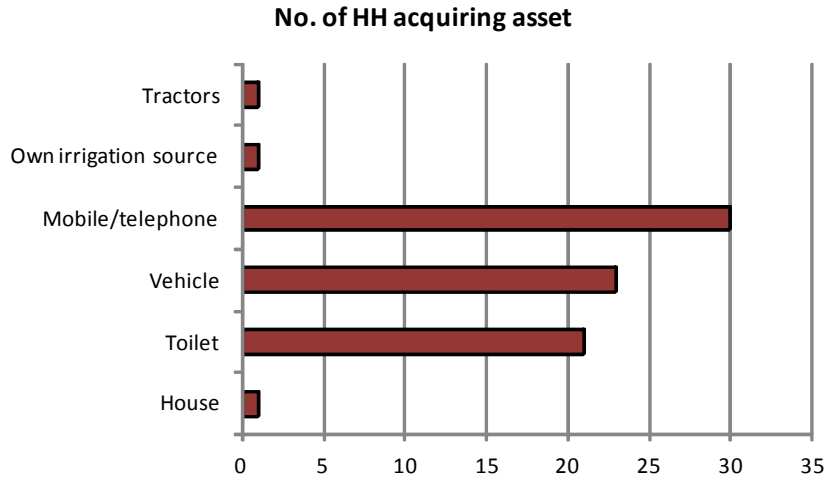


Fig. 4.16 Impact on assets in Muldwarka

Like in the case of Barda bandhara, animal husbandry seems to have been taken up in a big way in villages benefitting from the Muldwarka TR. This is evident from the fact that additional income from selling milk has been reported by a majority of the surveyed households (Fig. 4.17 A). The additional income generated is being invested by households on getting a toilet or tap connection in their house, followed by house renovation (Table 4.6).

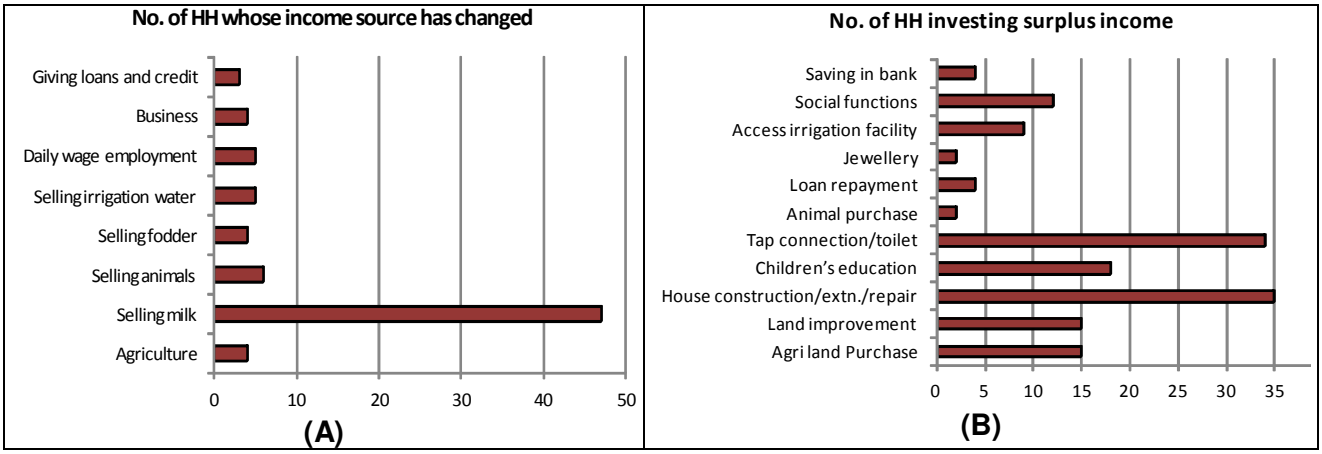


Fig. 4.17: Impact on Income Source (A) and Investment of Surplus Income (B) in Muldwarka

4.3.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 4.8: Impact on fodder availability due to agriculture, Muldwarka TR

Impact	Quantity
Increase in Green Fodder (%)	38
Increase in Dry Fodder (%)	17
Increase in Cow dung (%)	0

Green fodder availability due to improved agriculture has shown a healthy increase of 38 per cent even as dry fodder availability has risen by a more moderate 17 per cent in villages benefiting from the Muldwarka TR (Table 4.8).

Increase in milch animals such as cows and buffaloes as well as their milk production has been between 45-55 per cent (Fig. 4.18) post the scheme which can be attributed mainly to better availability of fodder. This has led more families to sell the excess milk as could be seen earlier under impact on income sources.

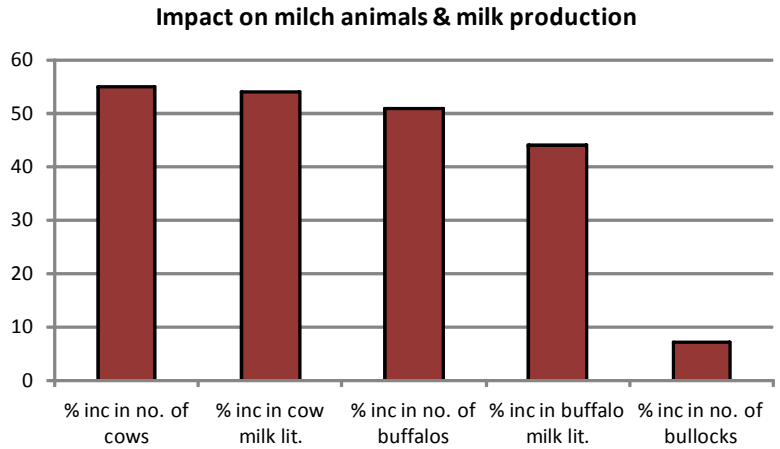


Fig. 4.18: Impact on milch animals and milk production in Muldwarka

4.3.3 GROUNDWATER AVAILABILITY AND QUALITY

There seems to be very little impact of the tidal regulator on groundwater table with a majority of the surveyed households stating that water levels have either gone down by upto 25 feet or there has been no change. Only about 10 per cent of the households have reported water tables increasing by up to 50 feet as shown in Fig. 4.19 A.

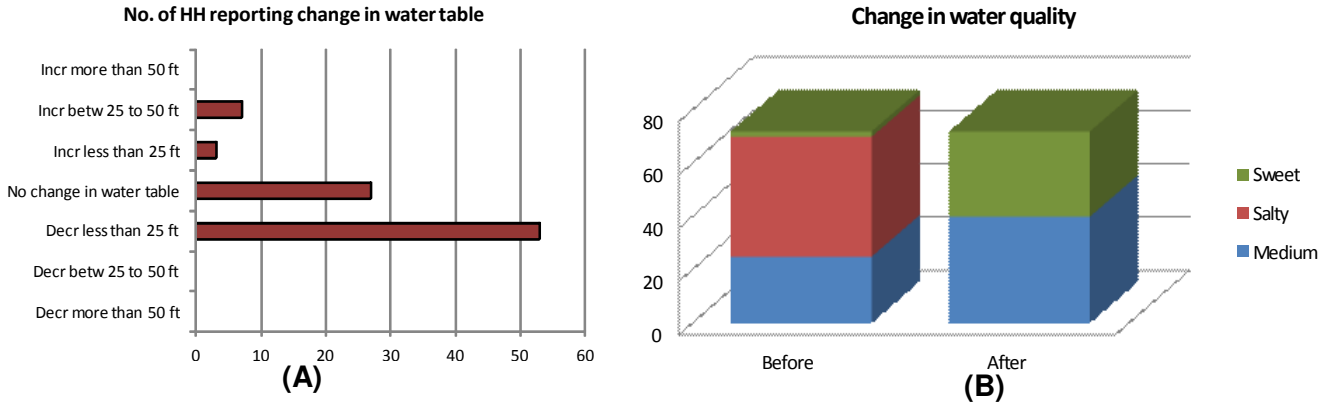


Fig 4.19 People's View on Change in Water Table (A) and Water Quality (B) in Muldwarka TR

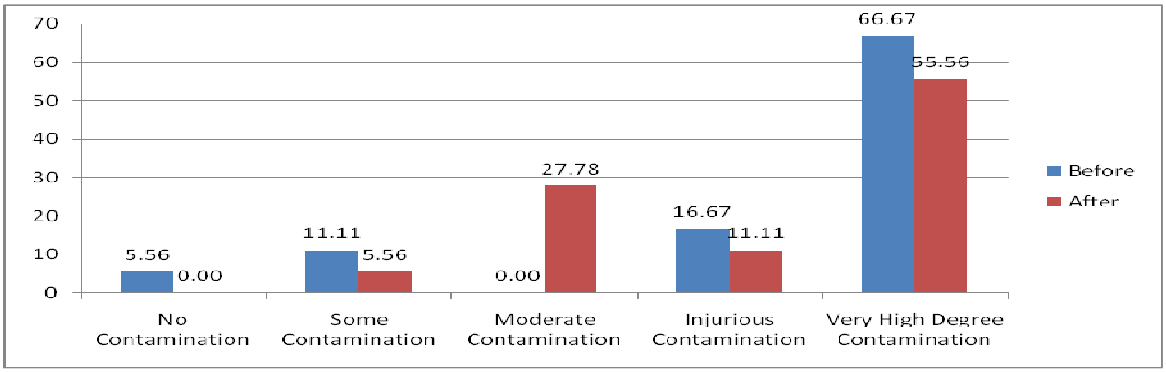
In terms of water quality, none of the 63 per cent of households getting salty water before the scheme reported incidence of salt in groundwater after the scheme. Equally significant was the fact that the proportion of families getting sweet water before and after the scheme increased from less than 3 per cent to over 44 per cent. An increase could similarly be seen in the case of households getting medium quality water (Fig. 4.19 B).

In addition to people's view, impact on groundwater in term of water level (Table 4. 9) and water quality (Table 4.10) have understood through analysing SIPC monitored data (Table 4.11) from pre construction year i.e. 1987 to 2011. The data were plotted on village wise hydrograph especially for water level (Fig. 4.20) and TDS (Fig. 4.21) concentration while quantitative analysis had been held for salinity status based on chloride carbonate ratio.

Table 4.9 Village Wise Pre and Post Construction Status of Groundwater around Muldwarka TR

Village	Impact on Groundwater	
	RWL	TDS Concentrations
Chhara	Gradual rise in water level pre construction it was about less than 2 m from AMSL while after construction the trend shows rising above 2 m	OW MTRU 2 shows increase in TDS concentration from less than 2000 ppm in before condition to 6000 ppm in after condition while remaining observation wells in this village shows gradual decreasing trends in TDS concentration from above 6000 ppm to less than 4000 ppm in after condition
Pipli	Gradual rise in water level pre construction two wells (MTRU 4 & 12) were having water level below AMSL while after construction the trend shows rising above AMSL	All wells shows gradual improvement in water quality. The TDS concentrations in 1987 were above than 7000 ppm that has gone down up to or less than 5000 ppm
Kodinar	Significant rise in water levels after construction before construction all monitoring wells show water level more than 5 m below AMSL those are now above AMSL	Except OW MTRU 15 TDS of both wells have reduced from 5000 ppm to less than 4000 ppm. In case of MTRU 15 TDS has slightly increased but the maximum limit still remains less than 2000 ppm
Pandar **Muldwarka**	Water level behaviour shows balance trend almost around AMSL	Immediately after construction the TDS values have gone down from 5000 ppm but from year 2005 its shows almost balance fluctuation during pre and post monsoon seasons.
Cho. Khan	Water level fluctuation shows normal fluctuations up to year 2000 than it shows gradual rise and now it is above AMSL	Very good improvement in groundwater quality through decrease in TDS from more than 4000 ppm at the time of construction and now during year 2011 it less than 2000 ppm
Math	Water level behaviour shows balance trend almost around AMSL	No significant change in water quality shows similar behaviour as water level

Quantitative analysis of Chloride Carbonate ration clearly shows that before construction about 66.67 % of groundwater had vary degree of contamination that has reduced upto 55.56 % similarly about 16.67 % of groundwater was having injurious level of contamination that also decreased up to 11.11 %. It is also one of the important notice that about 5.56 % water was of no contamination category before condition, that is no more exist after construction condition.



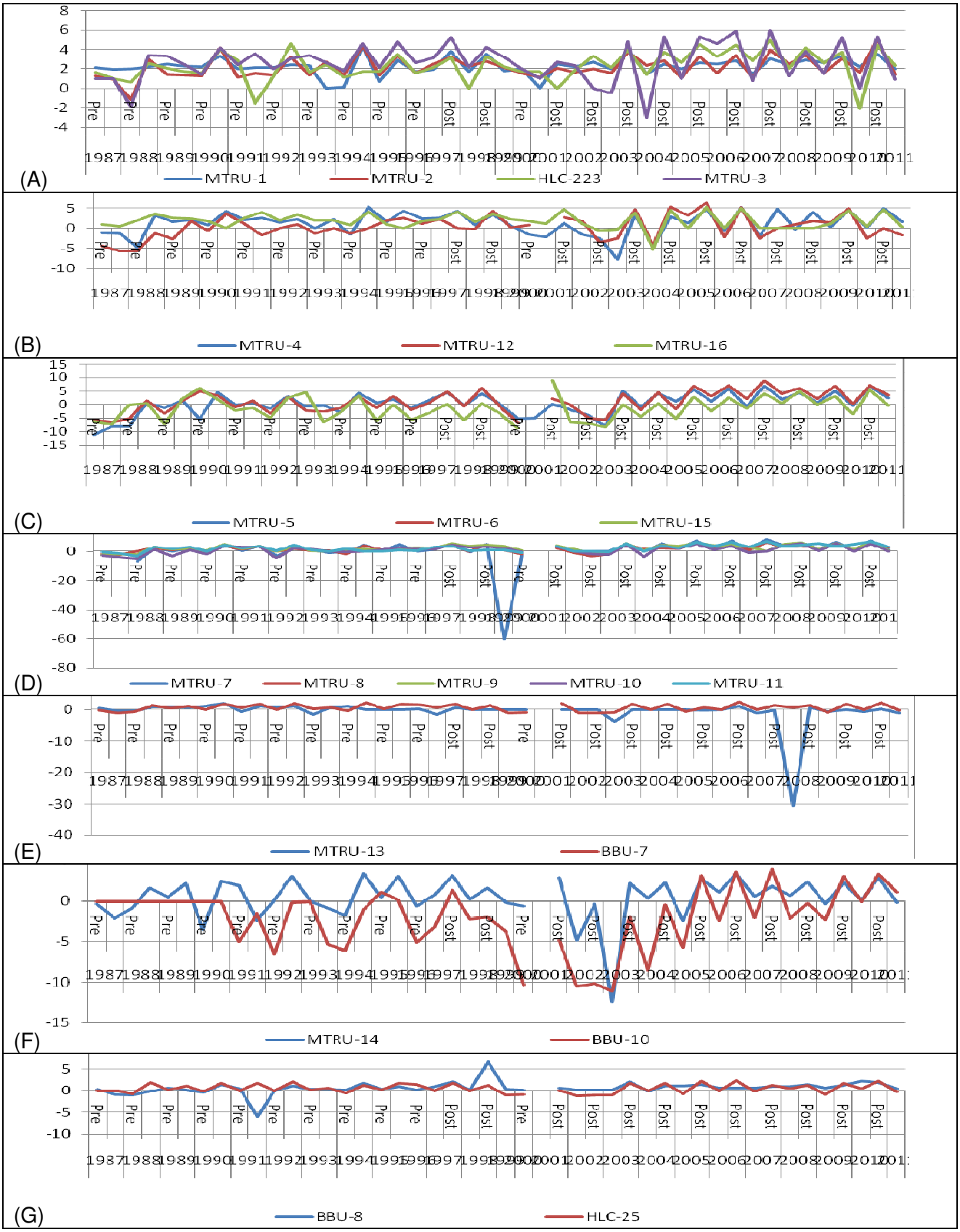


Fig 4.20 Village Wise Well Hydrograph Showing Water level Fluctuations around Muldwarka TR from Year 1987 to 2011 (A) Chhara (B) Pipli (C) Kodinar(D) Pandar (E) Muldwarka (F) Cho. Khan (G) Math (Source: SIPC 1987 0 2011)

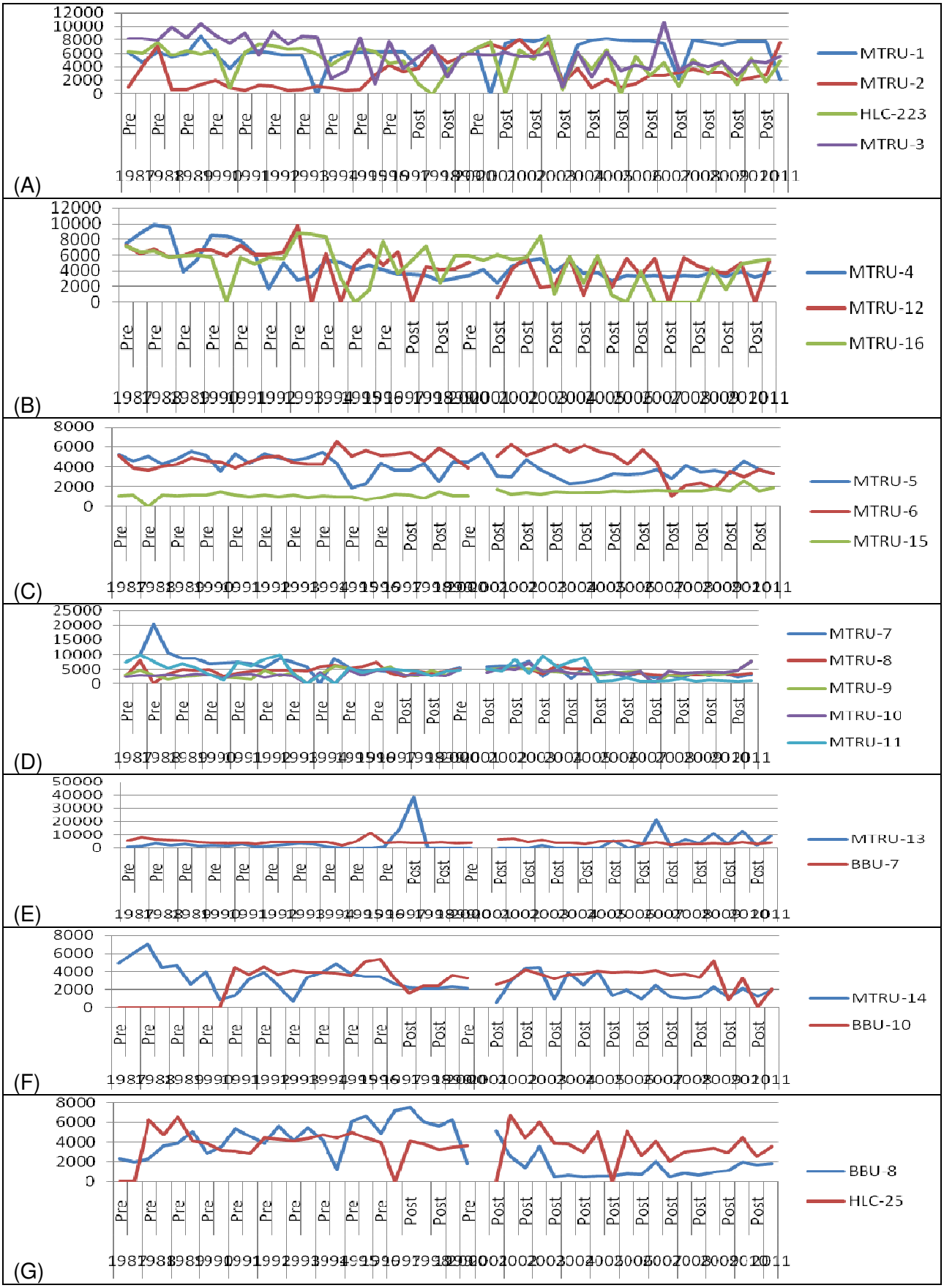


Fig 4.21 Village Wise Well Hydrograph Showing Fluctuations in TDS Concentrations around Muldwarka TR from Year 1987 to 2011 (A) Chhara (B) Pipli (C) Kodinar(D) (E) Muldwarka (F) Cho. Khan (G) Math (Source: SIPC 1987 to 2011)

Table 4.10: Pre and Post Monsoon Water Levels in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011)

VILLAGE		CHHARA				PIPALI		
WELL NO.		MTRU-1	MTRU-2	HLC-223	MTRU-3	MTRU-4	MTRU-12	MTRU-16
GLRL (M)		6.49	6.36	6.11	7.02	7.83	7.74	6.25
1987	Pre	2.09	1.26	1.61	1.02	-1.07	-4.36	1.05
	Post	1.89	0.96	1.01	1.02	-1.17	-5.66	0.55
1988	Pre	1.99	-1.15	0.62	-1.85	-4.8	-5.7	2.05
	Post	2.19	2.94	2.52	3.42	3.33	-1.26	3.65
1989	Pre	2.49	1.46	2.01	3.32	1.63	-2.76	2.55
	Post	2.24	1.36	1.67	2.42	2.08	1.69	2.5
1990	Pre	2.19	1.26	1.52	1.42	0.83	-0.56	1.75
	Post	3.29	4.16	4.02	4.2	4.43	3.64	-
1991	Pre	1.99	1.16	2.82	2.42	2.13	1.04	2.55
	Post	2.09	1.56	-1.59	3.62	2.63	-1.76	4.05
1992	Pre	2.09	1.39	1.17	2.02	1.43	-0.06	2.05
	Post	2.39	3.16	4.57	3.02	2.33	0.94	3.45
1993	Pre	2.29	1.36	1.62	3.42	0.13	-1.26	1.9
	Post	-	2.66	2.42	2.62	2.33	-	1.95
1994	Pre	0.14	1.36	1.15	1.82	-1.57	-1.26	0.9
	Post	4.29	4.36	1.7	4.62	5.33	-	4.25
1995	Pre	0.69	1.36	1.72	2.12	1.63	1.96	0.95
	Post	2.89	3.36	3.52	4.82	4.43	2.54	-
1996	Pre	1.69	1.56	1.52	2.62	2.43	1.14	1.85
1997	Pre	1.89	2.46	2.11	3.12	2.63	2.24	2.25
	Post	3.79	3.16	3.11	5.22	4.33	-	4.25
1998	Pre	1.69	2.26	-	2.22	0.83	-0.16	1.65
	Post	3.49	2.76	3.21	4.22	3.43	4.34	3.55
1999	Pre	1.79	2.16	2.21	3.22	0.63	0.14	2.35
2000	Pre	1.99	1.56	1.71	2.02	-1.57	0.74	1.75
2001	Pre	-	1.16	1.71	1.02	-2.17		1.25
	Post	2.49	2.06	-	2.72	1.33	2.64	4.8
2002	Pre	2.19	1.66	1.81	2.32	-1.47	1.74	1.25
	Post	2.69	1.96	3.31	0.02	-2.47	-3.56	-0.55
2003	Pre	1.99	1.56	2.11	-0.48	-7.77	-2.56	-0.25
	Post	3.99	3.76	3.91	4.82	3.43	4.54	3.85
2004	Pre	1.49	2.36	1.41	-2.98	-4.67	-4.46	-5.25
	Post	2.49	2.86	3.71	5.32	2.93	5.24	4.55
2005	Pre	1.99	1.06	2.61	1.02	1.33	3.24	0.05
	Post	2.59	3.26	4.51	5.32	4.83	6.34	5.35
2006	Pre	2.49	1.56	3.21	4.62	-0.37	-2.26	-
	Post	2.79	3.36	4.41	5.82	5.23	5.14	4.95
2007	Pre	1.49	1.16	2.81	0.78	-1.97	-2.46	-
	Post	2.99	3.96	4.91	5.92	4.93	-	-
2008	Pre	2.39	2.46	2.01	1.32	-0.27	0.94	-
	Post	2.89	3.36	4.11	3.82	4.13	1.74	-
2009	Pre	2.59	1.56	2.51	1.52	0.43	1.44	1.15
	Post	3.29	3.06	3.71	5.22	4.73	4.94	4.55
2010	Pre	2.19	1.66	-2.09	0.02	0.23	-2.46	0.55
	Post	3.49	5.06	4.41	5.32	5.03	-	4.75
2011	Pre	1.99	1.46	2.31	0.92	1.63	-1.76	0.35

Table 4.10: Pre and Post Monsoon Water Levels in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011) contd…

VILLAGE		KODINAR			PANADAR				
WELL NO.		MTRU-5	MTRU-6	MTRU-15	MTRU-7	MTRU-8	MTRU-9	MTRU-10	MTRU-11
GLRL (M)		8.99	11.3	9.62	10.01	7.11	7.49	6.46	7.64
1987	Pre	-11.21	-5.7	-6.08		-1.69	-2.11	-2.54	-0.56
	Post	-8.01	-6.3	-7.28		-2.39	-1.91	-4.14	-1.46
1988	Pre	-8.11	-5.2	-	-6.8	-	-2.21	-5.04	-3.05
	Post	0.69	1.5	0.52	2.41	2.31	3.09	1.46	3.24
1989	Pre	-1.31	-3.2	-7.18	-0.09	0.81	1.19	-3.14	1.64
	Post	1.54	1.45	2.27	2.16	2.11	2.04	1.06	3.29
1990	Pre	-5.51	5.1	6.28	-1.09	-0.09	0.29	-2.04	0.14
	Post	4.49	3.6	2.12	4.41	3.71	5.19	3.76	4.34
1991	Pre	-0.01	-0.77	-2.08	0.61	1.21	1.99	3.26	2.04
	Post	0.57	1.53	-1.18	3.31	3.41	3.79	3.06	3.64
1992	Pre	-1.41	-3.2	-4.88	-3.39	-0.09	-0.01	-4.54	0.34
	Post	3.1	3	2.82	2.01	1.81	3.09	2.26	4.34
1993	Pre	-0.71	-2.05	4.58	0.69	0.31	0.39	1.26	0.94
	Post	-0.14	-2.4	-6.28	-0.79	0.61	-	-	-
1994	Pre	-2.81	-1.1	-2.88	-	-1.79	0.99	-0.64	1.64
	Post	4.19	3.3	3.52	4.31	4.11	1.49	-	-
1995	Pre	0.71	-1	-5.98	0.31	0.91	0.69	0.86	0.14
	Post	1.79	3.3	0.12	4.81	2.11	2.29	2.66	0.94
1996	Pre	-1.21	-1.7	-5.78	-0.09	0.71	2.99	2.06	0.54
1997	Pre	1.59	0.9	-3.08	1.31	2.51	2.49	1.56	3.04
	Post	4.39	5	0.42	5.01	3.91	5.49	4.56	3.74
1998	Pre	-0.31	-0.3	-5.78	-0.29	0.11	3.49	2.66	0.64
	Post	4.09	6.3	0.62	4.81	4.31	4.49	3.26	1.04
1999	Pre	0.29	-0.7	-3.18	-60	0.91	3.69	2.46	0.74
2000	Pre	-5.21	-6.6	-8.78	-2.79	-1.69	0.69	-0.44	-0.96
2001	Pre	-5.01							
	Post	0.29	2.3	9.2	2.81	2.41	4.19	2.96	3.64
2002	Pre	-1.81	0.2	-6.38	-0.19	-1.09	1.49	-0.04	-0.16
	Post	-4.01	-4.8	-6.98	-	-3.19	-1.31	-2.04	-
2003	Pre	-7.91	-5.7	-8.38	-	-1.89	-0.71	-2.44	-0.56
	Post	4.99	4.1	0.02	4.9	4.41	5.69	4.46	5.24
2004	Pre	-1.01	-1.7	-4.38	0	1.61	0.49	-3.54	BH
	Post	4.19	4.6	0.62	5.3	2.41	4.69	4.26	3.84
2005	Pre	1.29	-1.5	-5.18	1.6	2.01	3.49	1.96	2.14
	Post	5.49	7	2.92	7.2	5.91	6.09	5.46	6.34
2006	Pre	1.19	3.2	-2.28	1.8	2.71	4.09	0.86	3.44
	Post	5.99	7.3	2.62	7	5.71	4.49	3.66	6.04
2007	Pre	-0.81	2.3	-1.38	0.9	0.91	3.09	-0.74	3.14
	Post	6.89	9	4.22	8	6.31	-	-	6.64
2008	Pre	1.89	4.3	0.62	4.1	3.01	4.99	4.16	3.34
	Post	4.39	6.3	5.12	5.6	4.31	5.79	5.26	4.24
2009	Pre	0.59	2.3	0.12	1.8	1.51	1.79	0.66	5.34
	Post	4.99	7	3.12	6.2	5.31	5.49	5.26	3.74
2010	Pre	-0.31	0.3	-3.48	0.91	1.01	2.09	0.16	5.041
	Post	6.89	7.3	5.62	6.91	6.01	6.39	5.26	6.44
2011	Pre	2.39	3.8	-0.18	1.01	2.91	0.69	0.06	3.14

Table 4.10: Pre and Post Monsoon Water Levels in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011) contd…

VILLAGE		MULDWARKA		CHO.KHAN		MATH	
WELL NO.		MTRU-13	BBU-7	MTRU-14	BBU-10	BBU-8	HLC-25
G.L.R.L (M)		3.18	4.02	4.61	5.91	3.19	4.01
1987	Pre	0.38	-0.38	-0.39	-	0.39	-
	Post	-0.42	-1.18	-2.19	-	-0.81	-
1988	Pre	-0.52	-0.68	-0.89	-	-1.01	-0.69
	Post	0.88	1.22	1.61	-	-0.11	2.01
1989	Pre	0.78	0.32	0.41	-	0.69	0.3
	Post	0.58	1.12	2.11	-	0.19	1.1
1990	Pre	1.01	-0.08	-3.49	-	-0.31	-0.09
	Post	1.98	1.82	2.41	-	1.49	1.81
1991	Pre	-0.82	0.62	1.91	-4.99	0.55	0.12
	Post	0.98	1.82	-2.41	-1.49	-5.95	1.81
1992	Pre	0.68	0.02	0.11	-6.49	0.15	0.01
	Post	1.18	1.92	3.01	-0.09	1.19	2.05
1993	Pre	-1.51	0.27	-	-	0.39	0.27
	Post	0.58	0.67	-0.91	-5.34	0.39	0.66
1994	Pre	1.08	-0.58	-1.79	-6.09	0.19	-0.59
	Post	-	2.22	3.41	-1	1.89	1.31
1995	Pre	-	0.22	0.41	1.16	0.39	0.22
	Post	-	1.72	3.01	0.11	1.09	1.71
1996	Pre	0.18	1.42	-0.59	-5.09	0.29	1.41
1997	Pre	-1.52	0.52	0.71	-3.19	1.09	-
	Post	0.58	1.82	3.11	1.41	2.2	1.81
1998	Pre	-	0.02	0.16	-2.19	0.19	0.01
	Post	-	1.32	1.61	-1.89	6.79	1.31
1999	Pre	-	-1.08	-0.19	-3.69	0.49	-1.09
2000	Pre	-	-0.88	-0.59	-10.29	0.19	-0.89
2001	Pre						
	Post	-	2.02	2.9	-4.79	0.69	-
2002	Pre	-	-1.18	-4.89	-10.49	0.19	-1.18
	Post	-	-1.08	-0.39	-10.09	0.19	-1.09
2003	Pre	-3.82	-0.98	-12.39	-11.09	0.19	-1.09
	Post	-	1.72	2.11	-1.89	2.19	1.71
2004	Pre	-	0.02	0.31	-8.59	-0.11	0.01
	Post	-	1.72	2.21	-0.39	1.19	1.71
2005	Pre	-	-0.68	-2.39	-5.69	1.19	-0.69
	Post	-0.32	0.68	2.81	3.21	1.59	2.31
2006	Pre	-	0.02	1.1	-2.39	0.69	0.01
	Post	1.18	2.42	3.41	3.61	0.79	2.41
2007	Pre	-1.12	-0.08	0.51	-2.06	0.79	-0.09
	Post	-0.32	1.32	1.81	3.91	1.09	1.31
2008	Pre	-30.52	0.52	0.61	-2.09	1.09	0.51
	Post	0.68	1.32	2.31	-0.19	1.49	1.31
2009	Pre	-0.82	-0.88	-0.39	-2.29	0.79	-0.89
	Post	-0.12	1.72	2.21	3.11	1.39	1.71
2010	Pre	-0.82	-0.09	0.11	-0.08	2.41	0.49
	Post	0.18	2.22	2.91	3.41	2.09	2.21
2011	Pre	-1.12	-0.28	-0.19	1.1	0.59	-0.29

Table 4.11: Pre and Post Monsoon Total Dissolved Solids Concentration in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011)

VILLAGE		CHHARA				PIPALI		
WELL NO.		MTRU-1	MTRU-2	HLC-223	MTRU-3	MTRU-4	MTRU-12	MTRU-16
1987	Pre	6152	1082	6290	8154	7513	7222	7164
	Post	4570	4113	6071	8225	8813	6169	6430
1988	Pre	6272	7200	7680	8000	9920	6720	6560
	Post	5427	746	5720	9837	9498	5699	5699
1989	Pre	5896	752	6398	8272	3880	5956	6016
	Post	8525	1492	5970	10308	5471	6571	6074
1990	Pre	5836	1985	6618	8723	8577	6618	5715
	Post	3809	952	1014	7440	8482	5896	-
1991	Pre	6016	602	6266	9024	7918	7219	5775
	Post	6451	1290	7370	5830	6144	6052	4915
1992	Pre	5981	1168	7134	9256	1709	5981	5696
	Post	5632	640	6698	7360	4960	6400	5620
1993	Pre	5696	741	6835	8544	2793	9696	8829
	Post	-	1173	6016	8422	3249	-	8723
1994	Pre	5376	952	4272	2294	5284	6144	8294
	Post	6209	656	5679	3418	5127	-	3069
1995	Pre	6125	752	6835	8352	4176	4844	-
	Post	6317	2828	6317	1534	4753	6618	1504
1996	Pre	6232	4310	4557	7746	4135	4717	7746
1997	Pre	6238	3333	4916	3750	3571	6392	3690
	Post	3767	3773	1514	5412	3571	-	5373
1998	Pre	6547	6547	-	7142	3452	4464	7142
	Post	3395	4593	3395	2529	2662	4193	2529
1999	Pre	5416	5476	5654	5952	3095	4226	5952
2000	Pre	6738	6798	6858	5956	3429	5114	5956
2001	Pre	-	7440	7738	5714	4166		5357
	Post	7464	6711	-	6147	2446	558	6084
2002	Pre	8037	8095	6581	5591	4601	4252	5475
	Post	7703	6071	5143	5614	5222	5745	5679
2003	Pre	8463	7628	8601	6180	5624	1949	8519
	Post	1501	1501	737	1044	3917	2154	1044
2004	Pre	7219	3850	6071	6136	5234	5655	5836
	Post	7903	1004	3727	2446	3638	1004	2446
2005	Pre	8122	2106	6607	6136	3730	5535	6016
	Post	7987	1132	-	3395	2729	1864	932
2006	Pre	7821	1504	5654	4271	3369	5595	-
	Post	7840	2697	2767	3700	3261	3387	3889
2007	Pre	7461	2728	4647	10579	3452	5568	-
	Post	2263	3261	1198	3461	3128	-	-
2008	Pre	7974	3645	5126	4614	3418	5696	-
	Post	7521	3261	2944	4060	3328	4622	-
2009	Pre	7219	3249	4873	4753	3730	3971	4453
	Post	7744	2048	1408	2752	3328	3648	1664
2010	Pre	7706	2422	5229	4844	3853	5009	4899
	Post	7680	2816	1764	4608	3136	-	5248
2011	Pre	2097	7571	4881	5533	3786	5242	5533

Table 4.11: Pre and Post Monsoon Total Dissolved Solids Concentration in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011) Contd…

VILLAGE		KODINAR			PANADAR				
WELL NO.		MTRU-5	MTRU-6	MTRU-15	MTRU-7	MTRU-8	MTRU-9	MTRU-10	MTRU-11
1987	Pre	5183	5126	1082		2620	3076	2421	7338
	Post	4570	3852	1175	9923	7834	4700	2840	9727
1988	Pre	5056	3648	-	20480	-	3008	2624	7680
	Post	4274	4003	1153	10515	3528	1560	3188	5427
1989	Pre	4783	4211	1083	8573	4813	2351	2707	6768
	Post	5506	4889	1208	8720	4653	2616	3410	5683
1990	Pre	5144	4602	1173	6918	4873	3128	3219	3279
	Post	3541	4494	1514	7142	2678	2136	2076	1203
1991	Pre	5294	3850	1173	7520	3790	1985	3309	7219
	Post	4332	4515	983	6912	4300	1536	3440	6052
1992	Pre	5297	4956	1139	5696	4557	4671	2164	8402
	Post	4864	5056	1056	8640	4768	2800	3200	9760
1993	Pre	4671	4414	1168	7405	4614	3816	2677	3756
	Post	4873	4271	963	6016	4362	-	-	-
1994	Pre	5407	4209	1075	-	5837	3256	3901	3195
	Post	4325	6557	1046	8720	6418	6209	-	-
1995	Pre	1865	5011	1002	5568	5457	5401	4900	5568
	Post	2286	5595	692	4392	5896	3068	3008	3790
1996	Pre	4310	5125	932	4717	7417	4659	4601	4892
1997	Pre	3643	5214	1262	4178	3672	5970	5027	5113
	Post	3597	5431	1149	2468	2546	3009	2892	4583
1998	Pre	4345	4583	893	3809	4464	2797	2857	4285
	Post	2529	5857	1464	2862	3794	4593	2929	2729
1999	Pre	4464	4940	1071	4404	4326	2857	2797	4404
2000	Pre	4512	3850	1083	5595	5174	5234	5174	4753
2001	Pre	5357							
	Post	3073	5018	1693	5988	4829	4829	4014	5206
2002	Pre	2970	6232	1281	6232	5009	5475	5533	4310
	Post	4700	5092	1436	6267	5418	5288	4961	8291
2003	Pre	3675	5624	1281	7684	5178	5067	7127	3731
	Post	2938	6202	1501	2546	3525	4308	4243	9596
2004	Pre	2286	5414	1444	6257	6317	4151	4753	5918
	Post	2446	6147	1443	1819	5206	3700	3763	7652
2005	Pre	2767	5535	1444	5655	5114	3610	3489	8904
	Post	3328	5192	1597	2929	3661	3261	3787	799
2006	Pre	3249	4211	1504	3730	3670	3730	4091	902
	Post	3261	5645	1568	2258	3324	4077	3387	1944
2007	Pre	3675	4399	1670	4176	3675	4454	4454	780
	Post	2796	1065	1531	1864	3191	-	-	732
2008	Pre	4101	2108	1595	3076	3019	3019	4500	968
	Post	3461	2330	1536	1997	3128	2729	3776	1728
2009	Pre	3610	1805	1805	3670	3249	3910	3971	722
	Post	3328	3520	1536	2688	3264	2880	4160	1152
2010	Pre	4568	2972	2587	3743	3523	3412	3853	936
	Post	3648	3712	1536	2304	3264	4608	4608	768
2011	Pre	3320	3320	1864	3320	3727	7571	7629	903

Table 4.11: Pre and Post Monsoon Total Dissolved Solids Concentration in Observations Wells of Muldwarka TR (Source: SIPC, 1987-2011) Contd…

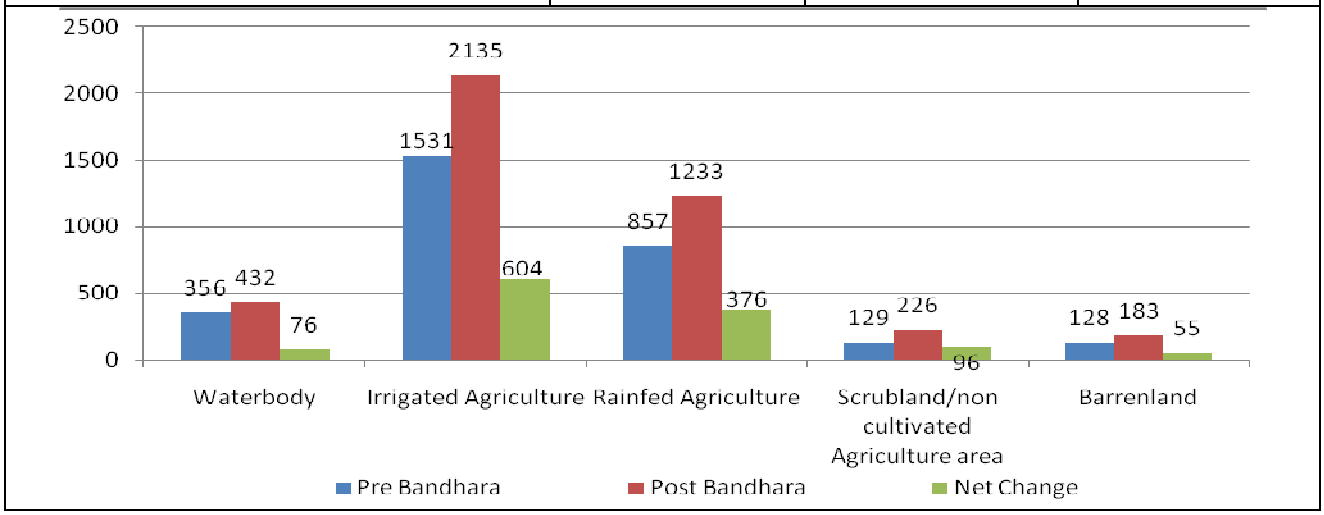
VILLAGE		MULDWARKA		CHO.KHAN		MATH	
WELL NO.		MTRU-13	BBU-7	MTRU-14	BBU-10	BBU-8	HLC-25
1987	Pre	854	5411	4899	-	2250	-
	Post	1632	7834	6006	-	1926	-
1988	Pre	3648	6272	7040	-	2304	6208
	Post	1764	5563	4410	-	3596	4736
1989	Pre	2856	5114	4632	-	3880	6547
	Post	1243	4227	2546	-	5079	4138
1990	Pre	1745	3790	3910	-	2858	3850
	Post	1474	3452	842	-	3541	3188
1991	Pre	3062	3549	1324	4452	5414	3047
	Post	922	2949	3072	3625	4608	2857
1992	Pre	1595	4500	3873	4529	3873	4426
	Post	2336	4032	2464	3648	5632	4252
1993	Pre	3304	4244	684	4101	4124	4124
	Post	3008	4271	3303	3850	5475	4345
1994	Pre	1044	4485	3840	3840	4175	4717
	Post	-	1744	4813	3804	1221	4439
1995	Pre	-	4956	3675	3564	6125	4956
	Post	-	11280	3369	5076	6721	4392
1996	Pre	874	3902	3378	5369	4950	3987
1997	Pre	14225	4143	2619	3202	7273	-
	Post	38385	3949	2167	1671	7566	4100
1998	Pre	-	3512	2083	2381	6071	3786
	Post	-	4060	2130	2330	5658	3261
1999	Pre	-	3393	2262	3571	6250	3452
2000	Pre	-	3610	2106	3249	1745	3610
2001	Pre						
	Post	-	6272	521	2509	5143	-
2002	Pre	-	6814	2854	2970	2504	6721
	Post	-	4374	4308	4178	1371	4390
2003	Pre	2060	5846	4454	3731	3564	5981
	Post	-	3786	914	3133	457	3840
2004	Pre	-	3790	3850	3670	541	3786
	Post	-	2885	2446	3700	452	2995
2005	Pre	-	4933	4031	4031	487	5059
	Post	5258	4933	1331	3860	470	-
2006	Pre	-	5114	1925	3971	722	5178
	Post	2446	2697	941	3889	690	2647
2007	Pre	21158	4120	2394	4120	2004	4120
	Post	1664	1997	1132	3528	419	2024
2008	Pre	6380	2905	1025	3702	854	3019
	Post	3200	2995	1152	3328	552	3136
2009	Pre	10949	3249	2286	5114	902	3436
	Post	2944	2938	1088	868	1044	2944
2010	Pre	12659	4247	2147	3226	1935	4403
	Post	2176	2560	1216	66	1600	2529
2011	Pre	8736	3669	1980	2028	1747	3532

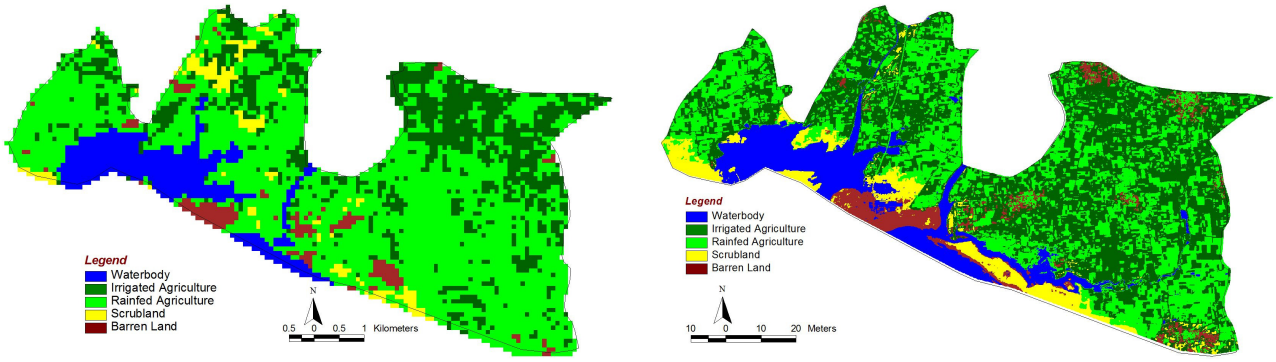
4.3.4 LANDUSE

Landuse pattern around muldwarka Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1988 Pre TR construction and 2013 post TR construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 4.12) Figure 4.22 shows analysis of changes in landuse pattern during pre and post construction of tidal regulator the results clearly shows about 604 Ha and 376 Ha areas have increased from irrigation and rainfed agriculture use point of view. In case of scrubland about 96 Ha area has some vegetation which may be dry before construction.

Table 4.12 Landuse Pattern around Muldwarka TR

Land use	Changes in Land use Area (Ha)		
	Pre TR	Post TR	Net Changes
Water body	356	432	76
Irrigated Agriculture	1531	2135	604
Rain fed Agriculture	857	1233	376
Scrubland/non cultivated Agriculture	129	226	96
Barren land	128	183	55
Total	**3605**	**3605**	0





Pre Construction

Post Construction

Source: NRSA LISS – III images (1988 and 2013)

Fig. 4.22 Pre and Post Construction Changes in Landuse Pattern around Muldwarka TR Area

4.4 VADODARA ZALA TIDAL REGULATOR

4.4.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephones, vehicle and toilet seem to be the predominant assets acquired, with 75 per cent of total families surveyed reporting acquisition of these assets post construction of the Vadodara Zala TR as can be seen from Fig. 4.19.

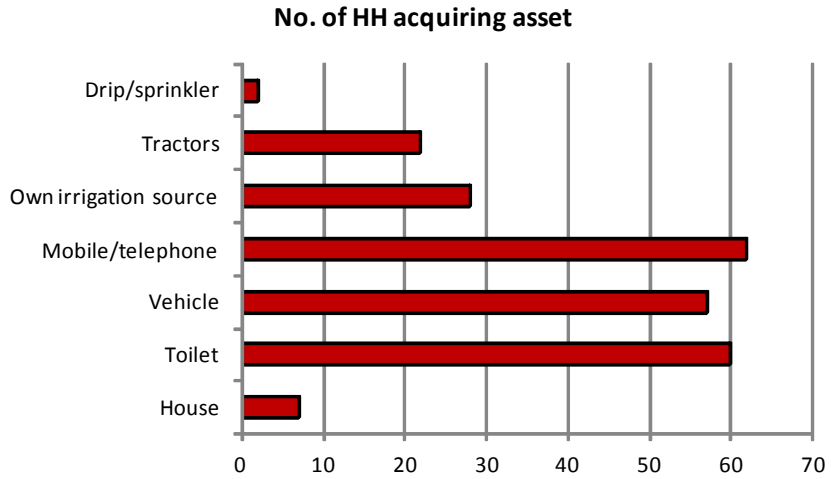


Fig. 4.23: Impact on assets in Vadodara Zala

As in the case of other schemes in Junagadh district, selling milk is the predominant source of additional income after the construction of the tidal regulator with 36 per cent of the surveyed households reporting income from this source (Fig. 4.24 A). This is followed by activities like business and selling milk which have been reported by approximately 17 per cent households each.

While the additional income generated has been invested by most households on purposes like getting a toilet or tap connection in their house, children's education and house renovation, a significant number of households (40) has also used it for buying jewellery (Fig. 4.24 B).

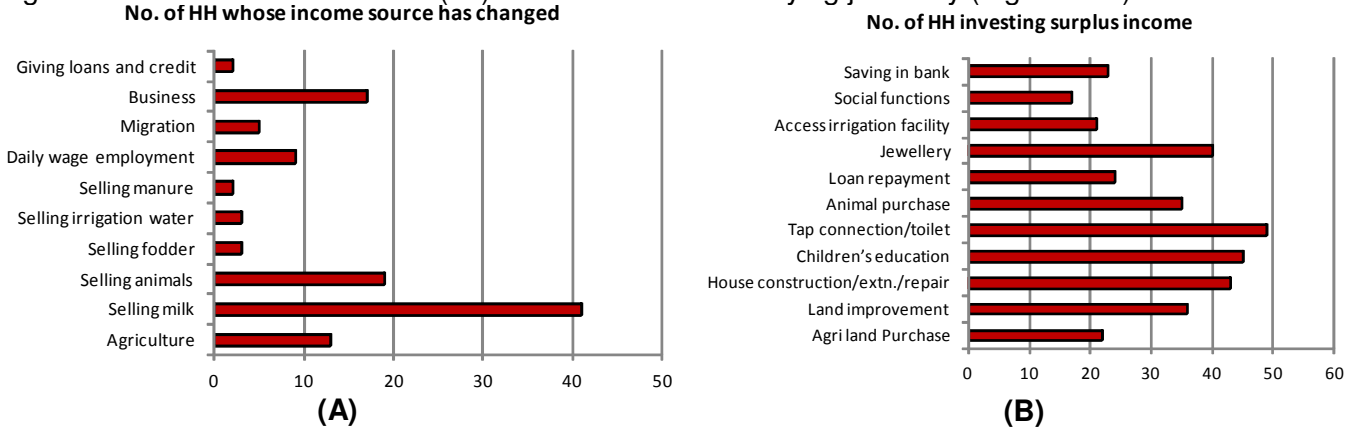


Fig 4.24 Impact on Income Source (A) and Investment of Surplus Income (B) in Vadodara Zala

4.4.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Green fodder availability due to improved agriculture has shown a moderate increase of 22 per cent even as dry fodder availability has risen by a more robust 36 per cent in villages benefitting from the Vadodara Zala TR (Table 4.13).

Table 4.13: Impact on fodder availability due to agriculture, Muldwarka TR

Impact	Quantity
Increase in Green Fodder (%)	22
Increase in Dry Fodder (%)	36
Increase in Cow dung (%)	0

Better fodder availability has had a positive impact on milch animals and milk production in villages affected by the Vadodara Zala TR. Whereas the number of cows and buffaloes has gone up by around 35 per cent, milk production from cows and buffaloes has increased by 67 per cent and 57 per cent respectively post the scheme. Also, improved agriculture has led to a nearly 50 per cent rise in bullocks. (Fig. 4.25)

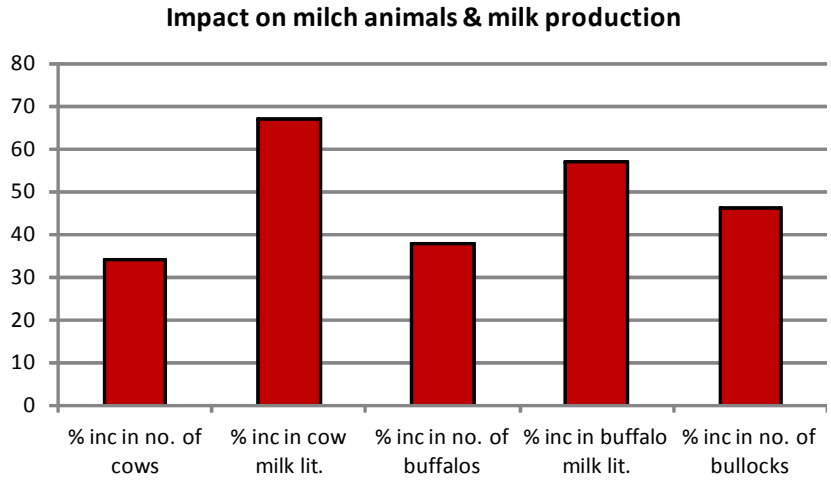


Fig. 4.25 Impact on Milch Animals and Milk Production in Vadodara Zala

4.4.3 GROUNDWATER AVAILABILITY AND QUALITY

Plate 4.2 Submergence Areas of Vadodara Zala Tidal Regulator

Vadodara Zala is one of the schemes where the impact on groundwater table has been quite marked. As can be seen from Fig. 4.26 A, a majority (57 per cent) of the surveyed households have reported water levels either increasing by upto 25 feet, between 25-50 feet or more than 50 feet post construction of the tidal regulator.

Sweet water availability has also shown a significant improvement. From a very small percentage of families receiving sweet water before the scheme, 60 per cent of the sampled families started receiving sweet water after the scheme. This change has been accompanied by a corresponding decline in the number of families getting salty and medium quality water as can be seen from Fig. 4.26B.

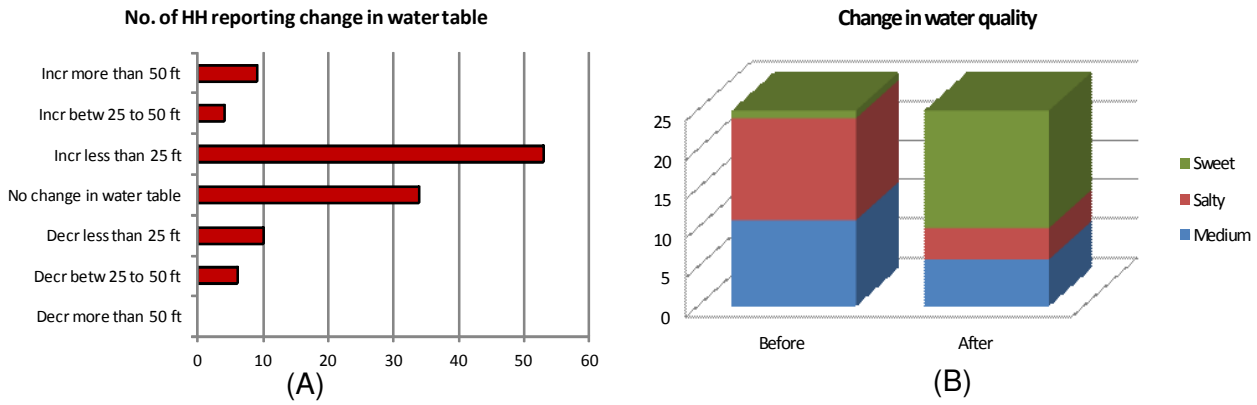


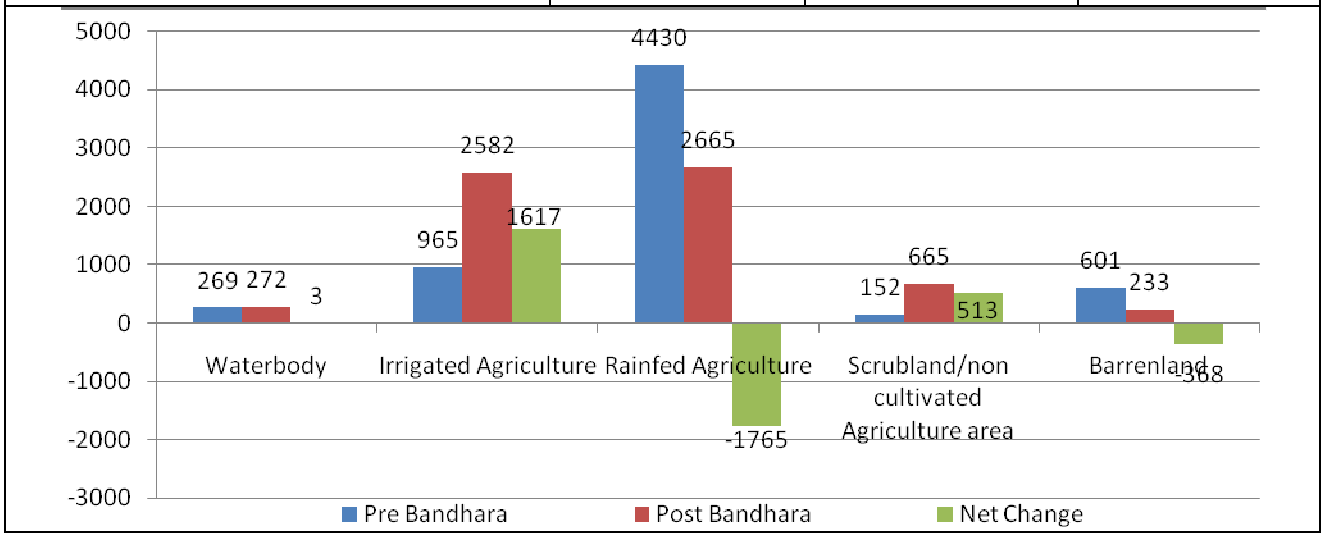
Fig. 4. 26 Change in water table (A) and Change in water quality (B) in Vadodara Zala

4.4.4 LANDUSE

Landuse pattern around vadodara zala Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1988 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 4.14)

Table 4.14 Landuse Pattern around Vadodara Zala Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	269	272	3
Irrigated Agriculture	965	2582	1617
Rain fed Agriculture	4430	2665	-1765
Scrubland/non cultivated Agriculture area	152	665	513
Barren land	601	233	-368
Total	**6417**	**6417**	0



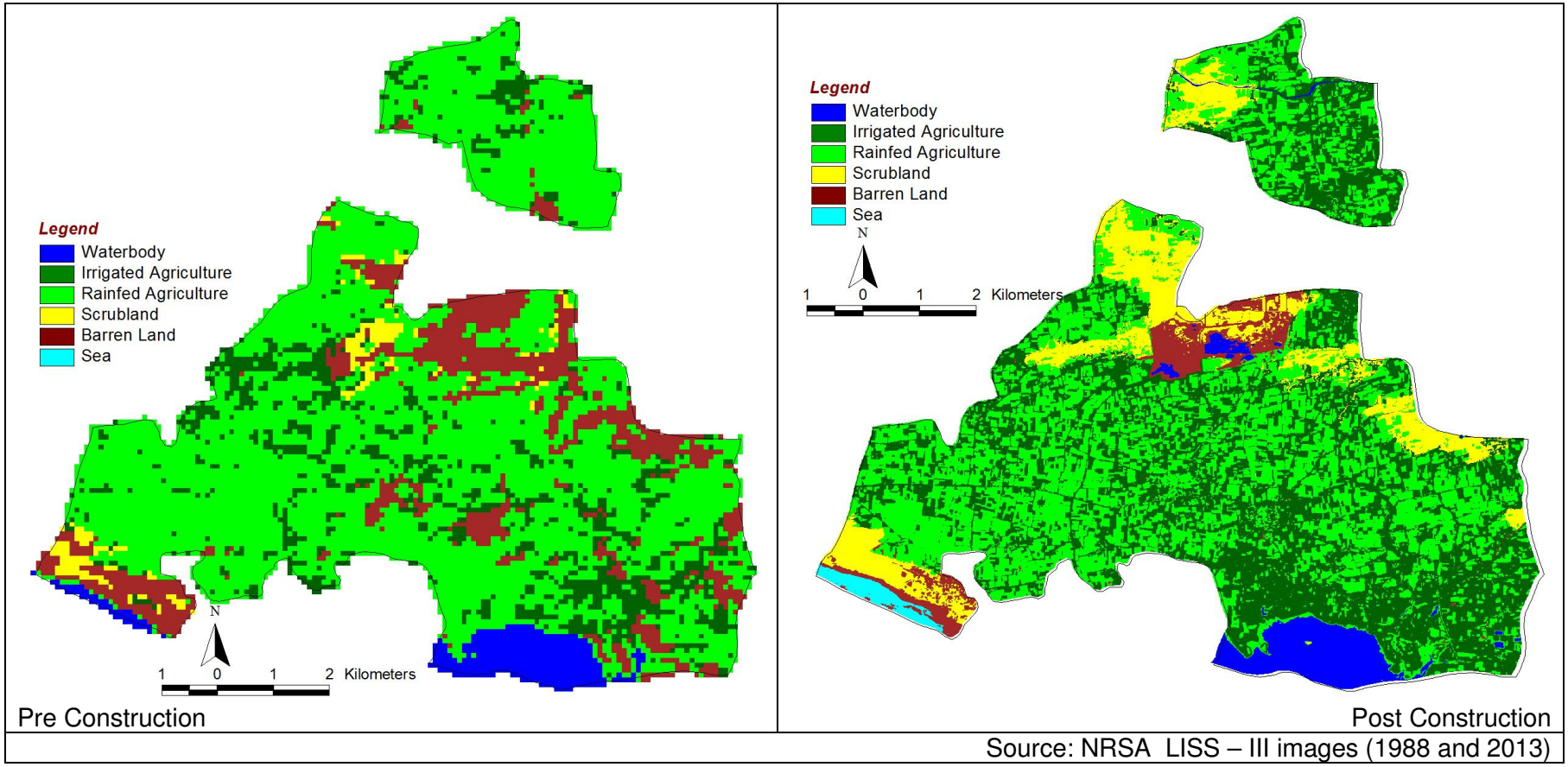


Fig. 4.27 Landuse Pattern around Vadodara Zala Bandhara Area

4.5 SOMNATH TIDAL REGULATOR

4.5.1 ASSETS, INCOME AND INVESTMENTS

Toilet, vehicle and tractors are some of the main assets acquired with 29 per cent, 28 per cent and 21 per cent of the surveyed households respectively reporting their acquisition post the construction of the Somnath scheme as shown by Fig. 4.28.

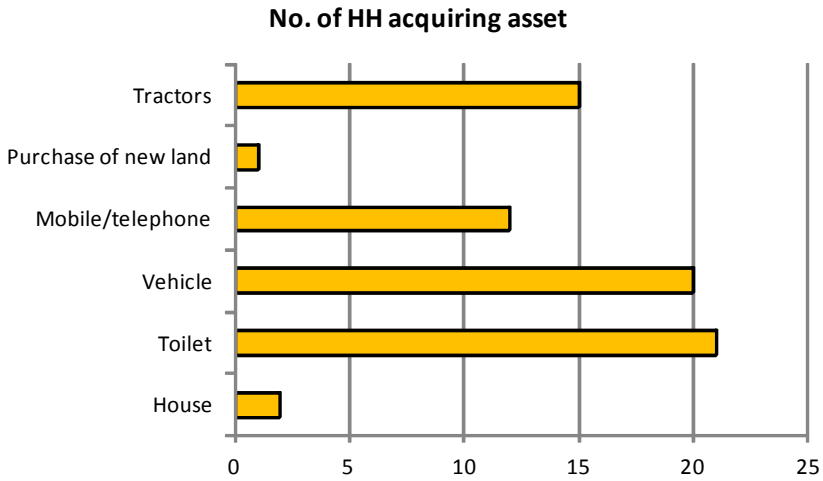


Fig. 4.28 Impact on Assets in Somnath

Selling of milk continues to be the predominant source of additional income after the scheme with 48 per cent of the surveyed households reporting income from this source (Fig. 4.29 A). Interestingly, selling of irrigation water has been reported by households as a source of income in Somnath followed by income from business.

The additional income generated has been invested by most households on getting a toilet or tap connection in their house. Other kinds of investments include purchase of animals, house renovation and land improvement (Fig. 4.29 B).

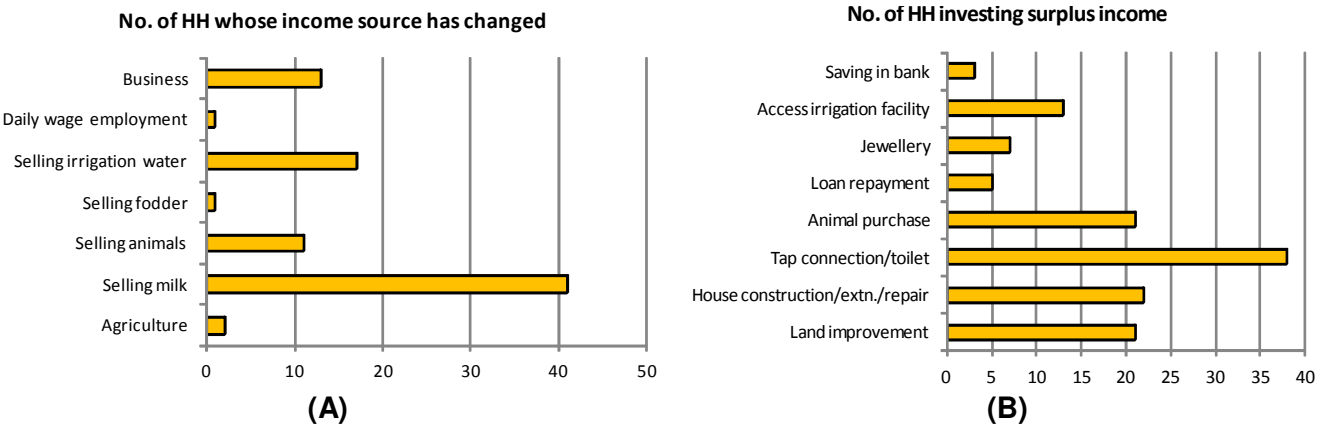


Fig 4.29 Impact on Income Source (A) and Investment of Surplus Income in Somnath

4.5.2 FODDER, LIVESTOCK AND MILK PRODUCTION

The situation of fodder availability in villages under Somnath bandhara has not shown much change as can be seen from Table 4.15.

Table 4.15: Impact on fodder availability due to agriculture, Somnath TR

Impact	Quantity
Increase in Green Fodder (%)	9
Increase in Dry Fodder (%)	10
Increase in Cow dung (%)	0

Despite limited improvement in fodder availability, many households seem to have opted for animal husbandry as an occupation which is indicated by the significant increase in milch animals and milk productivity (Fig. 4.26). Whereas the number of cows and buffaloes has gone up by 57 per cent and 43 per cent respectively, milk production from cows and buffaloes has increased by 33 per cent and 27 per cent respectively post the scheme.

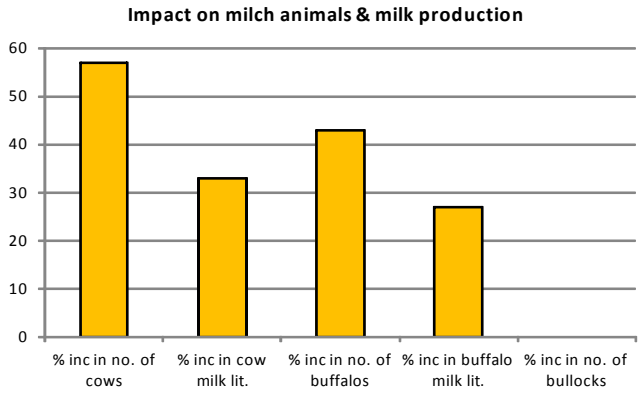
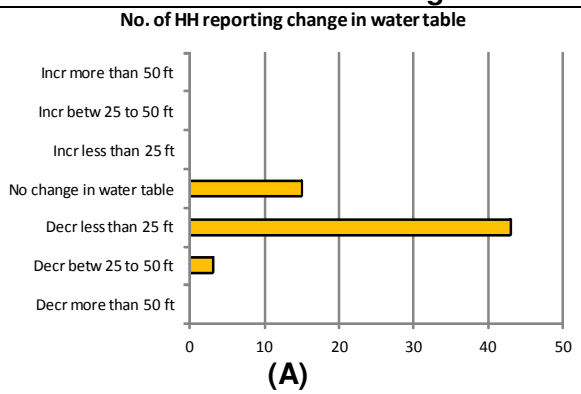


Fig 4.30 Impact on milch animals and milk production in Somnath

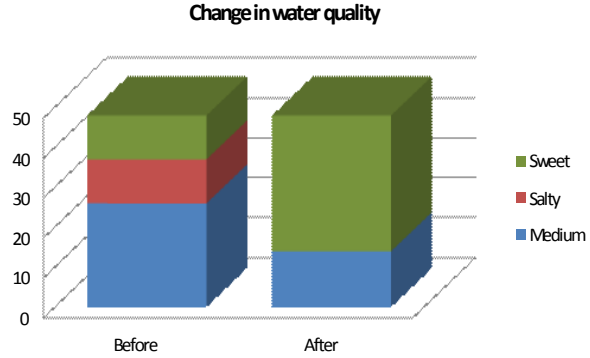
4.5.3 GROUNDWATER AVAILABILITY AND QUALITY

Plate No. 4.3 Field Photograph of D/S of Waste Weir of Somanath Tidal Regulator

The Somnath scheme has had a limited impact on the local water table with most of the surveyed households either reporting groundwater levels declining by upto 25 feet or no change in the water levels post the scheme as seen from Fig. 4.31 A. As far as impact of the scheme on water quality is concerned, the incidence of salty water has completely diminished post the scheme and the number of families getting medium quality water has almost halved. Moreover, there has been a more than three-fold increase in the number of households getting access to sweet water (Fig. 4.31 B).



(A)



(B)

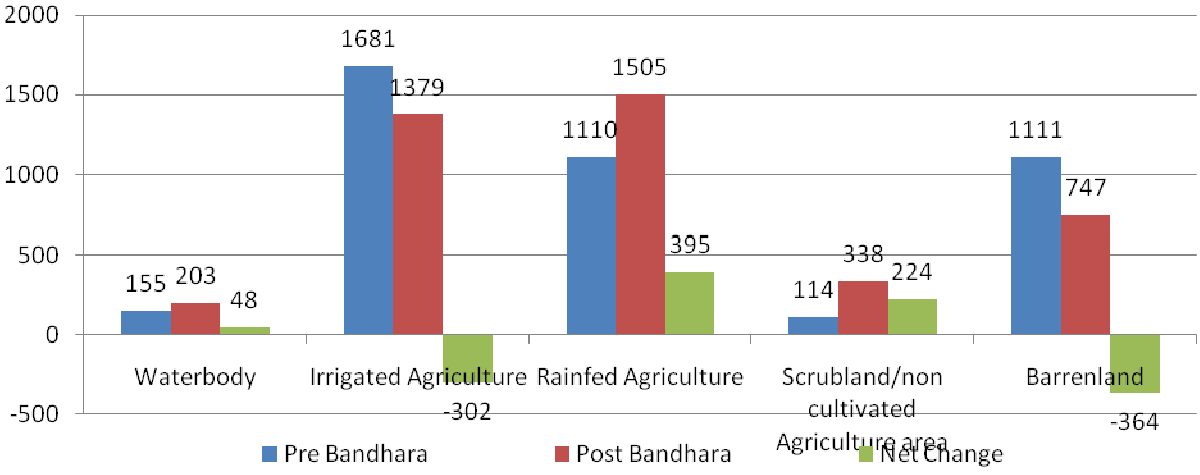
Fig 4.31 People's View on Change in Water Table (A) and Change in Water Quality in Somnath

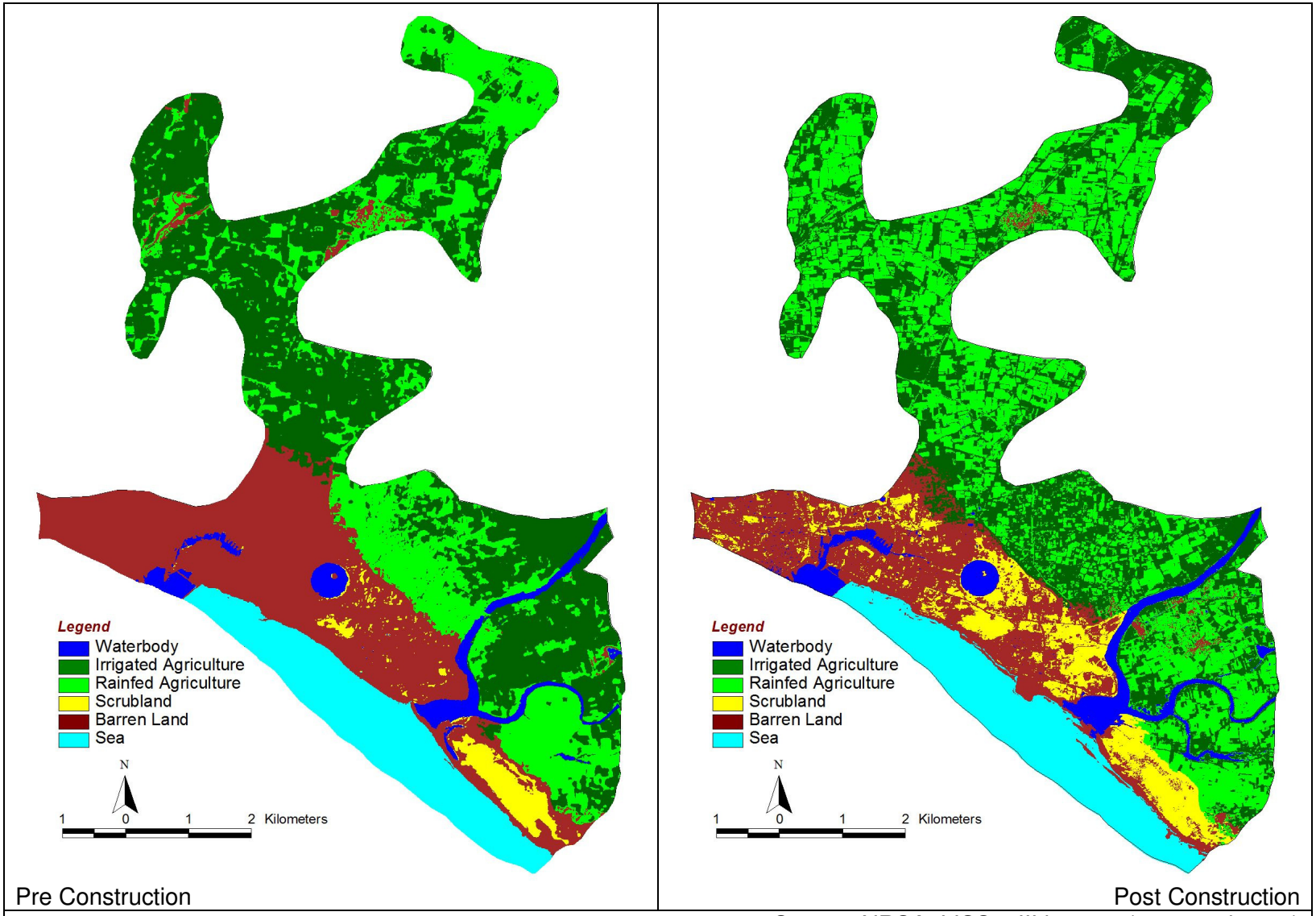
4.5.4 LANDUSE

Land use pattern around Somnath Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 2008 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 4.16)

Table 4.16 Landuse Pattern around Somnath Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	155	203	48
Irrigated Agriculture	1681	1379	-302
Rain fed Agriculture	1110	1505	395
Scrubland/non cultivated Agriculture area	114	338	224
Barren land	1111	747	-364
Total	**4171**	**4171**	0





Source: NRSA LISS – III images (2008 and 2013)

Fig. 4.32 Land use Pattern around Somnath Bandhara Area

4.6 SHEEL BANDHARA

4.6.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephone and vehicle ownership post the scheme have been reported by 35 per cent and 30 per cent households respectively in villages which have been benefitted by the Sheel bandhara. About 20 per cent of the respondent households have also mentioned undertaking toilet construction after the scheme (Fig. 4.33).

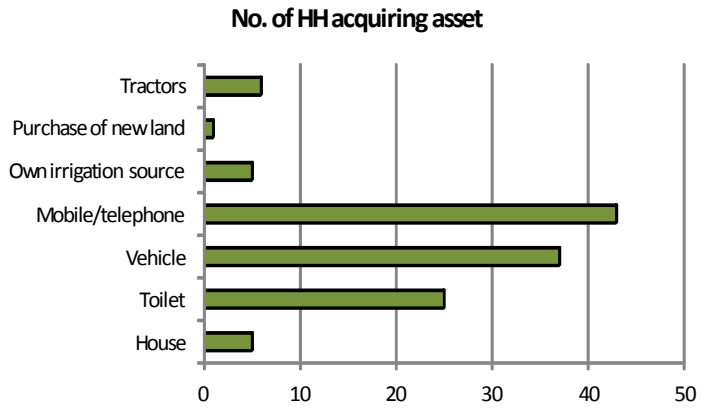


Fig 4.33 Impact on assets in Sheel

Selling of milk continues to be the predominant source of additional income after the scheme with nearly 60 per cent of the surveyed households reporting income from this source (Fig. 4.34 A). The additional income generated has been utilised for a wide variety of purposes which include land improvement, children's education and toilet/tap connection (by about 15 per cent of households each), followed by savings in bank. Interestingly, a few households have also been able to use this surplus income to pay off existing loans, a practice not seen in many other schemes of Junagadh (Fig. 4.34 B).

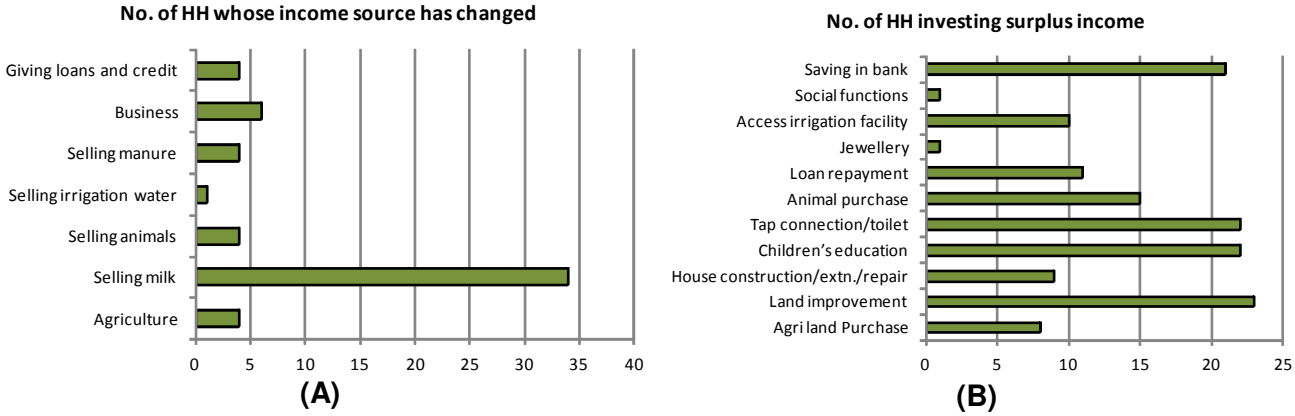


Fig 4.34 Impact on Income Source (A) and Investment of Surplus Income in Sheel

4.6.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 4.17: Impact on fodder availability due to agriculture, Sheel TR

Impact	Quantity
Increase in Green Fodder (%)	11
Increase in Dry Fodder (%)	10
Increase in Cow dung (%)	0

The situation of fodder availability in villages under Sheel bandhara has not shown much change as can be seen from Table 4.17. However, despite limited improvement in fodder availability, there has been a good increase (34 per cent) in population of cows and an even greater increase (74 per cent) in

the number of buffaloes. This has had a consequent effect on milk production as well where milk production from cows and buffaloes has increased by 41 per cent and 65 per cent respectively post the scheme. Due to better agriculture, there has also been a dramatic 67 per cent increase in the number of bullocks.

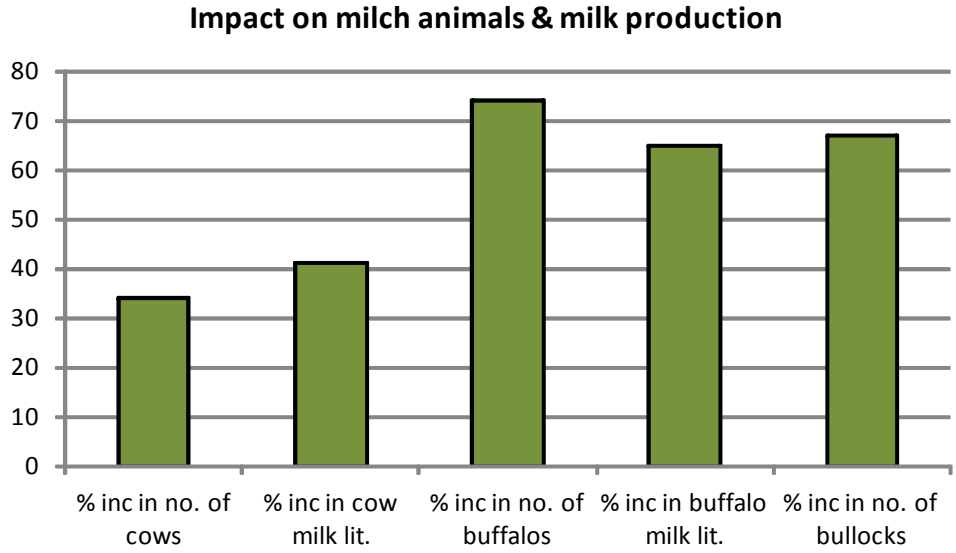
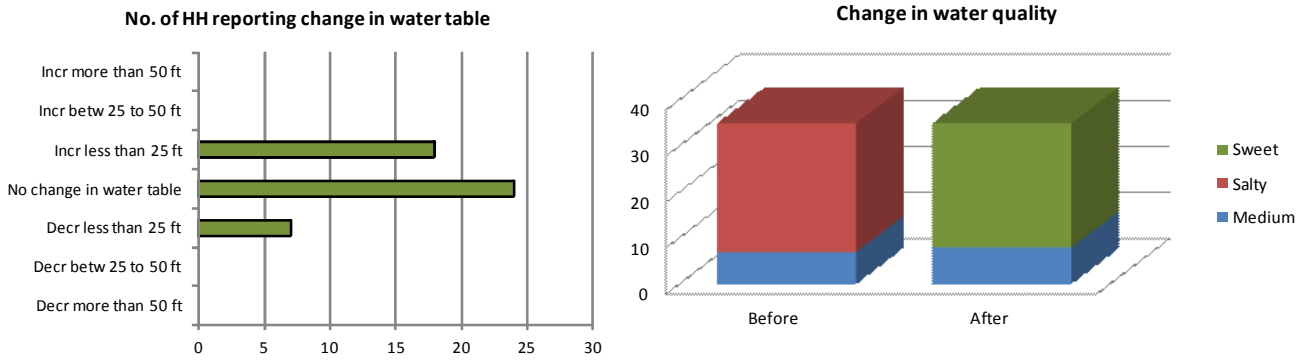


Fig. 4.35 Impact on milch animals and milk production in Sheel

4.6.3 GROUNDWATER AVAILABILITY AND QUALITY

Impact of Sheel bandhara on groundwater table and quality have been assessed with two methods such as (01) from people's point of view and (02) monitored data by SIPC. Even though no change in water table has been reported by nearly half of the surveyed households, about 37 per cent of the families have experienced rise in water table by upto 25 feet post the construction of the Sheel bandhara.



(A) **(B)**

Fig. 4.36 People's Point of View on Changes in Groundwater Table (A) and Quality (B) in Sheel Bandhara

As far as water quality is concerned, the number of households getting medium quality water has remained largely unchanged pre and post the bandhara. However, all the families receiving salty water before are now able to get sweet water, which has been the most notable impact of the bandhara (Fig. 4.36).

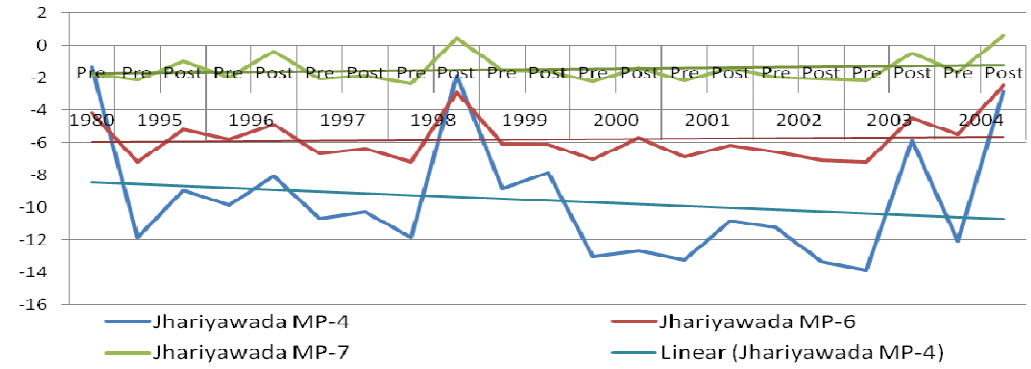
Construction of Sheel Bandhara has completed in year 1987. SIPC has monitored about seven wells in surrounding villages such as Jhariyawada (3 wells) and Sheell (4 wells) of bandhara since 1980. The present analysis of water table and groundwater quality changes has been held for pre

and post monsoon seasons of selected years 1995 to 2004 only since non availability of consistence data from year 2004. Table 4.9, 4.10 and 4.11 show records of reduced water levels, TDS concentrations and chloride concentrations respectively. Based on data hydrographs for these parameters have been prepared (Fig. 4.37, and 4.38)

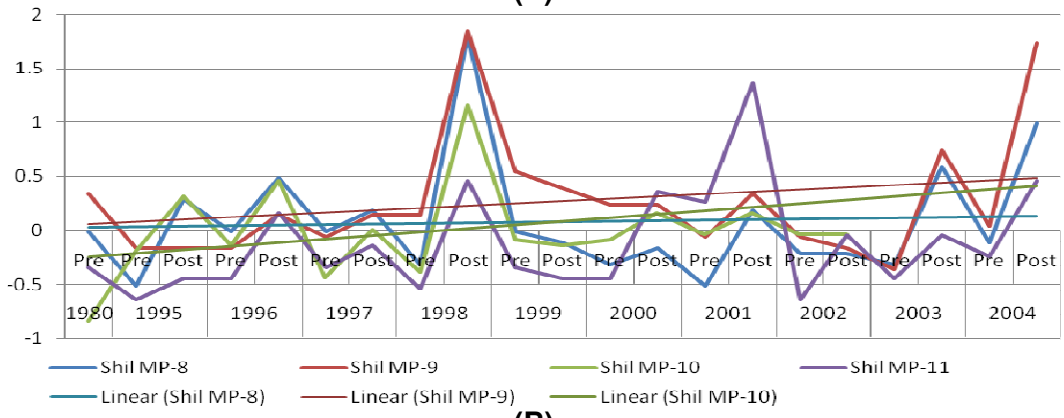
Well hydrograph of RWL shows that water level in Jhariwada villages is almost below AMSL maximum depth has observed in well no MP – 4 i.e. lower than – 6 M whereas in case of MP – 4 the water levels ranges between 0 to – 2 M. all the three wells of Jhariyawada village shows three different trends i.e. increasing trend in MP – 4, negligible fluctuation in MP – 6 and decreasing trend in well MP – 7. (Fig. 4.37A)

In case of wells of village Sheel, water level fluctuation range varies from -1 m to 1.5 with respect to AMSL. Maximum rise in water level has observed in during post monsoon seasons of year 1998, 2001 and 2004 that clearly indicates impact of good rainfalls during these years i.e. 771 mm and 1072 mm during year 2001 and 2004 respectively. The overall trend is rising trend that clearly indicates the water level in Sheel village is constantly increases even there are many bad rainfall years such as 221 mm rainfall in year 2002. (Fig. 4.37 B)

As far as groundwater quality is concerned in area around Sheell bandhara, only one well i.e. MP – 4 of Jhariyawada has both TDS as well as Chloride value within permissible limits or low concentration i.e. less than 1000 ppm in case of TDS and chloride. (Fig. 4.38 A and B) Further TDS values in observation well shows gradual rising trend even in good rainfall years also.



(A)

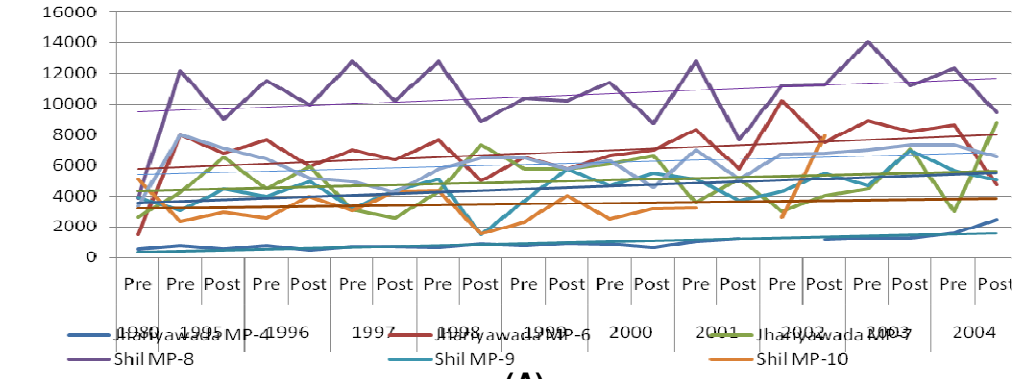


(B)

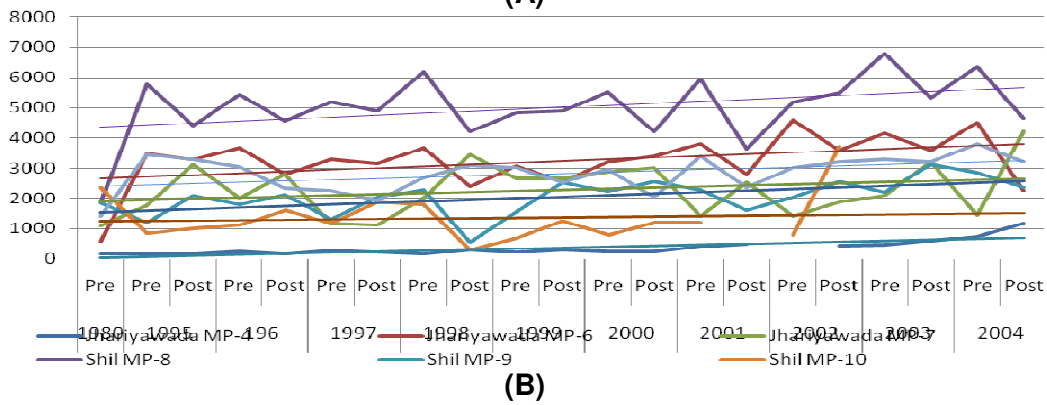
Fig. 4.37 Pre and Post Monsoon Changes in Reduced Water Levels in Observation Wells of Village Jhariyawada (A) and Sheell (B) around Sheel Bandhara

Table 4.18 Pre and Post Monsoon Fluctuation in Reduced Water Levels in Monitoring Wells Around Sheel Bandhara

Pre and Post Monsoon RWL (M)								
Year	Season	Jhariyawada			Sheel			
		MP-4	MP-6	MP-7	MP-8	MP-9	MP-10	MP-11
1980	Pre	-1.37	- 4.21	-1.79	-0.01	0.34	-0.84	-0.34
1995	Pre	-11.9	-7.21	-2.14	-0.51	-0.16	-0.19	-0.64
	Post	-8.97	-5.21	-0.99	0.29	-0.16	0.31	-0.44
1996	Pre	-9.87	-5.81	-1.99	-0.01	-0.16	-0.14	-0.44
	Post	-8.07	-4.91	-0.39	0.49	0.14	0.46	0.16
1997	Pre	-10.7	-6.71	-2.09	-0.01	-0.06	-0.44	-0.34
	Post	-10.3	-6.41	-1.89	0.19	0.14	0.01	-0.14
1998	Pre	-11.9	-7.21	-2.39	-0.31	0.14	-0.39	-0.54
	Post	-1.87	-2.91	0.46	1.79	1.84	1.16	0.46
1999	Pre	-8.87	-6.11	-1.54	-0.01	0.54	-0.09	-0.34
	Post	-7.87	-6.16	-1.59	-0.11	0.39	-0.14	-0.44
2000	Pre	-13.1	-7.06	-2.24	-0.31	0.24	-0.09	-0.44
	Post	-12.7	-5.71	-1.39	-0.16	0.24	0.16	0.36
2001	Pre	-13.3	-6.91	-2.19	-0.51	-0.06	-0.04	0.26
	Post	-10.9	-6.21	-1.39	0.19	0.34	0.16	1.36
2002	Pre	-11.3	-6.61	-1.99	-0.21	-0.06	-0.04	-0.64
	Post	-13.4	-7.11	-2.09	-0.21	-0.16	-0.04	-0.04
2003	Pre	-13.9	-7.21	-2.19	-0.31	-0.36		-0.44
	Post	-5.87	-4.51	-0.49	0.59	0.74		-0.04
2004	Pre	-12.1	-5.51	-1.69	-0.11	0.04		-0.24
	Post	-2.87	-2.51	0.61	0.99	1.74	0.96	0.46



(A)



(B)

Fig. 4.38 Pre and Post Monsoon Changes in TDS (A) and Chloride (B) Concentrations in Observation Wells of Village Jhariyawada and Sheell around Sheel Bandhara

Table 4.19 Pre and Post Monsoon Fluctuation in TDS Concentrations in Monitoring Wells Around Sheel Bandhara

Pre and Post Monsoon TDS Concentration (PPM)								
Year	Season	Jhariyawada			Sheel			
		MP-4	MP-6	MP-7	MP-8	MP-9	MP-10	MP-11
1980	Pre	560	1480	2600	3860	3920	5120	3300
1995	Pre	760	8000	4220	12160	3080	2360	8000
	Post	520	6800	6500	9040	4460	2940	7120
1996	Pre	760	7680	4480	11520	3960	2560	6400
	Post	480	5920	5940	9960	4980	3960	5140
1997	Pre	700	7040	3080	12800	3200	3080	4920
	Post	700	6400	2560	10240	4360	4280	4220
1998	Pre	640	7680	4280	12800	5120	4360	5760
	Post	840	5000	7300	8840	1480	1540	6460
1999	Pre	760	6520	5760	10360	3720	2300	6460
	Post	900	5760	5760	10240	5760	4040	5760
2000	Pre	840	6660	6080	11400	4680	2500	6280
	Post	640	7040	6600	8760	5500	3140	4540
2001	Pre	1020	8320	3580	12800	5120	3200	7040
	Post	1220	5760	5120	7680	3720		5120
2002	Pre		10240	3000	11200	4300	2620	6720
	Post	1120	7500	4040	11280	5520	7920	6780
2003	Pre	1280	8960	4480	14080	4680		7040
	Post	1280	8200	7040	11200	6980		7360
2004	Pre	1560	8650	3000	12340	5690		7360
	Post	2470	4750	8780	9450	5100	2880	6560

Table 4.20 Pre and Post Monsoon Fluctuation in Chloride Concentrations in Monitoring Wells Around Sheel Bandhara

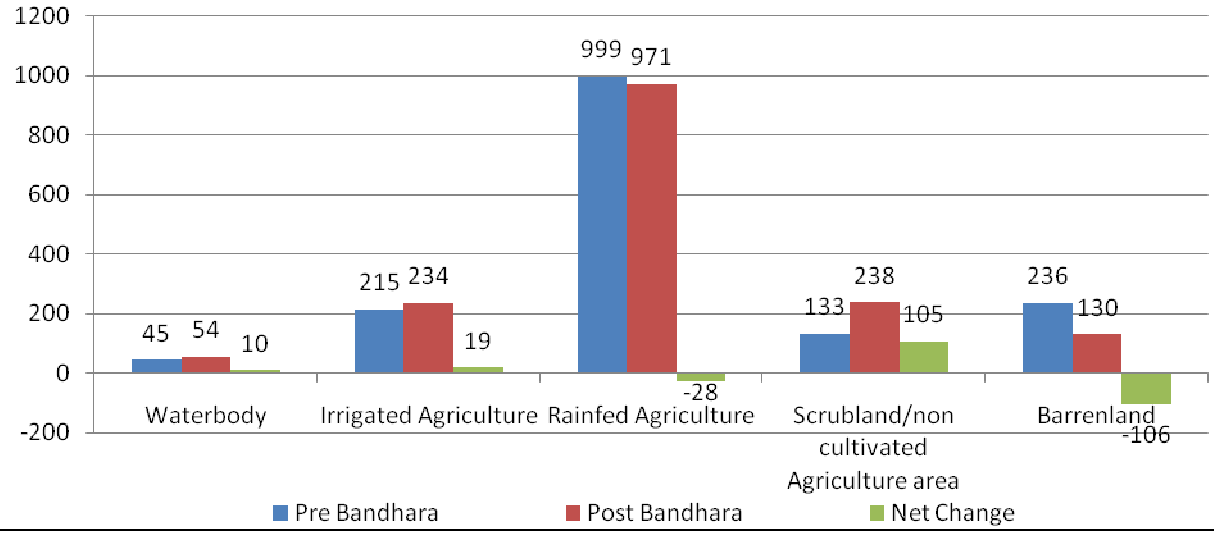
Pre and Post Monsoon Chloride Concentration (PPM)								
Year	Season	Jhariyawada			Sheel			
		MP-4	MP-6	MP-7	MP-8	MP-9	MP-10	MP-11
1980	Pre	152	560	1080	1840	1840	2360	1400
1995	Pre	160	3480	1760	5800	1200	840	3440
	Post	152	3280	3120	4400	2080	1000	3280
196	Pre	224	3680	2000	5440	1800	1120	3040
	Post	152	2800	2800	4560	2120	1600	2320
1997	Pre	256	3280	1160	5200	1320	1160	2240
	Post	216	3160	1120	4880	2040	1880	1920
1998	Pre	160	3680	2000	6200	2280	1800	2680
	Post	296	2400	3440	4200	552	304	3080
1999	Pre	200	3080	2640	4840	1560	680	3000
	Post	280	2560	2640	4880	2520	1240	2520
2000	Pre	240	3200	2880	5520	2240	800	2960
	Post	224	3400	3000	4200	2560	1200	2040
2001	Pre	408	3800	1400	5960	2280	1200	3400
	Post	480	2800	2520	3640	1600		2360
2002	Pre		4600	1400	5200	2040	800	3000
	Post	432	3600	1880	5480	2560	3720	3200
2003	Pre	456	4160	2080	6800	2200		3280
	Post	576	3600	3200	5320	3120		3200
2004	Pre	736	4520	1440	6360	2840		3800
	Post	1160	2240	4200	4640	2360	1280	3200

4.6.4 LANDUSE

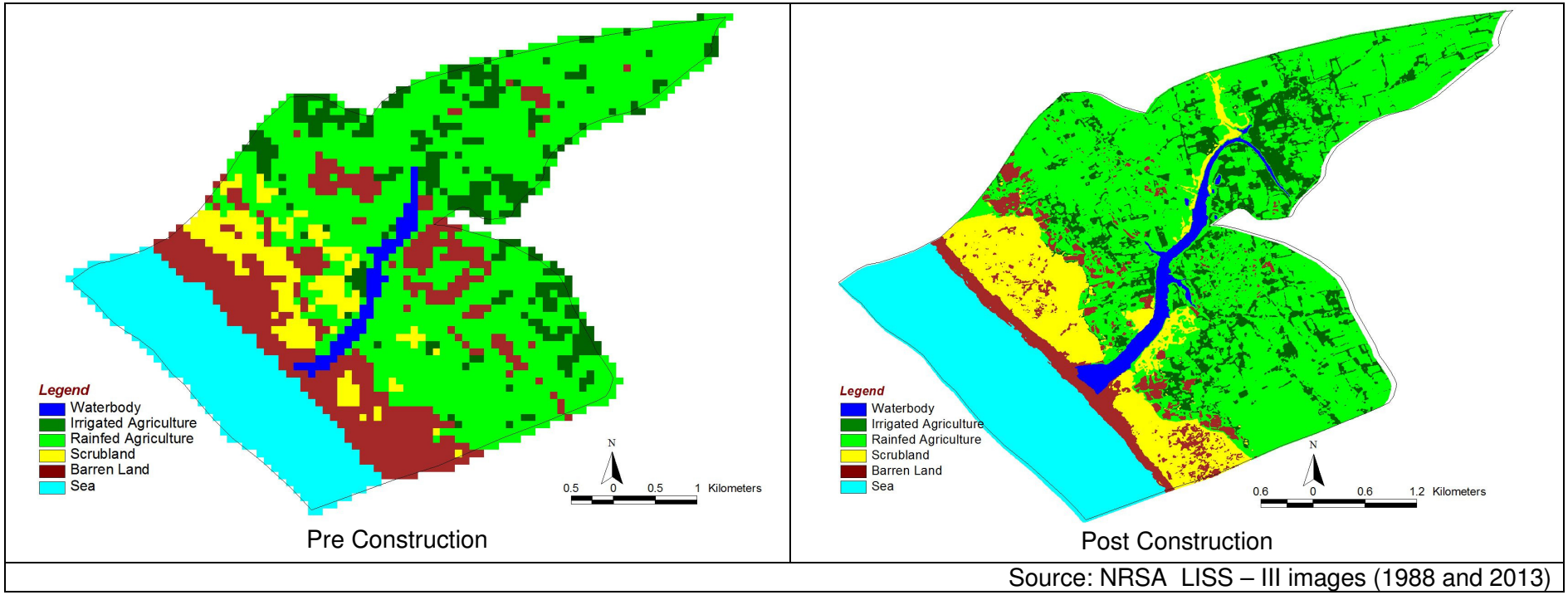
Land use pattern around Shell Tidal regulator has been studied with the help of remote sensing data. To understand land use pattern LISS – III image of the years 1988 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 4.21)

Table 4.21 Landuse Pattern around Sheel Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	45	54	10
Irrigated Agriculture	215	234	19
Rain fed Agriculture	999	971	-28
Scrubland/non cultivated Agriculture area	133	238	105
Barren land	236	130	-106
Total	**1628**	**1628**	0



Out of total analysed land area (2027 Ha) about 69 % area is categorized as agriculture land where all other areas such as water bodies, settlements, barren land and sea occupies about 31 percentages of total area is occupied by sea in surrounding area of Sheel Bandhara. About 221.96 Ha area is barren land around Sheel bandhara. It is important to clarify that, pre and post bandhara construction changes in landuse pattern especially in irrigated agriculture areas was not possible to compute due to non availability of pre construction remote sensing data. (Table 4.12, Fig. 4.39)



Source: NRSA LISS – III images (1988 and 2013)

Fig. 4.39 Landuse Pattern around Sheel Bandhara Area

4.7 SABLI NETRAVATI CANAL

4.7.1 ASSETS, INCOME AND INVESTMENTS

The most common assets acquired post construction of the Sabli Netravati canal include mobile telephone, vehicle and toilet with 31 per cent, 27 per cent and 27 per cent of surveyed households reporting these (Fig. 4.40). Selling of milk remains by far the most common source of additional income (as reported by 67 per cent of the households) post the scheme as shown by Fig. 4.41 A.

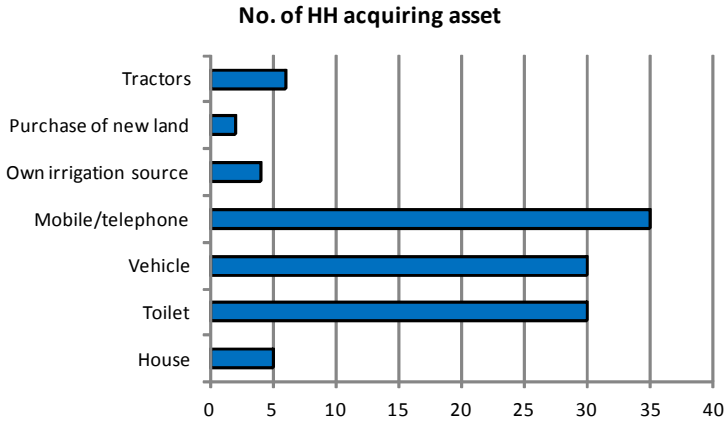


Fig. 4.40 Impact on assets in Sabli Netravati

The additional income generated has been utilised for a wide variety of purposes which include tap connection/toilet, land improvement and house renovation. Interestingly, about 11 per cent of households have also been able to use the surplus income generated to pay off existing loans, a practice not seen in many other schemes of Junagadh (Fig. 4.41 B).

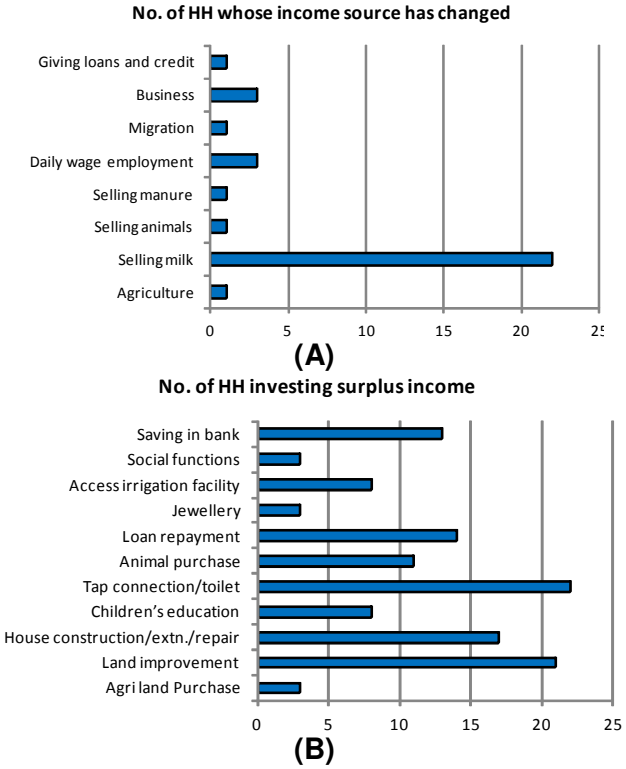


Fig. 4.41: Impact on Income Source (A) and Impact on Income Source (B) in Sabli Netravati

4.7.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Green fodder availability in villages affected by the Sheel bandhara has shown a modest increase of 15 percents even as dry fodder availability has declined marginally post the scheme (Table 4.22).

Table 4.22: Impact on fodder availability due to agriculture, Sabli Netravati Spread Channel

Impact	Quantity
Increase in Green Fodder (%)	15
Increase in Dry Fodder (%)	-10
Increase in Cow dung (%)	0

While there has been no increase in the number of cows, better availability of green fodder has presumably led to a substantial increase in milk production from cows. Similarly, despite a small increase of 20 per cent in the number of buffaloes, milk production from these animals has gone up by 140 per cent (Fig. 4.42).

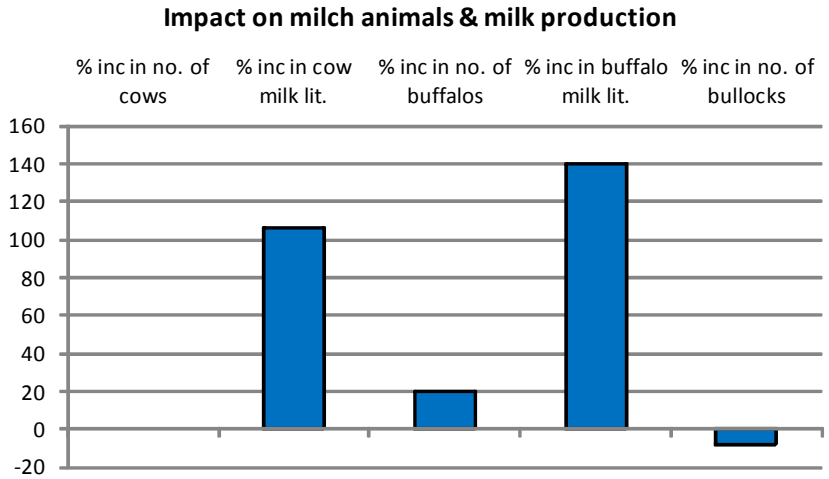


Fig 4.42 Impact on milch animals and milk production in Sabli Netravati

4.7.3 GROUNDWATER AVAILABILITY AND QUALITY

Despite 47 per cent of the families reporting no change in groundwater levels post the construction of the Sabli Netravati canal, an equal percentage of households have reported water levels either increasing by upto 25 feet, between 25-50 feet or more than 50 feet after the scheme as seen from Fig. 4.43 A.

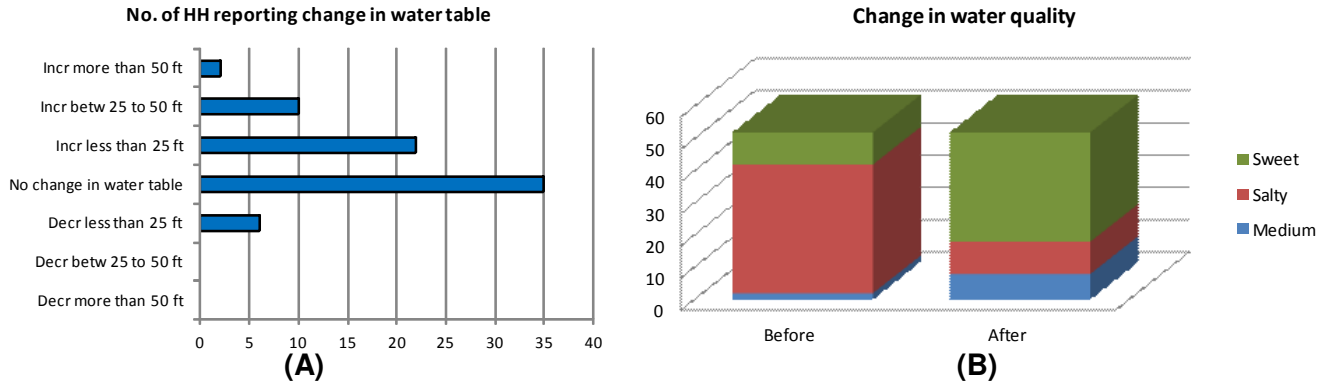


Fig. 4.43 People's View on Change in Water Table (A) and Water Quality (B) in Sabli Netravati

Like in other schemes of Junagadh district, the impact of the Sabli Netravati canal on water quality has been quite positive. As a result, the number of families dependent on salty water has come

down by 75 per cent while those being able to get sweet water post the scheme have increased from 19 per cent to 65 per cent as seen in Fig. 4.43 B.

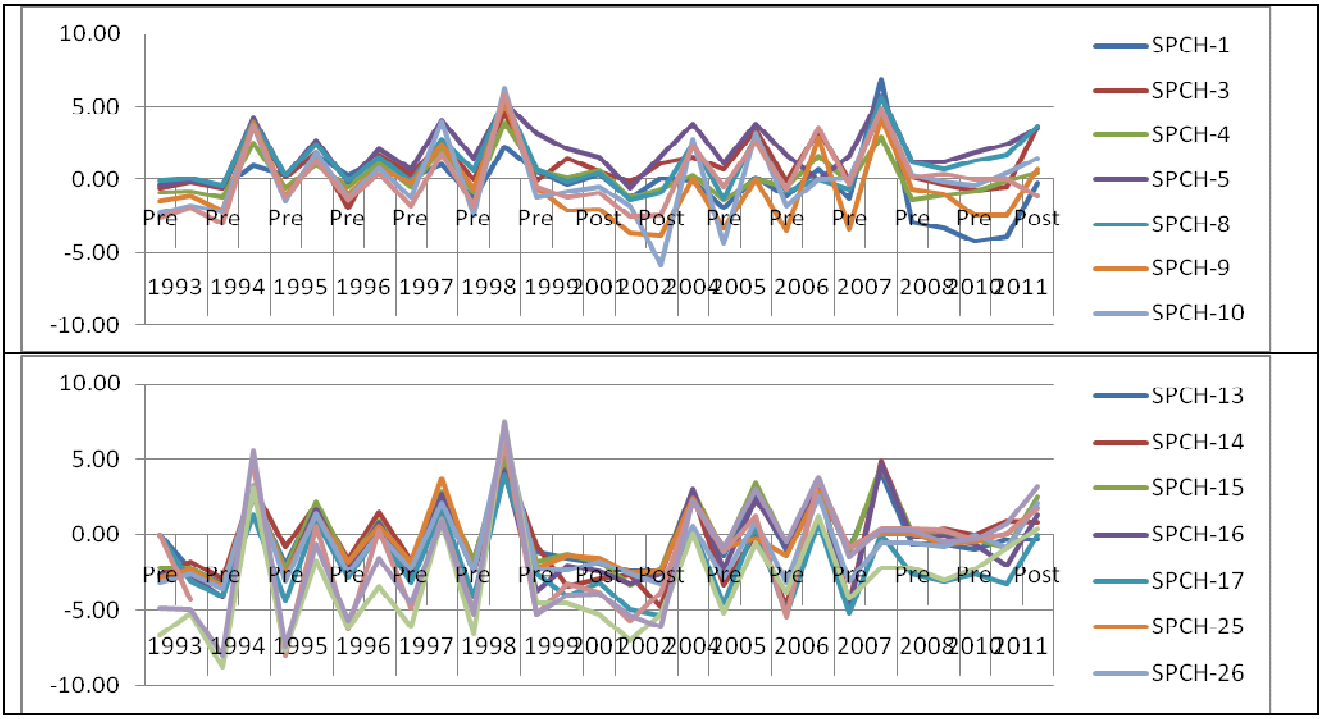


Fig. 4.44 Well Hydrograph Showing Changing Trends in Reduced Water level Around Sabli Netravati Spread Channel

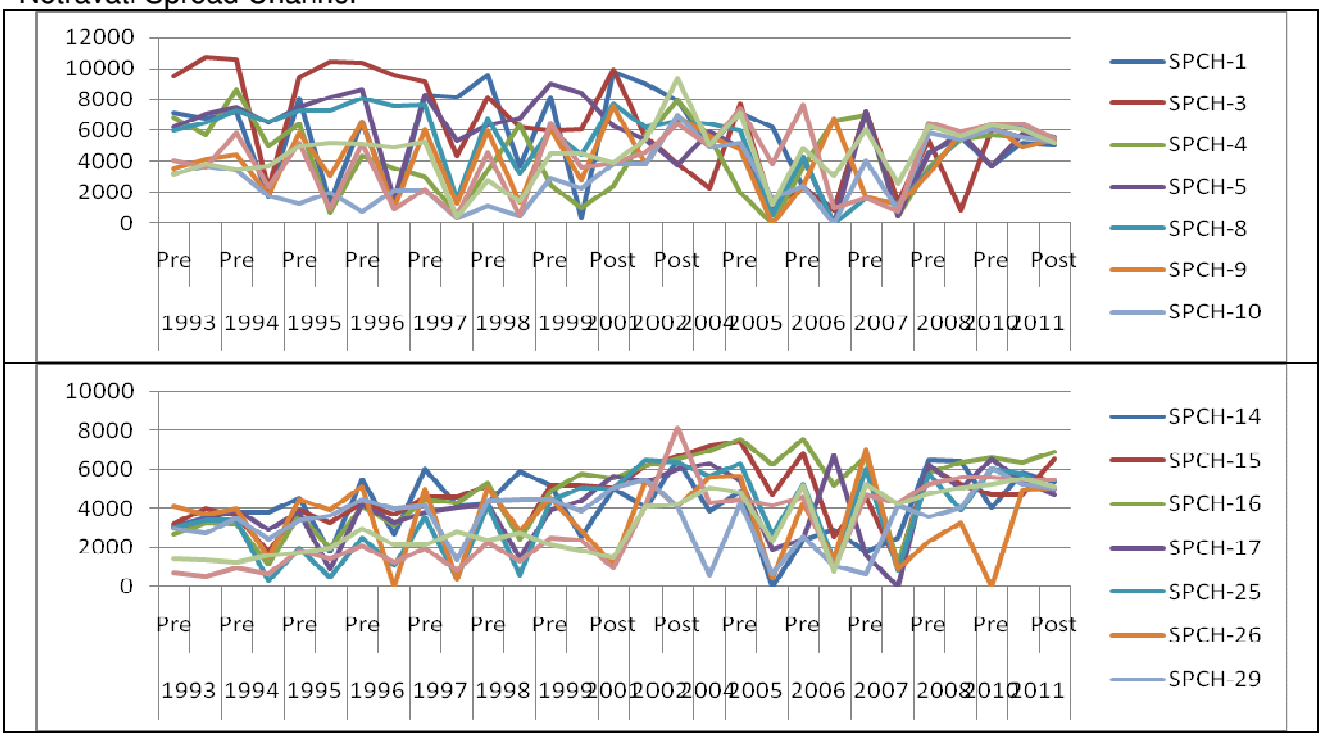


Fig. 4.45 Well Hydrograph Showing Changing Trends in TDS Concentrations Around Sabli Netravati Spread Channel

Further to understand the changes in groundwater levels around Sabli Netravati Channel hydrographs of some of the observation wells (those were have consistence monitoring data) Table 4.23 and Fig. 4.44 and 4.45) have been prepared. The hydrograph clearly shows following changes

- The water level is gradually rises from mean sea level from year 2005
- During the period of years 1998 to 2004 the water level depletion were maximum and in some cases it was below 5 m than AMSL.
- TDS concentrations in wells like SPCH 1, 3, 4, 5 show constant decreasing trends in TDS from 6000 – 10000 PPM to less than 6000 ppm during year 2011
- Whereas most of the well shows increasing trends in TDS concentrations that begins from period 2002-2004.

Table 4.23: Changes in Water Level and Concentration of Total Dissolved Solids in Observations Wells around Sabli-Netravati Spread Channel

OW Code	GLRL	1993				1994				1995			
		Pre		Post		Pre		Post		Pre		Post	
		RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)
SPCH-1	3.89	-0.31	7142	-0.01	6758	-0.51	7238	1.00	1656	0.29	8074	1.69	1311
SPCH-2	3.78	-0.72	2530	-0.52	5284	-0.82	6403	1.10	3155	-0.42	5846	1.28	2796
SPCH-3	6.62	-0.58	9510	-0.18	10752	-0.58	10579	3.80	2143	0.12	9466	1.82	10483
SPCH-4	4.93	-0.87	6845	-0.77	5714	-1.17	8630	2.50	5000	-0.57	6403	1.03	699
SPCH-5	7.97	-0.33	6250	-0.03	7066	-0.43	7517	4.20	6547	0.27	7517	2.67	8154
SPCH-6	6.20	-1.00	5773	-0.50	6758	-1.50	5568	3.90	2202	-0.60	5568	1.00	1107
SPCH-7	6.06	-1.24	5357	-0.84	6021	-1.04	6682	3.10	1667	-1.44	6960	1.26	5649
SPCH-8	7.70	-0.10	5952	0.10	6451	-0.40	7238	4.00	6547	0.30	7238	2.40	7280
SPCH-9	6.14	-1.46	3571	-1.16	4147	-2.16	4454	3.90	1845	-1.16	5846	1.64	3087
SPCH-10	7.20	-2.30	3214	-1.80	3686	-2.20	3452	3.70	1786	-1.50	1309	1.90	1980
SPCH-11	7.70	-1.30	3809	-0.70	6758	-0.20	6682	4.30	6250	-1.60	4900	2.00	1922
SPCH-12	6.90	-2.60	4077	-1.90	3625	-3.00	5846	3.80	2321	-1.20	5234	1.30	874
SPCH-13	6.05	_	3155	-2.25	3871	-3.25	3508	2.50	3690	-1.95	5011	1.95	5183
SPCH-14	6.80	-2.70	3095	-1.80	3502	-2.90	3786	3.10	3780	-0.80	4510	2.00	1805
SPCH-15	6.50	-2.20	3214	-2.20	3994	-3.40	3619	2.80	1786	-2.30	3898	2.20	3261
SPCH-16	5.70	-2.70	2678	-2.70	3287	-4.20	3174	3.00	1101	-2.80	3675	1.70	1922
SPCH-17	4.10	_	2976	-3.10	3471	-4.10	3898	1.30	2888	-4.40	3786	0.90	874
SPCH-18	4.00	-2.80	1697	-2.70	645	-4.60	2840	_	_	-5.30	1058	_	_
SPCH-20	5.10	-0.40	5952	-0.20	3932	-0.40	7238	2.20	3095	0.30	4454	1.90	4659
SPCH-21	6.60	-0.30	6250	0.00	7066	-1.10	7238	4.10	2738	-0.30	6403	1.60	4543
SPCH-22	8.10	0.10	4554	0.40	4485	-0.30	6125	3.10	645	0.60	6125	2.60	3261
SPCH-23	7.10	-1.60	3095	-1.00	3564	-2.00	5846	2.30	676	-0.70	4844	2.00	815
SPCH-24	8.20	-1.40	3333	-1.60	3686	-2.40	3508	4.00	3631	-1.90	3953	2.30	4077
SPCH-25	7.07	-2.83	3066	-2.33	3379	-3.43	3396	3.00	298	-2.73	1949	1.27	449
SPCH-26	5.88	-3.22	4107	-2.62	3717	-3.62	4009	3.20	1488	-3.12	4454	1.38	3932
SPCH-27	6.10	-4.30	3185	-2.20	2826		3341	0.80	1659	-3.00	4148	0.20	3727
SPCH-28	4.68	-4.42	1964	-3.82	645	-5.32	3062	2.80	280	-4.72	1699	_	_
SPCH-29	6.50	_	2976	-4.30	2734		3508	4.70	2440	-8.00	3396	0.60	3640
SPCH-30	4.81	-6.69	714	-5.19	510	-8.79	919	3.10	655	-7.69	1837	-1.69	1427
SPCH-31	7.10	-4.90	1399	-5.00	1321	-8.00	1225	5.50	1578	-7.40	1670	-0.70	1922
SPCH-32	3.87	-4.63	1250	-3.93	344		2450	1.30	440	-5.13	2227	-0.53	1311
SPCH-33	5.03	_	2202	-4.97	2703	-9.17	3619	0.13	2949	-6.97	4232	-0.77	3291
SPCH-34	3.55	_	128	-4.65	922	-7.75	2004	0.20	268	-6.25	1726	-0.25	582
SPCH-35	4.50	-4.20	982	-4.70	2642	-4.40	6682	0.60	3072	-3.10	1837	0.80	501

Table 4.23: Changes in Water Level and Concentration of Total Dissolved Solids in Observations Wells around Sabli-Netravati Spread Channel contd….

OW Code	1996				1997				1998			
	Pre		Post		Pre		Post		Pre		Post	
	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)
SPCH-1	0.29	6547	1.39	1054.1	0.13	8285	1.09	8154	-1.31	9626	2.3	3730
SPCH-2	-1.22	4166	0.88	1834.9	-0.32	4851	0.78	4422	0.28	2221	1.3	6858
SPCH-3	-1.98	10416	1.72	9626.9	0.42	9196	2.52	4363	0.02	8145	4.6	6196
SPCH-4	-0.47	4345	1.13	3564.2	-0.47	2976	2.23	673	-0.87	3418	3.9	6377
SPCH-5	-0.13	8630	2.17	1566.7	0.77	8273	4.07	5369	1.47	6380	5.3	6798
SPCH-6	_	_	0.2	2475.5	-0.50	2720	3.30	387	-0.9	6266	5.3	602
SPCH-7	-0.64	4464	1.16	2061.4	-0.54	4387	2.06	1077	-1.14	4329	4.7	782
SPCH-8	-0.10	8035	1.5	7530.2	-0.10	7624	2.80	1583	0.6	6721	5.5	3188
SPCH-9	-1.01	6547	0.84	1007.4	-0.26	6059	2.44	1274	-0.66	6038	5.4	1384
SPCH-10	-1.20	804	0.85	2149.1	-1.20	2155	4.00	369	-2.5	1139	6.3	481
SPCH-11	-0.50	5297	1.5	4659.2	-0.80	5535	3.20	7500	-0.5	4386	5.3	3610
SPCH-12	-1.40	5119	0.4	896.64	-1.80	2161	1.80	387	-1.8	4557	5.9	481
SPCH-13	-1.95	5119	0.45	4950.4	-1.85	5261	2.05	399	-2.25	2791	4.7	1384
SPCH-14	-1.60	5476	1.5	2643.8	-1.70	5999	2.30	4166	-1.7	4272	5	5896
SPCH-15	-1.90	4285	0.9	3646.1	-2.30	4547	2.80	4583	-1.7	5183	5.1	2527
SPCH-16	-2.30	4107	0.8	3156.5	-2.80	4440	2.70	4303	-2.5	5297	4.2	2406
SPCH-17	-2.90	4226	0.1	3255.7	-3.20	3833	1.60	4018	-4.2	4215	4	1504
SPCH-18	-3.10	3631	-0.7	285.44	-3.10	3500	_	_	-4.9	2905	4	301
SPCH-20	-0.30	5059	1.9	3785.6	0.20	5619	1.20	5833	-0.4	7063	3.25	4452
SPCH-21	0.10	5952	1.4	4251.5	-0.40	5387	3.00	1256	0.1	4557	4.5	2166
SPCH-22	0.5	5416.3	2.6	9225	0.30	5732	3.20	572	-0.1	2108	5.9	4091
SPCH-23	-0.2	5535.4	1.8	7163.5	-0.70	3542	3.30	1333	-1	2506	5.2	5174
SPCH-24	-0.9	4583	1.4	4223.4	-1.10	4125	3.00	4172	-1	2905	5.7	3128
SPCH-25	-1.83	2499.8	0.57	1052.8	-1.83	3613	3.77	393	-2.33	4158	6.2	602
SPCH-26	-2.52	5118.7	_	_	-2.32	5023	2.08	369	-2.42	5041	6.5	2888
SPCH-27	-3	4256	-0.1	4036.5	3.10	4392	2.60	5589	-3.4	4785	_	_
SPCH-28	-5.82	2261.8	-2.12	2490.9	-4.22	2470	_	_	_	_	_	_
SPCH-29	-6.3	4464	0.3	3994.9	-4.90	4125	1.10	1381	-5.1	4386	6.3	4452
SPCH-30	-6.19	2083.2	-3.39	1221.1	-6.09	1923	0.91	833	-6.59	2221	7.5	1263
SPCH-31	-5.7	2976	-1.6	2093.4	-4.60	2137	0.90	2780	-5.3	2335	7.4	2707
SPCH-32	-7.23	3095	-3.03	1065	-5.93	3059	1.57	845	-6.63	3133	6	2166
SPCH-33	-5.37	4404.5	-1.87	3609.6	-5.47	3839	1.13	3279	-5.27	3816	6.7	3549
SPCH-34	-5.45	4702.1	-1.85	1155.2	-4.95	4018	1.75	863	-5.75	2506	5.5	1564
SPCH-35	-3.9	2768	-0.6	787.84	-4.70	3167	_	_	_	_	_	_

Table 4.23: Changes in Water Level and Concentration of Total Dissolved Solids in Observations Wells around Sabli-Netravati Spread Channel contd….

OW Code	1999				2001		2002				2003			
	Pre		Post		Post		Pre		Post		Pre		Post	
	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)
SPCH-1	0.59	8122	-0.31	320	0.29	9806	-1.21	9020	0.09	7937	-1.51	6835	1.09	1167
SPCH-2	0.68	8061	-0.92	1152	-0.22	9926	-1.92	6570	-0.42	4342	-2.12	7348	0.48	1044
SPCH-3	-0.08	6016	1.42	6080	0.52	9926	-0.18	5568	1.12	3799	-0.28	6209	_	_
SPCH-4	0.63	2527	0.13	1024	0.63	2406	-1.17	5679	-0.67	7937	-1.47	6835	0.13	4362
SPCH-5	3.17	9024	2.17	8448	1.57	6317	-0.53	5457	1.67	3799	-0.63	6721	3.57	7188
SPCH-6	0.10	6136	-2.60	4032	-1.9	5354	-2.5	3898	-3.3	6513	_	_	2.2	3932
SPCH-7	-0.24	6437	_	_	-0.94	3910	-2.44	4510	_	_	-2.64	7006	1.86	4424
SPCH-8	0.70	6016	-0.20	4416	0.5	7700	-1.4	6177	-0.9	6648	-1.8	6380	3.6	1843
SPCH-9	-0.56	6136	-2.16	2816	-2.06	7580	-3.66	3842	-3.86	6920	_	_	0.84	614
SPCH-10	-1.20	2948	-0.80	2304	-0.5	3850	-1.8	3842	-5.9	6988	_	_	2	737
SPCH-11	0.60	5414	-1.00	4224	-0.3	5234	-1	6403	-2	6513	_	7462	2.7	4424
SPCH-12	-0.50	6497	-1.20	3584	-0.9	3910	-2.5	4566	-2.4	6445	-2.4	6550	2.1	737
SPCH-13	-1.15	4512	-1.55	4480	-1.85	3910	-2.45	5401	-2.45	9362	-2.75	5411	0.45	4301
SPCH-14	-0.70	5174	-3.40	2560	-2.9	4993	-2.7	4065	-4.8	6445	-3.2	5126	2.3	2458
SPCH-15	-1.80	5174	-1.30	5184	-1.8	5053	-3.3	6180	-2.3	6648	_	7291	2.3	3318
SPCH-16	-3.80	4873	-2.10	5760	-2.5	5535	-3.3	6180	-2.6	6580	_	7690	1.9	4669
SPCH-17	-2.60	3910	-4.10	4416	-3.2	5655	-5	5345	-5.4	6038	-5.2	6436	-2.6	4977
SPCH-18	-4.50	3850	-4.70	4352	-4.1	5655	-4.7	3842	-6	5970	_	_	-2.6	4608
SPCH-20	-0.40	7761	0.60	5888	-0.1	1925	-0.6	5401	0.2	9362	-1	10025	1.7	1106
SPCH-21	0.10	4632	-0.50	2496	-0.2	1865	-1.7	6180	-1.3	6241	_	_	_	_
SPCH-22	-1.10	2286	0.00	4736	-0.2	5114	-2.2	6403	-1	6241	-2.5	8202	0.7	2335
SPCH-23	-1.40	2767	-1.30	2944	-1.7	1865	_	_	-2.3	8073	_	_	_	_
SPCH-24	-0.50	3429	-0.70	2944	-0.2	4993	-0.9	4120	-1.5	8073	_	4614	2.8	614
SPCH-25	-2.23	4452	-1.43	5056	-1.53	4993	-2.53	6515	-2.43	6377	_	7405	1.77	2089
SPCH-26	-2.32	4512	-2.42	2880	-1.82	1143	-2.62	5401	-3.32	4138	-2.92	6721	-.12	307
SPCH-27	-2.00	4572	_	_	-2	1083	-3.5	4510	_	_	_	_	-1.1	430
SPCH-28	_	_	_	_	_	_	_	_	_	_	_	_	_	_
SPCH-29	-5.30	4452	-3.30	3840	-3.8	5053	-5.7	5457	-3.8	4070	_	6266	2	1352
SPCH-30	-4.59	2467	-4.59	2368	-5.29	902	-6.99	4120	-5.29	8141	_	_	-1.19	4178
SPCH-31	-5.30	2106	-4.00	1792	-3.9	1444	-5.4	4120	-6.1	4206	-6.6	5183	2.3	430
SPCH-32	-5.33	3068	-6.13	2368	-6.43	1083	-7.73	4120	-7.33	5088	-8.13	4671	-1.43	3686
SPCH-33	-4.37	3369	-5.37	3904	-6.37	1263	-8.07	4120	-6.57	5156	-8.87	4557	-5.67	3686
SPCH-34	-5.75	3971	-4.65	3968	-4.55	4632	-5.85	3842	-6.15	6716	-6.15	4215	-3.35	5100
SPCH-35	-6.80	2286	_	_	-4.8	3910	_	_	_	_	_	_	-3.3	3686

Table 4.23: Changes in Water Level and Concentration of Total Dissolved Solids in Observations Wells around Sabli-Netravati Spread Channel contd….

OW Code	2004		2005				2006				2007			
	Post		Pre		Post		Pre		Post		Pre		Post	
	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)
SPCH-1	-0.11	5009	-1.91	7142	0.19	6241	-1.11	2346	0.74	865	-1.31	7219	6.89	860
SPCH-2	0.18	5708	-0.72	5059	_	_	-1.82	2346	_	_	-1.62	7219	0.68	799
SPCH-3	1.52	2213	0.72	7738	3.42	1018	-0.08	2346	3.32	799	0.02	7219	4.72	1352
SPCH-4	0.33	5591	-1.37	1964	_	_	-0.47	3610	1.63	6656	-0.17	6979	2.93	529
SPCH-5	3.87	5940	1.17	4940	3.87	733	1.77	4271	_	_	1.67	7219	5.77	529
SPCH-6	1.9	6290	-2.5	3512	_	_	0.1	4332	_	_	0	7219	4.4	1659
SPCH-7	1.56	5708	_	_	_	_	0.66	4271	2.96	6723	0.76	7219	4.16	614
SPCH-8	2.4	6406	-1.3	5952	2.9	604	-0.8	4271	_	_	-0.7	1624	5.7	1290
SPCH-9	0.04	5649	-3.36	4821	_	_	-3.56	2406	2.89	6789	-3.46	1684	4.24	1229
SPCH-10	2.8	4892	-4.4	5178	3.2	1655	-1.8	2406	_	_	0.1	4091	4.8	860
SPCH-11	3.7	2737	-0.3	4881	_	_	-1.9	2406	_	_	-1.8	1624	5.6	1229
SPCH-12	2.4	4950	-0.5	7440	2.6	3867	-0.6	7640	3.6	932	-0.3	1624	4.9	737
SPCH-13	2.55	5067	-1.35	7142	2.75	1221	-1.05	4873	2.95	3062	-0.95	6076	4.05	2519
SPCH-14	2.7	3844	-3.3	4881	_	_	-4.7	2346	3.6	2929	-4.6	1805	4.9	2519
SPCH-15	2.9	7222	-1.1	7440	3.4	4681	-0.6	6858	3.5	2529	-1.2	4572	4.5	1106
SPCH-16	3	6989	-2.3	7559	2.3	6241	-0.8	7580	3.4	5192	-5	6678	4.7	1167
SPCH-17	0.3	6290	-4.6	5416	0.6	1900	-5.3	2467	0.8	6723	-5.2	1624	_	_
SPCH-18	0.1	5824	-5.1	7142	_	_	-5.5	4332	_	_	-5.4	1564	1.9	4485
SPCH-20	1.3	1726	-1.2	1726	1.7	2985	0.3	4271	1.95	6856	0.4	1564	2.9	4485
SPCH-21	2.4	4107	-1.2	4107	_	_	-1.2	4271	3.5	6789	-1.1	1624	_	_
SPCH-22	3	2446	-0.4	6309	3.4	1900	-0.9	6377	4.8	5658	-0.8	6979	_	_
SPCH-23	1.1	2563	-2.5	6190	_	_	-2.1	6257	_	_	-2	6979	0.5	4424
SPCH-24	_	_	0.4	2738	2.5	624	1	2828	_	_	-0.2	4632	_	_
SPCH-25	2.47	5649	-0.93	6309	-0.23	2714	-1.43	5234	2.82	1398	-0.93	6016	0.07	860
SPCH-26	0.58	5591	-2.92	5654	0.88	420	-3.22	4271	2.58	1398	-3.12	7039	-0.62	922
SPCH-27	2.3	3553	_	_	2.9	1560	-3	4271	2.85	799	-3.05	7039	_	_
SPCH-28	_	_	_	_	_	_	-7.42	2467	1.38	666	-7.32	5234	-2.12	860
SPCH-29	2.2	582	-1.1	4285	1.2	631	-5.5	2527	3.7	1065	-0.9	662	0.4	4178
SPCH-30	0.11	4252	-5.19	4464	-0.59	4138	-3.79	4572	1.21	932	-4.19	4692	-2.19	4239
SPCH-31	2.3	5067	-0.9	4821	3	2307	-0.5	5174	3.8	732	-1.5	5234	0.3	4239
SPCH-32	-0.43	5824	_	_	0.67	2985	-7.63	2286	0.47	799	-4.43	4285	_	_
SPCH-33	0.93	3378	0.67	4226	_	_	-3.47	5174	1.83	865	-3.17	3690	_	_
SPCH-34	-1.55	1980	_	_	_	_	-5.75	2346	0.15	799	-5.15	3759	_	_
SPCH-35	_	_	_	_	_	_	-5.1	4271	1	865	-3.9	4285	_	_

Table 4.23: Changes in Water Level and Concentration of Total Dissolved Solids in Observations Wells around Sabli-Netravati Spread Channel contd….

OW Code	2008				2010		2011			
	Pre		Post		Pre		Pre		Post	
	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)	RWL (M)	TDS (PPM)
SPCH-1	-2.91	4543	-3.31	5533	-4.21	3702	-3.91	5242	-0.21	5092
SPCH-2	_	5358	-2.72	2038	-3.92	5297	-4.22	5009	0.08	3917
SPCH-3	0.12	5358	-0.38	815	-0.78	6038	-0.48	5533	3.62	5549
SPCH-4	-1.37	3669	-1.07	5416	-0.77	5696	-0.07	5533	0.53	5353
SPCH-5	1.27	4543	1.27	5882	1.87	3759	2.47	5824	3.47	5418
SPCH-6	-0.6	3727	-1.5	5242	-0.9	6095	-1	6406	2.6	5614
SPCH-7	-0.74	6523	0.06	5125	-1.64	4614	-1.24	6406	1.86	5679
SPCH-8	1.2	3320	0.7	5591	1.3	6323	1.7	6115	3.7	5549
SPCH-9	-0.66	3203	-0.96	5882	-2.46	6380	-2.46	4950	0.74	5418
SPCH-10	0.3	5882	-0.2	5416	-0.4	6095	0.5	5591	1.5	5288
SPCH-11	0.7	5242	-0.1	2038	0.8	5411	1.4	5067	4.7	6854
SPCH-12	0.2	6465	0.4	5940	0	6323	0	6406	-1.1	5484
SPCH-13	-0.65	6266	-0.65	5649	-0.95	6323	-0.35	6057	-0.35	5222
SPCH-14	0	6465	0.4	6406	0	4044	0.9	5824	0.8	5353
SPCH-15	0.2	6115	0	5242	-0.3	4671	-0.9	4717	2.5	6528
SPCH-16	-0.2	5824	-0.1	6406	-0.7	6607	-2.1	6406	1.3	6920
SPCH-17	-2.6	6266	-3.1	5009	-2.6	6550	-3.3	5358	0	4700
SPCH-18	-2.9	4426	-2.1	5067	-3.2	5411	-3.1	4368	0.3	5092
SPCH-20	_	_	_	_	_	_	_	_	_	_
SPCH-21	0.1	3669	_	_	_	_	_	_	_	_
SPCH-22	1.4	4659	0.9	5009	-0.5	4426	0.4	5067	3.2	5222
SPCH-23	0.5	5824	0.7	4310	-0.4	6057	-0.6	5649	0.4	5418
SPCH-24	1.5	3203	0.6	1048	0.8	3320	-0.9	3960	2.2	3395
SPCH-25	0.07	5824	-0.63	3960	-0.53	6057	0.07	5824	1.77	4961
SPCH-26	-0.62	2330	-0.82	3261	_	_	-0.92	4950	2.08	5027
SPCH-27	-0.4	5242	0	5999	-0.5	5009	0	5009	_	_
SPCH-28	-2.12	4543	_	_	_	_	_	_	_	_
SPCH-29	0.4	3553	0.3	4019	-0.3	6057	0.1	5242	1.7	5027
SPCH-30	-2.19	5242	-2.99	5591	-2.29	5591	-0.89	5475	0.41	5484
SPCH-31	0.3	4776	-0.5	5067	-0.3	5242	0.7	5533	3.2	5092
SPCH-32	-2.83	4892	_	_	_	_	_	_	_	_
SPCH-33	-1.47	3844	-1.67	3786	_	_	0.03	5475	1.93	5157
SPCH-34	-2.95	5125	-2.25	6290	-3.25	5649	-1.95	4950	-1.25	5157
SPCH-35	-1.9	4252	-2	6406	-2.5	5009	-1.7	5824	1.1	6528

4.7.4 AGRICULTURE

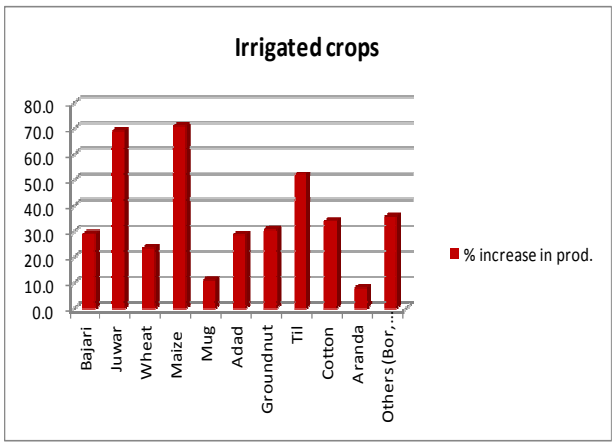
Agriculture seems to have been benefited most in villages falling under the Sheel bandhara due to groundwater recharge as well as irrigation available post the bandhara construction. This is evident from a 96 per cent increase in area under un-irrigated crops and an 81 per cent increase in area under irrigated crops. Also in the same district, the Vadodara Zala tidal regulator has led to a 33 per cent rise in area under irrigated crops. Overall at the district level, the salinity prevention structures have resulted in a 90 per cent and 200 per cent increase respectively in the area under un-irrigated and irrigated foodgrain crops and an 8 per cent and 100 per cent increase respectively in the area under un-irrigated and irrigated oilseed crops.

The more visible effect of the schemes has been on crop production. This is evident from Tables 4.24 and 4.25 where irrigated crops like juwar, maize and til and un-irrigated crops like bajri,

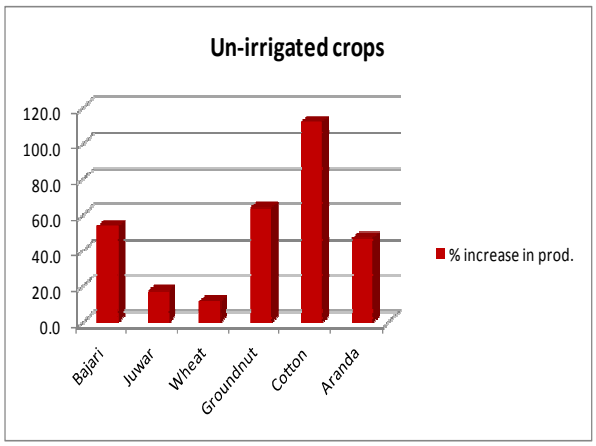
groundnut and cotton have shown an increase in production of more than 50 per cent post the scheme. Another significant change that has come about after the schemes is the change in cropping pattern in that a number of crops like maize, mug, adad, til, bor and sheradi which were earlier not grown in this area have started to be cultivated.

Table 4.24 Impact on agriculture production – irrigated crops

Sr. No.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	2451	3168	29.3
2	Juwar	192	325	69.3
3	Wheat	6343	7874	24.1
4	Maize	38	65	71.1
5	Mug	18	20	11.1
6	Adad	31	40	29.0
7	Groundnut	3077	4024	30.8
8	Til	105	160	52.4
9	Cotton	1522	2047	34.5
10	Aranda	496	537	8.3
11	Others (Bor, sheradi etc.)	467	636	36.2



(A)



(B)

Fig 4.46 Percentage Increase in Area Under Irrigated (A) and Un-irrigated (B) Crops

Table 4.25: Impact on Agriculture Production – Un-irrigated Crops

Sr. No.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	117	180	53.8
2	Juwar	69	81	17.4
3	Wheat	51	57	11.8
4	Groundnut	1489	2439	63.8
5	Cotton	41	87	112.2
6	Aranda	17	25	47.1

4.7.5 SITUATION OF WOMEN

As far as impact of the salinity prevention structures on women in Junagadh district is concerned, the most significant change reported by women is availability of drinking water in their village. Even as the drudgery of fetching a heavy load of water from outside the village has been eliminated, women have been able to save a significant amount of time to attend to household chores and children as well as take up agriculture labour or other work in the village which has helped increase household incomes.

Due to improved availability of water for agriculture, agriculture productivity has increased, wage rates have gone up and horticulture has been encouraged. Also, Migration from the village has come down since people can now find work in the village itself. Women, especially in Lati and Bamanwada villages of Junagadh have started growing vegetables at home. Many of them have started saving since they have become a member of SHGs in their village. Some of them have also become members of the village Pani Samitis which has helped increase their confidence and awareness levels. Increasingly, women are able to influence decisions related to crops and milch animals within the household as well as outside home by discussing problems and their resolution with the Sarpanch of the village.

5. SOCIO-ECONOMIC IMPACT IN PORBANDAR DISTRICT

There are five structures selected for socio-economic impact viz., (01) Ozat Madhuvanti canal; (02) Karli tidal regulator; (03) Barda Sagar; (04) Karlicreek Kindricreek canal and (05) Medhacreek tidal regulator. All the structures are located in Porbandar block only. (Fig. 5.1)

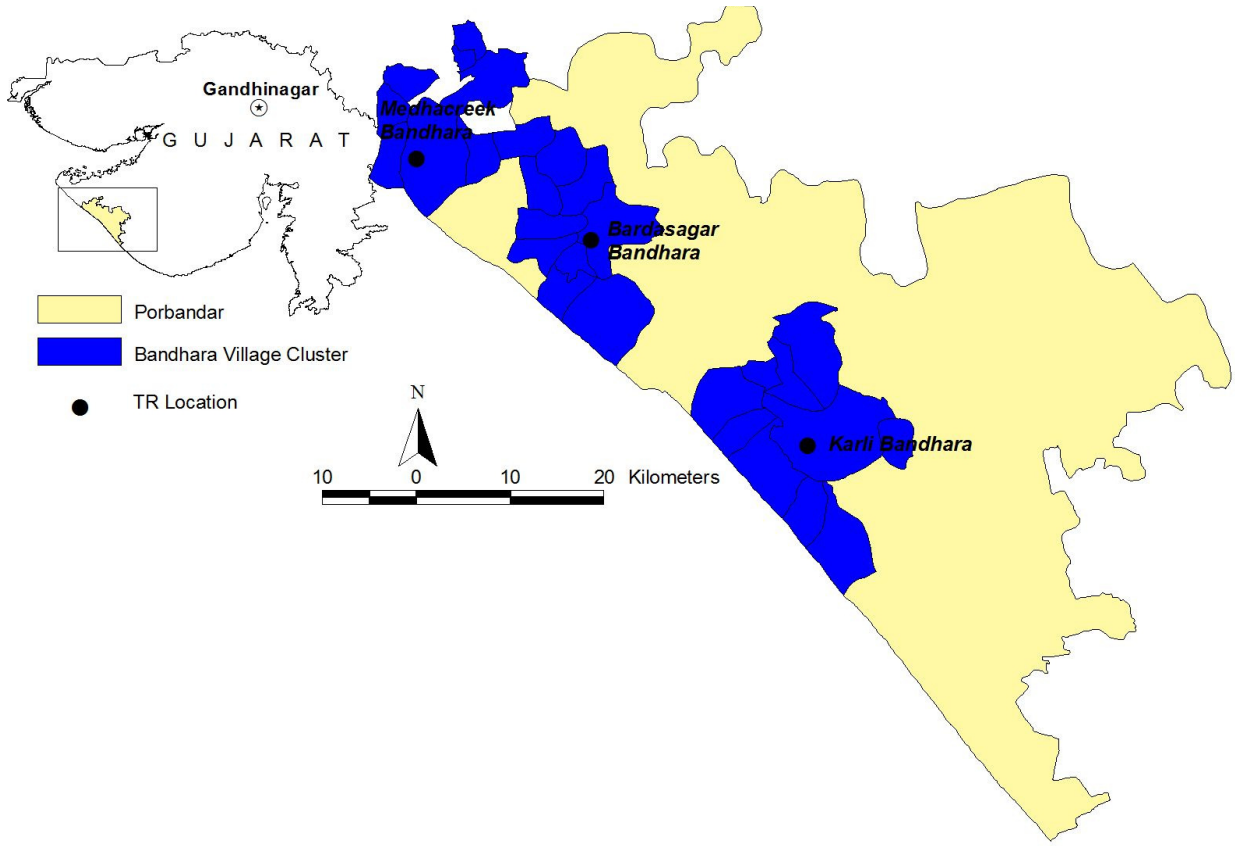


Fig 5.1 Location of Salinity Prevention Structures in Porbandar District

5.1 OZAT MADHUVANTI CANAL

5.1.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephones, vehicle and toilet remain the predominant assets acquired in the case of Ozat Madhuvanti canal as well, with 37 per cent, 34 per cent and 17 per cent of total surveyed families respectively reporting acquisition of these assets post construction of the canal as can be seen from Fig. 5.2 (A).

Very few families seem to have reported impact on income sources post the scheme. Out of these, selling milk is the predominant source of additional income after the construction of the canal with 73 per cent of the reporting households having income from this source (Fig. 5.2 B).

A majority of families (20 per cent) benefitting from the Ozat canal have invested the additional income on accessing irrigation facility in order to improve their agricultural productivity. Other significant investments have been on house renovation, land improvement, purchase of milch animals and on getting toilet/tap connection in their house (Fig. 5.2 C).

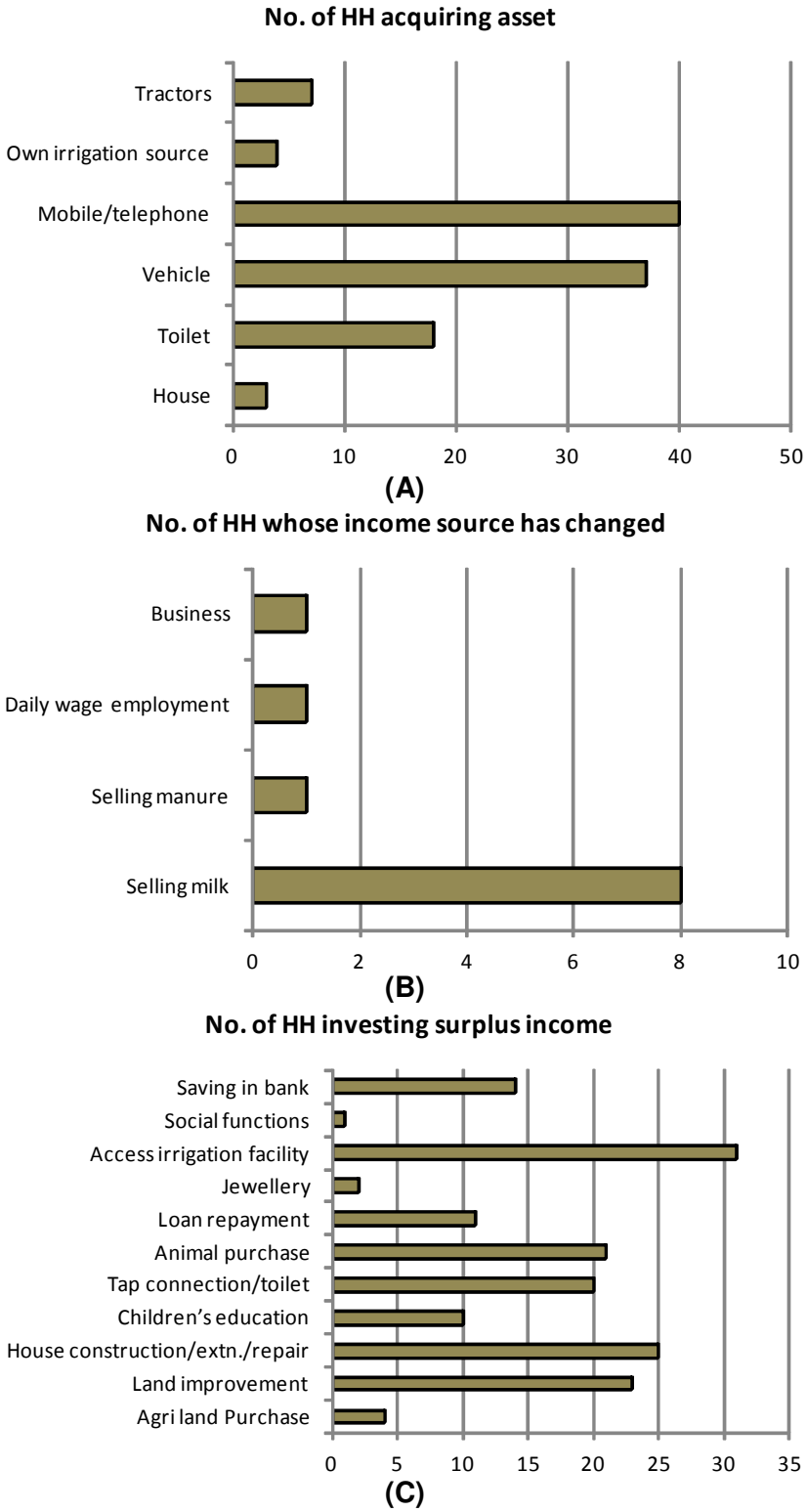


Fig 5.2 Impact on Assets (A), On Income Source (B) and Investment of Surplus Income (C) in Area Around Ozat Madhuvanti Canala

5.1.2 FODDER, LIVESTOCK AND MILK PRODUCTION

No improvement has been found in green or dry fodder availability in villages affected by the Ozat Madhuvanti canal. As a result, there has been only a modest increase in the number of cows and buffaloes in these villages as shown by Fig. 5.3. Still, milk production cows and buffaloes has risen

by 27 per cent and 48 per cent respectively. Also, improved agriculture has led to a nearly 70 per cent increase in bullocks.

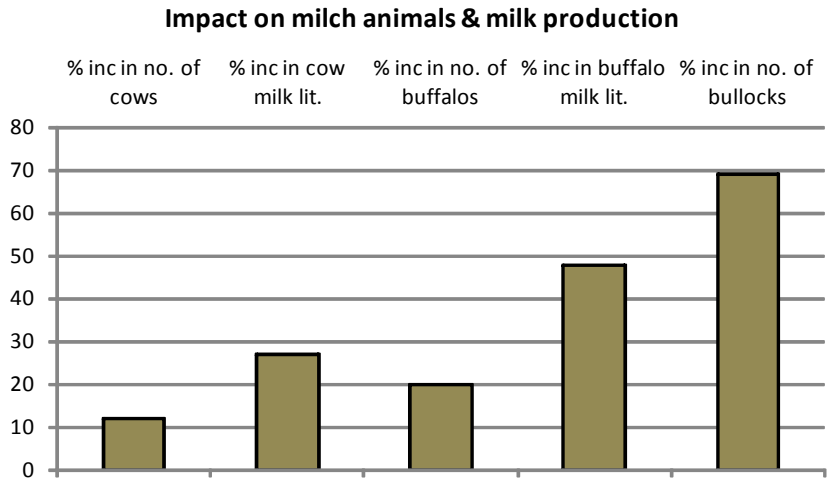


Fig. 5.3: Impact on Milch Animals and Milk Production in Ozat Madhuvanti

5.1.2 GROUNDWATER AVAILABILITY AND QUALITY

Changes in water level and quality have understood through people's point of view and by computing hydrographs of monitored water level and quality data by SIPC. As per people's experience largely, no change in the groundwater situation can be seen before and after construction of the canal as reported by 80 per cent of the surveyed households (see Fig. 5.4 A). A few households (18 per cent) however have found the water table height increasing by upto 25 feet post the scheme.

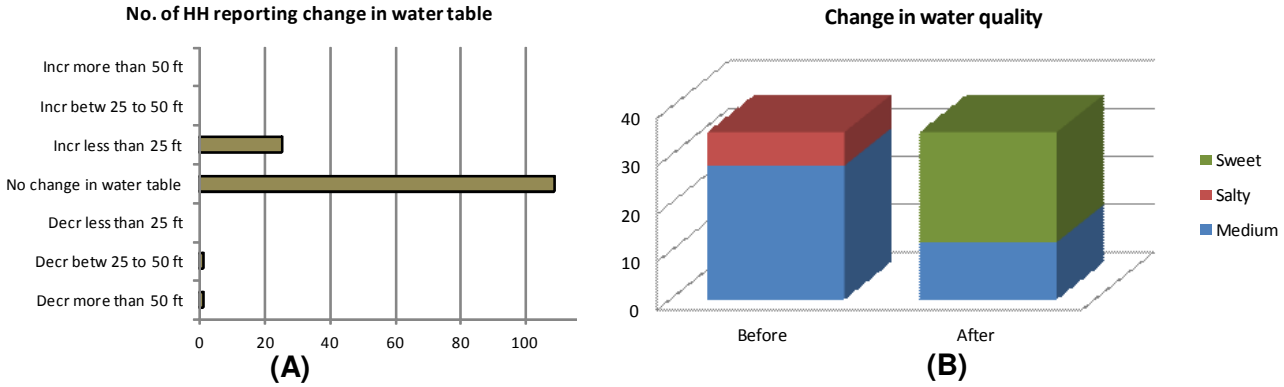


Fig. 5.4: Change in Water Table (A) and Water Quality (B) in Ozat Madhuvanti

From not even a single family receiving sweet water before the scheme, 66 per cent of the sampled families started receiving sweet water after the scheme. This change has been accompanied by a corresponding decline in the number of families getting medium quality water while the incidence of salty water has been completely eliminated post the scheme as seen from Fig. 5.4 (B).

There are about six observation wells have monitored by SIPC in village Mocha (2 wells), Bhesana (1 well) and in Ratia (3 Wells). Based on observed static water levels (Table 5.1 and 5.2) first of all reduced water levels were computed than hydrograph for RWL and TDS were prepared to understand changes taking place due to canal. (Fig. 5.5 and 5.6) It is important to clarify that the data were available for limited period i.e. from 1980 to year 2004 and year 2011.

Table 5.1 Pre and Post Monsoon Changes in Reduced Water Levels in Observation Wells Around Ozat Madhuvanti Canal

Year	Season	Reduced Water Levels (M)					
		MP-27 Mocha	MP-28 Bhesana	MP-29 Mocha	MP-30 Ratia	MP-31 Ratia	MP-32 Ratia
1980	Pre	4.15	6.5	1.8	2.3	5.1	3.1
	Post	---	---	---	---	---	---
1995	Pre	2.30	1.21	0.37	-1.07	1.29	0.98
	Post	2.40	1.41	0.47	-0.87	1.34	0.98
1996	Pre	2.00	1.11	0.22	-1.07	1.09	0.93
	Post	2.60	1.61	0.67	-0.87	1.09	1.08
1997	Pre	2.20	1.51	0.37	-0.92	0.99	0.78
	Post	2.60	1.71	0.62	-0.47	1.34	1.08
1998	Pre	2.35	1.21	0.47	-0.62	1.29	0.83
	Post	3.70	2.01	1.02	-0.37	1.59	1.23
1999	Pre	2.50	1.46	0.57	-0.47	1.39	0.98
	Post	2.30	1.11	0.37	-0.67	1.19	0.78
2000	Pre	2.10	1.11	0.37	-0.57	1.24	0.78
	Post	2.30	1.31	0.42	-0.62	1.29	0.78
2001	Pre	2.15	1.21	0.32	-0.67	1.19	0.73
	Post	2.00	1.11	0.32	-0.87	0.99	0.48
2002	Pre	2.10	1.01	0.27	-0.67	1.09	0.73
	Post	2.10	1.11	0.27	-0.57	1.29	0.78
2003	Pre	2.00	1.01	0.17	-0.67	1.19	0.68
	Post	3.00	2.21	0.47	-0.57	1.39	1.08
2004	Pre	2.50	1.41	0.42	-0.87	0.79	0.98
	Post	2.80	1.51	0.57	-0.37	1.49	1.03
2009	Pre	2.80	---	---	-0.17	---	---
	Post	3.60	---	---	0.08	---	---
2011	Pre	---	---	---	-0.17	---	---
	Post	---	---	---	0.43	---	---

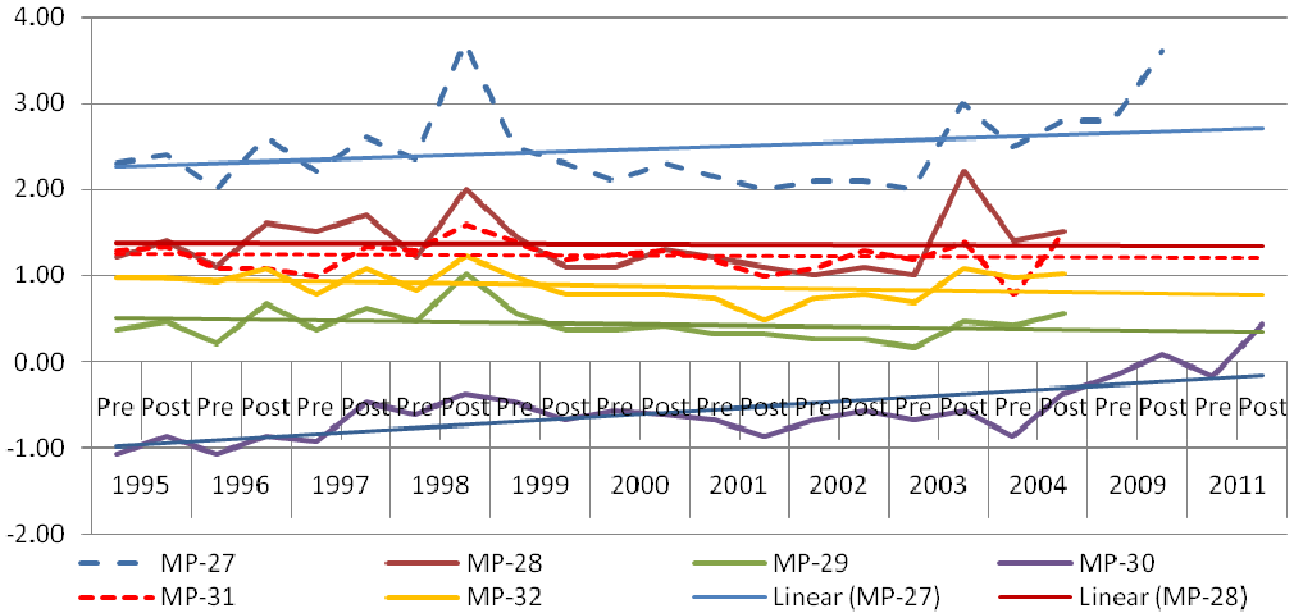


Fig 5.5 Well Hydrograph Showing Changes in Water Levels in Observations Wells Around Ozat – Madhuvanti Canal

Table 5.2 Pre and Post Monsoon Changes in Concentrations in TDS in Observation Wells Around Ozat Madhuvanti Canal

Year	Season	TDS (PPM)					
		MP-27	MP-28	MP-29	MP-30	MP-31	MP-32
1980	Pre	3220	2320	980	2180	2320	5040
	Post	---	---	---	---	---	---
1995	Pre	4480	3960	4220	7040	8320	8960
	Post	6300	4020	3960	7040	7680	4280
1996	Pre	5120	3840	6400	8960	8320	7040
	Post	5760	4160	5760	7680	7680	5440
1997	Pre	4800	4680	6400	7680	8960	7680
	Post	6400	6400	5760	8960	9600	11760
1998	Pre	4640	4540	6320	7960	8700	9760
	Post	4040	4280	4800	5000	1980	8320
1999	Pre	5120	5440	5760	7040	8960	9600
	Post	5240	4920	5760	8320	6400	8960
2000	Pre	5440	4740	5000	8700	9480	7880
	Post	4740	4420	4280	8320	8320	11260
2001	Pre	4480	5120	7040	9600	10240	8960
	Post	5760	5120	5120	7680	7680	8320
2002	Pre	3840	5440	5760	9400	10440	10880
	Post	7680	7040	7680	8000	8960	9600
2003	Pre	6400	6400	7040	9600	10240	9600
	Post	6280	7040	8960	10560	11000	3780
2004	Pre	6390	8490	8350	10640	11440	9720
	Post	7090	7080	7240	10180	10580	7610
2009	Pre	4800	---	---	7870	---	---
	Post	1350	---	---	8170	---	---
2011	Pre	---	---	---	2860	---	---
	Post	2070	---	---	2500	---	---

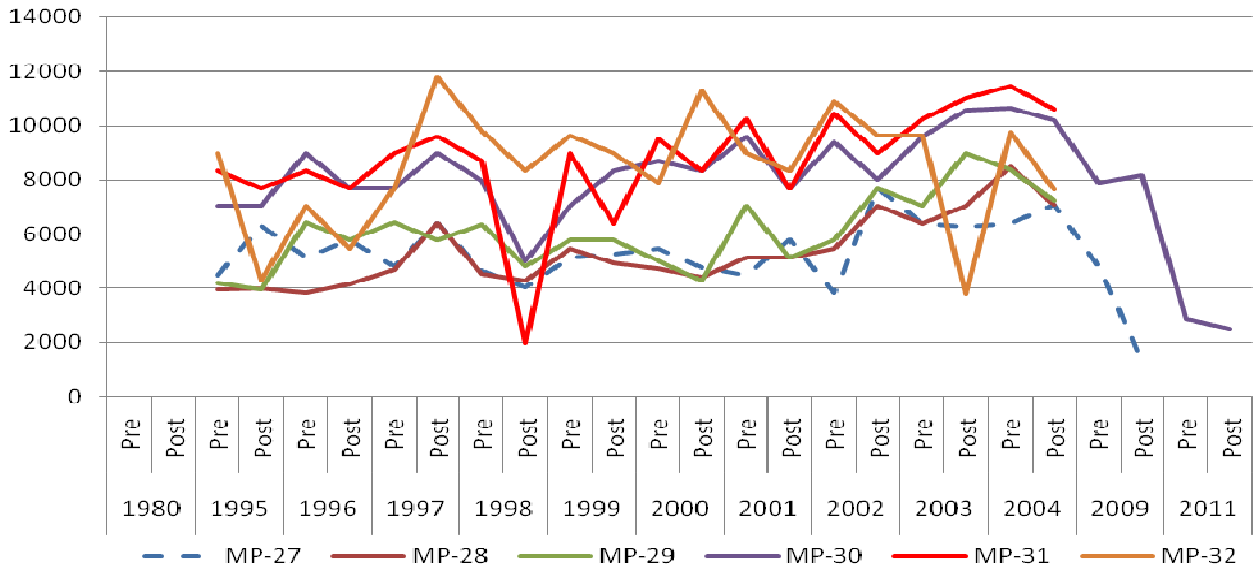


Fig 5.6 Well Hydrograph Showing Changes in Total Dissolved Solids in Observations Wells Around Ozat – Madhuvanti Canal

Well hydrograph of observation well no. MP – 27 village Mocha and MP – 30 of Ratia village shows rise in water levels where remaining all well hydrographs show very negligible no change in water levels in area.

As far as concentration of Total dissolved solid is concerned well hydrograph of all wells up to year 2004 show gradual increase. However, wells MP – 27 of Mocha village and MP – 32 Ratia village whose data were available for year 2011 shows there is sudden decrease in TDS value from year 2009. According to people of the area the declining in TDS is due to good rainfall along with canal construction. At the time of present study due to very low rainfall last year the water levels in the wells have gone down so it is difficult to assess water quality in rain scarce period even after canal excavation.

5.2 KARLI TIDAL REGULATOR

5.2.1 ASSETS, INCOME AND INVESTMENTS

In terms of assets acquired post the construction of the Karli tidal regulator, mobile telephone has been reported by 39 per cent of surveyed households followed by vehicle by 31 per cent households and toilet by 19 per cent of the households (Fig. 5.7).

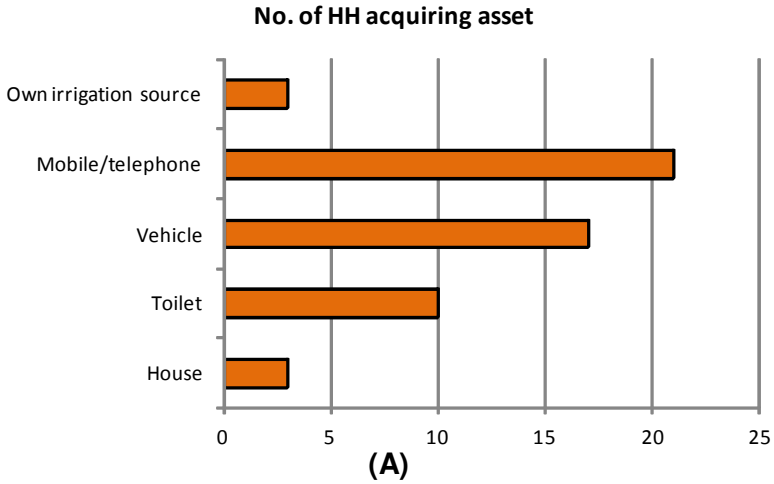


Fig 5.7 Impact on Assets in Karli

The limited impact that the scheme has had on income sources of families is evident from the extremely small sample of households reporting change as can be seen in Fig. 5.8 (A). However, Karli is one of the rare cases where more number of households have reported getting additional income from selling manure than from selling milk. Even so, considering the small size of the sample, it may not be possible to draw any firm conclusions.

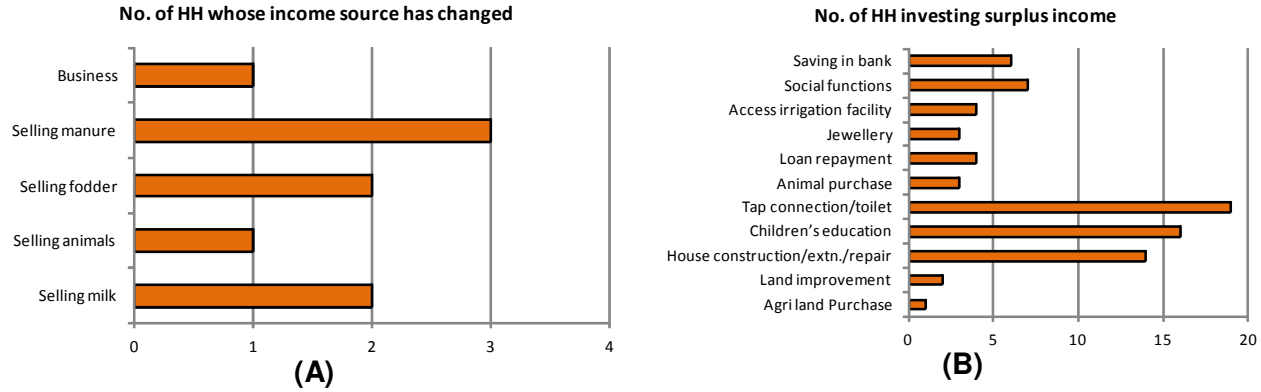


Fig 5.8 Impact Income Source (A) and Investment of Surplus Income (B) in Karli

The additional income generated has been invested by most households on getting a toilet or tap connection in their house, followed by children's education and house renovation (Fig. 5.8 B).

5.2.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 5.3: Impact on fodder availability due to agriculture, Karli TR

Impact	Quantity
Increase in Green Fodder (%)	70
Increase in Dry Fodder (%)	38
Increase in Cow dung (%)	0

Green fodder availability has shown a huge 70 per cent increase in villages under Karli TR while dry fodder availability has also increased by a robust 38 per cent (Table 5.3).

Better fodder availability has however not been able to lead to a corresponding increase in the number of milch animals or milk production as shown by Fig. 5.9.

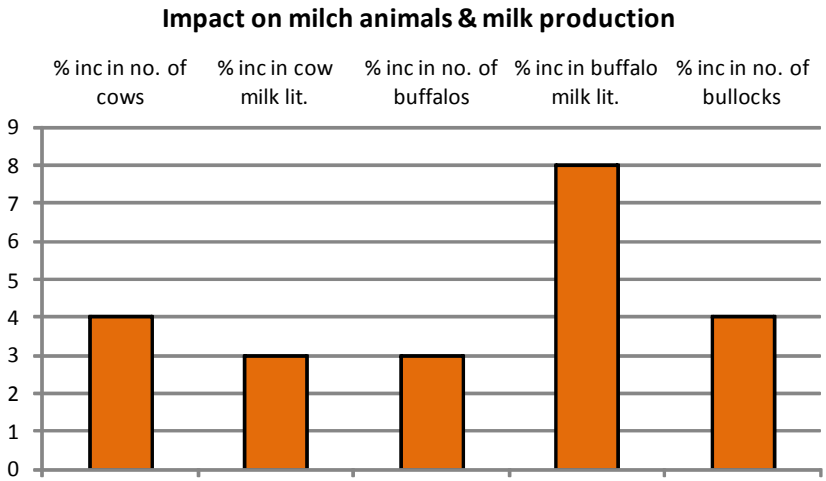


Fig. 5.9: Impact on milch animals and milk production in Karli

5.2.3 GROUNDWATER AVAILABILITY AND QUALITY

Similar to other TRs impact of Karli TR has also assessed by two methods viz., people's view and by analysing monitored data. According to people's view the Karli TR has failed to make a significant impact on water table in the affected villages with 87 per cent of surveyed households reporting no change in groundwater levels post the scheme (Fig. 5.10 A). However, 11 per cent of the households have reported a rise in water tables by anything from less than 25 feet to over 50 feet.

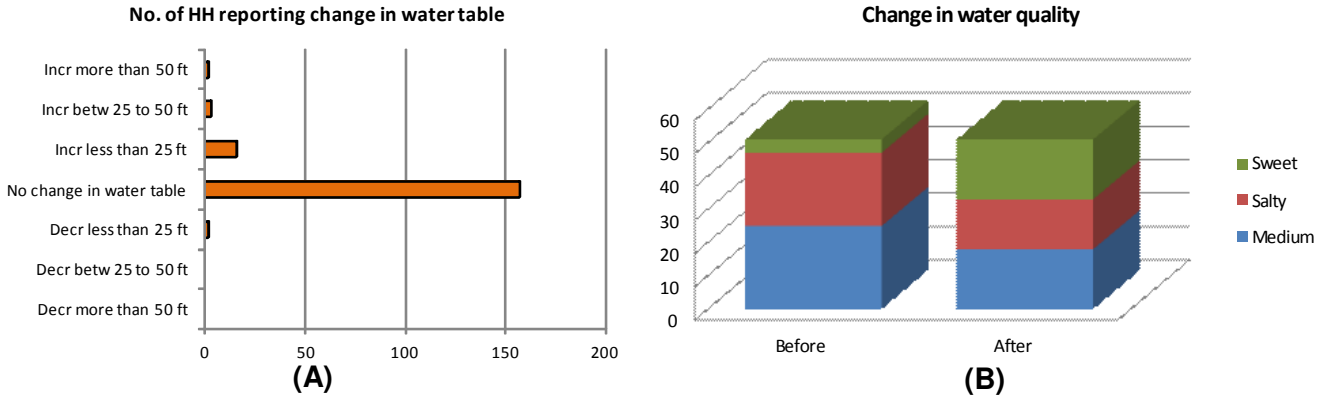


Fig 5.10 People's View on Change in water table (A) and Water Quality (B) in Karli

Sweet water availability has shown an encouraging trend post the scheme. From a mere 8 per cent of the sampled families receiving sweet water before the scheme, 35 per cent of families

started receiving sweet water after the scheme. The incidence of salinity also declined from 43 per cent to 29 per cent as can be seen from Fig. 5.10 B.

SIPC monitors about eight wells in surrounding villages of Karli TR. There are total 03 wells in Tukda, o4 wells in Ratanpur and 01 well under monitoring. (Table 5.4) Monitored static water levels has been converted into reduced water levels and than hydrograph for the RWL have computed for all the wells. (Fig. 5.11)

Table 5.4 Pre and Post Monsoon Changes in Reduced Water Levels in Observation Wells Around Karli TR

Year	Season	Reduced Water Level (M)							
		Tukda			Ratanpur				Chhaya
		K-26	K-27	K-29	MP-40	MP-41	MP-42	MP-43	MP-44
1980	Pre	0.00	0.05	1.85	-2.27	-0.63	6.99	3.51	2.08
1995	Pre	0.00	-0.60	-2.90	-3.52	-1.08	5.64	4.76	2.78
	Post	0.10	-0.50	-1.70	-2.97	-0.73	5.94	4.91	2.88
1996	Pre	0.10	-0.50	-2.70	-3.77	-1.33	5.64	4.61	2.63
	Post	0.10	-0.55	-2.80	-2.97	-0.73	5.94	4.91	2.88
1997	Pre	0.00	-0.60	-3.00	-3.67	-1.33	5.54	4.71	2.78
	Post	0.75	-0.20	0.80	-2.32	-0.33	6.34	5.16	2.98
1998	Pre	0.10	-0.45	-1.00	-3.32	-1.08	5.64	4.81	2.63
	Post	0.35	0.00	0.70	-1.57	0.52	7.14		3.28
1999	Pre	0.30	-0.25	-0.40	-3.02	-0.83	5.94	4.91	3.03
	Post	-0.40	-0.55	-4.00	-3.67	-1.28	5.64	4.71	2.78
2000	Pre	0.05	-0.55	-4.40	-3.92	-1.58	5.24	4.51	2.78
	Post	0.30	-0.40	-0.80	-3.27	-1.03	5.74	4.86	2.88
2001	Pre	0.20	-0.50	-1.80	-3.77	-1.48	5.34	4.61	2.78
	Post	0.40	0.90	1.00	-2.67	-0.63	6.04	5.01	2.88
2002	Post	-0.40	-0.50	-4.20	-3.27	-0.83	5.84	4.91	2.88
2003	Pre	-20.50	-11.10		-3.67	-1.33	5.44	4.61	2.78
	Post	-0.40	0.00	0.20	-2.07	-0.03	6.54	5.21	2.88
2004	Pre	-18.50	-14.90	-14.70	-3.37	-1.03	5.74	4.76	2.68
	Post	-0.40	-0.30	-0.80	-2.82	-0.63	6.09	5.01	2.98
2011	Pre								2.58

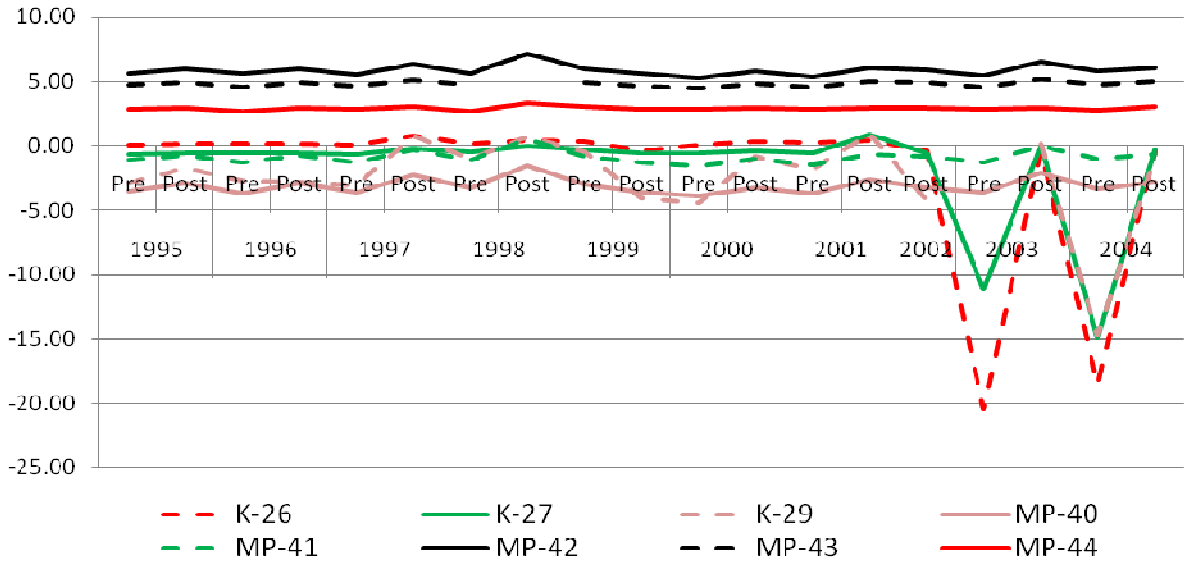
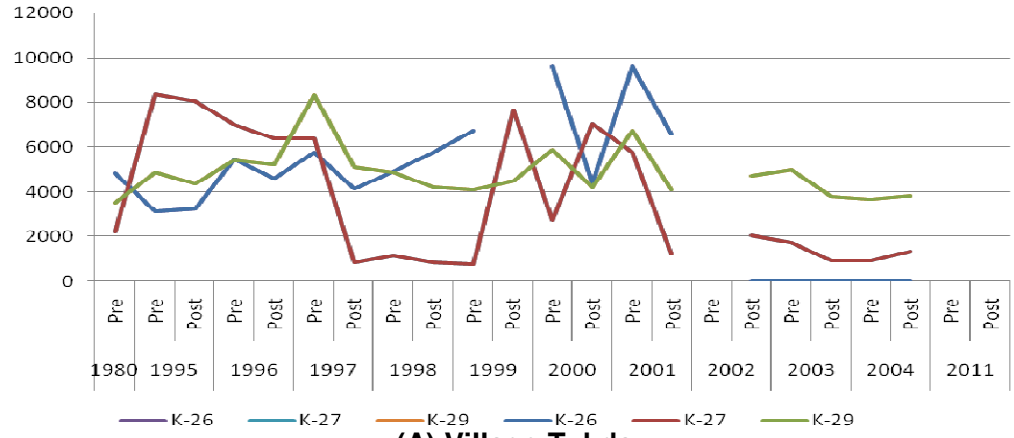


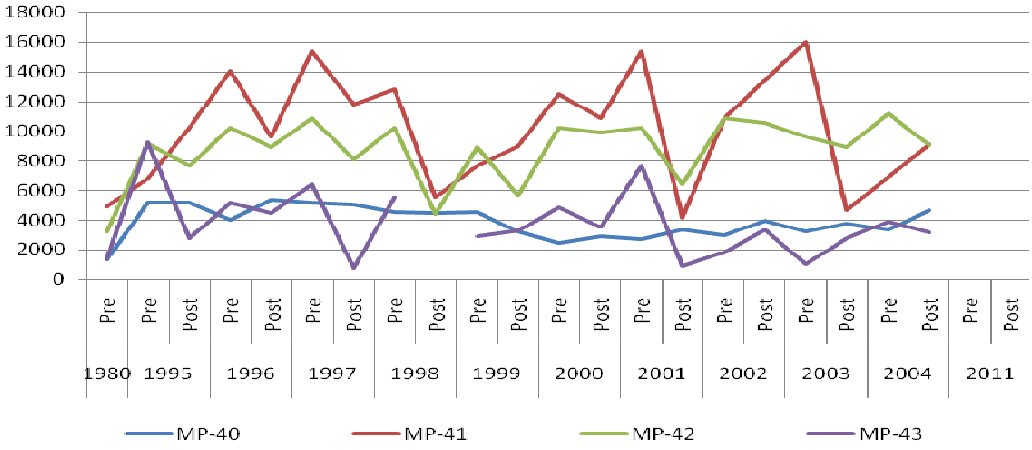
Fig 5.11 Well Hydrograph Showing Changes in Water Levels in Observations Wells Around Karli TR

Well hydrographs for RWL clearly supports people's view of negligible impact of Karli TR on water levels. Water levels in most of the wells shows almost steady trend of water level fluctuation. Only two wells i.e. K – 26 and K – 27 of Tukada village show more water level fluctuation especially after year 2003 however, the water level in these wells is below AMSL. (Fig. 5.11)

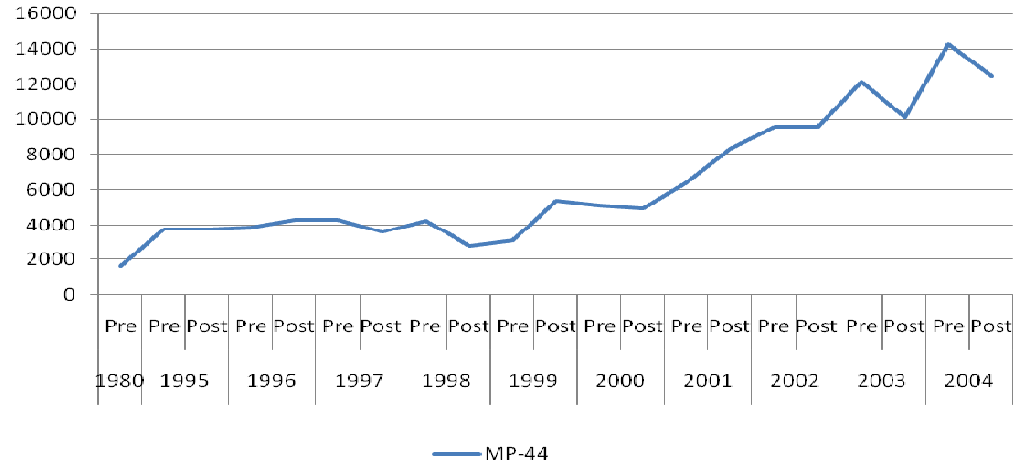
Another village wise hydrographs have prepared for fluctuation in concentration of Total Dissolved Solid in groundwater in these wells. (Fig. 5.12)



(A) Village Tukda



(B) Village Ratanpar



(C) Village Chhaya

Fig 5.12 Well Hydrograph Showing Fluctuation in Concentrations of Total Dissolved Solids in Villages Surrounding the Karli TR

Well hydrograph for TDS concentration again supports people's view for all villages. In case of Chhaya it shows gradual rise in TDS concentrations whereas in Tukada and Ratanpar village it shows very negligible decrease in TDS. It is important clarification here that this is a status of year 2004. Table 5.5 shows well wise TDS concentrations in Tukada, Ratanpur and Chhaya villages.

Table 5.5 Pre and Post Monsoon Changes in Concentrations in TDS in Observation Wells Around Karli TR

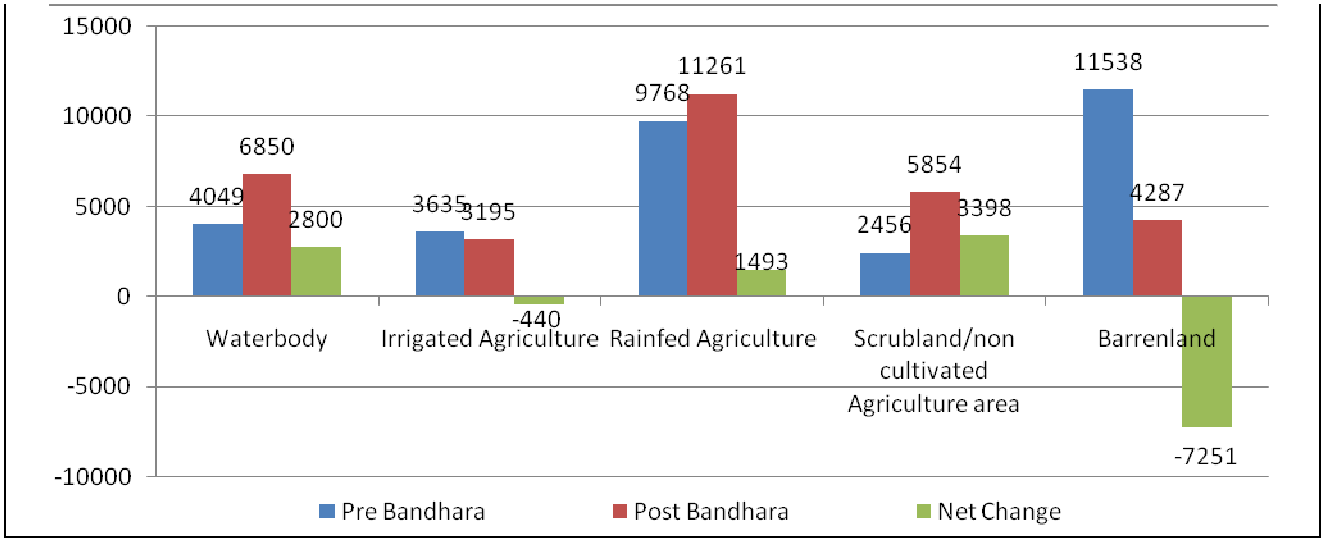
Year	Season	TDS (PPM)							
		Tukda			Ratanpur				Chhaya
		K-26	K-27	K-29	MP-40	MP-41	MP-42	MP-43	MP-44
1980	**Pre**	4840	2240	3520	1340	4900	3220	1400	1620
1995	**Pre**	3140	8380	4860	5120	6780	9160	9220	3720
	Post	3260	8060	4360	5120	10240	7680	2760	3720
1996	**Pre**	5440	7000	5400	4040	14080	10240	5120	3840
	Post	4600	6400	5240	5320	9600	8960	4480	4280
1997	**Pre**	5760	6400	8320	5120	15360	10880	6400	4280
	Post	4160	840	5120	5020	11820	8120	760	3600
1998	**Pre**	4920	1160	4860	4500	12820	10260	5540	4240
	Post	5760	840	4220	4480	5560	4420	---	2760
1999	**Pre**	6720	760	4100	4540	7680	8960	2880	3080
	Post	---	7680	4480	3200	8960	5640	3260	5380
2000	**Pre**	9600	2760	5880	2440	12480	10240	4860	5120
	Post	4420	7040	4220	2880	10880	9920	3520	4920
2001	**Pre**	9600	5760	6720	2680	15360	10240	7680	6400
	Post	6600	1220	4100	3320	4160	6400	900	8320
2002	**Pre**	---	---	---	2940	10880	10880	1840	9600
	Post	---	2040	4720	3960	13440	10560	3320	9600
2003	**Pre**	---	1720	5000	3200	16000	9600	1020	12160
	Post	---	900	3780	3780	4680	8960	2760	10120
2004	**Pre**	---	900	3680	3320	6920	11200	3920	14270
	Post	---	1360	3820	4620	9140	9080	3160	12470
2011	**Pre**	---	---	---	---	---	---	---	2850

5.2.4 LANDUSE

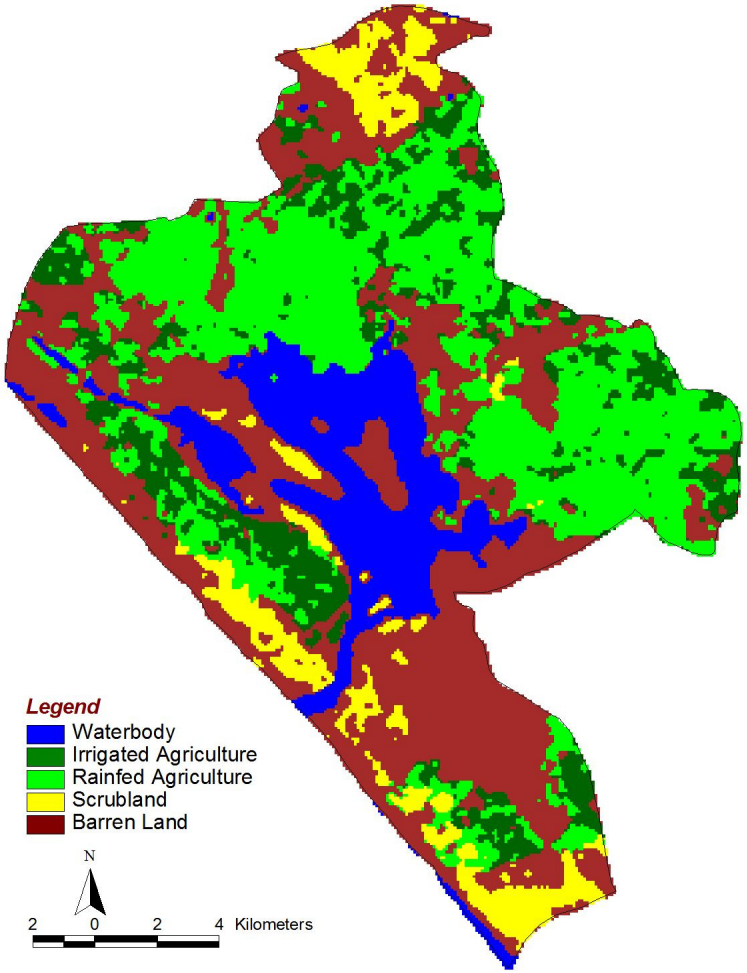
Landuse pattern around Karli Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1992 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 5.6)

Table 5.6 Landuse Pattern Around Bardasagar Bandhara

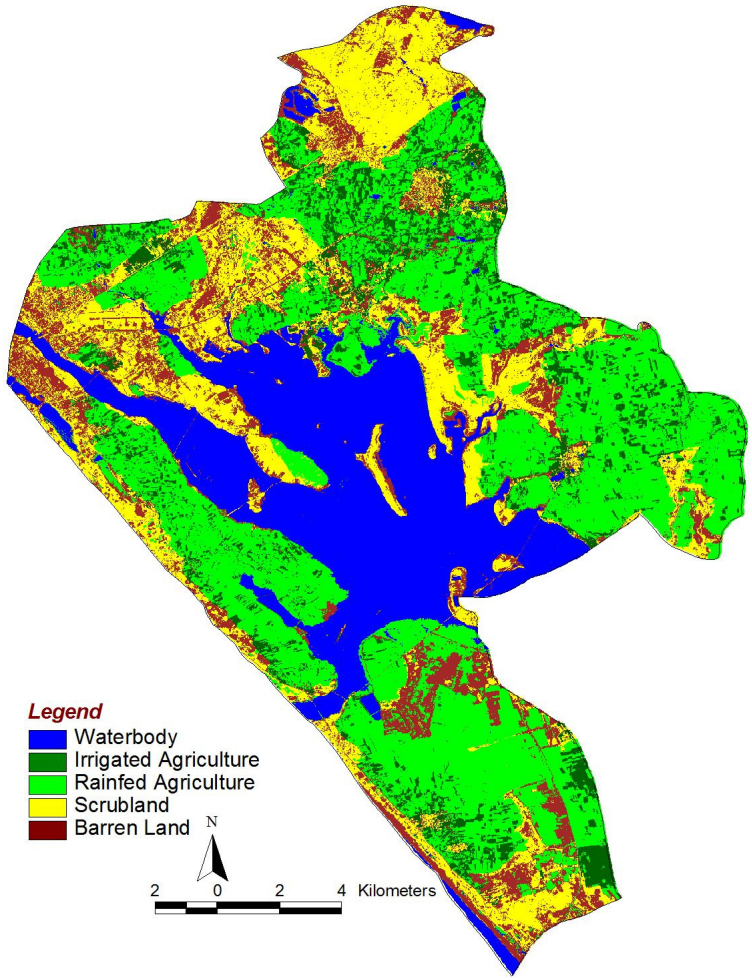
Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	4049	6850	2800
Irrigated Agriculture	3635	3195	-440
Rain fed Agriculture	9768	11261	1493
Scrubland/non cultivated Agriculture area	2456	5854	3398
Barren land	11538	4287	-7251
Total	**31446**	**31446**	0



Out of total analysed land area (31525 Ha) about 62 % area is categorized as agriculture land where all other areas such as water bodies, settlements, barren land and sea occupies about 38 percentages of total area is occupied by sea in surrounding area of Karli Bandhara. It is important to clarify that, pre and post bandhara construction changes in landuse pattern especially in irrigated agriculture areas was not possible to compute due to non availability of pre construction remote sensing data. (Table 5.6, Fig. 5.13)



Pre Construction



Post Construction

Source: NRSA LISS – III images (1992 and 2013)

Fig. 5.13 Landuse Pattern around Karli Bandhara Area

5.3 BARDA SAGAR

5.3.1 ASSETS, INCOME AND INVESTMENTS

Plot No.5.2 Information Collection with Villagers around Bardasagar Bandhara

Mobile telephones, toilet and vehicle are some of the main assets acquired post the construction of the Barda Sagar bandhara and have been reported by 42 per cent, 28 per cent and 19 per cent of the surveyed households respectively (Fig. 5.14 A).

Selling milk is the predominant source of additional income after the construction of the bandhara with 46 per cent of the households reporting income from this source (Fig. 5.14 B).

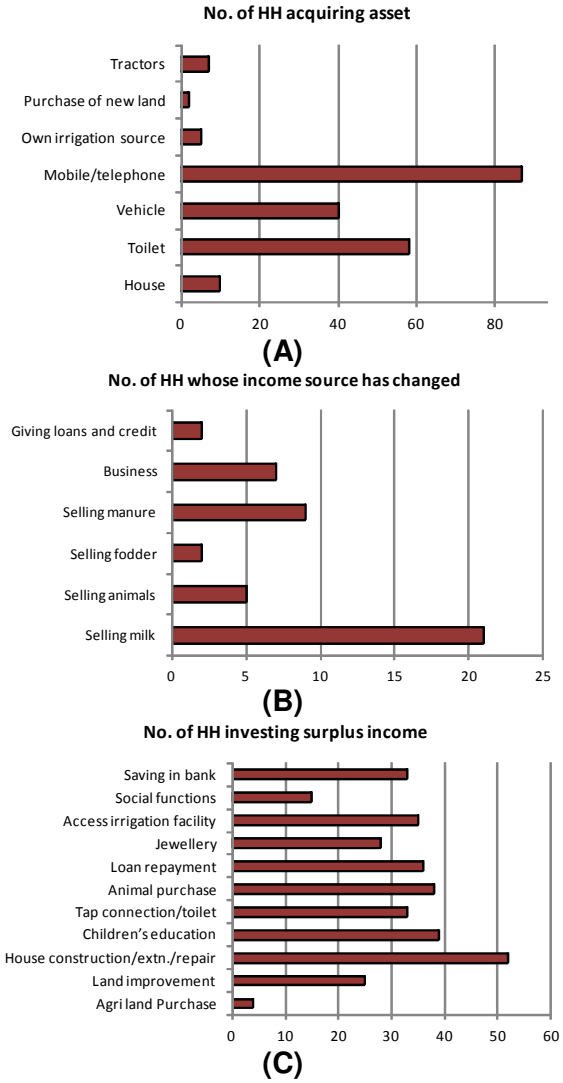


Fig. 5.14 Impact on Assets (A) Income Source (B) and Investment of Surplus Income (C) in Barda Sagar

This is followed by activities like selling manure and doing business. The surplus income generated has been invested in a wide variety of purposes which include house renovation, children's education, purchase of animals, repayment of existing loans and accessing irrigation facilities for their agricultural land (Fig. 5.14 C). A few households have also put this money aside as savings in a bank.

5.3.2 FODDER, LIVESTOCK AND MILK PRODUCTION

There has been no change in the fodder availability situation in villages under the Barda Sagar bandhara post the construction of the scheme. While this has negatively impacted the population of cows, milk production has not been affected, especially from buffaloes, which have seen a 60 per cent increase in their numbers after the scheme (Fig. 5.15).

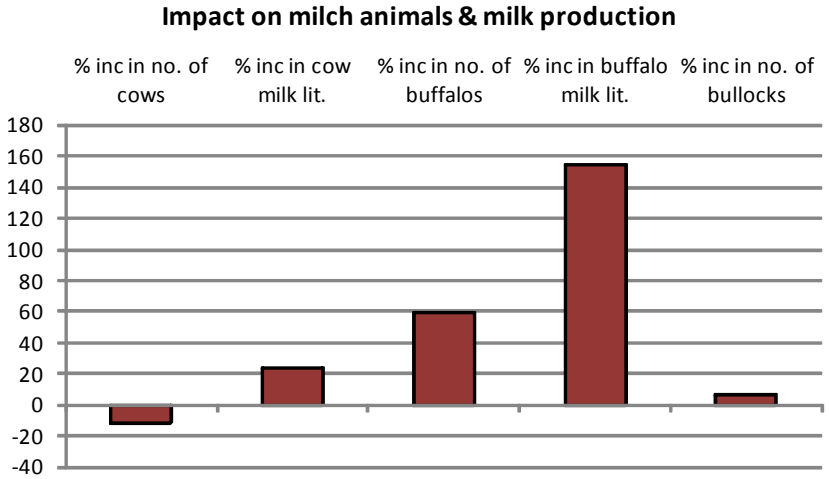
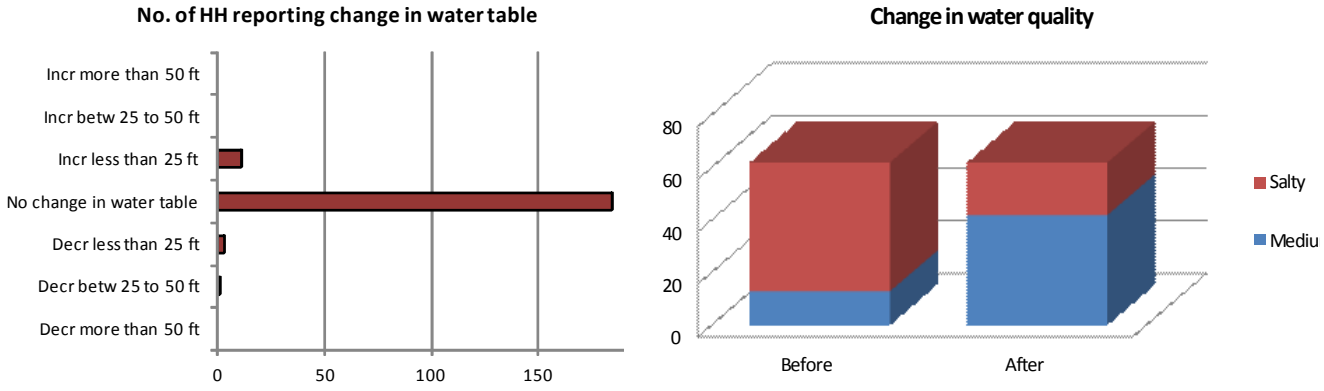


Fig. 5.15 Impact on milch animals and milk production in Barda Sagar

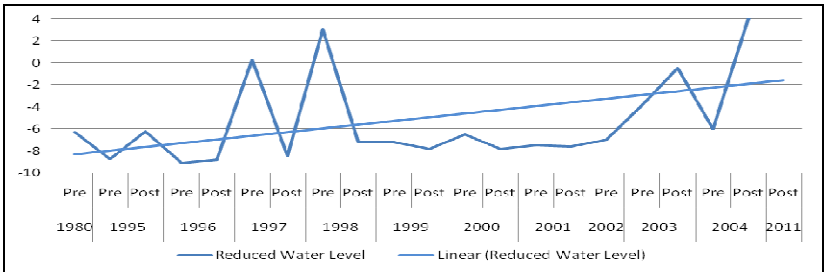
5.3.3 GROUNDWATER AVAILABILITY AND QUALITY

From People's point of view, nearly 93 per cent of the surveyed households reported no change in groundwater levels post the Barda Sagar bandhara while only a mere 5 per cent of households have experienced the water table rising by upto 25 feet (Fig. 5.16 A). Barda Sagar is perhaps the only scheme where households have not been able to get access to sweet water even after completion of the scheme. However, the proportion of families reporting salty water has declined from 70 per cent to 29 per cent while of those getting medium quality water has gone up from 19 per cent to 60 per cent as can be seen from Fig. 5.16 B.

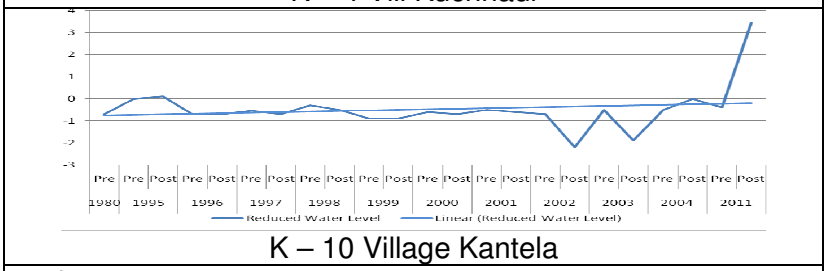


(A) **(B)**

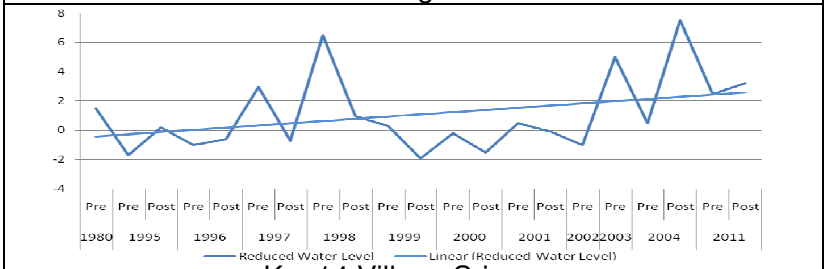
Fig 5.16 People's View on Change in Water Table (A) and Groundwater Quality (B) in Barda Sagar



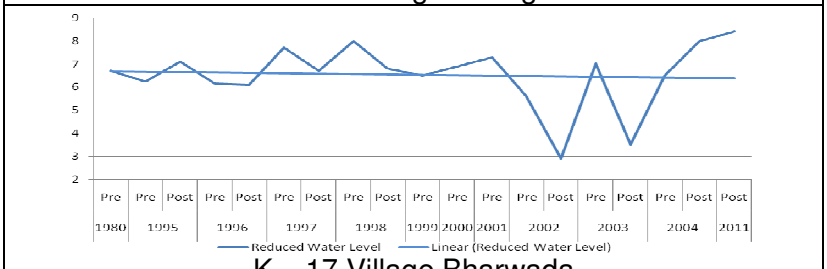
K – 4 Vill Kuchhadi



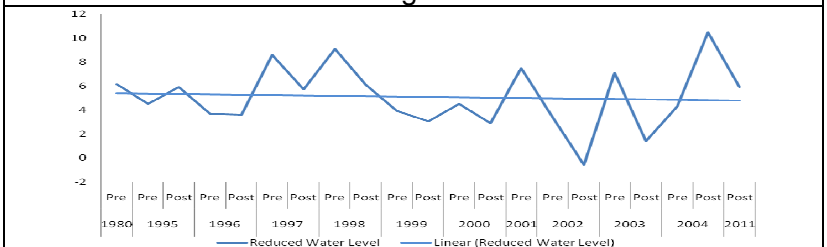
K – 10 Village Kantela



K – 14 Village Srinagar



K – 17 Village Bharwada



K – 19 Village Modhawada

Fig 5.17 Observation Wells Hydrograph for RWL around Bardasagar Bandhara

Another attempt have made to understand water level and water quality changes in Bardasagar Bandhara through analysis of water level and water quality data of SIPC. There are about 17 monitoring wells in different villages around bandhara. Monitoring wells are located in Kuchhadi (04 wells), Kantela (03 wells), Srinagar (02 wells), Bharwada (03 wells), Modhwada (03 wells) and Palakhada (02 wells) villages.

Details of monitoring of water levels and TDS are given in Table 5.7 and Table 5.8 respectively. Out of total wells village wise wells have been selected for hydrograph preparations such wells are K – 4 (Khuchhadi), K – 10 (Kantela), K – 14 (Srinagar), K – 17 (Bharwada) and K – 19 (Modhwada). Fig 5.17 and 5.18 are well hydrographs for RWL and TDS concentrations respectively. Well hydrograph prepared for Reduced Water levels shows in village Bharwada and Modwada water level depth is gradually decreases whereas in case of village Srinagar and Khuchadi the water level shows rising trends whereas water level in village Kantela still shows very less fluctuations.

Fig 5.18 is a well hydrograph for Total dissolved solid concentration that shows improvement in water quality due to decrease in TDS in wells of Kantela (K – 10) and Modhwada (K – 19) whereas in remains wells the TDS level shows less fluctuations even during good rainfall condition also.

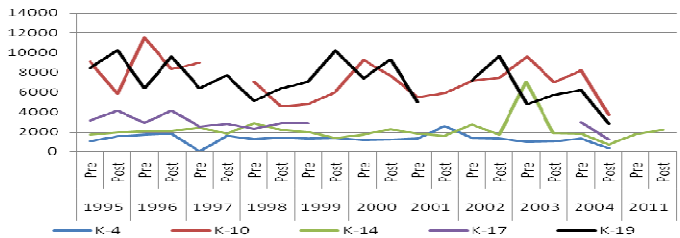


Fig. 5.18 Well Hydrograph Showing Changes in TDS around Bardasagar Bandhara

Table 5.7 Pre and Post Monsoon Changes in RWL in Observation Wells Around Bardasagar TR

Year	Season	Kuchadi				Kantela			Srinagar		Bharwada			Modhwada			Palakhada	
		K-1	K-2	K-3	K-4	K-10	K-11	K-12	K-13	K-14	K-16	K-17	K-18	K-19	K-20	K-34	K-21	K-23
1980	Pre	1.55	-0.3	-2.2	-6.3	-0.7	-2.3	0.15	6.6	1.5	3.6	6.7	5.15	6.15	2.25	8	1.7	-0.1
1995	Pre	-0.40	-0.30	-0.70	-8.8	0	-1.6	0	6.35	-1.7	0.4	6.25	-11	4.5	-0.4	3.2	-9.5	
	Post	-0.20	-0.20	-0.50	-6.2	0.1	-1.5	0	6.45	0.2	1.1	7.1	-6.2	5.9	3.2	4.2	-7	1.8
1996	Pre	-0.30	-0.30	-1.50	-9.1	-0.7	-1.6	0	6.3	-1	-0.1	6.15	-15	3.7	-1.6	2.2	-10	
	Post	-0.35	-0.30	-1.00	-8.8	-0.7	-1.6	0.05	6.3	-0.6	0	6.1	-21	3.6	-1.6	1.4	-11	-4.8
1997	Pre	-0.20	0.00	0.50	0.3	-0.6	-1.3	0.2	6.85	2.95	1.6	7.7	1	8.6	4.8	5.4	-3.5	0.8
	Post	-0.35	-0.30	-1.10	-8.5	-0.7	-1.5	0.05	6.5	-0.7	0.6	6.7	-9	5.7	0.2	4.8	-5.5	-1.3
1998	Pre	0.00	0.00	1.90	3.05	-0.3	-1.1	0.35	7.8	6.5	1.8	8	5.3	9.1	5.05	4.8	0.4	3.5
	Post	0.00	-0.15	-1.30	-7.2	-0.5	-1.4	-0.6	6.6	0.95	0.65	6.8	-4.1	6.1	1.6	4.1	-6.6	-0.8
1999	Pre	-0.30	-0.40	-0.90	-7.2	-0.9	-1.6	-0.9	6.5	0.3	0.4	6.5	-7	3.9	-0.9	3	-6.6	-3.3
	Post	-0.10	-0.40	-1.40	-7.8	-0.9	-1.5	-0.9	6.35	-1.9	-0.5		-18	3.05	-2.1	2	-7.5	-4.2
2000	Pre	0	-0.25	-1.20	-6.5	-0.6	-1.3	-0.7	6.85	-0.2	0.8	6.9	-13	4.5	-0.6	5.2	-6.7	-1.6
	Post				-7.8	-0.7	-1.4	-0.8	6.6	-1.5	-0.4		-17	2.9	-2.2	3.7	-11	-4.2
2001	Pre	-0.2	-0.15	-1.50	-7.5	-0.5	-1.2	-0.6	7.2	0.5	1.2	7.3	-3.5	7.5	4.4	4.5	-7.8	1.5
	Post		-0.35	-1.20	-7.6	-0.6	-1.4	-0.7	6.7	-0.1								
2002	Pre	-0.2	-1.40	-1.25	-7	-0.7	-1.4	-0.9	6.4	-1	-21	5.6	-24	3.4	-1.8	3.3	-10	-3.1
	Post					-2.2	-7.3	-11	5.9		-6.5	2.9	-6	-0.6	-3.4		0.9	
2003	Pre	0.5	-0.10	0.90	-3.8	-0.5	-1	-0.3	7.3	5	0.7	7	-10	7.1	3.7	5	-6	-1.4
	Post	-8.50			-0.5	-1.9	-4.9	-5.1	6.5		-6.2	3.5	-6	1.4	-1.9	6.5	2.1	
2004	Pre	2.5	-0.20	-0.80	-6	-0.5	-1.1	-0.5	6.75	0.5	0.05	6.5	-9	4.3	-1.3	3.5	-9.5	-1.2
	Post	2.50	1.00	1.50	4	0	1.5	0	8.5	7.5	1.5	8	11	10.5	3	11.5	6.5	7
2011	Pre					-0.4				2.5				5.9				
	Post				5.35	3.45				3.2		8.4		8.9				

Table 5.8 Pre and Post Monsoon Changes in Concentrations in TDS in Observation Wells Around Bardasagar TR

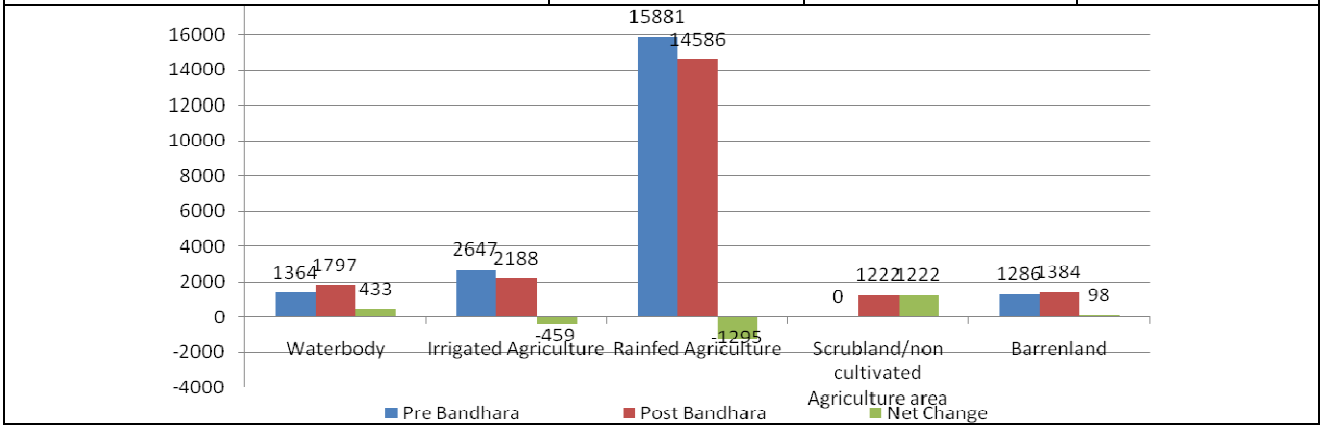
Year	Season	Kuchadi				Kantela			Srinagar		Bharwada			Modhwada			Palakhada	
		K-1	K-2	K-3	K-4	K-10	K-11	K-12	K-13	K-14	K-16	K-17	K-18	K-19	K-20	K-34	K-21	K-23
1995	Pre	3400	6020	6520	1080	9080	6020	6600	8840	1720	4480	3140	940	8440	5560	4360		1480
	Post	2580	8320	7900	1540	5820	7080	9560	9160	1920	4580	4160	1160	10240	7900	4480		1920
1996	Pre	2820	8960	8960	1720	11520	7040	10880	8960	2120	3840	2940	900	6400	5240	4040		1600
	Post	3000	8960	11520	1860	8320	7040	14080	8960	2120	4420	4160	1280	9600	7680	3840	2880	2240
1997	Pre	2880	7680	7040	10.2	8960	7040	8320	8000	2440	2880	2560	640	6400	4360	4160	2560	1020
	Post	3460	6400	8320	1600		6400	12160	8320	1800	3880	2820	1220	7680	3840	3960	2560	1600
1998	Pre	2040	7040	2940	1280	7040	7040	7680	7680	2880	2240	2300	960	5120	2120	4740	1720	1220
	Post	3200	5760	6400	1480	4540	6400	8960	8320	2180	3140	2880	1080	6400	2560	2040	1860	1600
1999	Pre	2820	7680	7360	1340	4800	4800	6400	9280	1980	3720	2880	1160	7040	3900	5120	1720	1780
	Post	2820	8320	9600	1400	6020	2760	11840	9600	1400	7680		1340	10240	8000	5440	1920	2040
2000	Pre	2120	6080	7040	1160	9280	2620	10240	7040	1720	3460	2240	960	7360	2560	4600	2240	840
	Post				1240	7680	2940	9600	10240	2240	4280		1080	9280	6400	4040	2820	840
2001	Pre	2440	7360	6840	1340	5500	3140	9540	8120	1800	2820	2300	900	5000	960	3900	1720	840
	Post		8120	8900	2620	5880	2680	7420	9660	1600								
2002	Pre	3400	7740	9540	1420	7180	2360	8240	9120	2780	4320		1120	7180	10000	4080	2240	1760
	Post	4100	8820	9680	1320	7460	3460	8520	9240	1720	4640		1300	9620	10380	3760	2180	1840
2003	Pre	7680	8320	4600	1000	9600	2360	8320	8640	7040	2560	2120	1020	4800	3200	3320	1800	1020
	Post	3650	7640	8530	1050	7000	3010	8490	7720	1900	4480		1050	5740	5310	3260	1120	1960
2004	Pre	7620	8380	8840	1360	8200	3460	8960	8520	1840	4460	3000	1040	6240	10120	3680	1160	1040
	Post	3360	3640	3760	336	3680	1600	4360	4040	720	1920	1200	160	2800	4680	1600	384	320
2011	Pre									1760								
	Post				1080					2220		1330						

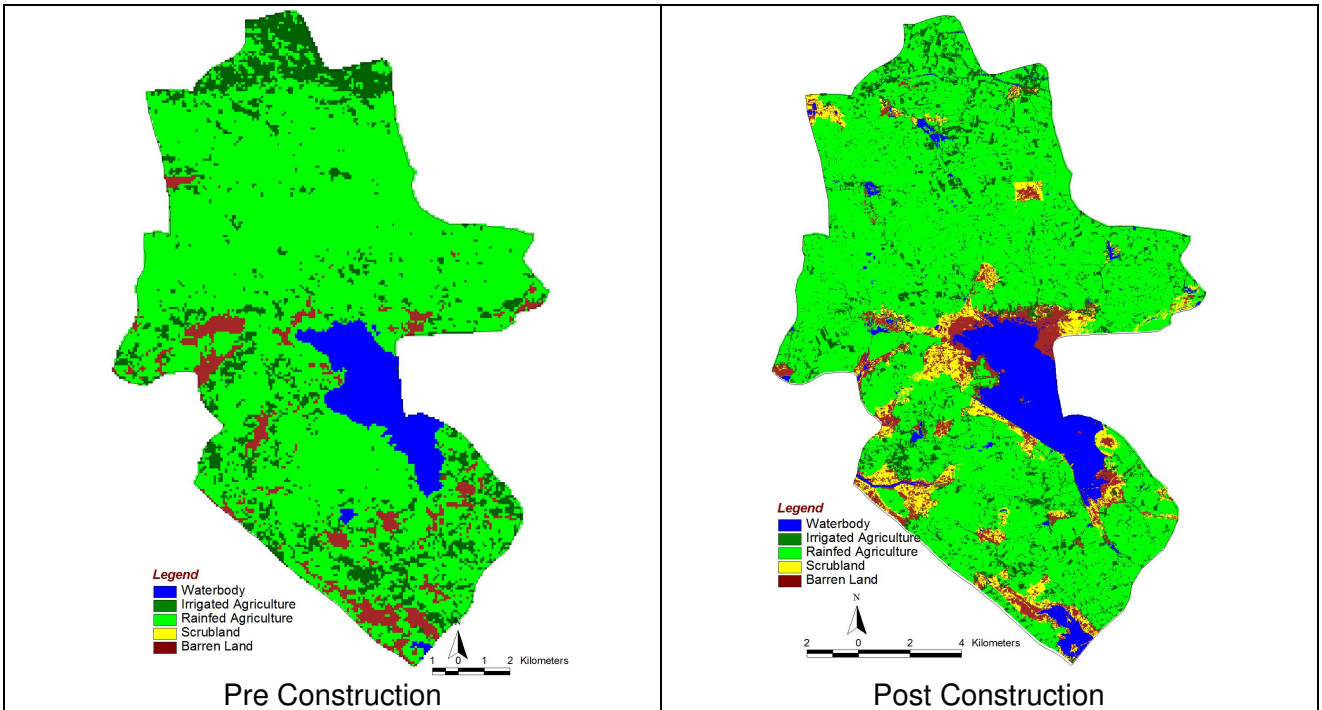
5.3.4 LANDUSE

Landuse pattern around Bardasagar Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1988 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 5.9)

Table 5.9 Landuse Pattern Around Bardasagar Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	1364	1797	433
Irrigated Agriculture	2647	2188	-459
Rain fed Agriculture	15881	14586	-1295
Scrubland/non cultivated Agriculture	0	1222	1222
Barren land	1286	1384	98
Total	**21178**	**21178**	0





Source: NRSA LISS – III images (1992 and 2013)

Fig. 5.19 Changes in Landuse Pattern around Bardasagar Bandhara Area

5.4 KARLI CREEK - KINDRI CREEK CANAL

5.4.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephones, vehicle and toilet are the predominant assets acquired, with 76 per cent of total families surveyed reporting acquisition of these assets post construction of the Karlicreek Kindricreek canal as can be seen from Fig. 5.20.

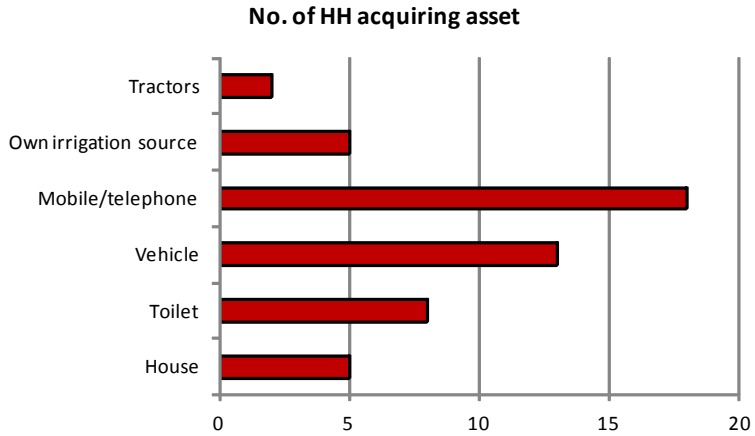


Fig. 5.20 Impact on Assets in Karlicreek Kindricreek

The scheme has had limited impact on income sources of families as is evident from the extremely small sample of households reporting change in income source in Fig. 5.21 A. However, Karlicreek Kindricreek canal is similar to another scheme – Karli TR - of the same district in that the number of households reporting additional income from selling manure is greater than those selling milk.

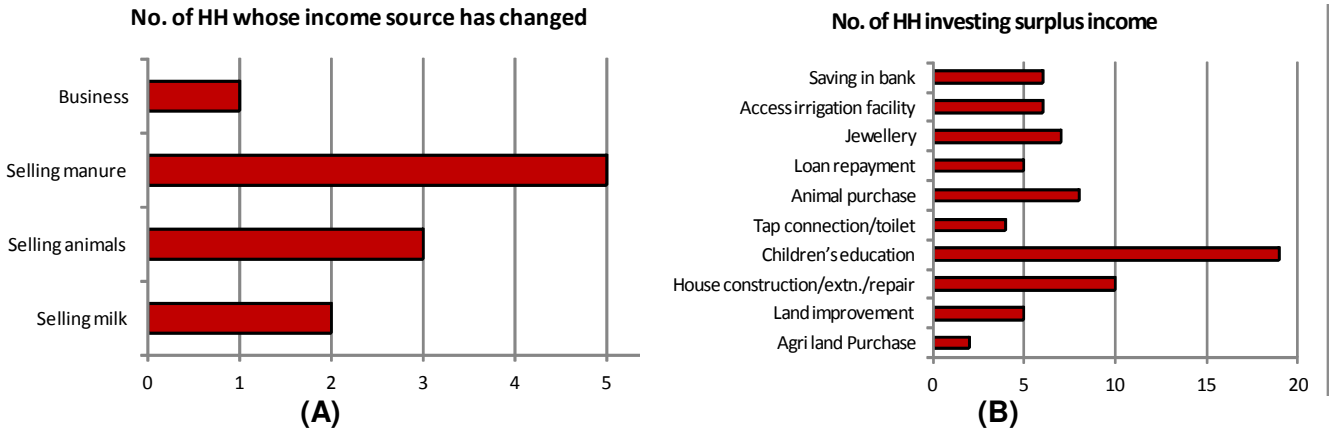


Fig. 5.21 Impact on Income Source (A) and Investment of Surplus Income (B) in Karlicreek Kindricreek

While a majority 26 per cent of the surveyed households have spent this additional income on their children's education, some of them have also undertaken house renovation and purchased animals or used it for buying jewellery (Fig. 5.21 B).

5.4.2 FODDER, LIVESTOCK AND MILK PRODUCTION

There has been no change in the fodder availability situation in villages benefitting from the KK canal. However, this has not impacted buffaloes or their milk production which has seen significant increase post the scheme. Also, improved agriculture has led to a rise in demand for bullocks (Fig. 5.22).

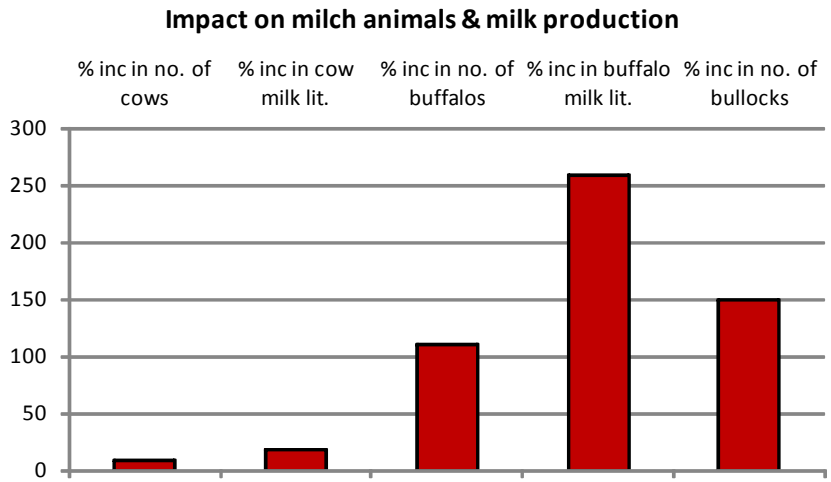


Fig. 5.22 Impact on Milch Animals and Milk Production in Karlicreek Kindricreek

5.4.3 GROUNDWATER AVAILABILITY AND QUALITY

Groundwater scenario in villages around Karli – Kindri Creek has studied from both the perspectives i.e. people's experience pre and post construction of canal as well as from technical point view with the help of monitoring data by SIPC. As per surveys held for this assessment about 78 percentages of households have not observed any significant changes in the situation of water table. Whereas only 13 per cent of families have experienced improvement water tables by upto 25 feet (Fig. 5.23 A).

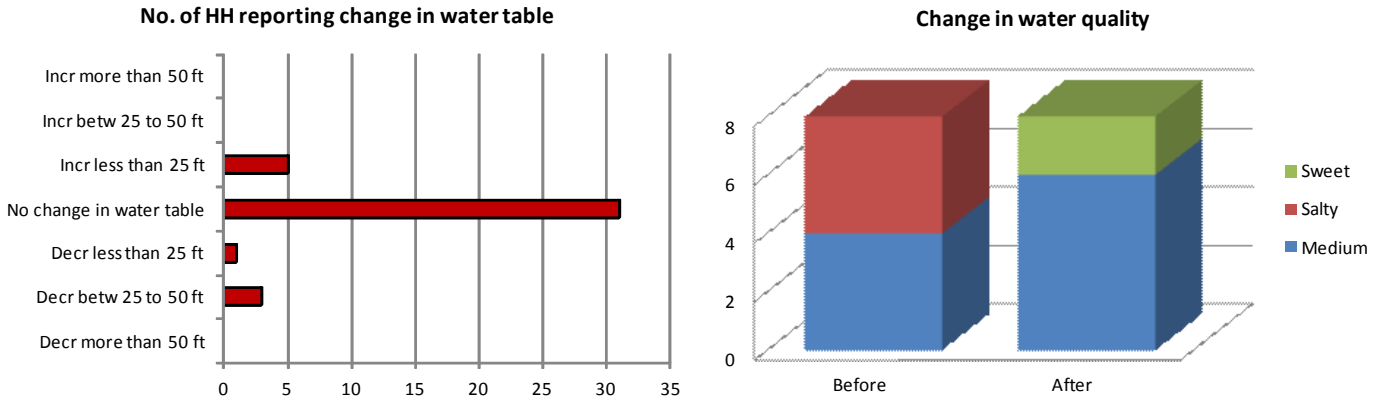


Fig 5.23 People's View Change in Water Table (A) and Water Quality (B) in Karlicreek Kindricreek

Although the small size of the reporting sample is certain to bring in a bias in analysis, the incidence of salty water has been eliminated post the scheme. As a result, some families have started receiving sweet water while dependence on medium quality water has also come down as seen in Fig. 5.23 B.

So far groundwater monitoring in study area is concerned SIPC has observations records of their observation wells. There are two wells in each in Srinagar (K – 13 and K – 14) and Ratadi (K – 24 and K – 25) village those have been monitored by SIPC since pre monsoon season of year 1980 i.e. before construction of Bandhara and canal. (Table 5.10) SIPC monitors mainly three parameters viz., static water levels, concentrations of Total Dissolved Solids and Chloride. In this particular analysis hydrographs have prepared for water level and TDS only. Since the objective of the structure is prevention of sea / saline water intrusion the static water levels (SWL) have been converted into reduced water levels by deducting SWLs from ground level (RL). Than year wise pre and post monsoon season wise data have been plotted on graphs. (Fig. 5.24) Another hydrograph has prepared for TDS concentrations. (Fig 5.25)

Well hydrograph for Reduced Water Level clearly shows there is very negligible change in water level since 1980 to even after construction of bandhara. However, there is high range of fluctuation has observed in well K- 24 of village Ratadi during year 2002, 03 and 04 but even after trends of the graph shows stability in condition. Average water level in all the wells is above AMSL.

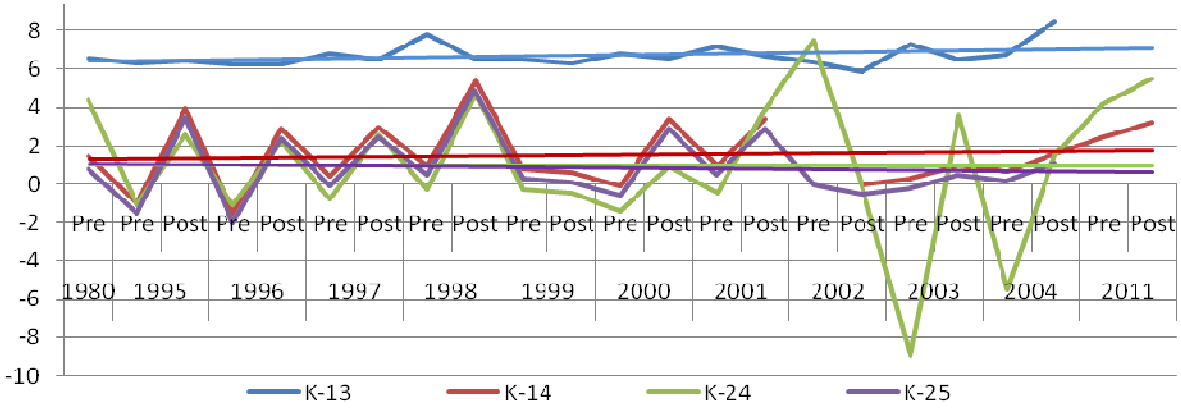


Fig 5.24 Pre and Post Monsoon Changes in RWL around Karli – Kindri Canal Area

Similar to hydrograph of water levels, well hydrograph for TDS concentration (Fig. 5.25) has also studied to understand overall changes in water quality. Well wise minor decrease in TDS concentration has been observed in both the wells of Srinigar and K-24 well of Ratadi village. However, average value of TDS is still high and can consider as saline water as they have TDS concentration above 4000 ppm. Whereas in case of well K – 25 there is slight increase in TDS, from less than 2000 ppm during pre monsoon season of year 1995 to more than 2000 during year post monsoon season of year 2011

Table 5.10 Pre and Post Monsoon Water Levels and TDS in Wells of village Srinigar and Ratadi of Karli – Kindri Canal Area

Year	Season	Reduced Water Levels (M)				Total Dissolved Solids (PPM)			
		Srinagar		Ratadi		Srinagar		Ratadi	
		K-13	K-14	K-24	K-25	K-13	K-14	K-24	K-25
1980	**Pre**	6.6	1.5	4.4	0.8	---	---	---	---
1995	**Pre**	6.35	-1	-1.1	-1.5	8840	1720	6020	5560
	Post	6.45	4	2.6	3.5	9160	1920	6400	5760
1996	**Pre**	6.3	-1.5	-1.1	-2	8960	2120	6400	4800
	Post	6.3	2.9	2.2	2.4	8960	2120	7040	5380
1997	**Pre**	6.85	0.4	-0.8	-0.1	8000	2440	7040	5120
	Post	6.5	3	2.6	2.5	8320	1800	5760	5760
1998	**Pre**	7.8	1	-0.3	0.5	7680	2880	5760	5120
	Post	6.6	5.4	4.7	4.9	8320	2180	5180	4280
1999	**Pre**	6.5	0.8	-0.3	0.3	9280	1980	6080	5320
	Post	6.35	0.6	-0.5	0.1	9600	1400	6080	5760
2000	**Pre**	6.85	-0.1	-1.4	-0.6	7040	1720	7040	5380
	Post	6.6	3.4	0.9	2.9	10240	2240	5060	5120
2001	**Pre**	7.2	1	-0.5	0.5	8120	1800	6140	4920
	Post	6.7	3.4	3.9	2.9	9660	1600	5060	4680
2002	**Pre**	6.4	---	7.5	---	9120	2780	---	---
	Post	5.9	0	-0.1	-0.5	9240	1720	5900	5240
2003	**Pre**	7.3	0.3	-9	-0.2	8640	7040	5880	4860
	Post	6.5	1	3.6	0.5	7720	1900	5060	4740
2004	**Pre**	6.75	0.7	-5.5	0.2	8520	1840	5220	4500
	Post	8.5	1.6	1.5	1.1	4040	720	5960	5280
2011	**Pre**	---	2.5	4.2	---	---	1760	3670	---
	Post	---	3.2	5.5	---	---	2220	3060	---

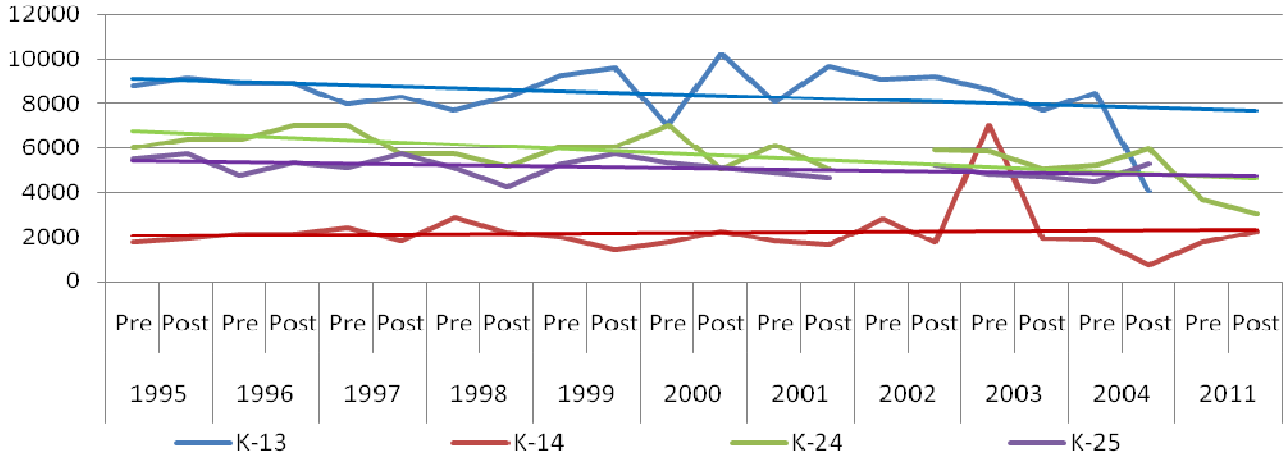


Fig 5.25 Pre and Post Monsoon Changes in TDS Concentrations, Karli – Kindri Canal Area

5.5 MEDHACREEK TIDAL REGULATOR

5.5.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephones, vehicle and toilet seem to be the main assets acquired after the construction of the Medhacreek tidal regulator as reported by 30 per cent, 24 per cent and 22 per cent of respondent households respectively. 16 per cent of families have also been able to acquire a house post the scheme as can be seen from Fig. 5.26.

Changes in income sources have been experienced by households mainly on account of selling milk (reported by 28 per cent of the sample), followed equally by agriculture and daily wage employment (18 per cent of households each). 16 per cent of the sample has also reported additional income from business activity (see Fig. 5.26 B).

The surplus income generated has been invested for a wide variety of purposes, predominant among which are house renovation, bank savings, children's education and toilet/tap connection with approximately 12 per cent of the households opting for each of these investments. 11 per cent of families have undertaken land improvement using this surplus while an equal proportion has used it for consumption purposes (like social function) instead of making an investment as brought out by Fig. 5.26 C.

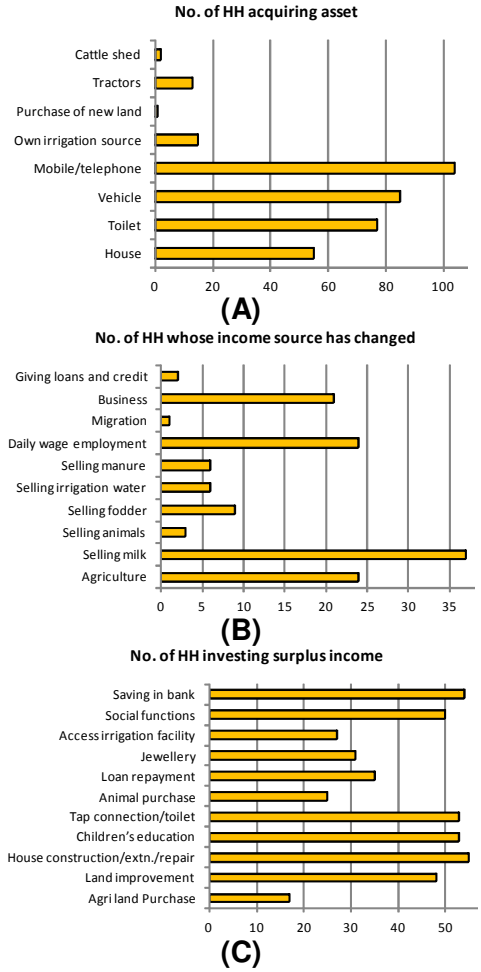


Fig 5.26 Impact on assets (A), income source (B), and Investment of surplus income (C) in Medha Creek

5.5.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 5.11: Impact on fodder availability due to agriculture, Medha Creek TR

Impact	Quantity
Increase in Green Fodder (%)	120
Increase in Dry Fodder (%)	130
Increase in Cow dung (%)	283

While green and dry fodder availability has increased by 120 and 130 per cent respectively after the scheme, the change in production of manure (cow dung) has been more remarkable, providing a source of organic fertiliser for agriculture (Table 5.11).

That better fodder availability has had a positive impact on milch animals and milk production in villages benefitting from the Medhacreek TR is evident from Fig. 5.27 where the number of cows and buffaloes has gone up by more than 60 per cent whereas cow milk production has risen by 54 per cent.

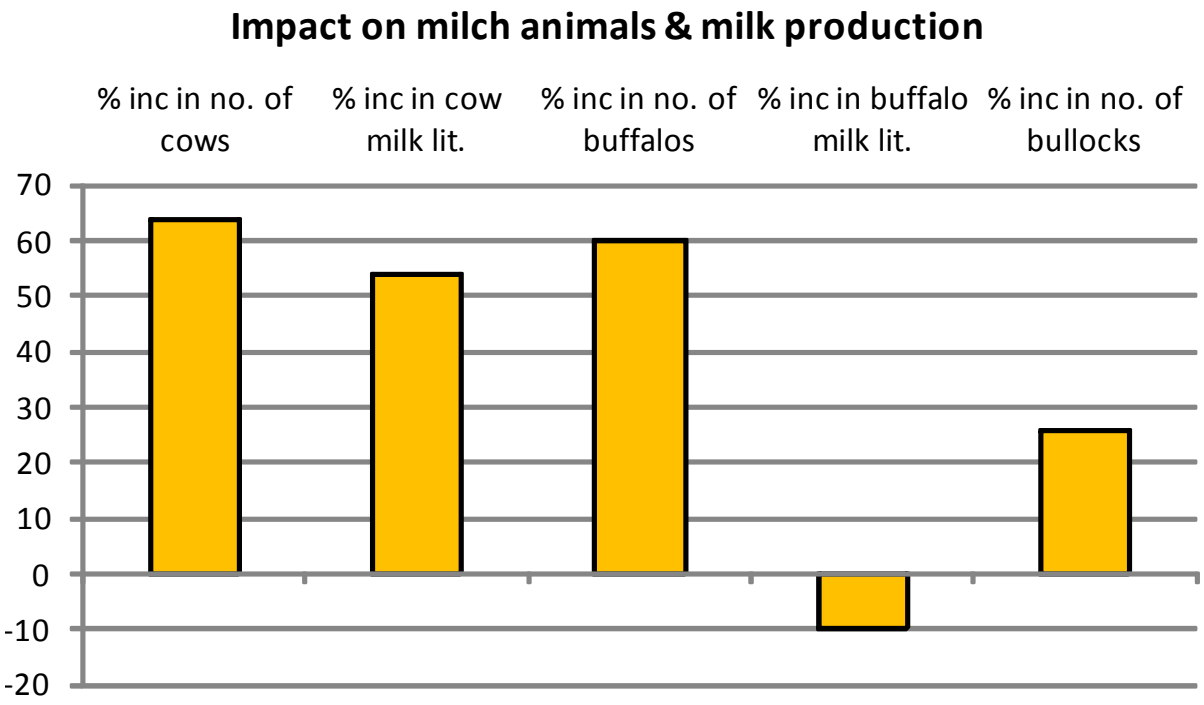


Fig. 5.27 Impact on milch animals and milk production in Medhacreek

5.5.3 GROUNDWATER AVAILABILITY AND QUALITY

Plate No. 5.3 Field Photograph Showing Waste Weir of Medh Creek TR

Impact on groundwater has been studied here by analysing hydrographs for RWL and TDS along with people's experience. According to people openion the impact of the Medhacreek TR on groundwater availability has been modest. Whereas 71 per cent of the surveyed households have experienced no change in the water table, an increase of upto 25 feet has been reported by 11 per cent, between 25-50 feet by 7 per cent and of more than 50 feet by 3 per cent of the households (Fig. 5.28 A).

In terms of change in water quality, while the number of families getting medium quality water before and after the construction of the tidal regulator has remained nearly the same, the

proportion of families getting salty water has declined drastically from 30 per cent to 3 per cent and of those getting sweet water has shot up from 15 per cent to 42 per cent after the scheme as depicted by Fig. 5.28 B.

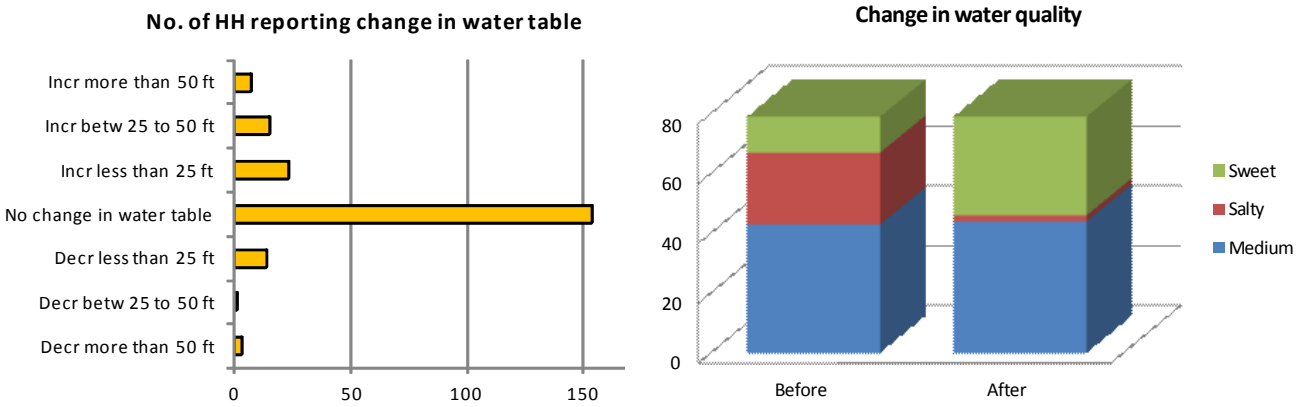


Fig 5.28 People's View on Groundwater Levels (A) and Quality in Medha Creek

SIPC has intensly set a monitoring network of about 25 wells in six villages viz, Ambarama (02 wells), Miyani (07 wells), Vadala (03 wells), Gandhavi (04 wells), Gangadi (06 wells) and Chachalan (03 wells) around Medha Creek TR. Table 5.12 shows water level and TDS fluctuation in monitoring wells of Kalyanpur taluka while Table 5.13 and 5.14 shows the RWL and TDS fluctuations in villages of Porbandar Taluka respectively.

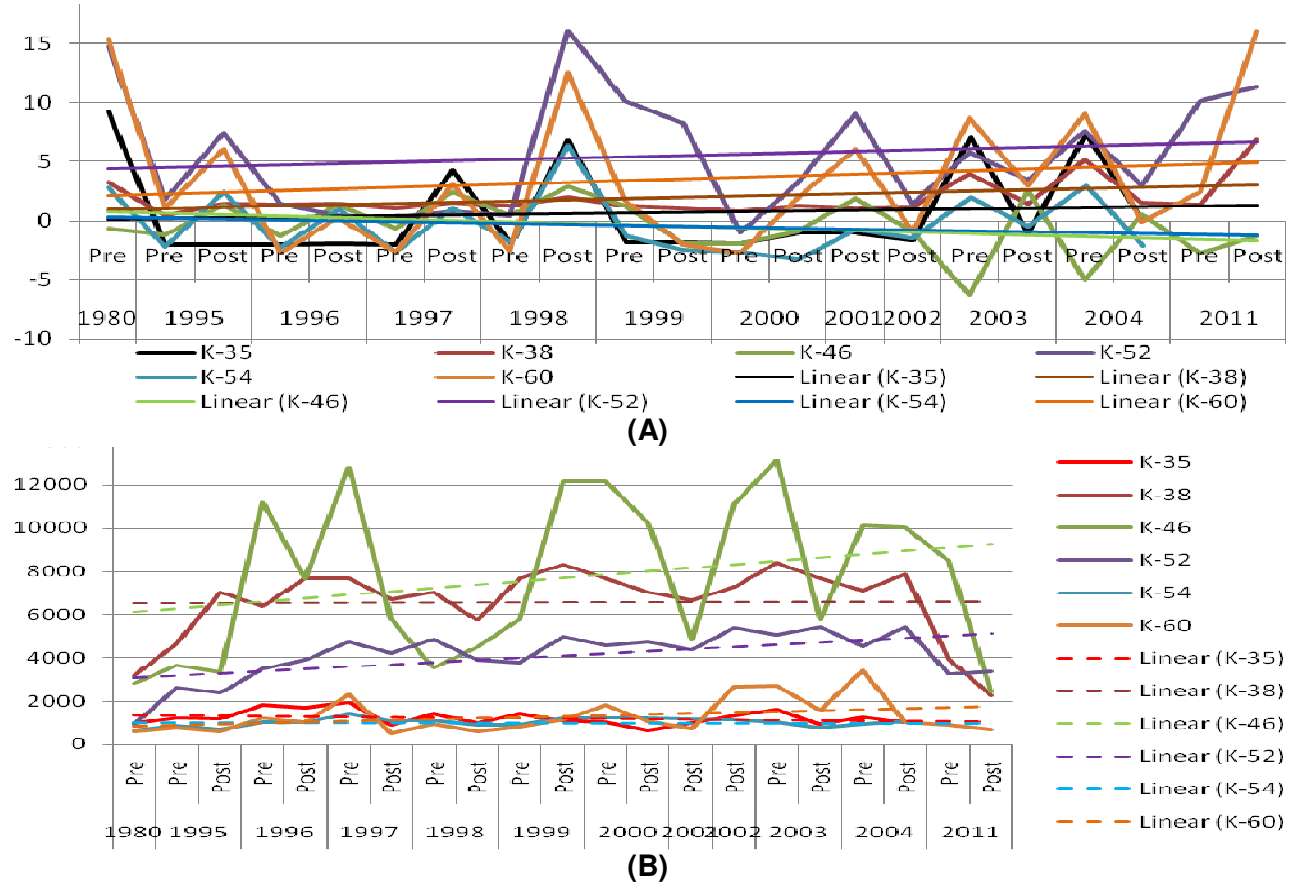


Fig 5.29 Wells Hydrographs for Changes in Water Level (A) and TDS concentrations (B) in Villages of Medh Creek TR

Based on consistant and latest data avialability about six wells have been selected at least one each village for hydrograph analysis to understand changes in groundwater conditions around Medha Creek TR. Fig 5.29 is well hydrographs for RWL and TDS values in different villages around Medha Creek Bandhara. Following are major inferences of hydrographs

- Hydrograph for RWL of wells K – 35 of village Ambama, K – 38 of village Miyani, K – 52 of village Gandhavi and K – 60 of Chachalana show constant increase in water levels. All these villages are located immidiate periphary of TR.
- In village Vadala and Gangali well hydrograph clearly show decrese in water levels.
- As far as TDS is concerned all hydrographs show increase in TDS concentraions
- Well K – 46 of village Vadala the average TDS value increased from 3000 ppm to more than 9000 ppm whereas Well K – 38 (vill. Ambarama) shows almost negligible change in TDS value however, the average TDS in this well is more than 6000 ppm
- In village Gandhavi (K – 52) TDS value has increased from 1000 ppm to 5000 ppm
- Wells of village Ambarama (K – 35), Gangadi (K – 54) and Chachalana (K – 60) show TDS fluctuation around or less than 2000 ppm
- Overall based on hydrograph can be said that the impact of Medha Creek is moderate to low in surroudning area.

Table 5.12 Pre and Post Monsoon Reduced Water Levels and TDS in Observation Wells of Village Chachalana of Kalyanpur Taluka for Medha Creek

Year / Season		RWL (M)			TDS (PPM)		
		K-60	K-62	K-63	K-60	K-62	K-63
1980	Pre	15.4	5.5	1.45	620	880	1020
1995	Pre	1.1	-2.8	-1.9	800	1280	900
	Post	6.1	-0.9	-1.5	640	840	840
1996	Pre	-2.7		-2.4	1240		1160
	Post	0.3	-3.6	-1.5	1020	1160	840
1997	Pre	-2.6	-3.7	-3.7	2300	2260	920
	Post	3.1	-0.5	1.2	540	900	840
1998	Pre	-2.5	-2.5	-2	960	1220	840
	Post	12.6	3.7	4.7	640	1160	960
1999	Pre	1.75	-0.8	-0.8	840	1480	900
	Post	-2	-2.9	-2.1	1160	1860	1020
2000	Pre	-2.7		-4.5	1800		1080
	Post	1.9	-2.9	-1.6	1080	2040	760
2001	Pre						
	Post	6.1	1.9	1.2	760	1400	1220
2002	Post	-0.9	-3.5	-3.8	2660		1020
2003	Pre	8.7	0.4	3.7	2720		820
	Post	3	-2.4	-0.9	1600	1220	900
2004	Pre	9.1	2.4	5.65	3420	1750	840
	Post	-0.1	-2.4	-2.3	1020	1420	1020
2011	Pre	2.5			920		
	Post	16.1			690		

Table 5.13 Pre and Post Monsoon Reduced Water Levels in Observation Wells of Villages of Porbandar Taluka for Medha Creek

Year / Season		Ambarama		Miyani							Vadala			Gandhavi				Gangadi					
		K-35	K-36	K-37	K-38	K-39	K-40	K-41	K-42	K-43	K-44	K-45	K-46	K-50	K-51	K-52	K-53	K-54	K-55	K-56	K-57	K-58	K-59
1980	Pre	9.3	9.8	2.8	3.3	-1.1	-3.05	-2.55	-2.8	-0.5	0.2	1.3	-0.6	-0.27	7.7	14.8	7.1	2.8	6.3	-0.35	-3.7	-3.7	7.3
1995	Pre	-2	2.5	0.5	0.5	1.55	1.05	-0.55	-3.2	-0.95	0.1	-0.15	-1.15	1.43	3	1.8	-2.7	-2.2	-3.6	-3.05		-4.6	-4.4
	Post	-2	2.5	0.6	1.5	2.25	1.75	0.75	0.9	0.2	2	-0.05	1.35	2.13	3.2	7.5	-2.2	2.5	2.8	-1.15	-5.9	-0.4	0.5
1996	Pre	-2	1.3	0.5	1.4	1.55	0.85	-0.7	-3.9	-1.25	0.1	-0.9	-1.3	0.83	1	1.5	-2.8	-2.3	-3.9	-3.65		-4.8	-6.8
	Post	-1.95	2.5	0.8	1.5	2.25	1.5	0.75	0.8	0.5	2.2	0.4	1.4	0.73	0.4	0.5	-2.2	1	0.2	-1.65	-5.9	-0.6	-3
1997	Pre	-2	1.2	0.75	1.1	1.5	0.65	-1.05	-1.3	-1.6	-0.3	-1	-0.6		-0.1	0.3	-2.4	-2.7	-4.6	-4.15		-5	-6.8
	Post	4.3	10	1	1.6	2.3	1.85	0.45	1.1	0.6	2.6	1	2.5	1.83	3.7	0.8	2	1.1	0.5	-1.65	-5.9	-1.3	-3.1
1998	Pre	-1.9	3.3		1.3	1.5	1	-0.5	-1	-1	1	0.4	0.5	1.13	2	0.5	0.5	-1.8	-2	-3.5		-2	-6.7
	Post	6.8	9.9	1.3	2	2.3	2.25	0.95	1.7	0.8	3.3	1.6	2.95	3.13	8.2	16.1	8.6	6.4	9	2.05	-5.9	0.4	7.5
1999	Pre	-1.85	3.4	0.4	1.3	1.8	1.25	-0.35	-0.8	-1	1.4	-0.3	1.3	2.18	4.3	10.2	1.3	-1.3	-1.25	-1.65	-2.95	-2	-3.7
	Post	-1.85	0.2	0.35	1.15	1.45	1.05	-1.45	-1.6	-3.3	-1.15	-0.8	-1.9	1.18	1.3	8.3	-5	-2.5	-2.8	-3.75	-5	-4.8	-6.6
2000	Pre	-1.9	0.05		0.9	0.85	0.25	-2.45	-2.1	-3.7	-1.2	-2.9	-1.9	0.63	-0.1	-1	-5.5	-2.7	-3.2	-4.05	-5	-5.6	-11
	Post	-1	3.8	0.4	1.3	1.6	0.75	-2.55	-3.1	-4.3	-0.6	-2.8	-0.9	1.53	1.3	3.2	-1.4	-3.3	-3	-3.65	-5.9	-2.4	-12.4
2001	Pre	-1.2		0.35	1	0.9	0.35									2.6							
	Post	-1	5.1	0.5	1.1	2.1	1.55	0.45	-0.1	-0.4	1.9	-1.1	1.9	2.33	5.2	9.1	1.7	-0.7	-0.4	-2.95	-3.3	-1.1	-1.5
2002	Post	-1.6	0.6	-0.5	1.2	1.1	0.65	-1.75	-2.1	-2.3	0.2	-1.6	-0.9	-1.77	0.5	1.5	-3.7	-1.5	-2.5	-4.65	-4.2	-3.5	-9.5
2003	Pre	7.1	11.6		4	-0.6	-5.15	-2.95	-6.1	-1.1	-5.2	-8.3	-6.3	-12.77	2.4	5.8	2.7	2	5.9	-18.15	-20.2		-4.3
	Post	-1	4.7	0.7	1.5	2.4	1.95	1.05	0.9	1.8	2.9	1.8	2.6	1.33	2.5	3.5	-2.7	-0.5	0	-2.65	-0.6	-1	-0.3
2004	Pre	7.4	12.3	6.7	5.2	0.5	-3.75	-1.7	-4.8	0.2	-3.2	-7.5	-5.05	-11.87	2.4	7.6	3.3	3	7.3	-17.15	-20	-12.3	-2
	Post	0	0.7	0.7	1.6	1.5	1.05	-1.15	-2.3	-1.2	1.2	-0.6	0.6	0.83	2	3	-0.6	-2.1	-0.7	-4.15	-3.3	-2.3	-8
2011	Pre				1.4								-2.7			10.2							
	Post				6.9								-1.3			11.4		-2.9					

Table 5.14 Pre and Post Monsoon Reduced TDS Concentrations in Observation Wells of Villages of Porbandar Taluka for Medha Creek

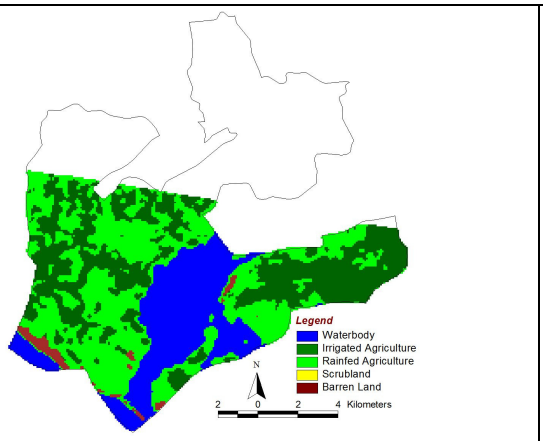
Year	Season	Ta. Porbandar																					
		Ambarama		Miyani							Vadala			Gandhavi				Gangadi					
		K-35	K-36	K-37	K-38	K-39	K-40	K-41	K-42	K-43	K-44	K-45	K-46	K-50	K-51	K-52	K-53	K-54	K-55	K-56	K-57	K-58	K-59
1980	Pre	960	1180	2400	3160	7200	2340	6620	6620	5100	11180	5360	2800	3120	1180	920	920	660	560	2900	3560	1120	760
1995	Pre	1180	2560	6020	4680	14080	3140	6720	6200	12160	32640	10880	3640	12680	13760	2620	1100	860	540	1480		1480	620
	Post	1160	1660	3680	7040	12800	3780	5800	6960	8560	12800	9600	3320	9600	9600	2360	900	700	440	960		3780	580
1996	Pre	1820	2420	4200	6400	13400	4240	4800	10800	11800	17200	10200	11200	14400	17200	3500	1600	1020	1120	1740		1740	1420
	Post	1660	1540	4740	7680	12800	3960	3840	7040	7040	8960	8320	7680	15360	14720	3900	1600	1020	1020	1980		3640	760
1997	Pre	1920	2620	6400	7680	13440	5760	4220	8960	8960	14720	9600	12800		17920	4740	1860	1400	1020	2180		4800	1260
	Post	860	1280	3720	6720	12800	7040	4480	4160	9600	13440	5440	5760	10460	9304	4240	880	1080	640	1360		4300	580
1998	Pre	1400	1800		7040	12160	4920	4860	9600	4480	10240	16000	3520	14080	19200	4860	960	1080	900	1860		4860	3200
	Post	960	1080	3000	5760	11520	6080	4280	8320	6400	11520	5760	4480	8320	7680	3900	960	900	580	1160		4100	
1999	Pre	1400	1540	2760	7680	9600	5960	4360	9600	7040	11520	8960	5760	7360	7040	3780	960	900	640	1800	4040	3720	760
	Post	1080	4100	3720	8320	10240	3840	4740	2680	10240	8000	10880	12160	3400	8960	5000	840	1220	2500	1800	7040	4600	3080
2000	Pre	1020	4800		7680	11520	7040	4480	8960	9600	15360	12160	12160	22400	10240	4600	1400	1220	760	2440	8320	7040	580
	Post	640	1600	5560	7040	12160	10240	4220	7680	12800	14400	14720	10240	14080	10240	4740	900	1220	640	1540		4920	380
2001	Pre	520		4480	14080	14720	6400									5700							
	Post	960	760		6660	11460	14400	3780	8380	9540	14340	8840	4860	6780	5440	4408	760	1160	640	1720	5120	5640	840
2002	Post	1320	2240		7280	10240	14080	4440	7960	12800	25060	12140	11120		7320	5380	1000	1120	1140	1800	8040	5720	6480
2003	Pre	1600	3780		8400			4240	8080	13860	19080	11820	13140		8520	5060	1260	1000	800	2000	9620	5160	2220
	Post	900	1480	3900	7680	12800	4280	3840	8960	3840	3140	6720	5760	6980	4600	5440	900	760	460	1020	3080	5120	700
2004	Pre	1240	2260	3780	7120	10490	7060	3190	9140	10320	15530	8650	10120	5250	5630	4570	990	920	490	1320	6400	5480	2770
	Post	1000	2360	4200	7860	9480	10200	3300	8540	9880	11960	9220	10040	7270	7660	5420	920	1040	700	1540	6300	6000	780
2011	Pre				3920								8480			3280							
	Post	1090			2250								2400			3390		450					

5.5.4 Landuse

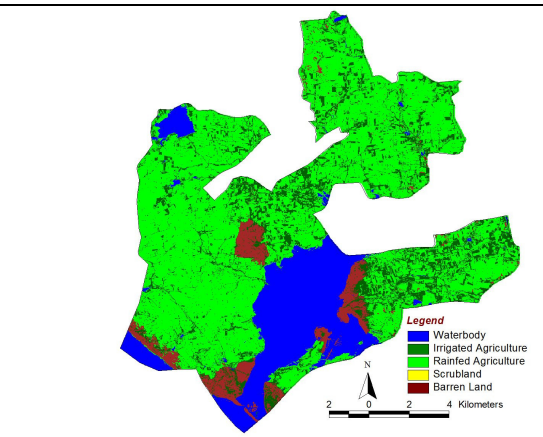
Due to non comparable remote sensing data the land use pattern analysis of Medha Creek area is difficult. Fig. 5.30 shows analysis of remote sensing data of Medha creek. However, the table 5.15 shows the status of landuse pattern around Medha creek of post construction phase.

Table 5.15 Landuse pattern Around Medha Creek during Post Construction Phase

Landuse	Area (Ha)
Water body	3091.92
Irrigated Agriculture	3146.34
Rainfed Agriculture	10987.38
Barren land	1013.81
Total	**18239**



Pre Construction



Post Construction

Source: NRSA LISS – III images (1992 and 2013)

Fig. 5.30 Changes in Landuse Pattern around Bardasagar Bandhara Area

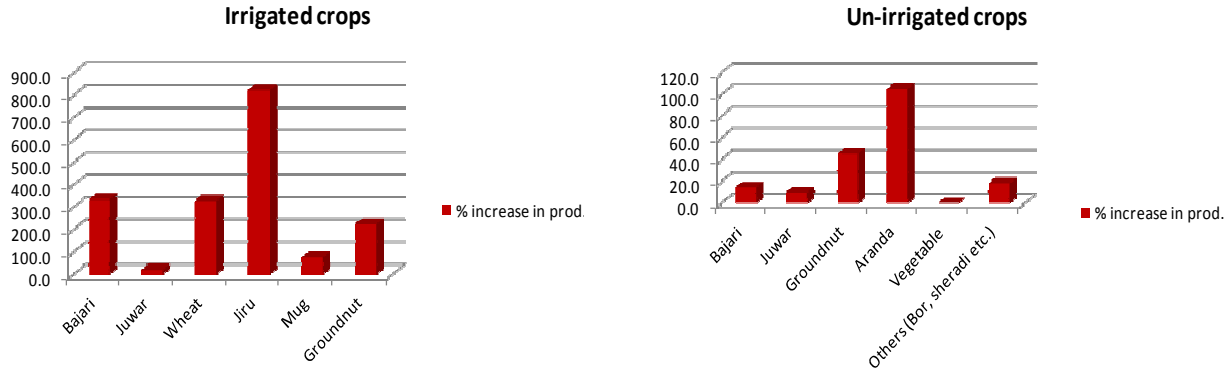
5.6 AGRICULTURE

At the overall district level, there has been an increase of 45 per cent in the area under un-irrigated food grains and a minor 3 per cent increase in the area under irrigated crops. A scheme wise analysis of impact reveals that villages falling under Ozat Madhuvanti, Karlicreek Kindricreek and Barda Sagar schemes have witnessed increases in area under irrigated crops by 215 per cent, 79 per cent and 46 per cent respectively post the construction of these schemes.

As far as agriculture production is concerned, irrigated crops like jiru, bajri, wheat and groundnut have shown huge increases before and after the scheme as can be seen from Table 5.15 whereas aranda leads among un-irrigated crops whose production has improved post the schemes, followed by groundnut (Table 5.16). Cropping pattern has also changed slightly with un-irrigated cotton, aranda, bor and sheradi replaced by irrigated wheat, jiru and mug.

Table 5.15 Impact on agriculture production – irrigated crops

Sr. No.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	23	100	334.8
2	Juwar	158	190	20.3
3	Wheat	468	2004	328.2
4	Jiru	456	4205	822.1
5	Mug	109	192	76.1
6	Groundnut	2345	7588	223.6



(A) **(B)**

Fig. 5.31 Percentage increase in area under irrigated and un-irrigated crops

Table 5.16 Impact on agriculture production – un-irrigated crops

Sr. No.	Major crops	Production in *mun*		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	140	161	15.0
2	Juwar	1320	1454	10.2
3	Groundnut	7695	11200	45.5
4	Aranda	500	1025	195.0
5	Vegetable	500	500	0.0
6	Others (Bor, sheradi etc.)	27	32	18.5

5.7 SITUATION OF WOMEN

While the problem of lack of drinking water in the village has been resolved to a large extent because of the salinity prevention structures, there have also been a number of other spin-off benefits for women like time savings, opportunities for employment and increase in incomes. Overall agriculture production has increased due to improved irrigation facilities, resulting in a decrease in migration from villages in search of work since wage rates have gone up.

Women have started participating in SHGs and Pani samitis, exercising greater decision making, both within their families as well as at the village level. They have also started securing their future by saving within their SHGs and taking loans for livelihood activities.

6. SOCIO-ECONOMIC IMPACT IN JAMNAGAR DISTRICT

Total five structures have been selected for impact assessment in Jamnagar district. These structures are (01) Bogat TR in Kalyanpur taluka (02) Sarmat khara Beraja Bandhara of Jamnagar Talka (03) Khijadiya Stepwell to Jambuda Bandhara canal (04) Kheri and (05) Balambha of Jodiya Taluka (Fig. 6.1)

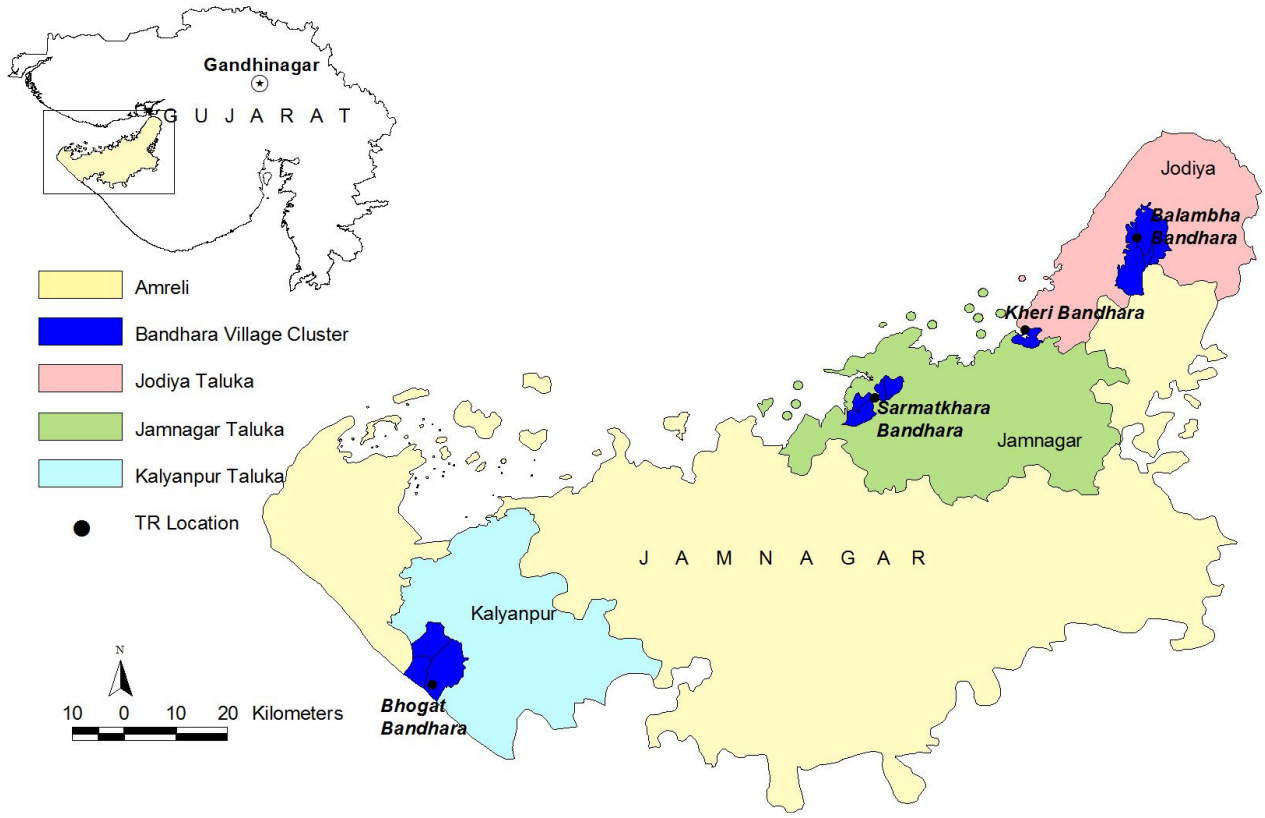


Fig 6.1 Location Salinity Structures In Jamnagar District

6.1 BHOGAAT TIDAL REGULATOR

6.1.1 ASSETS, INCOME AND INVESTMENTS

Mobile telephone, house and vehicle are the main assets acquired in villages benefitted by the Bhogaat TR. Here, 33 per cent of the respondent households have reported acquiring a mobile phone, 20 per cent, a house and 18 per cent, a vehicle after the construction of the TR as seen from Fig. 6.2.

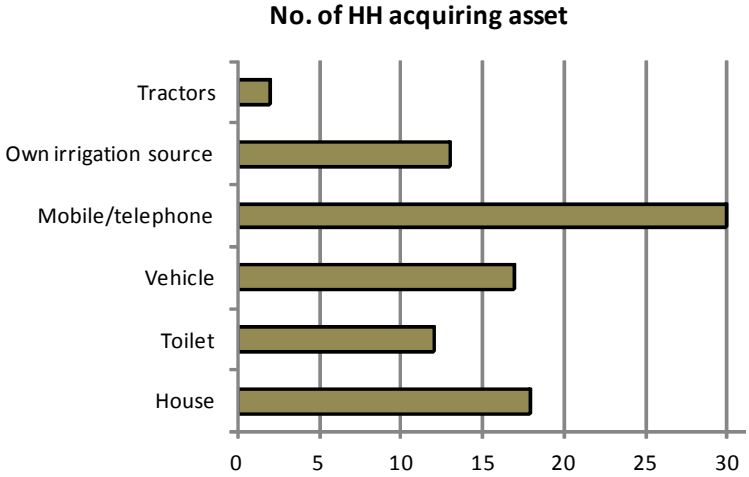


Fig 6.2 Impact on Assets in Bhogaat Bandhara

Selling milk is the most common activity generating additional income post the scheme (Fig. 6.3 A) with 29 per cent of households reporting income from this source. This is followed by 15 per cent of the

households reporting income from giving loans and credit. Most of the surveyed households have invested the additional income generated on purchase of animals. Among other significant investment avenues, 15 per cent of the sample has utilised this surplus for house renovation, 14 per cent for children's education and 11 per cent for undertaking land improvement activities (Fig. 6.3 B).

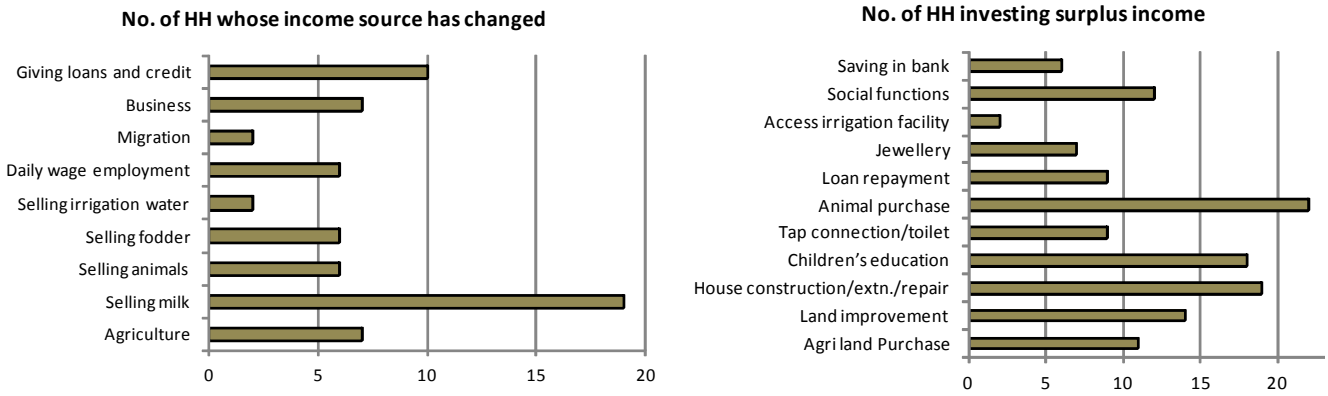


Fig 6.3 Impact on Income Source (A) and Investment of Surplus Income (B) in Bhogaat

6.1.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 6.1: Impact on fodder availability due to agriculture, Bhogaat

Impact	Quantity
Increase in Green Fodder (%)	50
Increase in Dry Fodder (%)	100
Increase in Cow dung (%)	00

Green fodder availability has increased by 50 per cent while dry fodder availability has doubled in villages falling under the Bhogaat tidal regulator (Table 6.1).

Even as the population of cows has shown a slight decline post the scheme, milk production has actually improved, most likely on account of better fodder availability for milch animals. This fact is endorsed by an increase both in the number of buffaloes as well as milk production from buffaloes. as can be seen from Fig. 6.4.

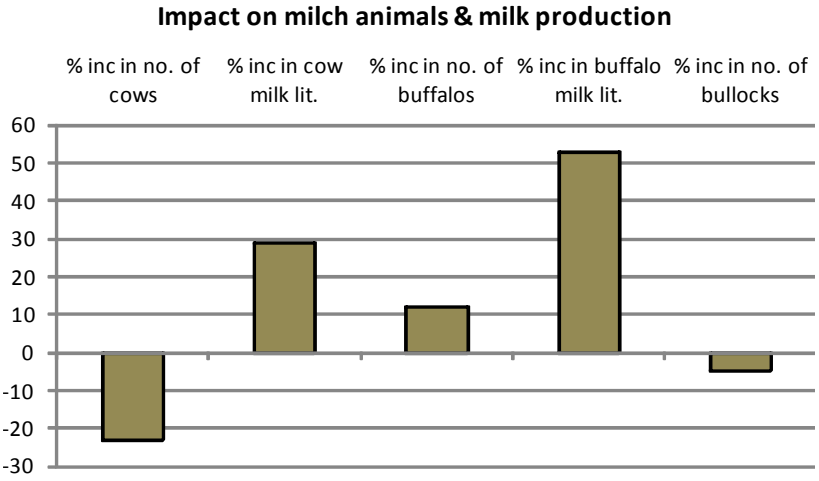


Fig. 6.4 Impact on milch animals and milk production in Bhogaat

6.1.3 GROUNDWATER AVAILABILITY AND QUALITY

Impact on groundwater in term of water level and quality Bhogaat bandhara has been studied with two methods first, people's experience by holding house hold surveys and second, by analysing respective data of monitoring wells of SIPC. According to most of the people there has been little

positive impact of the Bhogaat TR on groundwater tables in the area. This can be seen from the fact that nearly 76 per cent of the respondent households have noticed no change in the water table and another 20 per cent have experienced groundwater tables declining by upto 25 feet post the scheme (Fig. 6.5 A).

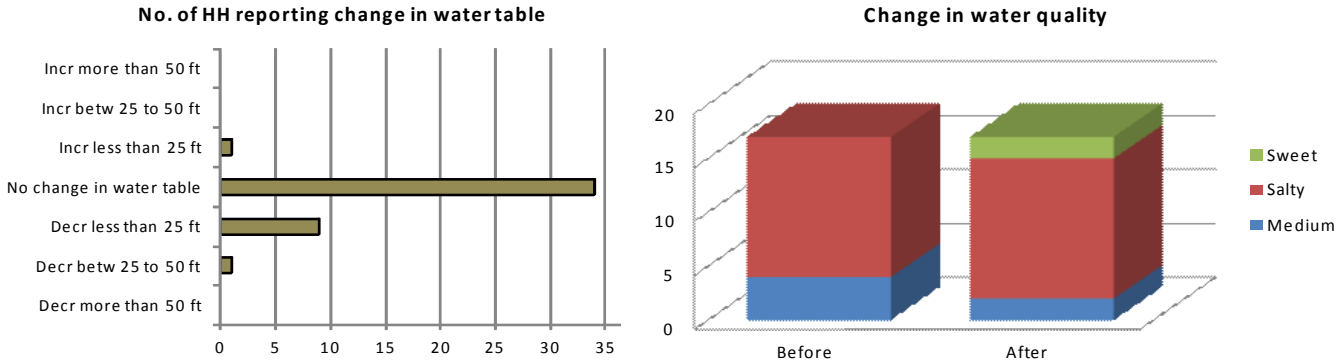


Fig. 6.5 People's Views on Change in Water Table (A) and Water Quality (B) in Bhogaat

As far as the issue of change in water quality due to the TR is concerned, while the proportion of households receiving salty water before and after the scheme has remained the same, 12 per cent of the households have now started getting sweet water as can be seen from Fig. 6.5 (B).

SIPC monitors only one well in village Bhogat for water level and quality changes in groundwater since 1980. Bhogat bandhara has completed in year 1998. Hydrograph for changes water levels (6.6 A) and fluctuation in total dissolved solids and chloride concentrations (6.6 B) have been computed based on recorded data. As far as water level is concerned first of static water levels have been converted into reduced water levels by deducting static water from ground levels.

Hydrograph for reduced water level clearly shows that until 2000 pre and post monsoon water level fluctuations ranges from 2 to 6 m above AMSL whereas 2000 onwards the fluctuation range has changed and it is from below AMSL – 5 m to more than 6 m above AMSL. However over trend in RWL is declining trend.

Table 6.2 Groundwater Table and Quality Monitoring in Bhogaat Bandhara Of Observation Well K – 87, Village Bhogat

Year	Season	RWL (M)	TDS (PPM)	Cl (PPM)
1980	**Pre**	4.6	5760	2480
1995	**Pre**	3.40	5760	2480
	Post	3.60	2660	1080
1996	**Pre**	2.10	2440	1040
1997	**Post**	4.20	2660	1160
1998	**Pre**	2.90	3840	1760
	Post	6.00	3200	1440
1999	**Pre**	4.70	3140	1400
	Post	5.15	3400	1440
2000	**Pre**	0.60	4160	1800
	Post	5.90	4160	1840
2001	**Post**	5.50	3520	1560
2002	**Post**	3.70	4040	1680
2003	**Pre**	-5.20	3960	1600
	Post	6.80	4040	1680
2004	**Pre**	-4.80	3410	1680
	Post	5.50	3760	1608

Source: SIPC (1980 2004)

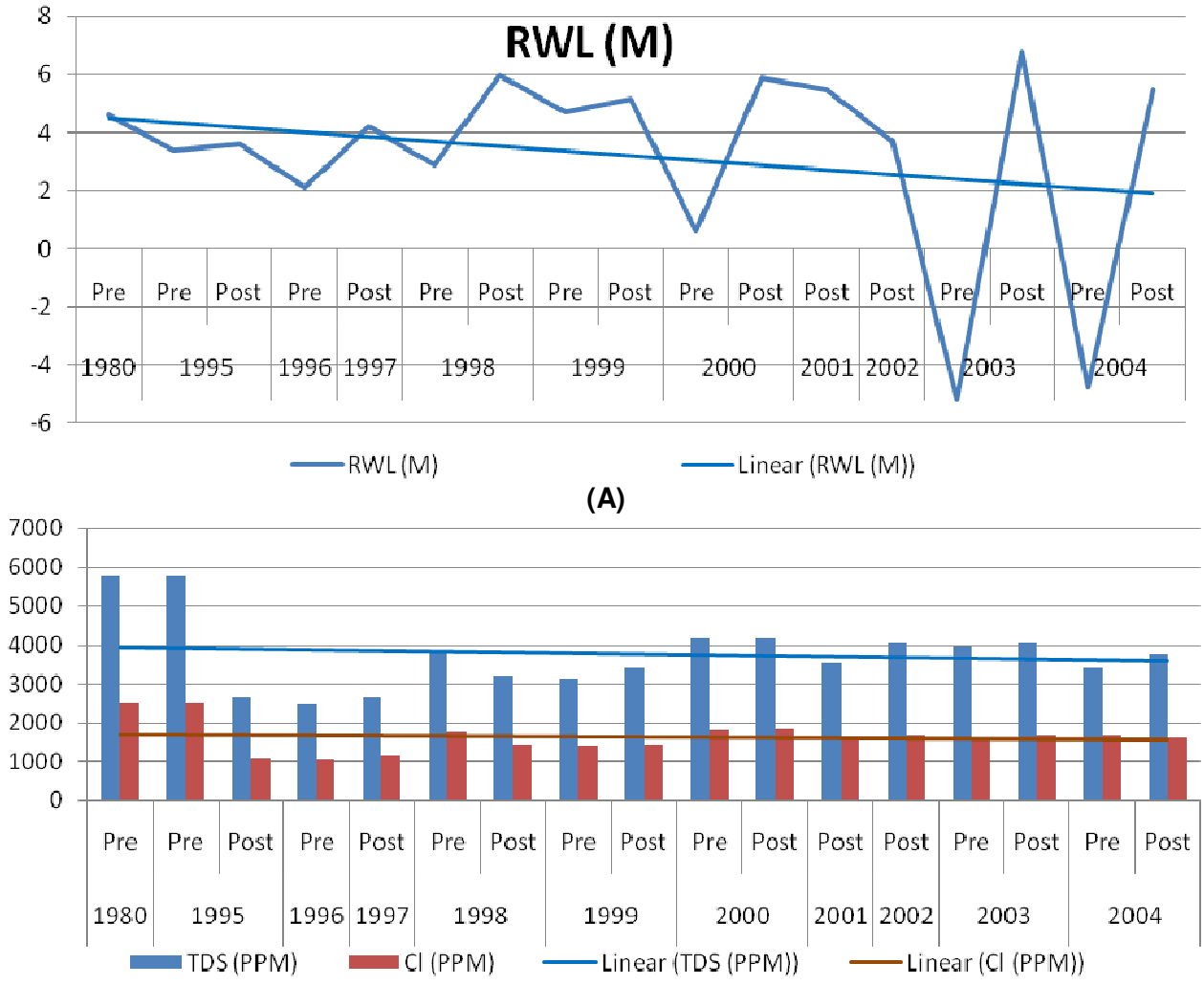


Fig 6.6 Hydrograph Showing Changes in Water Levels and Quality (TDS and Chloride) in Observation Well (K – 87) Village Bhogat

As far as water quality is concerned the quality of groundwater shows three different scenarios i.e. during1980 to 1995 the TDS values were more than 5000 ppm whereas as during 1996 to 1998 these values were less than 3000 ppm. After pre monsoon season of year 1998 the value of TDS remains above 3000 constantly. However, there is a gradual decrease in TDS value from more than 5500 in year 1980 to about 3500 in year 2004.

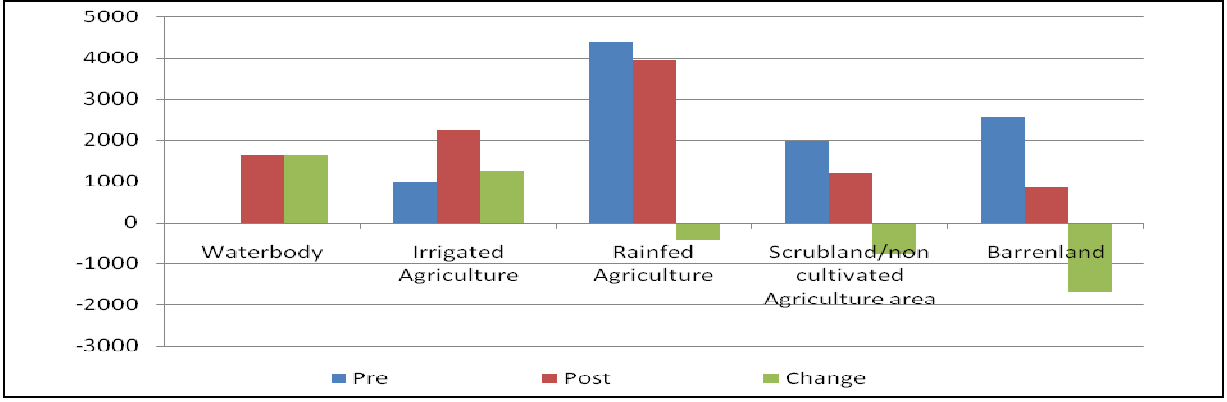
6.1.4 LANDUSE

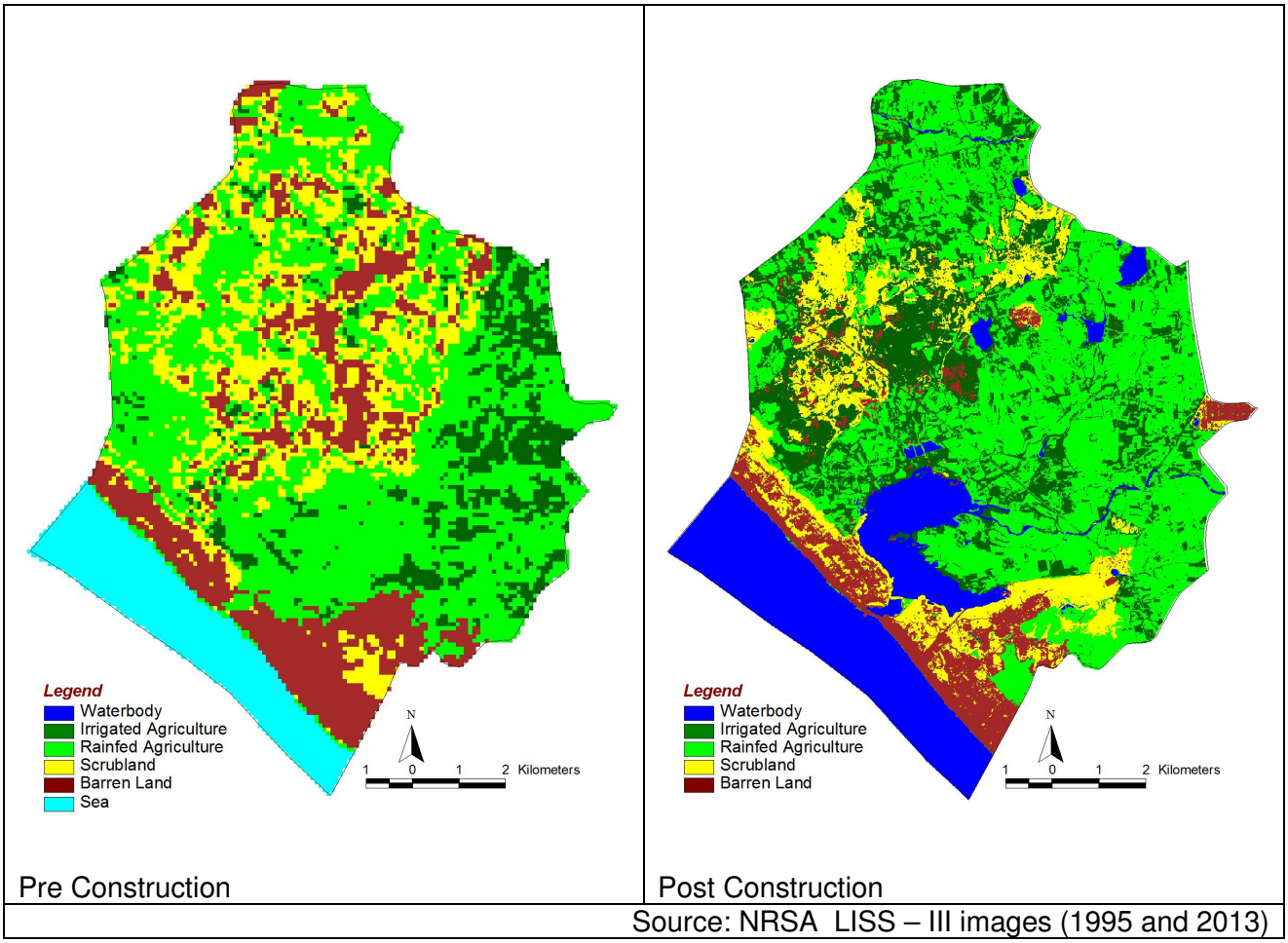
Landuse pattern around Bhogat Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1995 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 6.3)

The satellite image analysis shows very high increase i.e. about 1253 Ha in irrigated areas after Tidal regulator where as it also shows about 429 Ha area of rainfed have decreased. It also shows decrease in barren land and scrub land that clearly shows very positive impact of tidal regulator in surrounding areas.

Table 6.3 Landuse Pattern Around Bardasagar Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	0	1649	1649
Irrigated Agriculture	999	2252	1253
Rainfed Agriculture	4383	3954	-429
Scrubland/non cultivated Agriculture area	1971	1198	-773
Barren land	2554	854	-1700
Total	**9907**	**9907**	0





Source: NRSA LISS – III images (1995 and 2013)

Fig. 6.6 Changes in Landuse Pattern around Bhogat TR Area

6.2 SARMATKHARA BERAJA BANDHARA

6.2.1 ASSETS, INCOME AND INVESTMENTS

Marking a slight departure from the trend seen in other schemes and districts, vehicle, tractors and toilets seem to be the predominant assets acquired post the construction of the Sarmatkhara Beraja bandhara as seen from Fig. 6.7.

That there has been limited impact on households' income sources post the bandhara can be seen from the small number of sample households reporting change in income sources (Fig. 6.8 A). From the available data, nearly an equal proportion (40 per cent) of households has started getting additional income from a micro-enterprise/business activity and selling of milk while better opportunities for daily wage employment have been able to provide livelihoods to another 20 per cent of the sample households.

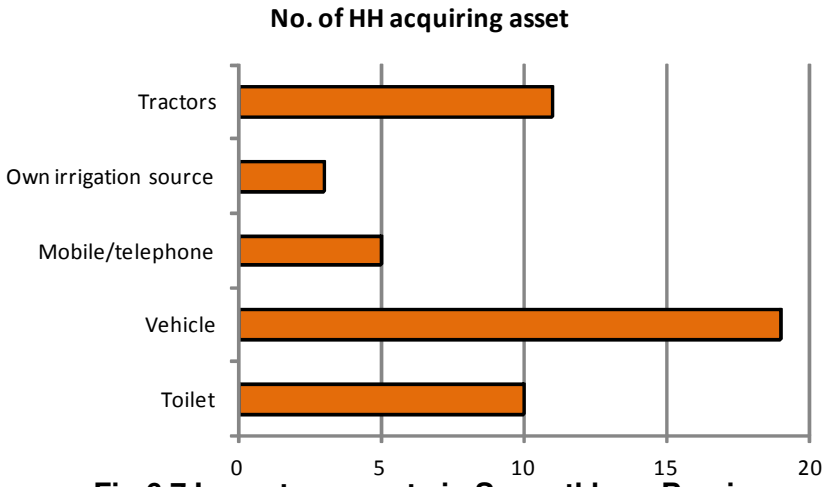


Fig 6.7 Impact on assets in Sarmatkhara Beraja

In terms of investment of the surplus income, 24 per cent of the surveyed households have gone for a toilet or tap connection in their house, 22 per cent have spent it on renovating their house and 18 per cent have spent it on children's education (Fig. 6.8 B).

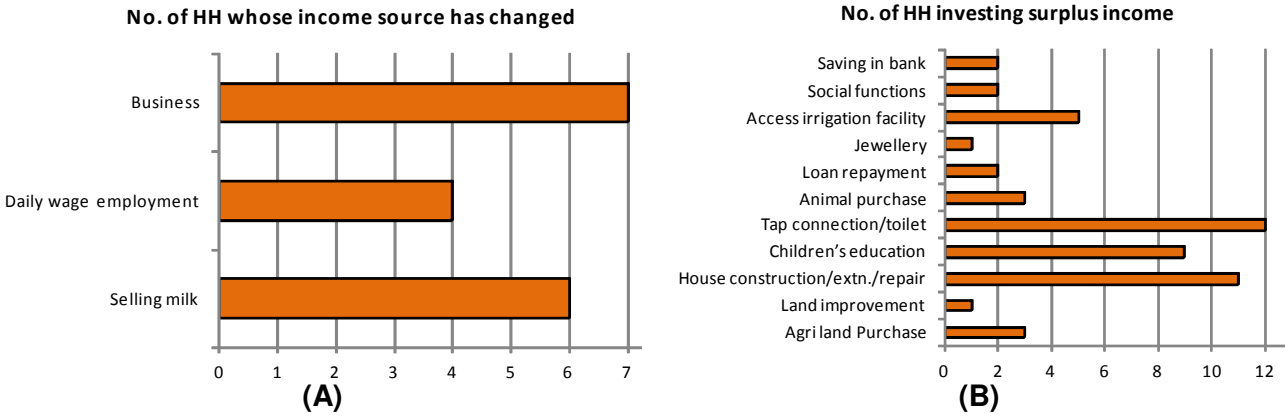


Fig. 6.8: Impact on Income Source (A) and Investment of Surplus Income (B) in Sarmatkhara Beraja

6.2 2 FODDER, LIVESTOCK AND MILK PRODUCTION

No change in fodder availability can be seen before and after the scheme in the case of Sarmatkhara Beraja bandhara. Despite this, increases in milch animal population have been quite good – 63 per cent in the case of cows and 57 per cent in the case of buffaloes. Milk production from these milch animals has also gone up by about 34-38 per cent. However, the most significant change can be noticed in the demand for bullocks on account of improved agriculture post the scheme in the sample villages (Fig. 6.9).

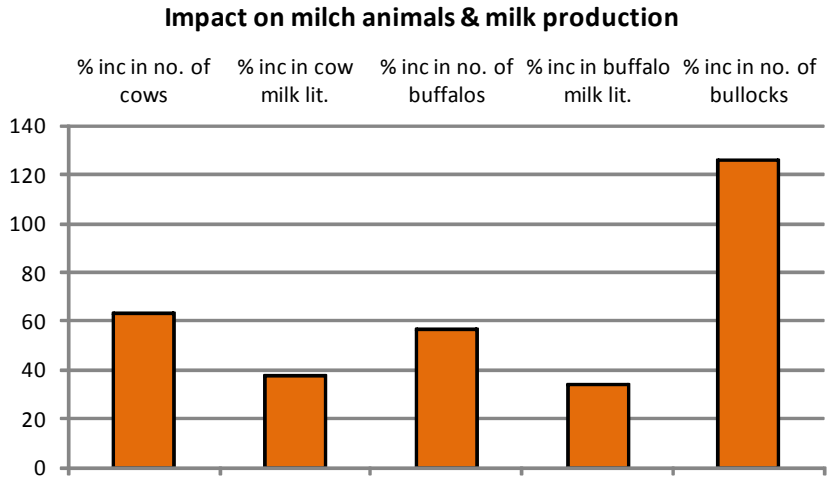


Fig. 6.9 Impact on milch animals and milk production in Sarmatkhara Beraja

6.2.3 GROUNDWATER AVAILABILITY AND QUALITY

While a majority 70 per cent of the sample households reported no change in the water table post the bandhara, 20 per cent of the families have experienced groundwater levels improving by upto 25 feet as can be seen from Fig. 6.10 A.

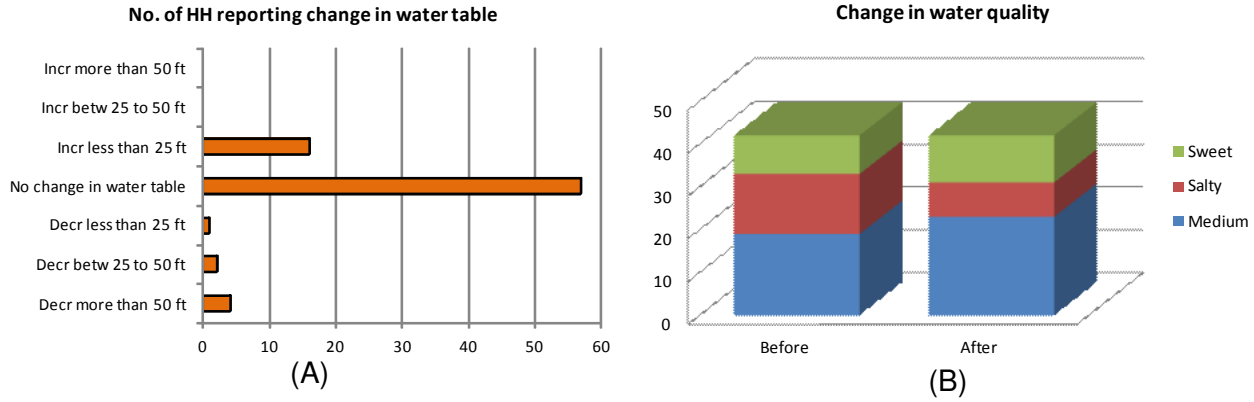


Fig. 6.9: People's View on Changes in Water Table (A) and Water Quality (B) in Sarmatkhara Beraja

Even the quality of water has undergone a perceptible change after the scheme where the proportion of families getting sweet water went up from 21 to 26 per cent and those getting medium quality water improved from 45 to 55 per cent (Fig. 6.10 B).

Besides people's observation with the help of SIPC records of observation wells in village Vasai (01 well) Sarmat (02 wells) and Dhichada (02 wells) changes in water levels (Table 6.3) and water quality (Table 6.4) have studied by preparing well hydrographs for selected observation wells such as K-264 of village Sarmat and K-269 of village Dhichada only looking availability of consistent data. (Fig. 6.10 A and 6.10 B)

Well hydrograph for changes in water level shows there is an average rise in water level in village Sarmat about 0.25 m while average decline of 1.0 m in water levels in Dhichadana village. in village Dhichada the average water level was just above the average mean sea level during 1980 that is now below than AMSL by 0.5 m average.

In case of water quality it shows almost reves condition than water level in village Sarmat along with rise in water level TDS value is also rising whereas in Dhichada village values of TDS shows

is decrease from about 4000 ppm before Bandhara and now it is less than 2000 ppm. Whereas in village TDS were about 4000 ppm has increase up to 9500 in year 2011.

Table 6.3 Pre and Post Monsoon Water Levels in Observation Wells of Village Vasai, Sarmat and Dhichada

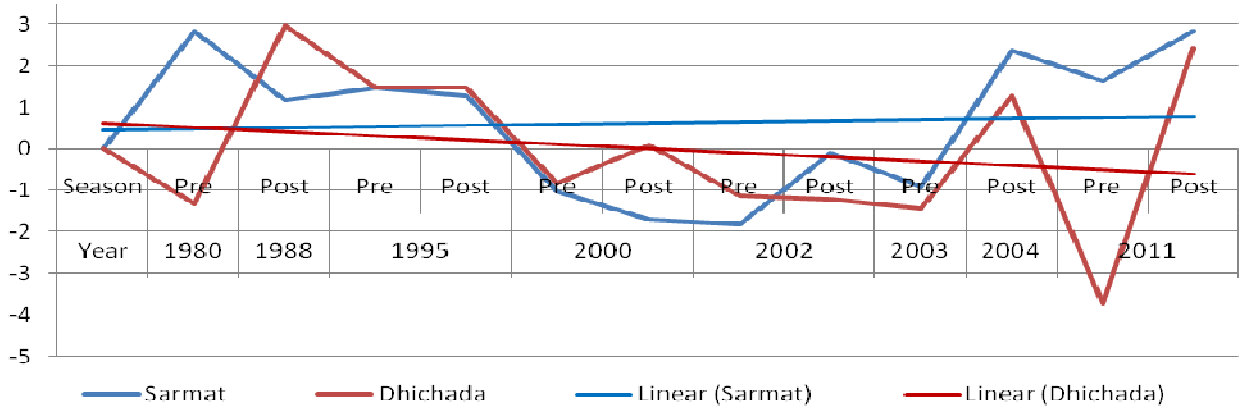
Year	Season	Reduced Water Levels (M)				
		Vasai	Sarmat	Sarmat	Dhichada	Dhichada
		K-262	K-263	K-264	K-268	K-269
1980	Pre	15.63	4.47	2.83	-1.72	-1.33
1988	Post	14.53	4.27	1.18	3.58	2.98
1995	Pre	14.03	2.67	1.48	2.48	1.48
	Post	12.73	1.67	1.28	2.48	1.48
2000	Pre	---	---	-1.02	---	-0.82
	Post	12.53	3.47	-1.72	0.88	0.08
2002	Pre	5.63		-1.82	-5.12	-1.12
	Post	11.43	1.97	-0.12	-5.52	-1.22
2003	Pre	10.53		-0.92	---	-1.42
2004	Post	14.63	4.37	2.38	5.28	1.28
2011	Pre	---	---	1.63	---	-3.72
	Post	---	---	2.83	---	2.43

Source: SIPC (1980 2011)

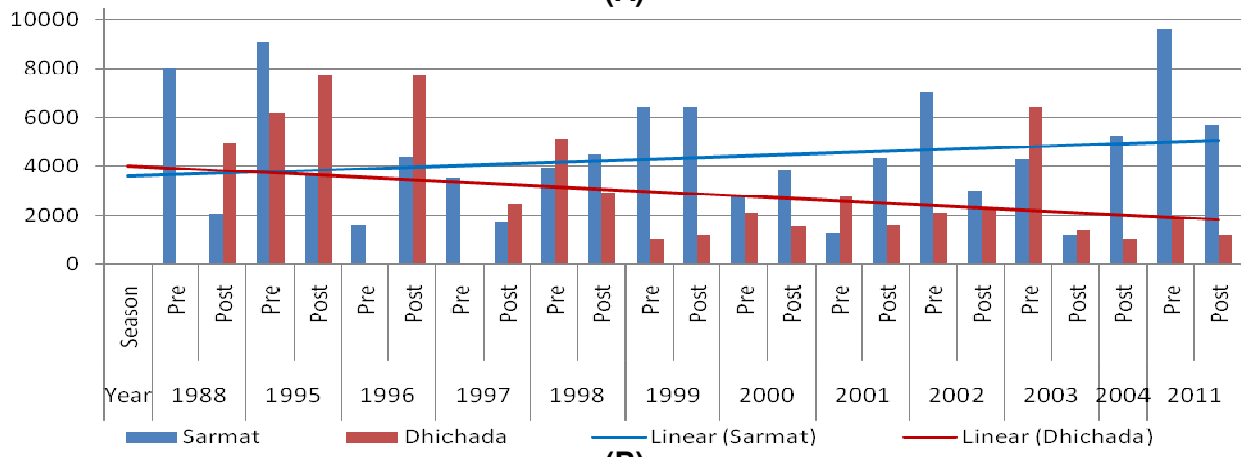
Table 6.3 Pre and Post Monsoon Water Levels in Observation Wells of Village Vasai, Sarmat and Dhichada

Year	Season	Total Dissolved Solids (PPM)				
		Vasai	Sarmat	Sarmat	Dhichada	Dhichada
		K-262	K-263	K-264	K-268	K-269
1988	Post	300	560	2060	1180	4940
1995	Pre	880	800	9080	1860	6200
	Post	960	900	3720	1860	7680
1996	Pre	900	1480	1600	4400	---
	Post	1020	780	4400	1280	7680
1997	Pre	840	1080	3520	1160	---
	Post	1040	940	1720	2120	2440
1998	Pre	900	1240	3940	1000	5120
	Post	960	840	4480	1980	2940
1999	Pre	1400	900	6400	1080	1020
	Post	1920	960	6400	1400	1220
2000	Pre	---	---	2820	---	2120
	Post	1540	900	3840	---	1540
2001	Pre	2040	5500	1280	---	2760
	Post	1280	1080	4360	1660	1600
2002	Pre	1500	---	7040	1280	2100
	Post	1280	740	3020	2120	2330
2003	Pre	1660	---	4280	---	6400
	Post	1446	2976	1220	1400	1390
2004	Post	---	1900	5230	2430	1020
2011	Pre	---	---	9570	---	1860
	Post	---	---	5660	---	1190

Source: SIPC (1988 2011)



(A)



(B)

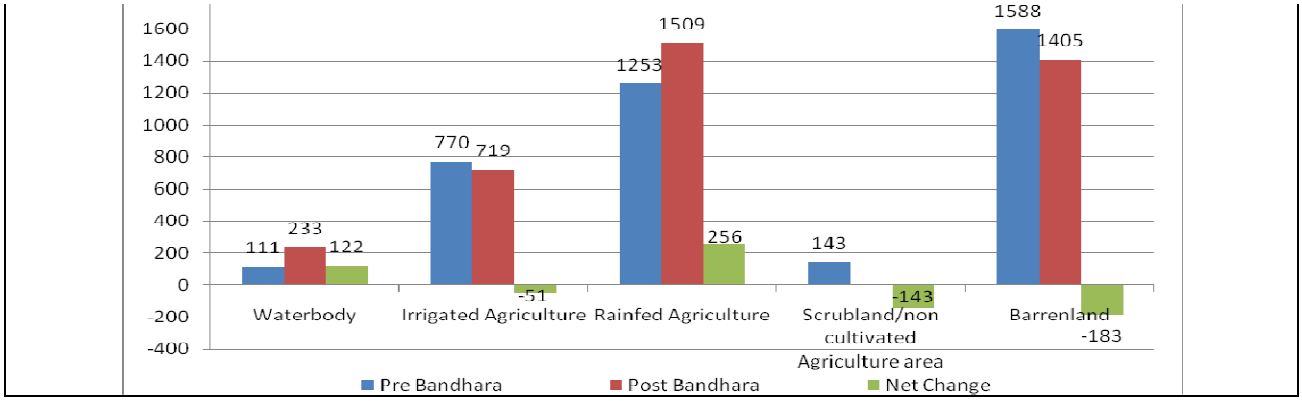
Fig 6.10 Well Hydrographs Showing Changes in Water Levels (A) and Concentrations of TDS in Groundwater of Village Sarmat and Dhichada of Sarmatkhara Beraja Bandhara

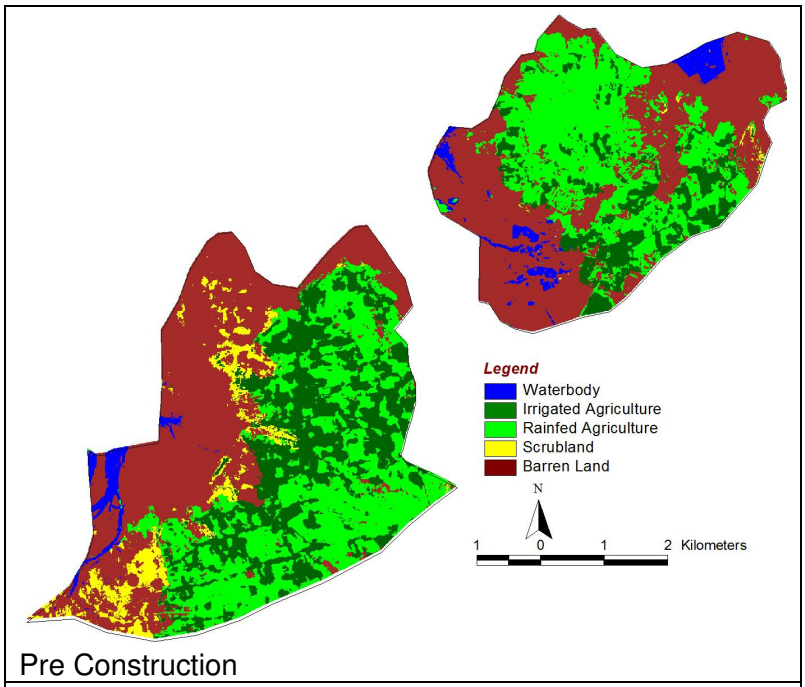
6.2.4 LANDUSE

Landuse pattern around Sarmatkhara Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1999 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 6.4)

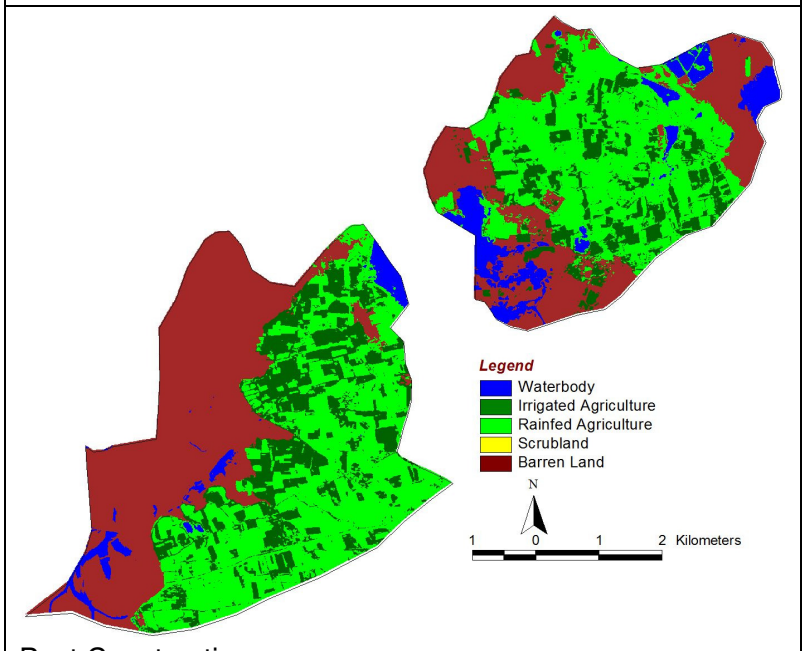
Table 6.4 Landuse Pattern around Sarmatkhara Beraja Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	111	233	122
Irrigated Agriculture	770	719	-51
Rain fed Agriculture	1253	1509	256
Scrubland/non cultivated Agriculture area	143		-143
Barren land	1588	1405	-183
Total	**3866**	**3866**	0





Pre Construction



Post Construction

Source: NRSA LISS – III images (1999 and 2013)

Fig. 6.11 Landuse Pattern around Sarmatkhara Bandhara Area

6.3 KHIJADIYA STEPWELL TO JAMBUDA BANDHARA CANAL

6.3.1 ASSETS, INCOME AND INVESTMENTS

34 per cent of the sample households in villages benefitting from the Khijadiya canal have been able to construct a toilet; 32 per cent have acquired mobile telephones and 20 per cent have bought a vehicle post the construction of the canal (Fig. 6.12).

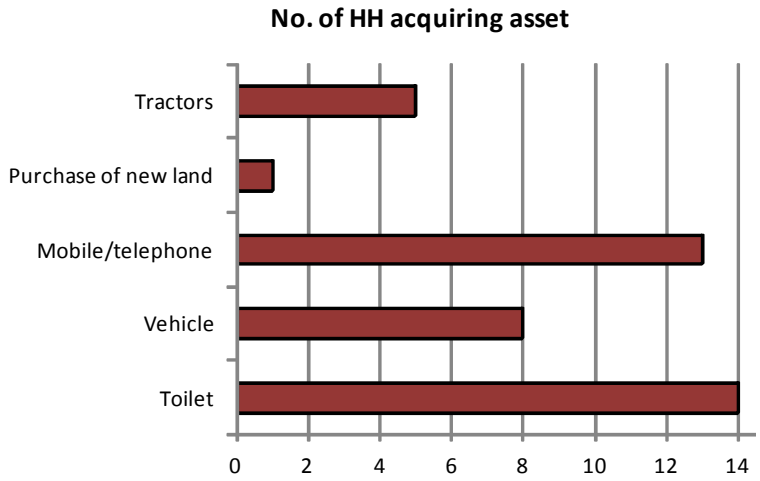


Fig. 6.12: Impact on Assets in Khijadiya

The limited impact that the scheme has had on income sources of families is evident from the extremely small sample of households reporting change in income source as can be seen in Fig. 6.13 A From the available data, while business seems to be the activity generating additional income for more number of households, considering the small size of the sample, it may be erroneous to draw any firm conclusions.

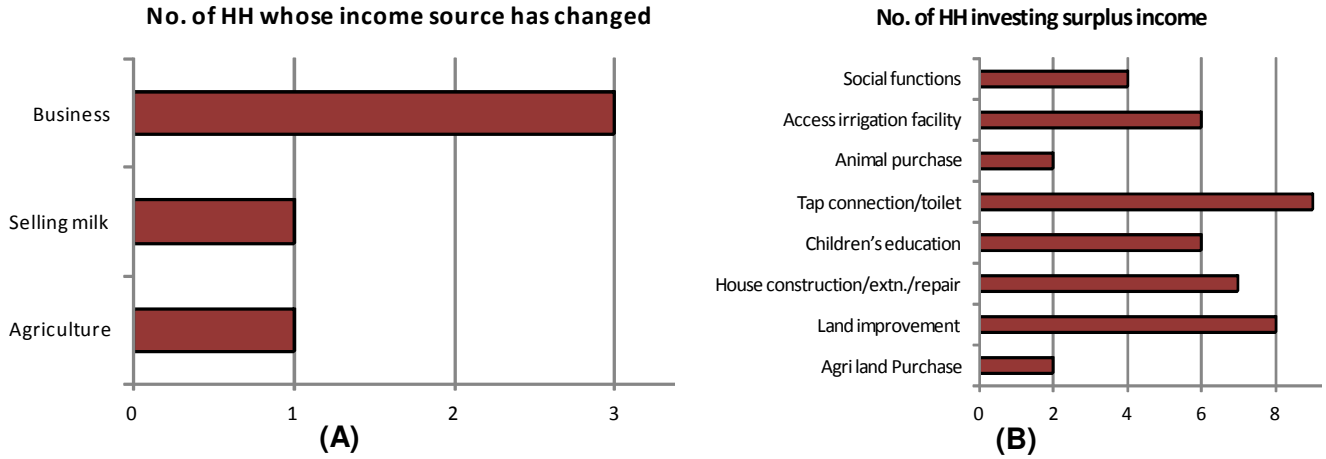


Fig. 6.13 Impact on income source (A) and Investment of Surplus Income (B) in Khijadiya

Investment of surplus income has largely been on getting a tap connection/toilet (20 per cent of households), followed by land improvement (18 per cent of HH), house renovation (16 per cent of HH) and accessing irrigation facilities and children's education (both 14 per cent HH each) as evident from Fig. 6.13 B.

6.3.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 6.5 Impact on fodder availability due to agriculture, Khijadiya

Impact	Quantity
Increase in Green Fodder (%)	35
Increase in Dry Fodder (%)	-13
Increase in Cow dung (%)	-3

Even though green fodder availability has increased by 35 per cent post the scheme, dry fodder availability has not been affected and has in fact declined marginally.

A shift away from animal husbandry as an

occupation can be seen in villages affected by the scheme. This can be inferred from the decrease in number of milch animals and milk production post the scheme as shown in Fig. 6.14.

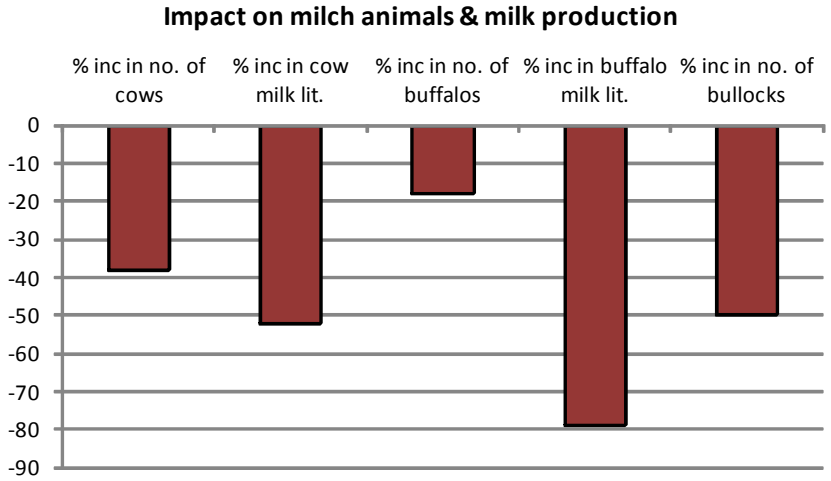


Fig. 6.14 Impact on Milch Animals and Milk Production in Khijadiya

6.3.3 GROUNDWATER AVAILABILITY AND QUALITY

The overall impact of the Khijadiya canal on groundwater availability has been positive. Even though a large proportion (74 per cent) of the surveyed households in Khijadiya has noticed no change in the water table after the scheme, a significant number (21 per cent) has seen water tables rising by between 25-50 feet and more than 50 feet (Fig. 6.15).

In addition to people's perspective attempt made to understand changes taken place in for water levels and water quality with the help of SIPC monitoring data (Table 6.6 and 6.7)

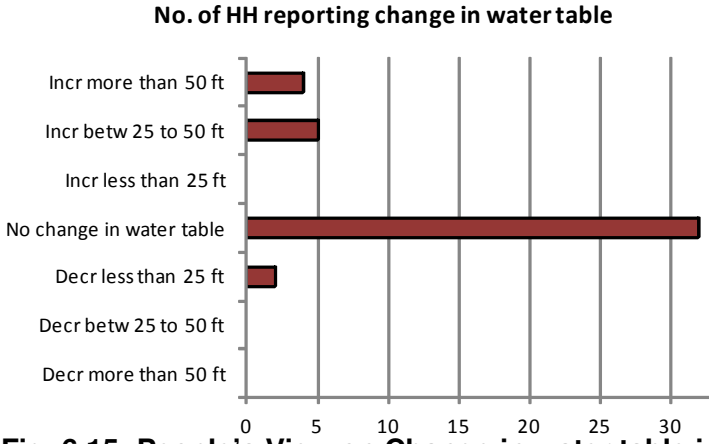
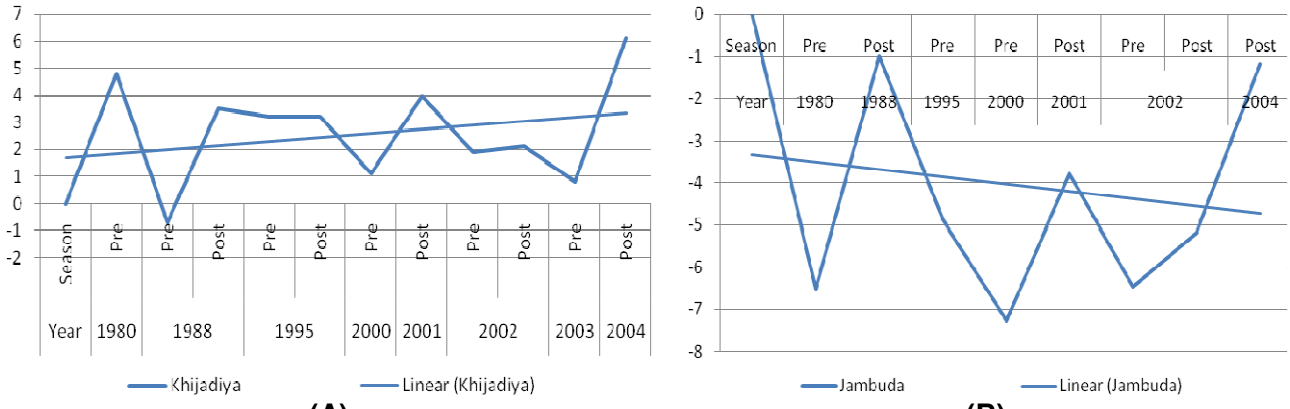


Fig. 6.15: People's View on Change in water table in Khijadiya

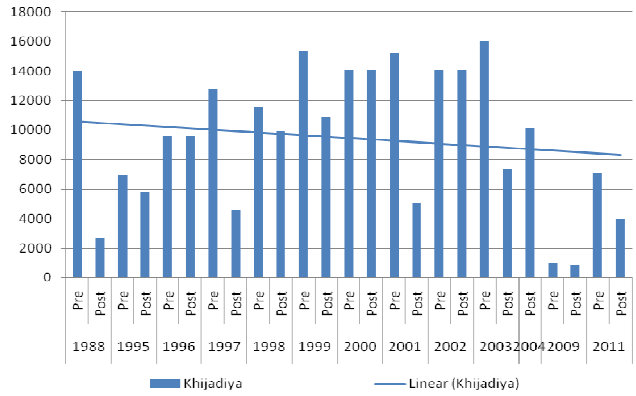


(A) **(B)**

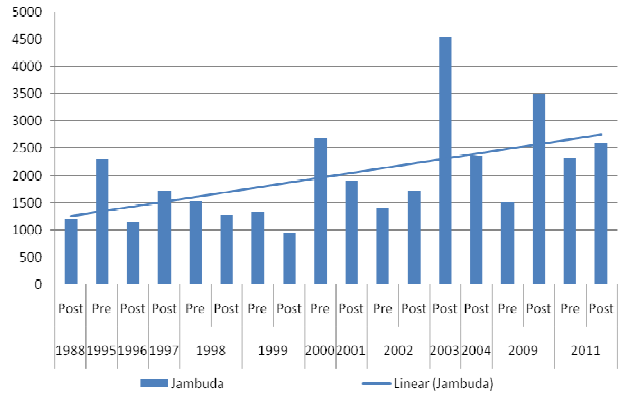
Fig 6.16 Well Hydrograph Showing Fluctuation in Reduced Water Levels in Village (A) Khijadiya (OW no. K – 272) and (B) Jambuda (OW no. K – 276)

SIPC has established a four well monitoring network around the Jambuda bandhara in two villages such as Khijadiya (01 well) and Jambuda (04 wells). Well hydrographs have prepared for two observation wells such as K – 272 and K – 276 of village Khijadiya and Jambuda respectively for water levels and concentrations of total dissolved solids. (Fig. 6.16 and Fig 6.17) Following are major findings regarding changes in groundwater levels and quality.

- Water levels in village Khijadiya (OW no. K – 272) shows average rise in water level of more than 1.5 m from 1980 to 2004. The water levels in year 1980 i.e. before construction of canal it bandhara was almost equal to AMSL that has risen up to 6 m above AMSL
- Water levels in Jambuda shows decreasing trend from year 1980 to year 2004. The average decrease is more than 1 m. The water level is below AMSL during both the phase i.e. pre and post constructions periods.
- Similarly RWL hydrograph of TDS shows clear relationship between water levels and total dissolved solids. In Khijidaya (K – 272) along with rise in water level improvement in water quality can been seen through hydrograph in Fig 6.17 A. Even though decrease in TDS concentrations it is more nearly 4000 ppm in year 2011 that was about 14000 ppm in year 1988 i.e. before construction
- There is a gradual increase in TDS concentrations in village Jambuda OW no K – 276. This also shows clear relationship with fall in water levels. Before construction the TDS concentration value was less than 1500 ppm that has increased more than 2500 ppm



(A)



(B)

Fig 6.17 Well Hydrograph Showing Fluctuation in TDS Concentrations in Village (A) Khijadiya (OW no. K – 272) and (B) Jambuda (OW no. K – 276)

Table 6.6 Pre and Post Monsoon Changes in Reduced Water Levels in Khijadiya and Jambuda Bandhara

Year	Season	Reduced Water Levels (M)				
		Khijadiya	Jambuda			
		K-272	K-276	K-277	K-278	K-279
1980	Pre	4.81	-6.53	-1.99	-1.66	2.75
1988	Pre	-0.69	---	---	---	---
	Post	3.51	-0.98	-3.44	2.84	-6.25
1995	Pre	3.21	-4.88	-1.94	-1.56	-5.25
	Post	3.21	---	---	-0.46	-6.95
2000	Pre	1.11	-7.28	---	---	---
2001	Post	3.96	-3.78	-2.19	---	---
2002	Pre	1.91	-6.48	-2.94	---	---
	Post	2.11	-5.18	-2.34	---	---
2003	Pre	0.81	---	-3.09	---	---
2004	Post	6.11	-1.18	2.26	5.34	3.15

Source: SIPC (1988 2004)

Table 6.7 Pre and Post Monsoon Changes in Concentrations in Total Dissolved Solids in Khijadiya and Jambuda Bandhara

Year	Season	Total Dissolved Solids (PPM)				
		Khijadiya	Jambuda			
		K-272	K-276	K-277	K-278	K-279
1988	Pre	14000	---	---	---	---
	Post	2640	1200	5100	1840	3580
1995	Pre	6980	2300	10500	6980	7040
	Post	5760	---	---	14080	9600
1996	Pre	9600	---	25600	---	---
	Post	9600	1160	1480	---	9600
1997	Pre	12800	---	63360	---	---
	Post	4620	1720	12800	7040	8220
1998	Pre	11580	1540	17660		9980
	Post	9920	1280	16320	8320	5120
1999	Pre	15360	1340	18590	---	---
	Post	10880	960	38400	---	---
2000	Pre	14080	2680	---	---	---
	Post	14080	---	20740	---	---
2001	Pre	15240	---	28740	---	---
	Post	5060	1920	16000	---	10240
2002	Pre	14080	1400	2496	---	---
	Post	14080	1720	16640	---	---
2003	Pre	16000	---	19840	---	---
	Post	7340	4550	89740	8170	11640
2004	Post	10120	2360	16790	640	10870
2009	Pre	1000	1510	---	---	---
	Post	820	3490	---	---	---
2011	Pre	7050	2330	---	---	---
	Post	3990	2600	---	---	---

Source: SIPC (1988 2011)

6.4 BALAMBHA BANDHARA

6.4.1 ASSETS, INCOME AND INVESTMENTS

37 per cent of the surveyed households in villages benefitting from the Balambha bandhara have been able to acquire a mobile telephone; 23 per cent have acquired a vehicle while 21 per cent have constructed a toilet post the construction of the bandhara (Fig. 6.18).

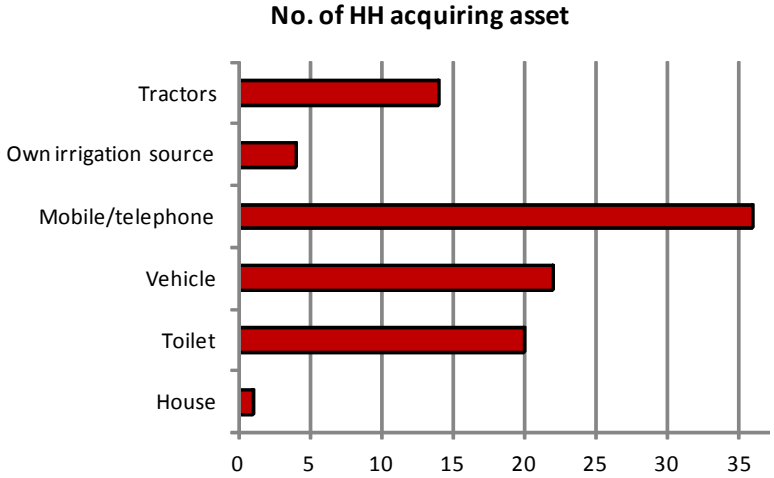


Fig. 6.18 Impact on assets in Balambha

Most households have reported that daily wage employment has been able to provide an income source to them post the construction of the bandhara. Also, about 15 per cent of households each have started getting additional income from selling milk and from money lending (see Fig. 6.19 A). The surplus income generated has been invested by families for a variety of purposes, predominant among which are tap connection/toilet, followed in that order by social function, accessing irrigation facilities, saving in bank, repayment of existing loans and buying jewellery (Fig. 6.19 B).

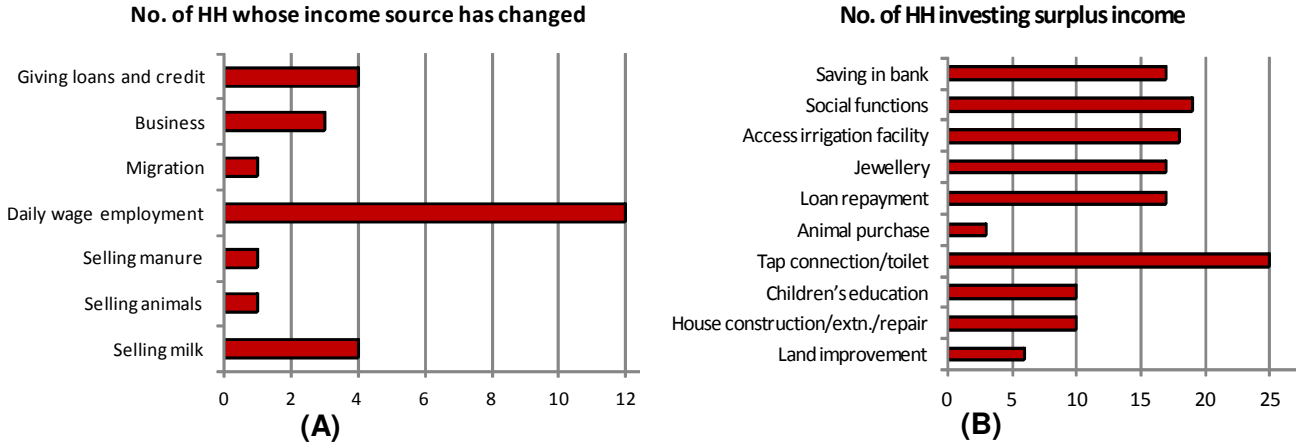


Fig. 6.18 Impact on Income Source (A) and Investment of Surplus Income (B) in Balambha

6.4.2 FODDER, LIVESTOCK AND MILK PRODUCTION

Table 6.8 Impact on fodder availability due to agriculture, Khijadiya

Impact	Quantity
Increase in Green Fodder (%)	33
Increase in Dry Fodder (%)	72
Increase in Cow dung (%)	82

Fodder availability post the bandhara has undergone a marked change where green and dry fodder production has risen by 33 per cent and 72 per cent respectively and manure (cow dung) availability has improved by 82 per cent (Table 6.8).

Better fodder availability has led to a positive impact on milch animal population as well as milk production as can be seen from Fig. 6.19. While the number of cows and buffaloes has increased

by 56 per cent and 81 per cent respectively, milk production from cows and buffaloes has increased by 67 per cent and 72 per cent respectively post the scheme..

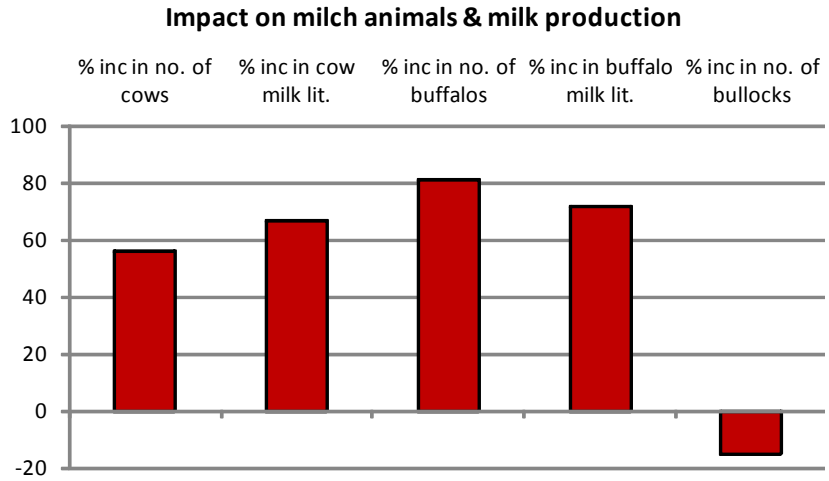


Fig. 6.19 Impact on milch animals and milk production in Balambha

6.4.3 GROUNDWATER AVAILABILITY AND QUALITY

As followed in impact assessment methods for all structures, assessment for Balambha Bandhara has also held with dual methods i.e. people's concern and technical assessment. According to people of Balambha area there has been a moderate to limited impact of the Balambha bandhara on water table in the affected villages can be seen from the fact that 58 per cent of the sample households have reported no change in the water table and 31 per cent of these have claimed that the water table has actually gone down by upto 25 feet. Only 10 per cent of the households have seen groundwater levels increasing by upto 25 feet as shown by Fig. 6.20 A.

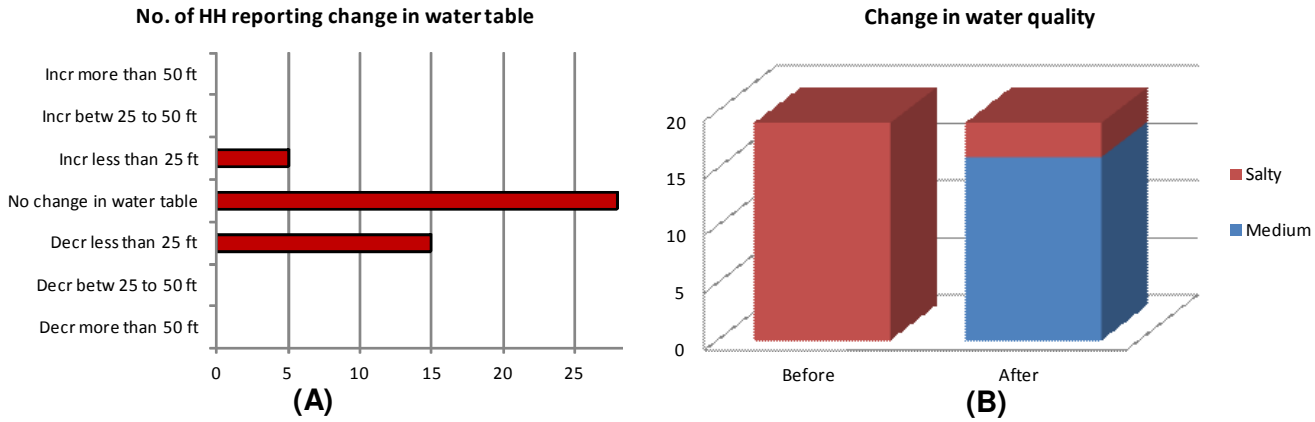


Fig. 6.20: People's View on Change in Water Table (A) and in Water Quality (B) in Balambha

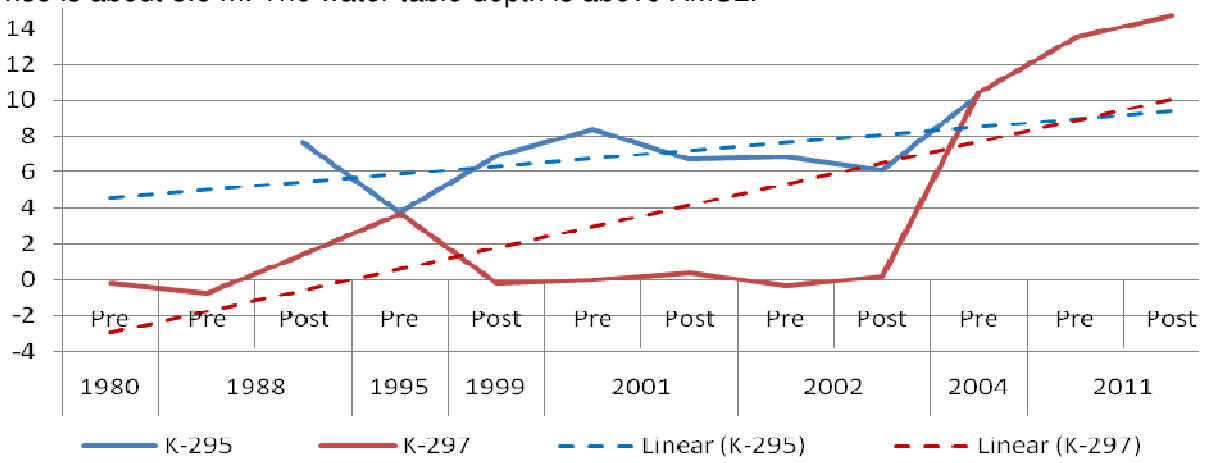
In terms of impact of the bandhara on water quality, the percentage of households receiving salty water has come down from 100 per cent before the scheme to 16 per cent afterwards. Also, the

remaining 84 per cent of the households have started receiving medium quality water as compared to salty water before (Fig. 6.20 B). However, sweet water availability has not been ensured by the Balambha bandhara in the benefitted villages.

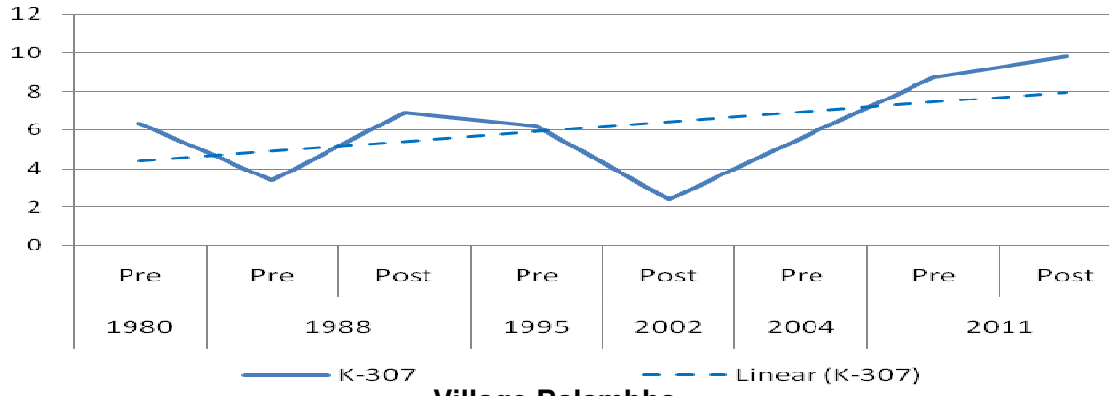
There arefive monitoring wells of SIPC in Balambha Bandhara area in Keshiya (03 wells) and in Balambha village (02 wells). (Table 6.9 and 6.7) Looking towards maximum consistence data hydrographs of three wells (K – 295, K – 297 and K -307) have been prepared for water levels (Fig. 6.21) and TDS concentrations (Fig. 6.22).

Plot No.

- Geologically both the village has weathered amydagaloidal basalt as aquifer.
- Well hydrograph for reduced water levels shows there is a rise in water levels in all three wells. Maximum rise in water has seen in observation well of K- 297 of village Keshiya. In this well the rise in water level is from 0 m in year 1980 to more than 14 m in year 2011. Average rise as per trend line is about 13 m
- In case of well K – 295 the average rise is about 7 m. This well has water level depth is above AMSL in both the period i.e. pre and post construction of Bandhara.
- In compare to Keshiya village well of Balambha shows little less rise in water level i.e. average rise is about 3.5 m. The water table depth is above AMSL.



Village Keshiya
(A)

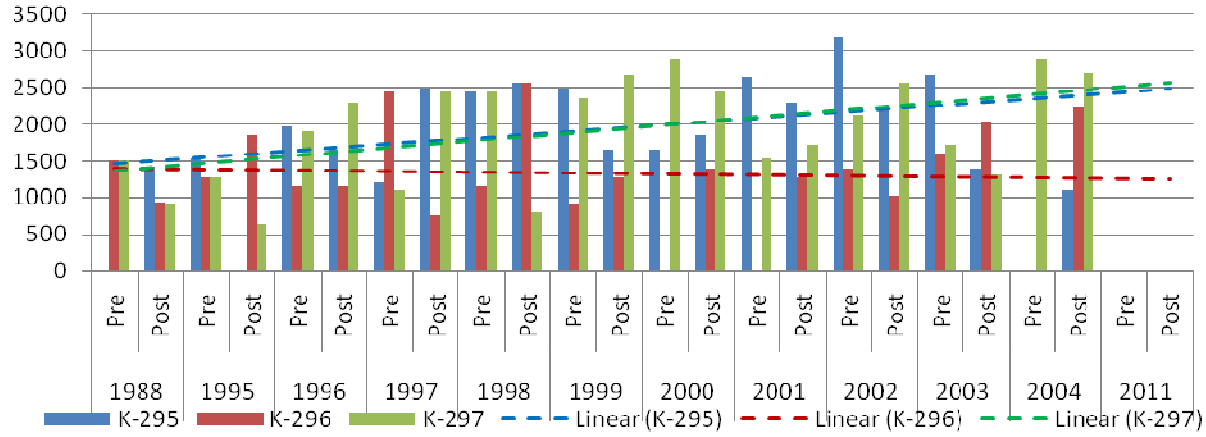


Village Balambha

(B)

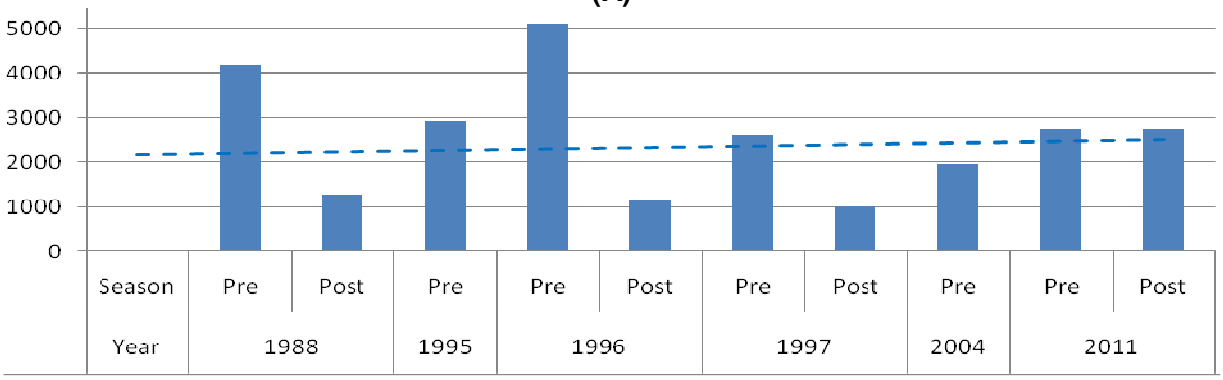
Fig 6.21 Well Hydrograph Showing Changes in Water Levels in Village Keshiya (A) and Village Balambha (B) Due to Balambha Bandhara

- In case of Total Dissolved solid all well shows different behaviour.
- Out of three wells of village Keshiya two wells (K – 295 and K – 297) show rise in TDS concentrations whereas K – 296 shows decrease in TDS. It is important to notice that wells K – 295 and K – 297 shows rise in water level. (6.21 B and 6.22 B)
- In case of village Balambha the water quality shows comparatively low degree of changes than wells of Keshiya. However, there is an increase in TDS concentrations but the average rise is is aout 500 ppm. (Fig. 6.22 B)



Village Keshiya

(A)



Village Balambha Well no K – 307

(B)

Fig. 6.22 Well Hydrograph Showing Changes in TDS in Village Keshiya (A) and in Balambha (B) in Balambha Bandhara Area

Table 6.9 Pre and Post Monsoon Changes in Water Levels in Balambha Bandhara

Year	Season	Reduced Water Levels (M)				
		Keshiya			Balambha	
		K-295	K-296	K-297	K-306	K-307
1980	Pre	3.79	2.03	-0.23	5.72	6.34
1988	Pre		3.03	-0.73		3.39
	Post	7.64	3.33	1.47	6.82	6.89
1995	Pre	3.74	4.83	3.67		6.19
1999	Post	6.94		-0.23		
2001	Pre	8.34	5.33	-0.03		
	Post	6.74	2.43	0.37		
2002	Pre	6.84	2.33	-0.33		
	Post	6.14	3.23	0.17		2.39
2004	Pre	10.29	10.33	10.37		5.59
2011	Pre			13.47		8.69
	Post			14.67		9.79

Source: SIPC (1988 2011)

Table 6.10 Pre and Post Monsoon Changes in TDS in Balambha Bandhara

Year	Season	Total Dissolved Solids (PPM)				
		Keshiya			Balambha	
		K-295	K-296	K-297	K-306	K-307
1988	Pre		1500	1500		4200
	Post	1420	940	900	1080	1280
1995	Pre	1540	1280	1280		2940
	Post		1860	640		
1996	Pre	1980	1160	1920		5120
	Post	1660	1160	2300		1160
1997	Pre	1220	2440	1100		2620
	Post	2500	760	2440		1020
1998	Pre	2440	1160	2440	1400	
	Post	2560	2560	810		
1999	Pre	2500	906	2360		
	Post	1660	1280	2680		
2000	Pre	1660		2880		
	Post	1860	1400	2440		
2001	Pre	2640		1540		
	Post	2300	1280	1720		
2002	Pre	3200	1400	2120		
	Post	2180	1020	2560		
2003	Pre	2680	1600	1720		
	Post	1400	2040	1320		
2004	Pre			2880		1980
	Post	1100	2230	2700		
2011	Pre					2750
	Post					2750

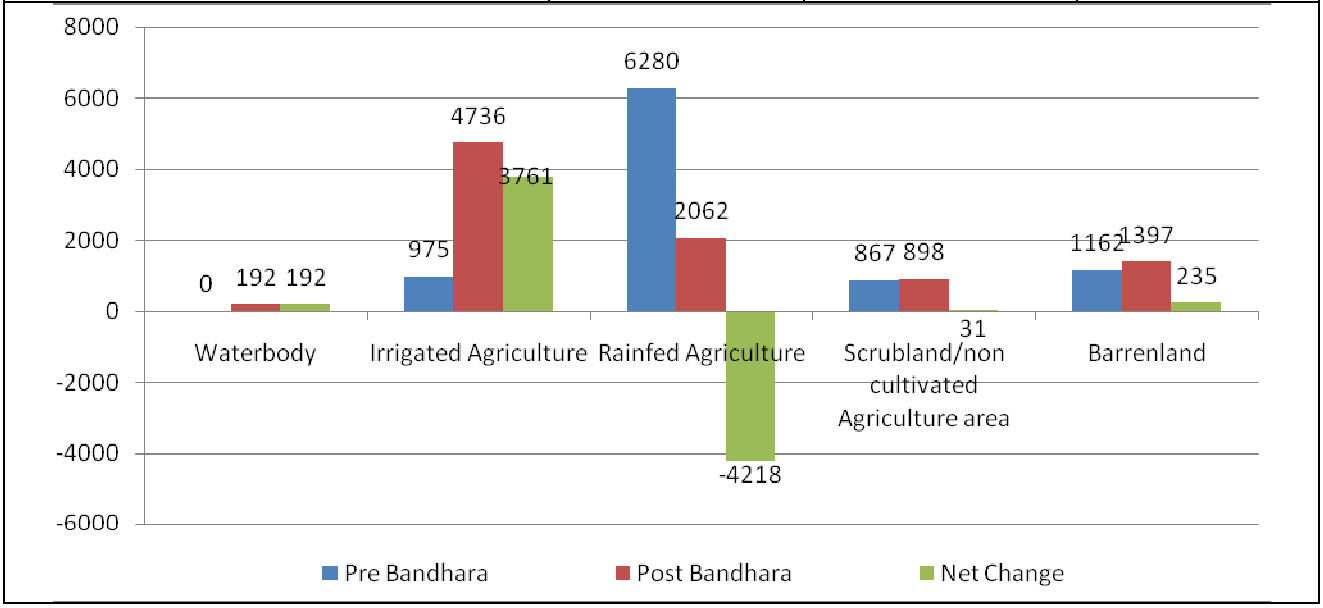
Source: SIPC (1988 2011)

6.4.4 LANDUSE

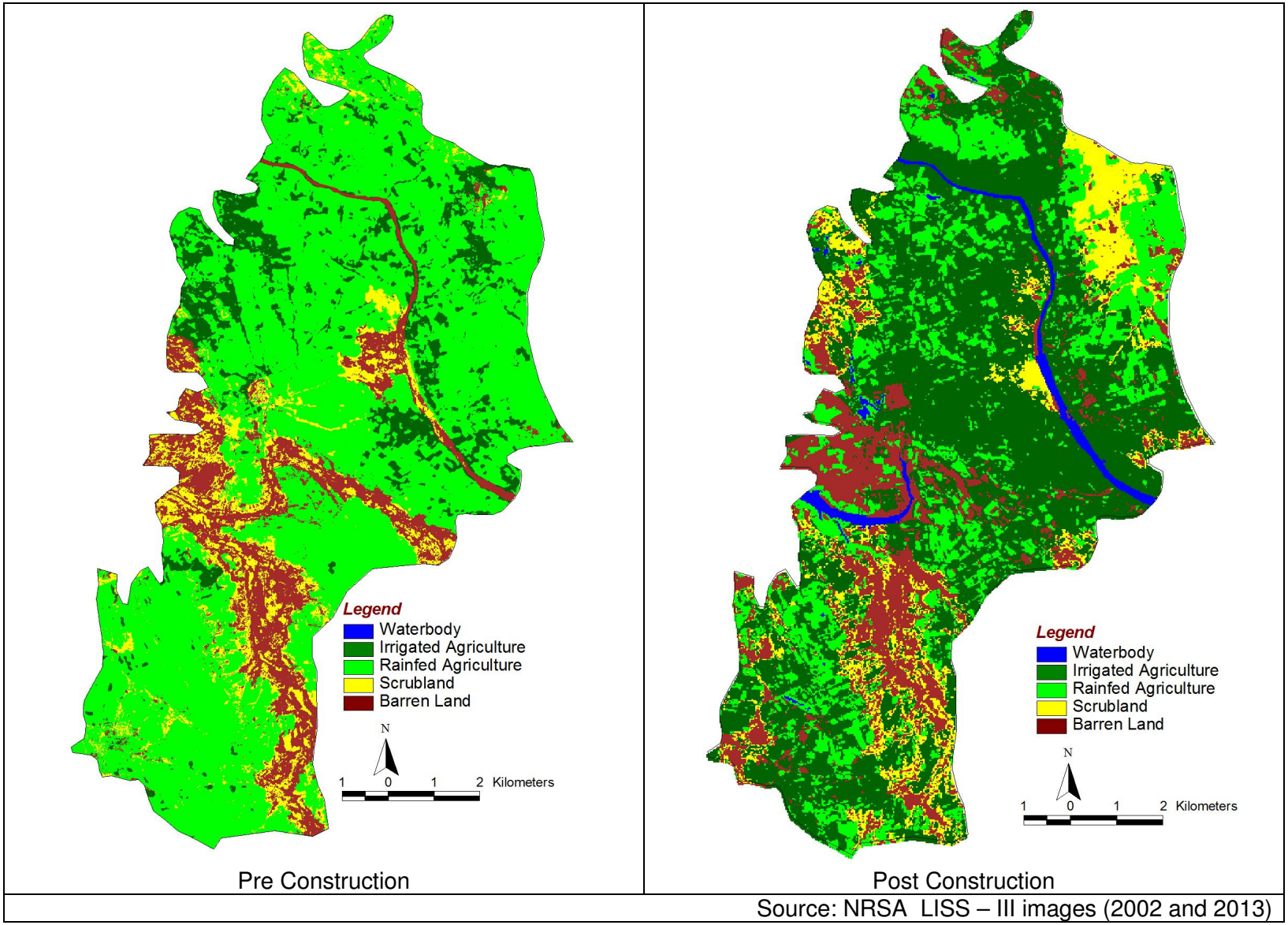
Land use pattern around Balambha Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 2002 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 6.11)

Table 6.11 Landuse Pattern around Balambha Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	0	192	192
Irrigated Agriculture	975	4736	3761
Rain fed Agriculture	6280	2062	-4218
Scrubland/non cultivated Agriculture	867	898	31
Barren land	1162	1397	235
Total	**9284**	**9284**	0



Out of total analysed land area (9288.42 Ha) about 94 % area is under agriculture use. Even within agriculture area about 51 % area is under irrigation agriculture whereas 43 % is rainfed area. This shows the importance of Bandhara in this area. It has also seen that there is a significant rise in water level may have its own impact on agriculture. There need to be cautious regarding the ground water quality since it can have adverse impact on soil quality of the area. The soils of the area again characterizes as clayey soils and therefore there need to be aware of using such poor quality water for irrigations since clayey soil are more susceptible for chemical reaction with saline water in compare to sandy soil. Only 6 % area is used for various purposes like settlements, barren lands as well as water bodies. It is important to clarify that, pre and post bandhara construction changes in landuse pattern especially in irrigated agriculture areas was not possible to compute due to non availability of pre construction remote sensing data. (Table 6.11, Fig. 6.23)



Pre Construction

Post Construction

Source: NRSA LISS – III images (2002 and 2013)

Fig. 6.23 Landuse Pattern around Balambha Bandhara Area

6.5 KHIRI TIDAL REGULATOR

6.5.1 ASSETS, INCOME AND INVESTMENTS

An extremely small sample of households has responded on aspects like impact of the Khiri TR on assets, income source and investment of surplus income as can be seen from Figs. 6.5.1, 6.5.2 and 6.5.3. As a result, it may be incorrect to draw any firm conclusions on these aspects.

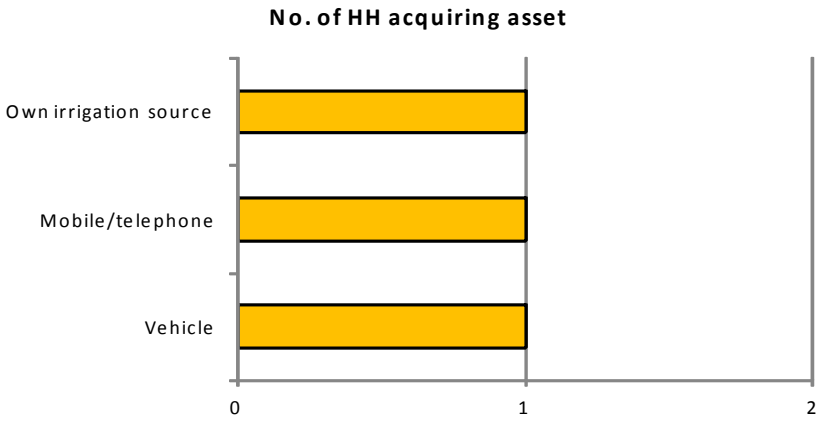


Fig. 6.24 Impact on assets in Khiri

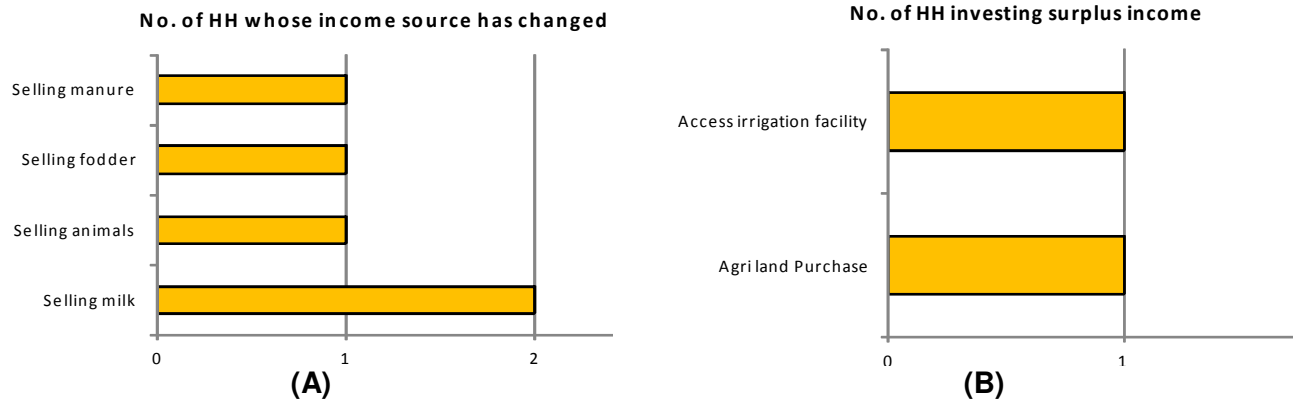


Fig. 6.25 Impact on Income Source (A) in Investment of Surplus Income Khiri

6.5.2 FODDER, LIVESTOCK AND MILK PRODUCTION

There is no change in fodder availability in villages affected by the Khiri TR. Also, a shift away from animal husbandry as an occupation can be seen in villages affected by the scheme. This can be inferred from the decrease in number of milch animals and milk production post the scheme as shown in Fig. 6.26.

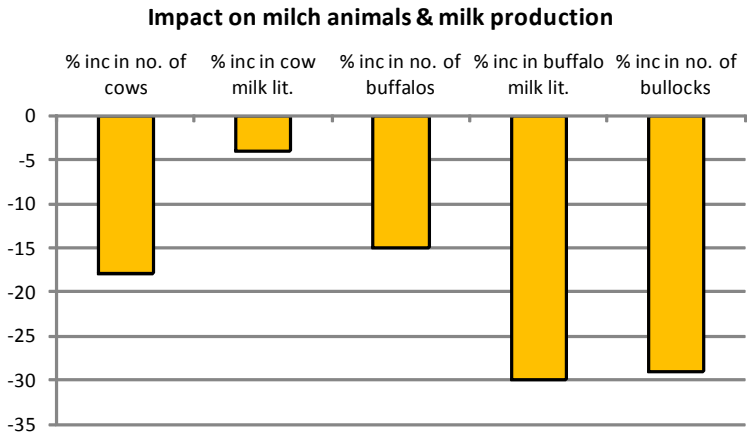


Fig. 6.26 Impact on milch animals and milk production in Khiri

6.5.3 GROUNDWATER AVAILABILITY AND QUALITY

As there is no any secondary data on water levels and water quality available during the study only people's opinion has taken in consideration for groundwater quality and quantity assessment. In terms of impact on the water table, despite the fact that 75 per cent of the surveyed households have reported no change in water table post the construction of the Khiri TR, 25 per cent of households have claimed that the water table has increased by upto 25 feet after the scheme, which is significant (Fig. 6.27).

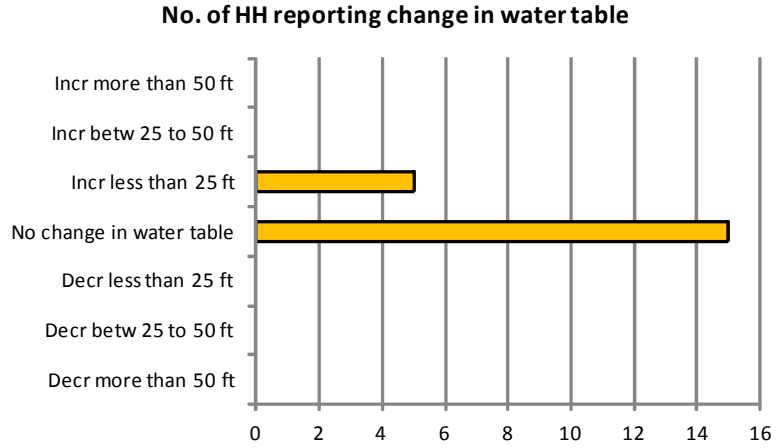


Fig. 6.27 Change in water table in Khiri

In addition to people's view, groundwater changes were also studied by using secondary data collected by SIPC from observation wells in area surrounding the Khiri structure. (Table 6.12) Further to assess trends in groundwater level hydrographs of few wells whose data were collected consistently were prepared (Fig. 6.28) Well hydrographs clearly shows, increasing depth of water level since year 2003 in well no KR 5 and KR 11 while in other observation the trend line shows more or less similar behaviour in all the year.(Fig. 6.28 A) As far as water quality is concerned the hydrograph clearly shows decreasing trends in TDS concentrations in all the observation wells. (Fig. 6.28 B)

Table 6.12 Pre and Post Monsoon Fluctuation in Observation Wells Around Khiri TR

OW No.		KR-1	KR-2	KR-3	KR-4	KR-5	KR-6	KR-7	KR-8	KR-9	KR-10	KR-11	KR-12
2003	**Pre**	6.70	3.20	4.30	6.10	9.30	8.40	-	4.20	4.80	4.50	6.50	-
	Post	-	0.80	0.90	4.80	4.90	2.10	2.00	3.80	2.90	3.00	3.40	3.30
2005	**Pre**	6.80	3.00	3.40	8.20	9.50	9.50	4.40	4.00	-	5.40	5.60	-
	Post	-	-	2.50	3.30	5.10	1.00	2.20	2.80	2.50	1.30	3.60	-
2006	**Pre**	6.20	2.80	3.10	7.10	8.70	4.10	3.00	5.80	3.90	4.50	4.00	7.90
	Post	2.80	0.70	-	4.00	4.80	1.40	3.00	2.00	2.10	1.30	5.00	3.00
2007	**Pre**	6.50	2.80	3.00	5.60	9.00	6.30	5.30	3.70	6.90	6.00	6.10	9.00
	Post	5.30	1.50	-	4.40	8.80	2.80	3.80	4.90	5.90	3.30	6.10	4.60
2008	**Pre**	6.30	3.20	3.40	5.90	9.70	6.60	5.70	3.90	5.10	4.30	6.20	BWS
	Post	7.00	3.20	3.70	6.00	10.50	8.00	-	3.90	5.00	4.40	7.20	-
2009	**Pre**	6.40	3.10	3.80	6.10	10.20	7.60	-	4.00	5.00	5.10	6.70	-
	Post	5.50	2.10	3.50	4.70	8.00	2.80	-	3.20	4.80	4.50	6.60	7.50
2010	**Pre**	6.50	3.40	5.30	6.40	10.40	9.00	-	4.40	5.10	5.00	7.00	-
	Post	4.30	N.A.	N.A.	3.10	8.50	1.20	2.20	N.A.	2.70	2.20	4.00	N.A.

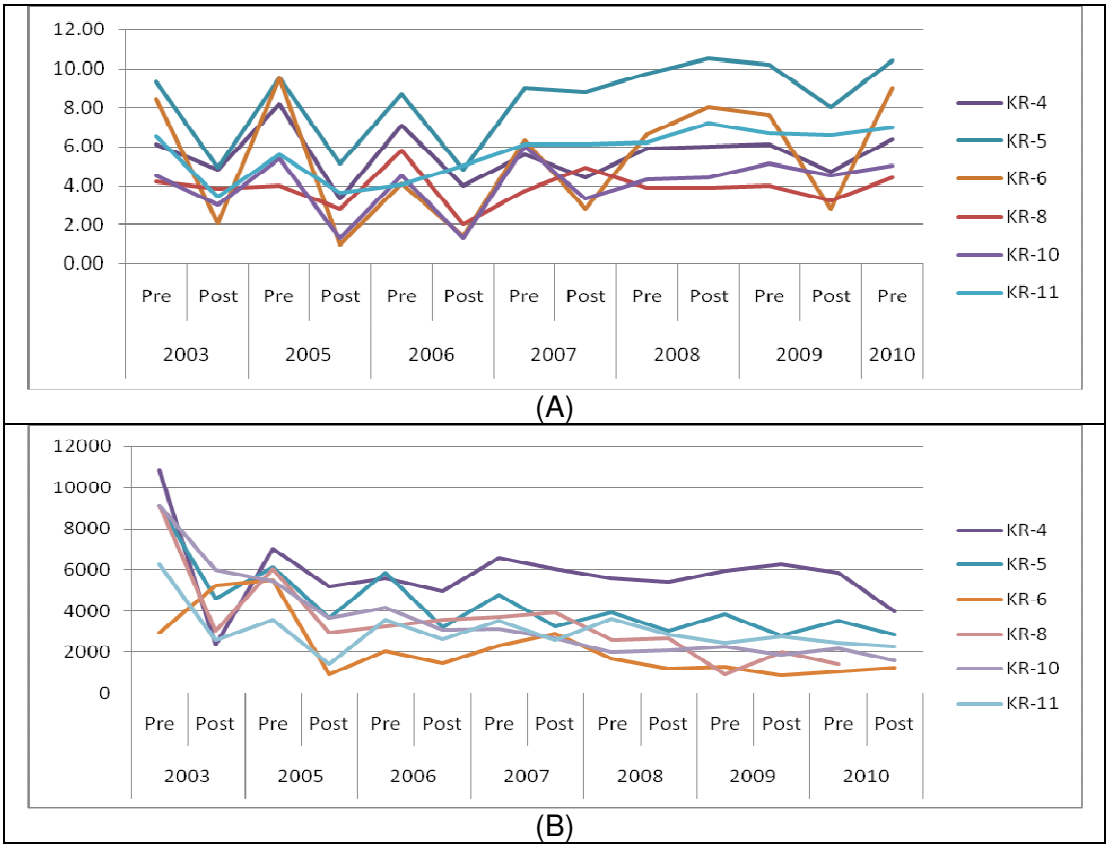


Fig. 6.28 Well Hydrograph Showing Pre and Post Monsoon Fluctuations of (A) Static Water Levels (Dept of Water Level) and (B) TDS Concentrations Observation Wells around Khiri TR

Table 6.13 Pre and Post Monsoon Fluctuation in Observation Wells Around Khiri TR

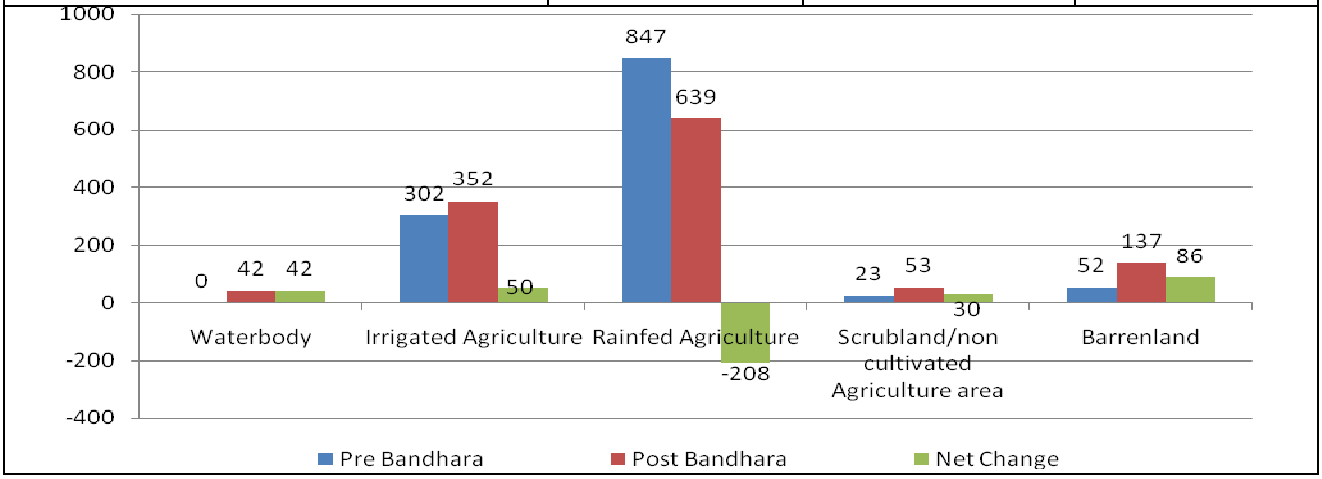
OW No.		KR-1	KR-2	KR-3	KR-4	KR-5	KR-6	KR-7	KR-8	KR-9	KR-10	KR-11	KR-12
2003	Pre	16518	10253	16518	10822	9114	2905		9114	9683	9114	6266	
	Post		2596	15309	2363	4593	5192	3927	3062	1997	5990	2596	2596
2005	Pre	518	9523	14582	7023	6131	5476	3512	6012		5416	3571	
	Post			6912	5184	3648	896	2432	2944	1280	3648	1408	
2006	Pre	4601	4484	9318	5598	5824	2038	4601	3251	3611	4135	3553	4834
	Post	494	2143		4940	3214	1436	595	3571	655	3036	2611	2807
2007	Pre	6013	3619	7684	6570	4788	2283	2450	3731	2227	3118	3508	4399
	Post	3133	2765		6021	3256	2888	3133	3932	1843	2642	2580	2273
2008	Pre	5345	3318	6758	5591	3932	1659	3625	2580	2949	1966	3625	5284
	Post	5696	3076	9284	5411	3019	1196		2677	2563	2051	2848	
2009	Pre	7025	14237	13548	5958	3826	1254		941	3889	2258	2446	
	Post	3036	2559	6250	6250	2797	863		2024	2262	1845	2738	1488
2010	Pre	6660	5614	9137	5834	3523	1046		1431	3743	2147	2422	
	Post	1398			3960	2854	1223	5242		990	1572	2271	

6.5.4 LANDUSE

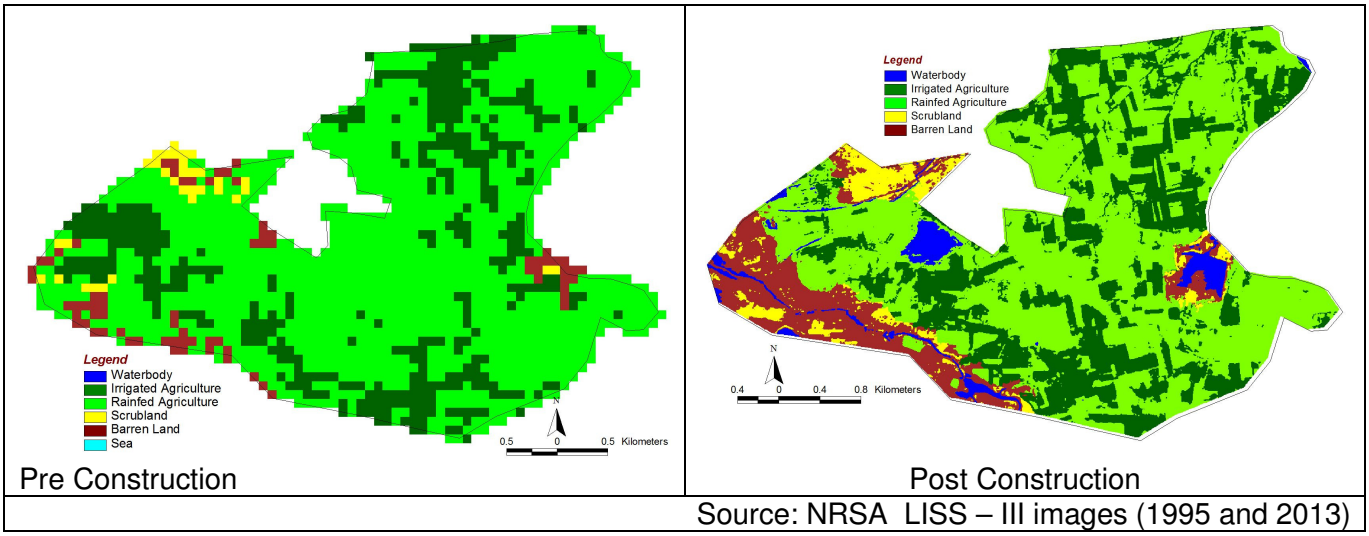
Landuse pattern around Khiri Tidal regulator has been studied with the help of remote sensing data. To understand landuse pattern LISS – III image of the years 1995 Pre Bandhara construction and 2013 post bandhara construction for the post monsoon seasons have purchased from NRSA, Hyderabad. All images were analysed through GIS softwares and area for different land use type has been computed (Table 6.12)

Table 6.12 Landuse Pattern around Khiri Bandhara

Land use	Changes in Land use Area (Ha)		
	Pre Bandhara	Post Bandhara	Net Changes
Water body	0	42	42
Irrigated Agriculture	302	352	50
Rain fed Agriculture	847	639	-208
Scrubland/non cultivated Agriculture	23	53	30
Barren land	52	137	86
Total	**1224**	**1224**	0



Satellite image interpretation shows following changes in landuse pattern such as (01) Irrigated agriculture area has increased by 50 Ha; (02) Rainfed agriculture area has decreased by 208 Ha and (03) Very marginal changes have observed in scrubland / non cultivated agriculture areas.
All these changes clearly show due to Bandhara no significant landuse pattern has changed in this area.



Pre Construction | Post Construction

Source: NRSA LISS – III images (1995 and 2013)

Fig. 6.29 Landuse Pattern around Khiri Bandhara Area

6.6 AGRICULTURE

The Balambha and Bhogaat schemes of Jamnagar district lead in as far as increase in area under irrigated crops before and after the schemes is concerned where villages benefitting from

Balambha bandhara and Bhogaat tidal regulator have seen area under irrigated crops increase by 39 per cent and 25 per cent respectively. In terms of agriculture production, nearly all irrigated crops except bajri and cotton have shown very significant increases ranging from nearly 200 per cent to over 750 per cent across the district (see Table 6.13).

On the other hand, un-irrigated crops like wheat and bajri have benefitted the most from increased water availability post the schemes while production levels of other un-irrigated crops like rajko, aranda and brinjal has remained relatively flat (Table 6.14). Interestingly, jiru, which was introduced in place of rajko and aranda due to post scheme availability of irrigation shows tremendous potential in Jamnagar district.

Table 6.13: Impact on agriculture production – irrigated crops

Sr. No.	Major crops	Production in mun		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	30	30	0.0
2	Juwar	15	50	233.3
3	Wheat	31	92	196.8
4	Jiru	15	128	753.3
5	Groundnut	156	530	239.7
6	Cotton	2108	1981	-6.0

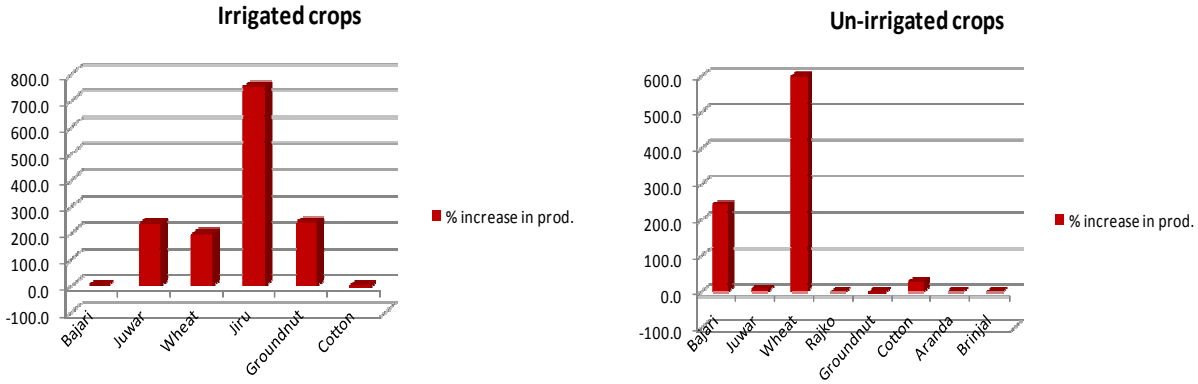


Fig. 6.29 Percentage increase in area under irrigated and un-irrigated crops

Table 6.14: Impact on agriculture production – un-irrigated crops

Sr. No.	Major crops	Production in mun		% increase in prod.
		Before Scheme	After Scheme	
1	Bajari	35	120	242.9
2	Juwar	865	935	8.1
3	Wheat	20	140	600.0
4	Rajko	20	20	0.0
5	Groundnut	243	237	-2.5
6	Cotton	658.5	856.5	30.1
7	Aranda	61	61	0.0
8	Brinjal	20	20	0.0

6.7 SITUATION OF WOMEN

Availability of drinking water within the village as a result of the bandharas has reduced women's drudgery of fetching water from outside their village. This has helped them give more attention to their children's education as well as take up agriculture labour or other work in the village, thereby increasing household incomes. Better agriculture productivity due to improved irrigation post the

bandharas has increased the number of days of employment and wage rates in the benefitted villages, resulting in a decline in out-migration in search of work.

Another positive impact on women has been that they have become part of SHGs in their village where they have started saving and even taking out loans for their livelihood activities. Some of them have also become members of the Pani Samitis in the village. This has helped improve their confidence and awareness levels to the extent that they now discuss problems of their village with the Sarpanch on a regular basis.

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