

Enhancing Ground Water Recharge and Management through Watershed Development Programme

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Background

The Watershed Development Programme was initially designed as a measure to bring about sustainable development through participatory management of natural resources. The project in the Khedbrahma taluka of Sabarkantha district has played an important role in the development of the tribal villages peripherally located in the district. The area has been neglected from any significant interventions by the civil society organizations, agriculture institutions or government district headquarters.

The project has harmonized the use of soil, water and vegetation; in a way to conserve the resources, maximize their productivity, minimize land degradation and decrease the pressure of the environment. The rise in water table due to the project activities has increased availability of water and changing the pattern of irrigation. Appropriate technology promotion in agriculture and domestic purposes has contributed to conservation and efficient use of bio mass resulting to climate change mitigation. It has also helped in reduction in use of electricity and fossil fuel for pumping water per hector of land. The increase in cropping intensity and vegetative cover has also resulted into better microclimate. With increased availability of food, fuel and fodder there has been reduction in drudgery.

In 2004, during a '*Food For Work*' survey undertaken by VIKSAT in the tribal belt of Poshina in the Khedbrahma block of Sabarkantha district, it was found that the villages therein were remotely located and situated far away from the district as well as taluka headquarters. The area was lacking in basic infrastructure like roads, health and education facilities. It was observed that the area was nearly cut off from the mainstream developmental work by either the civil society organizations and/or the government departments. VIKSAT identified this as a challenge and initiated integrated rural development activities since 2005.

Introduction:

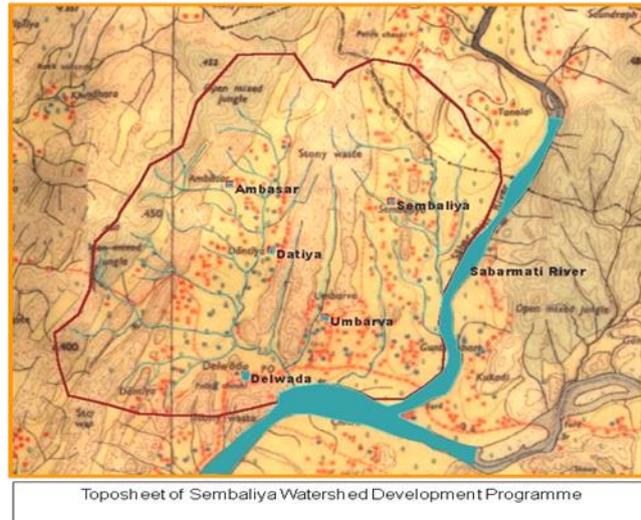
The semiarid regions of Gujarat in North-West India are facing the emerging issue of a decline in the groundwater table. The development of recent year reveals an increasing water stress potential in summer months due to a higher abstraction rate of groundwater, which cannot be equalized anymore by the natural recharge of the aquifers. This leads to the demand for sustainable water management, with sustainable measures not only considering natural resources, such as water and soil, but also in a social, technological and especially in an economical sense.

A comprehensive assessment of Sembaliya watershed programme was taken up under the present study to assess the impact of watershed development program. The specific objectives of the study were to:

- i) To assess the impact on groundwater availability and crop production
- ii) To assess the impact of watershed development on crop production, crop and fodder productivity, improved livelihoods, minimizing land degradation and groundwater availability in the micro watershed

Sembaliya Watershed Development Project:

The project area includes seven tribal dominated villages, namely **Sembaliya, Dantiya, Ambasar, Chhochhar, Delvada, Umbarva** of Khedbrahma taluka, Sabarkantha district and a very small portion of **Nayavas** of Kotda taluka of Udaipur district, Rajasthan. The project villages fall under Poshina tribal belt situated on left side of Himatnagar and Ambaji highway, bordering Rajasthan State, in Catchments area of Sabarmati River. The project villages are situated 22 km away from the highway occupying about 4090.8 ha.



The proposed watershed lies geographically between 24°20' & 24°23' N latitude and 73°04' & 73°07' E longitude as per the Survey of India Topo sheet No 45 H/3.

The total delineated area under the proposed watershed is 1705.47 Ha including CBP area 99.17 Ha. The balance area to be treated under FIP is 1605.83 Hectares. Details of the watershed area are given in Proforma:

Major Problems of Area:

- Excessive runoff and soil erosion due to undulating land resulting in reduced productivity of soil
- Lack of irrigation facilities
- Poor vegetative cover due to large scale deforestation
- Lack of awareness about improved agricultural practices
- Large number of unproductive animals
- Lack of awareness about improved animal husbandry practices
- Poor literacy rate due to isolation from the main stream of the society
- Typical social customs causing great hindrance in the sustainable developmental activities
- Large scale migration to urban areas for lab our work during drought conditions
- Extremely vulnerable socio-economic conditions of women and poor families due to lack of access and control over resources

Demographic details:

The total households and population is 2008 H/Hs and 12,362 persons in the 7 villages as per Census 2001 whereas the total households and population of the watershed area is 1099 H/Hs and 6765 persons respectively. It has been observed that only 12 households are landless in all the 7 villages and incidentally they all are located in the watershed area.

Education:

Education survey reveals that 266 (37.36%) persons, 140 male and 126 female are literate. The numbers of persons who have completed graduation or further are only 9 (1.26%)! Improvement in literacy rate through education drive during the project period will also create impact on the integrated development of the project villages.

Land holding pattern:

The total area, as per government record, of all the seven villages is 4090.80 Ha but the delineated area under watershed is 1705.47 Ha. Mainly due to partial contribution of two of the seven villages namely Chhochhar and Nayavas into watershed area. The area to be given watershed treatment is 1239.48 Ha.

| Govt. Forest Area | Revenue & Panchayat Land | Private Land | Total Land |
|-------------------|--------------------------|--------------|------------|
| 535.39 Ha | 320.35 Ha | 849.73 Ha | 1705.47 |
| 31.4% | 18.8% | 49.8% | 100% |

Hydrogeology of the area:

The geological formations in the Sabrakantha district are hard rock formations consisting of sandstone and alluvial deposits of Sabarmati River. The hard rock formations cover more than two thirds of the area, which are Vadali, Dhansura, Khedbrahma, Idar, Malpur, Bhiloda, Vijaynagar, Meghraj and Modasa talukas. The hard rock and alluvial formations occur in Bayad and partly in Prantij and Talod whereas sandstone and alluvial formation occur in Himatnagar and partly in Prantij block.

The ground water occurs both in unconfined and confined states and the water levels are normally in the range of 10 to 15 m below ground level (BGL) in hot weather while they are in the range of 8 to 12 BGL in Kharif and Rabi season.

Ground water studies:

The project area is having total 182 wells out of which 170 are dug wells and 12 are tube wells. 57 dug wells are defunct. Majority of the dug wells are kachcha wells having no RCC lining or brick support.

Detailed study of 16 wells has been carried out. The details are shown under pro forma No. 8. The survey carried out in the month of May 2008 shows depth of water table from 0.3 mtrs to 7 mtrs. However, the availability of water in the month of May '08 can be attributed to two previous consecutive successful monsoons having the

annual rain fall more than average rainfall calculated over a period of almost 3 decades.

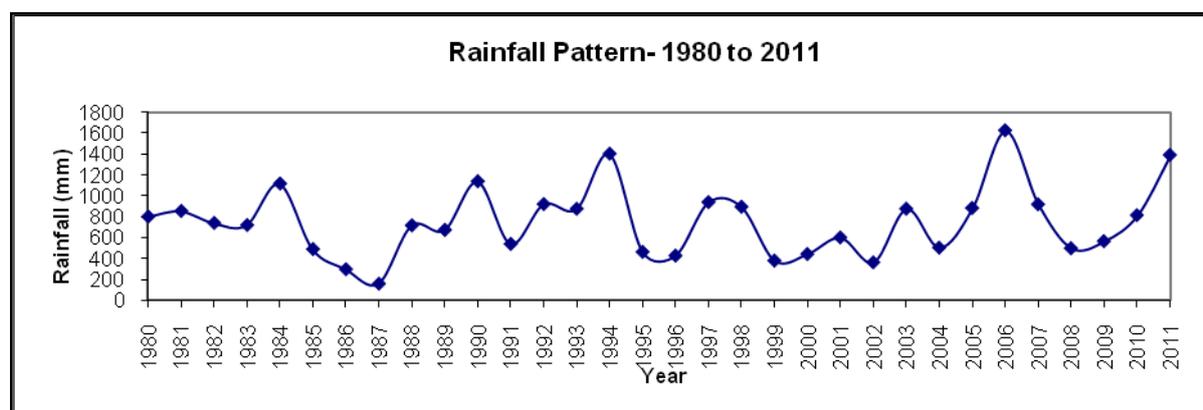
Climate and rainfall:

As already mentioned, the region is characterized by semi-arid climate, with hot summers and cold winters. The area receives southwest monsoon starting from mid June up to the end of September. As per the data collected from meteorological station located at Sardar Dantivada Agriculture University, Khedbrahma, the average annual rainfall is around 742.4 mm (average from 1980-2007), which is uneven and highly erratic (ranging from 160.9 mm during 1987 to 1625 during 2006) in nature. The annual potential evaporation is 1750 mm, which is estimated to be at least twice the annual rainfall. The temperature is at maximum during April to June (43.1°C), while minimum during Dec and Jan (10.3°C).

Years of 'Less than Average Rainfall' during the decades of Eighties, Nineties and Two thousand

| Year | Rain fall mm. | Year | Rain fall mm. | Year | Rain fall mm. |
|------|---------------|------|---------------|------|---------------|
| 1982 | 740.90 | 1991 | 540.9 | 2001 | 602.20 |
| 1983 | 721.10 | 1995 | 464.6 | 2002 | 364.6 |
| 1985 | 491 | 1996 | 429.2 | 2004 | 505 |
| 1986 | 298.9 | 1999 | 381.2 | 2008 | 499 |
| 1987 | 160.9 | 2000 | 444 | 2009 | 567 |
| 1988 | 717.80 | | | | |
| 1989 | 674.40 | | | | |

* As measured by VIKSAT at Kheroj office which is neared to Project Area (20kms) against taluka meteorological laboratory at Khedbrahma, nearly 50 kms from Project Area.



Land Capability classes:

Land capability classification of the FIP area under watershed indicates that 8.34 per cent area falls in class II, 24.25 per cent area falls in class III, 21.50 percent falls under class IV, Nil under class V and 45.91 percent under class VI.

Topography and drainage:

The topography of this region is gently undulating to rolling, upland with high degree of slope. The highest and lowest elevations in the watershed area are 450 meters and 260 m. above MSL respectively. Slopes range from 1% to 20 %. Soil being sandy loam, subsurface drainage is also very good and there is no problem of water logging in any season during the year. The watershed forms part of Sabarmati basin.

Agriculture:

The agriculture is mainly rain-fed and majority of farmers do not have irrigation facilities due to depletion of water table in the wells when the rain fall is inadequate. As such, the crops grown are also mainly dry varieties. The major crops raised in the watershed area are as under:

Maize, Cotton, Black gram and pigeon pea are cultivated during kharif season whereas cotton for rabi sason and green gram as summer crop subject to the availability of water for irrigation.

The project area receives erratic rainfall with large variations in annual rainfall, which is sometimes not adequate for good agriculture. Out of 1628.80 ha cultivated, only 308.6 ha (19%) have seasonal irrigation through wells and ponds, the remaining and 1320.2 ha (81%) depends on rainfall. The cropping intensity is shown below

Cropping Area in the Watershed:

| Particulars | Kharif Crops | Rabi Crops | Summer Crops | Total cultivated area in a year |
|----------------------|--------------|------------|--------------|---------------------------------|
| Cultivated Area (Ha) | 1665.73 | 943.67 | 227.53 | 2836.94 |
| Crop intensity (%) | 102.27 | 57.93 | 13.97 | 174.17 |

Drinking Water and Water resources:

The villages are having hand pumps and wells for drinking water but Delvada is having tap connections also and it is located on the banks of River Sabarmati. Sembaliya and Umbarva are having village tanks too as water reservoirs.

Socio-Economic Conditions:

The socio-economic conditions of the people are marginal to poor. Agriculture is a major occupation of the people followed by animal husbandry. Nuclear family is the prevalent system mainly because of their marginal to poor economic condition. As soon as the son gets married and becomes capable of independently farming, he lives in a separate hut and father allots him a part of his land under mutual understanding. However, government records would show the land in the name of the family head only. In this way, the factual land holding varies from half acre to five acres. The Agriculture is mainly rain fed. Only 19% of the land is irrigated whereas 81%, a large portion of land is un-irrigated.

Process of implementation:

Formation of Village Level Committees (VLCs):

VIKSAT is playing the role of facilitator wherein the activities are implemented through the peoples' institutions. VIKSAT approached each hamlet of the villages in the project area and organized group meetings to explain the concept of watershed development approach. Then after, a Gramsabha was organized to form VLC.

Watershed Committee:

Each VLC nominates two to three representatives to form a central committee called 'Village Watershed Committee' (VWC), consisting of thirteen members depending upon the village area falling under the delineated watershed area. The VWC has three women members also to ensure women participation in the development process. The VWC is responsible for the project implementation. Since VWC members do not have past experience of development process, VIKSAT has been supporting them in conduction of meetings, record keeping, banking and in the process of decision taking. The VWC is registered under Mumbai Public Trust Act 1950 and Society Registration Act 1860. The annual accounts are audited also. VWC meetings are organized at public places to ensure transparency in decision-making.

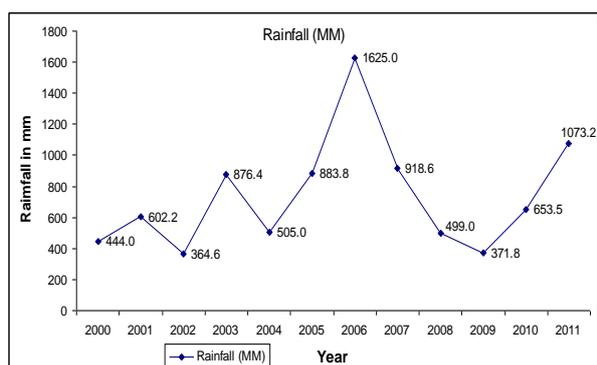
Largely, the locally available materials are used for creation of soil & water conservation structures except a few things like steel wire for construction of gabion structure. The beneficiary farmers themselves create these structures under guidance provided by VIKSAT field staff.

Results and Discussion:

Rise in ground water table:

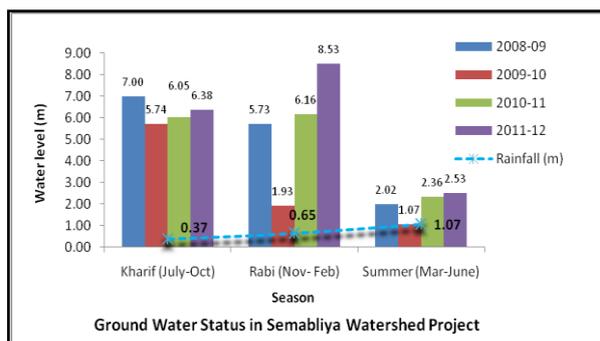
The SWC measures helped rainwater to infiltrate into the soil thereby gradually increasing the groundwater. The programme focused on area treatment under which in all the fields water conservation structures such as earthen bunds, stone bunds etc were constructed as well as building structures ranging from gully plugs to check dams were created in the main drainage lines to impound water. Outside of the drainage line, continuous contour trenches were dug along uncultivated hillsides.

The rain fall graph shown below, the amount of rainfall received by the area was below normal during the monsoons of consecutive three years, i.e. 2008 (499 mm), 2009 (371 mm) and 2010 (653 mm) whereas in the year 2011 it was 1073 mm, above normal. Considering 100% of rainfall in



2007(918.6 mm), the rainfall received in the consecutive years may be shown as - 45.68%, -59.53%, -28.86% and 16.83%.

As shown in the graph below, the water level shows significant change due to the rainfall received coupled with the SWC measures. The water level in Rabi season (Nov. to Feb.) recorded a decrease by 66.32% in 2009-10, followed by a increase by 7.5% in 2010-11 and 66.67% in 2011-12.



In case of Kharif (July to Oct) there was a decrease in all the three years (18%, 13.5% and 8.8% respectively). It may be noted that in 2010, the first rainfall was received on 26th June. While in 2011-12, the onset of rainfall was delayed by a month (monsoon onset was in 18th July).

In case of summer season (Mar-June), the water level recorded a decrease of 47% in 2009-10 and 16.8% increase in 2010-11.

Water security:

There has been an increase in the source of irrigation facilities (15.7%), drinking water sources (9.20%) and irrigation implements (39%). Six check dams have been added in the area. 110 farmers are using pipes during the year 2011-12 in comparison to 57 farmers in 2007-08 to transport water from well to distant fields (an increase of 98%); thus saving water that was being wasted while transporting through dug out channels. Three farmer groups comprising of ten farmers each have adopted 'state-of-the-art' micro irrigation systems (MIS).

The area has recorded an increase in duration of water availability in the water bodies (as much as 5.3% days/yr). The number of days per year for potable water availability has also increased from 240 to 280 (16.6%days/yr.). The average time spent for fetching drinking water has reduced from 60 minutes to 52 minutes per day (13.3% decrease).

There is a drastic improvement in soil erosion problem. In the year 2007-08, meager 8.34% private land was erosion free whereas now 71.63% land has become erosion free due to watershed development. In case of common land, it has risen from 0 per cent to 75.2%.

At least, 498 farmers have adopted improved agriculture practices and noted substantial increase in crop yield. As per farmers' perception during PRA, soil fertility has improved by 35% and soil moisture by 25% due to reduced run-off velocity and soil conservation. (Table of details of water security in Annexure –I)

Economic Benefits:

The various measures implemented through watershed program have improved food, fodder and fuel security over a period time.

Food Security:

The table below reveals that the availability and requirement of food per capita per month in monetary value to measure the food gap as well as security. In 2007-08, per capita food secured was only 72.64% against requirement, while the food security increased significantly to 93.38 % in 2011-12. This was due to the overall development activities of watershed programs in general and in particular due to additional water availability through rainwater harvesting and groundwater recharging structures.

The details are given in the following table.

| Particulars | Unit | Before 2007-08 | After 2011-12 |
|------------------------------------|-------------|-----------------------|----------------------|
| Total Population | No | 12362 | 12776 |
| Total House Hold | No | 2008 | 2208 |
| Agri. Income | Lakhs | 314.37 | 618.68 |
| Other income from labour and other | Lakhs | 210.71 | 347.55 |
| Total Income | Lakhs | 525.080 | 966.225 |
| Income Availability per HH | Lakh/Year | 0.261 | 0.438 |
| Income Availability | Rs./month | 2179.12 | 3646.68 |
| Income Requirement | Rs./month | 3000.00 | 3905.00 |
| Food Gap Rs.(Reqir-Avail) | Rs./month | -820.88 | -258.32 |
| % of food security | % | 72.64 | 93.38 |

Fodder security:

The fodder security increased from 33.86% in 2007-08, to 52.16% in 2011-12. Increase of vegetative growth, wheat and lucern cultivation has contributed to overall increase in fodder supply. Increased water availability has resulted in extension as well as intensification of agriculture in the area.

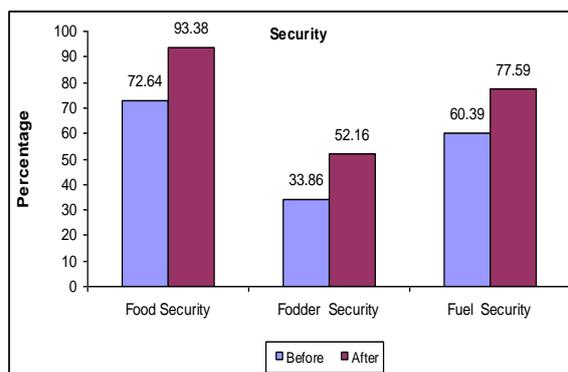
The details are in the following table.

| Particulars | Unit | Before 2007-08 | After 2011-12 |
|---------------------------------------|-------------|-----------------------|----------------------|
| Total Animal | No | 12725 | 12560 |
| Cultivable Area | ha | 2603 | 2723 |
| Common Area | ha | 1636 | 1636 |
| Fodder Production | | | |
| By-product as a Dry Fodder Production | Ton/yr | 6872.88 | 7557.66 |
| Fodder crop Production | Ton/yr | 0.00 | 3359.19 |
| Fodder from Common area | Ton/yr | 1187.87 | 1564.43 |
| Total Fodder Availability Ton./year | | 8060.74 | 12481.28 |
| Fodder requirement | Ton/yr | 23808.50 | 23929.89 |
| Fodder Insecurity per village | Ton/yr | 15747.76 | 11448.61 |
| % of fodder security | | 33.86 | 52.16 |

Fuel security

The fuel security increased from 60.39% in 2007-08 to 77.59% in 2011-12. The increase is mainly due to increase in cotton and cottonseed cultivation and recently introduced castor crop in the area.

The graph shows the before and after impact of watershed development programme on food, fodder and fuel security



Agriculture economics:

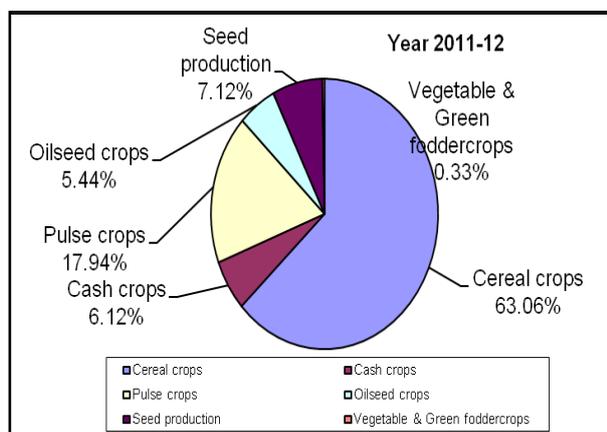
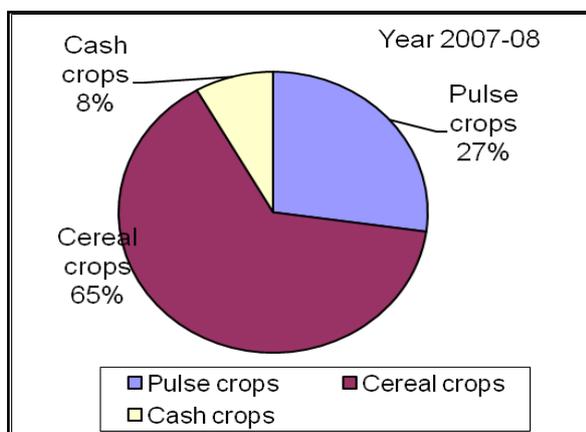
The net increase in production and income per hectore are as follows:

The following table illustrates the increase in gross (152%) as well as net income (82%) of production and resultant income per hector of land. The productivity has increased by 18%.

| Details | Before 2007-08 | After 2011-12 |
|-----------------------------|----------------|---------------|
| Average Production Qtl/Ha | 15.37 | 18.10 |
| Average Gross Income Rs./Ha | 15964 | 40312 |
| Average Net Income Rs./Ha | 11081 | 20210 |
| Cropping intensity (%) | 174.17 | 187.95 |

In cropping pattern, pulse crop has decreased by 28.8% while cereal crop has increased by 5.4%. Cultivation of cotton as a cash crop has reduced by 20%, but oilseed (castor) production has significantly increased in the area.

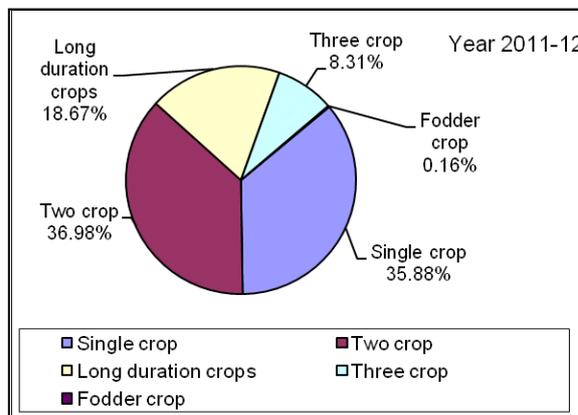
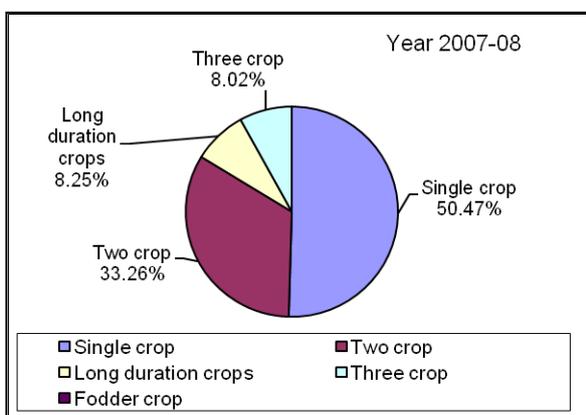
| Cropping Pattern | Before 2007-08 | After 2011-12 |
|-----------------------------|----------------|---------------|
| Pulse crops – Ha | 771.40 | 549.27 |
| Cereal crops – Ha | 1831.52 | 1930.34 |
| Oilseed (castor) crops – Ha | 0.00 | 166.49 |
| Vegetable crops – Ha | 0.00 | 5.00 |
| Cash crops – Ha | 234.01 | 187.21 |
| Green fodder crop – Ha | 0.00 | 5.00 |
| Cottonseed production – Ha | 0.00 | 217.94 |



Environment:

There is a notable improvement in the land use pattern as seen in the following table. With the increase in the water availability for irrigation in wells as well as Sabarmati River due to above normal rainfall during 2011 monsoon, there is an increase of cultivated area during Rabi and summer season leading to increase in vegetative area and thus reflecting on better environment. There is a decrease in area under single crop by 23.2%. The area under two crops (Kharif and Rabi season), long duration crop and three crops (Kharif, Rabi and summer season) has increased by 19.9%, 144.2% and 11.78% respectively, thereby increasing the vegetation cover by increasing the cropping intensity from 174.1% to 187.9%, in private landholdings .

| Land Use Pattern | Before 2007-08 | After 2011-12 |
|--------------------------------|----------------|---------------|
| Single crop – Ha | 1431.72 | 1098.24 |
| Two crop (two season) – Ha | 943.67 | 1132.04 |
| Long duration crops – Ha | 234.01 | 571.64 |
| Three crop (three season) – Ha | 227.53 | 254.33 |
| Fodder crop – Ha | 0.00 | 5.00 |



Conclusion:

This programme has been directed towards the promotion of overall economic development and improvement of the socio-economic conditions of the resource poor sections of people inhabiting the programme areas through natural resource enhancement.

- There was 2 to 4 meters increase in ground water level and Availability of water will increase by 1 to 2 months in the wells in watershed area
- There was 20 to 45% reduction in soil erosion in the watershed areas. However, the variation in the percentage of reduction primarily depended on quality of soil and moisture conservation activities in the respective ridges.
- It was observed that the programme is mostly successful in maintaining runoff reduction.
- There is positive change in food, fodder and socio economic conditions of families of watershed area
- There is positive change in the land use pattern reported in most of the watershed area

Annexure: I

The details of water security before and after of watershed programme:

| Sr. No. | Details | Before 2007-08 | After 2011-12 |
|---------|--|----------------|---------------|
| 1 | Source of Irrigation facilities | | +15.7% |
| | Open Wells(No) | 170 | 183 |
| | Borewells(No) | 12 | 23 |
| | Percolation Tank [No] | 13 | 13 |
| | Check dams[No] | 12 | 18 |
| | Sabarmati River (farmers drawing water) | 22 | 28 |
| 2 | Irrigation implements | | +39% |
| | Diesel engine(No) | 93 | 95 |
| | Ele. motor(No.) | 32 | 45 |
| | Pipeline(No of farmers) | 57 | 110 |
| | Drip irri. set(No) | 0 | 3 |
| 3 | Farmers adopted water management practices – use of pipe line - (No) | 57 | 113 |
| 4 | Duration of water availability in water bodies (days/yr) | | +5.3% |
| | Check dams / percolation tanks | 150 | 180 |
| | Sabarmati River | 298 | 292 |
| 5 | Source of drinking water | | +9.2% |
| | Bore wells(No) | 12 | 23 |
| | Panchayat Hand pump (No.) | 246 | 258 |
| | Piped water | 3 | 4 |
| 6 | Sufficient quantity of drinking water availability (Day/year) | 240 | 280 |
| 7 | Average time spent by women in fetching drinking water(min/day) | 60 | 52 |
| 8 | %of area free from soil erosion | | |
| | Private land | 8.34 | 71.63 |
| | Common land | 0 | 75.24 |
| 9 | Participants with changed in crop yield(No.) | | 498 |
| 10 | Participants with improved varieties of crop (No.) | | 498 |
| 11 | Change in status of soil fertility (%) | | 35 |
| 12 | Increase in soil moisture (%) | | 25 |



Soil and moisture conservation activities taken up in all villages under WDF-NABARD programme

