

Enhancing Ground Water Recharge and Management: A Micro Level Watershed Approach

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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.

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.

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.

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.

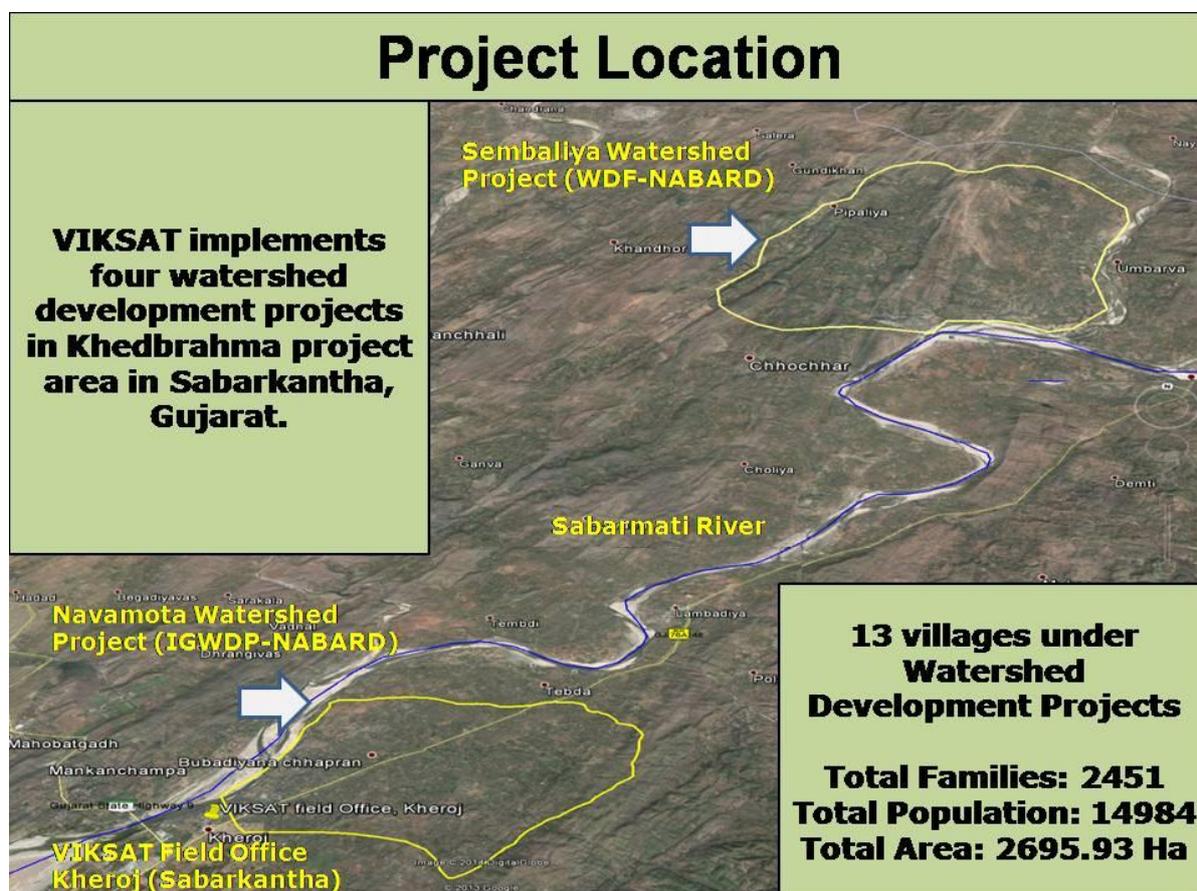
A comprehensive assessment of Sembaliya watershed programme was taken up under the present study to assess the impact of watershed development program.

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

Detailed description of the project:

The Project area of study is located in Northern part of Sabarkantha District Khedbrahma taluka of Sabarkantha District, Gujarat. The project area includes Bubadiya Chapra, Kheroj, Mahudi, Navamota, Tebda, Tebdi, Umbora, Sembaliya, Dantiya, Ambasar, Chhochhar, Delvada and Umbarva .The project area villages falls under poshina tribal belt of Khedbrahma Taluka of Sabarkantha District and catchment area of Sabarmati River. The total geographical area of project villages is 5184.40 Ha. The area under the watershed development is 2695.93 Ha and the total treatable area is 2657.55 Ha.



The average number of family members varies between 5 to 6. The total household is 2451 and population is 14984 including 7693 male and 7291 female. The literacy rate of project villages is 37.79% against the male literacy rate is 46.85% and female literacy is 27.80% and sex ratio is 947 women per 1000 male is very good as compare to Gujarat state (919 women per 1000 male).

The entire area is dominated, with more than 90 % population by tribal community. The socio-economic conditions of the people are marginal to poor.

Among all villages, Kheroj is somewhat a developed village since it is located near highway so items for daily needs are available at Kheroj but otherwise Khedbrahma is the nearest market place, 25 -50 kms from villages, to meet items of daily needs and for agriculture produce. There is no banking facility in the project area. The scheduled and nationalized banks are located at Khedbrahma, 25 to 50 kms from the project area villages.

In project area, majority of family depends on the agriculture well and hand pump (84%). More than 40 % of the women travel a distance of more than 0.5 Kms, thereby resulting in drudgery and increasing vulnerability especially among women and girl children who predominantly bear the responsibility of fetching water.

Owing to highly degraded lands, undulating topography and lack of adequate sources of irrigation, a large number of farmers depend on rain fed agriculture. To supplement their meagre income from agriculture, they have to temporarily migrate to other places in search of labour work.

The region is characterized with semi-arid climate, hot summer and cold winter. The area receives southwest monsoon starting from mid June up to the end of September. The average annual rainfall is around 730.80 mm (average from 1980-2012), which is uneven and highly erratic 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 (Average 43.1°C), while minimum during Dec and Jan (Average 10.3°C).

In project area, soil depth is found varying from d2 to d5. The 47% of the land is having soil depth more than 45 cm whereas degraded land is 53%. The soil type is medium.

Agriculture is a major occupation, followed by animal husbandry. The main crops are maize (50.67%) and in some areas they grow pigeon pea along with maize as mixed crop. The Rabi crops include wheat (51%) and cotton (but only when there is good monsoon) (21.9%) and green gram in summer. The average land holding is 0.61 ha of cultivable land.

Process of implementation:

Community Mobilization

Community Mobilization was undertaken through individual contact, orientation meeting and orientation training programmes.

Shramdan

A mandatory period of 4 days of Shramdan was undertaken by individual household under watershed development programme.

Capacity building phase (CBP)

10% of area of total watershed area was taken in this phase, wherein the capacity and willingness of the community and organization to participate in the rigorous and

long term measures were tested and all the watershed treatments were demonstrated in small patches.

Formation and Nurturing of People Institutions

- 2 Village watershed committee
- 14 Farmer Clubs already formed
- 62 SHGs already formed

Participatory Net Planning in watershed area

The participatory net planning was done in all survey numbers with participation from the farmers for deciding the nature of watershed treatment in their fields before implementation of soil moisture and water conservation (SMC) activities.

Meeting with Village Watershed Committees (VWCs)

The meetings with people institutions of area were conducted for sharing project objectives and modalities. 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.

Full implementation Phase (FIP)

The remaining area (90%) was covered under the FIP phase. In this phase, the various programmes were converged with watershed programme to build the livelihood resilience of tribal community.

Convergence:

- Soil and water conservation activities converged with IGWDP/NABARD watershed programme
- Improved agriculture programme with SRTT and CInI
- Micro irrigation system programme converged with John Deere Foundation
- MARCH programme converged with John Deere Foundation

Physical Activities undertaken:

The physical activities under project area included soil moisture and water conservation, improved agriculture development, irrigation resource development and livelihood activities. The activities undertaken have a cumulative impact on area leading to upliftment of the rural economy and improvement in the quality of life of the hitherto neglected tribal people in the Poshina belt.

Capacity Building

In order to generate awareness among people about soil & water conservation activities and improved agriculture practices, awareness meetings, trainings, exposure visits and farmer field school were organized. The capacity building programmes has resulted in helping the farmers adopt soil moisture and water conservation activities, improved varieties of seeds and thereafter understand and

follow the package of practices (PoPs) recommended for improved agriculture and micro irrigation system.

The details of activity under capacity building as follows:

Sr. No.	Activities	Physical Activities (No)
1	Meetings /Awareness Prog.	99
2	Field days	13
3	Village meeting	5
4	Trainings and exposure visits	10
5	Skill building training Programme	14
6	Film Show	12
7	Village Level Orientation training	39
8	Farmers' Field School	64
9	Staff Training	3

Soil moisture and water conservation

The participatory net planning was done with active participation of all the farmers for deciding about the nature of watershed treatment in their fields before implementation of soil moisture and water conservation (SMC) activities. The activities undertaken in the watershed program include soil and moisture conservation measures like CCT (Continuous Contour Trenches), SB (Stone Bund), FB (Farm bunds) with SO (Stone Outlets), SGP (Stone Gully Plug), plantation of forest species and horticulture on fields, plantation of forest species on waste land, plantation of Agave, seed sowing of forest species, grass seeding, WAT (Water Absorption Trench), Gabion, Earthen Bund with Stone Pitching, Waste Weir, Percolation tank, Check dam, Nalla plug etc. and irrigation resource development programme was taken in project area.

The details of work executed under watershed development programme in project area as follows.

Sr. No.	Activities	Unit	Physical
A	Crop Land Development		
1	Farm Bund (FB)	Cu mt	84680.58
2	Stone Outlets (SO)	No	925.00
3	Stone Bund (SB)	Cu mt	14189.88
4	Stone Gully Plugs (SGP)	R mt	1275.56
5	Continuous Contour Trenches (CCT)	Cu mt	1591.71
6	Water Absorption Trench (WAT)	Cu mt	339.63
B	Afforestation		
1	Plantation on bunds	No	59884
2	Seeds sowing and	Hect.	21.50
3	Grass seeding on all Bund	Hect.	52.65
C	Forest area Development		
1	Continuous Contour Trenches (CCT)	Cu mt	2318.23
2	Water Absorption Trench (WAT)	Cu mt	2323.00
3	Earthen Gully Plugs (EGP)	R mt	47.60

Sr. No.	Activities	Unit	Physical
4	Stone Gully Plugs (SGP)	R mt	619.09
5	Stone Bund (SB)	Cu mt	2725.26
6	Grass seeding and Seeds Sowing	Hect.	35.73
D	Drainage treatment activities		
1	Gabion Structure (GB)	R mt	69.45
2	Pond	No	1.00
3	Nalla Plug (NP)	R mt	155.40
4	Waste Weir (WW)	No	2.00
5	Check dam (CD)	No	12.00
E	Irrigation Resource Development		
1	Well deepening	No	36
2	Well strengthening	No	10
3	Irrigation Deve. on group basis	No	5
4	Pipeline support for Irrigation	No	44
5	Drip Irrigation System	No	7

Capitalizing the gains from Watershed development programme

VIKSAT, with support from SRTT, carried out watershed plus activities like crop demonstration, Seed Kit distribution, Exposure Visits, Trainings and Supplies of Agricultural inputs to farmers. Under a programme called KMS (Kharif Maize Stabilization) and Wheat programme efforts were made to ensure that households in the area get covered.

The details of improved agriculture development activities as follows:

Sr. No.	Activities	Physical Activities (No)
1	Horticulture Plant	
2	Ber grafting	400
3	Vegetable cultivation	11
4	Drum kit for vegetable crops	10
5	Compost Pit	42
6	Vermi compost Pit	29
7	Crop Demonstration Plot (0.20 ha)	30
8	Wheat Productivity Enhancement (0.20 ha)	324
9	Fodder (0.20 ha) Demonstration Plot	25
10	Seeds kits (0.5 acre area)	278

Women empowerment and drudgery reduction

Women, though unrecognized and unaccounted for, are predominantly involved in all the activities of agriculture. Adequate support through community mobilization, capacity building programmes, access to improved tools and equipments, provision of health care services and livelihood options, access to easy to pay, customized and tailored financial services are some of the steps to ensure that women reclaim their status as strong and potential contributors in agriculture sector and reduce their drudgery.

Under the watershed plus programme, several initiatives were taken to reduce the drudgery and empower the women farmers. The activities under livelihood support as follows:

Sr. No.	Activities	Physical activities (No.)
1	Transparent Sheet for light in kitchen	62
2	Chaff Cutter	20
3	Cattle medical checkup and treatment camp	13
4	Construction of Bathroom for lady	4
5	Livelihood support for landless & women	5

Results and Discussion:

The SWC activities have led to gradual recharge of the groundwater aquifers as evidenced by increase in water levels and rise in number of wells, reduction in soil erosion, increase in cropping intensity, change in cropping pattern leading to higher value crops, increase in crop productivity, reduction in rural and urban migration, and rise in overall bio-mass in the watershed.

Rise in ground water table

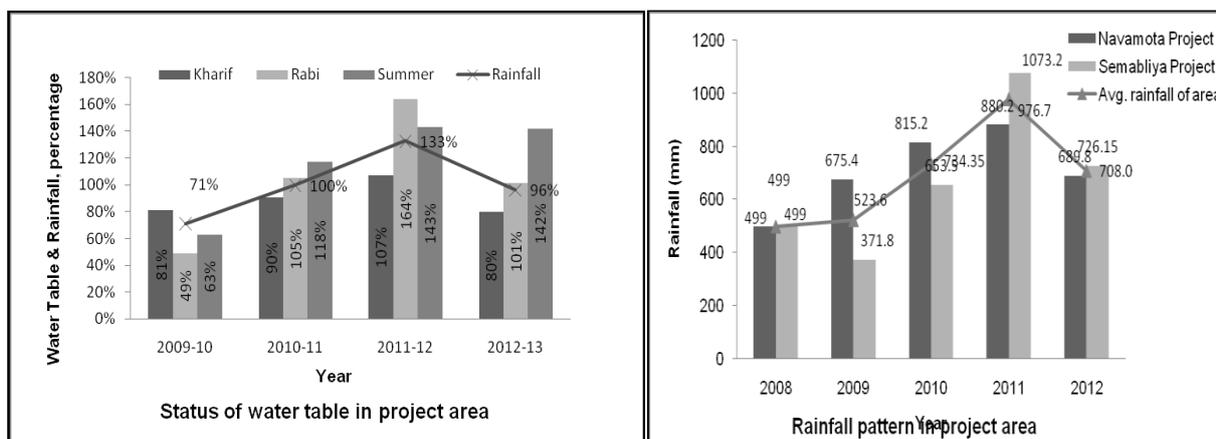
The SWC measures like CCT, earthen bunds, stone bunds, Gully plugs, Gabions, Nala plug and Check dams have reduced the slope of land, soil erosion, speed of the water and have helped the same to slowly percolate into the underground aquifers.

The study revealed that ground water table in project area is gradually increasing although the rainfall has remained below average over the past five years.

In the rainfall 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 (523.6 mm) and 2012 (708 mm) whereas in the year 2011 it was 976 mm, above normal. Considering 100% of avg. rainfall of area in over year (736 mm), the rainfall received in the consecutive years may be shown as -32.2%, -40.6%, -0.2%, 24.6% and -4.0%.

The details of water level in project area as follows:

Season/Crop	2008-09	2009-10	2010-11	2011-12	2012-13
Kharif	7	5.68	6.33	7.48	5.59
Rabi	5.73	2.80	6.02	9.41	5.80
Summer	2.02	1.27	2.37	2.89	2.87
Rainfall	499	523.6	734.4	976.7	708.00



As shown in the graph, the water level shows significant change due to the rainfall received coupled with the SWC measures. The water level in Kharif (July to Oct) showed a decrease in three years (19%, 10% and 10% respectively) as compared to the level of 2008-09. The water level in 2011-12 was increased by 7%. It may be noted that in 2009 the rainfall is 29% less than average rainfall. In 2010 the first rainfall was received on 26th June. While in 2012, the onset of rainfall was delayed by a month (monsoon onset was in 15th July).

The Rabi season (Nov. to Feb.) recorded a decrease by 51% in 2009-10, followed by increase in next three years by 5%, 64% and 1% respectively. In case of summer season (Mar-June), the water level recorded a decrease of 29% in 2009-10, equal in 2010-11 and 33% increase in 2011-12 followed by decrease of 4% in 2012-13.

Water security

There has been an increase in the source of irrigation facilities (20%), drinking water sources (16%) and irrigation implements (42%). Twelve check dams have been added in the area. 140 farmers are using pipes during the year 2012-13 in comparison to 57 farmers in 2007-08 to transport water from well to distant fields; thus saving water that was being wasted while transporting through dug out channels. Seven farmer groups comprising of twenty farmers each have adopted micro irrigation systems (MIS).

The area has recorded an increase in duration of water availability in the water bodies (as much as 20% days/yr). The number of days per year for potable water availability has also increased from 240 to 290 (20.83% days/yr.). The distance for fetching drinking water has reduced from 0.5 km to 100-200 meter.

The 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.

Economic:

The land development, increase in irrigation facility and increased awareness about advanced agriculture practices have led to gradual improvement in food, fodder and fuel sufficiency.

Towards food and nutrition sufficiency

The study reveals the availability and requirement of food per capita per month in monetary value to measure the food gap as well as security. In 2008-09, the food secured was 55.74 % against the requirement at household level. This situation has changed considerably and the food secured has increased to 72.80% during 2012-13. This was due to the overall development activities of soil moisture conservation and improved agriculture activities due to additional water availability through rainwater harvesting and groundwater recharging helps to take additional crop. The farmers have also started cultivating vegetables and installed MIS leading to addition of vegetables in their food basket in addition to the staple crop. This helps in provision of nutritious food for the people.

Table: Showing Gap in food security in two corresponding periods

Particulars	Unit	Before (2008-09)	After (2012-13)
Total Population under watershed area	No	12948	14984
Total House Hold under watershed area	HH	2055	2451
Net Income from all sources			
Agri. Income (consider only 75% of net income)	Rs	40449505	96220778
Agri. labour	Rs	11042757	12699171
Non agri workers	Rs	1461913	1681200
Other sources	Rs	9910420	11396983
Total Income	Rs	62864595	121998132
Income Availability Rs. per capita/year		4855	8142
Income Availability	Rs./Month	404.60	678.49
Income Requirement as per poverty line	Rs./Month	725.90	932.00
Food Gap Rs.(Require -Available)		-321.30	-253.51
% of food security		55.74	72.80

Ref: State specific poverty lines for 11-12, GOI, Planning Commission, July 2013

Towards fodder sufficiency

The fodder sufficiency has increased from 49.85 % in 2008-09, to 66.85 % in 2012-13. This is due to the increase in vegetative growth, introduction of the Rabi crop for example wheat, and growing of lucerne fodder in cultivable and common land. These changes are seen due to increased availability of ground water which again is the product of soil moisture and water conservation and intensification of agriculture efforts in project area.

Table: Showing Gap in fodder security in two corresponding period

Particulars	Unit	Before (2008-09)	After (2012-13)
Total Animals	No	9776	10265
Fodder requirement per unit		7470.73	7844.25
Feed requirement per Qtl unit/ animal/year	Qtl/animal/yr	25.10	25.10
Total Fodder requirement		187515.32	196890.68

Particulars	Unit	Before (2008-09)	After (2012-13)
Cultivable area	Ha	3039.67	2994.61
Common area	Ha	1414.94	1604.12
Fodder Production			
From Cultivable Area	Qtl/yr	81705.13	115756.94
From Common Area (Forest land, Waste land and Farm Bund)	Qtl/yr	11762.84	15872.67
Total Fodder Availability	Qtl/yr	93467.97	131629.61
Fodder Insecurity of families under project area	Qtl/yr	-94047.35	-65261.07
% of fodder security		49.85	66.85

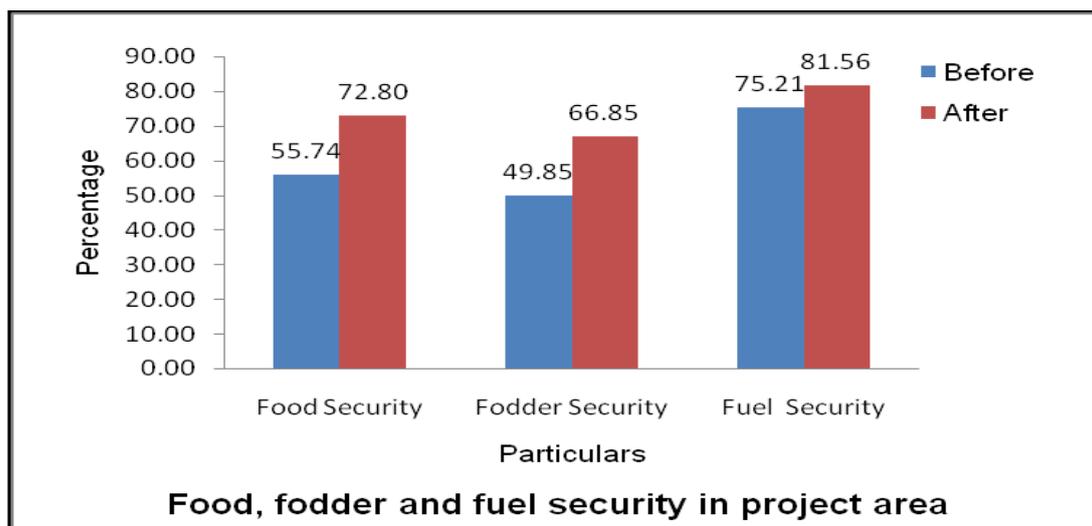
Women have now less botheration

Women do not have to travel long distance to fetch fuel wood. With crops like Cotton and Castor expanding in the area, women are a happier lot. The fuel security has increased from 75.21 % in 2008-09 to 81.56 % in 2012-13.

Table: Showing Gap in fuel security in two corresponding period

Particulars	Unit	Before (2008-09)	After (2012-13)
Total House Hold under watershed area	HH	2055.00	2451.00
Total area under crop (fuel wood)	No	2434.90	2776.06
Production of crop residue for fuel	Qtl/year	11780.76	14621.47
Production of others fuel	Qtl/year	4912.33	6967.64
Total Production	Qtl/year	16693.09	21589.11
Average Fuel requirement of kg per HH per month		90.00	90.00
Fuel requirement	Qtl/year	22194.00	26470.80
Insecurity of fuel	Qtl/year	-5500.91	-4881.69
% of fuel security		75.21	81.56

The overall impact of soil moisture conservation, improved agriculture practices, irrigation resource development and optimizing the use of water interventions helps the increase in food, fodder and fuel security in project area villages. The change in traditional practices with scientific package of practices in agriculture crops showed the increase in productivity of major crops. Though the area under the cereals crops reduced in project area but productivity was enhanced. The investment so made by the intervention and in association with the farmers group has brought in additional income to each of the households benefitting from this. This could be seen from the increased food security and also from the production of cash crops.



Graph showing all the three outcomes: food, fodder and fuel security

Agriculture economics

The farmers in the villages prefer growing Maize which is often grown in combination with other crops – Black gram and Pigeon Pea (both Lentils). Due to additional irrigation, farmers have started cultivating cash crops like cotton, wheat and green gram. There is an increase in growing wheat crop as subsistence food and maize in summer. Earlier due to lack of irrigation, maize was grown in Kharif season only. With assured irrigation facilities, land development and increased awareness about improved agriculture practices, people of area are also growing more cash crops like cotton, castor, cotton seed plots and vegetable cultivation that fetch a sizeable income.

The returns from agriculture too have shown to have increased the gross income (155%) as well as the net income (136%) due to agricultural revolution in project area. The productivity has enhanced by 12% as compare to the previous interventions.

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

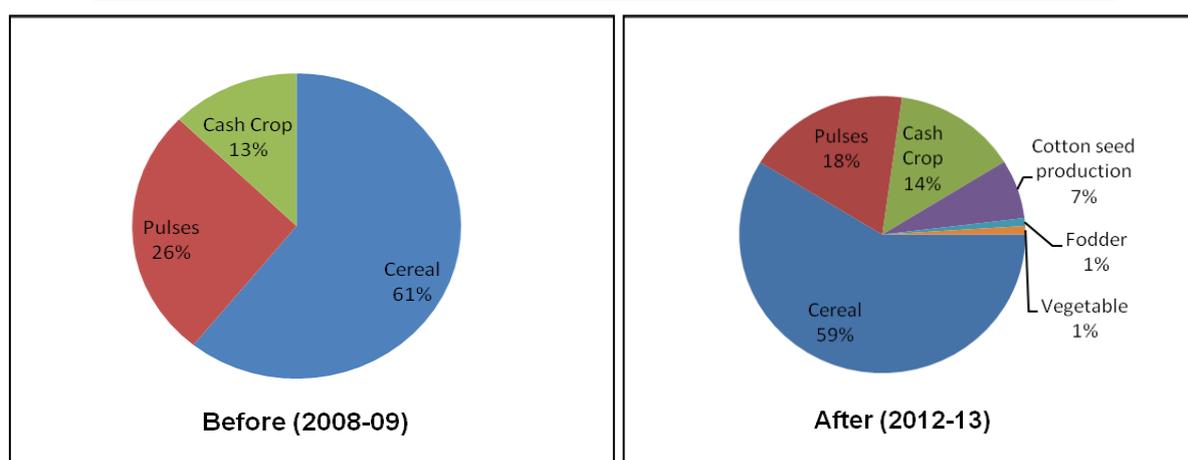
Details	Before (2008-09)	After (2012-13)	%
Average Production Qtl/Ha	13.90	15.56	12%
Average Gross Income (Rs./Ha)	30897	78897	155%
Average Net Income Rs./Ha	23336	55001	136%
Cropping intensity (%)	150.66	164.34	9%

The cereal crop has increased by 6% while pulses crop has reduced by 23% in project area. Cultivation of cotton as a cash crop has increased by 21%, but cotton

seed production, vegetable and fodder cultivation has significantly increased in the area.

Table: Showing the cropping pattern in two corresponding period

Details of crop	Before (2008-09)	After (2012-13)	%
Cereal	2117.85	2251.31	6%
Pulses	921.82	707.97	-23%
Cash Crop	442.30	536.71	21%
Cotton seed production		264.14	100%
Fodder		35.33	100%
Vegetable		37.80	100%
Total	3481.97	3833.26	

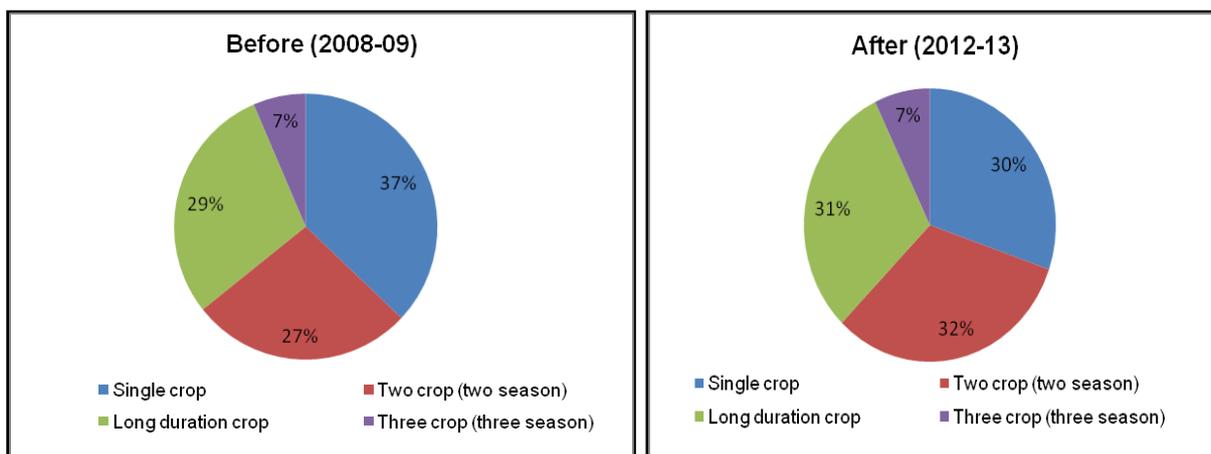


Graph showing cropping pattern in two corresponding year

SWC work has also helped in making the productive use of the available land

There has been a notable increase in the land use pattern as a result of SWC work. With the increase in the water availability for irrigation in wells there is an increase in area under agriculture during all the three seasons. : Kharif, Rabi and summer. One of the fallout of the programme is that farmers feel secure to invest in agriculture today than they were before the intervention. The youth is also getting attracted towards agriculture thereby strengthening the activity and decreasing the effects of urban pull. There is a decrease in area under single crop by 10%. The area under two crops i.e. Kharif and Rabi season, long duration crop and three crops i.e. crops during Kharif, Rabi and summer season has increased by 30%, 15% and 22% respectively, thereby increasing the vegetation cover by increasing the cropping intensity from 150.66 % to 164.34%, in private landholdings.

Land Use Pattern	Before 2008-09	After 2012-13
Single crop - Ha	1291.17	1160.64
Two crop (two season) - Ha	946.65	1227.32
Long duration crops - Ha	1019.97	1171.94
Three crop (three season) - Ha	224.19	273.36
Total	3481.97	3833.26



Graph showing land use pattern under all season in two corresponding year

Sustainability of Project:

Over the years of interaction with the community in the project area of Khedbrahma, VIKSAT has ensured creation of institutional spaces. The peoples' institutions were created with two basic objectives: (1) To empower the village community so that they take ownership of the village development plans (2) To strengthen the village institutions and capacitate them to execute development programmes.

VIKSAT has formed 82 people institutions covering 1315 members in the area such as SHGs Federation (Mahila Sang), Self Help Group, Village Watershed Committee (VWC), Famers Clubs and Aravali Agriculture Resource and Training Centre (AART).

The details of people institution in Khedbrahma Taluka of Sabarkantha District as follows:

Sr. No.	Name of People Institution	Total People Institutions	Total members
1	Aravali Agriculture Resource and Training Centre (AART)	01	13
2	Village Watershed Committee (VWC)	4	52
3	SHGs Federations	3	62
4	Self Help Groups (SHGs)	62	772
5	Farmers Club (FC)	14	478
	Total	84	1315

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 tribal people inhabiting the programme areas through natural resource enhancement.

- There was 2 to 3 meters increase in ground water level and Availability of water will increase by 1 to 2 months in the wells in watershed area
- The rainfall on the rainfed lands was conserved with various SMC measures. This saves the soil from erosion by reducing surface runoff, thereby mitigating the impact of droughts & floods, and minimizing siltation of reservoirs. This is in addition to optimizing the productivity of rainfed lands.
- Efforts to increase fodder availability for cattle is also emphasized to improve milk production for domestic consumption. Organizing medical camps for human beings as well as cattle also constitutes part of health programme.
- Improving productivity and production in rainfed croplands and promotion of horticulture development, particularly vegetables and fruits increased the food and nutritional security.
- Increase in water availability for irrigation and efficient irrigation water management would lead to increase in irrigated land leading to increased vegetation cover.
- Plantation on waste land will also lead towards improvement in the overall environmental quality of the area.
