Global Theme on Agroecosystems

Report no. 49

Impact of Watershed Development in the Low Rainfall Region of Maharashtra

A Case Study of Shekta Watershed

सत्यमेव जयते

Ministry of Rural Development and
Ministry of Agriculture, Government of India

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Abstract

Rainfed agriculture has an important role in development of agriculture in India and it will also continue to play in the future as 60% arable land in the country is rainfed. Watershed development is an important strategy for sustainable development of drylands. Impact assessment of Shekta Watershed in Ahmednagar District, a rain shadow region of Sahyadris in Maharashtra was undertaken as a micro-level case study. The region receives low rainfall (465 mm/yr), is drought prone, poverty is wide spread and migration from rural areas is common in this watershed village. The watershed development approach evaluated a capacity building phase, demand driven and net planning with each family. Exactly 59% of the watershed area was treated with soil and water conservation measures spending 38.6% (Rs. 1.1 million) development budget and 32.6% on rainwater harvesting structures.

Groundwater availability has substantially increased as evident from the 48% increase in number of wells, increase in number of seasonally and perennially active wells, increase in crop productivity of 3.6 to 189% over district average yield for different crops, increase in cropping intensity by 28% from 1998-99 to 2004-05 was observed.

Diversified farming systems with high-value crops such as wheat and vegetables as well as livelihood sources such as livestock rearing and micro-enterprise benefited people in terms of increased crop yields, income, improved livelihoods and reduced seasonal migration by 60%. Watershed development was economically beneficial with a benefit cost ratio (BCR) of 1.5 with an internal rate of return (IRR) of 16% along with development of rural institutions and protection of the environment.

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2008

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Contents

Acronyms/Abbreviations

CGR	compound growth rate
CBO	community-based organization
CPR	common property resources
CB	contour bunding
CRIDA	Central Research Institute for Dryland Agriculture
CCT	continuous contour trenches
FPC	Forest Protection Committee
FB	farm bunding
GS	*gram sabha*
NATP	National Agricultural Technology Project
NGO	non-government organization
NPV	net present value
NABARD	National Bank for Agriculture and Rural Development
NGP	Navjeevan Gramoday Pratishthan
WC	Watershed Committee
WAT	water absorption trenches
VWC	Village Watershed Committee
SHG	self-help group
SMS	Samyukta Mahila Samiti
IRR	internal rate of returns
B:C	benefit-cost ratio
WOTR	Watershed Organization Trust
WHS	water harvesting structures
EGS	Employment Guarantee Scheme
FGD	focus group discussion
SB	stone bund
GP	gully plug

Introduction

In India, although watershed program is silently revolutionalizing the developments in drylands, only 35% of them are performing above average (Joshi et al. 2005). There are few watersheds which are performing well in India because of innovative approaches (technical, social, institutional and linkages). In order to assess the impacts of successful watershed programs and document the learnings, specific detailed case studies were undertaken for the Comprehensive Assessment (CA) of impacts of watershed program in India. One such case study of Shekta Watershed in Ahmednagar district of Maharashtra of the Indo German Watershed Development Program (IGWDP) was undertaken. The results of detailed case study of Shekta Watershed are reported here.

About 60% of the net cultivated area is rain-fed and supports the livelihood of 40% of the total population, which contributes about 44% to national food stocks. Ninety one percent coarse cereals, 90% pulses, 85% oilseeds, 65% cotton and 55% rice are grown under rain-fed conditions (CRIDA 2004). The rain-fed agriculture has potential to increase yield of crops by two to three folds in India and the potential can be harnessed through the adoption of integrated watershed technologies. Currently, the average productivity of rain-fed areas in the semi-arid region is around 800-1000 kg ha^{-1}. At Adarsha watershed in Kothapally, Andhra Pradesh, the productivity of important crops increased from 2.2 to 2.5 times over farmers' traditional unimproved practices. The benefit-cost ratio of these important crops has gone up to 2.67 and net income for cereals are 45% higher even with irrigation (Wani et al. 2002). Several experiences have already proved that the watershed development programs have become engines of development especially to reduce poverty and maintain food, fodder and fuel security with sustainable manner for huge mass population in India. The basic problems of rain-fed agriculture are variations in seasonal rains during the crop growing period, several times the crops face drought and sometimes waterlogging due to torrential downpours causing runoff and in order to conserve rainwater, minimize land degradation, improve groundwater recharge, increase crop intensity and crop productivity watershed management approach is adopted (Kerr et al. 2000; Samra 1997 and Wani et al. 2002). The watershed development programs not only enhanced the crop productivity but also minimize the risk of degradation of natural resources base.

Description of Watershed

Shekta watershed located in Shevgaon tehsil of Ahmednagar district of Maharashtra, lies partly in the upper hills section of Sahyadris (Fig. 1). It forms the major portion of Deccan Plateau with a north-east south trend and the river basin of the Godavari on either side of the plateau. The watershed lies between 19°05' N longitude and 74°55' E latitude and it is accessible by pucca road and well connected with state transport bus services. About 675.6 ha out of 1052.38 ha of cultivable land is rain-fed in selected watershed spreading mainly in three villages viz., Shekta, Paragon and Ladgalgaon. Watershed development project was implemented between 1997 and 2004 based on ridge to valley concept for treatment of the catchment with appropriate soil and water conservation measures carried out with active participation of stakeholders through community-based organization (CBO). The project focused on three major aspects: human resources development, land and water resources development and infrastructure development.

Figure 1. Location of Shekta micro-watershed, Maharashtra, India.

Physical and Demographic Properties

The whole Ahmednagar district falls in the semi-arid zone of rain shadow region of Sahyadris and received 465 mm average annual rainfall during 1990-2004 (Fig. 2). The area receives all of its annual precipitation from the southwest monsoon. Rainfall starts in first week of June and gets over by beginning of October. The rainfall varied from 338 to 731 mm during 1990 to 2004. The highest rainfall was recorded in 1990 while the lowest in 1994. During this period of 10 years it received less than normal, while 5 years were above normal rainfall.

The watershed has a south to north slope and the upper catchment comprises moderates slope (3 to 7%), middle catchment steep slopes (7 to 25%) and lower catchment comprised of gentle slope (less than 5%). The texture of soil is clay to sandy clay and the pH ranges from 7.5 to 8.2 with low organic carbon content. Soil depth varies from 7.5 cm to 45 cm and soils are formed over a soft muram layer over a hard rock.

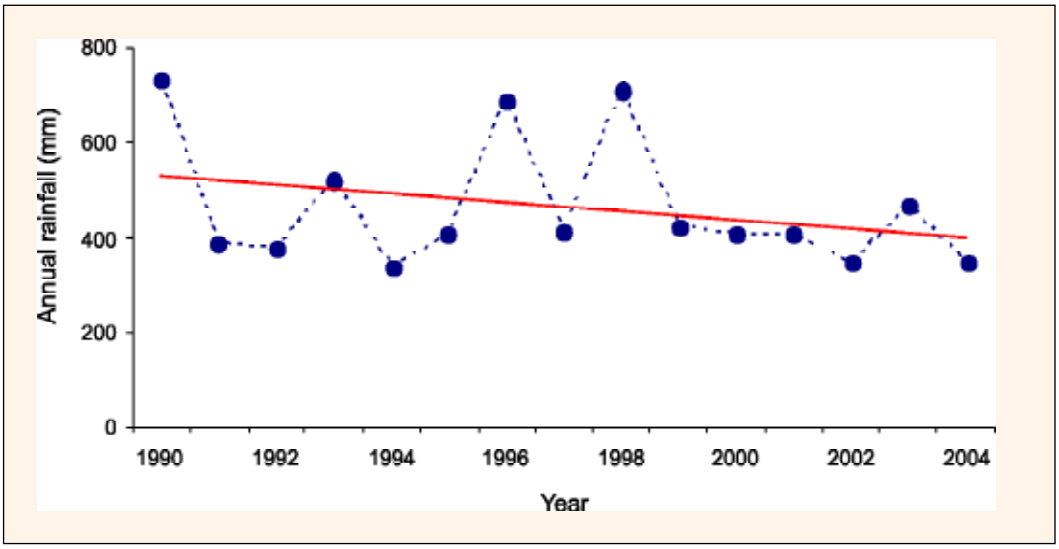

Figure 2. Average annual rainfall from 1990 to 2004 (average rainfall 465 mm).

Identification of Constraints

The village is situated in drought prone area under the semi-arid region of Ahmednagar district of Maharashtra, which is one amongst the worst drought hit area. The village receives rainfall from southwest monsoon, which begins in the first week of June and continue till the mid of October. Due to erratic and insufficient rainfall, the socio-economic status of the villagers is very poor compared to other surrounding districts in the state and the village even unable to avail the facilities of many kinds of rural development program run by State/Central Govt. of India. There are various constraints identified at village level as follows:

- land degradation because of felling trees, shrubs and free grazing had intensified and added to the problems of excessive runoff and soil erosion;
- due to irregular and insufficient rainfall, severe scarcity of drinking water availability throughout the year;
- rapid decline in groundwater table and frequent drying up of wells during summer;
- the livestock production in the villages is limited mainly to goats, sheep, indigenous cows, buffaloes and bullocks but there is no concentration on cross-breed and other ruminants;
- the socio-economic status of the people is very low and in order the education of children specially female is low although the village has set up a school up to 4th standard in village itself but the number of attendees is less because the female children are taking care of younger ones at home and keeping the house well maintained and also go for labor wages along with mother to support the family financially;
- inaccessibility of market and price fluctuations for farm produce;
- at initial stages of watershed development, the decision of community to ban on free grazing disturbed the livelihood of small size farmers, shepherds and families owning small ruminants.

- the upper reaches of the watershed are totally desiccated plants and no vegetation, most of the families depended on National Rural Employment Guarantee Scheme (NREGS) for their livelihood; and
- The seasonal migration from rural to urban areas also existed in village during post-harvesting season.

Data Sources and Research Methodology

The primary as well as secondary data were taken up for present study. The focus group discussion was conducted (Fig. 3) for observations and the farmers were interviewed with pre-tested questionnaires framed for the required information. The data were collected individually by administering the interview scheduled to the respondents and the objectives of the study clearly explained to the farmers just before conducting FGD and stratified detailed household survey and whenever necessities raised trial experiment were also conducted. To some extent, the secondary data were also taken into consideration to support present study. The data to measure yield gap and other indicators, published Gazette of District (2003-04), 7/12 and 8-A land records were reviewed thoroughly and in order the publication of WOTR's baseline and feasibility study report were also attempted for preparing of this report. To measure impact assessment of investment on water harvesting structure, the actual expenditure incurred and their additional benefit accrued were directly collected from the project

Figure 3. Focus group discussion in Shekta watershed.

implementing agency. The primary data collected were tabulated and analyzed using simple statistical techniques such as average, percentage and proportion. The other techniques of statistics such as regression, correlation, student t-test, variance analysis and hypothesis testing were used to examine the validity of impact of watershed programs in the region.

For collecting detailed household data, the nature of sampling was stratified using multi-stages and in order 37 farmers from different categories of land holding viz., marginal (<1 ha), small (1-2 ha), medium (2-4 ha) and large (>4 ha) were selected randomly from the village, where watershed activities were conducted widely. The sampling of data covered about 20% of farmers without double counting of their land holding in the village. The paper also highlights the impact of watershed development program on poverty and therefore gave more attentions on variable which affect the consumption/ income/wage rate of male and female in agriculture and other allied activities.

Results and Discussion

The on-site impact of watershed development activities gave more emphasis on impact of development in the village where works have been carried out. The enhancement in the following important components indicates development of on-site impact. The results from the comprehensive study of research reported in mainly three parts viz. bio-physical indicators, socio-economic indicators and environmental and ecological indicators.

Bio-physical Indicators

Various bio-physical indicators viz. soil and water conservation measures, water harvesting and groundwater recharging structures and crop production etc., were assessed and analyzed to evaluate the impact of watershed development program in the Shekta micro-watershed during the project period from 1999-2004.

Developmental strategies

The strategies for watershed development program were based on well prepared action plan on several experiments conducted in the rural remote area. In the village the watershed development program has gone through two phases.

In the first phase, the capacitization of community-based organization (CBO) was set up and in this phase the various activities were carried out like selection of watershed, identification and awareness of stakeholders, assessment of stakeholders needs, formation of CBO's like village watershed committee (VWC), self-help group (SHG), forest protection committee (FPC), and preparation of feasibility report took seven months. This activity continued for 18 to 24 months during initial stage of development. The capacity-building component was implemented in 24 months.

The process of development was started with the capacity-building phase in August 1997, in which watershed selection was done with the self-selection criteria. In this activity, all the villagers did four days voluntary labor contribution (*shramadan*) for various watershed works.

Primarily the *gram sabhas* (village meeting) were conducted and followed by exposure visits. In the exposure visit the villagers had an opportunity to interact with the farmers of developed watershed and also observed the progress due to the impacts of watershed development projects in the area. With

the principle of the "seeing is believing" after exposure visit, people came on consensus to implement the various watershed development programs in their village with all the social disciplines like, self-selection criteria, ban on free grazing, ban on cutting trees, voluntarily labor contribution to 16% of total unskilled project cost, thus by way of self-selection criteria people came together and performed for initial *shramdan* (voluntary labor contribution). Village watershed committee was formed through *gram sabha*. In the village, watershed committee went through different trainings, planning and implementation of the work regarding roles and responsibilities of village watershed committee members, ways and means of managing watersheds and maintenance of different structures.

Similarly, women in the village formed self-help groups and these self-help groups are utilized as a platform for the building of capacities among women towards participation in watershed activities, savings and credit activities. It also helped to create a space for women in overall decision-making and implementation of watershed process.

Figure 4. Participation of CBO in different farm activities.

In the CBOs capacity-building phase of about 100 ha micro-watershed was treated with ridge-to-valley principle (Fig. 4). After completions of CB, village watershed committee's did the net planning of remaining area and feasibility study report was prepared which was sanctioned 2 months after completing the feasibility study. In the net planning process, the planning of individual farmers' land was done with farmer couple (husband and wife). Thus, farmer's idea of his own land development along with technical aspects was incorporated into the plan. The village watershed committee treated remaining area under the guidance of local non-government organization (Navjeevan Gramoday Pratishthan).

To strengthen and accelerate the communication between all women self-help group members and village watershed committee members, an apex body of SHG's was formed which is called as Sahayukta Mahila Samiti (SMS). Thus the process of capacity-building was completed in the year 2000.

However, due to delaying in release of funds, the watershed project was held up for two years. The capacity-building measures towards decision-making and participation held on the implementation of watershed activities by CBOs (Fig. 5).

Figure 5. Participation of farmers in different farm activities during capacity building.

Soil conservation, water harvesting and groundwater recharging structures

During the development of watershed, number of soil conservation and rainwater harvesting structures were constructed (Table 1). In all, 19 rainwater harvesting structures storing 59298 m^3 water were constructed (Figs. 6, 7, 8 and 9). The cost of water storage m^{-3} varied from Rs 9.40 to Rs 64.0 depending on the type of structures (Table 1). The CCTs and water absorption trenches were quite cost effective (Rs 30 m^{-3} water stored) and in addition also served as traps for soil erosion. However, unless strict technical guidelines are followed while constructing the CCTs, they get filled with soil and also breached, causing severe erosion.

In this watershed, 620 ha land area was treated for soil and water conservation which covers 58.8% of total watershed area which is distinctly different than normal watershed programs, where large proportion of budget is spent on rainwater harvesting structures (Sreedevi et al. 2006). Out of Rs 2.85 million spent on watershed development, Rs 1.10 million (38.6%) were spent on the area treatment and Rs 0.93 million (32.6%) were spent on rainwater harvesting structures. Considering the rainfall in the region and low potential for runoff the approach of *in-situ* rainwater conservation as against the runoff harvesting is very appropriate. As revealed by the meta-analysis of 311 watershed

Table 1. Various soil and water conservation measures in Shekta watershed.

Drainage line treatment	No. of structures/ Area covered (ha)	Capacity (m^3)	Cost (Rs.)
Check weir	16	10220	843413
Check dam	1	2730	127498
Repair of *nala* bund	4	16000	172608
In-situ soil and water conservation treatment			
Continuous contour trenches (CCT), water absorption trench (WAT), afforestation	157		1084188
Contour bunding (CB), farm bunding (FB), stone bunding (SB), gully plugs (GP)	632		2130069

case studies from different agroecological zones, different rainfall zones need different approach. The principle of one size fits all approach generally adopted by watershed program resulted in low B:C ratios as well as impact measured with other parameters being far lower in low rainfall (<700 mm) zones than the 700-1100 mm rainfall zones (Joshi et al. 2005). Another important factor which emerges from the study is that in this, watershed community contributed 22% of the total cost for watershed development.

Figure 6. Check dam conserving runoff water in the village.

Figure 7. Castor planted on field bund to prevent soil erosion.

Figure 8. Low-cost mini-percolation structure for groundwater recharging.

Figure 9. Trench-cum-tree system of soil conservation on high slope area.

Various soil and water conservation measures viz. contour bunding, farm bunding and stone bunding were taken up to prevent the soil erosion and *in-situ* conservation of rainwater covering an area of about 789 ha. Table 1 shows the various soil and water conservation and water harvesting structures taken up during the project period.

To harvest the excess runoff water and to control erosion of major gully, 16 check weirs, one check dam were constructed and strengthening the *nala* bunding was done. Apart from the *in-situ* rainwater conservation through various soil conservation measures, runoff water harvesting structures of 28950 m^3 net storage capacity was created.

The economics of these structures reveal that the check weirs were constructed with a unit cost of Rs 82.50 per m^3 water stored, while the unit cost of the check dam was about Rs 46.70 per m^3 and the repair of *nala* bund worked out at Rs 10.80 per m^3 water stored.

The average cost of the water harvesting structures for the three structures was Rs 39.50 per m^3 and the total amount invested was Rs 1143519 with a net storage capacity of 28950 m^3.

Groundwater recharge and availability

Considering the percolation through structures about 12 mm of rainwater is contributing to the groundwater. Due to the water harvesting and various soil and water conservation structures, there is a significant improvement in the groundwater status. Prior to watershed interventions, there were about 189 wells, out of which 73 were functioning for 1-4 months, 35 wells were functioning 4-8 months, 25 were functioning 8-12 months and 56 wells were not in use. At present 280 wells exists,

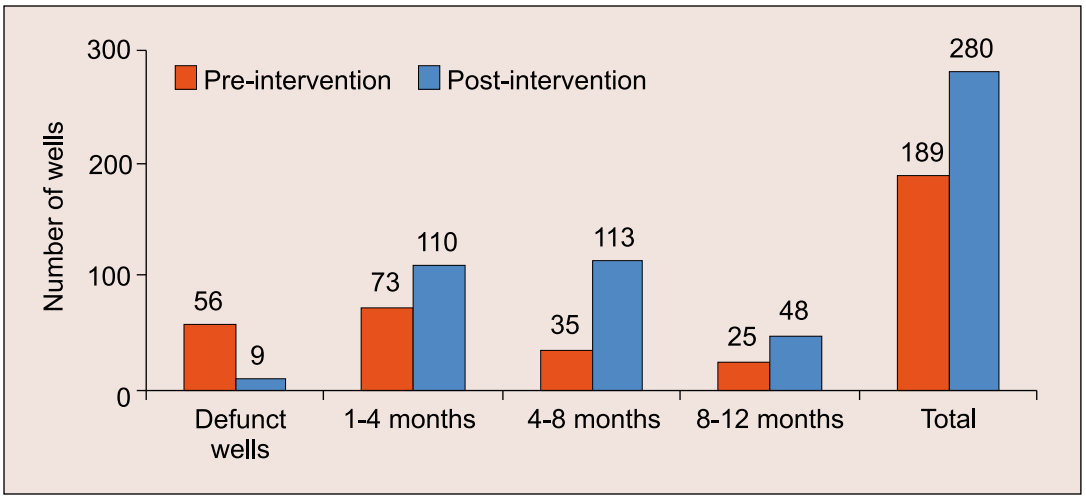

Figure 10. Effect of watershed interventions on duration of water available in the wells.

out of which 110 had water 1-4 months, 113 were functioning 4-8 months and 48 were functioning 8-12 months, whereas only 9 wells were not in use (Fig. 10). Overall, there was an increase of 48% in the total number of wells and 51% increase in the seasonally functional wells (1-4 months), while there was a drastic increase of 223% wells functioning during 4-8 months in a year and 128% increase was observed in perennially functioning wells (8-12 months in a year). There was a sharp decrease in the number of non-functioning wells (about 83% decrease) as a result of water conservation measures.

The status of groundwater in terms of water column in wells during pre-interventions of watershed programs was 1.5 m in rainy season, 0.90 m in post-rainy season and 0.65 m in summer, while after watershed interventions, water column in wells during rainy season was 4.5 m, during post-rainy season was 3.5 m and in summer was 1.5 m existed. An average water column of wells through out the year was 1.02 m before watershed intervention whereas after watershed interventions were implemented the water column in wells was 3.17 m, which is about 211% increase in the water column (Figs. 11 and 12).

Figure 11. A recharged well with pump for irrigation.

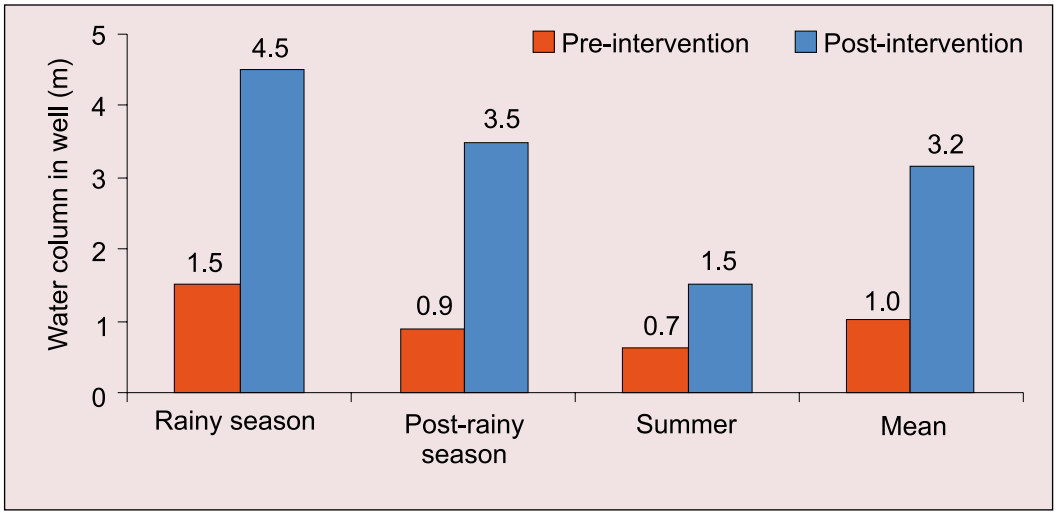

Figure 12. Effect of watershed interventions in improving the groundwater levels.

The monthly water levels in wells located in upstream, middle and downstream of watersheds are shown in Figure 12.

The water column in wells follows the similar trend in all the three topo positions of watershed (Fig. 13).

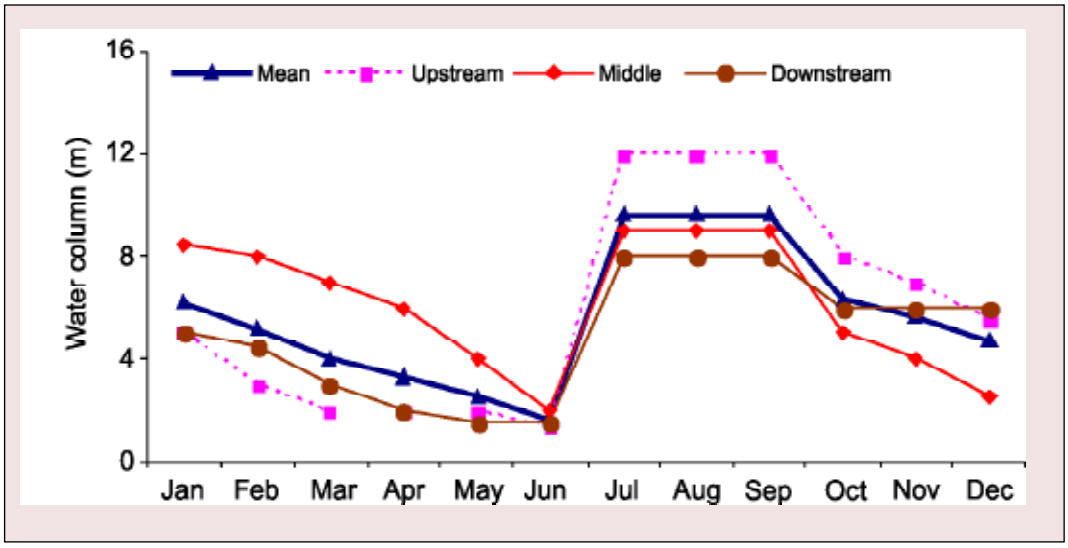

Figure 13. Water levels in wells at upstream, middle and downstream of watershed.

Changing scenario of land use pattern in the village

The Table 2 showing the land use pattern in the Shekta watershed clearly reveals that the availability of groundwater had led to a significant increase in the area under irrigation. Increase in seasonally irrigated area was 96% while the increase in perennial area was 88% during post-intervention period compared to pre-intervention period. There was also considerable increase in the area of pasture/ grazing land. The area left as cultivable fallow was totally brought under cultivation.

Table 2. Land use pattern in the Shekta micro-watershed.

Area under different land use (ha)	Before watershed interventions (1998-99)	After watershed interventions (2004-05)
Rain-fed	675.60	581.34
Seasonally irrigated	94.51	185.24
Perennially irrigated	64.28	120.52
Pasture/grazing	00.00	32.68
Cultivable wasteland	85.39	00.00
Govt. forest	132.60	132.60
Total	1052.38	1052.38

Area, production and productivity

An attempt was made to estimate the trend in area, production and productivity of important crops during the period 1998-99 to 2004-05 of watershed development programs in the village. To examine the relevancy of growth rate of variable, the exponential trend, which is approximately best uniform rate of growth (Elsamma and Nanda Mohan 2004) was used. The compound growth rate has been computed based on following equation:

$$GR = (\text{Antilog } B\text{-}1) * 100$$

The estimated compound growth rate of area of all important crops increased significantly and higher growth rate was observed for onion followed by cotton and vegetables (Table 3). In case of pearl millet (*bajra*), sorghum (*jowar*), pulses and vegetables the compound growth rate of yield were higher than growth rate in area and production which indicates the production of these crops increased because of acceleration in the growth rate of yield not only due to area expansion during project period while in case of other remaining crops the attribution of area was more for total production.

To examine the efficiency and potential of watershed programs on crop production, increased crop yields in watershed villages were compared with the district average yield and the yield gap differences between yield of important crops of watershed village over district level was calculated during the same period of time.

Table 3. Compound growth rate of area, yield and production.

Crops	Compound growth rate (%)			Yield gap % (1994-95) (Watershed village over district)
	Area	Yield	Production	
Pearl millet	13.86	15.01	14.59	3.57
Sorghum	13.33	14.30	13.51	106.75
Wheat	14.88	13.95	14.74	23.57
Cotton	15.73	14.40	15.66	188.89
Pulses	10.18	15.30	12.36	8.83
Oilseeds	14.25	13.96	14.58	25.00
Vegetables	14.98	15.81	14.79	40.00
Onion	17.06	15.72	16.18	44.00

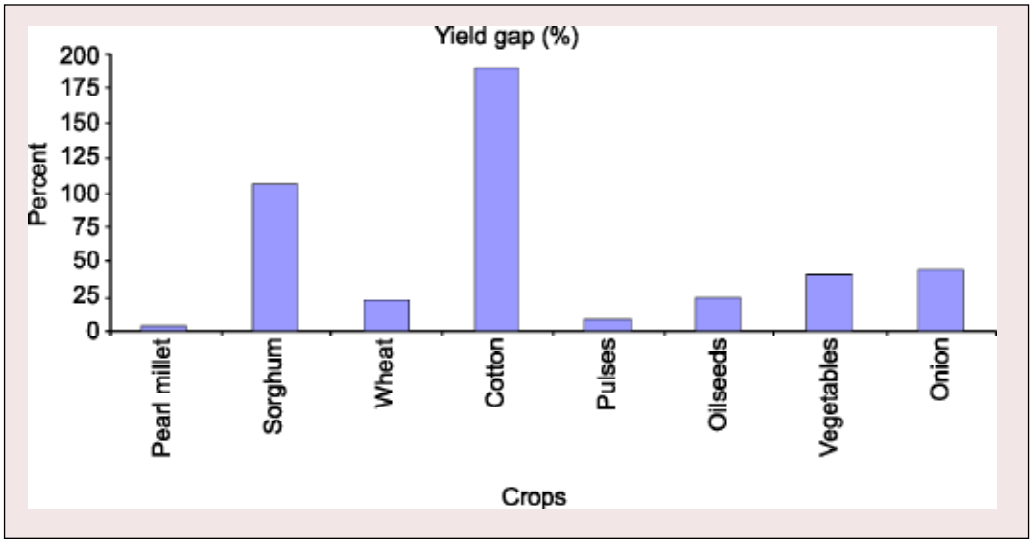

Figure 14. The yield gap of important crops in watershed village over district.

The highest yield gap of 189% was observed in case of cotton followed by sorghum 106.75%, onion 44% and vegetables 40% while the lowest in case of pearl millet only 3.6% (Fig. 14). These results indicated that farmers not only expanded area under high-value crops such as cotton, onion, wheat and vegetable with increased water availability in the watershed as reported earlier (Wani et al. 2003 and 2007) but also invested more in cultivation of high value crops due to assured water availability in the watershed. Large yield gap between watershed yields and district average yields for several crops demonstrated that vast untapped potential of rain-fed agriculture can be realized by adopting integrated watershed management approach (Wani et al. 2003 and 2006; Rockstorm et al. 2007) (Fig. 15).

Figure 15. A good crop at Shekta watershed.

Projection of productions of important crops

The linear equation trend fitted to project the production of cereal crops, pulses and vegetables etc. The incremental trend was noticed in all the crops and if present trend to be continued then this micro-watershed village will be able to produce the cereal crop of pearl millet about 609.9, 837.8 and 1065.7 tons in the year of 2010, 2015 and 2020 respectively. The other cereal crops like sorghum, wheat and cotton also follow the same trend. The trend in the projection of pulses, is not quite fast while oilseeds and vegetables are achieving accelerating trend. In the case of pulses, decreasing trend is found and the projected value of pulses are 19.0, 13.3 and 9.5 tons while oilseeds are 40.8, 56.0 and 71.2 tons and vegetables are 197, 273.2 and 349.5 tons in the consecutive years of 2010, 2015 and 2020.

The data revealed (Fig. 16) that the village has great potential for increasing crop production in the future with the help of interventions of watershed development programs, which can provide the path to accelerate the growth rate of crop production and rural development in the village.

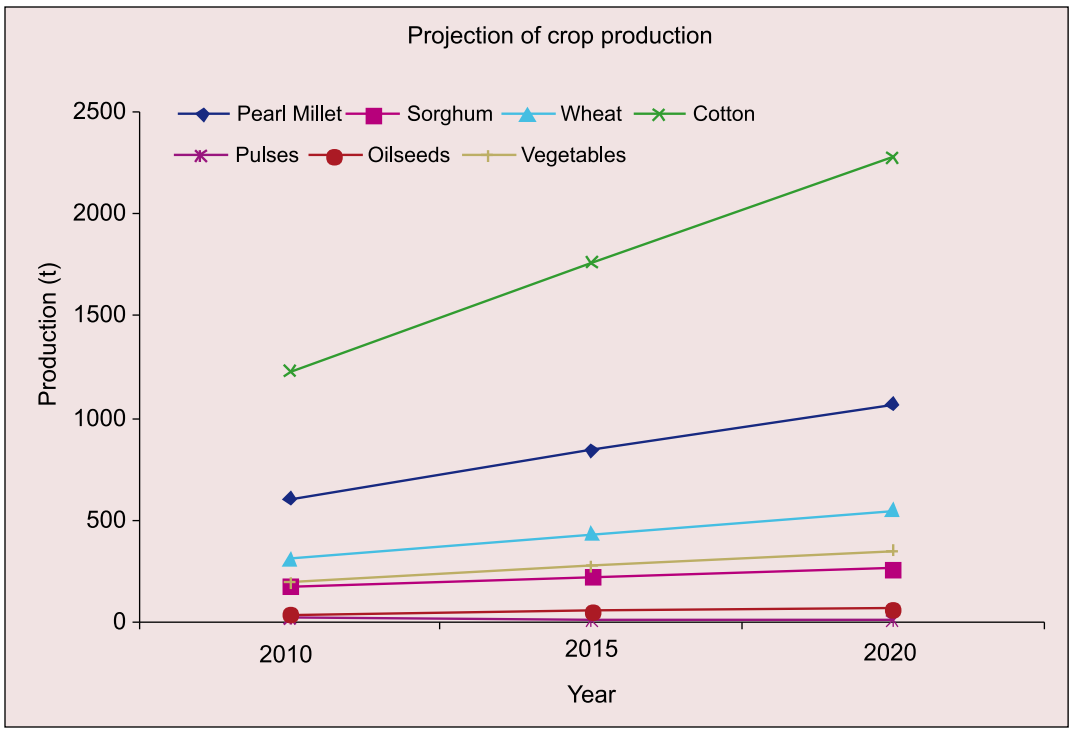

Figure 16. Projection of production of important crops in Shekta watershed.

At the all India level, the projection of cereal production as well as other commercial crops cannot provide the accurate estimation on the basis of past trend as the paper of G. Venkatramani in ''*India Lags Behind*" clearly mentioned that projection for future cereal production can not rely heavily on past trends. Further expansion of irrigated area will be costly and agriculture must increasingly compete with industry and urban households for limited water supplies. To resolve the cited problems, the watershed management is the best alternative to maintain the past trend of crop production for future generation in sustainable manner.

Table 4. The value of linear equation to project the production.

Major crops	Linear regression equation (Y = bx+a)	
	X co-efficient (b)	Constant (a)
Pearl millet	227.94	381.95
Sorghum	44.865	132.55
Wheat	119.43	191.78
Pulses	-5.78	24.82
Oilseeds	15.21	25.57
Cotton	526.01	701
Vegetables	76.25	120.73

Based on linear equation the production of important crops have been projected and the value of equation fitted in Table 4. Except pulses, the coefficient of x were positive and higher coefficient was found in case of cotton followed by pearl millet and wheat, which indicated the growth rate of these crops are very fast compared to other corresponding crops.

In the analysis the expected population and per capita availability of cereals, cotton, pulses and vegetables forecasted using linear equation of regression. On the basis of past trend of population, the per capita availability of cereals will be increased from 0.68 tons in 2010 to 0.98 tons in 2020 per year (Fig. 17).

Unfortunately per capita availability of pulses would be reduced in 2020. The cotton is one single crop, which has higher growth rate and per capita cotton availability would be 1.17 tons in 2020 compared to 0.63 tons in 2010.

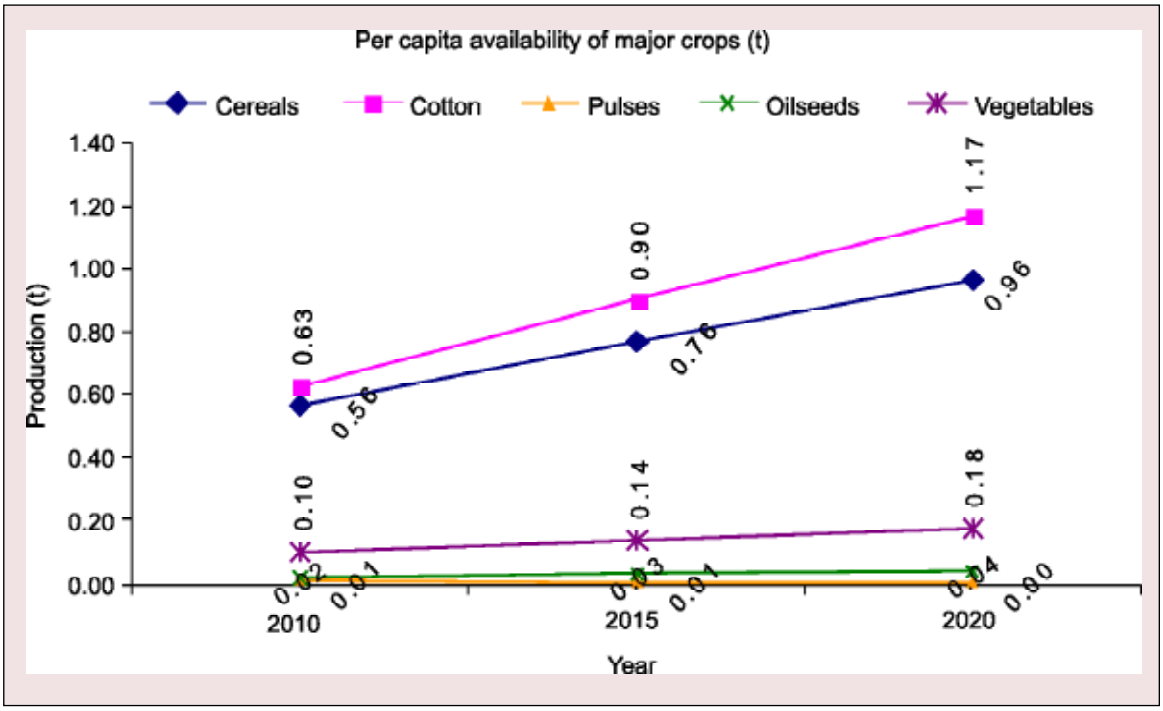

Figure 17. Projected per capita availability of crop production due to watershed intervention.

Cropping patterns and intensity

Watershed interventions provide an opportunity for change in cropping pattern and it was observed from the data analyzed that the farmers have been benefited from the change in cropping pattern and high cropping intensity during watershed development programs in the Shekta micro-watershed (Figs. 18, 19 and 20).

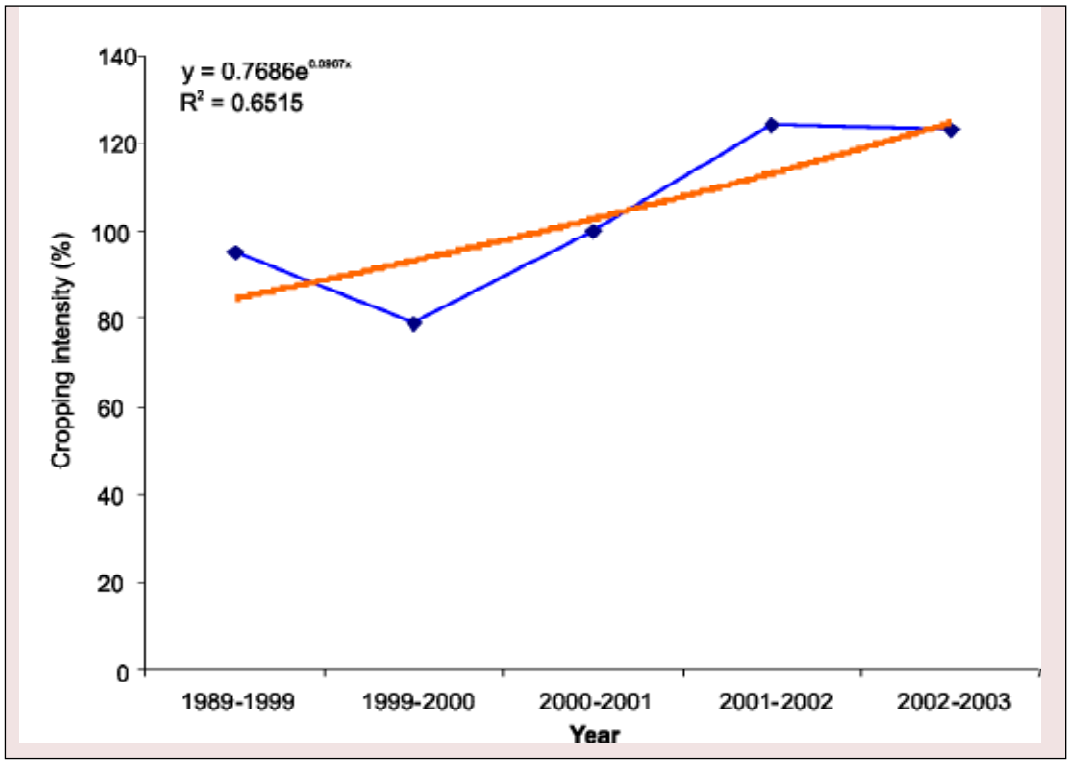

Figure 18. Cropping intensity during the period of program in Shekta watershed.

Figure 19. Intercrop as a crop diversification measure in Shekta watershed.

Figure 20. Cotton with castor intercrop as a crop diversification measure in Shekta watershed.

During the watershed development programs, the area of pearl millet increased sharply from 291.24 ha in 2002-03 by 96.8% but again it shrinked down to 113.15 ha (61% decline) in 2004-05 (Table 5). The area under pulses and sorghum crops declined sharply about 68.75 and 43.10% respectively over the period. The area of cotton and wheat increased by 152.9 and 90.9% respectively during the period while the area under groundnut increased marginally by 24.3%. The area under vegetables increased sharply by 125% and other new vegetables like onion, potato, chilly were added up during the same

Table 5. Change in cropping pattern (area in ha) **and intensity in Shekta watershed.**

Major crops	1998-99	2001-02	2002-03	2003-04	2004-05
Pearl millet	148	200	291.24	151.36	113.15
Pulses	168.6	25	12.48	16.5	52.68
Cotton	201.6	150	207	469.27	509.81
Sorghum	250	280	265	195	142.23
Wheat	70.5	105	115	125	134.61
Groundnut	22.45	25	17.15	25.5	29.67
Vegetables	90	12	59.5	131.86	120.58
Onion	0	8	55	136.27	124.82
Maize	5.98	0	8.25	11.55	21.87
Potato	0	0	4	10	0
Chilly	0	0	2.52	5.42	8.9
Castor	0	0	0	0	5.23
Sunflower	7	10	0	0	8.38
Sugarcane	13.3	0	0	0	0
Cropping intensity (%)	95	79	100	124	123

period. These results are in conformity with the earlier findings that with increased water availability in the watershed due to rainwater conservation and harvesting area under low-value crops decline and farmers shift towards growing high-value crops as observed in Adarsha Watershed, Kothapally in Andhra Pradesh (Wani et al. 2003) and Rajasamadhiyala Watershed in Gujarat (Sreedevi et al. 2006). The sugarcane cultivation was absolutely stopped in the village that indicate farmers are very keen of short-duration high-value crops, which provide continued income compared to perennial crops. This also indicates increased awareness amongst farmers to use available water resources efficiently for enhancing incomes. The intensity of crops also increased slightly by 29.47% from 1998-99 to 2004-05 (Fig. 18).

Crop diversification

Watershed development programs provided an opportunity to farmers to generate farm income within short period through crop intensification and diversification. Crop diversification is the technique of intensification of crop and maximum utilization of specific land for using multiple crops in a short period. One of the major objectives of watershed development programs was to diversify crop in order to generate high income and employment opportunities within short period from limited land. Therefore, the diversification examined the temporal shifts in the area and production and their sources.

During project period significant changes were observed in Shekta micro-watershed. Before watershed interventions, farmers were growing 10 crops which increased to 12 crops during the project period. Noteworthy thing is that not only crops like sugarcane were abandoned but more high-value and water efficient crops were cultivated. To measure the indices of crop diversification, the Simpson Index ($1-\Sigma Pi^2$), where Pi is the proportion of area under ith crop was used. The higher value of index indicate the higher magnitude of diversification while lesser indicate concentration of crops because of specialization etc (Fig. 21).

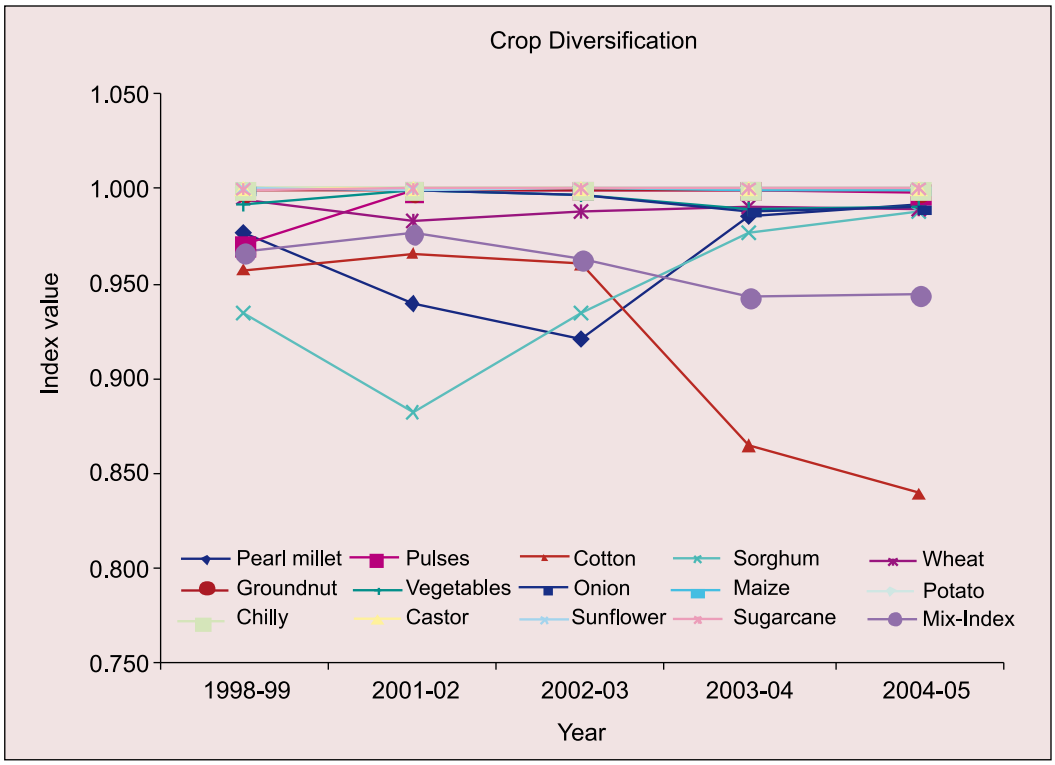

Figure 21. Crop diversification during watershed development program in the village.

There is mixed fluctuation of diversification observed during the watershed development program in the micro-watershed. Table 6 reveals that sorghum is more fluctuated crop towards diversification followed by pearl millet, wheat and onion while other remaining crops maintained stability. The crop-mix index of diversification has been declining continuously after 2001-02, which indicated slight concentration of cereal and perennial crops during watershed development program. The crops like maize, potato, chilly, castor and sunflower remain constant, resulting in neither diversification nor concentration during specific period of time.

Socio-economic Indicators

One amongst others the basic objectives of watershed development programs was to reduce poverty and improve socio-economic status of the farmers within short period of time. The new paradigm attributed under watershed development program changed sharply the socio-economic status of farmers in the Shekta micro-watershed.

Table 6. Diversification index of important crops in Shekta micro-watershed.

Crops	1998-99	2001-02	2002-03	2003-04	2004-05
Pearl millet	0.977	0.940	0.921	0.986	0.992
Pulses	0.970	0.999	1.000	1.000	0.998
Cotton	0.957	0.966	0.960	0.865	0.839
Sorghum	0.935	0.882	0.935	0.977	0.987
Wheat	0.995	0.983	0.988	0.990	0.989
Groundnut	0.999	0.999	1.000	1.000	0.999
Vegetables	0.992	1.000	0.997	0.989	0.991
Onion	1.000	1.000	0.997	0.989	0.990
Maize	1.000	1.000	1.000	1.000	1.000
Potato	1.000	1.000	1.000	1.000	1.000
Chilly	1.000	1.000	1.000	1.000	1.000
Castor	1.000	1.000	1.000	1.000	1.000
Sunflower	1.000	1.000	1.000	1.000	1.000
Mix-Index	0.967	0.977	0.963	0.944	0.944

Change in demographic pattern

During project period the number of households increased by 15.15% while the size of family reduced by 5.79%, a positive indicator of population control in the village. Although, the population of male as well as female increased yet the growth rate of population observed was minimal. The sex ratio increased by 1.91%, favoring females in the village over time period and at present there are 853 females for 1000 males while it was only 837 female for 1000 male available before implementation of watershed programs. There is increase in literacy rate (82.72%) in the village because of dissemination of information on education and health through different channels of watershed development

programs. The literacy among female increased sharply from 12.2 to 29.5% compared to the literacy of male which increased from 32.8 to 53.19% during the same period of time. This is a significant achievement to equalize the gender literacy in the Shekta micro-watershed. The density of population (number of person per square km) increased by 15.47% because of population increase. The per capita income also increased by 19.13% in the village within short period of time, which is a good indicator of prosperity (Table 7).

Table 7. Change in demographic profile in the Shekta watershed.

Parameter	Before watershed	After watershed
Households	165	195
Family size (person per HH)	6.39	6.02
Male (no.)	574	634
Female (no.)	481	541
Sex ratio	837	853
No. of females per 1000 males		
Literacy ratio	45.02%	82.72%
Male	333 (32.80%)	625 (53.19 %)
Female	124 (12.21%)	347 (29.53%)
Density of population (persons km^{-2})	97	112
Per capita income* (Rs y^{-1})	7222	8603

* Per capita income calculated on the basis of sampling of 31 sample of different category of farmers.

Consumption status, health and hygiene

Food intake and consumption status is the good indicator of measuring prosperity and standard of living of people in the area to assess the impact of watershed programs on consumption status along with health and hygiene expenses. Thirty one household samples using stratified random sampling method, different category of farmers were studied (Table 8). The analysis revealed that the expenditure on consumption increased from 9.61 to 45.97% of total income or total expenditure while on health and hygiene only from 11.96 to 25% for all categories of farmers. The changes on consumption as well as health and hygiene with high margin were noticed in case of marginal farmers i.e., 20.57% for male,

Table 8. Consumption status, health and hygiene in the Shekta micro-watershed.

Indicators	Before watershed				After watershed			
Farm size (ha)	>1	1-2	2-4	< 4	>1	1-2	2-4	< 4
Consumption* Expenditure (Rs per annum)								
Male	3525	4150	4550	4840	4250	4575	4780	5100
Female	3012	4215	4532	4650	4100	4750	4975	5100
Children	2400	2550	2810	2975	3700	3870	3900	4200
Health & hygiene** Expenditure (Rs per annum)								
Male	1200	1800	1800	2400	1800	2100	2350	2750
Female	2400	3600	3600	4200	2950	3900	3950	4650
Children	1600	1650	1820	1900	1850	1850	2100	2350

* Consumption expenditure included all food intakes
** Health and hygiene expenditure covers all general expenses on health and hygiene except expenses on accidental and chronic ease

36.12% for female and 54.17% for children on consumption while on health and hygiene it was about 50% for male, 22.9% for female and 15.6% for children because the poor farmers spend most of their income on consumption, health and hygiene. Similar trend with minor differences was observed in case of small farmers. On other remaining category of farmers, the temporal change of expenditure on consumption and health and hygiene were noticed during the project period. Figure 22 depicts on awareness among considerable households in watershed village on proper sanitation.

Figure 22. The facility of modern toilet available in the village.

Poverty and income distribution

Although, the government has taken several steps to eradicate poverty in the country yet the population pressure and other cyclical issues remain in existence in the villages. Poverty has been described as a situation of "pronounced deprivation in well being" and being poor as "to be hungry, to lack shelter and clothing, to be sick and not cared for, to be illiterate and not schooled." There is no doubt that implementation of watershed development programs provides opportunities to landless and poor farmers employing in construction of water harvesting structures, afforestation and management of common properties etc. with adequate labor wages. Before implementation of watershed development programs, the village was suffering from poverty and about 61 people were living below poverty line (Rs 327.56 per month). The Table 9 provides details of prevalence of poverty in the village before and after watershed development programs.

Table 9. The status of poverty in the watershed villages.

Indicators	Reflection	Before watershed	After watershed
Number of poor		61	17
Head-count ratio	Incidence	0.058	0.015
Poverty gap index	Depth	-0.031	-0.013
Squared poverty gap index	Severity	0.016	0.012

The head count ratio is the proportion of population below poverty line, which helps to measure the incidence of poverty. In the village the head count ratio declined sharply from 0.058 to 0.015 during project period from 1998-99 to 2004-05. To measure the depth of poverty in village, poverty gap index was calculated, which helps to measure the gap between poor people's standard of living and the poverty line. There was a good indicator about depth of poverty after implementation of watershed programs that reduced to –0.013 from –0.031 during the period. The severity of poverty is measured by squared poverty gap index, which measures the intensity of poverty and gives more weight to the poorest of the poor. Those farmers whose income is 75% of the poverty line or less and those who are suffering from hunger or not getting even two square meals a day as an extreme form of deprivation. The poverty was reduced amongst the poorest of the poor in the village, which was indicated clearly by the squared poverty gap index that fell about 25% during the same period of time.

The interventions of watershed improved the distribution of income from farm and non-farm activities for male and female farmers in the village. The marginal and small farmers were significantly benefiting compared to their counterparts in the medium and large farmers group. Particularly, female farmers were benefited more compared to male farmers from non-farm income in all the categories of land holdings because of their involvement in other village level enterprises through self-help groups and women association, etc (Fig. 23).

Figure 23. Flour mill – micro-enterprise activity by self-help group.

Table 10. Income distribution of farmers from farm and non-farm activities.

	Before watershed				After watershed			
Farm size (ha)	>1	1-2	2-4	<4	>1	1-2	2-4	< 4
Farm income (Rs. per annum)								
a) Male	1850	2450	4250	5100	2750	3250	6200	7320
b) Female	1200	3750	5250	6300	2100	4200	5110	6800
Non-farm income (Rs. per annum)								
a) Male	3875	4700	2100	2140	4300	3525	3080	3030
b) Female	4210	5165	2880	2550	6150	5250	3303	2450

Data in Table 10 reveals that farm income of both male and female in all category of land holdings increased but the ratio of change in male was significantly higher (43%), while in case of females was about one fourth of male (10.4%). However, in case of non-farm income the change in female was higher (15.8%) than the male counterpart (8.7%) because of watershed interventions over the period of time. The change in distribution of farm income of female farmers in marginal and small land holding category was significantly higher by 75 and 12%, respectively. However, in case of non-farm income, maximum change was observed in female's income (46%) of marginal land holding category while the change of male's income (46.7%) was higher to medium category of farmers over the period of time due to interventions of watershed program in Shekta micro-watershed.

Food, fodder and fuel security

Prior to watershed development, agriculture production was very low except in occasional years when rainfall was sufficient.

The Figure 24 indicates that watershed development activities improved per capita food availability. The highest increase of per capita availability of vegetables was clearly revealed in Figure 24. However, the availability of pulses and oil seeds were found to be increasing with slow rate. The reason behind this would be that farmers prefer short-duration crops that require less investment and provide higher benefits, comparatively with a short period.

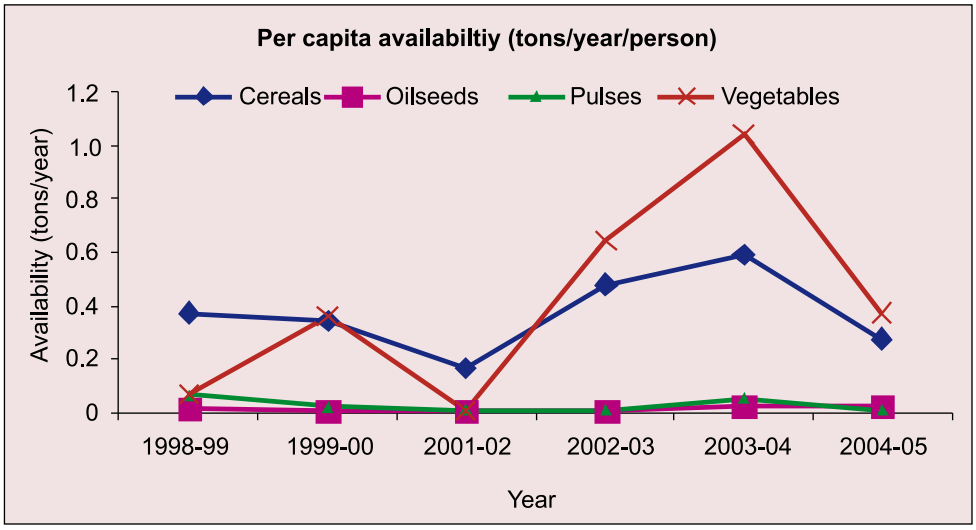

Figure 24. Per capita availability of food per year.

Fodder production

Figures 25 and 26 show the area under fodder production in Shekta watershed. During the base year 1998, the area under fodder production was only 3.5% of total cultivated area, as there was increase in the availability of water due to watershed interventions the area under fodder also consistently increased (in 2004 the area under fodder was 18% of total cultivated area). The significant increase in the area and productivity of fodder encouraged farmers to replace their local breeds with improved one and also increase the livestock production leading to increased milk production.

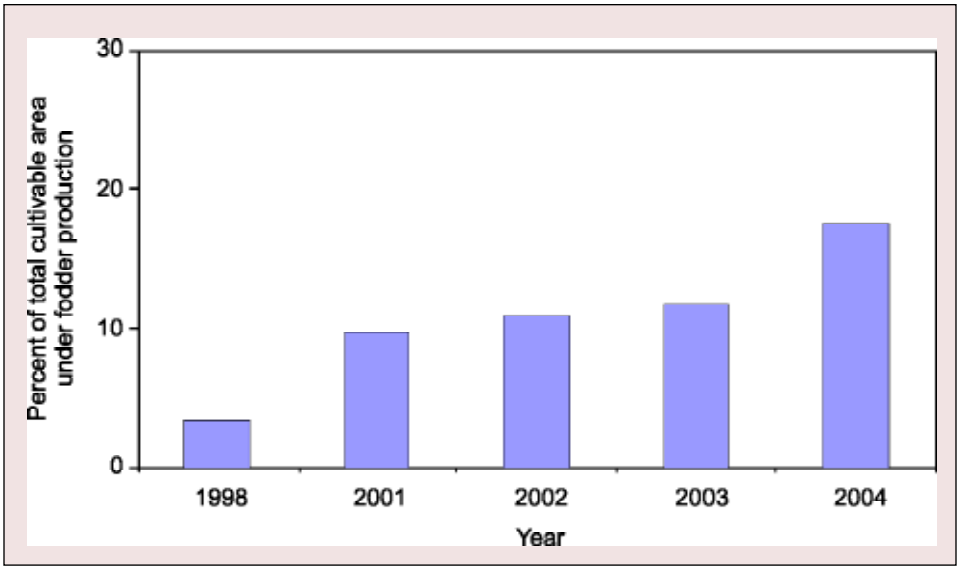

Figure 25. Area under fodder production (in% of total cultivated area), Shekta watershed, Maharashtra.

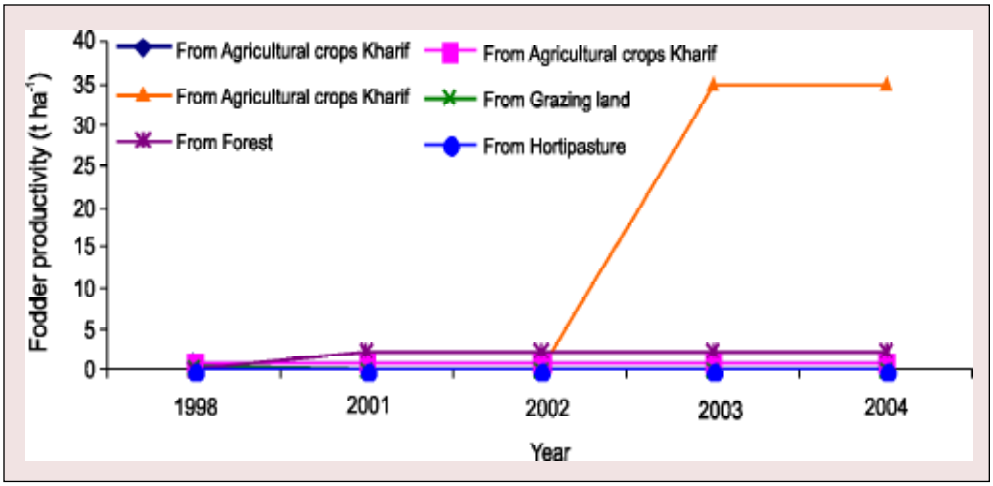

Figure 26. Fodder productivity in the village of micro-watershed during 1998-2004.

Livestock and fodder availability

The total population of the livestock before watershed was 1039, which comprised mainly bullocks, indigenous cows (89), a few crossbreed cows (139), buffaloes, goats and sheep (190). The indigenous cows were unproductive but were able to withstand the scarcity condition prevailing.

The impact shows that the 50% of indigenous cows were replaced by cross breed cows. The number of small ruminants also decreased with now the number of the small ruminants are 55. The milk production before initiation of watershed program in 1998 was only 250 liters d^{-1} but now it has increased by 100%.

The fodder availability for each animal in the year from summer agriculture produce increased constantly from year 2002 followed by *kharif* (rainy) and *rabi* (post-rainy) seasons agriculture produce from 1998 and forest. The summer season fodder availability from agriculture produce reached the mark of 5 t per animal, followed by *rabi* and *kharif* agriculture produce 1 ton each and fodder from forest by 0.5 t per animal respectively. The figure shows no change in the availability of fodder from grazing land (Fig. 27).

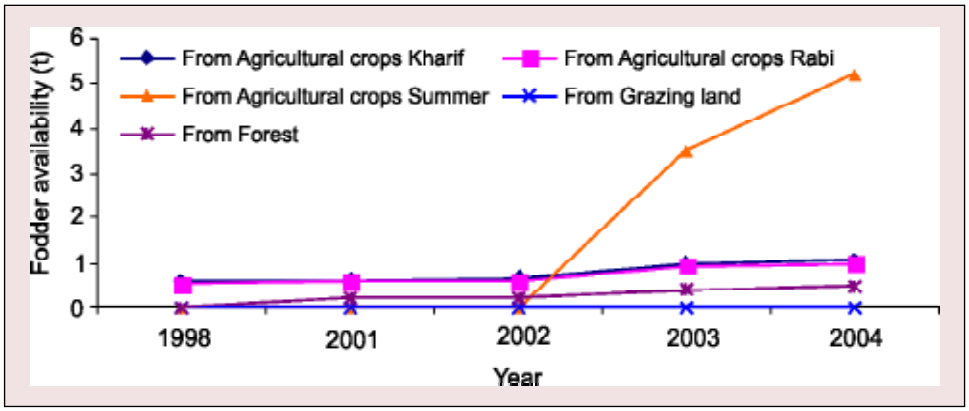

Figure 27. Fodder availability (ton per animal per year) in Shekta watershed during 1998-2004.

Economics of cost of cultivation

The cost of cultivation of important crops at different times was derived from the data collected from different categories of farmers. To evaluate the net benefit from different cost of cultivation the standard norms of unit costing was taken into consideration. In order to evaluate the net profit or loss the fixed as well as variable costs in rupees per ha for important crops at different times were taken into account. The fixed cost covers investment on land, irrigation and equipment, etc. while variable cost includes labor wages, irrigation, fertilizer application, insecticides and pesticides, weeding, interculturing and harvesting expenses along with transport charges, etc. In the present analysis to avoid the effect of inflation or deflation the components of costs during different years measured at current market price (2003-04) were used. Table 11 presents the costs and returns of important crops in order to align the analysis. The result revealed that at the initial stage (1998-99) of watershed development, most of the crops were able to pay out only their variable cost except sorghum but vegetables and groundnut were profitable after paid out their variable as well as fixed cost while there were no profits in other remaining crops. The profit volume ratio, which is the ratio between fixed costs to returns minus variable cost, accounted the highest (2.66) in case of sorghum while lowest in pearl millet. Groundnut was the single crop that provided the highest benefit-cost ratio (1.54), followed by vegetables and pulses.

During the project period the scenario of cost of cultivation changed with temporal effects and in this period most of the crops were able to pay off their variable as well as fixed costs. The profit volume ratio was higher in case of sorghum and wheat while cotton and pearl millet were in loss. Except cereals the benefit-cost ratios of other crops were profitable and higher profit benefit cost ratios were noticed in

Table 11. Economics of cost of cultivation (Rs ha^{-1}) of important crops during watershed development programs in the village.

Crops	Area (ha)	Area over cultivated area (%)	Fixed cost	Variable cost	Total cost	Gross returns	Returns over FC	Returns over VC	Profit/ loss	Profit volume ratio	Benefit-cost ratio
1998-99											
Pearl millet	148.00	14.33	2187	4587	6774	4628	2441	41	-2146	-52.34	0.68
Sorghum	250.00	24.22	2187	4924	7111	3605	1418	-1319	-3506	2.66	0.51
Cotton	201.60	19.53	3031	12122	15153	14824	11793	2702	-329	-0.12	0.98
Wheat	70.50	6.83	2187	7038	9225	7680	5493	642	-1545	-2.41	0.83
Groundnut	22.45	2.17	2187	5103	7290	11250	9063	6147	3960	0.64	1.54
Pulses	168.60	16.32	3031	5375	8406	8340	5309	2965	-66	-0.02	0.99
Vegetable	102.7	9.94	4561	6570	11131	15340	10779	8770	4209	0.48	1.38
2002-03											
Pearl millet	291.24	28.21	2187	5787	7974	6442	4255	655	-1532	-2.34	0.81
Sorghum	265.00	25.70	2187	6212	8399	5150	2963	-1062	-3249	3.06	0.61
Cotton	207.00	20.05	3031	14435	17466	15040	12009	605	-2426	-4.01	0.86
Wheat	115.00	11.14	2187	9057	11224	8000	5813	-1057	-3224	3.05	0.71
Groundnut	17.15	1.67	2187	7915	8702	10300	8113	2385	1598	0.67	1.18
Pulses	12.48	1.21	3031	7562	10593	15796	12765	8234	5203	0.63	1.49
Onion	136.27	13.19	4561	4750	9311	14205	9644	9455	4894	0.52	1.53
Vegetable	128.86	12.47	4561	8530	13091	16603	12042	8073	3512	0.44	1.27
2004-05											
Pearl millet	113.15	10.96	2426	7057	9483	9480	7054	2427	-3	0.00	1.00
Sorghum	142.23	13.78	2426	7575	10001	10000	7574	2425	-1	0.00	1.00
Cotton	509.81	49.41	3460	18650	22110	34880	31420	16230	12770	0.79	1.58
Wheat	134.61	13.10	2426	11537	13963	22560	20134	11023	8597	0.78	1.62
Groundnut	29.67	2.88	2426	7850	10276	17500	9245	9650	7224	0.75	1.70
Pulses	52.68	5.11	8255	8255	11715	12120	3865	3865	405	0.10	1.03
Onion	203.39	19.70	4561	5510	10071	16715	12154	11205	6644	0.59	1.66
Vegetable	120.58	11.68	4561	9470	14031	17825	13264	8355	3794	0.45	1.27

* Capital investment on land and irrigation facilities including water harvesting structures are taken into consideration for fixed cost

case of onion, which was introduced in 2004, followed by pulses and vegetables. Tremendous changes were observed in cost of cultivation of these important crops at the end of the project period due to availability of water and its proper management. The returns from cultivations of the crop covering their respective variable as well as fixed costs with additional profit while pearl millet and sorghum were at break even point, meaning neither profit nor loss. The highest benefit-cost ratio noticed in groundnut (1.70), was followed by onion (1.66), wheat (1.62) and cotton (1.58). The analysis of cost of cultivation reveals that farmers were getting more net profit from cash and commercial crops rather than traditional crops which resulted in diversification of crop from traditional to other cash and short period crops.

Labor wages and status of women

Since long back discrimination among men and women labor wages exist in agriculture in India. The wage differentials across gender are endemic in agriculture labor market all over India is a well-established fact. Even reported that when men and women perform the same task for the same job men are always paid a higher wage. There is no doubt that the interventions of watershed technology in the village not only played a role of gender equalizer but redistributed boundaries of work based on gender. The present study highlights the productivity of male and female for a particular crop through using Cobb-Douglas production function (Cobb and Douglas 1928).

$$\text{Log } Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + S$$

Where, Y = Productivity of a crop in quintals/ha
X_1 = Area under the crop in hectares,
X_2 = Male labor use in days/ha
X_3 = Female labor use in days/ha
a = Constant
b_1, b_2 and b_3 are parameters
S is the error

The labor productivity of male and female before and after implementation of watershed development programs in the village was evaluated for important crops viz., pearl millet, sorghum, wheat and cotton (Table 12). The physical as well as financial productivity of labor was calculated to examine the contribution of watershed programs towards enhancing the productivity of labor in different crops within specific period of time.

The overall output per worker at market prices during 2004-05 was worked out and after watershed development programs the productivity of labors increased by two times in all types of crops and the

Table 12. Output per worker of important crops before implementation of watershed program[1].

Cropping system/crop	Physical output (kg)	Total output (Rs)	Output per worker	
			(kg)	(Rs)
Pearl millet	132900	684435	16.94	87.25
Sorghum	175000	901250	11.11	57.22
Wheat	84600	541440	9.38	60.00
Cotton	160600	2987160	8.03	149.37

1. At 2005 market prices

Table 13. Output per worker of important crops after implementation of watershed program in Shekta watershed[1].

Cropping system/ crop	Physical output (kg)	Total output (Rs)	Output per worker	
			(kg)	(Rs)
Pearl millet	208300	1072745	32.29	166.31
Sorghum	276200	1422430	24.89	128.22
Wheat	474500	3036800	25.36	162.30
Cotton	956000	17781600	13.69	254.59

1. At 2004-05 market prices

highest physical output per worker was recorded in case of pearl millet while capital output in case of cotton (Table 13).

The highest physical output of labor was noticed in case of wheat by 170.36%, followed by pearl millet (90.61%) cotton (70.48%) and sorghum (55.36%) during watershed development programs.

The Cobb-Douglas production function was worked out to examine the correlation of output per worker with the wage rate of important crops during different period of time. The estimation of Cobb-Douglas function reveals that before watershed development program the productivity of all crops were significant at ($P \leq 0.005$) level with area but the coefficient of male and female labor were non-significant in the case of two crops out of four crops. The coefficient of male labor in wheat and cotton were significant while the coefficient of female labor was significant in case of pearl millet and wheat. The highest coefficient of correlation was noticed in case of sorghum followed by cotton, wheat and pearl millet. The adjusted value of r^2 was negative for all the crops viz., pearl millet, sorghum, wheat and cotton (Table 14).

Table 14. Production function estimates for important crops before implementation of project (1998-99) at Shekta watershed.

Crop	No. of observations (n)	Regression coefficient of						
		Constant (a)	Area (X_1)	Male labor (X_2)	Female labor (X_3)	R	R^2	Adjusted R^2
Pearl millet	31	1288.08**	0.483**	-1.317*	0.259**	0.158	0.0249	-0.084
	SE±	194.43	1.23	1.644	1.700			
	t-value	6.625**	0.3946*	-0.801*	0.1526*			
Sorghum	31	1583.83**	0.88**	-1.319*	-0.131*	0.3040	0.0924	-0.00836
	SE±	242.56	0.877	1.38	1.393			
	t-value	6.529**	1.00*	-0.95*	-0.094*			
Wheat	31	665.96**	1.21**	1.15**	0.328**	0.211	0.0448	-0.0575
	SE±	234.77	3.118	1.351	0.862			
	t-value	2.836**	0.388*	0.851*	0.381*			
Cotton	31	1518.42**	0.1572**	2.826**	-0.320*	0.2134	0.0455	-0.06051
	SE±	285.98	1.199	2.602)	1.987			
	t-value	5.30**	0.131*	1.987*	-0.161*			

* Non-significant; ** significant at 5% level

The estimated coefficient of productivity of all crops increased significantly, the coefficient of area was significant in case of three crops out of four crops preset and female's coefficient were significant only in case of sorghum and cotton. After implementation of watershed program the value of coefficient increased significantly except a few. The highest value of R^2 noticed in case of white wheat and the lowest in case of cotton. The adjusted value of R^2 was negative in all crops. The results reveal that these components viz., area, male and female labor do not contribute more towards productivity which reversibly indicates that the productivity of crops enhanced because of watershed program and not due to other factors (Table 15).

Table 15. Production function estimates for important crops after implementation of project (2003-04).

Crop	No. of observations (n)	Regression coefficient of						
		Constant (a)	Area (X_1)	Male labor (X_2)	Female labor (X_3)	R	R^2	Adjusted R^2
Pearl millet	31	2121.91**	-0.253*	0.0953**	-0.269*	0.127	0.016	-0.09
	SE±	59.97	0.498	0.420	0.670			
	t-value	35.37**	-0.50*	0.23*	-0.40*			
Sorghum	31	2786.71**	-0.294*	0.0695**	0.204**	0.176	0.031	-0.076
	SE±	64.68	(0.434	0.185	0.457			
	t-value	43.08**	-0.677*	0.375*	0.447*			
Wheat	31	5438.28**	1.034**	-1.805*	-12.308*	0.255	0.065	-0.0347
	SE±	1700.54	9.247	9.731	8.842			
	t-value	3.19**	0.111*	-0.185	-1.391*			
Cotton	31	9527.98**	0.00067**	0.3491**	0.0279**	0.0286	0.00082	-0.1102
	SE±	455.57	0.7676	2.3501	2.0388			
	t-value	20.91**	0.00087*	0.1485*	0.01368*			

* Non-significant; ** significant at 5% level

The percentage of women's contributions in agriculture activities were higher than their male counterparts in important crops before watershed development programs and slightly changed in both the cases of male and female after implementation of watershed development programs in the village (Tables 16 and 17). In each case, women's labor contributions to crop cultivation exceeded by about 37.5% and higher number of days of labor use were noticed in case of cotton, followed by vegetables while the lowest in case of pearl millet and sorghum. The women's participation in agriculture activities lies on specific work such as sowing, irrigation, intercultural, weeding and harvesting, etc.

There were significant changes observed in several activities after implementation of watershed development program in Shekta watershed. The time spent by male and female per day were significant only in case of domestic and animal related activities while insignificant in case of agriculture and non-agriculture activities in the micro-watershed of Shekta. At present, the livestock has become important component to generate additional income in the village and the time spent by male and female members on this aspect are not always statistically significant. In observation, these components are significant, which indicate the women's participation is increasing significantly (Table 18).

Table 16. Labor uses in different activities of important crops before watershed development program (days ha^{-1}).

	Pearl millet		Sorghum		Wheat		Cotton		Pulses		Potato		Vegetables	
Crop production operations	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Field preparation & tillage	4.5	0	2	0	4	0	19	0	6	0	5	0	3	0
Sowing/transplanting	1	0	1	0	2	0	1	12	2	0	2	3	6	5
Fertilizer application	1	0	1	0	2	0	2	15	1	0	3	3	4	0
Irrigation	0	0	22	0	64	0	30	0	1	0	16	0	30	0
Interculture/weeding	0	15	0	20	0	25	0	10	0	0	0	16	1	30
Plant protection measures	0	0	0	0	0	0	1	1	0	0	0	0	1	1
Harvesting/picking	8	8	4	4	4	22	0	40	2	20	3	3	4	24
Threshing and winnowing	6	8	3	5	2	2	0	0	2	10	0	0	0	0
Transportation	1	0	1	0	1	0	1	0	1	0	1	0	24	0
Total days	22	31	34	29	79	49	52	78	15	30	30	25	73	60

Table 17. Labor uses in different activities of important crops after implementation of watershed development program (days ha^{-1}).

	Pearl millet		Sorghum		Wheat		Cotton		Pulses		Potato		Vegetables	
Crop production operations	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Field preparation & tillage	5	0	4	0	6	0	20	0	8	0	6	2	6	4
Sowing/transplanting	1	0	1	0	2	1	4	18	4	0	4	6	8	5
Fertilizer application	1	0	2	0	2	0	6	22	2	1	3	5	4	3
Irrigation	0	0	25	0	65	0	45	0	1	0	20	3	35	5
Interculture/weeding	0	15	0	25	0	25	5	15	0	0	0	18	1	40
Plant protection measures	0	0	0	0	0	0	5	0	0	0	0	0	3	3
Harvesting/picking	10	8	6	6	6	26	2	45	4	22	6	5	4	28
Threshing and winnowing	6	10	3	5	2	3	0	0	2	15	0	0	0	0
Transportation	1	0	1	0	1	0	1	0	1	0	1	0	24	0
Total days	24	33	42	36	84	55	88	100	22	38	40	39	85	88

Table 18. Time distribution (h d^{-1}) of men and women workers in the village.

	Before watershed intervention			After watershed intervention		
Activities	Men	Women	t-value	Men	Women	t-value
Domestic	1.00	4.00	3.652*	2.00	3.00	1.89*
Agriculture	8.00	6.00	0.832^{NS}	10.00	8.00	0.00012^{NS}
Animals	4.00	1.00	1.35*	5.00	2.00	1.43*
Non-agriculture	1.00	1.00	0.967^{NS}	1.00	1.00	0.813^{NS}

* Significant at 5% level, NS = non-significant

Table 19. Labor wage rate (Rs per hour) of male and female workers in the micro-watershed village.

	Before watershed program	After watershed program
Agriculture		
Male	6.25	7.75
Female	5.00	6.66
Other than agriculture		
Male	6.25	6.75
Female	4.16	5.00

The discrimination of labor wages existed amongst men and women in India and the gender disparities in wages were marked in the sample and results highlighted in the Table 19. The male labor was getting about 25% more wage in agriculture while in other activities about 50.24% more than their female counterparts before watershed development program in the village. The gap between labor wages narrowed down during watershed program and at present male is getting about 16.67% in agriculture and in other activities about 35% more than their female counterparts (Table 19).

Employment opportunities and migration

To create additional employment opportunities for rural youth and landless farmers in the village, the watershed development program set up a mandate to achieve full employment in village itself (Fig. 28). The data in Table 20 revealed that drastic changes were observed in employment scenario of different type of works during the project periods in the village. After watershed development program, the agriculture activities of person day/week increased by 9.09% and the increment rate was

Figure 28. Additional employment opportunities through watershed program in Shekta watershed.

Table 20. Employment opportunities in the micro-watershed village (person days per week).

	Before watershed				After watershed			
Nature of work	<1 ha	1-2 ha	2-4 ha	>4 ha	<1 ha	1-2 ha	2-4 ha	>4 ha
1. Agriculture	2.0	2.0	3.0	4.0	2.0	2.0	5.0	4.0
2. Horticulture	0	0	1.0	1.0	0	1.0	1.0	2.0
3. Floriculture	0	0	0	0	0	0	0	0
4. Afforestation	0	0	0	0	2.0	2.0	1.0	0
5. Animal husbandry	1.0	2.0	2.0	1.0	1.0	2.0	1.0	1.0
6. Small enterprises								
a) Agriculture based	4.0	3.0	0	0	0	0	0	0
b) Non-agriculture based	0	0	0	0	2.0	1.0	0	0
7. Others	0	0	0	0	0	0	0	1.0

higher in case of medium and large farmers and the same pattern remained in horticulture activities. The afforestration activities in the village generated additional employment opportunities in the village and most of the farmers from marginal, small and medium categories were getting benefitted. A temporal change was observed in case of animal husbandry and agriculture-based small enterprises. After watershed programs, the marginal and small farmers got more benefit in non-agriculture based small enterprises in micro-watershed village of Shekta.

Status of migration in the village

Rural to urban migration of labor is one of the major problems of urbanization on one side and shortage of labor in agriculture another. The watershed program solved the problem of migration of labor by providing employment opportunities in the village. The Table 21 provides the information on seasonal and permanent migration of skilled and non-skilled labors in the village. After watershed development program, the seasonal migration of skilled labor reduced by 60% while sharp reduction of 36% was noticed in case of non-skilled labor. The influence of watershed program was observed visibly in case of permanent migration of skilled as well as non-skilled labor in the village.

Table 21. Status of migration (persons per year) in the Shekta micro-watershed.

	Before watershed				After watershed			
Nature of work	<1 ha	1-2 ha	2-4 ha	>4 ha	<1 ha	1-2 ha	2-4 ha	>4 ha
Seasonal migration								
Skilled labor	15	5	0	0	5	0	0	0
Non-skilled labor	165	105	10	52	105	57	0	0
Permanent migration								
Skilled labor	18	7	2	0	3	1	0	0
Non-skilled labor	24	7	1	0	5	3	0	0

Livestock production and ruminants

There is close nexus between watershed development program and livestock production. One of the basic objectives of watershed development programs is to increase the livestock production in proportion to population in the village so that employment opportunities can be enlarged through mixed livestock and crop production technology in sustainable manner. The result from Table 22

Table 22. Livestock production and associated details in Shekta micro-watershed.

	Before watershed				After watershed			
	<1 ha	1-2 ha	2-4 ha	>4 ha	<1 ha	1-2 ha	2-4 ha	>4 ha
Animal ratio per head	2.90	1.16	1.16	1.94	4.28	3.43	3.45	2.86
Milk availability per head (L)	1.18	0.47	0.47	0.79	2.34	0.93	0.93	1.56
Ruminants ratio per head	2.12	0.94	0.94	1.58	2.97	1.19	1.19	1.98
Bullocks availability per ha	60	75	75	90	70	88	88	105
Income from ruminants per annum (Rs)	473	189	189	314	663	265	265	397
Income from milking animal per annum (Rs)	1563	626	626	1044	2795	1246	1246	1838
Lactation period of cows (days/year)	210	210	210	210	240	240	240	240
Lactation period of buffaloes (days/year)	270	270	270	270	305	305	305	305

revealed that the animal ratio per head of population increased by around 96% in which marginal and small farmers got more benefits. Milk availability per head for marginal farmers increased sharply by two folds, while overall availability increased by 98% in the village. The ratio of small ruminants to population increased to 31% while the bullocks' availability ha^{-1} increased marginally by 17%. The net income per annum from both small ruminants and milching animals increased around by 36 and 85%, respectively. Due to availability of green fodder even in summer season the lactation period of cows increased by 14% while buffaloes by 12.96% during the period of watershed development programs in the village.

Ex-ante impact assessment and evaluation of investment

Ex-ante impact assessment examines the potential of research and development in near future and it also helps to identify the research areas and programs, which benefit the poor and regions. *Ex-ante* impact assessment done objectively to assess the research portfolio and prioritize the research agenda helps in decision-making and allocating resources in high returns research portfolio (Joshi et al. 2003). Under the preview of impact assessment, the water harvesting structures constructed under watershed development program and its impact on crop production and economic surplus for long-term were evaluated and analyzed. The economic surplus model (Alston et al. 1995) is used to measure the rate of returns to the research from investment in water harvesting structures during the project periods. Research benefits were computed as change in economic surplus:

$$\text{Change in total surplus} = K_t P_0 Q_0 (1+0.5 Z_t \eta)$$

Where $Z_t = K_t/(\varepsilon + \eta)$

K = Vertical shift in supply function

ε = Elasticity of supply

η = Elasticity of demand

P_0 = Base year output price

Q_0 = Base year output quantity

Using the above measure of total benefit from research, the different measures of economic rates of returns were estimated as follows:

Net present value:

$$\sum_{t=0}^{n} [(B_t - C_t) / (1+r)^t]$$

Internal rate of return:

$$\sum_{t=0}^{n} [(B_t - C_t) / (1+ IRR)^t] = 0$$

Benefit-cost ratio:

$$\sum_{t=0}^{n} [(B_t) / (1+r)^t] / - C_t) / \sum_{t=0}^{n} [(C_t) / (1+ r)^t] = 0$$

Where B_t is benefit (change in total surplus) in year t, C_t is cost in year t and r is the discount rate.

As per assumption the model was applied in a closed economy with no spillover effects on international market. And it further assumed that the output supply function was unitary elastic and linear with parallel research-induced supply shift and demand function is linearly inelastic.

The key interventions under watershed program increased the additional area for different crops, which resulted in crop diversification and economic surplus within short period. The details of interventions of watershed program at village level listed in Table 23.

There were various interventions such as crop cultivation; afforestration, horticulture and loose boulder (Table 23) that were implemented in the village. Evaluation and impact assessment were based on the returns of five important crops viz., cotton, wheat, groundnut, onion and vegetables, which covered more than 87% area of cultivation in the village.

Table 23. Additional area coverage and watershed interventions in the village over period of time.

Important crops	Area covered (ha)	Additional area (ha)	Interventions/treatment
Cotton	509.81	308.21	• Crop cultivation (contour bunds/broad-bed furrows/farm bunds/soil bunds/SO) • Afforestation and continuous contour trenches with refilling of the trenches, water absorption trenches, SB, stone gully plugs • Horticulture plantation, animal husbandry • Loose boulder, repair of *nala bund*, check weir and check dam, etc.
Wheat	134.61	64.11	
Groundnut	29.67	7.22	
Onion	203.39	203.39	
Vegetables	120.58	17.88	

Evaluation of economic impact: The evaluation of economic impact of investment on water harvesting structures were carried out with economic surplus model, keeping the following assumptions with respect to various technological and economic parameters:

- 15 years considered as a period of analysis
- Yield change between 0.12 and 0.17
- Change in cost of cultivation from 0.15 to 0.16
- Probability of success is expected to be 50%

- Adoption rate: Adoption starts five years after initiation of the project and increases at a rate between 10 to 35%.
- Depreciation of technology: The technology will be relevant for eight years and then starts depreciating at a rate of five percent per year.
- Research cost: Actual expenditure incurred during project period
- Discounting rate: Eight percent
- Elasticity supply: 0.80 (assumed)
- Elasticity of demand: 0.80 (assumed)

During the project period the cost of cultivation of important crops temporally increased with inequality. The highest increment of cost of cultivation (Rs ha^{-1}) was noticed in case of wheat (51.36%) with CGR of 6.10 followed by cotton (45.91%) and groundnut (40.96%) while the lowest in onion (8.16%). The yield kg ha^{-1} of all these important crops increased sharply and the yield of wheat, cotton and groundnut increased by 193.75, 135.29 and 55.56%, respectively. The cost of production of these crops except vegetables declined and higher percentage of decrease was observed in case of wheat (-48.50%) with CGR of -9.04, followed by cotton, groundnut and onion. The incremental positive rate was found in case of net returns of cotton, wheat and onion. Exceptionally, the net returns from vegetable declined by –9.86% with CGR (-1.47%) at the time of completion of the project.

The project incurred a total expenditure of Rs 43,57,776/- during the implementation of watershed activities. Using the economic surplus model, the NPV of the project was estimated to be Rs 38,766.18 ha^{-1} with an IRR of 16%. The benefit-cost ratio was 1.5, which indicate the investment in the project was remunerative and profitable (Table 24).

Infrastructure and Institutional Development

Initiatives of watershed development programs strengthened the infrastructural and institutional development in different kinds. The various institutional developments are as follows:

Watershed community/*gram sabha*

The watershed community is the main apex body to take decisions of development of the watershed and also determine the efforts to be made to include in the watershed. The watershed community consists of all the people living in the village and the nature of selection of president depends on the democratic style of voting.

The village watershed committee (VWC)

This is a executive body registered under the Societies Registration Act, 1860 and nominated by the watershed community for planning, implementing, and monitoring. The project has an official project co-holder, which is responsible for receiving and utilization of the funds available. The committee consists the representative of farmers including landless from the different micro-watershed and social groups. The village watershed committee was according to the guidelines of watershed development program and the total strength of this committee was 21 in which 9 members (42%) were from women and 12 (58%) men from the village.

Table 24. Impact of water harvesting structures on the yield and profitability during watershed development program in micro watershed village of Shekta.

	Years				
	1998-99	2002-03	2004-05	Differences *	CGR**
Cost of cultivation (Rs ha^{-1})					
Cotton	15153	17466	22110	6957	5.55
Wheat	9225	11224	13963	4738	6.10
Groundnut	7290	8702	10276	2986	5.03
Onion	9311	9311	10071	760	1.13
Vegetables	11131	13091	14031	2900	3.36
Yield (kg ha^{-1})					
Cotton	796.99	808.60	1875.26	1078.27	13.00
Wheat	1200.00	1250.00	3525.00	2325.00	16.64
Groundnut	750.00	687.00	1666.67	416.67	12.08
Onion	7102.50	7102.50	8357.50	1255.00	2.35
Vegetables	1278.33	1383.58	1485.41	207.08	2.17
Cost of production (Rs kg^{-1})					
Cotton	19.01	21.60	11.79	-7.22	-6.60
Wheat	7.69	8.98	3.96	-3.73	-9.04
Groundnut	9.72	12.67	6.17	-3.55	-6.30
Onion	1.31	1.31	1.21	-0.10	-1.20
Vegetables	8.71	9.46	9.45	0.74	1.17
Net return (Rs ha^{-1})					
Cotton	-329	-2426	12770	13099	268.66
Wheat	-1545	-3224	8597	10142	227.79
Groundnut	3960	1598	7224	3264	8.97
Onion	00	4894	6644	6644	4.46
Vegetables	4209	3512	3794	-415	-1.47

*The differences from 2004-05 to 1998-99 are significant at 5 percent level. ** Linear compound growth rate

Forest protection committee (FPC)

Under institutional development, the village is empowered with forest protection committee (FPC) consisting two members, one male and one female from the entire household in the watershed. An executive body is selected from the Forest Protection Committee, which is responsible for development and management of the forest under the Government of Maharashtra resolution on joint forest management. This committee takes all responsibilities for forest development in area of watershed which comes under the forest department, under the supervision of forest department. The community has usufruct rights over the produce of the forest under the gram sabha.

Self-help groups (SHGs)

There were 12 self-help groups constituted at different level in which 10 were for women and remaining 2 groups for men in the watershed during the watershed development program. The groups were formed for savings and providing credit to uplift their socio-economic status by adopting comprehensive strategies provided under the program (Figs. 29 and 30). These groups consisted of members from 13 to 20 and their monthly savings ranged from Rs 25 to 100 per month. The interest on loan provided

Figure 29. Meeting of women self-help group in Shekta micro-watershed.

Figure 30. Felicitation of village development activities by Watershed Organization Trust.

from accumulated funds within the groups is charged from 2 to 3% per month on the decision of group members. During the period, members of SHGs had taken loan from their respective groups from Rs 6500 to Rs 12800. The total savings of the groups varied from Rs 24375 to Rs 68000 during the same period of time.

Samyukta Mahila Samiti (SMS)

In the village all the women of self-help groups federated into an apex body known as Samyukta Mahila Samiti. Two members of each self-help group is a member of SMS and this SMS consists of 24 members. The SMS is responsible for coordinating the activities of SHG's and channelizing the resources pertaining to women's development activities.

Panlot sevak/supervisors

At field level there are three *panlot sevaks* (watershed workers) for undertaking the treatments and for distribution of work to the labors, taking measurements, supervising the quality of work, collecting data and maintaining records, etc. One supervisor is responsible for 30 to 40 laborers in the site. They are paid from the supervision component factor in the project, which is equivalent to 8% of the unskilled labor cost. They are employees of the village watershed committee (VWC) and also accountable for the village watershed committee. They also functions as animators and assist the NGO's and VWC in planning the village watershed committees.

Apart from these institutions the watershed development program enabled the farmers to develop other income-generating institutions like milk cooperatives and farmers clubs, which support the livelihoods of the poorest of the poor.

Environmental and Ecological Indicators

To maintain the ecological balance the program had executed different kind of interventions in the village, which is ultimately supporting the rural agricultural economy.

Biodiversity and water resources

In the zeal of development to complete area treatment comprising 156.62 ha afforestation, 8.50 ha agri-horticulture, 632.3 ha crop cultivation including contour bunding was done under area treatment measures to conserve soil and water to boost agriculture productivity of the crops grown. In addition, there were four *nala* bunds repairs, 16 check weirs and one check dam under drainage line treatment measures to enhance the irrigation potential of the watershed. The local species was selected with the help of local people and the species mix compotation to maintain the biodiversity of the area was carried out. The survival rate of the plants of different species is 80% approximately. However, in the fifth year, it was observed 95% in the first year.

Forest and common property resources

During the watershed development program forestland was developed through the formations of the institutions like *charibandi* (ban on free grazing on treated lands), *kurhad bandi* (ban on felling of trees) to support the regeneration of natural resources in the village and maintain the ecological balance.

The Forest Protection Committee is still play a major role to take care of the forestland by certain rules and regulations such as ban on grazing and ban on cutting the trees. They are also protecting the forest from forest fire hazards.

Land treatments like continuous contour treatments, contour bund, afforestation, etc., have been carried out on the CPRs to improve the productivity of land and to maintain the ecological balance. People generally take benefit from the CPRs in terms of grass and fodder for their animals, fuel wood, etc. The responsibility of monitoring CPRs was given to forest protection committee under their VWC. The cut and carry methods are generally used by the people for grass, fodder and fuelwood collection. In this process if any one is found guilty, the committee has the right to impose penalty on the defaulters. The other aspect of the common property resources is community well where all the villagers used the water. However, certain rules and regulations have been made to protect the wells and the water use in sustainable manner.

Land degradation and rehabilitation

Ridge-to-valley conservation approach is a very scientific way of conserving ground water, starting from the ridge. The conserved moisture can be utilized for growing more trees and increasing the vegetative cover. The surface runoff volume as well as runoff velocity is reduced to non – scouring one and ultimately the soil erosion process is reduced to some extent. Rainwater gets more time to infiltrate and percolate and hence the time of concentration is increased. Managing water at ridge area is much easier than managing the bulk of volume of runoff in the valley, thus allowing decentralization of conservation. The technological options for area treatments should be based on contours, wherever possible. This helps the water harvested to remain in a uniform level, leading to even moisture and prevention of breaches in and breakages of structures.

There are several measures adopted to minimize land degradations i.e. soil erosion, soil salinity, etc. Major treatments where continuous contour trenching, refilling of these trenches for plantations, gully plugging and repair of farm bunds along with land use measures such as crop cultivation, afforestation, reforestation and agro horticulture and hortipastural etc. were undertaken. Under farm and contour bunding the treatment involved repair of existing farm bunds and new bunds along the contour across the slope with interval. The other measures like construction of improved grass species such as *dinanath*, *pavana*, marvel, stylo were grown in order to protect soil erosion to improve soil status like organic contents of the soil through contour cultivation, cover cropping with pulse on greater slope land, crop rotation, green manuring, mulching, etc.

Under farm bunding activities pits and agro horticulture were introduced in the area to boost the productivity of land.

Strategies and Policy Implications

- Self auto motivational approach
- Periodic evaluation of watershed activities and impact assessment
- Democratic way of selection of members for specific period of time
- Transparency and accountability in financial dealings and watershed activities
- Dissemination of new technology and research
- Implementation of new policies on warehouses and creation of market for extra produce
- Micro-enterprises on field with help of government and villagers with equitable sharing profits

- Interlinking between livestock production and human resources development.
- More importance on sustainability of measures under watershed program through participatory approaches.
- Segmentation of market and policy on price fluctuations which, influences the decision-making power of farmers, rending imbalance between supply and demand of few crops in future.

Concluding Remarks

Despite erratic and uncertain rainfall in the village during watershed development program area, productivity and production of different important crops increased significantly. The water storage and harvesting structures in the village ensured to distribute benefits more equitably amongst farmers in different parts of the village. The area of cereals increased by 13 to 15% per annum (CGR) and the area of onion, which was introduced during project period increased significantly with compound growth rate of 17% per annum. The area of other important crops such as oilseeds and vegetables also increased with 14.25 and 14.98% per annum (CGR). The basic aim of watershed development program was to improve the productivity through natural resources conservation and interventions of soil and water conservation. The results in this regard are very progressive and during the period the productivity of all these crops increased by 13 to 16% per annum with little effects over change in area. The *ex-ante* impact assessment on water harvesting structures and crop production ensured the higher potential and efficiency of crop production from investment on such activities. The tangible and intangible benefits of the watershed development programs in the village were worked out as follows:

- Land degradation checked to some extent and soil fertility and moisture increased.
- The area and productivity of important crops increased significantly and the production of crops increased because of an increase in productivity with little spill over effect of change in area.
- The crop diversification occurred with cash and short-term crops from traditional cereal crops. And onion was the new vegetable grown in the area with higher increment in area as well as productivity during project period in the village.
- The cropping intensity also increased in the area and most of the farmers are using double or triple cropping systems.
- The socio-economic status of the farmers in all categories has improved and their purchasing power of commodities increased sharply.
- Proper utilization of labor exited in the village and to some extent discrimination of male and female labor wages narrowed down during project period in the micro-watershed of Shekta.
- The health and hygiene status of farmers improved sharply and farmers became aware of not only about chronic disease but also about AIDS and other sexually transmitted diseases.
- The status of women improved slightly and different groups such as SHGs, SMS etc. are strengthening them and their dependency on money lenders has reduced.
- In the village, the women SHGs were engaged in vermicomposting which provide them employment opportunities with additional income.
- There were rare case of absolute poverty in the village, the farmers were able to have credits in bank in addition to stored food grains.
- The livestock production in the village increased and the per head milk availability also improved.

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The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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