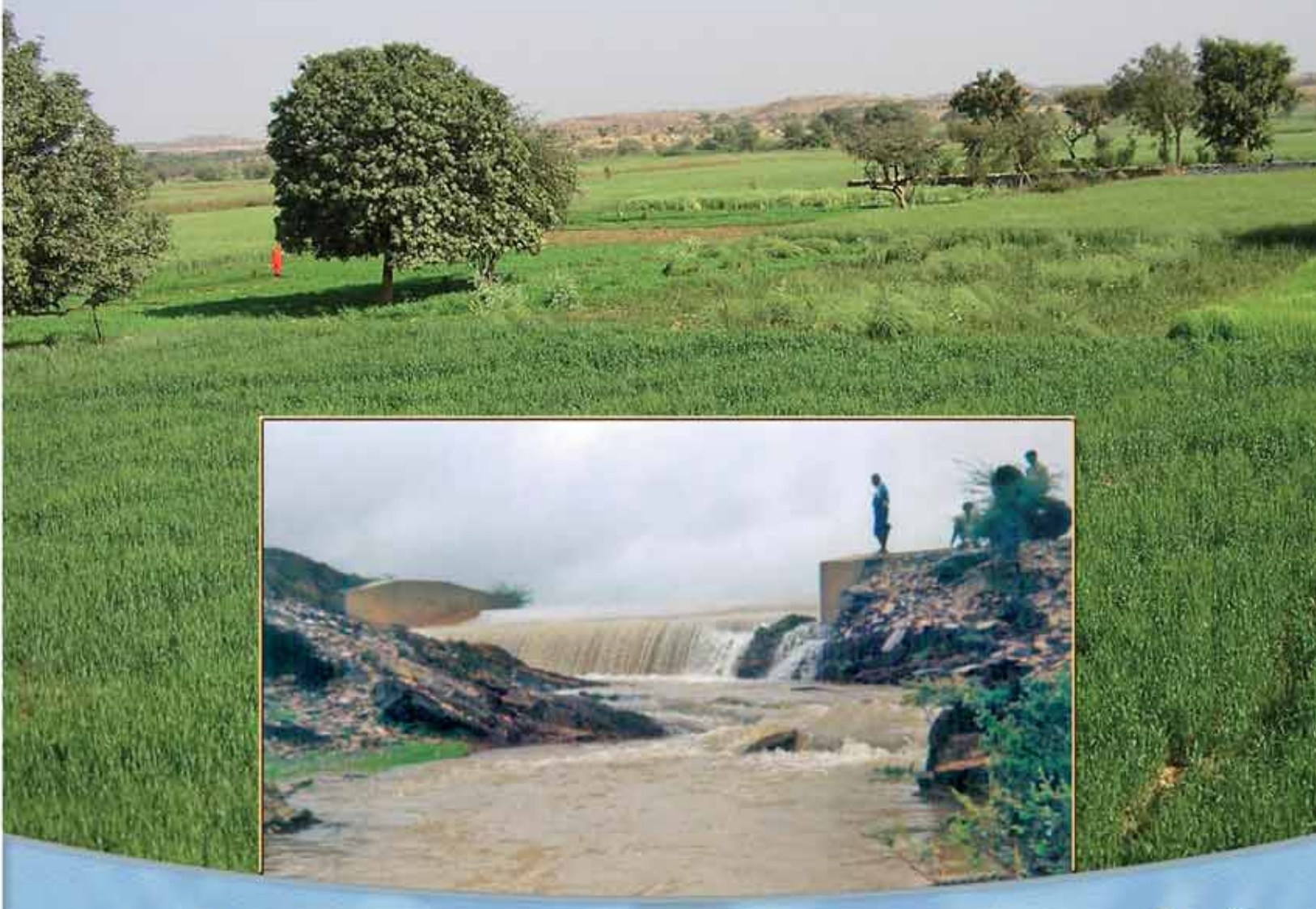
Global Theme on Agroecosystems

Report no. 36

Rural Prosperity through Integrated Watershed Management: A Case Study of Gokulpura-Goverdhanpura in Eastern Rajasthan



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Abstract

The agriculture in eastern Rajasthan is characterized by high risks from drought, degraded natural resources and pervasive poverty. At Gokulpura-Goverdhanpura village in Bundi Rajasthan, ICRISAT along with partners implemented integrated watershed project using holistic systems approach with integrated genetic and natural resource management (IGNRM) strategy. This report discusses the multi-faceted impact of this watershed program. It has been found that the science-led participatory watershed program at Gokulpura-Goverdhanpura had made positive impacts on natural resources, rural livelihoods and environment. The major impact of watershed interventions was seen in improving the surface and groundwater availability. Increased water availability resulted in increased cropping intensity and diversification to more remunerative land use systems involving livestock, horticultural and vegetable production. Overall, the watershed program has reduced land degradation, enhanced agricultural productivity and incomes, decreased poverty of rural poor, reduced labor migration and improved environment quality.

This publication is an output from a research project "Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan" supported by the Sir Dorabji Tata Trust (SDTT).

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Rural Prosperity through Integrated Watershed Management: A Case Study of Gokulpura-Goverdhanpura in Eastern Rajasthan

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Contents

Acronyms

BAIF	Bhartiya Agro-Industries Foundation
CAZRI	Central Arid Zone Research Institute
CPR	Common property resource
ICAR	Indian Council of Agricultural Research
ICEF	India Canada Environment Facility
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KVK	Krishi Vignan Kendra
LGP	Length of the growing period
MPUAT	Maharana Pratap University of Agriculture and Technology
NARS	National Agricultural Research System
NBSS&LUP	National Bureau of Soil Science and Land Use Planning
PIA	Project implementing agency
SAT	Semi-Arid Tropics
SAU	State Agriculture University
SHG	Self help group
UG	Users group
WDT	Watershed development team
WHS	Water harvesting structures

Executive Summary

In most SAT regions, lack of technological progress and increasing population pressure are taking heavy toll on the productive resource base. Water scarcity, land degradation and productivity loss are becoming major challenges to the eradication of poverty, especially in SAT areas, where there is a strong nexus between poverty and environmental degradation. Depletion of the resource base diminishes the capabilities of poor farmers to earn more and increases their vulnerabilities to drought and other natural disasters. The agriculture in eastern Rajasthan is characterized by high risks from drought, degraded natural resources and pervasive poverty. For such rainfed areas, the government has implemented watershed programs as vehicle of development to conserve natural resources and to alleviate poverty. In 2002, Sir Dorabji Tata Trust funded a project on "Combating Land Degradation and Increasing Productivity in Madhya Pradesh and Eastern Rajasthan" with a goal to prevent further degradation of fragile lands in western Madhya Pradesh and eastern Rajasthan. The overall objective of the project is to minimize land degradation and to improve food security and livelihood opportunities for rural people through efficient crop management and conservation of natural resources. The project adopts a consortium approach for technical backup through convergence of all development activities at benchmark watershed. The comprehensive assessment of Gokulpura-Goverdhanpura watershed in Bundi, eastern Rajasthan, was conducted to determine the multi-faceted impact of this watershed program.

Based on the community demand, the first major watershed activity was initiated on improving the water availability through construction of water harvesting and groundwater recharging structures. Due to water harvesting structures and other improved watershed interventions, most of the rainwater was retained and effectively utilized within the watershed. The major impact of watershed technologies was seen in improving the surface and groundwater availability. At Gokulpura-Goverdhanpura watershed, the groundwater level rose by 4.7 m in open wells in the treated area. After the watershed interventions, the availability of groundwater during the critical periods of post-rainy season and summer has substantially increased. On an average, every year about 313200 m^3 of additional groundwater recharge is taking place in the watershed, due to various water storage structures. Increased surface and groundwater availability resulted in increased cropping intensity and diversification to more remunerative land use systems involving livestock, horticultural and vegetable production. The cost-effective water harvesting and groundwater recharging structures were identified for different topographic and soil conditions. From a larger perspective, the earthen structures were found as the most economical method of water harvesting. The unit cost of water storage in different structures was in the range of Rs 13 – 116 per m^3.

As a result of watershed interventions, the productivity of most of the crops increased substantially, resulting in higher profit margin. The crops gave higher return even after considering both fixed and variable costs. Over the period, crops like maize and chickpea gave marginal increment of returns after meeting all variable as well as fixed costs. After the watershed interventions, profit volume (PV) ratio also increased for most of the crops, indicating a higher leverage of profitability. The highest ratio of profit volume was found in case of fodder (0.72) and followed by wheat (0.70), chickpea and vegetables (0.69), mustard and maize (0.59).

The watershed activities enhanced the productivity of most of the crops and decreased the adverse impact of drought and provided more food, fodder and fuel security to the community. Due to watershed interventions, the per capita availability of cereals increased from 0.09 to 0.14 t (55.5%), pulses from 0.03 to 0.04 t (33.3%) and vegetables from 0.01 to 0.05 t (400%) per annum.

Livestock and ruminants are important component of farming system and provide alternative source of income and livelihoods for the farmers. Due to watershed activities, the livestock population and their productivity increased substantially. Increase in the number of cows (44 – 77%), buffalo (27 – 41%) and small ruminants were recorded, particularly with the marginal and small farmers. The milk production increased from 2.5 to 4.0 litre per animal per day.

Community lands occupy quite large area in Rajasthan. Most of these common lands are degraded with low productivity. A model of rehabilitating common degraded lands with silvipasture system through community participation was developed. The developed silvipasture system has a promising alternative land use system, which integrates multipurpose trees, shrubs, legumes and grasses on arable, degraded and marginal waste lands for optimizing land productivity. It helps in conservation of vegetation, soil nutrients and provides forage, fuel and timber on a sustainable basis to the community. Small and marginal farmers who are engaged in livestock raising, especially benefited from this system. The silvipasture system provides resilience by ensuring continued and sustainable multiple outputs, besides soil and water conservation and positive effects on environment. Finally, using this approach, degraded common lands were converted into useful assets for community, particularly for poor and marginal farmers.

The socio-economic status of people significantly improved mainly due to impact of watershed program. Literacy rate increased among both men and women. We believe that the increase in literacy rate is due to the positive impact of watershed interventions on socio-economic conditions of farmers in addition to government programs related to improve literacy. The per capita income of the farmers increased by 28% (Rs 6754 vs Rs 8626). The watershed program has also increased income and reduced poverty of people in the watershed. The head count ratio, which reflects the proportion of population below poverty line, fell across farmer categories. Consequently, the poverty gap index declined over the period, resulting in sharp decline in poverty severity (squared poverty gap index) for all farmer categories. Results also indicated that the small and marginal farmers got relatively more benefits from the watershed activities. The head count ratio in case of marginal and small farmers fell from 0.13 to 0.006 and 0.09 to 0.04, respectively. Also index of poverty gap in case of marginal and small farmers declined steeply compared to medium and large farmers.

The assessment of ex-ante impact revealed that the investment in watershed development program is remunerative and profitable. The pay back period of investment was estimated at 5 years and 3 months, with an internal rate of return of 19% and benefit cost ratio of 1.53.

During watershed program, the working days of all categories of farmer increased substantially. In case of agriculture, working days of small and marginal farmers increased by 43 and 20 percent, respectively. Labor migration is one of the core issues in this region. The Gokulpura-Goverdhanpura watershed program achieved good success in reducing the seasonal as well as permanent migration from rural to urban areas by providing better employment opportunities to farmers in the village itself. Sharp decline was noticed in permanent migration as compared to seasonal migration in all categories of farmers.

In summary, the Gokulpura-Goverdhanpura watershed program has made significant positive impacts on natural resources, rural livelihoods and environment. The science-led participatory watershed development through consortium and convergence approach minimized land degradation, enhanced agricultural productivity and incomes, decreased poverty of rural poor, reduced labor migration and improved the environment quality. The technical backstopping of watersheds by consortium approach enhanced the benefits of watershed program to the community by several folds.

Introduction

The rainfed areas of eastern Rajasthan, India, are characterized by low and erratic rainfall, frequent droughts, high risk and uncertainty, low level of technological changes and degraded natural resources. Due to these adverse conditions, agricultural productivity and farmers' incomes are low and unstable. The area is under-developed and is home to sizeable unemployed, poverty-stricken and undernourished population. The majority of the population in the region is dependent on agriculture as a source of livelihood. In this harsh environment, water is the most critical resource and a major constraint to improve agricultural productivity. To minimize land degradation and to sustain agricultural productivity, effective management and efficient utilization of rainwater are essential. For such region, the Government of India adopted watershed management as a strategy to address the sustainable agricultural productivity and conservation of natural resources. Over a period of time, the nature and scope of watershed program has undergone considerable changes and now includes farmers' livelihood-related issues.

ICRISAT along with NARS partner in India developed a successful "consortium model" for the development and management of watersheds (Wani et al. 2003). The consortium model is a participatory with a multi-disciplinary and multi-institutional approach to technically support process involving people who aim to create a self-supporting system for sustainability. The approach is basically built on the principle of harnessing strengths of the consortium partners for benefiting farmers. The model uses holistic systems approach and demands collective efforts of all the stakeholders to address complex problems in watersheds. This watershed approach was used at the Gokulpura-Goverdhanpura watershed in Bundi district of eastern Rajasthan. Various watershed management activities viz water harvesting and groundwater recharging structures, integrated nutrient management, improved crop varieties, horticulture, vegetable cultivations, silvipastural system, afforestation and several other agricultural and non agricultural based enterprises were implemented from 1997 with the assistance from India Canada Environment Facility (ICEF), Sir Dorabji Tata Trust, Bhartiya Agro-Industries Foundation (BAIF) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Major emphasis was on improving water availability, minimizing land degradation, increasing productivity and income and improving livelihood of farmers. A comprehensive assessment of Gokulpura-Goverdhanpura watershed was taken up to assess multi-faceted impact of watershed program with following specific objectivities:

- To assess the multi-faceted benefits of farmers participatory watershed program on groundwater availability, land degradation, crop and fodder production and productivity, livestock and ruminants production and livelihoods of farmers.
- To assess impact of watershed interventions on employment generation, migration, status of marginal farmers and women and environment.
- To identify the promising cost effective technologies that can be scaled up in the region for improving livelihood of farmers.

Description of Watershed

Physiographical properties

Location

Gokulpura-Goverdhanpura watershed is situated in Hindoli Tehsil of Bundi district, southeastern part of Rajasthan in India. The watershed is located about 40 km northwest of Bundi town and lies between latitude 25° 35' N and longitude 75° 25' E. (Fig. 1) with total area of 1355 ha.

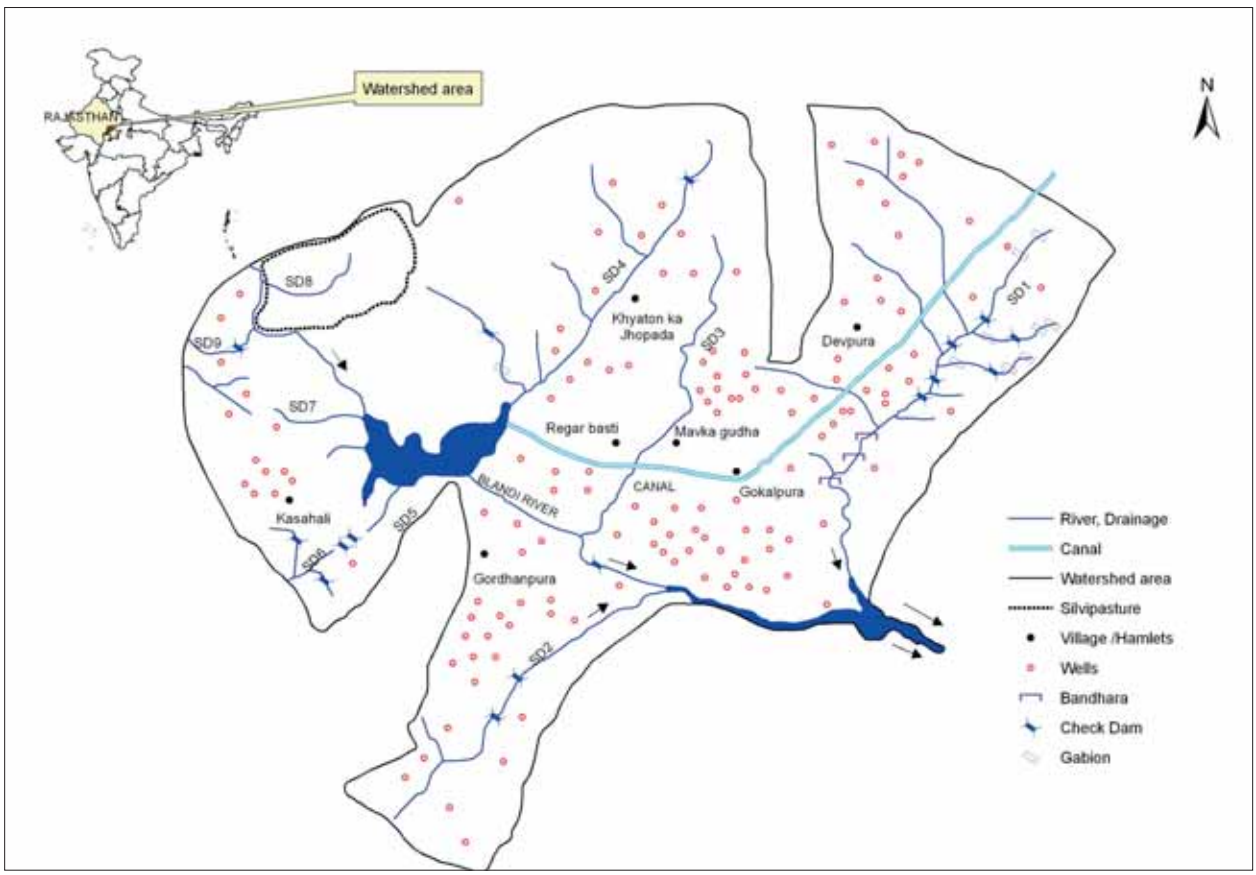

Figure 1. Physiographic map of Gokulpura-Goverdhanpura watershed.

Agroclimatic conditions

Rainfall at watershed site: The mean annual rainfall at Gokulpura-Goverdhanpura watershed is 426 mm with extreme variation in annual rainfall (Fig. 2). During 1996-2005, annual rainfall varied from lowest 240 mm in 1998 to the highest 605 mm in 2001. Most of the rainfall is received in June to September (85%). Rainy season usually begins in June and extends up to 1st week of October.

Agroclimatic characteristics of Bundi district: Bundi district experiences generally dry weather except during the southwest monsoon season. Monsoon starts by the end of June and withdraws by end of September. Due to movement of western disturbances, occasional little rains occur during winter. The highest temperatures above 39°C are recorded during April to June, with May and June experiencing almost 46°C. December and January are the coldest months with an average minimum

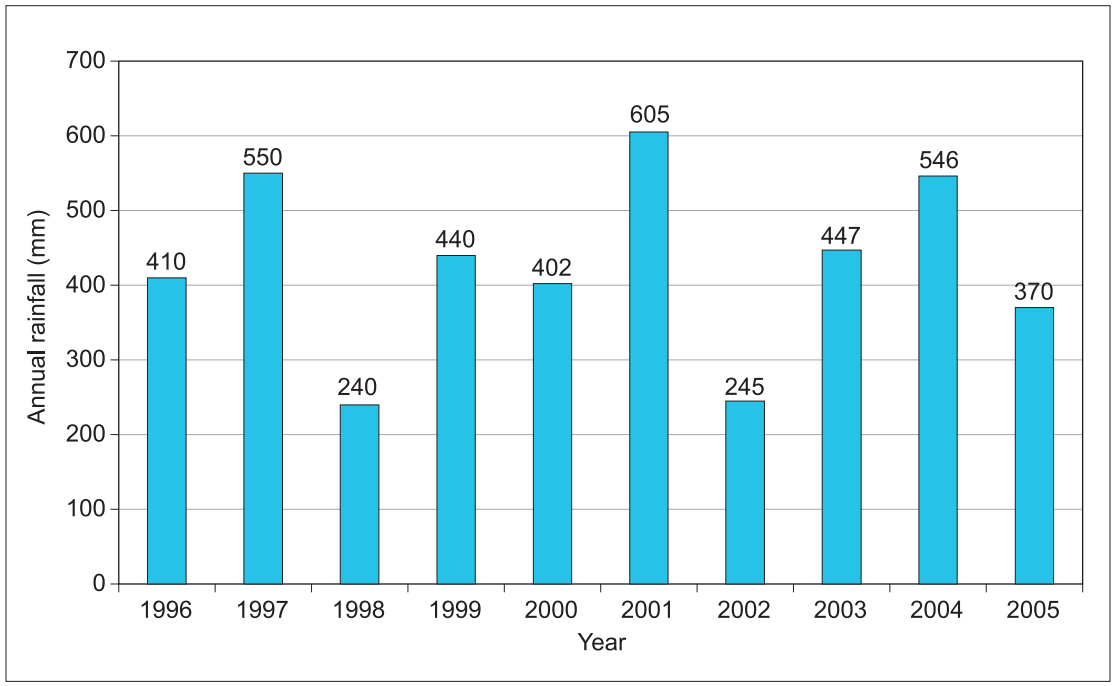

Figure 2. Variation of annual rainfall at Gokulpura-Goverdhanpura watershed, Rajasthan (1996-2005).

temperature of about 10-11°C. Winds with a speed above 10 km h^{-1} occur during May to August. June experiences strong winds of more than 15 km h^{-1}. During April-May, intense solar radiation of 20-25 MJ m^{-2} per day is received and during monsoon season due to cloudiness, radiation is about 15-20 MJ m^{-2} per day; and in winter it is around 10-15 MJ m^{-2} per day. Monthly normal climatic characters of Bundi district are presented in Table 1. Annual rainfall is about 761 mm with July and August being the wettest months. Almost 96% of annual rainfall is received in the four monsoon months. On an average, there are about 35 rainy days with rainfall of above 2.5 mm per day. About 65% of rainy days occur during July and August. Southwest monsoon sets in by third week of June and starts withdrawing by middle of September.

Table 1. Climatic characters of Bundi district (average of 1951-80).

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
Max.T (°C)	24.5	28.5	34.1	39.0	42.6	40.3	33.3	31.7	33.1	34.5	30.8	26.7	33.3
Min.T (°C)	10.6	13.1	18.5	24.4	29.7	29.5	26.4	25.4	24.7	21.0	14.8	11.3	20.8
Rainfall (mm)	5.4	3.4	3.2	2.5	7.2	67.6	281.0	273.5	106.2	7.8	2.1	0.9	760.8*
Rainy days	0.6	0.5	0.4	0.3	0.7	4.0	11.8	10.9	5.3	0.5	0.2	0.1	35.4*

*Rainfall and rainy days are total for the year.

Weekly rainfall characteristics (Fig. 3) show that above 20 mm per week rainfall is received from last week of June and by first week of October, it falls to below 10 mm per week. Normally, two peaks of rainfall of above 60 mm per week with runoff potential occur in rainy season, first in last week of July and second in third week of August.

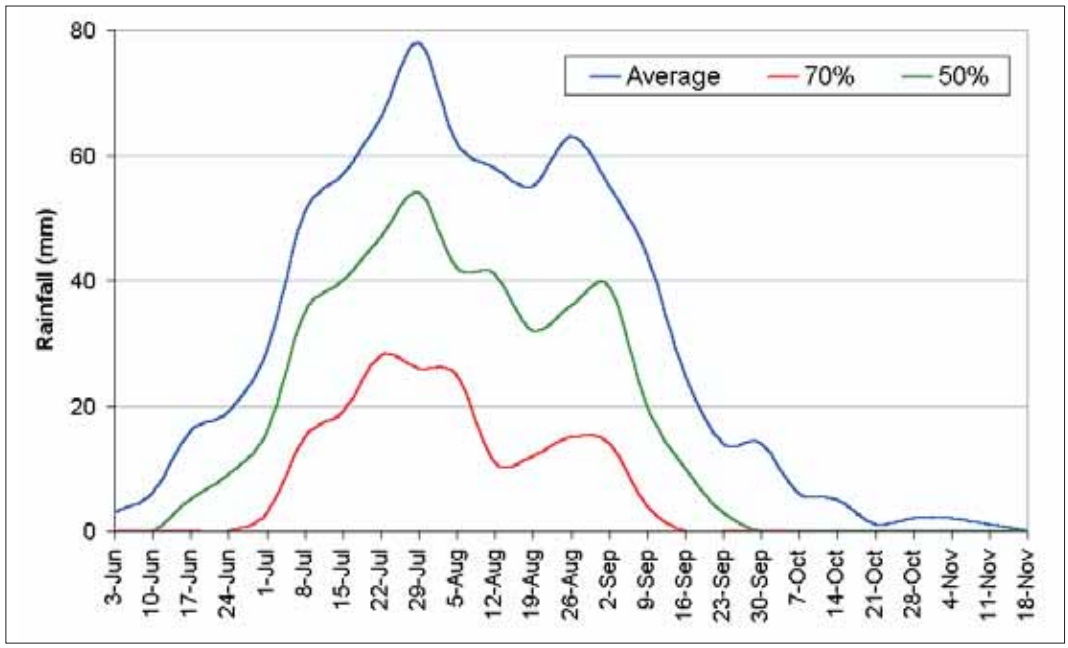

Figure 3. Weekly rainfall characteristics of Bundi.

Length of the growing period (LGP) analysis indicated that at Bundi, the rainfed growing period varies from 90 to 150 days. Figure 4 depicts normal LGP based on index of moisture adequacy (IMA) expressed as a percentage (IMA = AET/PET). Normal beginning of the growing period is 1 July and it ends by 25 October. Growing period can start as early as 10 June, but can be delayed up to 15 July. Season can end as early as 5 October, but in some years, it can extend up to 31 December.

The soils at Gokulpura – Goverdhanpura watershed are shallow to medium deep with sandy loam to silty loam in texture (Table 2). These soils generally get very hard when dry and sticky when wet. The structure of soil is very poor due to intensive cultivation and low clay and organic matter. The

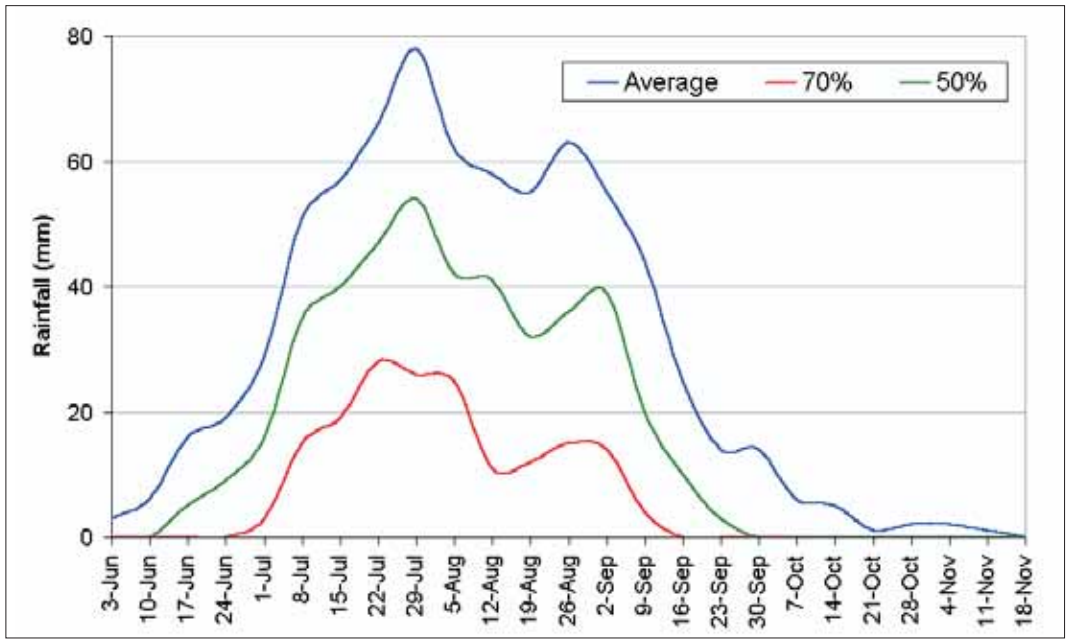

Figure 4. Length of rainfed growing period at Bundi.

Table 2. Physical and chemical properties of soil (0-15 cm) from Gokulpura-Goverdhanpura watershed, Bundi, Rajasthan (2004).

Physical properties		Chemical properties	
Texture		pH	7.56
Clay (%)	13.8	Organic C (%)	0.65
Silt (%)	30.1	Total N (mg kg^{-1} soil)	817
Sand (%)	56.1	Olsen P (mg kg^{-1} soil)	6.53
Gravel (%)*	8.9	Exch. K (mg kg^{-1} soil)	128
Moisture retention capacity		Boron (mg kg^{-1} soil)	0.49
Field capacity (%)	20.5	Sulphur (mg kg^{-1} soil)	7.35
Wilting point (%)	10.4	Zinc (mg kg^{-1} soil)	0.78
		EC (Ds m^{-1})	0.30

* Percent of total soil mass

soil moisture holding capacity is very low. The moisture retention properties of soil samples collected across the watershed at 0.33 bar ranged from 14.7 to 24.9% and at 15 bar ranged between 7 to 13.5%. The soils are deficient in sulphur, zinc, boron, organic carbon and available P. The deficiency of these nutrients in-terms of percentage of farmers' fields are about 83% in sulphur, 56% in zinc, 61% in boron and 56% in available P.

Physiography

The topography of the watershed is undulating with 1-15% slope. At a few places, there are isolated conical hillocks, aligned east-west and represent relicts of silica filled shear fractures traversing the watershed area. The hillocks slope down gently onto flat, low laying plains that represent lower reaches of the sub-basin of the Blandi river, a tributary of Chambal river. The hill slopes within the area are in the range of 10-15% slope and subjected to severe soil erosion and land degradation. The low laying areas adjoining the course of Blandi river are having a moderate slope of 1-3%.

Drainage

The watershed contains several small drains viz. SD1, SD2, SD3, SD4, SD5, SD6, SD7, SD8, and SD9 (Fig. 1), which drains runoff water in the sub-basin of Blandi river. Drainage pattern is weakly subdendric in upper reaches of watershed while it becomes rectilinear in lower portions (low-laying plains). Drainage is structurally controlled by trends of regional shear zones and by resultant foliation strike of the metamorphic rocks. However, land-use and agricultural activity in lower plains of watershed appears to have obliterated natural drainage of the area.

Hydrology

Hydrological parameters like runoff volume, peak runoff rate and soil loss were measured at Goverdhanpura watershed. Hydrological gauging station with a digital runoff recorder along with rectangular broad crested weir to measure runoff and a micro- processor based automatic sediment sampler for soil loss measurement was established at 50 ha sub watershed (Fig. 5). The annual runoff and soil loss data from 2002-2005 is shown in Table 3. In spite of very low rainfall in this area, still about 11.3% of seasonal rainfall is lost as surface runoff from the watershed. The maximum peak runoff rate recorded from the watershed was 0.152 $m^3 s^{-1} ha^{-1}$. The watershed scale hydrological data

Figure 5. Hydrological gauging station for monitoring runoff and soil loss at Goverdhanpura watershed, Bundi, Rajasthan.

Table 3. Rainfall, runoff, peak runoff rate and soil loss from Goverdhanpura watershed during 2002-2005.

Year	Rainfall (mm)	Runoff (mm)	Runoff as % of rainfall	Peak runoff rate ($m^3\ s^{-1}\ ha^{-1}$)	Soil loss ($t\ ha^{-1}$)
2002	393	12.8	3.7	0.108	0.01
2003	370	21.1	6.0	0.061	0.80
2004	546	78.3	14.3	0.152	2.97
2005	370	115.7	21.3	0.082	4.30
Mean	419.8	57.0	11.3	0.152*	2.02

* Maximum peak runoff rate

are lacking in this region. These data is very useful in planning, design and construction of various water harvesting and soil conservation structures.

Geohydrology

Although the Blandi river flows very close to the watershed, the main source of water supply to villages in the watershed area is from groundwater through open wells. Low-grade metamorphic

rocks underlie the watershed area of Gokulpura-Goverdhanpura (ACWRADAM, 1999). These hard rock terrains characterized by bedrocks, which possess low porosity and hydraulic conductivity. They constitute groundwater systems, showing uncertain well yields and a low aquifer-storage potential. The aquifer in the watershed area occurs in the phyllitic rocks and extends to a depth beyond 30 m. The phyllitic aquifer is tapped extensively through large size circular or rectangular shape open wells. The diameter of circular wells range between 1.8 m and 3.0 m while rectangular wells are generally 2.0 m x 3.0 m with a variation of 1 m on either side. The depth of these wells is highly variable, ranging from 10 m to 25 m.

Land use and crops

A major portion of land in the low-lying plains is private land where agriculture is practiced. Out of total watershed area of 1355 ha, arable area in the watershed is 701 ha. Summer cultivation is marginal where as rainy and post-rainy season cultivation with irrigation constitutes large component of agriculture land use. The major crops grown in the watershed are maize, sorghum, sesame, gaur, wheat, blackgram, mustard, chickpea and vegetables. The crop yields in the watershed area before the watershed program i.e. before 1997 were very low (eg. maize 1.11, sesame 0.6, wheat 3.0, blackgram 0.6, mustard 1.5, and chickpea 0.9 t ha^{-1}). Large tracts of hills and hill ranges belong to the Forest Department, covering 360 ha. These forests are classified as edaphic type of dry deciduous forests. Common lands in the watershed occupy generally an intermediate position between forest lands on upslope and private lands on down slope. Common lands (CPR) are perhaps the most neglected and mismanaged portion of the landscape because of poor mechanisms of management. Deterioration of common land is due to poor maintenance and unrestricted access to livestock for grazing, resulting in severe soil erosion and land degradation.

Demography

The Gokulpura-Goverdhanpura villages as per the base line survey in 1997 had a population of 1882, comprising of 334 families with a sex ratio of 55% men to 45% women. Average family size was 5.7 persons. The 334 households in the watershed comprised of 152 marginal, 125 small, 36 medium and 21 large landholding families; there were no landless families. The main community in the watershed village is *Meena* tribe (93%), *Regars* (6%), potters and others (1%). Agriculture followed by cattle rearing is the main occupation of the people. In general, women do more work (61%) than men (39%). Girls play an important role with 64% of them below 18 years of age help in agriculture and livestock activities as compared to only 36% of boys. They also help in fetching fodder, fuel, water and grazing animals, etc. The study area had very poor infrastructure facilities viz. no proper roads linking hamlets, no public transport, no schools and hospitals, (Ramdayal Verma et al., 1997 & BAIF-ICEF Report, 2002).

Major constraints

The Gokulpura-Goverdhanpura watershed is situated in the very harsh drought prone areas of eastern Rajasthan. The rainfall is characterized as low, erratic and undependable resulting in frequent droughts and often-total crop failures. Generally, severe water scarcity existed both for agriculture and domestic purposes before the watershed program. Poor soils with very low water holding capacity and inherent low fertility resulted in low crop yields. Migration of people in search of employment to nearby towns and cities for livelihood was common feature.

Data Sources and Collection Methodology

This study is based on primary as well as secondary data collected from the Gokulpura-Goverdhanpura watershed. A flow chart describing the process of data collection, tabulation and analysis is shown in Figure 6. During 2004-05, primary data was collected through focused group discussions (FGDs) as well as through stratified detailed household survey. For collecting primary data, sets of questionnaire were prepared by scientists of ICRISAT and BAIF staff. The multidisplinary team visited watershed villages and conducted meetings with farmers and had elaborate discussions followed by field visits to collect primary information on general agriculture, crops and productivity, surface and groundwater and socio-economic data (Fig. 7). The primary data was collected through investigation of farmers with pre-tested questionnaires and about 20 percent households/farmers were selected by stratified

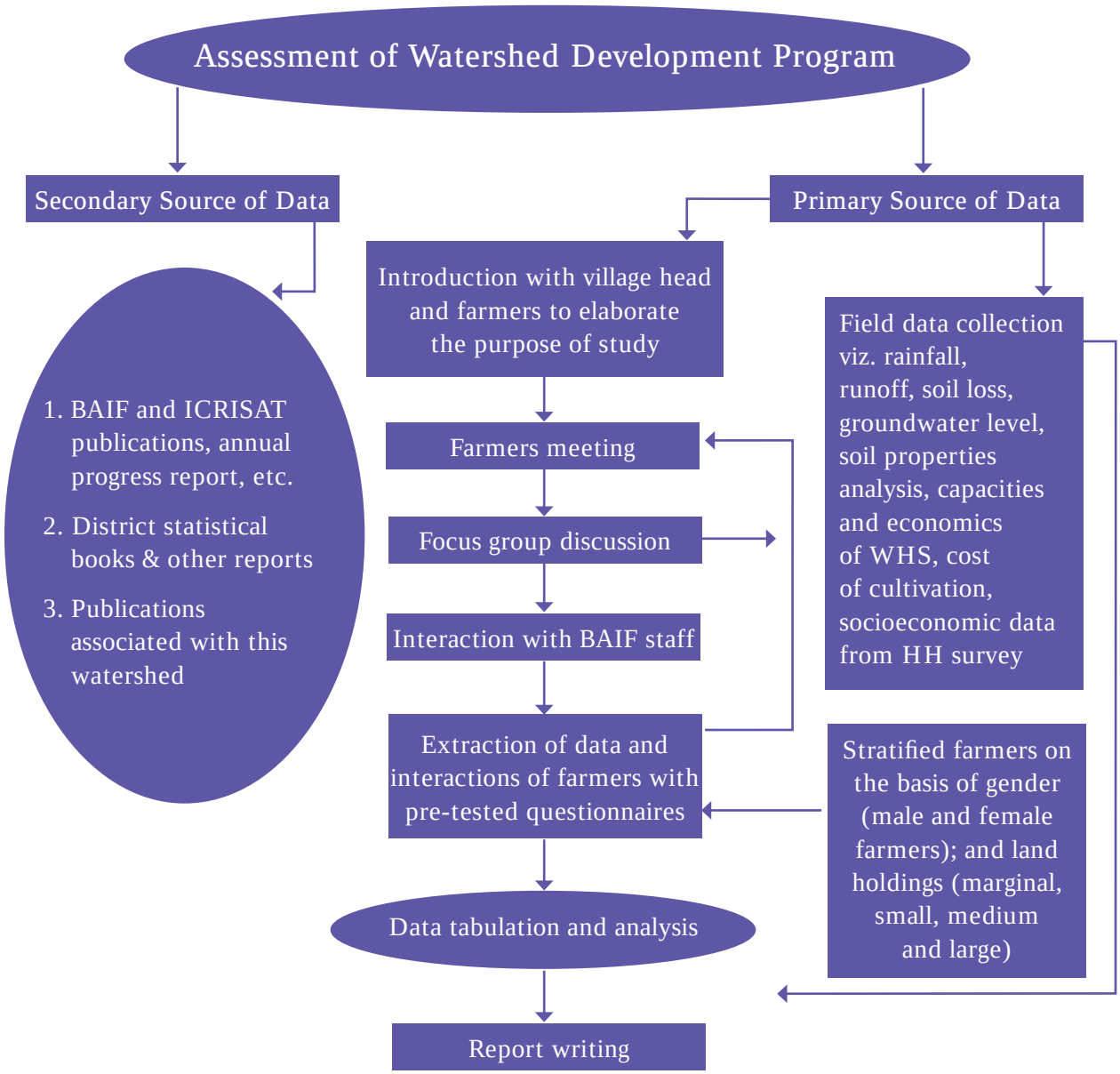

Figure 6. Process of data collection from the Gokulpura-Goverdhanpura watershed.

Figure 7. Data collection through meeting and interviews with farmers.

random sampling method. The data were collected personally by administering the interview scheduled to the respondents. However, before conducting survey the objectives of the study were explained to farmers. The secondary data were collected from various sources like reports prepared by ICRISAT, BAIF and other agencies. The storage capacity of water harvesting structures was quantified through measurements and other financial details were collected from project implementing agency (PIA). Wherever necessary the topographic surveys were done to supplement the existing data. To ascertain the extent of groundwater recharging due to water harvesting and soil conservation structures as well as natural recharging the groundwater levels in the open wells and the water balance were used.

All the primary and secondary data collected for this study were first thoroughly checked for error or discrepancy. The primary data were analyzed using statistical techniques such as percentage, regression, correlation and coefficient variance analysis. To measure the crop diversification, Hirschman-Herfindahl diversification index was used. The post project impact assessment of investment on watershed activities in the villages was carried out to examine the efficiency of economic returns.

Results and Discussion

Impact of watershed interventions

The basic goal of watershed management is to reduce rural poverty and improve livelihood security, while protecting the environment and enhancing sustainability of natural resources. The Gokulpura-Goverdhanpura watershed was taken for assessment of on-site impact of various watershed interventions such as water harvesting and groundwater recharging structures (check dam, percolation tank, farm pond, gully plug and earthen bund) on water availability, productivity enhancement initiatives on agricultural productivity, resource conservation measures on reducing land degradation (runoff, soil loss and groundwater), natural resource quality enhancement on rehabilitation of CPRs (biodiversity conservation, fuel and fodder availability), afforestation, waste land development and livestock improvement, which were implemented to support sustainable development. Impact of these watershed interventions are discussed in the following sections.

Bio-physical indicators

Process of watershed development

The development work at Gokulpura-Goverdhanpura watershed started in 1997. During 1997-2001, the main focus of the watershed program was on controlling soil erosion and increasing water availability mainly through water harvesting. In 2002, Tata-BAIF-ICRISAT initiated project "Combating land degradation and increasing productivity in rainfed area of eastern Rajasthan". The main objectives of this project were to minimize land degradation and to improve the food security and livelihood opportunities for rural people in rainfed areas of eastern Rajasthan through integrated watershed approach. The innovative consortium approach for technical backstopping of the watershed program was adapted. The consortium partners in the project are: Indian Council of Agricultural Research Institutions like Central Arid Zone Research Institute (CAZRI), Jodhpur, and state agriculture university like Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur; state government departments like Department of Agriculture, Watershed Development and Soil Conservation, Animal Husbandry and Health, Krishi Vignan Kendra (KVK) and *Zilla Parishad*, Bundi. To meet the objectives of the project, following activities were taken.

- Baseline data collection to identify the major constraints and opportunities
- Integrated soil-water-nutrient management practices appropriate to farmers resources and ecosystem
- Cost effective water harvesting and groundwater recharging structures (check dams, percolation tanks, etc.)
- Efficient irrigation systems (sprinklers and drip irrigation systems)
- Drainage line treatment (gully plugs, loose boulder structures and gabions)
- Improved agronomic practices (high yielding varieties, intercropping and introduction of new crops, nutrient management options, vermicompost, biofertilizers, improved implement, etc.)
- Crop diversification with high value horticulture/ vegetables
- Silvipasture development (rehabilitation of degraded common lands through integrated approach for improving profitability and sustainability)
- Cattle improvement programs (artificial insemination and animal health camp)
- Afforestation
- Income-generating micro-enterprises for improving livelihoods of women and landless farmers
- Capacity building and institutional building for sustaining the impact of watershed program

Emphasis was given to strengthen various watershed activities, which gave tangible economic benefits to farmers. The holistic system approach for watershed management was adopted to improve the livelihood of the farmers. Empowerment of communities, individuals and the strengthening of village institutions were given very high priority. For women and landless farmers, various income-generating micro-enterprise activities were taken up. Flow of technical and scientific knowledge to farmers was facilitated through the consortium of institutes.

Water harvesting and groundwater recharging structures

The various activities carried out for soil and water conservation and rainwater harvesting at Gokulpura-Goverdhanpura watershed are given in Table 4. At the watershed, the construction of water harvesting structures (WHS) was initiated in 1997. The farmers were involved in planning and implementation

Table 4. Soil and water conservation and water harvesting measures at Gokulpura-Goverdhanpura watershed, Bundi, Rajasthan.

Soil conservation and water harvesting measures	No. of structures
Gully plugging	1500
Loose boulder structure	34
Gabion structure	13
Sunken pond	24
Check dam	20
Field bunds	16224 m length

of these structures. Twenty masonry check dams have been constructed (Fig. 8) benefiting about 248 wells and which are irrigating about 343 ha (Table 5). Total storage capacity of all the check dams is 52590 m^3 with an average unit cost of water storage by WHS is about Rs 55 m^{-3}. The storage capacities of check dams range from 40 m^3 to 15360 m^3 and unit construction cost of water storage varied from Rs 7-285 m^{-3} (Annexure 1).

Table 5. Details of water harvesting structures and the area benefited.

Village	Number of WHS	Water storage capacity range (m^3)	Total water storage capacity (m^3)	Unit cost of recharging water range (Rs m^{-3})	Number of wells benefited	Total area irrigated by wells (ha)
Gokulpura	11	152-4610	20270	8-55	117	176
Goverdhanpura	9	40-15360	32320	10-45	131	167
Total	20		52590		248	343

Figure 8. Various soil and water conservation structures at Gokulpura-Goverdhanpura watershed.

Box 1. Prosperity due to increased water availability

The water harvesting structures constructed in the watershed helped in sustaining groundwater levels even during 2002, a drought year. During 2002, most of the neighboring villages were declared as drought affected area and drinking water was supplied through water tankers by district authorities, while the Goverdhanpura, Gokulpura and Thana villages (in the watershed area) were not declared as drought-affected villages as these villages had sufficient water in wells. This is attributed to the watershed development works done in the villages.

Farmer Mathuralal says that his wheat production has doubled in the recent years with rising groundwater levels, mainly due to watershed works. Despite drought in 2002, Goverdhanpura village did not need even a single water tanker for drinking water. Due to crop intensification, work opportunities for landless have increased. Labor charges in the village too have risen.

Considering the percolation/seepage through water harvesting structures, about 313200 m^3 runoff water is harvested with an unit cost of water recharging in range of Rs 8-55 m^{-3}, while the runoff potential estimated from the watershed is 769500 m^3. It has been observed that during high rainfall years there are substantial runoff outflow from the structures.

Cost of rainwater harvesting

The cost analysis of different size of WHS showed that for small size WHS, average cost of construction was 116 Rs m^{-3}, for medium structures, it was 68 Rs m^{-3}, while large size structures, it was 13 Rs m^{-3} of storage capacities (Table 6). Maximum number of wells per unit WHS were benefited (47 wells per WHS) in case of large size WHS; followed by medium and small size. This indicates that for this region large size structures particularly earthen ones are more cost effective in terms of cost per m^3 of groundwater recharging.

Table 6. Cost of construction of different size of WHS at Gokulpura-Goverdhanpura watershed, Bundi, Rajasthan.

WHS category based on storage capacity	Average construction cost per unit storage capacity (Rs m^{-3})	Construction cost per unit storage capacity range (Rs m^{-3})	Number of WHS	Number of wells benefited per WHS
Small (< 1000 m^3)	116	31-285	12	7.75
Medium (> 1000-5000 m^3)	68	44-90	6	12.00
Large (> 5000 m^3)	13	7-19	2	47.00

Groundwater recharge and its availability

In 1997, there were 227 open wells with low water yield, while in 2004 there were 248 open wells. In spite of 8% increase in the number of wells over the period of time; still there is a significant improvement both in terms of duration of water availability and the water yield from the wells. Before watershed interventions, only 88 wells used to have water for 8 to 12 months in a year where as after the watershed interventions the well numbers increased to 187 (Fig. 9). Before the watershed interventions, 52 wells out of 227 were functional only for 1-4 months mainly during rainy season, where as after the watershed interventions particularly due to the construction of WHS, majority of the seasonally functional wells have become functional through out the year. Similarly, the mean depth of water column in the wells before the watershed interventions was 4.5 m, compared to 9.5 m after interventions (Fig. 10). There is a big increase (more than 100%) in mean depth of water column in wells after the watershed interventions. Particularly during post-rainy season, the depth of water column in wells increased substantially.

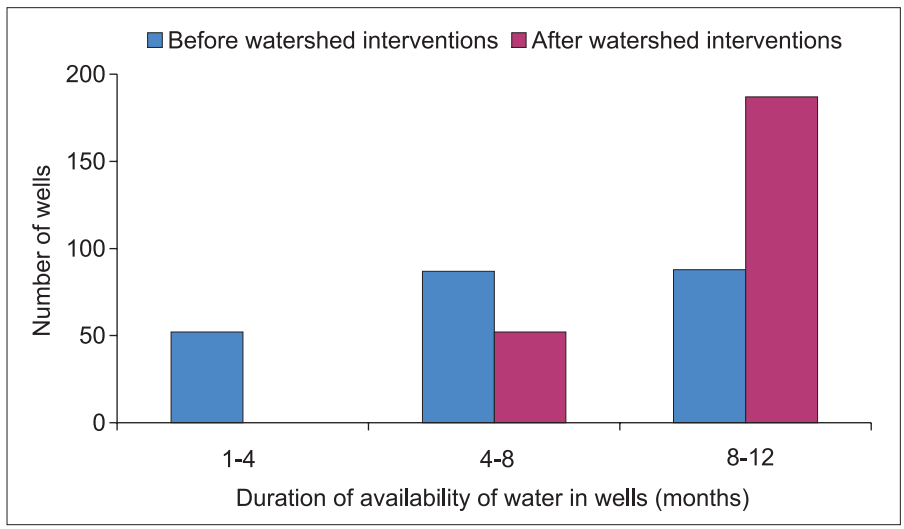

Figure 9. Duration of water availability in open wells during pre and post watershed interventions periods at Gokulpura-Goverdhanpura watershed.

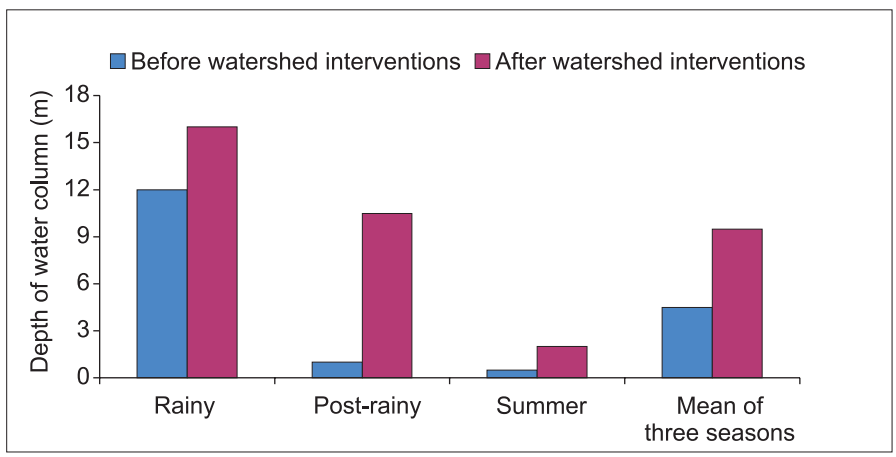

Figure 10. Depth of water column in open wells during different cropping seasons at Gokulpura-Goverdhanpura watershed.

There is a three-fold increase in the mean pumping duration, substantial improvement in water recovery or recharge period and area irrigated by wells during post watershed intervention periods (Table 7).

Table 7. Effect of watershed interventions on the performance of open wells.

Season	Pumping duration (h)		Recharge / recovery period in well (h)		Area irrigated by each well (ha)	
	BWI*	AWI*	BWI	AWI	BWI	AWI
Rainy	4	11	13.5	10	1	2.5
Post-rainy	1.5	6.5	21	16	0.5	1.5
Summer	0	1	30	21	0	0.2
Mean	1.83	6.2	21.5	15.7	0.5	1.4

*BWI is before watershed interventions and AWI is after watershed interventions

Before watershed interventions, mostly the traditional method of lifting irrigation water by *chadas* (traditional leather bucket system of water lifting using a pair of bullocks) was used in the village (Fig. 11). The increased availability of water in wells encouraged farmers to invest more to acquire improved irrigation facilities. Post-project scenario recorded about 76% increase in diesel pump sets and 38% increase in electric pump sets for lifting irrigation water along with increase in pipeline to save water from seepage loss. (Table 8).

Figure 11. A traditional water lifting device (Chadas) used for irrigation before watershed program, Gokulpura-Goverdhanpura watershed.

In the watershed, all wells were monitored fortnightly to assess the impact of groundwater recharging structures and other watershed interventions. The WHS have significant effect in improving water availability in wells. The water level in wells near WHS was consistently higher compared to the water level of those wells away from WHS (Fig. 12). This trend in groundwater level was observed during all four years (2002-2005). Even during a low rainfall year (2002), groundwater levels in wells near the WHS were higher than those wells away from the WHS. The Figure 13 clearly shows the

Table 8. Effect of watershed program on irrigation equipment at the Gokulpura-Goverdhanpura watershed.

Irrigation equipment*	Before watershed interventions		After watershed interventions	
	Number of equipments	Number of families	Number of equipments	Number of families
Chadas (traditional method)	164	221	110	151
Diesel pumps	79	145	139	202
Electric pumps	8	18	11	18
Pipeline length (m)	1685	50	5982	82

(Source: Rajeev Ranjan, 2002)

** Some of the equipments jointly owned by the families*

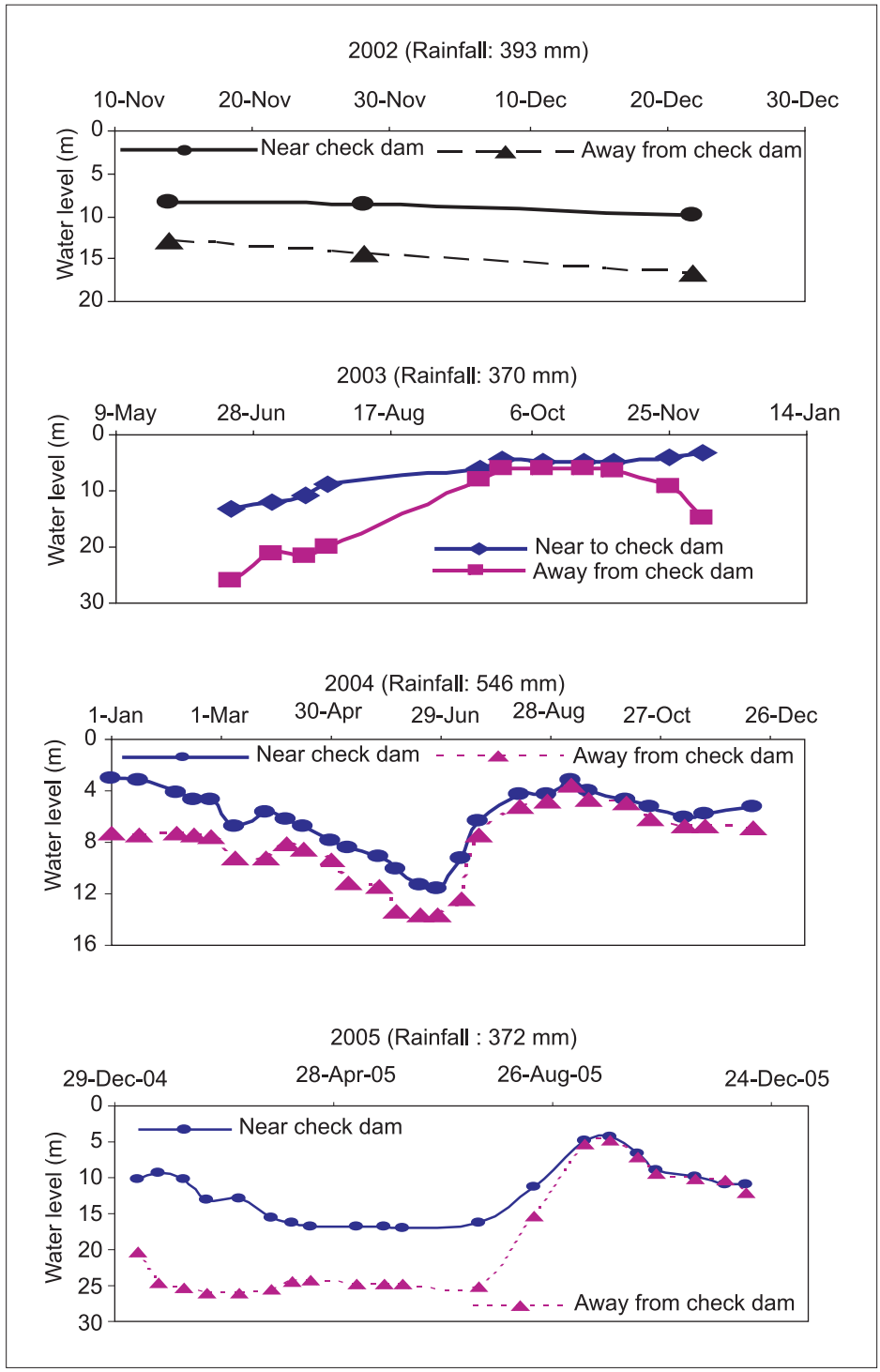

Figure 12. Effect of groundwater recharging structures on groundwater level, Gokulpura-Goverdhanpura watershed, 2002-05

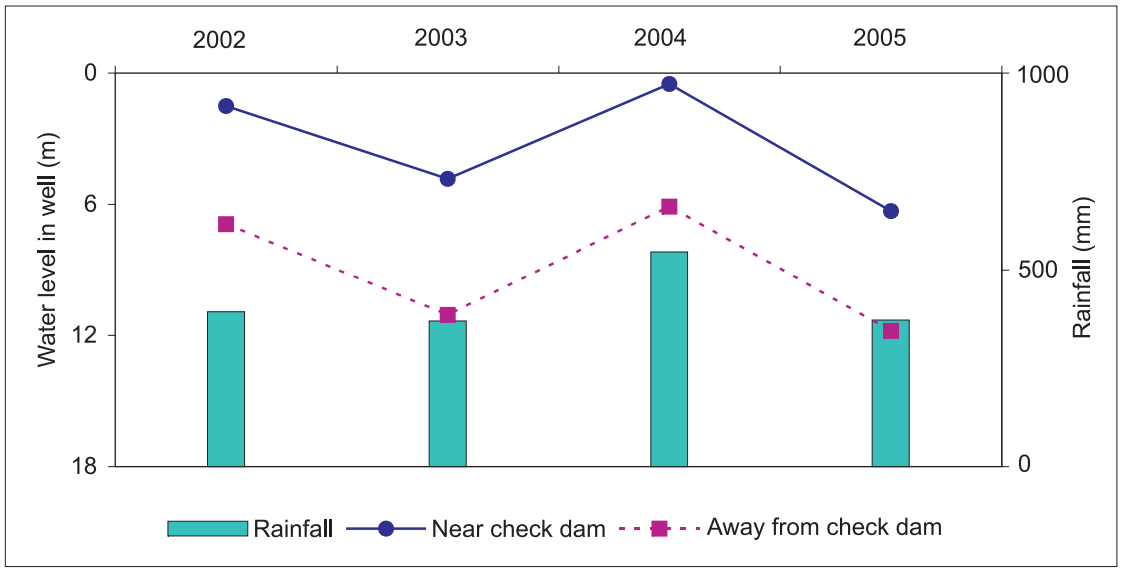

Figure 13. Effects of groundwater recharging structures on mean depth of water column in wells, Gokulpura-Goverdhanpura watershed, 2002-05.

positive effect of WHS on groundwater levels during low, medium and normal rainfall years. During four years from 2002-2005, there was a significant increase in the mean depth of water column in the wells near WHS. In addition to WHS, other measures like field bunding, in-situ moisture conservation and land management practices and other improved practices must have contributed to the groundwater recharging.

It is quite evident from Table 9 that the area under irrigation has increased by 66% due to the increased water availability in the wells after the implementation of watershed program. Area under rainfed agriculture came down due to increased availability of water in the watershed. This resulted in marked reduction in crop failures in the watershed area and gave greater confidence to farmers to use improved agricultural inputs. In addition, about 35 ha land was brought under horticulture with irrigation facility. Data in the subsequent sections will show that there is a substantial increase in crop productivity and greater diversification, mainly due to increased water availability in the watershed area.

Table 9. The changes in land use pattern at Gokulpura-Goverdhanpura watershed, Bundi during 1997-2004.

	Area (ha)	
Land use system	Before watershed interventions (1997)	After watershed interventions (2004)
Irrigated	207 (15)*	343 (25)
Rainfed	327 (24)	209 (15)
Pasture	167 (12)	114 (8)
Horticulture	Nil	35 (3)
Forest	360 (27)	360 (27)
Dwelling and river	294 (22)	294 (22)
Total	1355	1355

* Values in parentheses are the percent of total area

Growth rate of area, productivity and production of important crops

Due to WHS, increased water availability and its proper utilization and other improved interventions during watershed program have increased growth rate of productivity resulting similar increase in area and production of important crops. The trend in cropped area, productivity and production of important crops during the period of watershed development programs (1996-97 to 2004-05) in the village are shown in Table 10. To examine the relevance of growth rate of variables the exponential trend, which is approximately best uniform rate of growth is used.

Table 10. Compound growth rate of area, productivity and production over the period (1996-97 to 2004-05) at Gokulpura-Goverdhanpura watershed.

	Compound growth rate (CGR)		
Crops	Area	Productivity	Production
Maize	1.85	14.18	12.75
Wheat	0.93	8.11	9.12
Mustard	0.25	6.05	6.32
Chickpea	3.13	6.59	9.63
Vegetables	9.05	7.99	25.59

The estimated compound growth rate of area of all important crops increased substantially. The highest growth rate was observed in vegetables followed by chickpea and maize. The compound growth rate of productivity (yield) is higher than growth rate in area. The production of these crops increased because of increase in productivity and area during project period. The diversification towards vegetables is mainly due to increased irrigation water availability and expected higher income.

Crops and cropping systems

Due to various watershed interventions, the crops and cropping patterns in the watershed have changed in all three cropping seasons (Table 11). After the watershed interventions there is a significant increase in the high value crops. This is particularly true during the summer season in which the areas under vegetable and horticulture have increased by several folds after the watershed interventions. Before the watershed program, most of the small and marginal farmers were growing low-value crops, which have changed significantly after the watershed program. The area under different crops during the three seasons viz. rainy, post-rainy and summer has been increased substantially (particularly during summer season). After the introduction of watershed program, new crops like pigeonpea, groundnut, greengram, pearl millet and soybean in rainy season while green pea and vegetables in post-rainy season were taken up by the farmers. The area under maize increased by 15.8% while vegetables by 100% during rainy season. In post-rainy season, the area under wheat and chickpea increased by 7.7% and 28%, respectively. The area under horticulture, vegetables and fodder has increased by several folds during the post-rainy and summer seasons.

Crop diversification and yield gap

In a harsh climate of eastern Rajasthan, the crop diversification is highly recommended. Crop diversification not only provides a wider choice in production of various crops but also minimizes risk and increases profitability besides harnessing the maximum potential of land, water, human

Table 11. Crops and their cultivated areas before and after the watershed interventions, 1997-2004.

Crops	Area (ha)	
	Before watershed interventions (1997)	After watershed interventions (2004)
Rainy season		
Maize	133	154
Blackgram	16	19
Sesame	13	16
Vegetables	3	6
Other crops	76	59
New Crops*	Nil	11
Fodder	Nil	5
Post-rainy season		
Wheat	104	112
Mustard	100	102
Chickpea	25	32
Lentil	22	9
Rapeseed	2	2
Fodder	7	14
Vegetables	Nil	3
Green pea	Nil	26
Summer season		
Vegetables	1	4
Fodder	6	9
Horticulture	Nil	35

* Pigeonpea, groundnut, greengram, pearl millet and soybean

and climate. The various watershed interventions changed the crops and cropping pattern in the watershed (Fig. 14). Most of the small and medium farmers are moving towards cash crops and short duration remunerative crops such as pigeonpea, groundnut, greengram, soybean and fodder sorghum. Various factors like increased availability of irrigation water, institutional and infrastructural development, adoption of SWNM technology, availability of improved varieties, availability of micro-financing and improved channel of rural marketing etc., are responsible for changes in crops and cropping pattern. Improved skills and awareness also aided to diversification of high value crops like vegetables, etc. During watershed program about 35 ha was planted with various horticulture plants viz. mango, guava, lemeon, sapota, orange, jackfruit, amla, karonda, ber, *kalipatti* and custard apple. Total 10231 plants were planted by 225 farmers using water efficient irrigation systems (Fig. 15). The crop diversification over period of time was measured using Simpson Index ($1-\Sigma P_i^2$), where P_i is the proportion of area under i^{th} crop. The higher diversity index indicates greater crop diversity in production pattern.

In the watershed, mustard was the most diversified crop followed by wheat (Fig. 16). The diversification index value of wheat has increased from 0.890 to 0.912 whereas for mustard it has gone up 0.854 to 0.923. The diversification index value of maize declined from 0.964 to 0.921. Other crops in the watershed show mixed influence of diversification and concentration.

To measure the extent of yield gap, the average productivity of important crops in the district were compared to the average productivity of same crops in the watershed (Fig.17). For most of the crops,

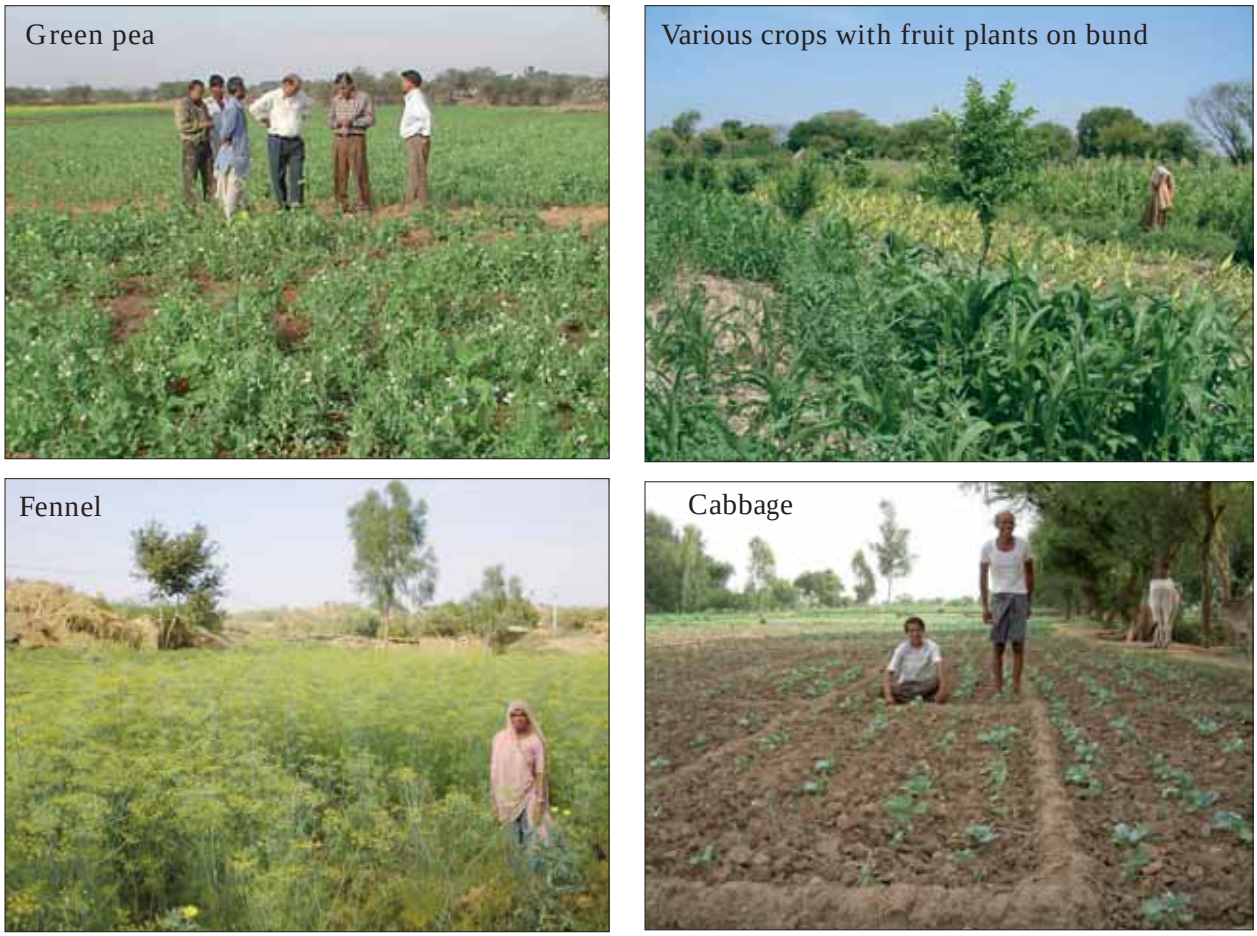

Figure 14. Crop diversification at Gokulpura-Goverdhanpura watershed.

Figure 15. Horticultural plant with earthen pot irrigation.

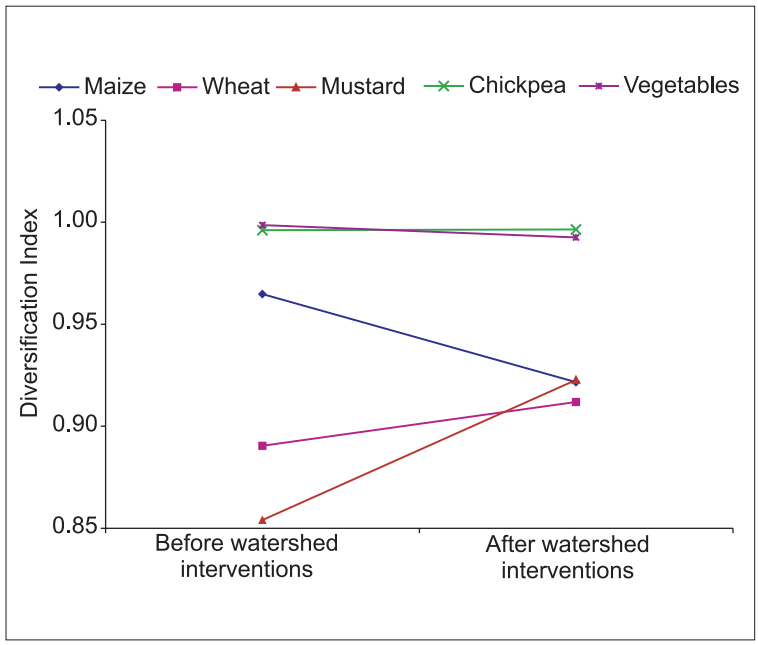

Figure 16. Changes in diversification index of major crops due to watershed interventions.

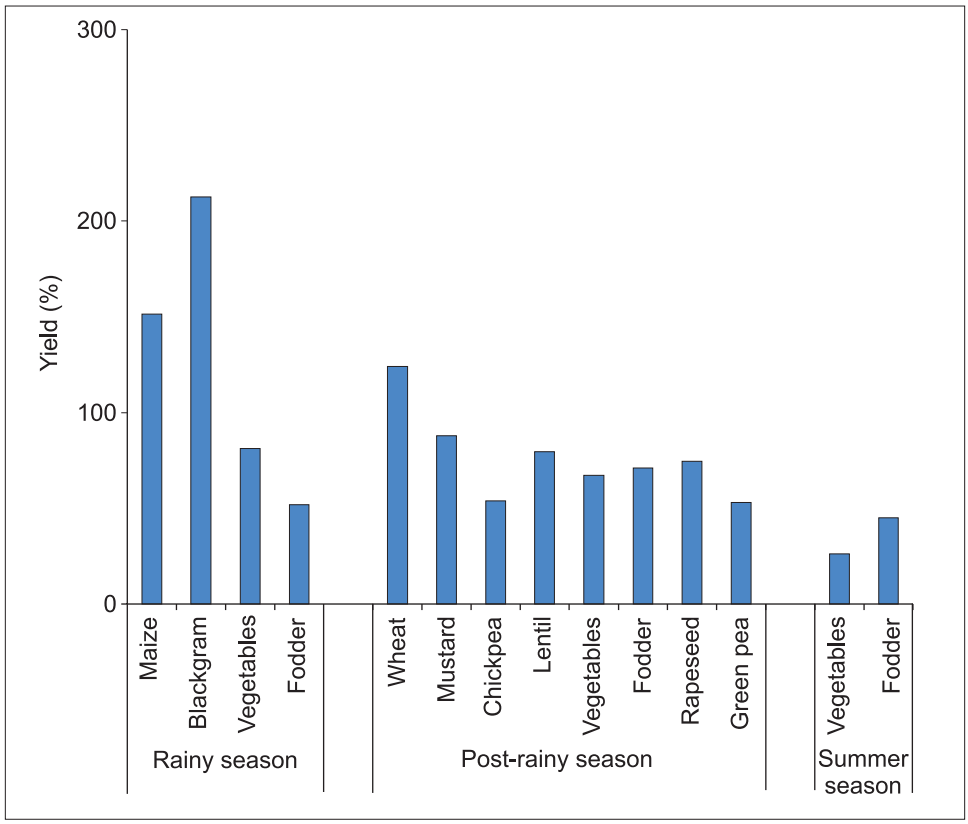

Figure 17. Crop yield gaps between district average and watershed villages.

high yield gaps were observed in different cropping seasons. For the rainy season crops, the yield gap varied from 52 to 213 percent. During the rainy season the highest yield gap was found in case of blackgram (213%) followed by maize (151%) and vegetables (81%). In the post-rainy season, wheat had the highest (124%) yield gap, followed by mustard (88%), lentil (80%) and rapeseeds (75%). The crop yield gap during summer season was relatively less. In the summer, mostly vegetables and fodder were grown under irrigation.

These data clearly show that the watershed program is successful in increasing the crop yields and the yield levels for most of the crops are much higher compared to district average yields. The high crop yield gaps may be attributed to increased groundwater availability and improved crop management practices like integrated nutrient and water management, integrated pest management and improved crop varieties adopted by the farmers in the watershed.

Environmental and ecological indicators

Tank-bed cultivation

Innovative water efficient land use system of using tank-bed for the cultivation of crops after receding water in the structures was adopted by the community at the Gokulpura-Goverdhanpura watershed. One such system for a tank “Prajapat ka Bhandha” at Goverdhanpura is described here (Fig. 18). The tank was constructed in 2003 with a storage capacity of 14600 m^3 providing irrigation to 57.5 ha mainly through wells in the down stream and benefiting 71 farmers. The submerged area (area under water) is 6.5 ha, which belongs to 15 farmers. These farmers have also their land in the downstream

Crops in the tank bed

Excellent crops in downstream of tank

Figure 18. Crops cultivation in upstream and downstream of Prajapat ka Bhandha tank at Goverdhanpura village.

of the tank. These 15 farmers have formed a user group. The user group farmers use the stored water as surface irrigation for about 5 ha in the command area. The surface irrigation charges for other than these 15 user group farmers is Rs 100 per 0.16 ha (1 Bigah) per irrigation. In addition to surface irrigation facility, the tank is benefiting about 18 wells through groundwater recharge. The revenue collected is used for the repair and maintenance of the tank and its irrigation system. All the farmers involved in this activity belong to one community called 'potters' (pottery makers). The members of the user group have contributed 30% of cost of tank construction in the form of cash, labor and materials. The fields cultivated in the tank bed have significantly increased yield due to the better soil moisture and improved soil fertility attributed mainly to the eroded sediment deposition. Before the construction of the tank, the area in tank bed was severely eroded due to high runoff flow during rainy season and more than 50% of these lands were left fallow. In most years, the rainy season crops were damaged due to heavy runoff flow through this area. After the tank construction, entire 6.5 ha area is cultivated. Crop yields of some of the major crops grown in the area are shown in Table 12. During rainy season only a very small area is generally available for cultivation due to submergence of stored water, where as in post-rainy and summer seasons complete area is cultivated with annual crops and vegetables.

The area under tank bed cultivation has its own potential to provide higher yields with lesser cost of cultivation, as every year sediment deposited in the tank bed is rich in nutrients. After the tank construction, the crops grown in the tank bed has resulted in increased yield ranging from 22 to 170% for different crops than the crop yields obtained before the tank construction in the same land. Due to this, the net income and benefit-cost ratio increased substantially (Table 12).

Table 12. Crop yields, net income and benefit-cost ratio of major crops grown in tank bed area, Gokulpura-Goverdhanpura watershed.

	Before tank construction			After tank construction		
Crops	Yield (t ha^{-1})	Net income (Rs ha^{-1})	B:C	Yield (t ha^{-1})	Net income (Rs ha^{-1})	B:C
Maize	1.0	-600	-0.07	2.7 (170)*	10750	1.13
Sesame	0.6	-2400	-0.22	0.9 (50)	-200	-0.02
Wheat	2.7	7100	0.49	3.8 (41)	16650	1.21
Chickpea	0.9	1350	0.10	1.1 (22)	7850	0.76

*Figures in parentheses are % increase over before tank construction

Some of the benefits perceived by the farmers in this land use system are:

- Only one irrigation is given to wheat in tank bed area compared to 4-6 irrigations in other areas.
- The fertilizer applied to the crops grown in tank bed is about half compared to other area.
- Before construction of tank, about 50 percent of the area (tank bed) was not cultivated due to heavy runoff flow and now after tank construction the entire area is cultivated.
- Cropping intensity and productivity has increased.
- Earlier, during summer no crops were grown, but now, during summer vegetables are grown in tank bed area. This provides good income to farmers.
- The constructed tank has substantially increased the groundwater recharge for the downstream wells.

Common property resource development and biodiversity

Over-grazing, over-exploitation and other anthropogenic factors resulted severe problem of degradation of community lands. Most of the grazing takes place in forestland and community pasture land. During past few decades stray grazing, indiscriminate wood cutting and illegal mining resulted in the severe degradation of community land, resulting in severe scarcity of fodder.

To combat this hazard, watershed development program implemented a management system for degraded community land and biodiversity development through silvipasture, which was initiated in 1998 at Gokulpura village on 45 ha of degraded community land (Fig. 19).

Degraded common land | Treated land | After the development

Figure 19. Silvipasture development on degraded community land at Gokulpura village.

This land had undulating topography and severely degraded soil with very shallow depth, supporting no more than a scattering of short, stunted bushes. A village level *Charagah Samiti* was formed involving local people to maintain the developed silvipasture sustainable. This *samiti* was made responsible to maintain post-production and monitor benefit sharing from the silvipasture system. Activities taken up for the development of the silvipasture were: Stone wall fencing to protect from stray animals (2565 m); stone wall terrace on steep slopes; trench cum bund (200 no.); gully plugs (112 no.); percolation pits (290 no.); daman grass and *stylo hemata* seeds were broadcasted; trees of 9 species (*subabul, desi babul, bamboo, palas, neem, grafted ber, khejari, sheesham,* and *kher*); and local plants, bushes and shrubs were planted. Plant species planted on the community silvipasture land and their major characteristics with survival rate are described in Table 13.

Besides these, this *charagarh* (silvipasture) project had several local plants, bushes and shrubs (Table 14). All the interventions in this project were carried out involving local people, which provided

Table 13. Plant species and their characteristics planted in the silvipasture system.

Name of species	No. of plants	Survival plant (%)	Major characteristics
Subabul (*Leucaena leucocephala*)	9050	8353 (92.3)	Leaves and pods; good protein, moderate to good energy sources
Desi Babul (*Acacia nilotica*)	5125	3742 (73.0)	Pod: good protein source Leaves moderate source of protein and energy
Bamboo (*Dendrocalamus strictus*)	700	521 (74.4)	Leaves: moderate source of protein and energy
Palas (*Buteamonosperma*)	2500	2257 (90.3)	Good energy source
Neem (*Azadirachta indica*)	1000	1000 (100)	Leaves: good energy source
Grafted ber (*Zizyphus mauritiana*)	1000	633 (63.3)	Leaves: good energy source, moderate protein source
Khejari (*Prosopis cineraria*)	2860	2060 (72.0)	Pod: good protein and energy source Leaves: poor energy source
Sheesham (*Dalbergia sissoo*)	28	12 (42.9)	Leaves: poor protein and energy source
Kher (*Cappairs deciduas*)	35	29 (82.9)	Young leaves used as fodder for cattle and goat & fruits for human consumption
Total	22298	18607 (83.4)	

Source: Dixit et al. 2005

Box 2. Community role in biodiversity conservation and management

The only source of open grazing, the 95 ha common grazing land at Gokulpura- Goverdhanpura watershed was degraded and unable to supply good quality of fodder to support increasing population of livestock. The fodder and grasses grown were neither palatable nor sufficient to the cattle. The project has initially recognized these problems and got involved with community to find out appropriate solution to them. Most of the people reciprocated positively and agreed to part their half of the common grazing area for rehabilitation and other remaining half land was still accessible to common grazing. The stakeholder community consisting of grazers, herd and farmers through Panchyat resolve to erect stone wall around the 45 ha grazing land and did not allow any cattle to graze that particular fenced area. Thus the area was physically and socially fenced and villagers contributed their labor in the development activities. There was perceptible improvement in the density of vegetation in the protected area in contrast to unprotected area. The treated area has attracted many birds and animals, prominent among these are blue bulls. The community efforts over six years have brought out remarkable changes in the flora and fauna of this piece of land. Most importantly, it is now producing good quantity and quality of fodder for the livestocks. These activities generated good income to the community, particularly marginal and small farmers.

Table 14. Local plants, shrubs and bushes in the silvipasture system.

Plant, shrub and bushes	Total no	Uses
Trees		
Dhokara (*Anogeissus latifolia*)	258	Leaves - used as fodder Gum - used for medicinal purpose Wood - used as fuel
Khejari (*Prosopis cineraria*)	3960	Leaves - used as fooder Pods - used as fooder Wood- used for furniture and specially in bullock cart making
Desi Babul (*Acacia nilotica*)	81	Leaves - used as fooder Pods - used as fooder and Achar making (medicinal purpose) Wood - used for furniture and leather coloring
Neem (*Azadirachta indica*)	378	Medicinal plant - act as Dewormer, seeds used for oil and seed cake Wood - used for making house and furniture
Palas (*Buteamonosperma*)	23	Leaves - used for Pattal Duna making, Gum- used for medicinal purpose
Total trees	4700	
Shrub and bushes		
Salur	2187	Fodder for small ruminant
Ber bush	5638	Excellent fodder for goat and for controlling soil erosion
Total shrub and bushes	**7825**	

additional 9901 person-days employment. After two years, the silvipastural system started producing good quality fodder for the livestock besides restoring the degraded lands. Major benefits are going to small and marginal farmers. These farmers have access to the developed silvipasture in CPR to cut the grasses. Some part of the fodder fetched by these farmers will be collected by *Charagah Samiti* for the maintenance of this silvipasture in CPR, while major quantity of quality fodder is available to the farmers. The increased availability of fodder has reflected in the increased livestock population and income particularly for marginal and small farmers.

For this silvipasture system, the benefit cost ratio was calculated using 10 percent discount rate. On the basis of following assumptions, the returns on investment were evaluated.

- Expenditure and benefits were evaluated after making provision of depreciation yearly.
- Total benefits would be accrued after 10 years at the rate of Rs 25 per plant per year by pruning and at 5% incremental rate during 11^{th} to 15^{th} year while grasses and grass seed would give gross return at the rate of Rs 1500 per hectare after 2 years.
- Capital cost of silvipasture includes total development cost and maintenance cost, which is taken as 5% of the total capital cost per year.

Benefit cost ratio of silvipasture after 15 year arrived is 1.92, which indicates the potential of harnessing the benefits from community wasteland through silvipasture development. This is not only remunerative in economic terms but also beneficial from the point of conservation of natural resources and protection of environment.

Some of the major impact of silvipasture development are:

- Availability of good quality fodder for livestock round the year
- Availability of wood
- Regeneration of old plants, shrub and bushes
- Additional groundwater recharge and increased soil moisture
- Shelter provided for birds and wild animals
- Increased ground cover
- Controlled runoff and soil erosion
- Two natural streams appeared at pasture land during the rainy season with 90 days flow due to intensive soil and water conservation measures
- Improved managerial capacity of silvipasture committee as well as field staff
- Provided good employment to local community
- Degraded waste land converted in to valuable and beneficial asset for community

The number of species of useful grasses and fodder has increased tremendously. Besides, the flora, and fauna have been rehabilitated in this area. The area is safe for *nilgai* (a species of wild cows). To assess the impact of the system, a participatory biodiversity assessment of the regenerated grazing lands was undertaken with the involvement of community, participating actively in enumerating and listing the uses of the various herbs, shrubs, and grasses that have been rehabilitated in the area. A team of ecologists assessed the biodiversity in the same areas simultaneously. Microbial diversity of the soils of the grazing lands was also assessed. The results of the assessment revealed that community initiatives combining social and biophysical measures could yield best results in quantifying the impact on the rehabilitation and conservation of biodiversity in fragile ecosystems (Dixit et. al. 2005).

Developed Silvipasture system is a very promising alternate land use system which integrates multipurpose trees, shrubs, legumes and grasses mostly on non arable, degraded and marginal waste lands for optimizing land productivity. Silvipastoral practices help in conservation of vegetation, soil and nutrients and provide forage, fuel, and timber on sustainable basis to the community. Small and marginal farmers who are engaged in raising livestock got good benefit from this system. The system provides resilience by ensuring continued and sustainable multiple outputs, besides, soil and water conservation and other positive environmental effects.

Forest resources

Total 42617 plants of 22 different species of forest plants were planted in which 72 households were involved. Along with tree plantation, various other developmental activities such as construction of stonewall fencing, trench-mound and pits were constructed to ensure proper growth of plants.

Energy conservation

Wood as an energy source for cooking still predominant in most of the villages. The source of wood is gradually decreasing while demand is increasing with increasing population. This is leading to further increase in the drudgery on women folk and pressure on forest wood for fuel. To address these issues, several energy conservation activities such as distribution of pressure cookers, stove, establishment

Table 15. Households using improved cooking devices.

Village	Baseline status	Current status
	% of house holds	
Gokulpura	Nil	57
Goverdhanpura	2	54

Figure 20. An improved fuel-efficient cooking device

of bio gas plant and ball bearing fixed grain grinding stone and pottery wheel were initiated in the watershed villages. In Gokulpura-Goverdhanpura watershed, due to the introduction of improved fuel-efficient *chullas* (Fig. 20), kerosene stove and pressure cookers the quantity of wood and animals dung cakes used for cooking have come down considerably, which has reduced the pressure on forest cutting for fuel wood and the dung for the use of organic compost (Table 15). One biogas plant was also established in Goverdhanpura village. These energy conservation measures were effective in reducing the wood and other fuel requirements and benefited community and environment.

Socio-economic indicators

Socio-economic indicators are very important parameters to assess the impact of watershed programs. The data collected from Gokulpura- Goverdhanpura watershed on various socio-economic indicators viz. demographic pattern, poverty and income distribution, food, fodder and fuel security, livestock and labor migration are discussed below:

Change in demographic pattern

During the study of watershed program (1996-97 to 2004-05), sharp changes in the demographic pattern were observed in the village Gokulpura-Goverdhanpura. The concept of nuclear family resulted in an increase in the number of households by 25.2 percent. However, the size of family slightly decreased. During the period of interventions, the population increased by 23.7 percent and literacy rate increased for both male and female. Various government programs for improving literacy must have also contributed in increasing the literacy rate. The literacy among female increased from 22 percent to 37 percent, while in male it increased from 38 percent to 53 percent. The per capita income of farmers also increased by 27.7 percent (Table 16).

Table 16. Change in demographic patterns of the Gokulpura- Goverdhanpura villages.

	Before watershed interventions (1996-97)	After watershed interventions (2004-05)
No. of households	334	418
Family size	5.63	5.57
Population	1882	2328
Literacy rate (%)		
Male	38	53
Female	22	37
Per capita income (Rs per annum)	6754	8626

Poverty and income distribution

Before the watershed program many people in watershed area were suffering from the malnutrition and poverty. In this section an attempt has been made to measure the status of poverty before and after watershed development. The indicators such as the head count ratio, which is the proportion of population below poverty line has been used to measure the incidence of poverty. The poverty gap, which measures depth of poverty and squared poverty gap, indicates the severity of poverty in the village also has been estimated.

The various poverty indicators during pre and post watershed development are shown in the Table 17. The data clearly indicates that the farmers belonging to marginal and small land holdings are getting more benefits from the watershed development activities. The head count ratio in case of marginal and small farmers fell down from 0.13 to 0.0058 and 0.09 to 0.038, respectively. The depth of poverty gap is also down in all categories of farmers, resulting overall declining in squared poverty gap. After the watershed interventions, the head count ratio among all categories of farmers declined significantly and in case of large farmers, it is only 0.005, which indicate that the proportion of population below poverty line is very low. The index of poverty gap in case of marginal and small category of farmers has declined more sharply as compared to medium and large farmers. The substantial reduction in all the three poverty indicators could be attributed to successful of watershed development program at the site.

Table 17. Status of poverty before and after watershed interventions in Gokulpura-Goverdhanpura villages.

		Land holdings (ha)							
		Before watershed interventions				After watershed interventions			
Indicators	Reflection	<1	1-2	2-4	>4*	<1	1-2	2-4	>4
No. of household		152	125	36	21	208	173	23	14
Head count Ratio	Incidence	0.13	0.09	0.054	0.027	0.0058	0.038	0.034	0.005
Poverty gap Index	Depth	0.065	0.048	0.028	.014	0.024	0.014	0.007	0.001
Square poverty gap Index	Severity	0.034	0.023	0.009	0.002	0.010	0.005	0.001	0

Note: 1. Rs 327.5 per person per month is considered to measure all indices of poverty for living above poverty line, as per the Planning commission report, 2004.
*Farmers category based on land holdings: Marginal = <1 ha; Small = 1-2 ha; Medium = 2-4 ha; Large = >4 ha.

In addition to conventional watershed activities, several additional income-generating activities were carried out in the integrated watershed program, which brought significant increase in farm as well as non-farm income to farmers. Inter-crossed analysis of data reveals that the farm income of male farmers in all categories of land holdings increased gradually. The rate of increment was higher in case of medium (63%) and large (59%) farmers than in the case marginal (24%) and small (38%) male farmers. However, the incremental rate was higher in the case of marginal (10%) and medium (11%) as compared to small (8%) and large (6%) female farmers. Consequently, it appears that the medium and large male farmers and the marginal and medium female farmers are in more advantageous position from watershed development program during the periods of interventions (Table 18).

The percentage change of non-farm income among medium farmers were found higher in both male and female farmers. After the implementation of the watershed development program, non- farm income of male farmers in medium and marginal category increased by 33 and 22 percent, respectively, whereas it was only 17 and 13 percent in case of small and large farmers. The percentage changes of

Table 18. Income distribution of farmers from farm and non-farm activities.

	Land holdings (ha)							
	Before watershed interventions (1996-97)				After watershed interventions (2004-05)			
Landholding	<1	1-2	2-4	>4	<1	1-2	2-4	>4
	Farm income (Rs per annum)							
Male	1700	2220	3200	4100	2100	3055	5200	6500
Female	1750	2550	3500	3300	1925	2750	3900	3500
	Non-farm income (Rs per annum)							
Male	2500	2700	2400	2400	3050	3150	3180	2700
Female	3100	3300	2350	2200	3500	3750	3000	2575
	Livestock particularly milk and milk products income (Rs per annum)							
Male	1210	1350	1500	2800	1425	2100	2700	3900
Female	850	1000	1150	1500	1050	1100	1200	1700
	Total income (farm, non-farm and livestock income) (Rs per annum)							
Male	5410	6270	7100	9300	6575	8305	11080	13100
Female	5100	6850	7000	7000	6475	7600	8100	7775
HH income	31275	36933	39692	45885	36345	44295	53416	58137

Note: 1. The income is based on sample of 32 respondents and represents per person and income before watershed intervention is calculated on current market price to avoid inflation effect.
2. The income from livestock divided among male and female member in the proportion of their contribution of time for livestock management.

non-farm income of female farmers are comparatively lower than their male counterparts. However, the increments are higher in case of medium (28%) and large (17%) as compared to marginal (13%) and small (14%) farmers, respectively. Both male and female medium farmers' incomes from farm and non-farm category are higher.

Overall, the data revealed that the adoption of watershed program enhanced the productivity of major crops and generated more income from both farm as well as non-farm activities. Livestock and its products are important sources of income for farmers in agrarian society. Therefore income from livestock, particularly milk and milk products have been calculated from the sample respondents. Female farmers in the marginal category are highly benefited. Female farmers in large holding category benefited more than small holding female farmers. Intervention of watershed activities enhanced the income of farming community and benefited all categories of farmers, resulting in substantial increase in household incomes during the period. Of course, the household incomes increased substantially in case of medium (35%) and large (26.7%) land holding, while in case of marginal and small land holdings it has increased by 16 and 20 percent, respectively.

The results clearly indicate that the proper management of watershed activities, which are properly designed and executed, benefits the whole farming community.

Consumption status, hygiene and healthcare

The expenditure on consumption status, hygiene and healthcare before and after watershed interventions are shown in Table 19. The percentage increase in the expenses of consumption, hygiene and healthcare of male, female and children for all categories viz., marginal, small, medium and

Table 19. Expenditure pattern before and after watershed interventions.

	Before watershed interventions (1996-97)				After watershed interventions (2004-05)			
Land holdings (ha)	<1	1-2	2-4	> 4	<1	1-2	2-4	> 4
	Consumption expenditure[1] (Rs per annum)							
Male	2710	3050	3600	3800	3150	3505	3800	4150
Female	2800	3251	3530	3600	3100	3530	3800	3900
Children	2100	2780	2900	2900	2300	3100	3350	3700
	Hygiene and healthcare expenditure[2] (Rs per annum)							
Male	1300	1600	1750	2050	1500	1850	2100	2550
Female	1800	2900	3100	3200	1950	3100	3500	3550
Children	1400	1750	1900	2100	1450	1920	2150	2500
HH expenditure	22726	28771	31490	33123	24972	31573	34720	37783

Note: 1. Consumption expenditure included all food intakes while hygiene and healthcare expenditure covers all general expenses on health and hygiene except expenses on accidental and chronic disease.
2. The value of consumption calculated at present price (2004-05) to avoid inflation effects

large farmers, increased substantially after the watershed interventions. Interestingly, the percentage increase in the expenses on consumption by male farmers was higher in the category of marginal (16%) and small (15%) farmers as compared to medium (6%) and large (9%) farmers. Moreover, the expenses on consumption by female farmers were found higher in the same categories such as marginal (11%) and small (9%) as compared to medium and large (8% each) farmers because in large categories the female farmers were already spending enough on consumption before interventions of watershed program. Surprisingly, medium and large farmers were spending more on food consumption for children after watershed program and the expenses increased by 28 percent in the category of large farmers, while 16 percent in the case of medium farmers. The expenses on consumption by children belonging to marginal and small farmers also increased with the increase in their incomes but the percentage change was relatively less as compared to by large farmers.

After the watershed interventions, the expenditure on hygiene and healthcare of farmers also increased due to increased awareness of hygiene and healthcare, but a higher increase was observed in the case of large and medium farmers. The expenditure on hygiene and healthcare of male increased in case of large farmers by 24% and 20% among medium farmers, while in case of small farmers, by 16% and marginal by 15%. The increase at expenditure in hygiene and healthcare of female farmers was also higher in medium (13%) and large (11%) farmers and moreover the expenditure on children hygiene and healthcare was also higher in large (19%) and medium (13%) farmers. The household expenditure per annum increased by 14% in large holdings and 10 % for both small and medium holdings while only 6% in case of marginal holdings. The result shows that the watershed program has been successful in providing more food to all categories of farmers and they have become more aware of hygienic conditions. Further, the analysis reveals that the increased disposable income of the farmers influenced the increased expenditure on consumption (food items) of the poor while on luxurious commodities by rich people. With the increase in household incomes due to watershed interventions, it appears that now farmers are able to spend money on hygiene and healthcare, which was lacking during pre-project period.

Box 3. A barefoot doctor in the village

Across the border in Rajasthan, Suman Devi is the village medico of Goverdhanpura in Bundi district. Even though a matriculate, she has been chosen by the BAIF to be trained in identifying common basic symptoms and matching medicines to these.

Her face hidden behind a long veil, Suman Devi remains the dutiful "bahu" of the village – neither speaking in front of men nor sitting down in their presence. However, she displays a good confidence as she opens her medicine box and taking one flap of tablets at a time describes the illness for which it is meant for. This "barefoot doctor" keeps her medicine-box full of dispirin, crocin, iodine ticture and other 'over-the counter' medicine and charges Re. 1 for each tablet.

Her efforts brought down medical costs by three or four times during tenure of this practice, says Mathuralal Meena, one of the prominent farmer of the village. "Now we rarely go to the doctor in Thana village, which is five km from the village"

(The Hindu, 09 Jan, 2005)

Numbers of activities were initiated to improve the hygiene and health of people at village level. A local woman has been trained at Primary Health Center, Thana, for the treatment of first aid and common ailment in Goverdhanpura village. She provides basic/primary health services for headache, fever, diarrhea, worm infestation, etc., as first aid in the village. The primary requirement of the medicine kit was provided by the project and it runs on self-sufficiency basis. About 1200 people have benefited from this initiative that was started in 2003 and went up till 2004. Now this activity has been extended to 10 other villages.

Environmental clubs have been established involving school children to create awareness about hygiene and healthcare and environmental concerns through rallies, lectures and exhibitions. These clubs also took up chlorination of open wells in villages (Fig. 21). Now 30 such environmental clubs with 734 members have been established in Bundi, Bhilwara and Baran districts of Rajasthan. Soak pits and hygienic sanitations have also been taken up to improve the health and hygiene conditions of villagers (Fig. 22).

Fig. 21. School children doing chlorination of open well at Goverdhanapura village.

Figure 22. Soak pit constructed at Gokulpura village.

Box 4. Environmental club, innovative steps created by school children to save environment

Formation of environmental clubs was an innovative effort initially established in Bundi and later extended to three districts of Rajasthan involving school children. Club provides an opportunity to create awareness about environmental protection among school children through organized lectures. School children helped to carry the message of environmental protection and hygienic practices in the villages through rallies, exhibitions and posters. Thus, the club has become more effective in creating awareness, when these children speak to their elders.

Food, fodder and fuel security

The parameters to measure food security in the village are based on food availability, accessibility and acceptability. As the availability of food requires adequate and reliable food for the present and future generation, and the accessibility ensures distribution and access to food within and between societies while the acceptability measures culturally acceptable food and distribution systems (World Food Summit, 1996).

The watershed activities enhanced the productivity of crops and to some extent mitigated the adverse impact of drought thereby provided more food, fodder and fuel security to farmers. The per capita availability of food grains of cereal increased more than 50 percent and the per capita availability of vegetables increased by five times (Fig. 23). Over the period, the per capita availability of cereals has increased from 0.09 to 0.14 tons (55.5%), while the availability of pulses increased from 0.03 to 0.04 tons (33.3%) per annum. The production of vegetables before watershed program was low but with increased availability of water even during summer and other infrastructural changes, the per capita availability of vegetables increased from 0.01 to 0.05 tons (Fig. 23).

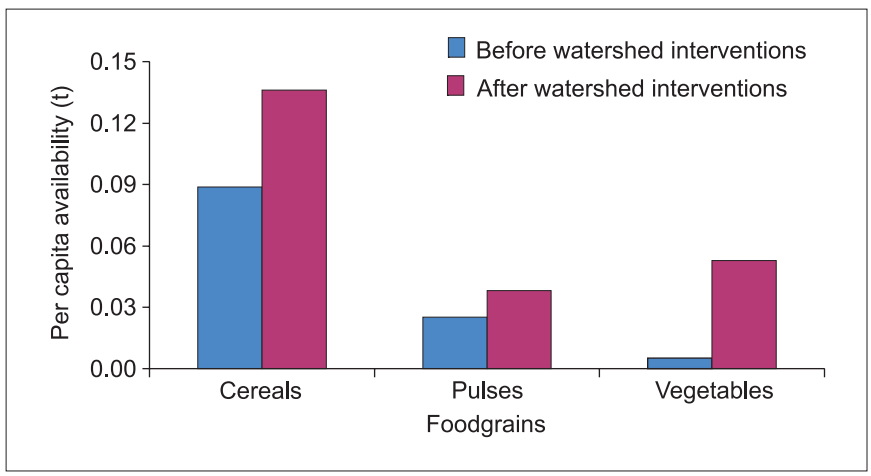

Figure 23 . Effect of watershed program on the per capita availability of food grains and vegetables.

Economics of cost of production

The economics of cost of cultivation of major crops i.e., maize, wheat, mustard, chickpea, vegetables and fodder were worked out for pre- and post- watershed periods. During the periods, input cost of all crops increased marginally but higher productivity with increased market prices made farmers earn profits, especially in maize and chickpea. Before watershed program, the cultivation of maize crop was in loss as the gross returns recovered only variable cost but not fixed cost and therefore profit volume ratio, which indicate the rate at which fixed cost are recovered was the lowest (0.09) compared to other crops, including vegetables and fodder. It implies that if fixed cost added up in the cost of cultivation then all inputs costs were not fully recovered by the revenues incurred from the maize crop. Of course, the cultivation of other crops including vegetables and fodder were economically beneficial for farmers even before watershed development program because gross returns of most of the crops recovered both fixed as well as variable costs with marginal profits and PV ratio varies from 0.41 in chickpea to higher 0.61 in fodder. Surprisingly, the area under cultivation of vegetables and fodder before watershed development counted was very less, which pertains lower share in fixed cost, resulting the highest benefit cost ratio.

The watershed interventions were successful at various stages of development. The productivity of most crops increased gradually, resulting in higher increase in profit margin. The data in Table 20 reveal that watershed interventions are giving higher returns even after considering both fixed and variable costs. The cultivation of maize was in loss before watershed program, but its cultivation has turned into profitability as providing higher rate of returns and consequently the area under cultivation increased after watershed program. The benefit cost ratio of maize shows economically beneficial even after sharing higher value (35%) of fixed cost. Wheat is one of the major staple crop in the region and enhanced productivity tend to increase benefit cost ratio by 52.83 percent followed by chickpea (40.91%) and mustered (32.85%). Although the benefit cost ratio of vegetable and fodder is higher because of their lesser share in fixed cost, percentage change in benefit cost ratio are comparatively lower.

Over the period, all crops providing higher grass returns and recovering all variable as well as fixed costs, as the profit volume ratio increased sharply, which indicates the fixed cost of the crops are recovered at higher level and farmers are in profitability even after including the imputed cost of their own capital in the cost of cultivation, particularly in these crops. While calculating cost of cultivation, the fixed cost, incurred from capital investment in land and irrigation facilities including water harvesting structures, was distributed among crops proportionally with the coverage area of particular crops under cultivation and therefore the share of vegetables and fodder in fixed cost emerged quite less because its cultivated area were comparatively lesser than other crops and therefore exceptionally, the benefit cost ratio of vegetables and fodder came very high.

In summary, the results suggest that rainfed crops have more potential and economical benefits if they are managed properly through integrated watershed management. The vegetables and fodder crops are found to be most beneficial for this area (Fig. 24).

Labor wages and output

The integrated watershed program provides wider and better opportunities to the farmers including women to improve their socio-economic status and minimize the inequality between male and female. The status of women further strengthened during watershed program through formation of SHGs, users groups, watershed committee and other committees at village level.

Table 20. Cost of cultivation and economic returns from major crops Gokulpura-Goverdhanpura watershed.

Crops	Area (ha)	Fixed Cost (FC)	Variable Cost (VC)	Total cost	Gross returns	Returns over FC	Returns over VC	Profit/Loss	Profit volume Ratio	Benefit cost ratio
		---------- (Rs ha^{-1}) ----------								
Before Watershed Development Program (1996-97)										
Maize	133	4541	7500	12041	8250	3709	750	-3791	0.09	0.69
Wheat	104	3551	11550	15101	24000	20449	12450	8899	0.52	1.59
Mustard	100	3414	11900	15314	21000	17586	9100	5686	0.43	1.37
Chickpea	25	854	8500	9354	14400	13546	5900	5046	0.41	1.54
Vegetables	5	171	12300	12471	28000	27829	15700	15529	0.56	2.25
Fodder	13	444	15300	15744	39000	38556	23700	23256	0.61	2.48
After Watershed Development Program (2004-05)										
Maize	154	7113	9800	16913	24000	16887	14200	7087	0.59	1.42
Wheat	112	5173	13300	18473	44800	39627	31500	26327	0.70	2.43
Mustard	102	4711	13700	18411	33600	28889	19900	15189	0.59	1.82
Chickpea	32	1478	9600	11078	24000	22522	14400	12922	0.60	2.17
Vegetables	18	831	15900	16731	51800	50969	35900	35069	0.69	3.10
Fodder	28	1293	17500	18793	61500	60207	44000	42707	0.72	3.27

Note: 1. Capital investment on land and irrigation facilities including water-harvesting structures is taken into consideration for fixed cost and fixed cost divided in the proportion of area coverage under particular crop.

2. To avoid inflationary effects the cost including fixed, gross returns before and after watershed program were valued at current market price (2004-05).

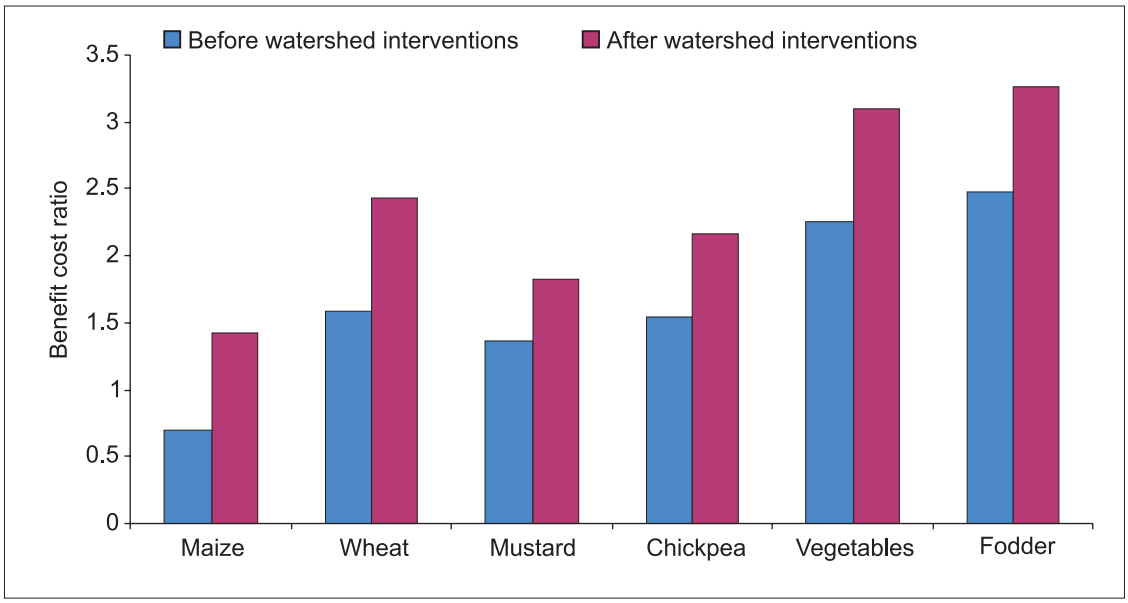

Figure 24. The change in benefit cost ratio during the pre and post of watershed program.

For major crops, the workers' output before and after watershed program were estimated. Excluding vegetables and fodder, the higher value of physical output was recorded in wheat and mustard followed by maize (Table 21). The preponderance of different prices once again revealed different scenario and that per worker output was higher in case of chickpea, followed by wheat and mustard. After the watershed interventions, the physical output of all major crops increased substantially and the highest increase was noticed in case of vegetables, followed by maize and fodder. The output per worker in all the major crops also increased substantially, but in case of maize, it was highest (183%), followed by vegetables (68%) and wheat (58%) (Table 22).

Table 21. Worker output in major crops before watershed program.

(at current market price)

Crop	Physical output (t)	Total output (Rs)	Output per worker (t)	Output per worker (Rs)
Maize	146.3	1097250	0.0174	131
Wheat	312.0	2496000	0.0272	218
Mustard	150.0	2100000	0.0108	152
Chickpea	22.5	360000	0.0204	327
Vegetables	20.0	140000	0.0253	177
Fodder	507.0	507000	0.5490	549

Note: The imputed cost of family labor treated as hired labor and taken into consideration

In most of the crops the labor use increased during watershed development program (Table 23 and 24) and in order about 19.2 percent male and 30.9 percent female labor per ha increased in the maize crop while in wheat and mustard the percentage of female labor days ha^{-1} increased by 20.6 and 8.5 percent respectively. The highest increment female labor was noticed in case of chickpea crop i.e., 61.9 percentage days ha^{-1}. The increment in the percentage of female labor was also higher (12.64%) as compared to their male encounter parts (7.04%) in vegetables. The changing scenario indicates the additional requirement of labor in agriculture was met by the higher participation of female labor.

Table 22. Worker output in major crops after watershed program.

(at current market price)

Crop	Physical output (t)	Total output (Rs)	Output per worker (t)	Output per worker (Rs)
Maize	616.0	4620000	0.0493	370
Wheat	627.2	5017600	0.0430	345
Mustard	244.8	3427200	0.0162	227
Chickpea	48.0	768000	0.0250	400
Vegetables	133.2	932400	0.0425	297
Fodder	1722.0	1722000	0.8540	854

The working hours were also influenced by the watershed activities and working hours of both male and female in agriculture activities increased by 2 hours per day, while in other activities of livestock the working hours of male increased by 2 hours (including grazing etc.) as compared to females only by one hour per day. However, the working hours for non-agricultural activities were not affected.

The working hours of women in domestic activities decreased by 1 hour per day due to less time they spent in fetching water and fuel wood as well as in doing other allied activities. Statistically, the effect on working hours of man and women were significant in the case of domestic and animals, while agricultural and non-agricultural activities were non-significant (Table 25).

The social constraints in agriculture are stigma for overall development in rural economy but interventions of watershed program helped to downsize the social constraints, especially against women. In the watershed villages, the labor wages discrimination in agricultural as well as other activities reduced to some extent. Before watershed development program, the differences in wages paid to male and female were about 37.5 percent in agriculture, while 15.4 percent in non-agricultural activities. But, after watershed development program, the labor wages of male and female in agriculture increased by 36.4 and 62.5 percent, respectively and the labor wages in other than agriculture activities also increased by 23.1 percent for male and 36.4 percent for female. The differences in labor wages paid to male and female declined to only 18.2 percent in agriculture and 6.7 percent in non-agricultural activities (Table 26).

Livestock production and ruminants

At the Gokulpura-Goverdhanpura watershed, livestock and ruminants are the important component of farming systems. Before the watershed program most of livestock and ruminants were of local breed and their productivity was low. To improve the breed, artificial insemination was started with the help of trained persons. The farmers were made aware about cross breeding and its potential benefits. To improve the knowledge and skills of the farmers, several training programs and exposure visits were conducted in the village. During watershed program, the livestock production increased to a satisfactory level. Substantial increase was noticed in the number of cows for the category of marginal (44.4%) and small (77.4%) farmers. Small farmers owning buffaloes had seen a rise (by 40.6%), followed by medium holding farmers (27.3%) (Table 27). A substantial increase in milk production from 2.5 lit to 4.0 lit per day per animal was achieved. This was reflected in increased additional income, besides improving the nutritional value of food intake of farmers. The incomes from milk production and fodder availability are discussed in the previous sections. In case of other animals like goat and sheep, a satisfactory increase (9 to 17%) was recorded for all categories of farmers.

Table 23. Labor uses in different activities of major crops before watershed program (person days ha^{-1}).

		Maize		Wheat		Mustard		Chickpea		Vegetables		Fodder		Lentil	
SNo	Crop production operations	M *	F *	M	F	M	F	M	F	M	F	M	F	M	F
1	Field preparation & tillage	5	2	4	1	6	2	5	2	5	2	5	0	7	1
2	Sowing/transplanting	1	0	2	1	2	10	1	5	4	7	2	3	3	2
3	Fertilizer application	1	0	3	1	2	8	2	0	5	3	3	2	2	0
4	Irrigation	1	1	16	12	11	3	1	0	12	8	13	5	3	0
5	Intercultural / weeding	0	18	5	15	4	12	2	1	9	21	0	9	5	9
6	Plant protection measures	2	5	4	1	5	1	2	1	7	18	0	0	2	7
7	Harvesting/picking	5	7	5	25	7	40	5	7	11	21	0	0	3	11
8	Threshing and winnowing	4	9	7	3	5	18	3	5	0	0	0	0	5	7
9	Transportation	2	0	1	4	2	0	2	0	18	7	14	5	7	3
	Total person Days	21	42	47	63	44	94	23	21	71	87	47	24	37	40

Table 24. Labor uses in different activities of major crops after watershed program (person days ha^{-1}).

		Maize		Wheat		Mustard		Chickpea		Vegetables		Fodder		Lentil	
SNo	Crop production operations	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	Field preparation & Tillage	7	3	5	1	5	1	5	1	7	1	7	1	5	3
2	Sowing/transplanting	1	0	2	2	3	7	1	7	5	9	3	5	3	2
3	Fertilizer application	1	3	3	1	3	1	1	3	2	7	5	1	1	1
4	Irrigation	9	8	13	17	9	5	1	1	15	11	7	3	3	1
5	Intercultural / weeding	1	7	7	21	5	18	2	2	10	19	1	3	5	7
6	Plant protection measures	3	9	5	3	6	3	1	1	7	21	3	5	7	14
7	Harvesting/picking	4	7	7	27	7	47	7	11	9	21	0	0	9	11
8	Threshing and winnowing	3	11	5	3	5	19	5	7	0	0	0	0	7	5
9	Transportation	5	0	7	1	3	1	3	1	21	9	19	9	9	5
	Total person Days	34	48	54	76	46	102	26	34	76	98	45	27	49	49

* M = Male, F = Female

Table 25. Time distribution (hours day^{-1}) of men and women workers on various activities at Gokulpura-Goverdhanpura watershed.

	Before watershed interventions			After watershed Interventions		
Activities	Men	Women	t-value	Men	Women	t-value
Domestic	1.5	5.0	6.23*	2.0	4.0	6.43*
Agriculture	8.0	7.0	0.067**	10.0	9.0	0.061**
Animals	3.0	1.0	3.72*	5.0	2.0	8.65*
Non-agriculture	1.0	1.0	1.00**	1.0	1.0	1.00**

* Significant at 1% level, ** = non-significant
Note: 1. Time spent on different activities concerned to peak periods (sowing and harvesting) only

Table 26. Daily wage rate (Rs per day) of male and female workers Gokulpura-Goverdhanpura watershed.

	Before watershed program	After watershed program
Agriculture		
Male	44	60
Female	32	52
Other than agriculture		
Male	52	64
Female	44	60

In the village, the number of bullocks increased during the period of watershed development program, which indicated that the farmers still prefer using bullocks for the farming purposes. The results from poultry farming were also encouraging and good increase was noticed during the watershed program. It was observed that the marginal and small farmers had increased number of poultry birds by 60 and 46 percent while medium and large farmers by 43 and 30 percent respectively. Interestingly, the increase in poultry followed the opposite of landholdings, which means that the marginal and small farmers are more keen in this activity compared to medium and large farmers.

Ex-ante impact assessment and evaluation of investment

The potential benefit in the future from the investment in watershed program has been examined. The economic surplus model was used as it is applied in close economy framework with the assumption of no spillover effects on international market and further also assumes that the output supply function is unitary elastic and linear with a parallel research-induced supply shift and demand function is linearly non-elastic (Alston et al., 1995). In the analysis, variables related to commodity prices and output quantities in the target domain were obtained from the secondary and published sources. Further, the farm harvesting prices were used to compute the value of production.

In the economic analysis following assumptions with respect to various technological and economical parameters were made.

- The base year 2004-05 is assumed for the ex-ante analysis
- Proportionate yield change from 0.60 (mustard) to 1.91 (wheat)
- Proportionate change in input cost 0.25
- Proportionate change in variable cost from 0.13 (chickpea) to 0.31 (maize)

Table 27. Livestock and small ruminants numbers per households at Gokulpura-Goverdhanpura watershed.

Livestock/ small ruminants	Before watershed program				After watershed program			
	Land holding (ha)							
	< 1	1-2	2-4	> 4	< 1	1-2	2-4	> 4
Cow	0.136	0.094	0.258	0.318	0.173	0.147	0.280	0.360
Buffalo	0.076	0.097	0.167	0.248	0.080	0.120	0.187	0.240
Goat	0.227	0.176	0.091	0.067	0.219	0.173	0.093	0.067
Sheep	0.155	0.224	0.097	0.055	0.163	0.227	0.109	0.056
Bullocks	0.176	0.230	0.121	0.085	0.160	0.213	0.120	0.085
Poultry birds	0.455	0.364	0.212	0.152	0.640	0.467	0.267	0.173

- Probability of success of watershed technology is expected to be 75 percent
- Adoption rate: Adoption starts 5 years after initiation of the project and increases at a rate of 5 percent per annum
- Depreciation of technology: The technology will be relevant for 5 years and then starts depreciating at a rate of 5 percent per year
- Research cost: Actual expenditure incurred on watershed program during project period
- Elasticity of demand: 0.60 (assumed)
- Elasticity supply: 0.50 (assumed)
- Discounting rate: 12%

Box 5. Livestock development an integral components in subsistence agriculture

Livestock component is next to agriculture, as a source of livelihood in farming community of India and provide alternative source of income for the farmers. In the process of watershed development for the last four years, more than 1000 animals were inseminated with improved breed and out of which about 61% conceived and insured pregnancy. The improvement of local breeds through artificial insemination (AI) at the doorsteps of farmers benefited in increasing milk production and its product. Three milk societies were established in the watershed area and impact of these activities increased farmers' average income by about Rs 6000 per annum.

With the support of revolving fund, other remunerative activities were taken up to distribute the fast growing Sirohi buck to improve the local breed of goat. About 32 families benefited with this activity and farmers earned about Rs 62500 by selling them in the open market.

Increase in input cost and adoption of high-yielding varieties of various crops increased the cost of cultivation of crops except fodder (Table 28). During watershed development program the cost of cultivation increased substantially and in case of maize it was the highest with 4.34 compound growth rate, followed by vegetables with 3.74 compound growth rate and wheat with 2.55 compound growth rates. The highest increment in yield also goes to maize with 14.28% with compound growth rate, followed by wheat (8.11%) and vegetables (7.9%). The yields of other crops like mustard, chickpea

Table 28. Impact of watershed program on the yield and profitability of different crops in the village.

	Before watershed program (1996-97)	After watershed program (2004-05)	Differences*	CGR**
Cost of cultivation (Rs ha $^{-1}$)				
Maize	12041	16913	4872	4.34
Wheat	15101	18473	3372	2.55
Mustard	15314	18411	3097	2.33
Chickpea	9354	11078	1724	2.14
Vegetables	12471	16731	4260	3.74
Fodder	15744	18793	3049	2.24
Yield (kg ha $^{-1}$)				
Maize	1100	3200	2100	14.28
Wheat	3000	5600	2600	8.11
Mustard	1500	2400	900	6.05
Chickpea	900	1500	600	6.59
Vegetables	4000	7400	3400	7.99
Fodder	39000	61500	22500	5.86
Cost of production (Rs kg $^{-1}$)				
Maize	10.95	5.29	-5.66	-8.70
Wheat	5.03	3.30	-1.73	-5.15
Mustard	10.21	7.67	-2.54	-3.51
Chickpea	10.39	7.39	-3.01	-4.18
Vegetables	3.12	2.26	-0.86	-3.94
Fodder	0.40	0.31	-0.10	-3.42
Net returns (Rs ha^{-1})				
Maize	-3791	7087	10878	36.25
Wheat	8899	26327	17428	14.52
Mustard	5686	15189	9503	13.07
Chickpea	5046	12922	7876	12.47
Vegetables	15529	35069	19540	10.72
Fodder	23256	42707	19451	7.89

Note: 1. The differences from 2004-05 to 1996-97 are significant at 5 percent level.
2. To calculate CGR of net returns of Maize the negative value before watershed has been equalized at Rs.1000
3. Linear compound growth rate

and fodder also increased at substantial rate. The cost of production of all crops was reduced over the period of time because of higher crop yields gained during the watershed program. The cost of production of maize declined with 8.70 compound growth rates while other crops like wheat, chickpea and mustard declined by 5.15, 4.18 and 3.51, respectively. The declining cost of production and increasing trend of yields has resulted creeping trends of increasing net returns during the watershed program in the villages. Before watershed interventions, the net returns of maize was negative while after watershed interventions the net returns for maize increased to Rs 7087 ha^{-1} with the highest

compound growth rate (36.25%). The net returns of other crops such as wheat, mustard and chickpea also increased substantially; however, the lowest growth (7.89%) of net returns was found for fodder crops over the period of time.

Considering assumptions and other components of study, the pay back period of investment is calculated as 5 years and 3 months, while the net present value is Rs 41,929,640. The pay back period of investment was more because of gestation period to recover the returns. The net present value of investment with internal rate of returns and the benefit cost ratio was quite good[1]. The internal rate of return was found to be 19 percent and the benefit cost ratio was arrived at 1.53. These results of ex-ante impact assessment of investment are highly positive and optimistic, indicating that the investments on watershed program in rainfed agriculture over period have high economic returns, besides environmental and other ecological tangible and intangible benefits.

Employment opportunities and status of migration

The watershed program increased the working days of farmers due to various activities i.e., agriculture, horticulture, floriculture, afforestration, animal husbandry and small enterprises, etc. Various soil conservation measures like water storage structures, gully control structures, mini percolation pits and gabion structures were constructed in the village, which provided additional job opportunities to the small and marginal farmers (Table 29).

Table 29. Employment opportunities (man days per month) at the Gokulpura-Govardhanapura watershed.

	Before watershed program				During watershed program			
	Land holdings (ha)							
Name of work	<1	1-2	<2-4	>4	<1	1-2	<2-4	>4
Agriculture	7	10	10	12	10	12	11	13
Horticulture	Nil	Nil	Nil	Nil	3	3	5	6
Floriculture	0	0	1	1	2	2	3	2
Afforestation	1	0	2	2	2	2	1	2
Animal husbandry	3	2	3	2	4	3	2	1
Small enterprises								
Agriculture based	1	1	2	3	2	2	3	2
Non-agriculture based	2	2	1	1	2	3	2	3
Others	1	1	1	1	1	2	1	1

During watershed program, the working days of all categories of farmer increased substantially (Table 29). In case of agriculture, the working days of small and marginal farmers increased by 42.9 and 20.0 percent respectively. Floriculture is new activities in the area and provides addition employment to medium and large farmers. Introduction of afforestration has become main sources of income, especially for marginal and small farmers; and it provides at least 24 man days employment in a year. Animal husbandry also supports the livelihoods of poor farmers and is one of the best ways of generating additional income. During watershed program, the working days of small farmers increased substantially (50%), while the declining trends were noticed in case of large farmers. The data revealed that the small enterprises based on agriculture provide good opportunities to marginal and small farmers, by increasing the employment, whereas the industries based on non-agriculture activity provide better opportunities to medium and large farmers.

1 Ex-ante impact assessment is merely based on benefits of a few important crops while other components of watershed activities like livestock income, CPR incomes, etc, playing crucial role to increase total income were not be taken into consideration because of lack of adequate information

The migration from rural to urban areas is one of the core issues in this region. The Gokulpura-Goverdhanpura watershed achieved high success in reducing the migration from rural to urban areas by providing better employment opportunities to the farmers in the village itself with satisfactory remunerative work (Table 30).

Table 30. Status of migration at Gokulpura-Goverdhanpura watershed.

	Before watershed program				During watershed program			
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 (persons per annum)								
Skilled labor	25	18	10	7	7	5	3	1
Unskilled labor	62	43	15	14	21	18	8	2
Permanent migration (persons per annum)								
Skilled labor	5	2	1	1	2	1	1	0
Unskilled labor	12	5	3	1	3	5	1	1

In the village, both seasonal and permanent migrations were significantly reduced due to watershed program. Huge decline was noticed in case of seasonal as well as permanent migration and the decline rate was greater in case of large holding, followed by medium landholding farmers. However, a sharp decline was noticed in all categories of farmers in permanent migration as compared to seasonal migration. Inter cross analysis of data revealed that the seasonal as well as permanent migration of skilled labor in all categories of farmers were reduced with higher rate as against to unskilled labor. Interestingly, the percentage of reduction of migration was lower in case of marginal and small holding farmers as compared to medium and large landholdings farmers.

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ANNEXURE 1

Details of water harvesting structures at Gokulpura-Goverdhanpura watershed.

Name of the structure	Location	Storage capacity (m^3)	Cost of construction (Rs)	Unit cost (Rs m^{-3} of water stored)	No. of wells benefited	Area benefited (ha)	No. of farmers benefited
Ramdev	Gokulpura	150	14228	95	7	10.5	18
Krishna	Gokulpura	610	52487	86	8	11.5	22
Devnarayan	Gokulpura	2090	92181	44	10	11.5	17
Gouri	Gokulpura	1630	147297	90	5	6.5	8
Kamadhenu	Gokulpura	2370	146688	62	13	15	42
Janchetna	Gokulpura	910	121659	134	17	18	48
Mansukha	Gokulpura	3600	267685	74	16	21	44
Sagas	Gokulpura	4610	346490	75	16	49.5	99
Ganga Sagar	Gokulpura	3260	200918	62	12	21.5	12
Vikas	Gokulpura	360	31819	88	7	10.5	12
Charaghar	Gokulpura	680	67823	100	10	15	23
Murali	Goverdhanpura	50	14229	285	3	3.5	5
Meghadut	Goverdhanpura	40	10666	267	3	3	4
Pragati	Goverdhanpura	380	34050	90	6	14.5	6
Ganesh	Goverdhanpura	470	67370	143	17	39.5	21
Kundiya	Goverdhanpura	15360	284085	19	76	60	66
Chittar	Goverdhanpura	500	15350	31	3	4	5
Talai	Goverdhanpura	520	16447	32	Situated in forest, used for animals		
Rasta Talai	Goverdhanpura	400	17550	44	12	18	10
Prajapat Ka Bhanda	Goverdhanpura	14600	95553	7	18	57.5	71
Total		*52590*	*2874295*	*55 **			

** Unit cost = Total cost divided by Total storage capacity of the structure*

ANNEXURE 2

Area, productivity and production of major crops before and after watershed interventions, Gokulpura-Goverdhanpura watershed.

Before watershed interventions					After watershed interventions				
Season	Crops	Area (ha)	Yield (t h^{-1})	Total production (t)	Season	Crops	Area (ha)	Yield (t h^{-1})	Total production (t)
Rainy season	Maize	133	1.11	147	Rainy season	Maize	120	3.20	384
	Fallow	76	-	-		Maize	34	4.80	163
	Blackgram	16	0.60	9.6		Fallow	59		
	Sesame	13	0.60	8.00		Blackgram	19	0.90	17
	Vegetables	3	4.50	13.5		Sesame	16	10.50	17
Post-rainy	Wheat	104	3.00	312		New crops	11	1.80	20
season	Mustard	100	0.15	150		Vegetables	6	8.70	52
	Chickpea	25	0.90	23		Fodder	5	68.40	342
	Lentil	22	1.20	26	Post-rainy	Wheat	112	5.60	627
	Rapeseed	2	1.00	2	season	Mustard	102	2.40	245
	Vegetables	1	4.20	4.2		Chickpea	32	1.50	48
	Fodder	7	43.00	387		Lentil	9	1.80	16
Summer	Vegetables	1	3.50	3.5		Vegetables	3	8.70	26
	Fodder	6	35.00	210		Fodder	14	71.00	994
						Rapeseed	2	1.20	2.4
						Peas	26	12.00	312
					Summer	Vegetables	4	4.80	19
						Fodder	9	45.00	405

ANNEXURE 3

Detail calculation of BC ratio for silvipasture system on degraded community land.

No. of year	Capital cost (Rs)	Net incremental income (from grass & seed) (Rs)	Net incremental income (from tree) (Rs)	Total net incremental return (Rs)	Present worth of total cost (Rs)	Present worth of net incremental return (Rs)	B:C Ratio
1	620325.00	0.00	Nil	0.00	620325.00	0.00	
2	31016.25	0.00	Nil	0.00	28196.59	0.00	
3	31016.25	67500.00	Nil	67500.00	25633.26	50713.75	
4	31016.25	70875.00	Nil	70875.00	23302.97	48408.58	
5	31016.25	74418.75	Nil	74418.75	21184.52	46208.19	
6	31016.25	74418.75	Nil	74418.75	19258.65	42007.44	
7	31016.25	74418.75	Nil	74418.75	17507.86	38188.59	
8	31016.25	74418.75	Nil	74418.75	15916.24	34716.90	
9	31016.25	74418.75	Nil	74418.75	14469.31	31560.81	
10	31016.25	74418.75	582675.00	657093.75	13153.92	253338.09	
11	31016.25	74418.75	611806.75	686227.50	11958.11	240518.55	
12	31016.25	74418.75	642399.19	716817.94	10871.01	228400.29	
13	31016.25	74418.75	674519.15	748937.90	9882.73	216940.63	
14	31016.25	74418.75	708245.10	782663.85	8984.30	206099.85	
15	31016.25	74418.75	743657.36	818076.11	8167.55	195840.92	
Total	1054552.50	956981.25	3963304.55	4920285.80	848812.02	1632942.58	1.92

*(**Source**: Nadoda M.S. & Vader M.H., 2001)*

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