SOCIOECONOMIC DEVELOPMENT OF VILLAGE PEOPLE THROUGH WATERSHED MANAGEMENT

By

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ABSTRACT

Rainfall in India generally, occurs, in short period, most of which is lost as run-off; eroding significant quantities of precious top soil, hence rainfall goes unproductive. This results in reduction of farm production, ultimately hampering the overall economic growth of rural people. Watershed management can play a vital role in resolving this problem. The paper studied watershed management developments for Kaneri village which is located at outskirts of Kolhapur city. In spite of sufficient monsoon rainfall (973 mm) people in this village face scarcity of water for agricultural and domestic use in summer. The rainwater does not percolate into the ground, but flows over the earth surface. This has resulted in depletion of ground water table, so reduce crop yield and income from agricultural activity is low. So it has become necessary to develop the means to storage of runoff and recharge ground water resources, which are essentials for improving living standard of people. In this paper, the existing economical status and causes behind economical problems of people living in Kaneri village, is discussed. This paper describes the watershed condition by watershed budgeting and using other engineering measures. This data is used to identify the best watershed management options and solutions for improving economical status of Kaneri village. Further this paper presents the effectiveness of various watershed management options for economical development with the help of a case study and using before-after concept. It is found that watershed management activities increase crop production by 38.33% and per capita income by 30.14%. Thus it is concluded that economical development of rural people can be achieved through watershed management.

Keywords: Socio-Economic Survey, Watershed Budgeting, Runoff Estimation, Contour Survey, People Awareness, Economical Development.

INTRODUCTION

Rainwater, a scarce and critical resource for growing food and providing livelihood support for rural populations, is under threat particularly in the arid and semi-arid regions of the world. Rainfall in the semi-arid tropics (SAT) - occurs in short period (Mishra, 1996; Gregersen & Lundgren, 1988). Most of this water is lost as run-off, eroding significant quantities of precious top soil.

The economical development and management of villages in India are important factors for the growth of Indian economy. In India most of the villagers have agriculture as their primary occupation, which is depended on monsoon rains. But in spite of sufficient rainfall, people have to depend upon tankers even for their domestic use because of large runoff and soil loss of the land. By having soil and land management along with the water management, thus, developing watersheds, economical development of rural area is possible.

Importance of Watershed Management

There is risk in heavy investment in agriculture due to uncertainty of rainfall and poor socio economic condition of farmer to save the crop from drought or meet the water needs of crop. Hence watershed management is important to handle these problems. Watershed management renders the rural population self sustaining in food, fat, fiber, firewood, fodder, fruit, health, and hygiene (Shwetha, 2009). As a result dependence of poor reduces, their farm produce increases and per capita income improves resulting in overall economic growth of the rural poor. Hence, it is decided to find out technologies, which

are sustained in such situation to improve economical status of people. And for that Kaneri village situated in Kolhapur district of Maharashtra state is taken as case study.

1. Objective

- To study the existing economical status of the Kaneri village people.
- To find causes behind the economical problems in the area.
- To find solutions to improve economical status of the village people.
- To identify the best watershed management options to improve economical status of the people.
- To evaluate the effectiveness of watershed management options on economical status of the village people.

2. Study Area

2.1 Location and Climatic Condition

Kaneri village is located at 10 km away from Kolhapur city on Pune-Bangalore highway as shown in Figure 1. As per Department of Agriculture, Government Maharashtra it falls in transition zone-2 (sub mountain zone) of agro-climatic zone which characterizes rainfall ranges from 750 mm to 2000 mm and temperature ranges from 20 ^{0}C to 30 ^{0}C. It is suitable for kharif crop only; hence, irrigation facility is required for rabbi crop and perennial crop.

The main occupation of village people is farming. The village is known for its Lingayat monastery or math in a hamlet on a neighbouring hill. Siddhagiri Museum is a wax museum probably the only one of its kind in India. This museum showcases village life of India.

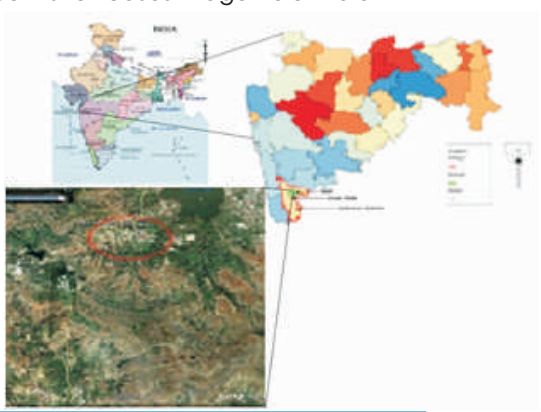

Figure 1. Location of Kaneri Village

Watershed area is fan shaped with direction of slope towards South-East. Black cotton soil and reddish brown soil is found in the watershed area (Swami & Kulkarni, 2011).

2.2 Cropping Pattern

The gross cropped area in the Kaneri village during 2010-11 was 661 hectares. Table 1 shows distribution of geographical area as per use. Groundnut (175.25 ha.), Rice (85.5 ha.), Kharif Jawar (45.20 ha.), soyabean (42.13 ha.), and sugarcane (56.92 ha.) are the major crops in this area.

2.3 Existing Structures

Village ponds are the structures existing in watershed area. There is no rain water harvesting, insufficient number of soil and water structures, and lack of plantation. Runoff water possesses erosive action to ground. Mostly shortage of water for drinking and irrigation occurs from January to June end.

3. Socio-Economic Survey

In order to understand the present position of village in regard to various human social and infrastructural aspects, a baseline survey based on questionnaire is carried out (Anantha, Wani, & Sreedevi, 2009). Questionnaire survey is carried out in three stages, first for village details, second for household details, and third for detailed survey for randomly selected 60 households. By analyzing this data following socio- economic status of village people is known.

3.1 Population, Gender Distribution, And Household Characteristics

There are total of 4909 persons dwelling in 1007 households

Land details		Area in hectare
Geographical area		965.94
Total land under cultivation (661 Ha)	Under kharif	594.58
	Under rabbi	9.50
	Irrigated land	56.92
Area under pasture		1.01
Area under fallow land		147.89
Roads, Gaothan, School, etc.		23.86
Pond and canal		95.09
Non agriculture use		16.02
Saline land		21.07
Irrigation facility		Ponds & wells

Table 1. Land use Details of the Village

in the Kaneri watersheds. Out of that 53.25% is male and 46.75% female. From the survey results, the overall sex ratio in the watersheds was 1:1.14 or there were 114 males for every 100 females. Household (HH) is a demographic concept, defined by various literatures, as all persons who live in the same dwelling unit. The average household size of village is 4.87.

3.2 Livestock Distribution

Total livestock and poultry in watershed area are 1099 and 400, respectively. Table 2 shows distribution of livestock.

3.3 Land Holding and its Classification

The land holdings were classified as landless, marginal, small, and large farmers, presented under Figure 2. Average land holding is 1.80 acre. Majority of the farmers belonged to marginal farmer category with equal proportion of 23%.

3.4 Household Income Analysis

Crops, livestock, and their products are the main sources of household income in the study areas. Figure 3 categorizes the families of Kaneri village as per annual income. Average annual income of village people from farm activity is ₹ 39564/- and from non-farm activity is ₹ 49638/-, means average total annual income from combining both activities is ₹ 56971/-.

3.5 Causes behind Economical Problem

- Water scarcity- due to steep ground slope most of water wasted as runoff, which results in water scarcity. Most of money, time, and energy spend to meet water needs.
- Insufficient conservation structures- it reduces water recharge and leads to soil erosion. Hence, non-availability of water for irrigation, which affect agriculture production.
- Traditional cropping pattern- Most of the farmer practices traditional cropping pattern and due to ill-literacy they have no trust on improved seed and modern cropping pattern. Hence, faces low agricultural income.
- Less green vegetation- Due to less vegetation cover and low agriculture production there is less availability of fodder that leads to low milk production from cattle and bovine strength decreases. Hence income from non agriculture activity is low.
- Low literacy rate- The literacy rate of the village people is very less (41%). Also people do not know about skill development training and self employment facilities. So large workforce work as unskilled labour in nearby industries with less incentive.
- No irrigation facility- This leads to cropping only for kharif season which reduces income.

Description	Quantity (no.)
She Buffalos and cow	958
Young stock	78
He Buffalos and oxen	30
Goats (He and She)	33
Poultry	400

Table 2. Livestock Characteristics

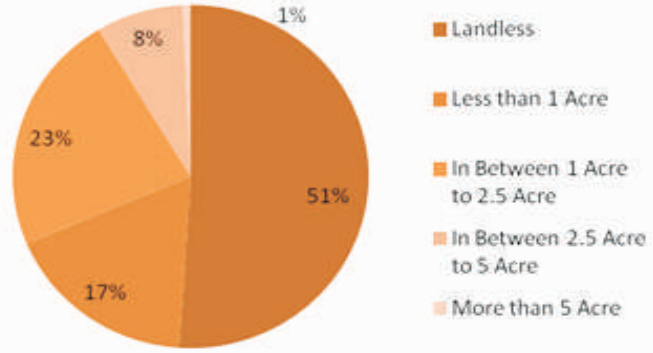

Figure 2. Percentage Distribution of and Holding Families

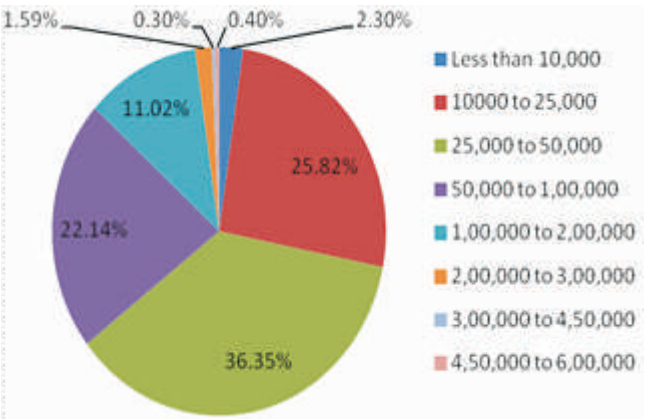

Figure 3. Percentage Distribution of Families as Per Annual Income Range

Figure 4 shows distribution of cause behind economical problems based on discussions with people (from 60

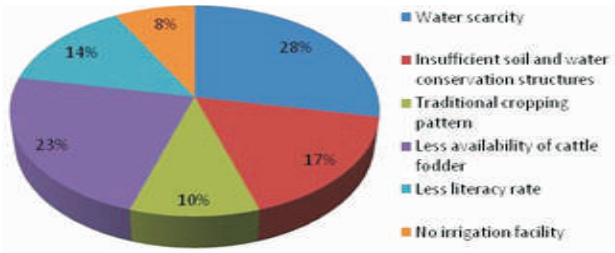

Figure 4. Percentage Distribution of Cause Behind Economical Problem

households) through the questionnaire.

4. Watershed Budgeting

In Kaneri watershed, 4909 people are living in 965.94 hectare area and 1099 bovine strength of cattle and milch animals (Murty, 2004). Watershed budgeting is necessary to know the situation of food, fuel, and fodder for all human beings in watershed area.

Figure 5 and Figure 6 shows actual situation of watershed. All essential food and fuel requirement of people and animal are in short supply excepting fat (oil) and sugar in people food requirement.

Fuel requirement is 45 quintal/ annual per family. But only

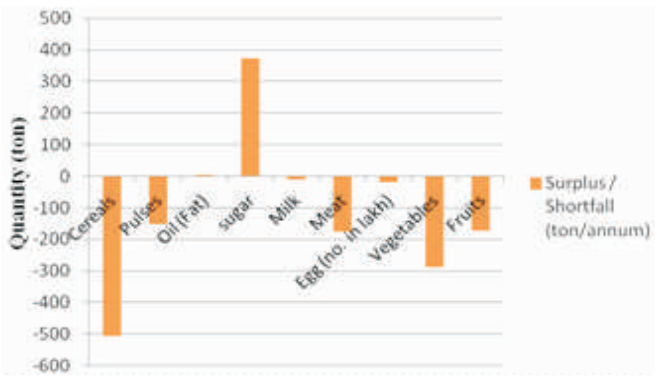

Figure 5. Surplus / Shortfall Situation of Food for People

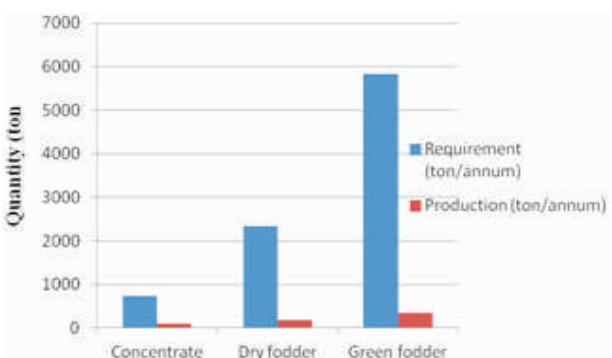

Figure 6. Requirement and Production Situation of Fodder

1/3rd of family uses Chula in the Kaneri watershed. This is main reason for felling the trees. Hence, fuel wood requirement of village is 1510.5 ton. But, Fuel wood is nearly vanishing from watershed area. This entire situation leads to watershed management, which is to be done for this area (Vishal, Kulkarni, & Swami, 2012).

5. Rainfall-runoff Estimation

Before recommending water conservation measures it is necessary to evaluate rainfall and runoff potential of the watershed. Rainfall and evaporation are two of the most important parameters, essential for planning water conservation. Yearly rainfall data for 46 years is collected from metrological department (Figure 7). Daily rainfall data for 14 years is collected from agriculture department (Figure 8). Annual average rainfall is 973 mm. As per meteorological department watershed evaporation losses are considered as 30 percent of total runoff.

5.1 Runoff Estimation

A) Avg. yearly rainfall in Kaneri village = 0.973 m.

1) Rainwater on the watershed (P)

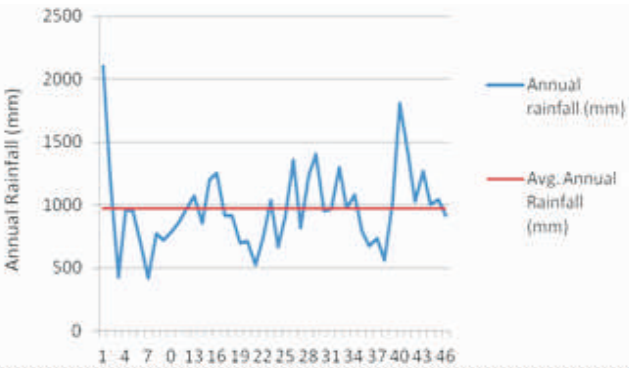

Figure 7. Annual Average Rainfall

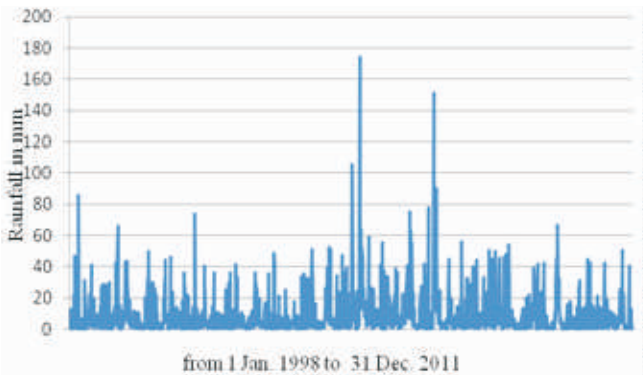

Figure 8. Daily Rainfall From Year 1998 to 2011

= Watershed Area (sq.m) x Avg. Rainfall

= 965.94 x 10000 x 0.973 = 93.99 M.cum.

2) Groundwater recharge (R_G)

= Watershed Area (sq.m) x Avg. fluctuation

x Specific yield

= 965.94 x10000 x 1.5 x 0.15 = 21.74 M.cum.

3) Surface storage (R_B)

= Pond area x Avg. Depth

= 94.86 x 10000 x 3.0m = 28.46 M.cum.

4) Evapotranspiration = (30%) of Precipitation

= 0.3 x 93.99 = 28.19 M.cum.

B) Runoff by using basic formula

Runoff (R) = Precipitation (P) - Basin recharge (R_B) - Groundwater recharge (R_G)

= (93.99 - 28.46 - 21.74) M.cum.

= 43.79 M.cum.

C) Water available for artificial recharge for watershed development

=Runoff – Evapotranspiration

= 43.79 M.cum. - 28.19 M.cum.

= 15.60 M.cum.

5.2 Simple Markov Chain Analysis

This is simple technique of predicting the probabilities of future occurrence by analyzing presently known probabilities. In the present study, the simple Markov chain analysis is used for predicting the wet year occurrence (rainfall). Tables 4 and 5 show probability of wet and dry event occurring for rainfall and expectation of wet years for rainfall, respectively.

If $X_0, X_1, X_2 \ldots\ldots, X_n$, a random variable distributed identically and taking only 2 values.

$$X_n = \begin{cases} 0 \text{ if the } n^{th} \text{ month is dry} \\ 1 \text{ if the } n^{th} \text{ month is wet} \end{cases}$$

Let $p = P(X_t = 1)$. Here p is the absolute probability of a month being wet.

$$p_0 = \frac{n_0}{n} \quad \text{and} \quad p_1 = \frac{n_1}{n}$$

where,

n_0: number of dry month

n_1: number of wet month

n : number of years of data

The choice of threshold value for Markov chain model is very important, especially when it is used for agriculture purpose. The following Table 3 gives threshold values.

Let Y be the random variables such that,

Y = number of wet years among n years period, i.e.,

Y follows normal distribution with mean = n_p i.e., $E(Y) = n_p$

where,

Y is the number of wet years;

n is the number of years of data used;

p is the initial probability of occurrence of wet months.

This condition also leads to watershed management.

6. Contour Survey

It is a technical survey carried out to know the topography of the study area. The results of the survey are presented in the form of contour lines on maps of the study area. The

Threshold level	Code
<60	0 (Dry)
>60	1 (Wet)

Table 3. Threshold Level for Rainfall (mm)

Year	Total Rainfall (mm)	No. of Wet Month	No. of Dry Month	Probability (Wet)	Probability (Dry)
1998	899	5	7	0.42	0.58
1999	1053	4	8	0.33	0.67
2000	712	5	7	0.42	0.58
2001	712	5	7	0.42	0.58
2002	704	4	8	0.33	0.67
2003	541	4	8	0.33	0.67
2004	1027	5	7	0.42	0.58
2005	1743	6	6	0.50	0.50
2006	1397	7	5	0.58	0.42
2007	1036	4	8	0.33	0.67
2008	1087	6	6	0.50	0.50
2009	900	5	7	0.42	0.58
2010	898	5	7	0.42	0.58
2011	912	5	7	0.42	0.58
Average Probability				0.42	0.58

Table 4. Probability of Wet and Dry Event Occurring for Rainfall

Variables	Average Probability	Expectation of wet years occurring
Rainfall	0.42	14* 0.42 = 5.88 ≈ 6

Table 5. Expectation of Wet Years for Rainfall

watershed area is hilly area as lot of undulations is there. Gradients are steep (1in10) on hill-slopes and slopes between 1in10 to 1in 50 usually occur on foothill regions, which may be suitable only for various water conservation measures (Sadgir, Patil, & Takalkar, 2006).

7. Soil Test

Three trial pits were used for strata classification and permeability; results are tabulated below in Table 6.

In watershed area, highly clayey soil with very low permeability is found, where the land is cultivated throughout the year. In remaining land, murum and porous rock with moderate and moderately rapid permeability is found. So land terracing, Farm pond, Contour trenching structures are possible to apply according to slope of ground for effective recharging of land (Survase, Pore, & Pawar, 2011).

8. Watershed management – Important Engineering Technique

In modern methodologies, both planning process and engineering solutions have equal roles. Engineering techniques assist in creating an optimized solution for many complex problems occurring in management of watershed. Engineering structures are widely used in various goals of watershed management like soil conservation, water conservation (quantity and quality), flood control, slope stabilization, indirectly economical development, etc. (Desai, 2005; Goyal, 2011).

8.1 Proposed Watershed Development Technique

Farm pond, farm terracing, contour bunds, contour trenching with tree plantation, gully plugs, check dams, and percolation tank, etc., structures are suggested (Table 7) based on contour survey, watershed budgeting, soil investigation result, discussion with farmers and experts, etc.

Trial Pit No.	Soil Type	Depth of layer (m)	Permeability (mm/h)	Class
	Reddish Soil	0.45	1.65	Low
1	Murum	3.00	37	Moderate
	Porous Rock	1.50	135	Moderately Rapid
	Reddish Soil	0.40	1.60	Low
2	Murum	2.90	42	Moderate
	Porous Rock	1.70	130	Moderately Rapid
	Reddish Soil	0.50	1.75	Low
3	Murum	3.10	46	Moderate
	Porous Rock	1.60	142	Moderately Rapid

Table 6. Soil Investigation Results

Details of land in watershed	Area (Ha.)	Proposed watershed management technique
Area under cultivation	661.5	1 Farm pond/acre, Bench terracing, Contour furrowing, inter cropping pattern, planning of water use.
Area under pasture	1.01	Contour bunding, Contour trenching, Plantation, Check to human & animal activities, Gully plugs.
Area under fallow land	147.9	Gully plugs, Contour bunding, Contour trenching. Plantation, use for cultivation.
Saline land	21.27	Contour trenching, Proper cultivation as per advice of agriculture board.
Stream line	_	Gully plugs, Check dams, percolation tanks, Public participation is necessary.

Table 7. Recommended Best Watershed Management Option

Generally, farmers in the Kaneri village uses single cropping pattern. As per discussion with agriculture officer of the area, he suggested cropping pattern as shown in Table 9. Also for fallow land, maintaining it properly by cutting grass two times and also by production of grass by bund cultivation (nearly 3 Ha -5% of cultivated land), supply of green fodder increases. Cultivated land use changes shown in following Table 9 (Wani & Ramakrishna, 2005).

8.2 Water to be Recharged by Proposed Conservation Structures

A) Water available for artificial recharge in watershed is 13.01 M.cum. from 790.07 ha land.

Water to be recharged / ha

= 13.01 M.cum. / 790.07 ha.

= 16000.00 cum/Ha. =6400.00 cum/Acre

It means that in the absence of water conservation structures there would be a loss of 6400.00 Cum. / Acre of water due to runoff

B) If structures were constructed-

a) The water recharge by farm pond

= [(15x15) + (9x9)]/2 x 3 = 459.00 Cum. / Acre

(Assuming it is recharged 4 times)

= 4 x 459.00 = 1836.00 Cum. / Acre

b) There would be water recharge by Contour trenching / Contour bunding / Contour terracing, etc.

= 6400.00 cum/Acre x 60%

= 3840.00 Cum. / Acre

c) There would have runoff in nala

= Total runoff - (a) - (b)

= 6400.00 -1836.00 -3840.00

= 724.00 Cum. / Acre

d) There would have water recharge by Gully plugs, Check dams,

= 724.00 x10% = 72.40 Cum. / Acre

C) Total recharge of water due to water conservation structures per acre

= (a)+(b)+(d) =1836.00+3840.00+72.40

= 5748.40 Cum. / Acre

D) Total recharge of water due to water conservation structures per Ha.

= (5748.40 x 2.5 x 790.07) /1000000

= 11.35 M.cum.

Hence 71% water will be recharged if we construct water conservation structures.

Table 8 shows current situation of water requirements and storage availability including proposed structures for water storing.

8.3 Possible Development

- Table 9 shows that crop area can be increased by 90%. This gives benefit that near about 140% increase in crop production. Figure 9 shows possible increase in crop production.
- Also from increase in crop production, bund cultivation and properly maintaining the fallow land, there is increase in cattle food as concentrate 2 times, dry fodder 3 times, and green fodder 1.5 times (Figure 10).
- There is also increase in milk production by 10% - 25%

Requirement		Storage	
Uses	Quantity (M. cum.)	Storage Type	Quantity (M. cum.)
Domestic Use	2.42	Storage in pond	28.45
Agricultural Use	46.11	Ground-water recharge	21.96
Public facilities, small industries and wastage	12.58	From proposed structures	11.35
Total	61.23	Total	61.76

Table 8. Kaneri Village - Water Requirement and Possible Storage Situation

Actual land use (Ha)	Suggested cropping pattern		Total change in land use (Ha)	% Increase in land use
160.7 (Cereal crop)	cereal + pulse cereal + vegetable	2:1 3:1	305.6 (Cereal crop)	90%
105 (Pulse crop)	pulse + cereal pulse + vegetable	1:2 3:1	201.9 (Pulse crop)	92%
237.4 (Oil crop)	oil crop + cereal oil crop + pulse	1:1 2:1	237.4 (Oil crop)	---
15 (vegetable)	---		57.6 (vegetable)	280%

Table 9. Possible Increase in Cultivated Land Use

due to dry and green fodder as per discussion with veterinary officer. By selling the milk and inter-treading of crop production and cattle feed there is increase in income from agricultural and non-agricultural activity.

Hence due to increase in inter-trading there is increase in income, i.e. Economical Development.

9. People Awareness

For increase in income through the watershed management there is necessary for peoples participation. People's participation is very important in watershed planning, implementation and management. In the Kaneri

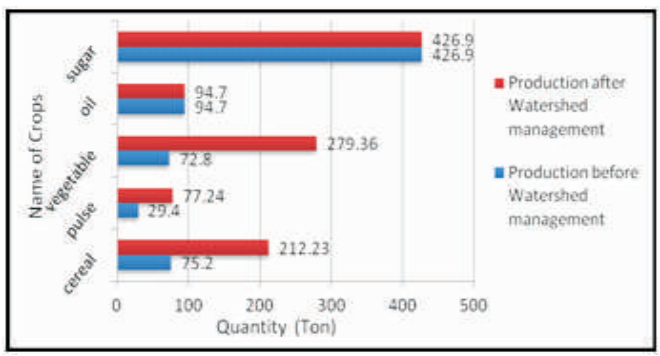

Figure 9. Possible Increase in Crop Production

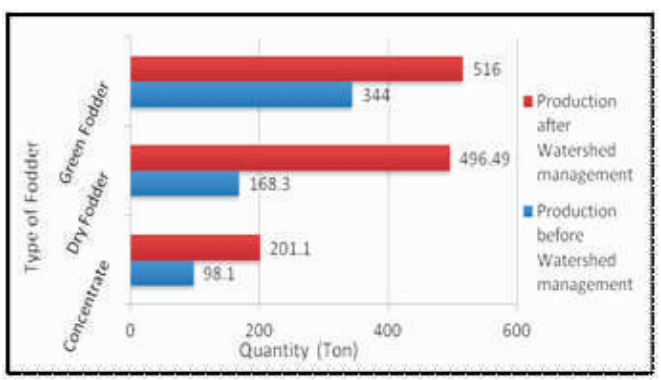

Figure 10. Possible Increase in Fodder Production

village, where they are less aware about watershed management concept and benefited schemes. For that, 100 video CDs and 150 pocket books are distributed, which explain the concept of watershed management and knowledge about self-employment works to improve economical benefits (Figure 11). Also after the discussion with the young people, their suggestions are such that: 1) after watershed management eco-tourism is possible with nearby tourism spot; 2) Hotel and lodging business which gives village life experience by constructing huts and providing Maharashtrian meal to the tourist; 3) And also supportive business (Joshi, Pangare, Shiferaw, Wani, Bouma, & Scott, 2004).

10. Effectiveness of Watershed Management

10.1 Before - After Concept

The year 2011-12 is taken to explain 'Before watershed management work' and the year 2012-13 is taken to explain 'After watershed management work'. This concept is used on a farmer which belongs to a small farmer (land holding 2 Ha.) in Kaneri village (Habtamu, 2011).

Figure 11. Distribution of CDs and Booklet

Figure 12. Constructed Farm Pond

It is found that land slope is 1in 10 to 1in 50. After a discussion and site visit, the watershed management strategy are introduced in the month of May 2012, which includes farm pond, gully plug, small earthen bund, and contour trenching (Figures 12, 13, and 14). The intercropping pattern is applied for kharif season: (Figure

Figure 13. Constructed Gully Plugs

Figure 14. Constructed Contour trenching

Figure 15. Applied Inter-cropping Pattern

15) Groundnut and Jawar in proportion with 1:1 and Corn and Tur in proportion with 2:1. Also for rabbi season, Jawar as sole crop is used. Rainfall in year 2012 is only 510 mm. Table 10 shows the cost of construction and estimated quantity of water recharged by structures.

10.2 Impacts of Watershed Management

The rain-fed land in the year 2011-12 is changed into irrigated land in the year 2012-13 after watershed management work. Figure 16 shows percentage change on cropping pattern. This resulted change in crop production is shown in Figure 17. There is also increase in milk production from buffalo, which is 0.75-1.00 liter / day to1.00-1.25 liter / day (Sreedevi, Shiferaw, & Wani, 2004).

For calculating per capita income, the value of each crop is considered according to current market price at the time of study 'before' and 'after' situation. Total income is calculated without considering expenditure. Table 11 shows status of per capita income of the farmer. Due to impact of watershed management per capita income increases by ₹ 4963/-. Thus, discussion suggested that watershed management is effective to improve economical development of village people.

Recharge Structure	Water Recharged	Cost of Construction
Farm Pond (15 m x 15 m x 3 m)	1836 Cu.m.	
Contour Trenching Gully Plug and Earthen Bunds	1224 Cu.m.	₹ 35,000/ -only
Total Recharge of Water	3060 Cu.m.	

Table 10. Result of Constructed Watershed Management Technique

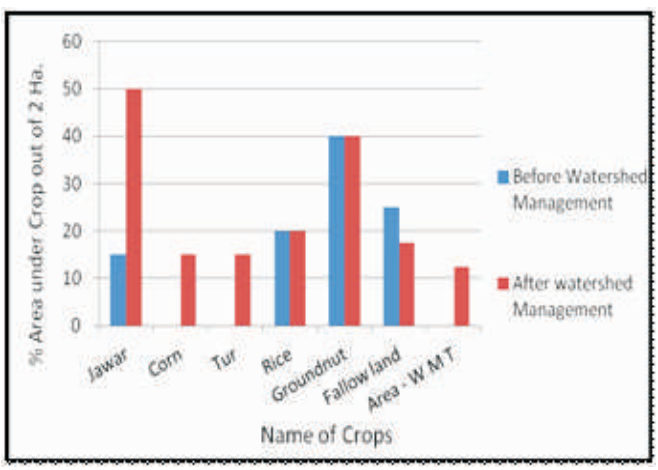

Figure 16. % Area of Different Crop - Before and After Watershed Management

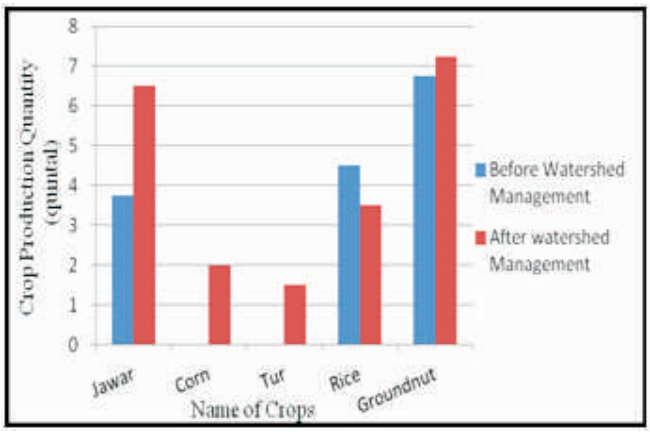

Figure 17. Crop Production - Before and After Watershed Management

Description	Before Watershed Management	After watershed Management
Total Income (₹)	65850.00	85700.00
Family Member (No.)	04	04
Per Capita Income (₹)	16462.00	21425.00

Table 11. Per Capita Income - Before and After Watershed Management

Conclusion

In the Kaneri village, productivity from agriculture and total average household income is low. So, for economical development and security of rural livelihood, there is necessity of watershed management.

- Constraints for economical development - Through the questionnaire survey, it is known that 40% of families have less than 2.5 acre farm land and 64.47% of families have income less than ₹ 50,000/-. This is due to water scarcity, insufficient conservation structures, traditional cropping pattern, less availability of cattle fodder, and low literacy rate. This study understands that detailed baseline survey of watershed before watershed management activities is important to understand profile of watershed, watershed problem, and economical constraints and identification of appropriate technologies.
- Watershed situation - It is found that Kaneri watershed has shortfall of food production for people and cattle. Also15.60 M.cum rainwater wasted as runoff and around 42% of wet years are observed in the study

area. This entire situation leads to necessity of watershed management activities to improve economical status.

- Management of watershed - By contour survey of area, it is found that watershed area has slope 2% to 10%. So management of watershed can be made possible by using a variety of technologies such as gully plug, contour trenching and bench terracing on steep slope; contour bunding, contour trenching, farm pond on gentle slope; series of check dams and earthen bunding in the streams and also inter cropping pattern.
- Possible Change in watershed - about 16.91% of water out of total precipitation is available for recharge and out of that 71% of water can be recharged by applying above technique. Also, after watershed management there will increase in land use efficiency by 90%, which will increase agricultural production by 140% and milk production by 10% to 25%. This will finally result in increase of income.
- Future solutions - Also this village is famous for tourism; hence after watershed management, eco-tourism or farm tourism is possible with related self-employment business. That will result in economical development. But for that awareness among politicians, government officials and people about watershed concept and self-employment concept is must. This can be done through various ways of advertisement.
- Impact of watershed management - The case study gives the effectiveness of watershed management. After implementation of watershed management techniques such as farm pond, gully plug, contour trench and inter-cropping pattern, there is increase in crop production by 38.33% and increase in milk production. And also per capita income increase by 30.14%. Very interestingly, this has been implemented at the expenses of only ₹35000/- for two hectare area.

Thus, through the people participation and implementation of very simple and cost effective conservation structures, economical development of people of village can be possible.

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