IMPACT OF WATER HARVESTING ON GROUNDWATER RECHARGE, PRODUCTIVITY AND NET RETURNS WITH INTEGRATED FARMING SYSTEMS APPROACH IN EASTERN DRY ZONE OF KARNATAKA[1]

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Abstract

The paper evaluates the performance of water harvesting structures by looking at the case of the Sujala watershed in Karnataka. The water harvesting structures have facilitated the rejuvenation of failed wells and enhanced the water yield. About 75% of the failed bore wells were rejuvenated as against 66% in the non-watershed. The yield of bore wells were increased by 21% in the watershed where as in non-watershed area the water yield has reduced by 11%. Investment analysis of water harvesting structures indicated that for every rupee of present investment on water harvesting structure there is a return of Rs. 2.79 in farm pond and Rs. 2.19 in recharge pits. Further, productivity of crops has enhanced through protective irrigation given at critical stages of crop growth and moisture conservation, which in turn increased the net returns of the farmer.

1. INTRODUCTION

In India, semi arid areas are characterized by low and variable rainfall, low productivity, degraded natural resources and extensive poverty. In these areas, green revolution had created little impact, where 50% of the rural population depends on agriculture for their livelihood (Kerr, 2001). Recurrent droughts coupled with reduction in number of rainy days, uncertainty of rainfall and its ill distribution are affecting surface and ground water resource availability for irrigation and potable purposes. Further, rural people are facing the predicament of acute water scarcity not only for agriculture but also for livestock and domestic needs. In response, there has been alarming increase in private and public investment on wells for irrigation and drinking water needs leading to overexploitation of groundwater. Hence, it is imperative to conserve rainwater in order to sustain not only rainfed agriculture but also groundwater-irrigated agriculture. The creation of water harvesting structures in a watershed for artificial groundwater recharge entails lumpy investments, which need to be evaluated for their cost effectiveness and social benefits. These structures for surface storage and groundwater recharge offer scarcity value for water and improve access to surface water and groundwater for rural people. Restoration of groundwater through these structures facilitates conservation and management of groundwater ensuring drinking water and sustaining agricultural production. Thus, it is imperative to evaluate the relative economics of different water harvesting structures on improving groundwater recharge and associated benefits of improved agricultural productivity, resource sustainability and livelihood security of the farming community in the watersheds.

The specific objectives of the study are: i) estimation of benefits from water harvesting structures in improving groundwater recharge, agricultural productivity, and profitability; and, ii) analysis of cost effectiveness and feasibility of investment on water harvesting structures

2. METHODOLOGY

Sujala Watershed Project is a World Bank sponsored project being implemented in 5 districts of Karnataka. Its activities are implemented in Kolar, Tumkur, Chitradurga, Haveri and Dharwad covering 1270 villages over

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5.11 lac ha. The project outlay is Rs. 676.96 crore, which includes a loan from World Bank and contribution from government of Karnataka. The objective of the project is sustainable alleviation of poverty in rain fed areas by improving production potential and natural resource base through strengthening institutional arrangements. The project lays emphasis on strengthening capacity of communities in the project area.

2.1 Selection of the Study Area

In consonance with the objectives of the study and consultation with Sujala officials, Kurudi micro watershed of Kumudavathi sub watershed in Gauribidnur taluk of Kolar district was selected for this study, and here most of the watershed activities are completed. The Kadalaveni village outside the watershed, seven kilometers away from the watershed area, was chosen as control area to compare the impact of watershed project. A random sample of 30 respondents from watershed and 30 from control area were selected from each of these villages to constitute a total sample size of 60.

Both secondary and primary data were collected for analysis. Secondary data on investment on water harvesting structures, investment pertaining to watershed activities in private and common land, transaction cost of implementation and sustainable management of watershed assets were collected from Sujala watershed office at Cauvery Bhavan, Bangalore. For evaluating the specific objectives of the study, primary data were elicited from farmers through personal interviews with pre-tested and structured schedule for 2006-07.

3. ANALYTICAL FRAMEWORK

3.1 Amortized Cost of Watershed Programme

The amortized cost represents the annual share of the fixed cost component of watershed development programme. Amortized cost of watershed programme = [(Compounded cost of total public investment on watershed structures)*((1+i) ^{15} * i)] ÷ [(1+i) ^{15} - 1].

The working life of watershed structures differed across structures. But the life of the watershed development programme as a whole was considered 15 years considering the average life of different components of watershed development programme.

Compounded cost of groundwater recharge structures = total investment on groundwater recharge structure * (1+i) $^{(2006\text{-year of construction})}$.

Average life of well $= \sum [(f_i X_i) \div \sum (f_i)]$

Where,

f_i = frequency of wells yielding irrigation water in each group

X_i = age group of well (1, 2, 3.….n in years)

i = ranges from 0 to n, where n refers to the longest age of well group

3.2 Yield of Irrigation Wells

The yield of bore well was estimated considering the perception of the bore well owners. In order to revalidate the data from farmers regarding yield of groundwater from their wells, a few cases of actual measurement of groundwater yield from the selected borewells of the sample farmers were made during collection of primary data. The measurements recorded were converted into gallons per hour using appropriate conversion[2].

3.3 Costing of Irrigation Well

Groundwater is commonly extracted from bore - wells in Kurudi micro-watershed. In order to obtain the annul share of irrigation cost, investment on well irrigation is amortized. The amortized cost of irrigation bore

[2] The time required to fill a container of known volume was recorded and converted to gallons per hour. If a bucket of 15 litres, took 5 seconds to fill when borewell was put on, then for 60 seconds or 1 minute, it would fill 180 litres, or 10,800 litres per hour equal to 2379 gallons per hour.

well = [Amortized cost of borewell + Amortized cost of pumpset and accessories + Amortized cost of conveyance + annual repair and maintenance cost of pumpset and accessories]

Amortized cost of bore well = [(Compounded cost of borewell)*$(1+i)^{AL}$ *I]   [$(1+i)^{AL}$ -1]

Where:

AL = Average life of bore wells

Compounded cost of bore well = [(Bore well cost)*$(1+i)^{(2005\text{-Year of construction})}$

Amortized cost of pump set and accessories = {[(Sum of compounded cost of pump set + pump set house + electricity at current price)* $(1+i)^{15}$ * i] [$(1+i)^{15}$ - 1]}

The working life of pump set and pump house is assumed to be 15 years

Amortized cost of conveyance = {[(Compounded cost of conveyance pipe used) * $(1+i)^{10}$ * i]+ [$(1+i)^{10}$ - 1]}

The working life of conveyance pipe (PVC) is assumed to be 10 years.

3.4 Economics of Irrigation

The amortized cost per acre-inch of water is computed by dividing the amortized cost of bore-well by the total water used on the farm. The cost of cultivation is obtained by including expenditure on human labour, bullock labour, machine hours, seeds, fertilizers, plant protection chemicals, manure, transportation and bagging, amortized cost of irrigation and the opportunity cost of working capital. The opportunity cost of working capital is considered at 12%. Cost of production is cost of cultivation + amortized cost of irrigation + interest on variable cost.

The gross cropped area (GCA) is the sum of area under crops in all the three seasons (Kharif, Rabi and Summer) + Area under perennials. The net cropped area (NCA) is calculated as, the sum of area under crops for a season (Kharif) + Area under perennials.

Gross returns for each crop are the value of the output at the prices realized by the farmers. Net returns from well irrigation are the gross returns from crops in irrigated area minus cost of production of these crops. While computing the cost of production, establishment cost of crops like tamarind, which are newly established, could not be considered, as they were still giving returns. Crop wise cost of cultivation is calculated by including water used on the farm in acre inches valued at the cost of water per acre inch for each farm. In the case of rain fed crops, the net returns are derived from subtracting the total costs from the gross revenue.

3.5 Discounted Cash Flow Techniques

The investment appraisal measures such as NPV, BCR and IRR are used to evaluate the economic feasibility of investment on different water harvesting structures. The benefit cost analysis and economic value analysis are carried out based on the investment on water harvesting structures and incremental returns accruing due to water harvesting structures in the upstream and downstream area of the watershed.

Investments on watershed projects are public investment. Hence, choice of discount rate is debatable in benefit-cost analysis. The choice of discount rate is indicative of social time preference, which is a proxy for inflation, risk and opportunity cost and it usually ranges between 3-5%. This represents the difference between the institutional lending rate and the inflation rate. The impact of watershed projects is long term in nature and for the project to be viable; the discount rate should be low. The discount rate considered for this study was 5%.

Many assumptions are made while computing the investment evaluation measures such as NPV, BCR and IRR. The difference in the incremental net returns between watershed and non-watershed was considered as the incremental net returns due to the impact of watershed development programme. This incremental net return due to the impact of watershed development programme was extrapolated for the total cultivated area. The benefits from water harvesting structures like net returns realized from fish rearing were also considered. The incremental net returns after the project implementations were considered for all the farms. Returns from second year onwards are assumed to be same over the entire period, assuming that farmers will fallow the same technology, package of practice and crop cultivation.

3.6 Land Use Pattern in the Micro Watershed

Land use pattern in Kurudi micro watershed is presented in the Table 1. Total cultivable area of the micro watershed is 600.02 ha. Bulk of the cultivable area is under rainfed farming (92%) and only 8% of the area is under irrigated farming with bore wells being the major source of irrigation. Dry land agriculture is dominated and the proportion of irrigated area was relatively low reflecting their reliance on rainfall for even moderate cropping. Thus, watershed development in this area is a gain to farmers, as it richly contributes to soil and moisture conservation and in improving natural resource base. Among the total bore wells in the micro watershed failed wells (52%) proportion was more than the functional wells (48%) emphasizing the importance of watershed on ground water recharge.

Table 1: Land use pattern in Kurudi micro watershed

Particulars	Area (ha)
Rainfed land	554.32 (92)
Irrigated land	45.7 (8)
Fallow land	41.15
Forest area	365
Total cultivable area	600.02
Total number of bore wells	117
Functional wells	56 (48)
Failed wells	61 (52)

Note: Figures in parentheses indicate percentage to total cultivable area

3.7 Investment Pattern on Watershed Treatment in Kurudi Micro Watershed

Investment pattern on watershed treatment in Kurudi micro watershed (Table 2,) indicated that soil and water conservation activities involved major investment on private land (75.11%) followed by the forestry (15.01%). Horticulture component received about 6% of the total investment. In the forestry component, silver oak, pongamia, neem and in horticulture component tamarind, sapota, and mango seedlings were given to the beneficiary farmers. These plants were mainly planted on private lands around water harvesting structures like farm ponds because of access to protective irrigation from farm ponds.

Table 2: Particulars of Investment made by Sujala on Private land

Activity	Value (Lac Rs.)	Percentage
Soil and Water conservation	33.43	75.11
Drainage line treatment	0.59	1.33
Horticulture	2.73	6.13
Forestry	6.68	15.01
Others	1.08	2.43
Total	44.51	100.00

Source: Compiled from the Sujala Watershed Project reports, Cauvery Bhavan, Bangalore

In the common land, only two components were considered viz., soil and water conservation and drainage line treatment. In both, Gokattes were constructed for impounding rainwater for domestic and livestock use (Table 3).

Table 3: Particulars of Investment made by Sujala on Common land

Activity	Value (lac Rs.)	Percentage
Soil and Water conservation	0.57	47.11
Drainage line treatment	0.64	52.89
Total	1.21	100.00

Note: Figures in the parentheses are the percentage of total investment

Major water harvesting structures constructed in the Kurudi micro watershed are farm ponds, recharge pits, earthen bunds in private land and Gokattes in the common land. Farm ponds have gained prime importance in the private land accounting for 58% of the total investment followed by recharge pits (37%). Earthen bunds, Gokatte and Nala revetment altogether accounted for less than 5% of the total investment (Table 4).

Table 4: Major Water Harvesting Structures in the Private land.

SL.No.	Structure	Total cost (Lac Rs.)	Percentage
1	Earthen Bund	1.01	3.00
2	Farm Pond	19.55	58.12
3	Recharge Pits	12.48	37.10
4	Gokatte	0.54	1.61
5	Nala Revetment	0.06	0.18
	Total	33.64	100.00

Investment on water harvesting structures was amortized to get the annual share of the fixed cost on water harvesting structures. About 104 farm ponds were constructed in the entire micro watershed and amortized cost per unit is Rs.2092. There are 28 recharge pits and the amortized cost per unit worked out to be Rs.1674. Earthen bunds were constructed in about 63 ha and amortized cost per ha is about Rs.554.81 (Table 5).

Table 5: Amortized cost of investment on Water Harvesting Structures

Structure	Unit	Qty	Cost per unit	Total cost	Average life (years)	Amortized cost (Rs.)
Common land						
Gokatte	No	9	13444.44	1.21	10	1496.72
Individual land						
Earthen Bund	Rmt	63	1600	1.01 (3)	5	554.81
Farm Pond	No	104	18798.08	19.55 (58)	10	2092.72
Recharge Pits	No	58	21517.24	12.48 (37)	15	1674.59
Gokatte	No.	4	13444.44	0.54 (1.61)	10	1496.72
Nala Revetment	No	24	250	0.06 (0.18)	5	53.04

Note: Figures in the parentheses are the percentage of total investment.

The purpose of amortization of investment on irrigation well(s) is to offer weightage to the repetitive investment on irrigation wells which is made necessary due to reducing life/age of irrigation wells, their initial or premature failure, as well as reduction in groundwater yield of wells, with different probabilities. Else, investment on irrigation wells would be considered as fixed cost which would not enter into the decision making process as the marginal cost is unaffected. However, due to increasing incidences of premature and initial failures of irrigation wells, the investments can no longer be considered as fixed costs, since they become recurring variable costs varying with well failures.

3.8 Impacts of Water Harvesting Structures on well Irrigation in the Study Area

Groundwater is an important resource in watershed development for enhancing productivity and sustainability of farming. Water harvesting structures in watershed development programme facilitates ground water recharge leading to improvement in the availability of water for irrigation. The groundwater recharge in the eastern dry zone of Karnataka with sandy loam soils is largely a function of rainfall intensity and the associated efforts to recharge irrigation wells through surface water bodies such as irrigation tanks, farm ponds and other watershed structures. There have been instances where the ground water in the wells is recharged on the very next day of a heavy rainfall, to several months for recharge. Nevertheless, the impounding the runoff rain water in surface water bodies is crucial for recharge of groundwater. Thus, even though recharge is relatively faster, it is the absence of surface water bodies with adequate water which is responsible for low or poor recharge of irrigation wells in the eastren dry zone. And hence the importance of watershed development, integrated farming systems, drip irrigation and the associated wise use of scarce groundwater. The impact of water harvesting

Table 6: Particulars of Irrigation wells in Kurudi micro watershed

Particulars		Watershed	Non watershed
Number of farmers owning irrigation wells		14	14
Total number of bore wells		20	14
Number of functioning wells	Before watershed	9	4
	After watershed	16	8
Number of Failed wells	Before watershed	11	10
	After watershed	4 (175)	6 (66)
Total number of dug wells		2	2
Average age of the irrigation wells (years)		10.8	10.7
Average life of the irrigation wells (years)		11.4	12
Average depth of the irrigation wells (feet)		323 (80-600)	380(250-700)
Water used per farm (acre inch)		62.20	42.62
Water used per acre of GIA (acre inch)		17.63	21
Irrigation cost per acre inch of water (Rs.)		159.75	246
Amortized cost per all well (Rs.)		9937	10499
Amortized cost per functioning well (Rs.)		10542	11925
Net returns per acre of GIA (Rs.)		29233	19680
Net returns per acre inch of groundwater (Rs.)		1658	1209
Average yield of the bore well (gallons per hr)	Before watershed (2001)	1979	2000
	After watershed (2005)	2396	1800
		(21)	(-11)

Note: Figures in Parenthesis indicate percentage change structures is assessed based on the number of failed irrigation wells rejuvenated, increase in the water yield in the bore wells and reduction in water cost. About 46% of the farmers have irrigation wells in both watershed and non-watershed area. Watershed farmers owned 20 bore wells. Before watershed there were about 9 functional wells and 11 failed wells. After the watershed there are about 16 functional wells and 4 failed wells. About 75% of the bore wells were rejuvenated due to the recharge effects of the recharge pit facilitated by good rain in the previous year. Studies also indicated that watershed development activities have significant impact on groundwater recharge and hence policy focus must be for the development of water harvesting structures (Palinisami and Kumar, 2005, Chandrakanth and Nagaraj, 2005).

In non-watershed areas also about 66% of the borewells were rejuvenated due to good rain but the rejuvenation of bore wells is higher in watershed compared to the non watershed. The yield of bore wells increased from 1979 gallons per hour to 2396 gallons per hour with a 21% change in the watershed. In contrast, in non-watershed area, the water yield reduced by 11% (Table 6).

Average depth of the bore wells was 323 feet in watershed area and 383 feet in non-watershed area. The average age of well was found to be 10.8 and 10.7 years in watershed and non-watershed areas respectively. The average life of bore wells in the watershed area was 11.4 years and 12 in non-watershed area. Amortized cost per bore well was lower in watershed areas (Rs. 9937) than that of non-watershed area (Rs. 10499).

Water used per acre of gross irrigated area is another indicator to assess the impact of watershed development programme on groundwater recharge. The estimated groundwater use was 62 acre-inch per farm in the watershed and 42 acre-inches for non-watershed farmers. Irrigation cost per acre-inch of water is lower in watershed (Rs.159) compared to non watershed (Rs.246). Thus analysis of cost of groundwater irrigation reveals that groundwater recharge has contributed in reducing irrigation cost. Net returns per acre of gross irrigated area is found to be much more in watershed area (Rs. 29233) compared to non-watershed area (Rs.19680). This clearly indicates positive impact of water harvesting structures on ground water recharge.

3.9 Case studies on Farm Pond based Integrated Farming Systems

Farm pond is an in situ water conservation and storage structure. Few case studies of a farm pond where the beneficiary farmer has put the water into multiple uses are given below. There are 48 farm ponds in the sample area with a dimension of 15m X 15m X 3m costing Rs. 18798 per farm pond. About two percent of farm ponds are used for multiple uses, Six percent are or growing fodder crops, six percent of ponds for crops as supplementary irrigation, 17% of farm pond were used for rearing fish and 54% used for trees which are planted and surrounded by farm pond. Hence, we have chosen some of the case studies for economic analysis.

Case Study 1

The beneficiary farmer possessed 3 acres of dry land, of which 2 acres had been devoted towards maize cultivation and 0.75 acre for finger millet. Protective irrigation was provided for maize from the farm pond water resulting in a net return of about Rs.3330. In finger millet, the incremental net returns realized were about Rs. 250, which is the result of the improved field bunds for moisture conservation.

The farmer allotted two guntas of land for napier and haemata grass and the associated net returns realized was about Rs.1700. Returns from fishery component at explicit cost in the farm pond was Rs.867. From livestock component, there was an improvement in the milk yield to the tune of two lt per day due to increased availability of fodder. The cumulative incremental return from all these activities was Rs.9406 (Table 7).

Further costing of farm pond water has been carried out to know the productivity of water. The actual dimension of the farm pond is 15 x 15 x 3 m. Considering the slope (1:1.2), the dimension of the farm pond comes to 11.5 x 11.5 x 3m. Depth of water impounded was about 10 feet and it was filled three times in year. So the total water impounded was about 1190 cubic meter in a year. The amortized cost of farm pond per year was Rs.2092. The cost per cubic meter of water was Rs.1.76 and net return per cubic meter of water is worked

Table 7: Costs and returns of Farm pond based farming system

Crop	Before				After			
	Area	Yield	TC	NR	Area	Yield	TC	NR
Maize	2	15	5130	6320	2	20	4850	9650
Ragi	0.75	3	1125	2325	0.75	4	1125	2575
Napier and Haemata (kg)	-	-	-	-	2 gunta	1900	200	1700
Fishery (number)	-	-	-	-	250	32	107.73	867.27
Livestock	1	12	14762	6805	1	14	15112	10064
Total	-	-	21017	15450	-	-	21394	24856

out to be Rs.7.90 with multiple use of water from the farm pond. This situation is again compared with the farm pond where the water is not used for multiple purposes. The cost per cubic meter of water remains same. Farm pond water is used for only haemata, which was planted on the bunds. So the increase in milk yield due to availability of fodder is considered in the net incremental returns, which comes to Rs.2.70 per cubic meter of water (Table 8). Farmers with integrated farming system have realized more benefits compared to those who have not.

Table 8: Comparison of cost and returns with and without multiple use of water

Particulars	With multiple use of water (Crop+Fodder+ Fishery +Livestock)	Without multiple use of water (Crop+Livestock)
Dimension (m)	15 x 15 x 3	15 x 15 x 3
Dimension with slope (1.2:1)	11.5 x 11.5 x 3	11.5 x 11.5 x 3
Depth of water filled (ft)	10	10
No. of times water filled in year	3	3
Water impounded in one filling (Cubic meter)	396.75	396.75
Total water impounded (m^3)	1190.25	1190.25
Amortized cost (Rs.)	2092	2092
Cost per cubic meter of water (Rs.)	1.76	1.76
Net returns per cubic meter of water	7.90	2.70

Case Study 2

In another case study, the farmer had three acres of dry land, of which 0.75 acre was devoted towards cultivation of chilly using the farm pond water. Around 4 irrigations were provided from farm pond water using kerosene oil pump. The net return realized from chilly was about Rs. 3720. On the periphery of the farm ponds, vegetables were grown resulting a net return of Rs. 1160. Similarly, the net returns due to fishery component in the farm pond was Rs. 867, while the incremental net return from increased milk yield was about Rs. 1804. The sum of incremental net return realized was about Rs. 7551 (Table 9).

Case Study 3

In this particular case, a number of components are included such as vegetables, flowers and fodder crops. In the adjacent land, different layers of trees have been grown (silver oak, drumstick, bamboo, lemon, papaya, mango, sapota, jack, jamoon, tamarind and ficus). Fish rearing was undertaken in the farm pond water

Table 9: Case Study

Particulars	Area	Yield	TC	NR	Area	Yield	TC	NR
Maize (Qtls)	2	16	3780	7420	2	16	3780	7420
Chilly (Qtls)	-	-	-	-	0.75	6	8280	3720
Vegetables grown								
inside the farm pond	-	-	-	-			445	1160
Fisheries	-	-	-	-	250	32	107.73	867
Livestock (Buffalo) (ltrs/day)	1	4.5	5040	5112	1	5	5040	6916
Total	0	0	8820	12532	0	0	17652.73	20083

Note: Vegetables grown are ridge gourd, Bottle gourd, Pumpkin, Ladies finger, castor and red gram

and haemata was grown on the farm pond for fodder as well as it serves as a good soil binder. The total present net benefits from the farm pond were about Rs.4543 per year (from vegetables, fishery and livestock). For the tree crops, the expected benefits over the lifespan are considered for working out the net present value. There are about 100 trees planted around the farm pond and NPW from these constituted around Rs.6, 92,293 and per tree, it worked out to be Rs.6923. The BC ratio was 14 and the IRR was 38%. In addition to the economic benefits, the bio diversity of the field has improved (Table 10).

Table 10: Case study

Particulars	Net returns
Present benefits	
Vegetables grown in small scale	708
Returns from fishery (Explicit cost)	460
Returns from live stock (incremental net returns)	3375
Total present benefits	4543
Expected benefits from the trees grown around the farm pond	
NPW (Rs.)	6,92,293
BC ratio	14
IRR (%)	38

3.10 Additional Costs and Returns Due to Introduction of WHS

Partial budgeting analysis was carried out to analyze the profitability of water harvesting structures. In this regard, the additional cost and additional returns realized due to the investment on water harvesting structures is considered. Analysis was carried out separately for each water harvesting structure.

In the case of farm pond, partial budgeting analysis was carried out with integrated farming system and without integrated farming system. Integrated farming system approach includes fishery, vegetables on a small scale and livestock. In this case additional returns (Rs. 6144) obtained exceeded the additional cost (Rs. 2994) resulting in a net gain of Rs. 3154 (Table 11).

Table 11: Additional costs and returns due to farm pond with Integrated farming system.

Cost		Benefits	
Added costs		Increase in benefits	
1. Amortized cost of farm pond	2092	1. Additional returns from fishery	975
2. Additional cost on fishery	107	2. Additional returns from the vegetables grown	1605
3. Additional cost incurred on growing vegetables	445	3. Additional returns from cow (increase in milk yield by 1.5 ltr per day due to haemata grown on farm pond)	3564
4. Additional cost on Haemata	350		
Total	2994	Total	6144

Net gain: Rs. 6144 - Rs.2994 = Rs.3150

Table 12: Partial budgeting for the Farm pond without Integrated farming system.

Cost		Benefits	
Added costs		Increase in benefits	
1. Amortized cost of farm pond	2092	Additional net returns from increased productivity of tamarind	1000
2. Additional cost on Haemata	350	Additional returns from cow (increase in milk yield by 1.5 ltr per day due to haemata grown on farm pond)	3564
Total	2442	Total	4564

Net gain: 4564-2442 = 2122

Without integrated farming system, the additional returns realized were Rs.4564 and the additional cost was Rs.2442 with a net gain of Rs.2122. In this case, farmers had sown only haemata seeds as fodder on the farm pond to feed livestock. There was also an added return due to plantation of the tamarind trees (Table 12). Thus, the integrated farming system approach generated more benefits than without integration of enterprises.

In the watershed, recharge pits were exclusively constructed for the recharge of borewells. As a result, the added cost (amortized cost) was about Rs.1674, and the added gains in terms of net returns realized from additional area bought under irrigation was Rs. 14160. The recharge pits enabled to increased area under irrigation to the tune of 0.54 acre (Table 12).

3.11 Benefit Cost Analysis

The results of Benefit-Cost analysis of water harvesting structures are presented in the table. Sensitivity analysis was also carried out to determine the feasibility of the investment on water harvesting structures with a fall in expected net returns by 10-20%. Farm pond yielded a net present worth of Rs.132 lac upon realization of expected returns. If there is 10% reduction in expected returns, it would give a net present worth of Rs. 118 lac and with 20% reduction in expected returns it was 105 lac. Discounted benefit cost ratio was Rs. 2.79, Rs. 2.51 and Rs. 2.23 upon realization, 10% reduction and 20% reduction in expected net returns. The IRR worked out to be 14% and 13% upon a reduction of 10 and 20 percent expected net returns. In the case of recharge pits, the net present worth per acre was Rs. 62 lac, 54 lac and 45 lac respectively under three conditions. With respect to

BCR Rs. 2.10 is obtained per rupee of investment on recharge pit on realization of expected returns. All these measures indicated that the investment on farm pond and recharge pits (which forms around 95% of total investment on water harvesting structures) is economically feasible (Table 13).

Table 13 : Benefit cost analysis of water harvesting structures

Particulars	Investment on WHS (Lac Rs.)	Total cost including maintenance cost (Lac Rs.)	NPV @5% (Lac Rs.)	Discounted BCR	IRR (%)
Farm ponds					
Upon realization of expected returns	19.55	47.36	132.18	2.79	14
Upon reduction of 10 percent of expected returns	19.55	47.36	118.97	2.51	14
Upon reduction of 20 percent of expected returns	19.55	47.36	105.75	2.23	13
Recharge pits					
Upon realization of expected returns	12.48	29.95	62.93	2.10	56
Upon reduction of 10 percent of expected returns	12.48	29.95	54.27	1.81	49
Upon reduction of 20 percent of expected returns	12.48	29.95	45.61	1.52	42

4. SUMMERY AND CONCLUSIONS

The productivity of crops has enhanced through protective irrigation given at critical stages of crop growth and moisture conservation, which in turn increased the net returns of the farmer. About 75% of the failed borewells were rejuvenated as against 66% in the non-watershed. The yield of bore wells were increased by 21 percent in the watershed where as in non-watershed area the water yield has reduced by 11 percent. Few case studies of a farm pond where the beneficiary farmer has put the water into multiple uses have been compared with the case where water has not been put into multiple uses. Cost per cubic meter of farm pond water is Rs. 1.76 while net return is Rs. 7.90 with multiple uses of water (integrated farming system) and Rs.2.70 for without the multiple use of water. Partial budgeting analysis indicated the highest net gain (Rs. 3154) in the case of multiple use of water (IFS) compared to without multiple use of water (Rs. 2122). In the case of recharge pits additional returns (Rs. 15834) exceeded the additional cost (Rs.1674) with a net gain of Rs.14160. In earthen bunds, there was a net gain of Rs.696/ha. Investment analysis of water harvesting structures indicated that for every rupee of present investment on water harvesting structure there is a return of Rs. 2.79 in farm pond and Rs. 2.19 in recharge pits. IRR is around 14% in farm pond and 56% in recharge pits.

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