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Economical evaluation of water conservation measures and water management practices adopted by ground water used farmers in micro watershed of Karnataka

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■ **ABSTRACT :** The groundwater is a highly scarce resource in Karnataka state and is also depleting fast. It is one of the major factors of production in the agrarian economy of the state. The groundwater draft in the state is more than its recharge, particularly in the arid and semiarid regions and has caused deepening of groundwater table. The watershed management approach is considered as a sound approach for achieving better agricultural development as forges soil and water conservation practices, so that we can achieve sustainable crop production. Present study was conducted in the Gamanagatti (1002 ha) micro watershed which is located at a distance of 12 Km from Hubli city of Karnataka state. The individual farmer adopted different package of conservation practice on their own depending upon the requirement and availability of resources. Soil and water conservation is a long range benefit programme and the immediate returns on the investments are never spectacular. The evaluation of water conservation methods are being carried out in terms of physical, social and economic aspects. For the purpose of economic evaluation, the most widely used technique is benefit-cost analysis (BCA). Apart from BCA, other criteria such as internal rate of return (IRR), net present value (NPV) and pay back period were also used.

■ **KEY WORDS :** Bore well, Drip irrigation, Ground water, Watershed management, Benefit cost ratio

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Groundwater is one of the largest available sources (22.1%) of fresh water in the hydrologic cycle. About 35% of the total irrigated area is irrigated using groundwater. However, it's over exploitation is leading to continuous decline in the groundwater table. The ultimate irrigation potential of Karnataka, including groundwater is assessed as 5.5 million ha, out of which 3.5 million ha will be from major irrigation, 1.0 million ha from minor irrigation and the remaining 1.0 million ha from groundwater. The estimated groundwater potential of the Karnataka state is 18.18 per cent of the total irrigation potential of the state (Anonymous, 2002). Groundwater usage and its development are also controlled by the socio-economic conditions of the farmers apart from the technical feasibility. The factors which determine the extinct of groundwater use are the cropping pattern, crop water requirement, groundwater management, efficiency of irrigation methods and systems, policy interventions in providing subsidized electrical power to agriculture, type of groundwater extraction devices and well density. Excessive usage of groundwater will lead to its irreversible degradation.

Recently Karnataka has witnessed an explosive increase in the development and use of groundwater. This is because of expansion of the area under well irrigation. The current availability of groundwater is not uniform, as intensive groundwater extraction in several areas has led to critical shortages and premature failure of irrigation wells. A cursory look at the groundwater map of Karnataka indicates that there is still a large proportion of white area (Sufficient water availability) wherein groundwater development is below 60 per cent. This is further leading to converting of 'white' to 'grey' areas and 'grey' areas to 'dark' areas (zero availability).

It is reported that soil conservation practices have a net effect in increasing recharge to an extent of 14.02 to

19.52 per cent of rainfall in Udaipur region (Gund *et al*., 1992). It is predicted that, in the coming decades, water quantity used for present day agriculture will be reduced by 20 to 25%. Micro irrigation which includes drip and micro sprinklers is an effective tool for better and scientific management of water resources. The watershed management approach is considered as a sound approach for achieving better agricultural development as forges soil and water conservation practices and crop production practices sustainably. In areas where access to surface water is limited, groundwater usage becomes more significant. It is also a function of recharge. The major impact of watershed development is conservation and effective utilization of resources including groundwater. Preliminary studies have indicated that area irrigated with well water has increased after water conservation methods are adopted in a few watersheds in Karnataka.

Sujala watershed programme is a World Bank sponsored project undertaken by the Government of Karnataka, and it integrates the technologies and social strategies to develop and conserve land and water resources. Sujala watershed programme covers five districts of Karnataka (Chitradurga, Haveri, Kolar, Tumkur and Dharwad) consisting of 479 micro watersheds of 38 talukas to undergo watershed treatments. Soil and water conservation is a long range benefit programme and the immediate returns on the investments are never spectacular. There was a need to carry out a systematic study on the economical benefits accruing to farmers who are benefiting from the enhanced availability of ground water for raising of irrigated crops in areas where watershed development works have been implemented in the rainshadow areas of in the vicinity of the western Ghats in Dharwad district.

METHODOLOGY

The need for groundwater recharge through rainwater harvesting is an important phase under Sujala Watershed programme. The Unkal watershed (Catchment area spread over an area of 3800 sq km) constitutes its runoff to Unkal tank. The Unkal watershed comprised of Sattur, Sutagatti, Gamanagatti, Amargol, Bhairidevarakoppa and Unkal micro watersheds. Out of these six, Gamanagatti and Sutagatti were under taken for the study. The Gamanagatti (1002 ha) and Sutagatti (384 ha) micro watersheds are located at a distance of 12 and 14 km, respectively from Hubli city. Area of these micro watersheds are spread between 15^0 20'' to 15^0 25'' N latitude and 75^0 0'' to 75^0 10'' East longitude. In Gamanagatti and Sutagatti micro watersheds the arable land under irrigation is less than 20 and 31 per cent, respectively and the rest remains under rainfed farming.

At present Gamanagatti and Sutagatti micro watersheds have total populations of 4177 and 2200, respectively. Agriculture is the main occupation for more than 80% families and livestock activity serves as a subsidiary occupation as well as majority of the holdings were small (less than 2.5 ha). The average size of holding was 2.7 ha. Groundwater is the major source of irrigation in Gamanagatti and Sutagatti micro watersheds. There were 125 bore wells, 20 open wells and 2 ponds as sources for irrigation purpose in the micro watersheds. Indian Development Service (IDS) a Non-Governmental Organisation (NGO) was pivotal in implementation of interventions in Unkal watershed under the assistance of Sujala Watershed Programme in 2003.

The activities of watershed development programme include implementation of soil and water conservation structures at terrace and inter-terrace levels. The requisite data for the study was obtained directly from the operational area of research and also from secondary sources. On-farm data for the study were collected through personal interviews using structured questionnaire proforma from 50 sample farmers (out of 435 farmers) in Gamanagatti micro watershed and 20 farmers (out of 229 farmers) in Sutagatti micro watershed. The sample farmers were selected randomly on the basis of changes perceived in irrigation practices and adopted by the farmers in consultation with watershed management institution.

In order to quantify the impact of soil and water conservation due to different combination of mechanical measures, five farms were identified from Gamanagatti and Sutagatti micro watersheds. Inter terrace soil and water conservation measures adopted by selected farmers using ground water were studied. Commonly adopted water conservation in this area is contour bunds, farm pond and recharge pits. The economic viability of irrigation methods and practices adopted by sample farmers using groundwater source was taken up.

The cost of well irrigation was worked out taking into account of total cost of bore well construction, cost of pump set, cost towards conveyance, electricity at current price and repairs and maintenance of pump sets and its accessories. A total cost of irrigation from well is calculated as the sum of average annual cost towards the above items. The Average annual returns obtained, before and after the years of adoption of well irrigation were estimated for the purpose of economic evaluation in case of each well.

Unit cost of irrigation water can be calculated by considering the amortization cost of well (the annual fixed cost component of irrigation water).

Amortized cost of irrigation using bore well water = (Amortized cost of bore well + amortized cost of pump set + amortized cost of conveyance + amortized cost of irrigation system + repairs and maintenance cost of pump set and its accessories).

Amortized cost of bore well (BW)= {Compounded cost of bore well * $(1+i)^{Al}$ * i] / [$(1+i)^{Al}$ – 1}

where, Al= Average life of bore well (15 years) (Sripadmini, 2000). Compounded cost of BW=Cost of BW * (1+i)(2005-year of construction)

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

where, Al= Average life of bore well : (15 years) (Sripadmini, 2000).

Amortized cost of conveyance = [(compounded cost of conveyance pipe used) X $(1+i)^{Al}$ X i) / [$(91+i)^{10}$ -1]

where, Al= Average life of bore well : (10 years) (Diwakar, 2000).

Amortized cost of irrigation system = [(compounded cost of irrigation system) X $(1+i)^{Al}$ X i) / [$(1+i)^{10}$ -1]

where, Al= Average life of furrow irrigation system : 3 years.

Sprinkler irrigation system:(12 years) (Acharya *et al.*, 1996).

Drip irrigation system =(10 years) (Shete *et al.*, 1996).

The amortization cost gives the total fixed cost component of irrigation water for each year, which is divided by total volume of water supplied to field in the year to get the unit cost of irrigation water.

Different combinations of water conservation methods adopted by sample farmers were grouped in five categories. The sum of average annual cost of cultivation, average cost of irrigation and average cost of conservation structures of individual farm were compared with net returns for computation of financial feasibility. The average life of the conservation structure was considered as 10 years for calculation purpose (Rambabu *et al*., 1994).

The investment made by the farmers on various water conservation measures were evaluated using the standard as NET present value (NPV), benefit-cost ratio (BCR) and pay back period (PBP). The net present value represents the discounted value of the net cash flow from the project. This is simply the present worth of incremental net benefit or incremental cash flow stream.

$$\mathbf{NPV} = \sum_{i-1}^{n} \frac{\mathbf{Y_i}}{(\mathbf{1+r})^{\mathbf{i}}} - \mathbf{I}$$

$$\frac{\mathbf{Y_i}}{(\mathbf{1+r})^{\mathbf{i}}} = \frac{\mathbf{Y_1}}{(\mathbf{1+r})^{\mathbf{1}}} + \frac{\mathbf{Y_2}}{(\mathbf{1+r})^{\mathbf{2}}} + ----- + \frac{\mathbf{Y_n}}{(\mathbf{1+r})^{\mathbf{n}}}$$

where, Y_i = Net cash flow at the end of Year (i) = i=1, 2, 3, ——n

n= life (productive) period of the project, r = Discount rate.

The investment made in project is said to be financially feasible, if NPV is positive, not feasible if NPV is negative and if NPV is zero, the investment is of no difference.

BC ratio gives NPV per Rupee of investment. It is worked out by discounting the net returns between the life periods of the project.

$$\mathbf{BCR} = \frac{\textbf{Discounted netreturns}}{\textbf{Initial investment}}$$

$$\mathbf{BCR} = \sum_{i-1}^{n} \frac{\mathbf{Y_i}}{(\mathbf{1+r})^{\mathbf{i}}} \Big/ \mathbf{I}$$

$$\frac{\mathbf{Y_i}}{(\mathbf{1+r})^{\mathbf{i}}} = \frac{\mathbf{Y_1}}{(\mathbf{1+r})^{\mathbf{1}}} + \frac{\mathbf{Y_2}}{(\mathbf{1+r})^{\mathbf{2}}} + ----- + \frac{\mathbf{Y_n}}{(\mathbf{1+r})^{\mathbf{n}}}$$

It is the time required to cover the invested money in the project. It is interpreted that the lower the pay back period better the project.

$$\mathbf{PBP} = \frac{\textbf{Initial Investment}}{\textbf{Net Return}}$$

RESULTS AND DISCUSSION

The falling water table and declining water quality implications in micro watershed area showed that dug wells are often limited 20 to 30 ft. As the water table declines these go out of production and many farmers cannot afford to construct tube wells (Nagraj and Chandrakanth, 1995). The economic implications of groundwater irrigation stated that the lowering of water table is one of the critical issues which directly results in the rise of both capital cost and operating costs. The decline of water table in the hard rock area of Karnataka, has led to increase in capital cost and consequently increase in the annual fixed cost of irrigation (Janakrajan, 1993). The economic feasibility of investment on borewell irrigation will be worked out using standard discounting cash flow techniques. The average Net Present Value (NPV) of bore well irrigation in Gamanagatti (Rs. 66,212) and Sutagatti (Rs. 40,334) micro watersheds show the positive NPV which signifies that well irrigation is economically viable but such a huge investment restricts the small and marginal farmers from venturing into well irrigation. The average BCR worked out at 10 per cent discount rate was higher in Sutagatti (2.46) than in Gamanagatti (1.82) micro watershed (Table 1).

Table 1 : Economics of bore well irrigation

Particulars	Gamanagatti*	Sutagatti**
Net present value (10%)	Rs. 66,212	Rs. 40,334
Benefit cost ratio (10%)	1.82	2.46
Pay back period (years)	2.85	3.19

* 90 Bore wells ** 35 Bore wells

The falling water table causes ground water used farmers to go for scientific water management approaches that address both the water supply and end use. The major factors responsible for over exploitation of the groundwater are flat rate of tariff and free supply of electricity and cultivation of water intensive crops (Singh, 1995). Flat electrical charges (Rs. 1000/ 1hp pump/year) imposed by state government make farmers less interested in adopting improved irrigation practices like drip and sprinkler system. Economics of irrigation water will give the knowledge on benefits of different irrigation methods. To know the unit cost of irrigation water from different irrigation methods, total volume of water applied to the selected farms in a year and annual expenditure on irrigation system were calculated to get the cost of unit irrigation water. The result reveals that unit cost of irrigation supplied by furrow method in farm1 was the lowest (0.44 Rs/ m^3) followed by sprinkler system at farm 2 (0.63 Rs/ m^3), drip system at farm 3 (0.68 Rs/ m^3), sprinkler at farm 4 (0.71Rs/m^3) and drip irrigation system at farm5 (0.78Rs/m^3) (Table 2). However, unit cost of irrigation water through drip and sprinkler system was slightly higher than the furrow irrigation system. The farmers using ground water for irrigation through electrical pumps are needed to pay at flat rate per year based on the HP of irrigation pump. For this reason micro irrigation is believed to be expensive venture in Karnataka state. Thus, if water saving is considered the unit cost of water will be less in case of drip and sprinkler irrigation system. Government may intervene in this and should make policy that subsidiary electricity will be available to those who will adopt the micro irrigation system.

Table 2 : Unit cost of irrigation water at selected farms

Sr. No.	Irrigation type	Unit cost of irrigation water (Rs/m^3)*
Farm 1	Furrow	0.44
Farm 2	Sprinkler	0.63
Farm 3	Drip	0.68
Farm 4	Sprinkler	0.71
Farm 5	Drip	0.78

* Considered flat electrical charge for the purpose of calculation *i.e.* Rs. 1000 /1 Hp/ Year

Watershed treatment is one of the important practices which protect the two important natural resources *i.e.*, land and groundwater. The investment made on conservation measures was evaluated by using the project evaluation criteria. The project evaluation techniques of net present value (NPV), benefit cost ratio (BCR) and pay back period (PBP) were employed. The economic life of farm pond, contour bund and recharge pit was assumed to be 10 years each. Cash flows were discounted at 10 per cent rate as this discount rate represents the opportunity cost of capital.

The NPV was positive and highest at Rs. 6582 in case of recharge pit followed by combination of contour bund, recharge pit and farm pond with Rs.4,967, only contour bund Rs.3,618, combination of contour bund and farm pond Rs. 3,364 and contour bund and recharge pit combination with Rs. 3,183 which implied that investment in all combination is economical viable (Table 3). All the measures as a package

Table 3 : Economic feasibility of different water conservation methods

Sr. No.	Water conservation methods adopted	NPV (10%)	BCR (10%)	PBP (years)
1.	Contour bund only	Rs.3,618	2.27	3
2.	Recharge pit only	Rs.6,582	1.66	4
3.	Contour bund + recharge Pit	Rs.3,183	1.24	5
4.	Contour bund + farm pond	Rs.3,364	1.22	5
5.	Contour bund + recharge pit + farm pond	Rs.4,967	1.20	5

Table 4 : Economic feasibility of conservation structure in selected farms

Sr. No. (1)	Cost of irrigation (Rs./year) (2)	Cost of cultivation of total area (Rs./year) (3)	Cost of cons. measures adopted (Rs.) (4)		Total cost (Rs./year) (5)=(2+3+4)		Gross return (Rs./year) (6)		Net returns (Rs./ha) (7) = (6)-(5)		Enhanced returns in 2005 (Rs.) (8)=(7A-7B)	B-C ratio (9)	
			2004*	2005	2004	2005	2004	2005	2004 A	2005 B		2004	2005
Farm 1 (1.6 ha)	9,891	15,000	-	4,000	29,891	33,891	69,891	77,391	25,000	27,187	2,187	1.33	2.05
Farm 2 (1.4 ha)	6,494	12,000	-	10,000	28,494	38,494	65,994	82,497	26,785	31,428	4,643	1.30	1.14
Farm 3 (2 ha)	21,866	20,000	-	13,600	49,866	63,466	1,22,466	1,51,466	36,300	44,000	7,700	1.45	1.38
Farm 4 (4.8 ha)	19,438	20,000	-	14,000	39,438	53,438	1,04,438	1,23,438	32,500	35,000	2,500	1.64	1.30
Farm 5 (8 ha)	42,336	30,000	-	26,000	72,336	98,336	1,97,336	2,43,336	25,000	29,000	4,000	1.73	1.47

could pay back with in a reasonably short span of time, although the economic life was much longer. This supports the view that soil and water conservation technologies adopted to improve crop production are viable under farmers' management level (Pande, 2000).

Among all the measures contour bund system found to pay back with in a short span of 3 years and recharge pit requires 4 years to get back the investment. All the combination of water conservation structures had positive NPV which signifies that investment is economically viable. The BCR was highest for contour bund system (2.27). The combination of contour bund, recharge pit and farm pond had given low BCR(1.20) with longer pay back period (5 years) as compared to other combinations. While interpreting results, it is found that farm pond not only conserves the water, it also harvests the water for recycling for crop production. On the other hand, groundwater recharging has additional in balancing ecosystem importance. The criteria of project evaluation amply justifies that it is economically viable if harvested water gets economic value. These findings are in accordance with finding of Rambabu *et al*. (1994). Detailed economic feasibility test was carried in selected five farms (Table 4). During the period 2004, there was no conservation measures imposed in the farms. Further, on imposition of water conservation measures in farms, enhancement in net returns could be seen in all farms. To a maximum extent of Rs.7,700 incase of Farm3, followed by Farm2 (4,643) and Farm5 (4,000). The BCR was higher in case of Farm1 2.05 during 2005 compared to the year 2004 (1.33). Other than Farm1 all farms show decreased B-C ratio during 2005 because of the higher investment on water conservation measures. Even returns were positive after implementation of soil and water conservation structures.

Conclusion and future directions:

Of the total area under irrigation, maximum area was under furrow irrigation followed by drip irrigation and sprinkler irrigation. For optimum utilization of ground water resources drip irrigation may be promoted by the Government. However, the investment per ha in drip irrigation infrastructure was the highest (Rs. 14,065) followed by sprinkler irrigation (Rs. 6,082) and furrow irrigation (Rs. 5,135). Thus, drip irrigation could be promoted with the help of government intervention through provision of easy credit-subsidy combination. Even farm ponds are not economically feasible at individual farm level because of small fragment land holding and higher initial investment. This may construct on community base. Depletion of water table, increase in bore well operating cost and increase in failure of wells are the concerns for micro watersheds. Hence, Government may think of bringing in a legislation to declare "Groundwater as a National Resource" so that groundwater resource could be utilised optimally and equitably.

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