Economic Contribution watershed program to groundwater recharge in India

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Abstract

In this study economic impact of Sujala watershed is assessed with regard to groundwater recharge, efficiency and equity in the distribution of benefits in India. Field data for 2004-05 (drought year) and 2005-06 (normal year) from 30 sample farmers in Sujala watershed forms the data base for the study. Another sample of 30 farmers from Non-Sujala (or DPAP) watershed, and 30 from outside watershed area form the control. Farmers were further classified as (i) those who had bore well irrigation and (ii) those who had no borewell irrigation in order to assess the impact of watershed.

The amortized cost per functioning well and cost per acre inch of groundwater in Sujala watershed (Rs. 9,470, Rs.125) is lower than Non-Sujala watershed (Rs. 10,027, Rs. 117) and non-watershed area (Rs. 11,140, Rs. 138). The economic contribution in terms of incremental net returns per acre in (i) Sujala over non-watershed area (in drought year, normal year) equal to contribution of Sujala watershed (is Rs. 1726, Rs. 3650); (ii) Sujala over Non-Sujala (DPAP) watershed (equal to the contribution of Sujala watershed institutions) (is Rs. 1067, Rs. 898); (iii) Non Sujala (DPAP) over non-watershed area (equal to contribution to Non-Sujala or DPAP watershed) (is Rs. 133, Rs. 2226) all indicate economic supremacy of Sujala watershed program.

The incremental net returns of Sujala over non-watershed area (in drought year, normal year) for farmers possessing irrigation wells (is Rs. 614, Rs. 5056); for farmers not possessing irrigation wells (is Rs. 7354, Rs. 5326); for all classes of farmers (is Rs. 3066, Rs. 4967) are the *prima facie* indicators of economic contributions of Sujala watershed program. The negative externality per well per year in Sujala is Rs 2652, in Non-Sujala watershed is Rs. 2735, and in non-watershed area is Rs. 4285, and shows that the negative externality in groundwater irrigation has reduced by 38 percent in Sujala over non-watershed area.

Key words: Watershed development, externality, Economic contribution

Preamble

Water harvesting for groundwater recharge has been a major objective of watershed programs in India. Sujala project initiated by Government of Karnataka, India, with the assistance of the World Bank is an unique program where the project is implemented on both common lands and farmers' lands with cost-sharing. Sujala is being implemented in 5 districts of Karnataka covering 5.11 lakh hectares of land spread over in 77 sub-watersheds, 741 micro watersheds and 1270 villages benefiting 0.4 million farmers including landless. The overall Sujala watershed project cost is Rs. 6777 million of which Rs. 5408 millionis financed by the World Bank, Rs 725 millionis borne by the Government and Rs 643 million is contributed by farmers. This study aims to assess the economic impact of Sujala watershed programme and Non-Sujala watershed in Karnataka on groundwater recharge, agricultural productivity, and equity in distribution of benefits among different classes of farmers (Figures 1, 2,3)..

Methodology

The main feature of this study is in its estimation of economic contribution of watershed program by comparing performance in drought year (2004) with normal rainfall year (2005), along with comparison of Sujala watershed (with relatively strong institutional background) with non_Sujala watershed (here the Drought Prone Area Program- DPAP watershed) as well as Non watershed area. We have used the ANOVA to reflect the differences.

In the *Veda river* sub-watershed of Sujala watershed in Hosadurga taluk, one micro watershed Sivanekatte -1 was selected for detailed study. Non-Sujala (DPAP) watershed in Hosdurga taluk was selected for comparison with Sujala watershed to estimate the differential impact. A sample of 30 farmers each from Sujala watershed and Non-Sujala watershed and Non-watershed area was chosen, totaling 90 farmers for this study.

Usually there are two types of farmer benficiaries in Watershed program: (i) farmers totally dependent on rainfall and (ii) farmers possessing irrigation wells, as watershed program complements the agricultural activities of farmers possessing irrigation wells. It is hypothesized that if the watershed impact is relatively higher on the first category than the second, the purpose of the watershed development program is served. In this study, the impact of watershed program is estimated on these two categories of farmers and in addition estimated for the overall group (i.e. both these classes taken together). In this study, a sample of 30 farmers is drawn from Sujala watershed program, another sample of 30 farmers is drawn from Non-Sujala (DPAP) watershed.

A third sample of 30 farmers is drawn from non-watershed program area as control for comparison. The required farm level data have been obtained for the drought year of 2004 and for the normal rainfall year of 2005 from Veda River bank sub-watershed and Shivanekatte micro watershed. The DPAP watershed is located in Bokkikere and Srirangapura. The control area villages are Nagenahally and Honnekere. In each sample, the farmers were post stratified into two groups of farmers (i) those who are totally dependent on rainfall and not possessing irrigation wells, and (ii) those who are possessing irrigation wells in the watershed.

I. Contribution of watershed program for farmers not possessing irrigation wells:

Farmers who are totally dependent on rainfall and not possessing irrigation wells form an important class of beneficiaries in a watershed program. They are far more exposed to the vagaries of weather and market uncertainties than the 'haves'. The contribution of Sujala watershed program for these farmers totally dependent on rainfall is thus a serious equity issue, since these farmers with a relatively low endowment, will have been benefited the most, compared with the impact on farmers who are in possession of irrigation wells. The contribution of Sujala and Non-Sujala watershed (DPAP) in a drought year (2004) as well as in a normal rainfall year (2005) for these farmers is thus estimated using the net returns (as enunciated in Table1).

Table 1: Estimated contribution of Sujala watershed development program exclusively for farmers who totally depend on rainfed agriculture (and not possessing irrigation wells) in Veda river bank in Chitradurga district, 2004-05

Rs per acre

Sl. No	Particulars	Drought year (2004)	Normal rainfall year (2005)
1	**Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)**	**(= 4405 - 4849) = - 444**	**(= 5245- 6094) = - 849**
2	**Contribution of Watershed institutions (= net returns in Sujala minus Net returns in Non-Sujala WDP)**	**(=12203- 4405) = 7798**	**(=11418- 5245) = 6173**
3	**Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)**	**(= 12203- 4849) = 7354**	**(=11418-6094) = 5324**

The estimated contribution of watershed institutions in the drought year (2004) as well as in normal rainfall year (2005) for farmers totally dependent on rainfed agriculture is Rs. 7,798 and Rs. 6,173 respectively. The overall contribution of Sujala watershed program to farmers

totally dependent on rainfall is Rs. 7,354 in the drought year (2004) and Rs. 5,324 in the normal rainfall year (2005). Thus, Sujala watershed program has richly benefited the 'have nots' (farmers dependent on rainfall).

In corroboration of these findings, the ANOVA performed by comparing the net returns per acre for farmers dependent on rainfall in a drought year (2004) as well as in normal rainfall year (2005) in Sujala watershed, Non-Sujala watershed and Non-watershed area, indicates that the net returns per acre from all sources for farmers totally dependent on rainfall in Sujala watershed are significantly higher than those in Non-Sujala (DPAP) watershed and in Non-watershed area. Thus, the contribution of Sujala watershed to farmers totally dependent on rainfall is both statistically and economically significant *(Tables 4 and 5)*.

II. Contribution of watershed program for farmers possessing irrigation wells

Considering the contribution of watershed program for farmers possessing irrigation wells, the results (Table 2) indicated that the contribution of Non-Sujala watershed (DPAP) on the farmers possessing irrigation wells is Rs. 680 in a drought year (2004) while it rose to Rs. 5,417 in a normal rainfall year (2005). However, the role of Sujala watershed institutions is negative in 2004 and 2005 indicating that the institutions have to have different and better strategies exclusively for farmers possessing irrigation wells. This does not mean that watershed institutions have'nt performed well. While the watershed institutions have done their best in augmenting incomes of 'havenots' (i.e. those depending totally in rainfall), their role in augmenting incomes of 'haves' has to improve (Table 2). Discerning the contribution of Sujala watershed program, it is apparent that the overall contribution of Sujala watershed program to farmers possessing irrigation wells is Rs. 614 per acre in a drought year (2004) and Rs. 5,056 per acre in normal rainfall year. Thus, the contribution of Sujala watershed as well as non-Sujala (DPAP) watershed is uniform for the farmers possessing irrigation wells.

While considering whether the net returns per acre for farmers possessing irrigation wells in Sujala, Non-Sujala watershed are different from that of the control area through ANOVA, it is found that these net returns per acre are not statistically significantly different (Tables 4 and 5). However, this result was not true for the farmers totally dependent on rainfall as already discussed. Thus, while the contribution of Sujala watershed program is statistically significant

for farmers not possessing irrigation wells, it is not statistically significant for farmers possessing irrigation wells *(Tables 4 and 5)*.

Table 2: Estimated contribution of Sujala watershed development program exclusively for farmers who are possessing irrigation wells in Veda river bank in Chitradurga district, 2004-05

Rs per acre

Sl. No	Particulars	Drought year (2004)	Normal rainfall year (2005)
1	**Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)**	(= 6615- 5935) = 680	(= 10787- 5370) = 5417
2	**Contribution of Watershed institutions (= net returns in Sujala minus Net returns in Non-Sujala WDP)**	(=6549- 6615) = -66	(=10426 - 10787) = -361
3	**Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)**	(= 6549- 5935) = 614	(=10426 -5370) = 5056

III. Overall contribution of watershed program for farmers dependent on rainfall as well as for farmers possessing irrigation wells

Considering the overall contribution of Non-Sujala (DPAP) watershed on farmers possessing irrigation wells and those not possessing irrigation wells, it was found to be Rs. 380 per acre in a drought year (2004) and Rs. 2,467 per acre in a normal rainfall year (2005). Considering the contributions of the Sujala watershed institutions in a drought year (Rs. 2686 per acre) and in a normal year (Rs. 2500 per acre) for farmers, the contribution of watershed institutions is not only uniform irrespective of the agroclimatic conditions, but also higher than the contributions of non-Sujala (DPAP) watershed program.

The contribution of Sujala watershed program in a normal rainfall year (2005) being Rs. 4967 is higher than the contribution of Sujala watershed program in a drought year (2004) being Rs. 3066 per acre. Thus, the contributions of Sujala watershed program in both normal and drought years are higher than the contributions of Non-Sujala (DPAP) watershed as well as the contributions of Sujala watershed institutions (Table 3). Upon performing ANOVA, it is found that the net returns per acre from all sources in Sujala watershed is significantly different from that in non-watershed area in a drought year (2004) as well as in a normal year (2005). Thus, the overall contribution of sujala watershed program to farmers not possessing irrigation wells as well as farmers possessing irrigation wells, is statistically significant (Tables 4 and 5).

Table 3: Estimated contribution of Sujala watershed development program in Veda riverbank in Chitradurga district, 2004-05

(Rs per acre)

Sl. No	Particulars	2004	2005
1	**Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)**	(= 5689- 5309) = 380	(= 8246-5779) = 2467
2	**Contribution of Watershed institutions (=net returns in Sujala minus NRs in Non-Sujala WDP)**	(=8375-5689) = 2686	(=10746-8246) = 2500
3	**Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)**	(=8375-5309) = 3066	(=10746-5779) = 4967

Table 4: One way Anova for net returns per acre from all the sources across different categories of sample farmers in Veda river bank in Chitradurga district, 2004-05

Sl.No	Particulars	Mean	F statistic
1	**Net returns per acre from all the sources for all the sample farmers in 2004**		
	a. Sujala watershed	22537.1	3.395**
	b. Non-Sujala watershed (DPAP)	9612.1	
	c. Non-watershed area	7387.6	
2	**Net returns per acre from all the sources for all the sample farmers in 2005**		
	a. Sujala watershed	22971.3	2.572**
	b. Non-Sujala watershed (DPAP)	11663.1	
	c. Non-watershed area	9627.7	
3	**Net returns per acre from all the sources for sample farmers possessing irrigation wells, 2004**		
	a. Sujala watershed	8019.6	1.459
	b. Non-Sujala watershed (DPAP)	7740.2	
	c. Non-watershed area	4667.4	
4	**Net returns per acre from all the sources for sample farmers possessing irrigation wells, 2005**		
	a. Sujala watershed	11744.9	0.178
	b. Non-Sujala watershed (DPAP)	11299.3	
	c. Non-watershed area	9427.4	
5	**Net returns per acre from all the sources for farmers not possessing irrigation wells, 2004**		
	a. Sujala watershed	30942.0	3.764**

	b. Non-Sujala watershed (DPAP)	10548.0	
	c. Non-watershed area	8376.8	
6	**Net returns per acre from all the sources for farmers not possessing irrigation wells, 2005**		
	a. Sujala watershed	29470.8	2.79**
	b. Non-Sujala watershed (DPAP)	11845.0	
	c. Non-watershed area	9700.6	

*Note: ***, ** and * indicate significance at 1, 5 and 10% respectively*

Table 5: Comparison of Net returns per acre of Sujala watershed over Non-Sujala watershed (DPAP) and Non-watershed area across different categories of farmers in Veda river bank, Chitradurga district, 2004-05

Sl. No	Group(1)	Group(2)	Mean Difference (1-2)	Std. Error	Sig.	90 % Confidence Interval	
						Lower Bound	Upper Bound
1	**Net returns per acre from all the sources for all the farmers in 2004**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	12925.0	6278.5	0.105	-132.5	25982.7
		Non-watershed area	15149.5	6278.5	0.047*	2091.9	28207.1
2	**Net returns per acre from all the sources for all the farmers in 2005**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	11308.2	6338.9	0.181	-1875.1	24491.5
		Non-watershed area	13343.6	6338.9	0.095*	160.2	26526.9
3	**Net returns per acre from all the sources for farmers possessing irrigation wells in 2004**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	279.4	1988.5	0.989	-3988.9	4547.7
		Non-watershed area	3352.2	2114.7	0.27	-1186.9	7891.4
4	**Net returns per acre from all the sources for farmers possessing irrigation wells in 2005**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	445.6037	3785.4	0.992	-7679.6	8570.8
		Non-watershed area	2317.557	4025.6	0.834	-6323.3	10958.4
5	**Net returns per acre from all the sources for farmers not possessing irrigation wells in 2004**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	20394.0	9130.3	0.074*	1278.2	39509.8
		Non-watershed area	22565.2	8925.8	0.037*	3877.5	41252.9
6	**Net returns per acre from all the sources for farmers not possessing irrigation wells in 2005**						
	Sujala Watershed	Non-Sujala watershed (DPAP)	17625.8	9244.4	0.146	-1728.9	36980.5
		Non-watershed area	19770.2	9037.4	0.082*	848.9	38691.4

*Note: * significant at 90 %*

This analysis on incremental net return due to Sujala watershed pertains to a drought year. With this backdrop, the incremental return in Sujala watershed has been positive for the sample farmers who are not possessing irrigation wells. However, barring the medium farmers, for all sample farmers possessing irrigation wells, the incremental net return per acre is negative. This is because, in Sujala watershed, arecanut crop is still in establishment stage. Once arecanut crop begins bearing, this difference would be positive. When the incremental net return is computed between Sujala watershed and non watershed area, it turns to be positive for sample farmers possessing irrigation wells as well as for those who are totally dependent on rainfall. Here too, the incremental returns are relatively higher for farmers not possessing irrigation wells than for farmers not possessing irrigation wells. **This reiterates that Sujala watershed program has contributed substantially for farmers who are totally dependent on rainfall compared with those farmers who are dependent on irrigation wells**. (Table 6)

Table 6: Incremental net returns due to Sujala watershed over Non- Sujala watershed area and Non-watershed area in Veda river bank in Chitradurga District, 2004

Type of farm	Sujala WDP over Non Sujala WDP = Rs. 8375 -Rs. 5689 = Rs. 2686		Sujala WDP over Non-watershed area WDP = Rs. 8375 – Rs. 5309 = Rs. 3066	
	For sample farmers possessing irrigation wells	For sample farmers not possessing irrigation wells	For sample farmers possessing irrigation wells	For sample farmers not possessing irrigation wells
Small and marginal farmers	-3782	5863	3618	7714
Medium farmers	2184	7765	3461	6739
Large farmers	-1672	NA	1195	NA
Overall	-65	7798	614	7354

NA: There were no large farmers in the sample not possessing irrigation wells

Note: *Incremental net return in Sujala over Non-Sujala watershed = net return per acre from all sources in Sujala minus that in non-sujala watershed*
Incremental net return in Sujala over Non- watershed = net return per acre from all sources in Sujala minus that in non-watershed area

The year 2005, has been a relatively better year compared with year 2004 which is recognized as to be drought year. First, the overall net return between the sample farmer with irrigation wells, those who don't, the gap in overall net return, of around Rs. 992 in drought year (2004) is far lower then Rs. 5,654 in normal rainfall year (2005). Thus a normal rainfall year can bridge the gap by 470 percent within the Sujala watershed.

Nevertheless the farmers not possessing irrigation wells realized the highest proportion (38 percent) net return from wage employment. Similar to the drought year (2004) contribution of wage income, income generating activity and livestock are relatively higher for these farmers than those possessing irrigation wells who derive only 21 percent from livestock, income generating activity and wage employment.

Considering, sample farmers possessing irrigation wells, their net return is largely influenced by Agriculture and horticulture which contribute to 78 percent of net return. The overall net return is Rs. 10,746 which is higher than the one obtained in drought year Rs. 8,375 in Sujala watershed and Rs. 5,689 in Non-Sujala watershed (DPAP).

Thus in both years of drought (2004) and normal rainfall (2005), the farmers totally dependent on rainfall (Not possessing irrigation wells) are realizing more than 70 percent of their net return from livestock, wage income and income generating activity. This pattern is not very different in Non-Sujala watershed as well as Non-watershed area where around 50 percent of their net return is obtained from livestock, wage income and income generating activity. This situation gets reversed for farmers possessing irrigation wells..

In drought year (2004) as well as in normal rainfall year (2005) farmers possessing irrigation wells are deriving atleast 80 percent of their net return from agriculture and horticulture irrespective of whether they are located in Sujala watershed, Non-Sujala watershed (DPAP) or Non-watershed area. Thus, it is apparent 1. Sujala watershed benefits are higher for farmers who are totally rainfed over Non-Sujala watershed (DPAP) as well as Non-watershed area. 2. The effect that as the farmers possessing irrigation wells are duly engaged in agriculture and horticulture in this farm, their time is unavailable for earning through wage employment, income generating activity and livestock.3. That coconut crop occupies atleast 70 percent of gross irrigated

area for farmers with irrigation wells in Sujala watershed, Non-Sujala watershed and Non-watershed area. There were no other major commercial crops cultivated by them other than Arecanut (still in bearing stage), onion and groundnut in Sujala watershed, onion and groundnut in Non-Sujala watershed and onion and sunflower in Non-watershed which occupy around 10 percent.

Overall contribution of watershed and rainfall

The contribution of Non-Sujala watershed per acre is Rs. 380 in drought year (drought year 2004) and Rs. 2,467 in year of good rainfall (normal year 2005). The contribution of watershed institutions is Rs. 2,686 in drought year (drought year 2004) and Rs. 2,500 in good rainfall year (normal year 2005). The contribution of Sujala watershed is Rs. 3,066. It is needless to mention that rainfall plays a vital role in shaping the contribution of watershed program. The contribution of rainfall to DPAP watershed is Rs. 2,087 per acre, contribution of rainfall to watershed institutions Rs -186 i.e. in a drought year institution had to put greater effort. The contribution of rainfall to Sujala watershed is Rs. 1,901. Net contribution of Sujala watershed is Rs. 3,066 per acre while the net contribution of Non-Sujala watershed Rs. 380 *(Table 7)*.

Table 7: Estimated contribution due to Sujala watershed development program, institutional innovations, people's participation and rainfall in Chitradurga district, 2004-05

(Rs per Acre)

Sl. No	Particulars	drought year 2004	normal year 2005
1	Contribution of (Non-Sujala) DPAP Watershed program (= net returns in Non-Sujala WDP minus net returns in Non-watershed area)	(= 5689- 5309) = 380	(= 8246-5779) = 2467
2	Contribution of Watershed institutions (=net returns in Sujala minus NRs in Non-Sujala WDP)	(=8375-5689) = 2686	(=10746-8246) = 2500
3	Contribution of Sujala Watershed (= net returns in Sujala minus Net returns in Non- watershed area)= (1) + (2)	(=8375-5309) = 3066	(=10746-5779) = 4967
4	Contribution of rainfall to (Non-Sujala) Watershed program = (contribution of NS watershed in normal year 2005 minus contribution of NS watershed in drought year 2004)	(=2467 - 380) = 2087	
5	Contribution of rainfall to Watershed institutions (=contribution of watershed institutions in normal year 2005 minus contribution of watershed institutions in drought year 2004)	(=2500- 2686) = -186	
6	Contribution of rainfall to Sujala Watershed (= contribution of Sujala watershed in normal year 2005 minus contribution of Sujala watershed in drought year 2004 is also equal to (4) + (5)	(=4967- 3066) = 1901	
7	Net contribution of non Sujala (DPAP) watershed	= 2467-2087 = Rs.380	
8	Net contribution of Sujala watershed	Rs. 4967 – Rs. 1901 = Rs.3066	

Note: drought year 2004 was a drought year. normal year 2005 was a good rainfall year. Net effect is the effect good rainfall

Implications of the study

- **The contribution of sujala watershed program per acre (in normal year, in drought year) for farmers who are totally dependent on rainfall and not possessing irrigation well (Rs. 5324 per acre, Rs. 7354 per acre) is higher than the contribution of Non Sujala (DPAP) watershed (Rs. –849 per acre, Rs. – 444 per acre)**

- **The contribution of sujala watershed program per acre (in normal year, in drought year) for farmers who are possessing irrigation wells (Rs. 5056 per acre, Rs. 614 per acre) is almost on par with the contribution of Non Sujala (DPAP) watershed program (Rs. 5417 per acre, Rs. 680 per acre)**

- **The contribution of Sujala watershed program per acre (in normal year, in drought year) considering all types of farmers (Rs. 4967 per acre, Rs. 3066 per**

acre) is higher than the contribution of Non-Sujala watershed program (Rs. 2467 per acre, Rs. 380 per acre)

- **The expenditure on Sujala watershed is around Rs.4048 per acre, and that on Non-Sujala (DPAP) watershed is Rs. 2632 per acre. If this is assumed to last for five years and at a sustainable (or zero) interest rate, the expenditure on Sujala watershed amounts to Rs. 810 per year per acre, while that on DPAP amounts to Rs. 526 per year per acre. Considering contribution per acre as benefit and the expenditure per acre as cost, the benefit-cost ratio of sujala watershed is 3.78 while that of Non-Sujala (DPAP) watershed is 0.72 in a drought year, while it was 6.13 and 4.69 respectively in a normal year. Thus, Sujala watershed has performed well in both normal and drought years, while Non-Sujala (DPAP) watershed has performed well in normal year.**

Fig 1 :Boulder checks in coconut orchard, Sujala watershed, Karnataka

Fig 2 :Spillway constructed for runoff in the Sujala watershed, Karnatak

Fig 3: Recharge pit for irrigation borewell in Sujala watershed program