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Evaluation of Watershed Development Programmes in India Using Economic Surplus Method

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Abstract

Watershed programmes in India are contributing to water resources development, agricultural production and ecological balance. Conventional methods to value them using financial measures attempt to quantify the impacts of watershed development in an isolated manner. In order to evaluate the impacts of watershed programmes in a holistic manner, the Economic Surplus (ES) approach has been applied using the data from a cluster of 10 watersheds in the Coimbatore district of Tamil Nadu.The distributional effects of watershed programmes are also captured through the ES method. Hence, possibilities of using this methodology in the future watershed evaluation programmes could be examined. The study has suggested that people's participation, involvement of Panchayati Raj Institutions, local user groups and NGOs alongside institutional support from different levels, viz. central and state government, and district and block levels should be ensured to make the programme more participatory, interactive and cost-effective.

Introduction

Watershed development in India is not a new concept and has travelled a long way from a simple soil and water conservation programme to the recent integrated rural development programme with more people participation. Both central and state governments and international donors have been implementing watershed development programmes across the country in different modes. The overall objectives of these development programmes, by and large, are three fold, viz. promoting economic development of the rural area, employment generation, and restoring ecological balance (Department of Land Resources, 2006). The watershed development programme assumes importance in India where 60 per cent of the cropped area is rainfed and is characterized by low productivity, water scarcity, degraded natural resources and widespread poverty. Under such situation, understanding the nature and extent of impact of these watershed development programmes on various domains in the rural economy is crucial for the development personnel/specialists, economists and policymakers. It would guarantee more food, fodder, fuel, and livelihood security for those who are on the bottom of the rural income scale.

A watershed is a geographical area that drains to a common point, which makes it an attractive unit for technical efforts to conserve soil and maximize utilization of surface and subsurface water for crop production (Kerr *et al.*, 2000). Different ministries like Ministry of Agriculture (MoA), Ministry of Rural Development (MoRD) and Ministry of Environment and Forest (MoEF) are involved in the implementation of watershed development programmes in the country. Watershed development has been conceived basically as a strategy for protecting the livelihoods of the people inhabiting the fragile eco-systems, experiencing soil erosion and moisture stress. Different types of treatment activities are carried out in a watershed. They include soil and moisture conservation measures in

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agricultural lands (contour/field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retention walls), water resource development/ management (percolation pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture plantation and afforestation (Palanisami and Suresh Kumar, 2003). Training in watershed technologies and related skills is also given periodically to farmers in watersheds. In addition, members are also exposed to other successful watershed models and research institutes implementing the watershed programmes The aim has been to ensure the availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000). Today watershed development has become the main intervention for natural resource management.

As an important development programme, watershed development has received much attention from central and state governments. Up to Tenth Plan (till March 2005), an area of 17.24 million hectares was treated with a total budget of Rs 9368.03 crore under Ministry of Agriculture, 27.52 million hectares with an outlay of Rs 6855.66 crore under Ministry of Rural Development and an area of 0.82 million hectares with an outlay of Rs 813.73 crore under Ministry of Environment and Forest. A total of 45.58 million hectares has been treated through various programmes with an investment of Rs 17,037 crore. The average expenditure per annum during the Tenth Plan comes to around Rs 2300 crore (Department of Land Resources, 2006). As millions of rupees are being spent on the watershed development programmes, it is essential that the programmes become successful.

With programmes so large and varied, it is important to understand how well they function overall and which aspects should be promoted and which be dropped. However, despite this importance, little work has been done to assess their impacts. This paper partially fills this gap by examining both social and environmental outcomes. In particular, it tries to answer the questions: (i) What impacts the watershed development activities have on rural areas? and (ii) How do watershed development activities impact on groundwater resources, soil and moisture conservation, agricultural production and socio-economic conditions?. It would help the policymakers in up-scaling and mainstreaming watershed development programmes in the country.

To successfully implement the watershed development activities, the Government of India has been issuing various guidelines since 1995. In order to make more participation of people in the watershed development and management, the GoI guidelines were revised and reissued in 2001. Subsequently, to involve Panchayati Raj Institutions more meaningfully in the implementation of watershed development activities, the popular Haryali guidelines were introduced in 2003. In addition to all these guidelines, the guidelines for NWDPRA watershed development programmes, CAPART, NABARD and NGO implemented watershed guidelines were released separately over the period. Though these guidelines have, by and large, been successful in the implementation of various watershed development activities, they have some lacuna particularly in the context of institutional issues, post-project maintenance and sustainability and monitoring and evaluation of watershed development activities. Recently, the GoI has issued Common Guidelines 2008 for the effective implementation of watershed development programmes in the country.

In spite of the guidelines, the implementation aspects normally deviate due to local demand. Several studies have indicated that the watershed structures are not maintained after completion and benefits may decline over years (Palanisami and Sureshkumar, 2006). Also, to push up the implementation of the watersheds at other locations, the evaluation of the existing watersheds has been conducted positively. But, it is always mentioned that the benefits and costs are based on several assumptions. Impact analysis of an area-based programme like watershed development has inherent difficulties. Apart from the benefits accrued from different technologies, the impact of watershed development should be looked into three scales (household level, farm level and watershed level) in time and space. The dimensions of impact of watershed technologies further complicate the impact assessment.

Different studies have developed a variety of indicators for impact assessment. These indicators cover watershed development activities including soil erosion, groundwater recharge and water resources potential, agricultural production, socio-economic conditions and overall impact incorporating the extent of green cover. These indicators have been compared with before and after the watershed treatment activities with that of the control village where watershed treatment activities are not taken up. The other methodologies, such as Total Economic Valuation (Logesh, 2004) and bio-economic modelling have also been employed by the researchers. However, still the researchers face challenges in quantifying the impacts of watershed development activities.

The problem of impact assessment of watershed development project includes the following aspects: (i) Developing a framework to identify what impacts to assess, where to look for these impacts and selecting appropriate indicators to assess the impacts, and (ii) Developing a framework to look after the indicators together and assessing the overall impact of the project. The nature of watershed technologies and their impact on different sectors pose challenges to the project monitoring and evaluating agencies, economists, researchers and policymakers. More specifically, major challenges include (i) choice of methodologies, (ii) selection of indicators, (iii) choice of discount rate, (iv) quantifying benefits in upstream and downstream, (v) defining the zone of influence, and (vi) extent of natural and artificial recharge (Palanisami and Suresh Kumar, 2006).

Since the watershed development technologies benefit not only the participating farm households, but also non-participating farm and other rural households in the watershed village, the economic surplus method has been used to study the impact of the watershed programmes using data from sample watersheds in the Coimbatore district of Tamil Nadu state.

Methodology

Economic Surplus Approach

The Economic Surplus (ES) approach is widely followed for evaluating the impact of technology on the economic welfare of households (Moore *et al.*, 2000; Wander *et al.*, 2004; Maredia *et al.*, 2000; Swinton, 2002). The economic surplus method measures the aggregated social benefits of a research project. With this method it is possible to estimate the return to investments by calculating a variation of consumer and producer surplus through a technological change originated by research. Afterwards, the economic surplus is utilized together with the research costs to calculate the net present value (NPV), the internal rate of return (IRR), or the benefit-cost ratio (BCR) (Maredia *et al.*, 2000). The model can be applied to the small/large open/closed economy within the target domain of production environment. The term surplus is used in economics for several related quantities. The consumer surplus is the amount that consumers benefit by being able to purchase a product for a price that is less than they would be willing to pay. The producer surplus is the amount that producers benefit by selling at a market price mechanism that is higher than they would be willing to sell for. In the case of watershed programmes, producers are mainly the farm households who produce the goods using the benefits of the watershed interventions such as soil and moisture conservation, water table increase and livestock improvement activities and consumers are mainly the other stakeholders in the region, viz. non-farm households representing the labourers, business people and people employed in non-agricultural activities.

Theoretical Framework

The model is based on the Marshallian theory of economic surplus that stems from shifts over time of the supply and demand curves. In Figure 1, the rightward shift (S_1) of the original supply curve (S_0) generates economic surplus for producers and consumers. Such a shift can stem from changes in production technology, in the present case watershed development intervention. Given that the demand function remains constant, the original market equilibrium a (P_0, Q_0) is transferred by the effect of technological change to b (P_1,Q_1).

Consumers gain because they are able to consume a greater amount (Q_1) at a lower price (P_1). The area P_0abP_1 represents the consumer surplus. The watershed development intervention affects agricultural producers in two ways: (i) Lower marginal costs (according to the theory, the supply curve corresponds to the curve of marginal costs as of the minimum value of the curve of average variable costs), and (ii) Lower market price (P_0 reduced to P_1). Thus, the producers' surplus is defined as the Area P_1bl_1 - Area P_0al_0.

The mathematical model used was based on the scheme proposed by Pachico *et al*. (1987), in which supply and demand functions were nonlinear with constant elasticity, i.e. log-linear. The supply function for a product market was assumed that supply curves of the following functional form:

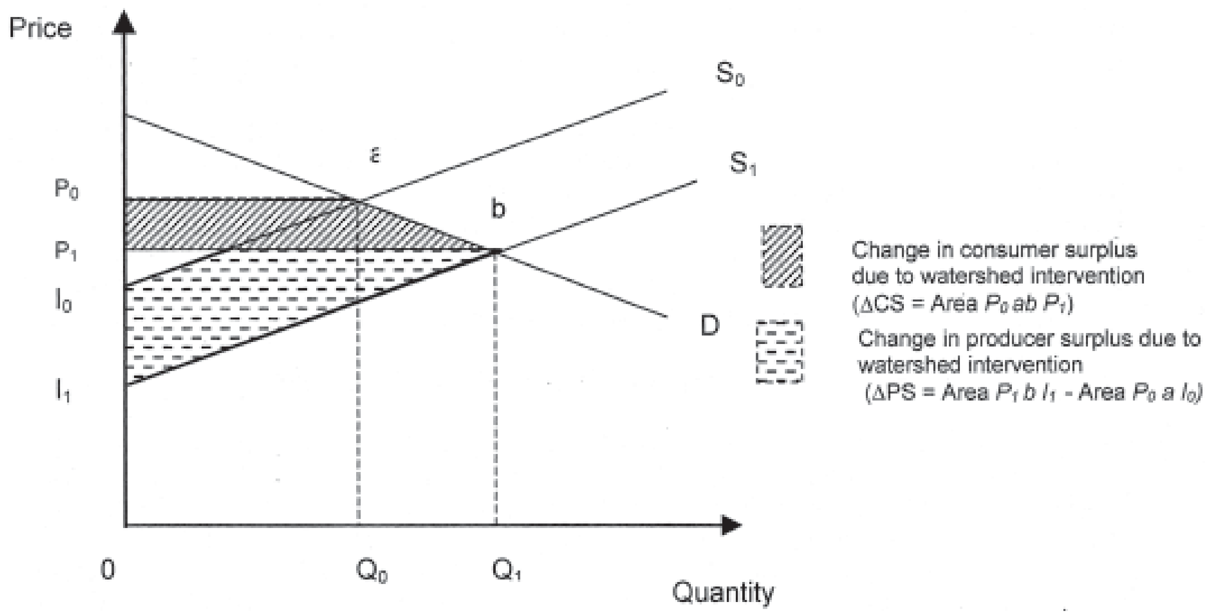

Figure 1. Graphical representation of economic surplus method

$$s_0 = c(P_0 - P_{lo})^d \qquad \ldots(1)$$

where,

s_0 = Initial supply before watershed intervention,

c, d = Constants,

P_0 = Price of product, and

P_{1o} = Minimum price that producers are willing to offer.

Typically, the watershed development programmes involving the entire community and natural resources influence different aspects such as agricultural production system, environment and socio-economic conditions of the watershed villages. By virtue of its nature, watershed is an area-based technology cutting across villages comprising both private and public lands. Thus, the benefits from watershed development activities are not limited only to the users/beneficiaries but are to the non-participating farmers also. For instance, the watershed development technologies are expected to have positive impacts on groundwater recharge, soil and water conservation, maintaining ecological balance, increased fodder availability, reduced siltation, increased greenery, increased crop yield etc. Similarly, the increased agricultural production favours the non-farming community like labourers, rural artisans and other rural households. Thus, the watershed development brings benefits not only to the producers (farmers) but also to the consumers (farmers, labour households and other households in the watershed village). In this context, the economic surplus approach captures the total benefits accrued due to watershed development intervention in the rural areas.

The advantage of the economic surplus approach lies in the fact that the distribution of benefits to different segments of the society could be estimated. The watershed development could be treated as a 'public good' and covers both the private and public lands. Moreover, the benefits due to watershed development activities are not restricted to the producers alone. Increased supply and hence changes in price of the agricultural products will also benefit the consumers positively. In this context, the economic surplus approach captures the impact of watershed development activities in a holistic manner.

Application of Economic Surplus Method to Watershed Evaluation

Watershed programmes play a dual role of safeguarding the interest of the producers as well as consumers, as in several locations, the drought-proofing aspects of the watershed programs are easily felt (Palanisami and Suresh Kumar, 2007). In the case of producers, they can change the crop pattern due to increased water levels in their wells, moisture conservation in the soil, increase water use for the existing crops, increase the number of livestock and fodder production. There is also a change in the cost of production of the commodities in the watershed. Over the years, there is an increase in technology adoption due to watershed programmes. In the case of consumers, the increased crop production in the watershed results in availability of produce at lower prices. Consumption levels also get increased among the consumers. Labour employment is increased due to increased land and crop production and processing activities in the watershed. Evidences show that the production levels have increased as a result of watershed interventions and the consumers have started enjoying the benefits of localized production in the regions. Hence, for the purpose of the analysis, it was assumed that, the output supply curve shifts gradually over time when the benefits from the watershed developmental activities start benefiting the agricultural sector through water resource enhancement. The supply shift factor due to technological change, in our case, watershed intervention, is known as K. This factor varies in time depending on the dynamics of the rainfall, adoption, dissemination of soil and moisture conservation technologies and maintenance activities undertaken in the watershed. The supply shift factor (K) can be interpreted as a reduction of absolute costs for each production level, or as an increase in production for each price level (Libardo *et al.*, 1999).

Micro economic theory defines consumer surplus (individual or aggregated) as the area under the (individual or aggregated) demand curve and above a horizontal line at the actual price (in the aggregated case: the equilibrium price). Following IEG, World Bank, 2008, the demand curve is assumed to be log-linear with constant elasticity. Thus, the demand equation for this demand function can be written as:

$$P = gQ^{\eta} \qquad \ldots(2)$$

where, η is the elasticity and g is a constant. Once, the parameters η and g are estimated, then consumer surplus could be estimated by Equation (3):

$$CS = \int_{Q_0}^{Q_1} gQ^{\eta} dQ - (Q_1 - Q_0)P_1 \qquad \ldots(3)$$

Combined, the consumer surplus and the producer surplus make up the total surplus.

Estimation of Benefits

Following the theory of demand and supply equilibrium, economic surplus (benefits) as a result of watershed development intervention is measured by Equation (4):

$$B = K * P_0 * A_0 * Y_0 * (1 + 0.5\, Z * \varepsilon_d) \qquad \ldots(4)$$

where, K is the supply shift due to watershed intervention.

The supply shift due to watershed intervention can be mathematically represented by Equation (5):

$$K = \forall * \rho * \psi * \Omega \qquad \ldots(5)$$

where, K represents the vertical shift of supply due to intervention of watershed development technologies and is expressed as a proportion of initial price. ψ is the net cost change which is defined as the difference between reduction in marginal cost and reduction in unit cost. The reduction in marginal cost is defined as the ratio of relative change in yield to price elasticity of supply (ε_s). Reduction in unit cost is defined as the ratio of change in cost of inputs per hectare to (1+change in yield). ρ is the probability of success in watershed development implementation. ψ represents adoption rate of technologies and Ω is the depreciation rate of technologies.

Z represents the change in price due to watershed interventions. Mathematically, Z can be defined by Equation (6):

$$Z = K * \frac{\varepsilon_s}{(\varepsilon_d + \varepsilon_s)} \qquad \ldots(6)$$

where, P_0, A_0, and Y_0 represent prices of output, area and yield of different crops in the watershed before implementation of watershed development programme. If we use the with and without approach, then these represent area, yield and price of crops in control village.

Cost of Project

The analysis considered cost towards watershed development investment during the project period and maintenance expenditure incurred in the project. For watershed development projects with multiple technologies or crops, incremental benefits from each technology and crop were added to compile the total benefits. The worthiness of the watershed development projects was then evaluated at 10 per cent discount rate. Using above estimates of returns and costs, net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR) were computed.

Study Area and Data Collection

The study was conducted in the Coimbatore district of Tamil Nadu, India. The predominant soil types are red soil, laterite, clay loam, sandy clay loam, and black cotton soil. Differences in soil types have differential impact on the water resources and agricultural production and productivity. The success of the watershed development programmes critically depends on rainfall in the region. The major crops grown were: sorghum, cotton, sugarcane, maize, coconut and vegetables. Of the total cropped area, the area irrigated accounted for 56.82 per cent. The chief source of irrigation in the district was through wells. Over the years, there has been a general decline in the water level in the whole of Coimbatore district, which is attributed to indiscriminate pumping of groundwater. The groundwater resource degradation has in turn resulted in changes in crop patterns, well deepening, and an increase in well investments, pumping costs, well failure, and abandonment and out migration of farmers (Palanisami and Suresh Kumar, 2007). It is in this context that groundwater augmentation by artificial recharge through watershed development programmes gained momentum.

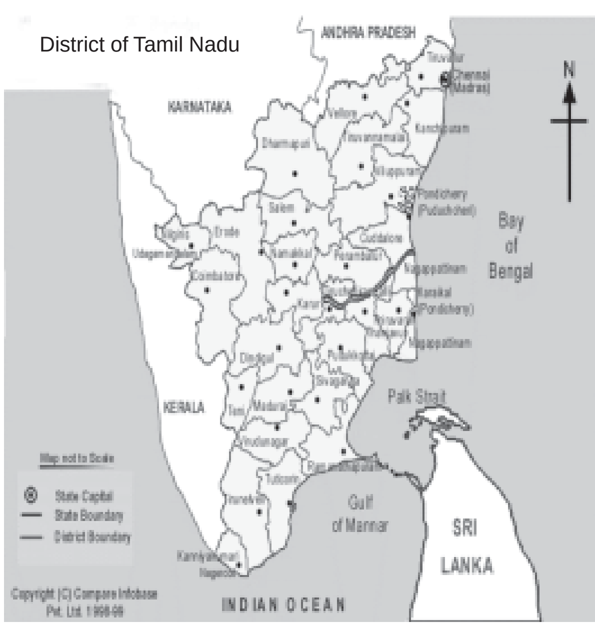

Figure 2. Map of study area

Data

The major data were derived from the recently completed study on Comprehensive Assessment (CA) of Watersheds Programmes in India implemented by the ICRISAT- led consortium team (Wani *et al*., 2008). For the purpose of our study, the data were drawn from a cluster of 10 watersheds implemented in the Coimbatore district of Tamil Nadu. The details of all these watersheds with area treated are given in Table 1. A variety of indicators were developed and used for the impact assessment. The indicators of impact of watershed development activities covering soil erosion, groundwater recharge and water resources potential, agricultural production, socio-economic conditions and overall impact including the extent of green cover were developed. To make a comparative study, one control village where no watershed treatment activities were carried out, was selected for each watershed. The control villages were selected so as to have similar agro-climatic conditions. The select indicators were compared with before and after the watershed treatment activities also with that of the control village. Thus, the data pertaining to 10 watershed villages and 10 control villages were gathered. The information on price elasticity of demand and supply of various farm products was obtained from the published sources.

Table 1. Details of watersheds covered for the study in the Coimbatore district of Tamil Nadu

Name of the block	Name of watershed	Area (ha)
Annur	Kattampatty I	460.0
	Kattampatty II	467.5
	Kuppepalayam	672.5
Avinashi	Naduvenchery	767.5
	Karumapalayam	752.5
	Chinneripalayam	524.8
Sulur	Arasur I	605.0
	Arasur II	590.0
	Rasipalayam	560.0
Palladam	Kodangipalayam I	455.0

Results and Discussion

This section presents the key results and findings from the field experience of impact assessment of watershed programmes implemented under Drought Prone Area Programme (DPAP) in the Coimbatore

Table 2. General characteristics of sample farm households

Particulars	Watershed village	Control village
Farm size (ha)	1.28	1.75
Household size	3.31	3.34
Land value (Rs/ha)	230657	153452
No.of wells owned	1.35	1.20
Average area irrigated by wells (ha)	1.48	1.80
Value of household assets (Rs)	261564*	184385
No. of persons in the household	4.07	4.2
Number of workers	2.5	2.1
Labour force participation (%)	61.48	50.79

Note: *indicates that value was significantly different at 10 per cent level from the corresponding values of control village

district of Tamil Nadu. The general characteristics of the sample farm households in the study watershed were analysed and have been presented in Table 2. It could be seen that the average size of the holding worked out to be 1.28 ha and 1.75 ha, respectively for watershed and control villages. It is evident from the analysis that the average number of workers was 2.5 and 2.1 out of 4.07 and 4.2 for watershed and control villages.

The labour force participation rate came out to be 61.5 per cent and 50.8 per cent. The higher labour force participation was due to better scope for agricultural production, livestock activities and other off-farm and non-farm economic activities. It is evidenced from the analysis that the labour force participation rate among farmers in watershed villages was higher, implying that the enhanced agricultural production was due to watershed treatment activities. Construction of new percolation ponds, major and minor check dams and the rejuvenation of existing ponds/ tanks had enhanced the available storage capacity in the watersheds to store the run-off water for surface water use and groundwater recharge. The additional surface water storage capacity created in the watersheds ranged from 9299 m^3 to 12943 m^3. This additional storage capacity further helped in improving the groundwater recharge and water availability for livestock and other non-domestic uses in the village. On the basis of the data collected from the sample farmers, it was found that the water level in the open-dug wells had risen in the range of 0.5 - 1.0 metre in watershed villages. The depth of the water column in the few sample wells was recorded both in watershed and control villages for comparison. The depth of the water column in the wells was found to be higher in the watershed villages than in control villages. For instance, depth of the water column in the wells in Kattampatti watershed village, during July – January months was 3.5 m compared to 2.2 m in the control village, leading to a difference of 63.4 per cent.

Information related to duration of pumping hours before well went dry (or water level depressed to a certain level) and time it took to recuperate to the same level were collected for the sample farmers across villages. Due to watershed treatment activities, groundwater recuperation in the nearby wells had increased. The increase in recuperation rate varied from 0.1 m^3/hour to 0.3 m^3/hour. It was also observed that the recharge to wells decreased with their distance from the percolation ponds and check dams and the maximum distance where the recharge to the wells had occurred was observed to be 500 - 600 m from the percolation ponds.

The area irrigated in watershed villages registered a moderate increase after the watershed development activities in most of the watersheds, whereas in control village, it declined slightly over the period. The irrigation intensity was found higher in watershed treated village than in untreated village. This shows that watershed development activities helped increase the water resource potential of a region through enhanced groundwater resources coupled with soil and moisture conservation activities. In the case of control villages, the watertable in the wells had declined due to continuous pumping. It is one of the reasons why farmers in most of the villages demand watershed programmes in their villages.

Table 3. Cropped area, cropping intensity and crop diversification

Particulars	Watershed villages		Control villages	
	Before	After	Before	After
Net area irrigated (ha)	1.08	1.10***	1.68	1.62
Gross area irrigated (ha)	1.25	1.35**	1.84	1.62
Irrigation intensity	115.74	122.73**	109.52	100.00
Net cropped area (ha)	1.15	1.28**	1.78	1.62
Gross cropped area (ha)	1.38	1.88**	2.43	2.16
Cropping intensity (%)	120.00	146.88	136.52	133.33
Crop Diversification Index (CDI)	1.0		0.97	

Notes: ** and *** indicate that values were significantly different at 1 per cent and 5 per cent levels from the corresponding values of control village

Crop diversification index (CDI) was worked out by employing Composite Entropy Index (CEI) based on the proportion of different crops in the farm. The Composite Entropy Index for crop diversification was worked out as:

$$C.E.I = -\left(\sum_{i=1}^{N} P_i . \log_N P_i\right) * \{1-(1/N)\}$$

where,

CEI = Composite Entropy Index,

P_i = Acreage proportion of the i^{th} crop in total cropped area, and

N = Total number of crops.

The analysis also revealed increase in net cropped area, gross cropped area and cropping intensity in both the watersheds (Table 3). For example, the cropping intensity worked out to be 146.9 per cent in the watershed village, which is higher than in the control village (133.3 per cent). The composite entropy index (CEI) was used to compare diversification across situations having different and large number of activities. The CEI has two components, viz. distribution and number of crops or diversity. The value of crop diversification index (CDI) increases with the decrease in concentration and rises with the number of crops/ activities. In general, CDI is higher in the case of watershed treated villages than control villages, confirming that watershed treatment activities help diversification in crop and farm activities.

The details regarding livestock per household and per hectare of arable land have been furnished in Table 4. The livestock income has been a reliable source of income for the livelihood of the resource-poor farmer households. Cattle, sheep and goats were maintained as important sources of manure and were the liquid capital resource. It could be seen that nearly 46.7 per cent and 93.3 per cent of the households in watershed and control villages maintained cattle. Access to grazing land and fodder had made the farm households to maintain livestock in their farms to derive additional income. But, the analysis revealed that relatively more number of households in control villages maintained livestock. It was mainly due to the fact that inadequate grazing land and poor resource-base for stall feeding persuaded them to feed their livestock with green leaves and fodder obtained from crops and crop residues. The farm households in control villages maintained mainly milch animals to derive additional income for their livelihood.

Table 4. Livestock per household and per hectare of arable land

(Number)

Particulars	Watershed village	Control village
Per cent of households	46.67	93.33
Herd size (number)	2.57	2.64
Per hectare of gross cropped area (number)	2.01	1.63

Application of Economic Surplus Method

The impact of watershed development activities on yield of crops and hence the cost was estimated and has been presented in Table 5. The change in yield

Table 5. Impact of watershed development intervention on yield and cost

Crops/Enterprises	Change in yield (%)	Reduction in marginal cost (%)	Reduction in unit cost (%)	Net cost change (%)
Sorghum	33	63.6	3.76	59.8
Maize	31	39.9	2.29	37.6
Pulses	36	41.0	1.47	39.6
Vegetables	32	32.8	0.76	31.9
Milk	28	27.3	7.81	19.5

Note: The reduction in marginal cost was the ratio of relative change in yield to price elasticity of supply (ε_s). Reduction in unit cost was the ratio of change in cost of inputs per hectare to (1+change in yield). Ci was the input cost change per hectare, i.e., C_u = Ci/(1+Change in yield);. The net cost change ( ) was the difference between reduction in marginal cost and reduction in unit cost, i.e. = Cm-Cu.

due to watershed intervention across crops varied from 31 per cent in maize to 36 per cent in cotton. It was the maximum change in yield due to watershed intervention. Reduction in marginal cost due to supply shift ranged from 32.8 per cent in vegetables to 63.6 per cent in sorghum. Net cost change varied from 32 per cent in vegetables to 59.8 per cent in sorghum.

The change in total surplus due to watershed development activities was estimated and has been∀ presented in Table 6. The change in total surplus was higher in sorghum and maize than crops like pulses and vegetables. Being the major rainfed crops, these two crops benefited more from the watershed interventions. The change in total surplus due to watershed intervention was decomposed into change in consumer surplus and change in producers surplus. It was evident that the producers surplus was higher than the consumer surplus in all the crops. For instance, in sorghum, the producers surplus worked out to be 61.2 per cent, whereas the consumers surplus was only 38.8 per cent. Watershed development activities benefited the agricultural producers more. It was interesting to note that unlike in the crop sector, the milk production had different impacts on the society. The decomposition analysis revealed that watershed development activities generated more consumers' surplus in milk production.

The overall impact of different watershed treatment activities was assessed in terms of net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR). The NPV, BCR and IRR were worked out using the economic surplus methodology assuming 10 per cent discount rate and 15 years life period.

The BCR is worked out to be more than one, implying that the returns to public investment such as watershed development activities were feasible. Similarly, the IRR worked out to be 25 per cent, which is higher than the long-term loan interest rate by commercial banks indicating the worthiness of the government investment on watershed development. The NPV worked out to be Rs 567912 for the entire

Table 6. Impact of watershed development activities on the village economy

Crops/ enterprises	Total benefits due to watershed intervention (B)		
	Change in total surplus (ΔTS)	Change in consumer surplus (ΔCS)	Change in producer surplus (ΔPS)
Sorghum	293177.3	113636.3	179541.0
	(100.00)	(38.8)	(61.2)
Maize	177774.2	85424.0	92350.2
	(100.00)	(48.1)	(51.9)
Pulses	25777.5	12580.3	13197.2
	(100..00)	(48.8)	(51.2)
Vegetables	29663.6	10627.5	19036.1
	(100.00)	(35.8)	(64.2)
Milk	176878.5	105974.1	70904.4
	(100.00)	(59.9)	(40.1)

Note: The change in total surplus in the village economy due to watershed intervention was decomposed into change in consumer surplus and change in producer surplus. The decomposition of total surplus was as follows:

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K(1 + 0.5 Z\eta)$$

$$\Delta CS = P_0 Q_0 Z(1 + 0.5 Z\eta)$$

$$\Delta PS = P_0 Q_0 (K - Z)(1 + 0.5 Z\eta)$$

Table 7. Results of economic analysis employing economic surplus method

Particulars	Economic surplus method	Conventional method
Benefit-cost ratio	1.93	1.23
Internal rate of return (%)	25	14
Net present value (Rs)	2271021	567912

watershed. The NPV per hectare worked out to be Rs 4542 (where the total area treated was 500 ha). It implied that the benefits from watershed development were higher than the cost of investment of the watershed development programmes of Rs 4000 /ha[1].

Conclusions and Policy Recommendations

The study has concluded that the watershed impact assessment should be given due importance in the future planning and development programmes. The study has demonstrated that the economic surplus method captures the impacts of watershed development activities in a holistic manner and assesses the distributional effects, and therefore it would be a fairly good methodology to assess the impacts of watershed development. The watershed development activities have been found to have significant impact on groundwater recharge, access to groundwater and hence the expansion in irrigated area. Therefore, the policy focus must be on the development of these water-harvesting structures, particularly percolation ponds wherever feasible. In addition to these public investments, private investments through construction of farm ponds may be encouraged as these structures help in a big way to harvest the available rain water and hence groundwater recharge.

Watershed development activities have been found to alter crop pattern, increase in crop yields and crop diversification and thereby could provide enhanced employment and farm income. Therefore, alternative-farming system combining agricultural crops, trees and livestock components with comparable profit should be evolved and demonstrated to the farmers.

Once the groundwater is available, high water intensive crops are introduced. Hence, appropriate water saving technologies like drip is introduced without affecting farmers' choice of crops. The creation and implementation of regulations in relation to depth of wells and spacing between wells will reduce the well failure, which could be possible through Watershed Association. The existing NABARD norms such as 150 metres spacing between two wells should be strictly followed.

People's participation, involvement of Panchayati Raj Institutions, local user groups and NGOs along side institutional support from different levels, viz. the central and state governments, and district and block levels should be ensured to make the programme more participatory, interactive and cost-effective.

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[1] However, recently the watersheds in India have been allotted a budget of approximately Rs 6000 per ha. Thus, a watershed with a total area of 500 hectares receives Rs 30 lakhs for a five-year period. The bulk of this money (80 per cent) is meant for development/treatment and construction activities. According to the new Common Guidelines 2008, the budgetary allocation is of Rs 12000 per ha.

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