## About CRIDA

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The Central Research Institute for Dryland Agriculture (CRIDA), a part of Natural Resource Management (NRM) Division of Indian Council of Agricultural Research (ICAR), is a national level research institute with a mandate to carry out basic and strategic research in the field of rainfed agriculture. The current research thrusts include resource characterization, rainwater management, crops and cropping systems, integrated nutrient management, alternate land use systems etc. CRIDA was responsible for implementation of 30 Model Watershed Programmes in the country during 1980s and their success lead to formulation of national level watershed programme. CRIDA is leading the consortium on Sustainable Rural Livelihoods Program in selected districts of AP with NGOs as partners under National Agricultural Innovation Project.

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## About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 644 million poor people to overcome hunger,poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).


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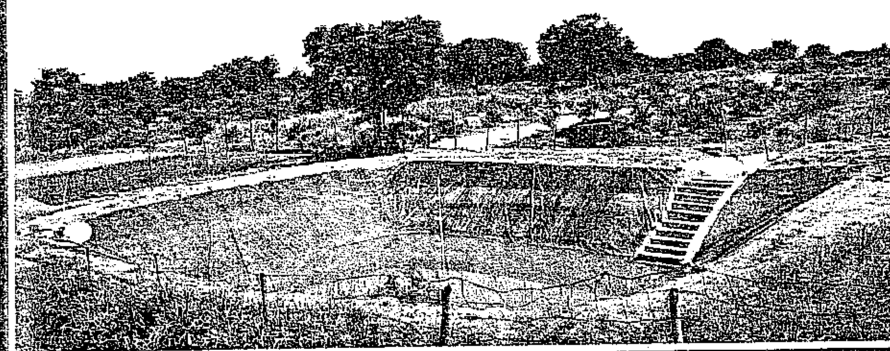
RAINWATER HARVESTING & REUSE - FARM PONDS

NAIP

# Rainwater Harvesting and Reuse through Farm Ponds

## Experiences, Issues and Strategies

Proceedings of National Workshop-cum-Brain Storming




Editors

K.V. Rao, B.Venkateswarlu, K.L. Sahrawath, S.P. Wani, P.K. Mishra, S.Dixit, K. Srinivasa Reddy, Manoranjan Kumar and U.S. Saikia



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# Rainwater Harvesting and Reuse through Farm Ponds

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recharge. Major portion (83.6%) of the inflow to the tanks contributed to groundwater recharge, but major recharge to groundwater was through fields (71%) as compared to tanks (29%). Due to groundwater irrigation, groundwater withdrawal formed the major outflow (65.5%) from the groundwater storage. Though the investment in tanks was found economical (BC ratio 1.34), the tanks were over designed when the inflow/capacity ratio was 0.82. Hence any treatment (like CCTs) in the catchments of these tanks should be discouraged.

Soils in the watershed vary in depth, colour and other morphological characteristics. Common crops grown in the watershed are sorghum, pearl millet, wheat, gram and fodder. Fields are used for a single *kharif* or *rabi* cropping or double cropping. Most of the area downstream of the percolation tanks comes under double cropping system. The area in the catchment of the tanks is mostly under shrubs.

## Lessons Learnt

The SOFTANK model offers a comprehensive analytical tool for studying the detail water balance of watershed-based water harvesting tanks. It incorporates many new features, which are unique to the watershed-based tank system. The model can be used to evaluate the existing tank system. The existing tank system can be improved by running alternate management scenarios with the help of simulation utility of the model. An optimum tank system can be suggested for new watershed projects with the help of optimization utility of the model. In this paper only the evaluation utility of the model is discussed. The model gave the detail water balance of the watershed and showed that 42% runoff is harvested by the tanks and 58% went out of the watershed. The tanks were economical but over designed and therefore any treatment in the catchments of these tanks, which will reduce the inflow to the tanks, should be discouraged.

## Strategies for Upscaling

The SOFTANK model can be used for designing the water harvesting tanks for preparing plan for developing a watershed. There is thus scope for the use of the model for watershed projects. The model needs user friendly for that purpose.

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# Evaluation of Watershed Development Programs in India using the Economic Surplus Method


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## Abstract

Watershed programs in India are contributing to water resources development, agricultural production and ecological balance. Conventional methods using financial measures attempt to quantify the impacts in an isolated manner. In order to evaluate the impacts of watershed programs in a holistic manner, the Economic Surplus (ES) approach has been applied using the data from a cluster of 10 watersheds in Coimbatore district of Tamil Nadu, India. The ES method captures the impacts of watershed development activities in a holistic manner than the conventional methods. The distributional effects of watershed programs are also captured through the ES method. Hence the possibilities of using this methodology in the future watershed evaluation programs could be examined.


## Introduction

Watershed development in India is not a new concept and has traveled a long way as a simple soil and water conservation programs to the recent integrated rural development program with more people participation. Both Central and State governments and international donors have been implementing watershed development program across the country in different modes. The over all objectives of these development programs, 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 program assumes importance in India where nearly two third of the cropped area is rainfed, characterized by the low productivity, degraded natural resources and widespread poverty particularly in rural areas. Under this situation, understanding the nature and extent of impact of these watershed development programs on various domains in the rural economy is crucial for development personnel/specialist, economists and policy makers. This is will guarantee more food, fodder, fuel, and livelihood security for those who are in 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 the 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 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 agricultural lands (contour/field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retaining walls), water resource development/management (percolation pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture Plantation and afforestation (Palanisami and Suresh Kumar, 2006). Training in watershed technologies and related skills is also given periodically to farmers in watersheds. In addition, members are also taken to other successful watershed models and research institutes for exposure. These efforts appear to be contributing to groundwater recharge. 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. Watershed development programs not only protect and conserve the environment, but also contribute to livelihood security.

As an important development program, watershed development received much attention from both the Central and state governments. Up to X[th] Five Year Plan (till March 2005), an area of 17.24 million hectares was treated with a total budget of Rs. 9368.03 crores under Ministry of Agriculture, 27.52 million hectares with an outlay of Rs. 6855.66 crores under Ministry of Rural Development and an area of 0.82 million hectares with an outlay of Rs. 813.73 crores under Ministry of Environment and Forest were spent. A total of 45.58 million hectares has been treated through various programs with an investment of Rs. 17,037 crores. Average expenditure per annum during the X[th] Five Year Plan is around Rs. 2300 crores (Department of Land Resources, 2006). As millions of rupees have been spent on watershed development programs, it is essential that the programs become successful.

With the programs so large and varied, it is important to understand how well they function overall and which aspects should be promoted and which will 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 bring to rural areas, (ii) how do watershed development activities impact on groundwater resources, soil and moisture conservation, agricultural production and socio-economic conditions?. This will help the policy makers in up-scaling and mainstreaming watershed development programs in the country.

Hence, it is important to apply relevant methodologies for the evaluation of the watershed programs so that future programs will be planned in an efficient manner. Most evaluators use conventional financial analysis to assess the impact of watershed development programs. However, the question is whether the conventional financial analysis captures the impacts in a holistic manner? Should we have a better methodology to assess the impacts of watershed program, as watershed development technologies not only benefit the participating farm households, they also benefit the not-participating farm and other rural households in the watershed village. Keeping these issues in view, this paper outlines the economic surplus method to study the impact of the watershed programs using data from sample watersheds in Coimbatore district, Tamil Nadu State, India.







## Background

Watershed development and management has become big concern in India. As the Central and State governments diverting huge fund towards watershed development, proper assessment of the benefits accrued to the economy is essential. A program like watershed development, which involves a hierarchy of administration and communities at the grass roots level in highly varying agro-climatic and socio-economic conditions, invariably requires periodical assessment for achieving the developmental objectives. Typically, an implementing agency would see a greater value in spending an extra few millions of rupees for undertaking works in the field rather than spending this money for monitoring and evaluation.

In addition, the impact assessment contributes to improve the effectiveness of policies and programs by addressing the questions such as: (i) Does the program achieve the intended goal?, (ii) Can the changes in outcomes be explained by the program, or are they the result of some other factors occurring simultaneously?, (iii) Do program impacts vary across different groups of intended beneficiaries (males, females, indigenous people), regions, and over time?, (iv) Are there any unintended effects of the program, either positive or negative?, (v) How effective is the program in comparison with alternative interventions? and (vi) Is the program worth the resources it costs? (Palanisami and Suresh Kumar, 2006).

To successfully implement the watershed development activities, the Government of India has issued various guidelines. The GoI guidelines were first issued in 1995. In order to make the watershed development and management more people participatory, the GoI guidelines were further revised and issued in 2001. Subsequently, to involve Panchayat Raj Institutions more meaningfully in 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 programs, CAPART, NABARD and NGO implemented watershed guidelines were implemented separately over the period. Though these guidelines were by and large successful in implementation of various watershed development activities, these are not exempted from 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 2008 Common Guidelines for effective implementation of watershed development programs in the country.

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

Different studies have developed a variety of indicators for the impact assessment. The indicators of impact will cover 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. These indicators were compared with before and after the watershed treatment activities, and also with that of the control village where watershed treatment activities is not taken up. The other methodologies such as Total Economic Valuation (Logesh, 2004) and bio-economic modeling were also 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 lies on the following: (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 at the indicators together and assessing the overall impact of the project. The nature of watershed technologies and its impact on different sectors pose challenges to Project Monitoring and Evaluating Agencies, economists, researchers and policy makers. More specifically, major challenges include (i) the choice of methodologies, (ii) selection of indicators, and (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).

## Methodology

### Economic Surplus Approach (ES)

Economic Surplus (ES) is widely used for evaluating the impact of a technology on the economic welfare of households (Joseph and Quddus, 1998; Moore et al, 2000; Wander et al, 2004; Maredia et al, 2000; Swinton, 2002). The economic surplus method's goal is to measure the aggregated social benefits of a research project. With this method, it is possible to estimate the return of 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 programs, the 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 Fig.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 the changes in the 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 this

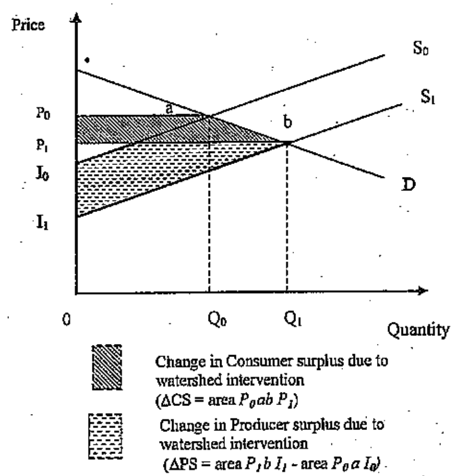


*Figure 1. Graphical representation of Economic Surplus Method*

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 $P_1bI_1$-area $P_0aI_0$.

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

$$s_0 = c(P_0 - P_b)^d \quad \text{.......................(1)}$$

where: $s_0$ = Initial supply before watershed intervention

c,d = Constants

$P_0$ = Price of product, and

$P_{lo}$ = Minimum price that producers are willing to offer

Typically, the watershed development programs 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 the watershed developmental activities are not only limited to the users/beneficiaries but also to the non-participating farmers. For instance, the watershed development technologies expected to have positive impacts on groundwater recharge, soil and water conservation, maintaining ecological balance, increased fodder availability, 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 ES 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 developmental activities are not restricted to the producers alone. Increased supply and hence changes in the price of the agricultural products 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 in Watershed Evaluation

Watershed programs play a dual role by safeguarding the interest of the producers as well as consumers, as the implementation of drought proofing aspects of the watershed programs are easily felt (Palanisami and Suresh Kumar, 2007). Producers 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 change in the cost of production of the commodities in the watershed. Over years, there is an increase in technology adoption due to watershed programs. In the case of consumers, the increased crop production in the watershed results in the availability of produce at comparatively lower prices. The consumption levels also increased among the consumers. The labour employment also increased due to increased land and crop production and processing activities in the watershed. Evidences show that the production levels increased as a result of watershed interventions and the consumers started enjoying the benefits of localized production in the regions. Hence, for the purpose of the analysis, it is assumed that, the output supply curve shifts gradually over time when the benefits from the watershed developmental activities started benefiting the agricultural sector through water resource enhancement. The supply shift factor due to technological change, in this 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, the demand curve is assumed to be log-linear with constant elasticity. Thus, the demand equation for this demand function can be written as:

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

Where η is the elasticity and g is the constant. Once, the parameters η and g are estimated, and then consumer surplus could be estimated by

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

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 as follows:

$$B = K * P_0 * A_0 * Y_0 * (1 + 0.5\,Z * \varepsilon_d) \qquad \text{.(4)}$$

Where, K = Supply shift due to watershed intervention. The supply shift due to watershed intervention can be mathematically represented as:

$$\dot{K} = \forall * \rho * \psi * \Omega \qquad \text{.......(5)}$$

K represents the vertical shift of supply due to intervention of watershed development technologies and expressed as a proportion of initial price. ∀ is 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 ($\varepsilon_s$). 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 as:

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

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

## Cost of the 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

Our 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 type have differential impact on the water resources and agricultural production and productivity. The success of the watershed development programs critically depends upon the rainfall in the region. The major crops grown are sorghum, cotton, sugarcane, maize, coconut and vegetables. Of the total cropped area, the area irrigated accounts for 56.82 per cent. The chief source of irrigation in the district is through wells. Over the years, there has been a general decline in the water level in all of Coimbatore district, which is attributed to indiscriminate pumping of groundwater. 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 (Palansami and Suresh Kumar, 2007). It is in this context that groundwater augmentation by artificial recharge through watershed development programs gained momentum.

## Data

The major data were derived from the recently completed study on Comprehensive Assessment (CA) of Watersheds Programs in India implemented by the ICRISAT-lead consortium team (Wani et al. 2008). For the purpose of our research, the data were drawn from a cluster of 10 watersheds implemented in the Coimbatore district of Tamil Nadu, India. The details of all these watersheds with area treated are given in Table 1. A variety of indicators were developed and used for impact assessment. The indicators of the impact of watershed developmental 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 was selected for each watershed. The control villages were selected so as to have the similar agro-climatic conditions. The select indicators were compared with before

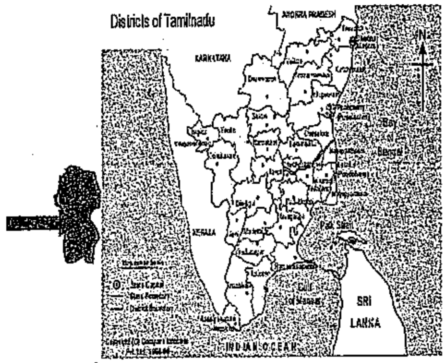


*Figure 2. Map of the study area*

and after the watershed treatment activities, and also with that of the control village where watershed treatment activities were not taken up. 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 were obtained from published sources.

## Results and Discussion

This section presents the key results and findings from the field experience of impact assessment of watershed programs implemented under Drought Prone Area Programme (DPAP) in the Coimbatore district of Tamil Nadu. The general characteristics of the sample farm households in the study watershed were analysed and are presented in Table 2. It could be seen that the average size of the holding is worked out to 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 is 2.5 and 2.1 out of 4.07 and 4.2 for watershed and control villages.

The labour force participation rate thus comes out at 61.48 per cent and 50.79 per





cent. The higher labour force participation is 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 the farmers in the watershed villages is higher implying that the enhanced agricultural production is due to watershed treatment activities. Construction of new percolation ponds, major and minor check dams and rejuvenation of the existing ponds/tanks enhanced the available storage capacity in the watersheds to store runoff water for surface water use and groundwater recharge.

Construction of new percolation ponds, major and minor check dams and rejuvenation of existing ponds/tanks enhanced the available storage capacity in the watersheds to store runoff 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 groundwater recharge and water availability for livestock and other non-domestic uses in the village as a result of watershed treatment activities. On the basis of the data collected from the sample farmers, it was found that the water level in the open dug wells has risen in the range of 0.5 to 1.0 meter in watershed villages. The depth of the water column in a few sample wells were collected both in watershed and control villages for comparison. The depth of the water column in the wells of the watershed villages was found to be higher than those in the control villages. For instance, the depth of the water column in the wells in Kattampatti watershed village was 3.53 meters compared to 2.16 meters in the control village with a difference of 63.43 per cent.

Information related to the duration of pumping hours before well goes dry (or water level depressed to a certain level) and time it takes to recuperate to the same level were collected for the sample farmers across villages. Due to watershed treatment activities such as construction of percolation ponds, checkdams etc., the groundwater recuperation in the near by wells increased. The increase in recuperation rate varied from 0.1 $M^3$ to 0.3 $M^3$/hour. It was also observed that the recharge to the wells decreased with the distance of wells away from the percolation ponds and check dams and the distance generally was 500 to 600 meters in the case of percolation ponds.

The impact of watershed treatment activities on area irrigated by groundwater revealed that the area irrigated in watershed villages registered a moderate increase after the watershed development activities in most of the watersheds. When compared to watershed villages, the area irrigated in the control village declined slightly over the period. It is evidenced that the irrigation intensity is higher in the watershed treated village than in the untreated village. This shows that the watershed developmental 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 water table in the wells declined due to continuous pumping with out making any interventions in recharging the aquifers. This is one of the reasons why farmers in most of the villages demand watershed programs in their villages.

The analysis of impact of watershed treatment activities on the increase in cropped area indicated that the increase in net cropped area, gross cropped area and thereby cropping intensity is realized in both the watersheds.

(Table.3.).

The cropping intensity indicates that it was relatively higher in the case of watershed treated villages and this appears to be a common phenomenon in all the watersheds. For example, the cropping intensity was worked out to 147 percent in the watershed village and it was little higher than the control where it is only 133 per cent. The CEI is used to compare the diversification across situation having different and a large number of activities since it gives due weight to the number of activities. The CEI has two components viz,. distribution and number of crops or diversity. The value of CDI increases with the decrease in concentration and increases with the number of crops/ activities. In general, the CDI was higher in the case of watershed treated villages than the control villages confirming watershed treatment activities help diversification in crop and farm activities.

The details regarding livestock per household and per hectare of arable land is furnished in Table.4. Livestock income has been a reliable source of income for the livelihood of the resource poor farmer households. Cattle, sheep and goats are maintained as important sources of manure and kept as liquid capital resources. It could be seen that nearly 46.67 per cent and 93.33 per cent of the households in watershed and control villages maintain cattle. Access to grazing land and fodder will make 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.

This is mainly due to the fact that inadequate grazing land and poor resource base for stall feeding persuade them to feed their livestock with green leaves and fodder obtained from crops and crop residues. Moreover, having poor resource base with little scope for improved crop production, the farm households in the control villages maintain mainly milch animals to derive additional income for their livelihood.

## Application of Economic Surplus Method

The watershed developmental intervention is expected to impact first on the natural resources such as land and water. Increase in the water resources impacts agricultural production. Thus, various watershed treatment activities lead to increased agricultural production. The impact of watershed developmental activities on the yield of crops and the cost estimated are presented in Table 5.

The change in yield due to watershed intervention across crops varied from 31 per cent in maize to a maximum of 36 per cent in cotton. This is the maximum change in yield due to watershed intervention. Reduction in marginal cost due to the supply shift ranged from 33 per cent in vegetables to 64 per cent in sorghum. Net cost change due to watershed developmental activities varied from 32 per cent in vegetables to 60 per cent in the case of sorghum.

The change in total surplus due to watershed developmental activities were estimated (Table 6). The change in total surplus was higher in sorghum and maize compared to other crops like pulses and vegetables. Being the major rainfed crops, these two crops benefited more from the watershed interventions. The change in the total surplus due to watershed intervention is decomposed into change in consumer surplus and the change in producers' surplus.

It is evident that the producers' surplus







was higher than the consumer surplus in all the crops. For instance, in sorghum, the producers' surplus if worked out to 61.2 per cent where as the consumers surplus was only 38.8 per cent. No doubt, the watershed developmental activities benefited more the agricultural producers. It is interesting to note that unlike in crop sector, the milk production had different impacts on the society. The decomposition analysis revealed that watershed development activities generate more consumers' surplus in milk production.

Efforts were made in the present study to assess the overall impact of different watershed treatment activities in terms of Benefit Cost ratio (BCR) and Internal Rate of Return (IRR). The NPV, BCR and IRR were worked out by economic surplus methodology assuming 10 per cent discount rate for a life period of 15 years.

The results of the economic surplus method indicated that the BCR worked out to more than one, implying that the returns to public investment such as watershed development activities are feasible. Similarly, the IRR is worked out to 25, which is higher than the long-term loan interest rate by commercial banks, indicating the worthiness of the government investment on watershed development. The Net Present Value worked out to Rs. 567912 for the entire watershed. The net present value per hectare worked out to Rs.4542 (where the total area treated is 500 hectares). This implies that the benefits from watershed development is higher than the cost of investment in the watershed development program of Rs.4000 ha[5].

## Conclusion and Policy Recommendations

Experiences show that the watershed development programs produced desired results and there are differences in their impacts. Hence, the watershed impact assessment should be given due importance in the future planning and developmental programs. Comparing the results of economic surplus approach with conventional method of investment analysis, it is observed that there are significant differences between the economic surplus approach and the conventional approach. All the three indicators NPV, BCR and IRR worked out to be higher in the case of economic surplus approach compared to conventional methodology. It is hard to conclude whether conventional methodology underestimates the impacts or economic surplus method (ES) over estimates the impacts. However, as the economic surplus approach captures the distributional effects on different sectors of the economy in a holistic manner, this is possible to conclude that the conventional methodology underestimates the impacts of watershed development programs in the rural areas.

Regarding the policies, watershed developmental activities have significant impact on the groundwater recharge, access to groundwater and hence the expansion in irrigated area. Therefore, the policy focus must be for the construction of water harvesting structures particularly percolation ponds wherever feasible. In addition to these public investments, the private investments through construction of farm ponds may be encouraged as these structures help

*[5] However, recently the watersheds in India are allotted a budget of approximately Rs. 6000 per hectare. 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 budget allotment is Rs.12000 per hectare.*

in a big way to harvest the available rainwater and hence groundwater recharge.

Watershed developmental activities altered crop pattern, increased in crop yields and crop diversification and thereby provided enhanced employment and farm income. Therefore, the 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, the appropriate water saving technologies like drip is introduced without affecting farmers' choice of crops. The creation and implementation of regulations in relation to the depth of wells and spacing between wells reduces the well failure, which could be possible through Watershed Association. The existing NABARD norms such as 150 meters spacing between two wells should be strictly followed upon.
People's participation, involvement of Panchayati Raj Institutions, local user groups and NGOs along side institutional support from different levels, viz. the Union Government, the State, the District and block levels should be ensured to make the program more participatory, interactive and cost effective.

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**Table 1. Details of Watersheds covered for the study in Coimbatore District**

| Name of the Block | Name of watershed | Area (ha) |
|---|---|---|
| Annur | Kattampatty I | 460.00 |
| | Kattampatty II | 467.50 |
| | Kuppepalayam | 672.50 |
| Avinashi | Naduvenchery | 767.50 |
| | Karumapalayam | 752.50 |
| | Chinneripalayam | 524.85 |
| Sulur | Arasur I | 605.00 |
| | Arasur II | 590.00 |
| | Rasipalayam | 560.00 |
| Palladam | Kodangipalayam I | 455.00 |

**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 |

*indicates values are significantly different at 1 %, level from the corresponding values of control village

**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)[6] | 1.0 | 0.97 | | |

*, ** and *** indicate values are significantly different at 1 %, 5 % and 10% levels from the corresponding values of control village

(Number)

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

| 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 |

[6] *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
Pi = Acreage proportion of ith crop in total cropped area
N = Total number of crops





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

**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 (100.00) | 113636.3 (38.8) | 179541.0 (61.2) |
| Maize | 177774.2 (100.00) | 85424.0 (48.1) | 92350.2 (51.9) |
| Pulses | 25777.5 (100.00) | 12580.3 (48.8) | 13197.2 (51.2) |
| Vegetables | 29663.6 (100.00) | 10627.5 (35.8) | 19036.1 (64.2) |
| Milk | 176878.5 (100.00) | 105974.1 (59.9) | 70904.4 (40.1) |

NOTE: The Change in total surplus in the village economy due to watershed intervention is decomposed in to change in consumer surplus and change in producer surplus. The decomposition of total surplus is as follows:

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

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

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

**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 |