# Using the Economic Surplus Model to Assess Returns on Research investment: A Case Study of Developing Soil Water Conservation Measures for Cardamom

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## Introduction

Resources for agricultural research are scarce, but there is a competition for funding. This led to research sponsors to ask hard question about the impact they have funded. Therefore, the efficient resource allocation and the necessity to justify their use to the society require the assessment of economic impacts of research. This study is a joint effort of National Centre for Agricultural Policy Research (NCAP) and Indian Institute of Spices Research (IISR) in the direction. The objective was to:

- determine the adoption rates for Soil Water Conservation (SWC) measures as a technology to increase cardamom production.
- estimate the returns (social gain) to research investment, and
- estimate the benefits to producers and consumers separately due to technology adoption.

## Cardamom in India

India is the major producer, exporter and consumer of cardamom an important spice crop of commerce. The crop is cultivated as a rain fed crop in the hill districts of Kerala and Karnataka. In parts of coffee growing areas of Karnataka, cardamom is grown in isolated pockets, in ravines or in low-lying areas either as sole crop in narrow strips along the ravines or as scattered lumps interspersed with coffee plants. Increased degradation of forests, deterioration in forest ecology coupled with erratic trends of rainfall etc. adversely affected cardamom production (Ratnam and Korikanthimath, 1985). Further, the traditional system of cultivation led to soil erosion, runoff of rainwater and finally poor crop yield.

## The problem

Soil and water are the two important basic requirements of any crop production system. It is more so for crops like cardamom, coffee and pepper which are grown in areas receiving high rainfall. Nearly 75 to 80 % of total rainfall is received from South-West monsoon, which lasts for 3 months from June to August. Northeast monsoon and pre monsoon showers are not well distributed and dependable. Hence, these crops suffer from both excessive moisture and moisture stress.

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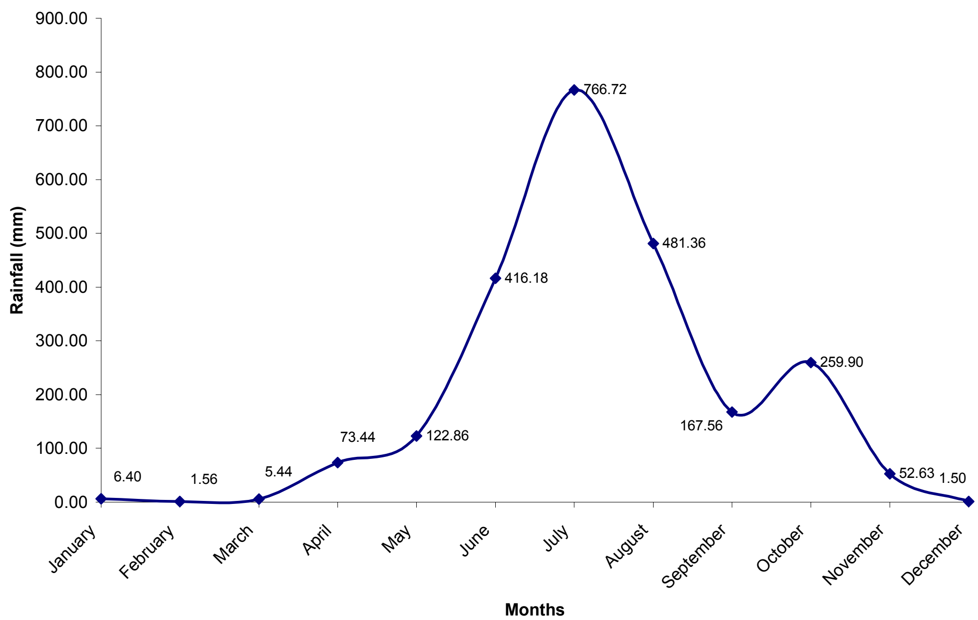
Cardamom is essentially a surface feeder and for its optimum growth, cool humid microclimate is most essential. The crop is extremely sensitive to drought conditions in its environment. The droughts of 1982-83, 1983-84 and 1986-87 had severely affected the crop and virtually devastated the cardamom plantations. The drought like situation in recent past (2001-03) has also resulted in wipeout of cardamom plantations where irrigation facility was not available. Though cardamom tracts in the region receive heavy rainfall (1500-4500 mm), availability of soil moisture during summer months is a limiting factor. There is a long dry period of 6-7 months in a year (Fig 1). This long dry spell is a major constraint in cardamom cultivation.

**Fig. 1. Average monthly rainfall (mm) in Kodagu district of Karnataka (1993-2003)**.




Frequent spells of drought and the prevailed low price for the crop led to rapid decline in cardamom production. Area under the crop has declined from 13225 hectares in 1991-92 to mere 5021 hectares in 2000-01 in Kodagu district alone (Table 1). The average annual rate of decline during the period from 1996-97 to 2000-01 was 14.9%. Problems of plantation crop in general and cardamom in particular in the region can be listed as follows:

1. Soil erosion and runoff loss of rainwater and soil nutrients.
2. Low cropping intensity in cardamom based cropping system leading to less income from unit area.
3. Poor water harvesting and management system leading to drought like situation during the summer months.

4. Lack of soil and water conservation measures for sustainable crop production.
5. Erratic rainfall and unstable price pattern over the years

Sustainable land management is an extension of “maximum economic yield”, in that it not only tries to maximize the efficient use of inputs but also considers the long-term environmental and social costs (Dumanski et al 1991). It is also an extension of the concept of “Best management practices” but treats each management technique as a component of a set of technologies, which act collectively on long-term sustainability. Keeping this principle in mind, an effort was made to analyse the economic impact of the investment to develop technology.

Table 1. Average annual rainfall and production of cardamom in Kodagu District of Karnataka (1991-92 to 2002-03).

| Year | Average annual rain fall (mm) | Cardamom in Kodagu district | | | Production of cardamom in Karnataka (ha) | % production of cardamom in the State |
|---|---|---|---|---|---|---|
| | | Area (ha) | Produc-tion (MT) | Productivity (kg/ha) | | |
| 1995-96 | 2852 | 14,440 | 800 | 55.4 | 1745 | 45.8 |
| 1996-97 | 2876 | 11,990 | 590 | 49.2 | 1360 | 43.4 |
| 1997-98 | 2636 | 9800 | 611 | 62.3 | 1860 | 32.8 |
| 1998-99 | 2167 | 9325 | 582 | 62.4 | 1510 | 38.5 |
| 1999-00 | 2887 | 8950 | 558 | 62.3 | 1945 | 28.7 |
| 2000-01 | 2491 | 8943 | 558 | 62.4 | 2100 | 26.6 |
| 2001-02 | 2181 | 8380 | 523 | 62.4 | 2116 | 24.7 |
| 2002-03 | 1999 | 8170 | 749 | 91.7 | 2310 | 32.4 |

Source: DASD, Calicut.

### *The technology*

Although rainfall is an extremely valuable resource in the region, its productivity is often low due to heavy runoff to lower level water bodies. Water harvesting, the practice of collecting surface runoff water for direct application to crops, storage in farm ponds, or ground water recharge, allows the productive use of the scarce rain water resources. Supplemental or protective irrigation, and application of a limited amount of irrigation at critical time, has been shown to improve yield and water productivity in these environments.

#### *i) Rain water harvesting for protective irrigation*

The terrain of cardamom estates is undulating with moderate to steep slopes. Quite a number of small and fairly big streams pass through many of these areas. Run off from the cardamom watersheds can be collected in farm ponds and check dams or underground water tapped through dug wells. All these available alternatives were analyzed in terms of their viability and usefulness for predominantly small land holdings and digging/construction of farm pond was recommended for adoption. Rainwater can be directed towards the pond using hedges. Harvested water can be stored in ponds by minimizing the losses through seepage and evaporation etc. and the same can be used for irrigation during the lean months. The technology apart from improving and stabilizing yields under rain fed cardamom cultivation reduces flood hazards and recharge ground water.

***ii) Contour Staggered Trenches and Bunds:***

The rainfall received on hill slopes immediately rushes from the slopes and very little water percolates to the underground strata. Therefore, to reduce this run-off and enable it to percolate to the ground water and to conserve adequate soil moisture and make provision for safe disposal of water the following measures were recommended:

1. Digging Contour Staggered Trenches (CST) in alternate row of cardamom and coffee to prevent water and soil loss by restricting soil movement.
2. Change in the system of planting i.e. pit system to trench system of planting for efficient utilization of rainwater in cardamom.

Though trench system of planting costs about 35-40 percent more of labor than pit system, the benefits of soil moisture conservation and its ultimate beneficial effect on plant growth and yield are significant. Inclusion of ginger, french bean, pineapple etc as mixed/hedge crop further improves the total income from the unit area.

***iii) Introduction of vegetative barrier***

Crops like ginger, french bean (in 1$^{st}$ year of planting) and pine apple are recommended for planting in strips in between the cardamom rows to act as vegetative barrier, which helped in retarding the runoff velocity and retained the eroded soil. Introduction of these crops not only act as barriers but also increased crop intensity and improved gross income to the farmer.

***iv) Improvement in irrigation management system***

Overhead irrigation with sprinkler unit is found well suited for cardamom on account of its several advantages over other irrigation methods (surface irrigation, sub-surface or trench irrigation). On hill slopes with undulating topography where cardamom is grown, sprinkler irrigation can provide uniform water supply without excessive loss of water due to surface run off or conveyance loss. This will also avoid piddling, leaching and runoff that are common with other methods of irrigation. Successful growth and production of cardamom can be achieved with the humid microclimate created by overhead sprinkling. The standardized sprinkler irrigation schedule recommended was:

Six hours sprinkler with 6" rain: 1. November to February - Once in 20 days
2. March to June - Once in 10 days

### Study region

Kodagu district accounts for more than 40% of the total cardamom production in the State of Karnataka (Table 1.). Fig 1. also reflects the fact that though the crop is distributed throughout the hill districts of Western Ghat, its concentration is more in Kodagu district next to Idukki and Wayanad districts in Kerala.

### Methodology

Impact of research investment on cardamom industry of the district was assessed using the economic surplus model. In order to measure the impact of research on SWC measures for cardamom production and productivity, it is necessary to estimate the adoption rate for the technology. For this, a ratio of area with technology to total area under the crop was worked out based on the Rapid Market Survey (RMS) data. The observed trend during 2001 to 2003 was assumed for the future up to 2009.

### Sampling and data collection

The economic analysis was done based on primary data collected from 34 cardamom growers in Kodagu District of Karnataka state. Villages from all the three taluks of the district were purposely-selected based on the area under the crop (Table 2). Farmers' field was taken as a base unit for the survey and was conducted during the crop years 2003 and 2004. Pooled average of two year data were analysed using appropriate technique.

***Table 2. Sample details***

| Sr. No. | District | Taluk | Village | No. of respondents |
|---|---|---|---|---|
| 1 | Kodagu | Virajpet | Kakkambe<br>Kabbirakad<br>Pallibetta | 4<br>6<br>5 |
| 2 | Kodagu | Madikheri | Hakatur<br>Halleri<br>Murnad | 6<br>3<br>6 |
| 3 | Kodagu | Somwarpet | - | 4 |
| Total | 1 | 3 | 7 | 34 |

**Yield and cost change**

Research benefits in terms of social gain were computed both for ‘with’ and ‘without’ the technology and the difference in benefits was attributed to research investment by NATP. Since the project was started in the year 2000-01 and the resultant technology was already in the field, the actual data for area, production and price for the first three years were collected and used in the analysis. The measured benefit is ex-ante estimate up to 2009. The incremental benefit was compared with the research cost incurred under the project. Only the actual amount spent out of the total sanctioned budget for the project period was considered and it did not include the salary of the project scientist, extension cost and other administrative costs. Net present value (NPV), internal rate of return (IRR) and benefit cost ratio are then computed using the above estimates of benefit and project cost.

Based on the on-farm trial data and post adoption survey data collected, the average yield enhancement of 291kg/ha was estimated. Conversion of this yield change to per unit (ton) cost change was done by dividing it by the elasticity of supply. Adoption of the new technology is expected to increase the cost of production per hectare by189%, when compared to the existing package of practice. This per hectare cost change was converted to per ton cost change using the formula given by Alston *et al* (1995) and subtracted from the per unit cost change due to the yield change to arrive at a net per unit (ton) cost change due to technology adoption.

**Data used**

Although India is one of the major exporters of cardamom to the world market, it is assumed that the Indian exports does not influence world price ($P_w$). The past decade world production level has increased from 10250 tons in 1980-81 to 24953 tons in 1997-98. However, share of Indian export in the world market has come down to the level (<10%), where it is not in a position to influence the world price. Unlike India, the other major producing country in the World (Guatemala) exports almost the entire production to international market. Actual border price prevailed during the period from 2000-01 to 2002-03 was used in the analysis as world price ($P_w$) for Indian cardamom.

Quantity produced refers to production volumes specific to the part of the region under study (Kodagu district of Karnataka State), where the evaluation is being carried out. District production of an average 700 tons in the recent past has been taken as base year production for analysis of economic surplus.

Since economic returns occurring at different points in time must be discounted to make them comparable, the issue of lags between when costs are incurred and when benefits are experienced is very important in the analysis of research impacts. Discount rate of 8% was used for the analysis.

Regarding adjustment against uncertainties, the change in total surplus was adjusted by the levels of adoption and length of research period to estimate the returns to research investment on developing the technology and its commercialization. Further, it is assumed that new technology being a eco-friendly one, it is expected to be a sustainable technology. Thus it was assumed that the benefits would not depreciate substantially and that this depreciation would not commence until 10 years after the new technology became available.

**Analytical Method**

The economic surplus method (Alston et al., 1995) was considered for the present study to estimate the rate of returns of SWC measures that have been adopted to increase cardamom production. The analysis was attempted with the small open economy model. The small open economy market model represents an open economy for which price is determined exogenously. The price field is labeled as world price ($P_w$), but can be considered as any relevant price determined outside of the region of interest and that will remain unaffected by changes within the single market region.

**Economic Surplus Model**

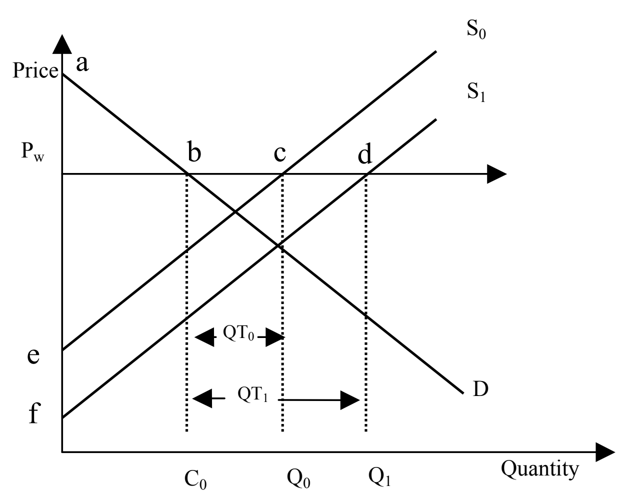
The concept of economic surplus has been used to measure economic welfare and the changes in economic welfare due to change in policy and other interventions. The methodology permits estimation of economic benefits generated by adoption of technological innovations, compared to the situation before (without) the adoption, where only traditional technology was available. With information on productivity change generated by research, equilibrium price of assessed product, adoption rate and costs, time frame between research and adoption, and price elasticity of supply and demand, it is possible to calculate the magnitude of change of supply as a result of the technology adoption (Maredia *et al.,* 2000).

Here in our study the analysis was attempted with small open economy model, because the target domain Kodagu district in Karnataka State is not only the producer but also the consumer of cardamom. Produce from the State moves to other markets in the country and international market. The region is one of the major contributor to the total cardamom production in the State. So, the open economy frame work, which operates under the assumption of a small market as related to the international market in the rest of the world (ROW, defined as all areas outside of Karnataka including the international market). In other words, quantities marketed abroad do not affect international prices rather any quantity can be sold in the international market at the prevailing world price. To simplify the models no transportation costs were assumed, resulting in constant price in both the regions. The local market therefore faces an infinitely elastic external demand ($\eta=\infty$). The partial equilibrium approach assumes that no other adjustments are made in the economy.

**Small open economy models - cardamom exports at the world price**

Figure 1 reflects the case of small open economy, where the changes in economic surplus due to parallel shift of supply curve. Though there is a possibility of pivotal shift of the supply curve, only the parallel shift is considered for further analysis in this case. The evaluation of research benefits is done at the world price and at the domestic market level. The initial equilibrium without technology is defined by consumption $C_0$ and production $Q_0$ at the world market price $P_w$ with a traded quantity $QT_0$., Consumer surplus is measured by area 'ab$P_w$' and producer surplus is measured by area $P_w$ce. With a new technology, producer surplus increased by area 'ecdf' because of the technology induced parallel shift of the supply curve from $S_o$ to $S_1$. Consumer surplus is not affected; consumers continue to face the same price and to consume the same quantity. However, the increase in supply ($Q_0$-$Q_1$) led to exportable quantity of $QT_1$ to ROW market.

Figure 2: Cardamom: Change in economic surplus when a new technology is adopted in a small open economy (parallel shift of the supply curve)




With no changes in consumer surplus, the total change in economic surplus is measured by the change in producer surplus, which corresponds to area delimited by curves $S_0$, $S_1$, and $P_w$). Using the world price $P_w$ the changes in economic surpluses in an open economy model is estimated using the following equations:

1) Parallel shift of the supply curve

K: Vertical shift of the supply function ($)

$\Delta CS = (P-P')Q+½(P-P')(Q'-Q) = 0$ because $\Delta P = \Delta Q = 0$ -------------------------- (1)

$\Delta TS = \Delta PS = KQ+ ½ K (Q'-Q) = KQ (1 + ½ (Q'-Q)/Q) = KQ (1 + ½ \varepsilon K/P_w)$ ---- (2)

2) Pivotal shift of the supply curve

$\Delta PS = ½ KQ (1 + K \varepsilon /P_w)$ (pivotal shift) ------------------------------------------------ (3)

$\Delta TS = \Delta CS + \Delta PS$ ---------------------------------------------------------------------------- (4)

Where,

Pw = World price

K = Supply shift

$Q_0$ = Quantity consumed

Q = Quantity supplied before supply shift

ε = Supply elasticity

e = Demand elasticity

$\varepsilon = [(Q'-Q\}/K]*[P_w/Q] > (Q'-Q)/Q = \varepsilon K/P_w$

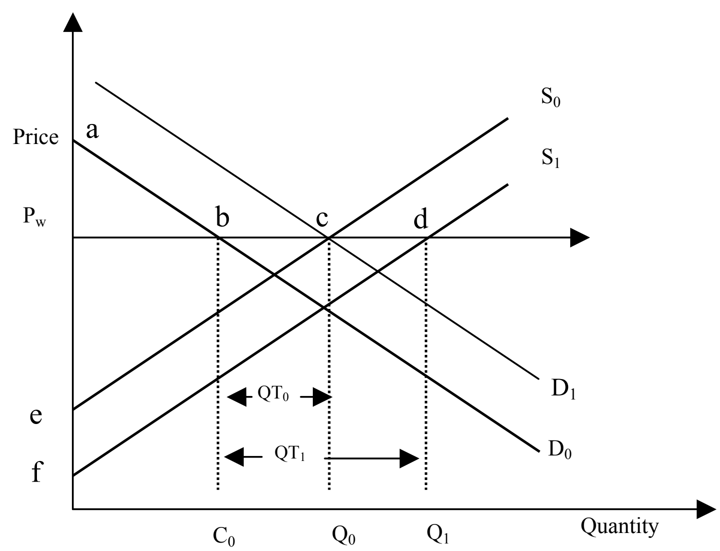
In figure 2, the consumer surplus doesn't change when the supply curve shifts. The producer surplus is affected by the supply shift, but is invariant to the demand shift. Therefore, the change in total economic surplus is only affected by the supply shift. Thus, the change in demand is not considered in the small open economy models.

The increased price induced the farmers to produce more by giving extra-care and inputs to the crop resulting in more production. Better prices are always followed by bumper crops (Madan, 2001). Though Cardamom has no substitute, its purchase can be avoided when the price becomes more i.e. it is not an essential food item. Figure 2. represents research benefits for one year. A successful research investment will yield benefits over a number of years. As the level of adoption increases there will be a further shift in the supply curve, a corresponding change in benefits.

**Assumptions**

It was assumed for ease of analysis that the output supply function was unitary elastic and linear with a parallel research induced supply shift, and the demand function was linearly inelastic. The assumption of a simple case of linear supply and demand functions with parallel shift has been applied in most of the studies on research benefits (Alston *et al.,* 1995). It may be noted that it is a realistic assumption in the absence of availability of reliable estimates of economies of scale and size in agricultural production influenced by these technologies. And, when a parallel supply shift was used, the functional form was largely irrelevant and a linear model provided a good approximation to the true (unknown) functional form of the supply and demand functions (Alston and Wohlgenant, 1990).

Figure 3: Cardamom exports: Change in economic surplus when a new technology is adopted in a small open economy (parallel shift of the supply and demand curve)




**Other assumptions**

*i. There are two markets for Indian cardamom- Domestic and Rest of the world (ROW).*

This assumption is purely a reflection of reality. It is expected that the cardamom grades that meet importer's requirement will be exported, while there is no grade specifications to the domestic market. The major destinations for India's cardamom are USA, Middle East Arab countries and Japan. Japan is the steady market for Indian cardamom in recent years.

*ii. The demand curve for the domestic market is downward sloping.*

This assumption implies that an increase in price leads to a reduction in quantity demanded and a fall in price increases the quantity purchased.

*iii. The supply curves for the two markets are upward sloping.*

This is a standard assumption based on the fact that an increase in the price of cardamom will, all other things being equal induce farmers to allocate more resources to the production of the crop. Similarly, a fall in the price of cardamom will serve as disincentive to farmers leading to a reallocation of inputs away from cardamom production. Cardamom being a perennial crop any change in input to the crop is not reflected in the same year, while the price change to the production change is instant. According to Madan *et al*., *(2002)* there exists a vicious circle for the crop.

In a closed economy, the price is determined by domestic supply and demand. However, in a small open economy, the price is set at the export price when the country is a net exporter. Producers benefit the most from research on export crops, whose demand is relatively elastic with a flat demand curve (Masters, 1996).

*iv. The demand and supply functions are linear in both the markets.*

This assumption eases the task of compiling the geometric areas of economic surplus changes; it facilitates the use of basic algebra for the calculation. As noted by Alston, Norton, and Pardey (1995), since linear demand and supply curves are characterized by varying elasticity, it is important to be explicitly about where any assumed elasticity apply. Not withstanding the criticisms of the use of linear supply and demand models within the economic surplus framework, it has been suggested (Alston and Wohlgenant, 1990, cited in Alston, Norton and Pardey 1995), that where a parallel supply shift is used, a linear supply model is a valid approximation regardless of the true functional form.

*v. The adoption of the technology leads to a parallel downward shift in the supply curve for the export market.*

It is implicitly assumed that the adoption of the technology would lead to a reduction in production cost per unit of cardamom exports. The technology-induced change in cost per unit is linked to the price premium enjoyed by farmers from selling in the world market. As a result, profits will increase due to the price premium derived from selling in the export market. Higher profits of farmers would eventually induce them to allocate more resources to cardamom production, resulting in a downward shift of the export supply curve. In other wards incentives for adoption lie in the price premium on export, the ability to increase sale, the resulting reduction in cost per unit. Thus, the adoption of the technology will lead to shifting of cardamom export supply curve downwards to the right.

The assumption of the parallel nature of the supply shift implies that the reduction in cost-per-unit is of the same magnitude at all potential output levels. Equivalently, it implies that the program adoption results in a equal quantity increase at each potential price level. As noted earlier, the assumption of a parallel shift in supply is complementary to the assumption of the existence of linear supply and demand curves (Alston and Wohlgeanant 1990).

*vi. The demand curves in the two markets are unaffected by the adoption of SWC measures.*

The implicit assumption here is that, the adoption of the program neither affects the performance nor income of the consumers and it also does not affect the prices of commodities related to cardamom.

It is assumed that there is no effect on the input and output markets as there are no changes in output prices. The production technology is the same for both adopted and non-adopted farms except for the cost of new technology in the adopted farms. Though there would be no increased demand for other inputs due to technology adoption, it is assumed that there will not be any change in the input price.

The analysis was carried out using a spreadsheet model designed to take the impacts of the technology into account. The conceptual model is based on the one suggested by Alston *et al., (*1995). Further, the analysis had to be adapted to accommodate the parallel shifts in supply associated with the technology impact. In this model the total surplus was equal to producer surplus, as there was no change in the consumer surplus.

The difference between the gains and the costs of generation and transfer represents the net benefit of the technology, explained by IRR, NPV and BCR (Gittinger, 1982). To enable calculations with present values, a discount rate of 8% is being used in this paper. Using this criterion, research programmes are profitable if the IRR is greater than the opportunity cost of the capital invested. Since many of the baseline assumptions are debatable, sensitivity analysis were undertaken to assess the effect of different discount rates, adoption levels research timing and cost assumptions, and probability of research timing and cost assumptions, and probability of research success on the NPV, IRR and BCR.

In this ex-ante analysis only the direct benefits from the increased yield (or quantity saved) was considered. The aspects of returns on maintenance research and the increase in quality or acceptability of the commodity through research is not taken into account.

## Results and discussion

### Economics of the technology

Cardamom plantations where the recommended SWC measures were implemented has earned an overall benefit equal to NPV of Rs.480856 at the end of 10 years with a BCR of 1.95 and IRR of 140% at discounted cash flow (Table 3). Further, the improved productivity level of 490kg/ha in the adopted farms against 199kg/ha in the non-adopted farms and encouraging price of Rs.465/kg enabled the adopted farms to recover the initial investment within two years. These findings corroborate with those of Korikandthimath and Hiremath (2000), where NPV was Rs.155476/ha and BCR was 2.01 for cardamom cultivation on steep slopes by resorting to appropriate soil and moisture conservation measures. Thus, the economic viability of the technology and increasing trend in price for cardamom encouraged the farming community to adopt the technology. Being an eco-friendly and environmentally sustainable, the technology was supported by both central and State government organizations like Spices Board, Coffee Board and NABARD etc. through various promotional activities.

**Table 3. Measures of project worth for SWC measures in cardamom**

| Measures | Adopted farms* | Non-adopted farms |
|---|---|---|
| NPV (Rs./ha) | 480856 | 166798 |
| BCR | 1.95 | 1.7 |
| IRR (%) | 140 | 121 |

Note: * Government subsidy (50% of the cost for farm pond construction and 25% of the cost for sprinkler irrigation equipment) is not taken into account.

### Estimation of economic surplus

Table 4, presents the summary of assumptions and results of economic analysis of the technology, while fig. 4 presents the research lags and adoption process for the project. Reduction in cost per ton production of cardamom (636%) due to the estimated potential productivity gain (146%) is much more than the per unit cost increase in production cost of 77% leading to net proportionate reduction of 559% in cost per ton output. The lower cost of production results in the increased amount of cardamom supplied by farmers. The estimated maximum proportionate productivity increase is 146% resulting in increased total economic surplus of Rs.3973 thousands (Table 5). The NPV of the research is estimated to be 2807 thousands, with an IRR of 38 % and a benefit cost ratio of 3.4.

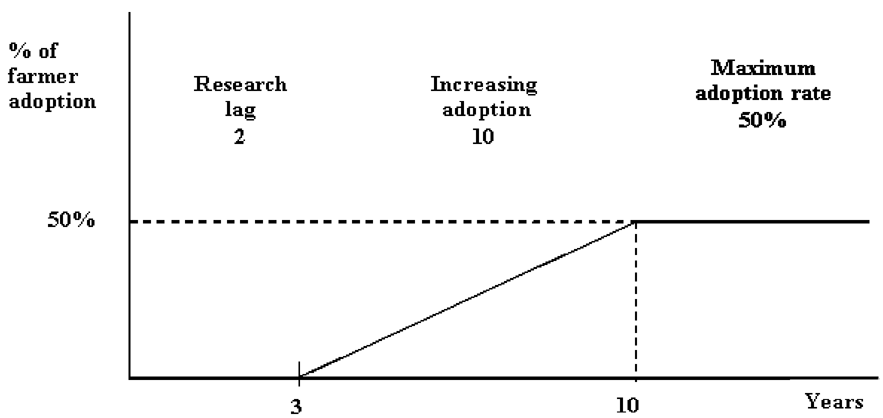
IRR of 38% for the base parameters indicate that, on an average for each rupee invested, returns came to 38% per year from the time it invested until the year 2009. The

BCR of 3.4 indicates that Rs.1 invested in developing and disseminating the technology produced an average benefit of Rs.3.4 throughout the period.

**Table 4. Summary of assumptions and results of economic analysis**

| | |
|---|---|
| Time to release of technology to farmers (Yrs) [1] | 3 |
| Adoption period – time to maximum/ceiling adoption level (yrs) [1] | 7 |
| Maximum adoption level - % of farmers expected to adopt by the end of the adoption period [1] | 50 |
| Probability of research success [1] | 100 |
| Research period within the research institute [1] | 3 |
| Research and development period – private and/or public sector [1] | - |
| Net Present Value (NPV) of the research | 2807 |
| Internal Rate of Return (IRR) | 38 |
| Benefit cost ratio (BCR) | 3.4 |
| Source: 1. Based on the information collected during the survey. | |

**Fig 4. Research continuum: research lag and adoption process**




| Yearly adoption rate (%) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 50 |

**Sensitivity analysis**

**Potential change in income**

The change in total surplus (table 6) is affected by the levels of adoption, probability of research success, and a depreciation factor. These uncertainty adjusted benefits generated over the period were then compared with research investment. The net benefit stream (i.e. benefits minus costs over the next 10 years) is given in table 7.

**Table 5. Economic surplus model: Potential maximum benefits (change in total surplus) within the domain**

| Open economy | Cardamom |
|---|---|
| ε = Elasticity of supply[1] | 0.23 |
| η = Elasticity of demand[1] | 0.16 |
| Maximum proportionate productivity gain per ha (%)[2] | 146 |
| Gross cost change per ton (%) | 636 |
| Input cost change per ha (%)[2] | 189 |
| Input cost change per ton (%)[2] | 77 |
| Net proportionate reduction in cost per ton output | 559 |
| Relative reduction in price (%)[2] | 330 |
| Price (Rs./kg)[3] | 465 |
| Quantity (tons)[3] | 700 |
| Change in total surplus (Rs. thousands) | 3973 |
| Change in consumer surplus (Rs. thousands) | - |
| Change in producer surplus (Rs. thousands) | 3973 |

Source:

1. In the absence of estimated elasticity for cardamom, based on the study by Bade and Smit (1995) the elasticity of pepper a similar type of crop is used.
2. Worked out from the survey data.
3. Average of actual prices prevailed during 2001-03 was used.

With a supply elasticity of 0.23, the net present value (total change in economic surplus minus research costs) is estimated to be Rs. 2807 thousands, Rs.2158 thousands and Rs.1142 thousand @ 8%, 11% and 20% discount rates respectively. These net present values are equivalent to the sum of area 'ecdf' calculated for each year in figure 3. (minus the research costs which are only in the early years) discounted over the 10 years period.

### Adoption levels

Assumption about the maximum level of adoption of the new technology strongly affected returns on research investment. The estimated actual adoption level was 10% in the beginning and was at maximum 50% after sever years. This was increased to 60% and 80% to examine the implications for research returns. The increase in adoption level to 60% has increased the NPV to Rs.2945 thousands with an IRR of 39% and BCR 3.5. Increased adoption level to 80% resulted in substantial net returns of 3222 thousands with IRR of 40% and BCR 3.8. It indicates the fact that better returns from the technology could have been obtained by investing on extension activities to increase adoption level.

**Table 6. Sensitivity of estimated return to various assumptions**

| Assumptions | Level | Net Present Value (Rs. '000) | Internal Rate of Return | Benefit : Cost Ratio |
|---|---|---|---|---|
| Maximum/ceiling adoption level (%) | | | | |
| Baseline | 50% | 2807 | 38 | 3.4 |
| Medium | 60% | 2945 | 39 | 3.5 |
| 10% more cost + | 80% | 3222 | 40 | 3.8 |
| Research period: years to reach output reaching farmers | | | | |
| Baseline | 3rd yr | 2807 | 38 | 3.4 |
| Longer research period | 4th yr | 2061 | 29 | 2.8 |
| Research cost (Rs.'000) | | | | |
| Baseline (Rs.'000) | 1419 | 2807 | 38 | 3.4 |
| Decrease by 20% (Rs.'000) | 933 | 3040 | 46 | 4.3 |
| Increase of 20% (Rs.'000) | 1400 | 2573 | 33 | 2.8 |
| Discount rate (%) | | | | |
| Base line | 48% | 2807 | 38 | 3.4 |
| Medium | 11% | 2158 | 38 | 2.9 |
| Higher | 18% | 1142 | 38 | 2.1 |

**Table 7. Estimated economic returns for the research investment on SWC measures**

(Value: ('000 Rs.)

| Year | Adoption rate | Depreci -ation | Supply shift | Z Value | Change in Total surplus | Research cost | Net social gain |
|---|---|---|---|---|---|---|---|
| 2000 | 0 | 1.00 | 0.00 | 0.16 | 0 | 650 | -650 |
| 2001 | 0.00 | 1.00 | 0.00 | 0.16 | 0 | 425 | -425 |
| 2002 | 0.10 | 1.00 | 0.45 | 0.61 | 313 | 252 | 61 |
| 2003 | 0.15 | 1.00 | 0.67 | 0.83 | 470 | 0 | 470 |
| 2004 | 0.20 | 1.00 | 0.89 | 1.05 | 627 | 0 | 627 |
| 2005 | 0.25 | 1.00 | 1.12 | 1.28 | 783 | 0 | 783 |
| 2006 | 0.30 | 1.00 | 1.34 | 1.50 | 940 | 0 | 940 |
| 2007 | 0.35 | 1.00 | 1.57 | 1.73 | 1097 | 0 | 1097 |
| 2008 | 0.40 | 1.00 | 1.79 | 1.95 | 1254 | 0 | 1254 |
| 2009 | 0.50 | 0.95 | 2.12 | 2.28 | 1490 | 0 | 1490 |
| Yield improved (kg/ha) | | 490 | Cost improved (Rs/ha) | | 106755 | NPV | 2807 |
| Yield existing (kg/ha) | | 199 | Cost existing (Rs/ha) | | 36964 | IRR | 38% |
| Sup. Elasticity (B) | | 0.23 | Dem. Elasticity (C) | | 0.16 | BCR | 3.4 |

Though the main objective of the project was technology development, equal effort was taken to extend the technology to farm through on-farm trials, and trainings to farmers etc. As such no expenditure was made exclusively towards extension activities during the project period. Continuous failure of rain fall in the district and desire to harvest better prices for the crop, when compared to other competing crops like coffee etc. worked as a catalyst for adoption of the technology. To check the result, the cost of research expenditure was increased by 20% to 1593 thousands (to be spent towards extension) and the result was encouraging with better returns over the investment.

**Research period**

As noted earlier, the technology and its adoption in the coffee plantations with similar landscape was going on even before the start of this NATP sponsored project. This project has sharpened the research outcome and has helped in speedy transfer of the resultant technology to the cardamom growers as well. During the final year of the project i.e. 3rd year itself the technology has covered 10% of the total area under the crop in the state. Promotional program by spices board also helped in improvement of the adoption level. The total 'research lag' was estimated at three yrs in the base line analysis. When this is increased to four yrs, returns fell drastically from Rs.2807 thousands to 2061 thousands, the IRR decreased from 38% to 29% and BCR from 3.4 to 2.8. This analysis indicates that the expected returns are much more sensitive to changes in the research period, than they are to changes in the adoption levels.

**Discount rate**

Cost of the capital or the choice of appropriate discount rate has a significant impact on the net returns. The discount rate is a time preference concept. We have used 8% as the baseline discount rate, as this was the rate used to evaluate the returns on research investment by NATP on various agricultural projects (Mruthyunjaya et al., 2004). We assessed the effects of the discount rate on returns by increasing it from 8% to 11% (medium and commercial rate) and 18% (maximum). The NPV fell to 2158 thousand and 1142 thousands respectively, while the BCR changed to 2.9 and 2.1 respectively indicating the fact that it is beneficial to invest on the project at slightly higher rate of interest also.

**Conclusion**

Soil Water Conservation (SWC) technology poses a certain challenges for program evaluation and impact assessment compared to technical interventions such as release of new varieties. However, the effort has brought out some interesting findings which will help both the funding and implementing agency (research institutes) involved in the field. The link between the Research Institute and the enterprising farmers involved in cardamom cultivation has been of tremendous benefit to the cardamom industry. The commitment of the farmers and their willingness to face risk and uncertainty enabled this useful technology to reach at least 50% of the total cultivators. An increased investment outlay for the extension activity could have helped in increasing the adoption level leading to augmented return over research investment. In the light of growing demand for cardamom both in domestic and international market there going to be a need for more such technologies to boost productivity level in the light of the competing demand for land. From the point of view of sustainability also, the technology leads to both socioeconomic and environmental sustainability. Thus this economic evaluation study may help not only the funding agencies to consider such projects for sponsorship but also developmental programmes aimed at promoting sustainable agriculture can promote this technology as one of the major component.

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