Farm Forestry for Dryland Management

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Abstract:

Land and trees occupy a significant role in maintaining ecological balance along with promoting economic development. Increased environmental concerns necessitated promotion of tree growing activities over the period. Farm Forestry, an activity of growing trees on farmlands by farmers was implemented to meet wood based requirements as well as to reduce pressure on forests by increasing tree cover, and arresting environmental degradation. Farm Forestry programme encourages farmers to grow tree on farmland, especially in arid and semi–arid regions so as to make efficient use of fragile resources. Hence, it is a measure to resolve economic and environmental problems of ecologically disadvantaged areas, as well as to improve farmers' income. The paper examines the determining factors of farmers' participation, comparative economics of tree crop vis-à-vis other crops and also assesses the economic viability of trees grown under farm forestry. The study shows that factors like food and cash requirements determine farmers' decision for tree growing and tree crops cultivation is remunerative and promises to improve incomes of farmers, especially of small farmers.

Key words: Dry Land, Farm forestry, Cost benefit analysis, viability

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World's population is projected to expand about nine billion over the next forty years, increasing demand for food and fuel tremendously (Alexandratos 1988; Preston 1993). Meeting this demand necessitates intensive use of natural resources - especially agriculture land, forest, water and fisheries. Attempts at meeting the increased demand and achieving economic development have resulted in misutilisation and improper exploitation of resources to a larger extent thus degrading environment in terms of destruction of eco–system, depletion of natural resources like land, water and air. These consequences of the development path followed, negated the opinion that mere existence and exploitation of available resources would lead to economic development and revealed that proper identification of use and tapping full potentiality in resources is essential to achieve sustainable development. Definition of sustainable development – a path of development which meets the needs of present without compromising with the ability of future generation to meet their own needs (WCED 1987) clearly recognised the significance of natural resources for economic development, not only in short run but also in long run. Keeping this in view it can be said that resources should be properly identified of their uses and appropriate user technology should be developed. This point is illustrated considering land and trees – the most important natural resources, especially in an economy dominated by agriculture sector.

Land and trees play an important role in maintaining the ecological balance along with promoting economic development especially in rural areas. Large-scale tree plantation on marginal, arid and semi-arid lands, which have less favourable agro-climatic features, can arrest the process of continuous deterioration in productive capacity, along with improving quality of such lands in particular and natural resource base and ecosystem in general (Gupta and Mohan 1982). Besides, trees contribute economically also by improving food security, meeting rural subsistence needs, generating income to rural populace, etc. (Broadly and McNamara 1994). Tree-growing activity is also acknowledged as one of the essentials to remove poverty and achieve sustainable use and management of resources in environmentally fragile regions (World Bank 1990). Despite its significance and potential for improving economic and natural resource base of ecologically fragile regions, trees were relatively neglected in the mainstream of development, particularly in the context of arid and semi-arid regions and other ecologically fragile regions. But increased economic and environmental concerns drew attention towards promoting tree growing activities especially in environmentally fragile areas, for meeting rural needs like fuelwood, fodder, fruits and small timber as well as that of the larger economy and also improving tree cover on degraded lands. It was in this context that tree-growing activities like Social Forestry, Farm Forestry and Agro-forestry were promoted in India from the eighties.

Development of Farm Forestry Programme

Farm Forestry Programme, an activity of growing trees on farmlands by farmers was introduced as a component of the Social Forestry Programme implemented on recommendations of the National Commission on Agriculture (GOI 1976) in India. The Social Forestry programme aimed to raise trees through different plantation models like *Farm Forestry, Community Forestry, Strip Plantation, Rehabilitation of Degraded*

Forests and Development of Recreational Forests, on farmer's own uncultivable and marginal lands, village common lands, wastelands, along canal, road and rail side and in the degraded forests close to habitation, to meet rural needs. The Farm Forestry Programme was directed to integrate tree-growing activity into land use pattern of farmers to attain ecological as well as economic requirements. Hence, the NCA (1976) defined the Farm Forestry Programme as 'the practice of forestry in all its aspects on farm or village lands generally integrated with other farm operations and it is a programme of planting trees on bunds and boundaries of the fields of the farmers and to be taken up by the farmers themselves'. This indicates a shift in land use towards tree cultivation, advocating for larger scale plantation on farmlands owned by farmers.

After introduction in late 1970s, large number of farmers participated in the Farm Forestry Programme, particularly in states like Gujarat, Uttar Pradesh, Karnataka and West Bengal area under tree crops increased significantly (Saxena 1994; GoK 1987). Promotion of Farm Forestry Programme provided an alternative land use, which attracted farmers. In many instances, farmers substituted annual crops with trees distributed under the Farm Forestry Programme (Saxena 1994; Aziz 1995). This wide spread shift in land use towards tree cultivation raises several questions about determinants of resource use, availability of required inputs, relative economics of different crops, etc. Besides, transferring land from one crop to another involves an opportunity cost. Considering these points, the present paper attempts to examine factors determining farmers' participation in tree cultivation activity, comparative economics of tree crops and annual crops and economic viability of tree crops grown under the Farm Forestry Programme. Addressing these issues could throw light on determinants of resource use; profitability of adopted crops and provides guidelines for promoting tree-based activities for economic and environmental concerns.

Data and Approach

The above issues are examined considering eucalyptus trees grown by farmers under the Farm Forestry Programme. Because, although several tree species were distributed by the programme agency farmers preferred mainly eucalyptus (GOI 1987; GOK 1987). Probing for motivational factors in selecting particular specie could depict farmers' considerations in resource utilisation. Karnataka State, located in Southern India, which is in forefront in implementing the Farm Forestry programme, is the setting for the present study. Karnataka with a large area under dry and semi–arid lands (63 per cent of the geographical area) provides an ideal setting for examining the objectives. Farmers in almost all districts (district is an administrative division below State) of Karnataka planted trees particularly eucalyptus, on their farmlands. For instance, area under eucalyptus on farmland increased from nearly 48 thousand hectares in 1988-89 to over 66 thousand hectares during 1996-97 (DES-GoK). In order to study the above objectives three districts viz. Bangalore Rural, Kolar and Tumkur, which are mostly semi–arid and accounting for about 72 percent of the state's total area under eucalyptus trees grown under the Farm Forestry Programme during 1994-95 to 1996-97, were chosen. Data were collected from eucalyptus-growing farmers, selected on the basis of stratified random sampling method from three village panchayats, choosing one from each district, where eucalyptus growing under Farm Forestry Programme attracted large number of farmers. Stratification of farmers is based on the size of holding i.e. Small Farmers with a holding

of less than 2 hectares, Medium Farmers between 2 and 4 hectares and Large Farmers holding more than 4 hectares. In each stratum 25 percent of the farmers were selected. Totally 160 sample farmers were chosen for the study, of which 99 are small farmers, 37 medium farmers and 24 large farmers. The data were collected during the agricultural year 1996-97.

As mentioned above eucalyptus planted under the Farm Forestry Programme is considered for the study. For studying comparative economics, *ragi* (i.e. finger millet) is selected from annual/ seasonal crop, because in majority of cases farmers have substituted ragi for eucalyptus. Analysing the economics of two different enterprises i.e. tree and annual/seasonal crop poses problems, since, eucalyptus tree is a perennial crop while *ragi* is seasonal. Hence, for comparing costs and returns of eucalyptus with that of *ragi*, cash flow of eucalyptus is discounted and then annualised to get year wise costs and returns. Cash flow of eucalyptus cultivation (Table 1), where costs and returns spread over a longer period consist of three important costs viz. establishment cost, maintenance cost and harvesting cost. While the establishment cost is incurred once in the life span of eucalyptus trees, maintenance cost is incurred during pruning activities carried on to keep trees in good shape and size. With regard to harvesting cost farmers had not spent as they sold off standing eucalyptus trees. Therefore, harvesting cost is not included in the cost stream of eucalyptus cultivation. But, this will not imply any under estimation of cost, as while determining price of eucalyptus trees the purchaser accounts for harvesting costs to be incurred. Therefore, if it is included in the cost stream again it leads to overestimation of costs. Regarding returns from eucalyptus cultivation, farmers could get different forms of outputs shown in Table 1 only if they harvest the tree crop themselves. Instead, if they sell the standing crop they would receive a lumpsum amount. This particular feature was observed in the present case, where farmers have sold off their standing eucalyptus to merchants rather than harvesting themselves. The various costs and returns considered for both crops are based on cost and income concepts of Farm Management Studies in India. For the analysis the cash flows are expressed on per hectare basis and in constant prices of 1996-97.

To assess the economic viability of tree crops (eucalyptus) viability measures such as Net Present Value (NPV), Benefit–Cost Ratio (B: C Ratio) and Internal Rate of Return (IRR) have been used as shown below.

The NPV determines the present value of net benefits from tree crops by discounting the streams of benefits and costs. The NPV is calculated by the following formula

$$NPV = \sum \frac{B_t}{(1+r)^t} - \sum \frac{C_t}{(1+r)^t}$$

where B_t = Discounted Benefits
C_t = Discounted Costs
r = Discount Rate
t = Time

The B:C ratio is assessed by

$$B:C\cdots Ratio\cdots=\cdots\frac{\sum\frac{B_t}{(1+r)^t}}{\sum\frac{C_t}{(1+r)^t}}$$

where B_t = Discounted Benefits
C_t = Discounted Costs
r = Discount Rate
t = Time

This ratio compares the discounted benefits to discounted costs.

The Internal Rate of Return (IRR) is the rate of return on the investment that equates the present value of benefits to costs. This is calculated as

$$IRR=\sum\frac{B_t - C_t}{(1+r)^t}=0$$

where B_t = Discounted Benefits
C_t = Discounted Costs
r = Discount Rate
t = Time

The IRR is the economic rate of return or the cut off rate, which would show the earning capacity of the investment made, when compared to some other financial discount rate.

While assessing the viability of tree crops life span of a tree during which it can yield economic returns assumes significance. For eucalyptus trees the number of years over which it yields economic returns found to be 20 years, as reported by farmers, who observed that after 20 to 25 years yield from eucalyptus declines. During evaluating the economic viability of eucalyptus cultivation, discount rate for discounting the cash flows becomes important as it serves two basic functions i.e. it compensates for inflation and reflects the scarcity of capital or time preference. Three alternative discount rates are used for discounting costs and returns of eucalyptus. The discount rates considered are 5 per cent, 12 per cent and 15 per cent so as to subject the results for sensitivity analysis. These three discount rates are selected for the following reasons. A 5 percent discount rate is selected because for afforestation activities a lower discount rate is favoured and particularly when the costs and returns of the project are expressed in real prices, a lower discount rate is suitable (Nadkarni et. al. 1994). The 12 percent discount rate is chosen following the recommendations of the Overseas Development Administration, which states that a discount rate in the range of 8-12 percent is appropriate in most developing countries (Abelson 1996). Another rate of discount i.e. 15 percent is used because the Report on Region wise Cost of Cultivation of Crops for the Year 1994-95 of the Government of Karnataka applies 15 percent interest in its cost and returns assessment. Considering the commercial nature of eucalyptus cultivation, 15 percent discount rate is applied for assessing the economic viability of eucalyptus. The viability of eucalyptus trees is assessed by size classes of holding i.e. small farmers, medium farmers and large farmers.

In the study region eucalyptus under the Farm Forestry Programme is cultivated at the expense of finger millet, main staple of the low-income strata, and grazing opportunity. Out of 160 farmers covered in the study 142 farmers substituted *ragi*, while 18 farmers shifted from grazing for eucalyptus cultivation. Hence,

eucalyptus cultivation involves an opportunity cost in terms of food (*ragi*) production foregone and grazing opportunity lost. Considering this fact, economic viability of eucalyptus under the Farm Forestry Programme is assessed at two levels i.e. by excluding and including the opportunity cost as shown below.

1. Opportunity Cost in terms of *Ragi* Production Foregone
2. Opportunity Cost in terms of Grazing Benefits Lost
3. Total Opportunity Cost i.e. *Ragi* Production and Grazing Benefits Lost

The opportunity costs in terms of *ragi* production foregone and grazing benefits lost are assessed in the following way.

1. Opportunity Cost in terms of *Ragi* Production Foregone = Returns from *Ragi* – Cultivation Cost of *Ragi*

While assessing the opportunity cost in terms of ragi production foregone only one ragi crop is considered keeping in mind the constraints in the study region (a dry land area) like low rainfall, lack of irrigation facilities and other weather related problems. With these constraints farmers can cultivate one crop during the rainy season and in the rest of the year land is not used unless irrigation facility is provided. Therefore, although ragi is a four months crop we cannot impute the value of opportunity foregone for the entire year as this will lead to overestimation of the opportunity cost against several constraints. Further while assessing the opportunity cost in terms of ragi production foregone we need to take the net returns of ragi after accounting for the cost of cultivation. But our assessment of net returns (returns minus total cost (i.e. paid-out plus imputed cost) of ragi illustrated no net returns (Table 4). In other words ragi cultivation incurs losses for majority of the farmers. But when only the paid-out costs are considered ragi yielded profits to all categories of farmers. Hence considering these points ragi returns after deducting only the paid-out costs are considered to assess the viability of eucalyptus cultivation[1]. Therefore,

Opportunity Cost in terms of *Ragi* Production Foregone = Returns from *Ragi* minus Paid-out Cost of *Ragi* Cultivation

2. Opportunity Cost in terms of Grazing Benefits Lost = Area planted with eucalyptus multiplied by the grazing benefits lost per unit of area

Estimation of grazing benefits foregone need to be assessed on the basis of quantum and duration of grass availability on land under consideration. But no information was available on these aspects from farmers. But in the survey area it was observed that farmers had rented out land for grazing purpose for a rent of Rs. 1500 per hectare. Due to non-availability of information on grass harvested the next best course i.e. rental value prevalent in the study area for grazing purpose is taken to assess the grazing benefits lost due to eucalyptus cultivation. In order to cross check, this rental value is compared with the grazing benefits scientifically assessed by Laksmikanthamma (1997) following the methodology of Nadkarni et al (1994). Lakshmikanthamma found grazing benefits foregone in Kolar district (one of the study districts in the present

[1] Here we should note that returns after paid-out costs (actual costs borne by farmers) are considered for assessing benefits foregone.

study) as Rs. 869.43 per hectare at 1989-90 prices. This figure was inflated by using the Consumer Price Index for Agricultural Labourers in Karnataka. Surprisingly it was found that the inflated grazing benefits lost (Rs. 1551.5 per hectare in 1996-97) were close to the prevalent rental value for grazing purposes in the survey area. Considering this fact the rental value prevailing in the study area is considered for estimating the grazing benefits foregone as the opportunity cost to assess the viability of eucalyptus cultivation.

3. Total Opportunity Cost is calculated by adding opportunity cost in terms of *ragi* production foregone and grazing benefits lost due to eucalyptus cultivation.

Discussion of Results

Determinants of Resource Use

Farmers' participation in tree raising activity is determined by relative benefits of trees vis-à-vis other crops. Benefits could be related to food, cash, etc., conditioned by characteristics of resources (particularly land) in their possession. That is, farmers consider various factors while making decision about resource use. This point could be seen through the theory of "livelihood strategies", which rather than assuming farmers as profit maximizers, focuses on welfare maximisation and suggests multiple household objectives, including secure provision of food and essential subsistence goods, cash for purchase of outside goods and services, savings and social security (Sherr 1995). Although farmers could use land for different crops, selecting a particular crop is guided by the above factors. Therefore, tree-growing activities are determined by farmers' overall livelihood strategies and resource base (Sherr 1995). This is especially true in environmentally fragile areas, which have less favourable agro-climatic features and hence farmers in these areas try to maximise benefits by selecting suitable crops.

The present study of the Farm Forestry Programme too elucidates the above points. Illustrations given below reveal that farmers consider both food security and cash requirements while making decision on resource use. Farmers depending mainly on land for sustenance select a utilisation pattern that meet their needs. Cropping pattern presented in Table 2 shows farmers cultivating food crops (*ragi*, paddy) as well as cash crops (eucalyptus, vegetables, mulberry, coconut and mango). Thus, farmers aim at ensuring both food and cash requirements by choosing appropriate crop-mix. But, selection of a crop mainly depends on type of land and other resources like capital, labour, etc. As the study region is a dry land, farmers have cultivated crops which can withstand the vagaries of dry lands like less rainfall, minimum irrigation facility, etc. and accomplish food and cash needs. Among the above crops paddy, vegetables, mulberry and coconut are cultivated with limited irrigation facility, while *ragi*, eucalyptus and mango are grown with available rainfall.

The table shows eucalyptus tree dominating the cropping pattern, as over 53 per cent of the average holding of all farmers is under eucalyptus. Considering the features of eucalyptus like fast growth, resistance against limited rainfall and earning cash income, farmers planted eucalyptus on large area under the Farm Forestry Programme. While *ragi* is cultivated on 16 per cent of the average holding, other crops are assigned less

percentage of land depending upon resources like irrigation facility. Relatively, coconut is grown in about 36 per cent of the average holding due to its advantages to be cultivated as a mixed crop. The land planted with coconut is also used for paddy or vegetables or mulberry cultivation i.e. multiple use. Further, a difference could be observed in the cropping pattern across categories of farmers. While small farmers have planted eucalyptus to over 65 per cent of their holding followed by *ragi*, medium farmers assigned about 58 per cent to eucalyptus and 22 per cent for *ragi*. Although eucalyptus is a major crop across the categories of farmers, percentage allocation of land for different crops varies by categories of farmers depending upon resources like land, irrigation facility, capital, etc. This picture of cropping pattern indicates that farmers try to maximise benefits from resource in their possession by selecting alternative crops. Selection of alternative crops again depends upon the relative economics of each crop and other factors.

Factors like natural and technical, economic and domestic needs influence farmers to participate in tree raising activity (GOI 1987; Bisalaiah 1995). The different factors identified by farmers for adopting eucalyptus under Farm Forestry Programme are presented in Table 3. Farmers expected higher returns from eucalyptus plantation by overcoming problems of labour shortage, increased cost of annual crop cultivation, weather vagaries, etc. The demonstration effect also played a role whereby eucalyptus cultivation by the neighbourhood farmers motivated a few farmers to go in for eucalyptus. It is interesting to note that multiple factors together have motivated farmers. Farmers ranked the main factors as higher returns, plantation of eucalyptus by neighbouring farmers and shortage of rainfall motivating them to opt for eucalyptus. While all categories of farmers quoted higher returns as an important factor, nearly 20 per cent of small farmers said eucalyptus plantation by neighbouring farmers influenced them for eucalyptus cultivation.

Additionally, few other aspects also have influenced farmers' decision to participate in tree growing activity under the Farm Forestry Programme. For example, the Forest Department encouraged farmers to grow trees on farmlands by distributing free seedlings, giving guidelines for tree plantation and creating awareness among farmers about expected benefits from eucalyptus. Meanwhile demand for wood products was increasing and the government had recommended wood-based industries to source their raw material requirements directly from farmers. Hence the demand for pulpwood, construction wood, etc. was quite high and increasing. Aziz (1995) observes that the demand for eucalyptus has not declined in Karnataka because of the existence of paper mills and construction activities. These factors have collectively attracted farmers to grow eucalyptus trees on farmlands. Thus various determinants have influenced farmers in adopting the cropping pattern. The above illustration shows that farmers do not use their resource entirely for any one crop i.e. food or cash crops, rather they allocate resource to meet multiple objectives. Hence, while promoting tree-based activities for environmental concerns it is prerequisite to consider the determinants of farmers' participation.

Comparative Economics of Tree Crops and Annual Crops

Farmers reported that higher cultivation cost of ragi is one of the factors responsible for shifting towards eucalyptus cultivation. This is borne out from Table 4, which presents the comparative economics of the two crops and indicates that cultivation cost of ragi is higher than that of eucalyptus. The table provides information

on cost and returns of eucalyptus discounted at 5, 12 and 15 per cent rate of discount and annualised along with the cost and returns of ragi. While farmers report a cost of over Rs. 10 thousand per hectare for ragi, eucalyptus involves discounted annualised cost of Rs. 415 per hectare at 15 per cent rate of discount. Ragi yields more returns than eucalyptus before accounting for the total cost (paid-out plus imputed cost), but as can be seen from the table ragi incurs losses after accounting for total cost. Eucalyptus yields positive returns even after imputing value to own inputs for calculating returns. The returns–cost ratio are also presented which illustrates that eucalyptus yield more returns per unit of expenditure. For instance, while the return – cost ratio for ragi is 0.94 taking all farmers as a whole, it is 4.8 for eucalyptus cultivation even at a higher discount rate i.e. 15 per cent. The cost of ragi cultivation varies directly with the size of holdings among the categories of farmers, while the discounted annualised cost in eucalyptus cultivation varies differently. The return varies differently across size classes of holdings for both crops. For eucalyptus, large farmers report a lower cultivation cost, and they receive higher returns per hectare than other categories of farmers whereas in ragi cultivation small farmers have less cost and also less return. In cultivating ragi large farmers incur more expenditure per hectare and also receive more returns than the other two categories of farmers.

The above description suggests that eucalyptus cultivation is advantageous to farmers considering return-cost ratio of both crops. Apart from low cost and higher return-cost ratio, eucalyptus is a commercial crop whereas ragi is a low value subsistence crop with limited market. In addition farmer will be free with his labour after planting eucalyptus which he can use elsewhere for earning additional income. Also eucalyptus provides contingency fund for farmers to use during emergencies and also for purposes like asset creation. Since farmers get returns from eucalyptus in lumpsum, most of farmers have used income for farm asset creation activities like digging borewells for irrigation facility, land purchasing, etc. (Puttaswamaiah 2001). Besides, the dependency of annual crops on weather conditions like rainfall and other factors too act as driving force in crops planting decisions. Rainfall is a major factor that determines annual crops production and is uncertain. And farmers are not sure of their crop production due to the uncertainty or shortage of rainfall. But eucalyptus is capable of withstanding moisture and other weather vagaries. These advantages associated with eucalyptus cultivation encouraged farmers to plant eucalyptus on their farmland.

Economic Viability of Tree Cultivation under the Farm Forestry Programme

Economic viability of eucalyptus cultivation under the Farm Forestry Programme assessed by using three different appraisal measures and by excluding and including opportunity cost is presented below.

Net Present Value of Eucalyptus Cultivation

The economic viability of eucalyptus assessed in terms of NPV at two stages i.e. by excluding and including the opportunity cost of eucalyptus cultivation in terms of ragi production foregone, grazing benefits lost and total opportunity cost is illustrated in Table 5. According to the table eucalyptus cultivation is economically viable to all categories of farmers and at all discount rates before including the opportunity cost of ragi production foregone. All farmers taken together report an NPV of nearly Rs. 25 thousand per hectare at 15

per cent rate of discount excluding the opportunity cost. Among the categories of farmers large farmers show a higher NPV than other categories of farmers before accounting for opportunity cost indicating more profitability. While small and medium categories of farmers report NPV of over Rs. 24 thousand per hectare and Rs. 22 thousand per hectare respectively at 15 per cent rate of discount, the large farmers show an NPV of Rs. 30 thousand per hectare at 15 per cent rate of discount before adding the opportunity cost in terms of ragi production foregone. The higher NPV of large farmers stems from higher yields (Puttaswamaiah 2001) and lower cost incurred by them for cultivating eucalyptus. NPV calculated by including the opportunity cost in terms of ragi production foregone also states that eucalyptus cultivation is economically viable. All farmers as a whole reported an NPV of Rs.2802 per hectare at 15 per cent rate of discount after including the opportunity cost. But, inclusion of opportunity cost in terms of ragi production foregone makes eucalyptus cultivation uneconomical to large farmers category, though they showed higher NPV than other categories of farmers before adding the opportunity cost. Eucalyptus turns out to be non-profitable to large farmers after accounting for the opportunity cost of ragi production foregone, because large farmers had received higher returns from ragi (Table 4). The small and medium farmers reported positive NPV even after considering the opportunity cost of the ragi production foregone, indicating the profitability of eucalyptus to these two categories of farmers. This observation shows that eucalyptus cultivation is economically viable to small and medium farmers even after accounting for the opportunity cost of ragi production foregone.

NPV presented in the table shows that eucalyptus cultivation is economically profitable for farmers who have foregone grazing benefits by taking up eucalyptus plantation. Before including the opportunity cost in terms of grazing opportunity lost, eucalyptus cultivation shows an NPV of nearly Rs. 23 thousand per hectare even at a higher discount rate of 15 per cent. Among the categories of farmers before adding the opportunity cost in terms of grazing opportunity lost, the NPV varies positively with the size classes of holdings at all discount rates. When the grazing benefits foregone is added to the cost stream, eucalyptus cultivation is still viable as seen from the NPVs which are positive and quite high. This shows that eucalyptus is viable and yields high returns even after accounting for the opportunity cost in terms of grazing benefits foregone, which explains why farmers have shifted to eucalyptus.

Table 5 which also presents NPV of eucalyptus cultivation at both levels of assessment i.e. excluding and including the total opportunity cost i.e. in terms of ragi production foregone and grazing benefits lost shows that eucalyptus cultivation is economically beneficial to farmers at all discount rates. For instance, at 15 per cent rate of discount farmers report an NPV of over Rs. 24 thousand per hectare before adding the opportunity costs. Inclusion of the opportunity cost reduces the NPV but still it is positive indicating the economic viability of eucalyptus even at a higher discount rate. Among the categories of farmers the NPV varies differently across categories of farmers before inclusion of total opportunity cost, where large farmers had shown a higher NPV per hectare (Rs.30 thousand) followed by small farmers (Rs.23 thousand). But when the total opportunity cost is accounted for the NPV varies inversely with farm size, small farmers reporting a higher NPV (Rs.7124 per hectare) than other categories of farmers showing profitability of eucalyptus grown under the Farm Forestry programme.

Benefit – Cost Ratio of Eucalyptus Cultivation

The Benefit – Cost Ratio (B:C Ratio) assessed by accounting for opportunity cost is presented in Table 6. According to the table, eucalyptus cultivation is profitable to all size classes of holdings as the B: C Ratio is more than one at all discount rates before adding the opportunity cost of eucalyptus cultivation in terms of ragi production foregone. For instance, all farmers as a whole report a B:C Ratio of 5.36 at 15 per cent rate of discount before accounting for the opportunity cost. Among the categories of farmers the B:C Ratio varies directly with the size classes of holdings before adding the opportunity cost. Inclusion of opportunity cost in terms of ragi production foregone has reduced the B:C Ratios as seen in the table, but still eucalyptus cultivation is economically viable at all discount rates. For instance, the B:C Ratio stands at 1.10 at 15 per cent rate of discount after accounting for the opportunity cost. The B:C Ratio varies inversely with size classes of holdings at 12 and 15 per cent rate of discount. At higher discount rates even after considering opportunity cost in terms of ragi production foregone the B:C Ratio illustrates that eucalyptus cultivation is more profitable to small farmers than medium farmers. For instance, at 15 per cent discount rate small farmers show a B:C Ratio of 1.18 while it is 1.12 for medium farmers after accounting for the opportunity cost. But, eucalyptus cultivation is non-profitable for large farmers after accounting for ragi production foregone.

The B:C Ratios assessed to check the economic viability of eucalyptus cultivation before and after including the opportunity cost in terms of grazing benefits lost are also given in Table 6. According to the table at both levels i.e. excluding and including the opportunity cost and at all discount rates, eucalyptus cultivation is beneficial. For instance, taking all farmers at a higher discount rate of 15 per cent the B:C ratio is 5.53 before including the opportunity cost and 4.4 after including the opportunity cost in terms of grazing benefits lost, indicating benefits from eucalyptus crop. The B:C Ratios before including the opportunity cost varies positively with the size classes of holdings. But when the opportunity cost in terms of grazing benefits foregone are added to the cost stream the pattern of B:C ratio differs among the categories of farmers. The small farmers report a higher B:C ratio than medium farmers after the opportunity cost is added.

According to the table before inclusion of total opportunity cost and also after inclusion of total opportunity cost, eucalyptus cultivation proves to be profitable at all discount rates. Though the B:C ratio declines after accounting for the total opportunity cost, it is still above unity even at a higher discount rate. Across different categories of farmers the B:C ratios differ before including the total opportunity costs, but varies inversely with the size classes of holdings after the total opportunity cost is added. While the small farmers report a B:C Ratio of 1.32 after accounting for the total opportunity cost, large farmers report a B:C Ratio of 1.09 at 15 per cent discount rate. This indicates that eucalyptus cultivation is more beneficial to small farmers considering all costs involved in eucalyptus cultivation. The higher opportunity cost for large farmers in terms of ragi production foregone and the gazing benefits lost reduces the B:C ratio, but still eucalyptus cultivation is profitable.

Internal Rate Return of Eucalyptus Cultivation

Internal Rate of Return (IRR) assessed by excluding and including the opportunity cost of eucalyptus cultivation are presented in Table 7. The table reveals that excluding the opportunity cost in terms of *ragi* production foregone the IRRs for eucalyptus are very high. For instance, taking all farmers together eucalyptus shows an IRR of 79 per cent excluding the opportunity cost. The IRR assessed for different size classes of farmers also states that eucalyptus cultivation yields high returns for all categories of farmers before including the opportunity cost. Inclusion of opportunity cost in terms of *ragi* production foregone however reduces the IRR to 22 per cent. Nevertheless, an IRR of 22 per cent is still high enough and indicates that eucalyptus gives high returns even after the opportunity cost of *ragi* production foregone is considered. Among the categories of farmers, small farmers have reported a higher IRR followed by medium farmers after including the opportunity cost, while the IRR for large farmers show no earnings from eucalyptus plantation after including the opportunity cost in terms of *ragi* production foregone. The IRR moves inversely with the size classes of holdings because of the positive relationship between returns from ragi and farm size. The higher returns received from *ragi* by large farmers makes eucalyptus cultivation as non-profitable for them when the opportunity cost of *ragi* production foregone is considered. Still large farmers cultivate eucalyptus considering the advantages of eucalyptus like low cost of cultivation, non-existence of supervision problem and assured income from eucalyptus. In the case of *ragi* cost of cultivation is not only high but also the returns are uncertain, since ragi is mainly a rainfed and relies on low and uncertain rainfall in the study region. After accounting for opportunity cost, eucalyptus cultivation yielded more returns to small farmers, although large farmers had reported a higher IRR before addition of opportunity cost. Considering the resource constraints like capital, land and other resources with small farmers, it can be said that eucalyptus cultivation has benefited small farmers.

Eucalyptus plantation raised on the land which was being used for grazing livestock before planting eucalyptus has shown an IRR of 70 per cent taking all farmers as a whole before including the opportunity cost in terms of grazing benefits foregone (Table 7). Even after including the opportunity cost also the IRR is very high being 65 per cent taking all farmers together indicating higher returns from eucalyptus. Considering the benefits of growing eucalyptus farmers replaced grazing activity with eucalyptus. The IRR exhibits an increasing trend with the size classes of holdings before adding the opportunity cost, while this pattern differs after adding the opportunity cost. Compared to medium farmers, small farmers reported a higher IRR after inclusion of opportunity cost indicating the profitability of eucalyptus plantations.

The IRRs for eucalyptus cultivation excluding and including total opportunity costs i.e. in terms of *ragi* production foregone and the grazing benefits lost are also presented in Table 7. As evident, all farmers as a whole reported an IRR of 82 per cent before including the total opportunity cost. The IRRs of eucalyptus after both opportunity costs are accounted for stands at 32 per cent for small farmers and at 20 per cent for large farmers. Among the categories of farmers, while large farmers have reported a higher IRR excluding both the opportunity costs, they show a lower IRR (20 per cent) after including the opportunity costs. The analysis

shows that eucalyptus trees are profitable to farmers who report an IRR of 26 per cent after accounting for total opportunity cost.

Conclusion

Under the present circumstances of heavy population, scarcity of resources and environmental problems efficient use of natural resources, particularly land and trees, is indispensable for economic development. Despite their significance especially in agriculture dominant economy, land and trees have been improperly exploited. In many instances these resources have not been efficiently used. In this context promotion of programmes like Farm Forestry is beneficial as it increases tree cover on land by meeting both economic and environmental requirements. Since farmers' participation in tree-growing activity is determined by various factors, promotion of appropriate species is essential to derive maximum benefits while accomplishing environmental requirements. As observed, adoption of a particular crop depends upon farmers' livelihood strategies i.e. farmers give due consideration for both food as well as cash needs while assigning resources. Meanwhile, several factors like natural, technical and economic motivate farmers to select certain crops. Farmers planted eucalyptus on larger scale considering its favourable features like fast growth, capacity to withstand against weather constraints and high commercial value. This indicates the necessity to consider the above determinants while promoting tree-based programmes like Farm Forestry.

Farmers' participation in tree-raising activities lies on relative economics and economic profitability from the promoted crop. The comparative economics revealed that eucalyptus grown under the Farm Forestry Programme provides more returns than *ragi*, the crop substituted by eucalyptus, when total costs are considered. Besides, eucalyptus has other advantages like commercial value, less labour requirement, etc. Analysis of the economic viability of eucalyptus by excluding and including the opportunity cost in terms of ragi production foregone and grazing benefits lost and total opportunity cost depicted that eucalyptus cultivation is profitable to farmers at all discount rates. Particularly for small farmers eucalyptus cultivation is more beneficial after accounting for the opportunity cost. Considering the above analysis it can be concluded that tree based activities like Farm Forestry Programmes be implemented as they could meet economic needs of people and improve the natural resource base.

Table 1: Cash Flow of Eucalyptus Cultivation under Farm Forestry

Inputs Items included under	Remarks	Outputs	Remarks
1. Establishment Cost a) Land preparation b) Planting c) Seedlings d) Replanting e) Transport of Seedlings f) Fencing	Will be at once	1. Main Products a) Round Wood b) Small Wood c) Twigs	These different forms of returns are available only if the farmer harvests himself, instead if he sells the plantation to the agent the farmer will get one lump sum amount.
2. Maintenance Cost a)Pruning b)Watch and Ward c) Fertilizer	After two years of planting and then once after each harvest Few Farmers keep a separate man for watch and ward	2. Minor Products a) Fuel Wood b) Dry leaves	If the farmer retains any portion of the tree products that will be accounted.
3. Harvesting Cost a) Felling b) Debarking c) Transporting	Not included in the total cost stream unless the farmer bears this cost.		

Table 2: Cropping pattern of sample farmers (Average Area in Hectares)

Categories of Farmers	Area under different Crops							Average Holding
	Eucalyptus Mango	Ragi	Paddy	Vegetables	Mulberry	Coconut		
Small	0.68	0.22	0.04	0.02	0.01	0.012	0.001	1.04
	(65.3)	(21)	(3.8)	(1.9)	(0.9)	(0.9)		
Medium	1.33	0.55	0.10	0.03	0.05	0.09	-	2.52
	(52.7)	(21.8)	(3.9)	(1.1)	(1.9)	(3.5)		
Large	3.15	0.63	0.33	0.17	0.12	0.35	0.85	6.68
	(47.1)	(9.4)	(4.9)	(2.5)	(1.7)	(5.2)	(12.7)	
All	1.20	0.36	0.10	0.04	0.04	0.81	0.12	2.23
	(53.8)	(16.1)	(4.4)	(1.7)	(1.7)	(36.3)	(5.3)	

Note: Figures in brackets are percentages to Average Holding
Total of percentages exceed 100 due to multiple crops and mixed crops

Table 3: Motivational factors for eucalyptus cultivation

Factors	Categories of farmers			
	Small	Medium	Large	All farmers
1) Better returns from tree crops	52 (52.5)	21 (56.8)	15 (62.5)	88 (55)
2) Non availability of Labourers	5 (5.1)	3 (8.1)	2 (8.3)	10 (6.3)
3) Increase in the cost of annual crops' cultivation	5 (5.1)	2 (5.4)	1 (4.2)	8 (5)
4) Shortage of rainfall	12 (12.1)	2 (5.4)	3 (12.5)	17 (10.6)
5) Supervision Problem	1 (1)	3 (8.1)	-	4 (2.5)
6) Neighbours' plantation of eucalyptus trees	19 (19.2)	1 (2.7)	2 (8.3)	22 (13.8)
7) To avoid leaving land unused	3 (3)	5 (13.5)	-	8 (5)
8) Long distance between residence and farmland	2 (2)	-	1 (4.2)	3 (1.9)

Table 4: Comparison of Cost and Returns between Eucalyptus and Ragi (Rupees per Hectare)

Districts and categories of farmers	**Eucalyptus***												Ragi			
	5 per cent Discount Rate				12 per cent discount rate				15 per cent discount rate							
	Costs	Returns	Net Returns	R/C	Costs	Returns	Net Returns	R/C	Costs	Returns	Net Returns	R/C	Costs	Returns	Net Returns	R/C
Small	606	3486	2880	5.8	455	2321	1866	5.1	412	1971	1559	4.8	9977	9172	-805	0.92
Medium	827	3352	2525	4.1	592	2154	1562	3.6	526	1808	1282	3.4	10040	8916	-1124	0.89
Large	439	4115	3676	9.4	349	2738	2389	7.8	323	2327	2004	7.2	11482	11361	-121	0.99
All	585	3592	3007	6.1	454	2369	1915	5.2	415	2006	1591	4.8	10100	9451	-649	0.94

Note: R/C = Return-Cost Ratio (Total costs are used)

* = Costs and Returns are discounted annualised

Table 5: NPV of Eucalyptus Cultivation by Accounting for Opportunity Cost (Rs. per Hectare)									
Excluding Opportunity Cost in terms of									
Categories of Farmers	Ragi Production Foregone			Grazing Benefits Lost			Total Opportunity Cost		
	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent
Small	44853	29093	24328	16452	13907	12974	43204	27985	23386
Medium	43731	26952	22130	36844	23637	19699	42679	26458	21771
Large	57312	36985	30951	45283	31025	26538	55139	35839	30069
All	46724	29992	24998	46719	28173	22939	45776	29348	24450
Including Opportunity Cost in terms of									
Categories of Farmers	Ragi Production Foregone			Grazing Benefits Lost			Total Opportunity Cost		
	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent
Small	10019	6235	4704	9944	9635	9306	14338	9044	7124
Medium	9499	4489	2845	15046	9334	7419	10128	5099	3434
Large	-565	-992	-1654	43761	29509	25024	6717	4067	2791
All	7323	4138	2802	44409	26657	21637	10549	6232	4605

Table 6: B:C Ratio of Eucalyptus Cultivation by Accounting for Opportunity Cost									
Excluding opportunity cost in terms of									
Categories of Farmers	Ragi Production Foregone			Grazing Benefits Lost			Total Opportunity Cost		
	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent
Small	5.97	5.28	4.96	2.65	2.9	2.98	5.75	5.1	4.79
Medium	6.6	5.5	5.06	6.74	5.63	5.17	4.05	3.64	3.44
Large	9.4	7.85	7.22	12.85	10.69	9.8	9.36	7.84	7.21
All	6.66	5.77	5.36	7.77	6.14	5.53	6.14	5.22	4.83
Including Opportunity Cost in terms of									
Categories of Farmers	Ragi Production Foregone			Grazing Benefits Lost			Total Opportunity Cost		
	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent	5 percent	12 percent	15 percent
Small	1.23	1.21	1.18	1.6	1.83	1.91	1.38	1.35	1.32
Medium	1.23	1.16	1.12	1.53	1.48	1.44	1.25	1.19	1.15
Large	0.99	0.98	0.96	9.19	7.25	6.53	1.12	1.11	1.09
All	1.15	1.13	1.1	5.82	4.81	4.4	1.24	1.21	1.18

Table 7: Internal Rate of Return of Eucalyptus by Accounting for Opportunity Cost (per cent)			
	Excluding Opportunity Cost in terms of		
Categories of Farmers	Ragi Production Foregone	Grazing Benefits Lost	Total Opportunity Cost
Small	78	65	80
Medium	72	74	72
Large	85	102	90
All	79	70	82
Including Opportunity Cost in terms of			
Categories of Farmers	Ragi Production Foregone	Grazing Benefits Lost	Total Opportunity Cost
Small	23	42	32
Medium	21	32	22
Large	0	74	20
All	22	65	26

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