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Methodological Issues In Forestry Mitigation Projects

A Case Study Of Kolar District

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Abstract. There is a need to assess climate change mitigation opportunities in forest sector in India in the context of methodological issues such as additionality, permanence, leakage, measurement and baseline development in formulating forestry mitigation projects. A case study of forestry mitigation project in semi-arid community grazing lands and farmlands in Kolar district of Karnataka, was undertaken with regard to baseline and project scenario development, estimation of carbon stock change in the project, leakage estimation and assessment of cost-effectiveness of mitigation projects. Further, the transaction costs to develop project, and environmental and socio-economic impact of mitigation project was assessed.

The study shows the feasibility of establishing baselines and project C-stock changes. Since the area has low or insignificant biomass, leakage is not an issue. The overall mitigation potential in Kolar for a total area of 14,000 ha under various mitigation options is 278,380 tC at a rate of 20 tC/ha for the period 2005-2035, which is approximately 0.67 tC/ha/yr inclusive of harvest regimes under short rotation and long rotation mitigation options. The transaction cost for baseline establishment is less than a rupee/tC and for project scenario development is about Rs. 1.5-3.75/tC. The project enhances biodiversity and the socio-economic impact is also significant.

Keywords. mitigation project, baseline, carbon stock change, leakage, transaction cost, biodiversity

1. Introduction

The forest sector is unique, in that it contributes significantly to global CO2 emissions and also provides significant opportunities to not only reduce the current or projected emissions but also to remove CO_2 accumulated from past emissions in the atmosphere, and sequester it in soil, vegetation and wood products. In the global effort to stabilize CO_2 concentration in the atmosphere, forest sector is expected to play a critical role. Several attempts have been made to estimate the mitigation potential in developing countries and the potential is shown to be large (Sathaye and Ravindranath, 1998). An earlier study for India by Ravindranath and Somashekar (1995) showed the mitigation potential to be in the range of 23 to 175 MtC annually. According to another study by Ravindranath et al. (2001), under the sustainable forestry scenario, an additional carbon stock of 237 MtC could be sequestered and in the commercial forestry scenario, after meeting the incremental biomass demands, an additional carbon stock of 78 MtC would be sequestered over a 12-year period.

- Develop case study of a forestry mitigation project
- Develop baseline for community forestry and farm forestry projects
- Estimate mitigation potential and cost-effectiveness using PROCOMAP model
- Assess contentious issues such as additionality, leakage and permanence for community and farm forestry projects
- Estimate the transaction cost of developing a baseline and developing a project case study
- Assess the socio-economic and environmental impacts of community forestry and farm forestry project activities.

2. The Study Area

The Kolar district is located in southern plains of Karnataka, India. It lies between 77^0 21' to 78^0 35' East longitude and 12^0 46' to 13^0 58' North latitude. The district extends over an area of 7,794 sq. km and has a total population of 3.52 million, with forests accounting for about 9% of the total geographic area. The area under wastelands (or degraded lands) in the district is almost as much as the area under forests and is about 63,000 ha. Rainfed area and crops dominate the agricultural sector in the district. The forest type of the district according to Champion and Seth (1935) is southern tropical dry deciduous and thorn scrub. The dominant species include *Anogeissus latifolia*, *Terminalia tomentosa*, *Chloroxylon swietinia*, etc. Bagepalli and Gauribidanur administrative block or forest range were selected for the study.

2.1. Past And Current Land Use Pattern

Bagepalli forest range with a geographic area of 90,009 ha and 7,498 ha under wastelands was selected for exploring the potential for community forestry. (Table 1). Gauribidanur range with a geographic area of 86,727 ha was selected for exploring the potential for farm forestry option. In Bagepalli and Gauribidanur, the area under wasteland and forests has remained constant and the net sown area has decreased over the period 1988-89 to 2001-02 (Table 1).

TABLE 1:

Current and past land use pattern (in ha) in Bagepalli and Gauribidanur forest range for the period 1988-89 to 2001-02.

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2.2 Afforestation And Reforestation Rates – Past And Projected

It is necessary to take into consideration the past, current and projected rates of A&R for projecting the "business as usual" or baseline scenario. The feasible area available and the technical potential for community forestry project activities in Bagepalli range was estimated based on secondary data, from Forest Department records and working plans regarding the past, current and likely future land use and afforestation rates in the region. The rate of afforestation was about 480 ha/year during the period 1995-2003 (Table 2). It is proposed that about 400 ha per year will be afforested during the next decade. Thus by 2012, about 5000 ha of degraded forestland can still be available for afforestation.

The technical potential for implementing farm forestry activities in Gauribidanur is similarly estimated considering past rates of farm forestry activities. The area afforested on farms in the past 10 years was estimated through household survey using questionnaire method. Further, Forest Department records were consulted to estimate the seedlings distributed for farm forestry on private farms and community grazing land, which was converted to area (at 11 seedlings/ha), based on field studies.

TABLE 2:

Rate of afforestation – past and projected on degraded forestland (ha) in Bagepalli.

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The average area brought under farm forestry per annum in the district over the period 1998 to 2003 is about 3400 ha. However, over 25,000 ha is yet to be covered and available for farm forestry in the region (Table 3). Further, the interest of the farmers in the region in promoting farm forestry is evident from the large area brought under farm forestry.

TABLE 3:

Farm forestry in Gauribidanur.

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The total area considered for community forestry option in Bagepalli is 8,625 ha (degraded forest + community grazing land) and for the farm forestry option, the area considered is 5,380 ha of agricultural land.

3. Baseline Scenario Development

Under the Climate Convention, "the baseline for project activity is the scenario that reasonably represents anthropogenic emissions by sources of GHGs and removal by sinks that would occur in the absence of the proposed project activity". The first step in determining a project's additional GHG benefits (additionality) is development of a 'without- project' baseline scenario against which changes in carbon stocks occurring in a project area over different time periods say 5, 10 and 20 years can be compared.

The following steps were adopted to project the baseline carbon stocks in the land categories proposed for project.

- Define land use systems and their tenurial status
- Define the project boundary and prepare a map
- Select carbon pools and define methods for measurement
- Develop sampling design and strategy for biomass and soil carbon estimation
- Lay plots in different land use systems and measure identified parameters

- Analyze data for aboveground biomass (AGB) carbon stock, below ground biomass and soil carbon
- Assess past and current A&R rates Project future land use and estimate potential area for the project activities
- Estimate carbon stocks using area and per ha carbon stock data, for the project area.

3.1 Project Area And Legal Status

Community grazing land under the control of Forest Department and degraded forestlands under the jurisdiction of revenue department were considered for A&R under community forestry option. Communities access these land categories for grazing and fuelwood requirements. The cropland considered for farm forestry belongs to farmers under private ownership.

3.2 Project Boundary

The project boundary needs to encompass all anthropogenic emissions by sources of GHGs and removals by sinks under the control of the project participants that are significant and reasonably attributable to the project activity. The project area consists of geographic domain with more than one discrete area of land, within which GHG emissions or removals and other attributes of a project are to be estimated and monitored.

In the case of community forestry, the discrete blocks of degraded lands (community grazing lands) in cluster of villages in Bagepalli block can be considered as the project boundary. Boundary for farm forestry is a cluster of farms (for plantation) in Gauribidanur.

3.3 Carbon Pools To Be Monitored

Reporting of changes in the stocks of five C-pools; Aboveground Biomass (AGB), Below Ground Biomass (BGB), litter, dead wood and Soil Organic Carbon (SOC) is desirable. For the present study, AGB, BGB, SOC and woody litter pools were selected for estimating carbon stock changes, since dead wood doesn’t exist.

3.4 Sampling Strategy For Baseline

Aboveground biomass: This dominant carbon pool is estimated through the most commonly used plot method. Quadrats were laid and all trees >1.5 m in height or >5 cm DBH (Diameter at Breast Height) were enumerated. In each tree plot, smaller plots were demarcated to enumerate shrubs and regenerating seedlings and record the species name, height and DBH (130 cm above ground) of each tree or sapling or shrub.

The selection of 4 replicates of 50 x 50 m plots for sampling and measurement under baseline is based on stratified random sampling procedure, avoiding bias. Sampling on farmlands involved enumeration of all trees on individual farms i.e., whole farms. Sampling strategy for farm forestry involved randomly selected 10 farms, out of which 5 were small (< 2ha) and 5 were large (>2 ha).

The field data was compiled and basal area estimated using DBH and height data. Species-specific or generic volume equations from FSI reports (1996) were used to convert DBH and height into volume (m^3/ha). The biomass estimate was obtained by using the density values of wood and the carbon value by using 0.45 of biomass as carbon content.

Below ground biomass: A default conversion factor of 0.26 of aboveground biomass was used to calculate the below ground biomass (IPCC, 2003).

Woody litter: The plots laid for shrub enumeration were used for estimating standing woody litter. All the woody litter was collected from these quadrats and fresh weight as well as dry weight estimated on per ha basis.

Soil carbon: To estimate soil organic carbon, soil samples at a depth of 0-30 cm was collected. Bulk density and soil organic carbon content was estimated in the laboratory using the Walkley Black method. Soil samples from tree plots in scrub, blanks and crop fields representing baseline scenario were collected. A composite soil sample from multiple soil samples was prepared for different land categories.

4. Project Scenario Development

The project scenario represents the changes in carbon stock due to project implementation. In the following sections, the approach adopted for selecting the project activities, features of the activities and the area proposed for the activities is described.

4.1 Approach For Developing Project Activities

Multiple approaches were used to identify the set of project activities including species to be planted and total area to be dedicated under the project activity.

Community forestry option: A reconnaissance survey of sample villages was done to ground truth the area defined and to estimate the actual area available for A&R activities to the secondary source of information obtained from revenue and forest department records. A Participatory Rural Appraisal was conducted in 10 sample villages of Bagepalli range to explore the interest of communities and the extent of land they wanted to dedicate for A&R, given that they are dependent on these land categories for fuelwood and grazing purposes. The communities were asked for their choice of species and the proportion of land to be dedicated for each of the species. Thus, a list and proportion of species to be promoted under community forestry and phasing of the activities was prepared.

Farm forestry option: Secondary data was obtained from revenue department regarding the land holding of different farmers within the villages chosen for sampling in Gauribidanur. They were further classified as large and small farmers based on their land holding. A sample of 10 whole farms was surveyed for estimating the potential for farm forestry. The farmers were interviewed using a questionnaire to elucidate their interest in farm forestry, the species choice, and the extent of land they were inclined to plant either as block or on bunds[1].

4.2 Technical Potential Versus Socio-Economic Potential Area For Afforestation And Reforestation Activity

Technical potential area available for forestry mitigation activities is the total area recorded as available for A&R in the official records of forest and revenue department. In reality all the technical potential land area may not be available for A&R due to several reasons;

- encroachment by individuals or conversion to infrastructure
- requirement for future settlement or infrastructure or other developmental activities
- conversion to agriculture in future
- requirement for grazing; current or future
- highly degraded (rocky or marshy)

Thus, socio-economic potential is the estimate of actual or feasible land area available for A&R activities obtained based on measurement of actual area, based on field visit, measurement of actual current area and consultation with stakeholders (local community, local government and the relevant land departments). The technical and socio-economic potential estimate for the 10 villages is given in Table 4.

TABLE 4:

Socio-economic land potential for afforestation for community forestry in Bagepalli.

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The socio-economic potential ranged from 18.2 to 100% with an average of 45.7% of the technical potential, as available for A&R activities. The activities proposed for implementation under the project scenario for the different land categories along with species to be promoted are given in Table 5. The community has opted for short rotation, long rotation, fruit and timber-oriented species. The area that the communities are ready to dedicate for community forestry in Bagepalli range is about 8,636 ha (3,524 ha of community grazing land and 5,112 ha of degraded forestland), which is less than 50% of the total land category (Table 5).

TABLE 5:

Land category and area proposed for different project activities and phasing under community forestry and farm forestry projects.

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The total crop area of Gauribidanur is about 40,000 ha, of which communities have proposed to dedicate less than 5% of the area for block planting and about 10% of the area for bund planting under farm forestry option (Table 5). The proposed activities for bund planting include long rotation trees of economic value such as teak (60%) and fruit trees (40%). This indicates that farmers are keen on getting regular as well as sustained economic benefits over several decades. In the same way, under block plantation activity too, the area proposed for raising of orchards is three-fourth of the land dedicated while about 10% and 15% of the land is for long rotation and short rotation crops, respectively (Table 5).

4.3 Approach For Carbon Stock Projections Under Project Scenario

Carbon pools: Selection of carbon pools and the field methods adopted for estimating the different carbon pools is similar to that adopted for the development of a baseline scenario (refer to Section 3).

Source of data for carbon stocks and growth rates: There is limited literature on biomass growth rates of different species as well as carbon stocks under different land use systems. The forest inventory reports and working plans of the Forest Department have no data on soil carbon and growth rates for many species. Data on aboveground biomass stock of plantation species is available to a limited extent in these reports. Therefore, in this study, field measurements of aboveground biomass, woody litter and soil carbon were made for the selected activities proposed in this project or block, in the same forest range for established plantations and agro-forestry systems with identical precipitation, soil and silvicultural management practices.

To estimate the potential rates of carbon uptake and changes in soil carbon for the selected project activities, the following approach was adopted.

Select sites where the identified project activities (such as eucalyptus plantation, fruit orchards of mango, tamarind, etc.) have already been planted under different programmes in the same forest range (or administrative block) and which are of different age (such as 5, 10 and 20 years) groups

Laying plots (quadrats) for measuring trees to estimate height, DBH, density, etc. and for soil sampling

Estimating rate of growth of AGB and soil carbon using methods described in section 3.

The vegetation sampling is same as that conducted for baseline scenario. The procedure adopted for estimating aboveground biomass, woody litter and soil carbon was similar to that adopted for the baseline scenario.

5. Carbon Stock Projections Under Project Scenario

The PRO-COMAP model, a microsoft excel based spreadsheet, was used to analyze the mitigation potential as well as cost-effectiveness of mitigation activities.

5.1 Estimation Of Stocks Of Different Carbon Pools

The model estimates the change is C-stock annually under the baseline and mitigation scenario. Adopting the C-stock change method to estimate the C-pool increment, mathematically, the change in carbon stocks attributable to a project (ΔCnet) at any given time can be expressed as:

$$\Delta\text{Cnet} = \sum_{i=1}^{n} [(\Delta\text{Cproject} - \Delta\text{Cbaseline})_{\text{time 1}} + (\Delta\text{Cproject} - \Delta\text{Cbaseline})_{\text{time 2}} + \ldots\ldots (\Delta\text{Cproject} - \Delta\text{Cbaseline})_{\text{time n}}]$$

*Where, Δ**C**project and Δ**C**baseline are the measured changes in carbon stocks at periodic monitoring time over the period i, associated with the project and the respective baseline case.*

5.2 Input Data For Analysis

Input data based on field measurements for the PROCOMAP model is given in Table 6.

TABLE 6:

Input data based on field studies for PRO-COMAP model to assess the mitigation potential.

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5.3 Carbon Stock Change Under Project Scenario

Carbon stock change per ha: The carbon stock change per ha for the various project activities under baseline and mitigation scenario for a period of 30 years at every 5 years interval is given in Table 7. The carbon increment under baseline for the community forestry project is 0.0045 tC/ha/yr, and nearly absent under farm forestry as there was negligible accumulation of woody biomass on the fallow lands. The mitigation potential per ha for the 30-year period (2005-2035) for various mitigation options ranges from 3.81 tC to 47.42 tC (Table 7).

TABLE 7:

Carbon stock change under baseline and mitigation scenario (excluding harvested wood products) and the carbon increment per ha for various project activities for 2005-35 (tC/ha).

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Carbon stock change for project area: Overall the mitigation potential for community forestry from an area of 8,625 ha is 196,630 tC and for farm forestry with an area of 5,381 ha is 81,750 tC (Figure 1). Thus, the overall mitigation potential in Kolar for a total area of 14,000 ha under various mitigation options is 278,380 tC (Figure 1) at a rate of 20 tC/ha for the period 2005-2035, which is approximately 0.67 tC/ha/yr, which is inclusive of the harvest regimes under short rotation and long rotation mitigation options.

Insert Figure 1

Figure 1. Total incremental carbon pool (‘000 tC) for the project area in Kolar

5.4 Uncertainty Estimates Of C-Stock Change

Methodology for estimating carbon benefits: Project level estimates of carbon stock changes are easier to quantify and monitor compared to say national forest inventories because of clearly defined project activities and boundaries, stratification of the project area and the choice of the carbon pools to be measured. Techniques and methods of sampling design and measuring carbon pools are available which are based on commonly accepted principles of forest inventory, soil chemistry and ecological surveys (Hamburg, 2000). Standard ecological methods have been used to estimate the various carbon pools, which have been well established and implemented worldwide in forest inventory, with minimal uncertainty.

Establishment of Baseline: The area and location for the proposed forestry activities is unlikely to change. The past land use records have shown minimum land conversion to other land uses. Hence the baseline area estimation and projection is fairly accurate with minimal uncertainty. Data on area availability for mitigation activities has also been verified through field visits and stakeholder consultation in the study area.

The estimate of aboveground biomass is based on field ecological measurements, which in the community grazing lands is very low (0.3 tC/ha) and is unlikely to change due to low tree density. Since time series data on AGB growth rates are unavailable and the field data is based on cross-section studies, an assumption of 0.01 tC/ha is considered as the mean annual increment in aboveground biomass, which is the annual extraction of fuelwood from the area. The uncertainty associated is likely to be insignificant due to the low tree density and aboveground biomass.

Measurement of Carbon Pools: Uncertainty is assessed using standard deviation for the mean carbon pools based on field measurements. Stratification of the project area into more or less homogeneous units, based on vegetation type, soil type, land-use history, or topography, can increase the precision of the carbon measurements, without increasing the cost unduly because it lowers the variance of measurements thus requiring fewer plots to be monitored within acceptable levels of precision.

The standard deviation is generally low for AGB growth rate and soil organic carbon stock (Table 8). However standard deviation for rate of soil carbon uptake is high for fruit orchard and low for Eucalyptus and Tectona grandis + mango. Thus uncertainty is generally low for estimates of carbon pools.

TABLE 8:

Uncertainty associated with the measured carbon pools.

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6. Estimates Of Cost-Effectiveness Of Project Activities

The cost of carbon mitigation is going to be a critical factor in selecting mitigation activities, as the focus will be on low cost mitigation opportunities at least initially. The importance of the forestry sector has been emphasized by several studies, which have shown that LULUCF sector mitigation activities are cost-effective and have the potential to provide large socio-economic benefits (Brown *et al*., 1996; Sathaye and Ravindranath, 1998). The PROCOMAP model, based on discount cash-flow technique, was used to estimate the cost-effectiveness (Rs/tC) and benefit-cost ratio.

6.1 Cost-Effectiveness Estimates

Estimation of cost or cost-effectiveness of mitigation activities is critical, but could be complex, depending on the method used, components of costs and revenue included and the discount rate used. The various components selected for determining cost-effectiveness are given in footnotes to Table 9.

TABLE 9:

Cost-effectiveness of mitigation options for the period 2005-2035 at 8% discount rate.

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Investment cost is considered for the first three years, with the assumption that the community/farmer will meet the annual or operating cost of later rotations. Investors, donors or banks are likely to be interested in funding or lending only the investment cost may be guided by these values. The present value of investment cost, extended over the first 3 years, varies from Rs. 4,125/ha for bund plantation to Rs. 63,716 per ha for long rotation at a discount rate of 8% (Table 9). The present value of initial cost/tC also varied from Rs. 615 for bund plantation to Rs. 2,270 for long rotation (Table 9).

Very often, funding only investment cost may not sustain a project and it becomes essential to consider annual or operating or maintenance costs as well. The lifecycle cost per ton of carbon varied from Rs. 2013 for short rotation to Rs. 4888 for fruit orchard at 8% discount rate. The lifecycle cost per ton of carbon abated varied from Rs. 2,800 for long rotation to Rs. 3,423 for bund plantation at 8% discount rate. The high value per ton of carbon abated for bund plantation is due to the fact that the number of trees per ha is limited and hence the carbon abated is less.

The Net Present Value of Benefits, which the policy makers and the local community are interested, is positive for all the mitigation options except long rotation at 8% (Table 9). The Internal Rate of Return is very high (30%) for mango fruit orchard even though the life-cycle cost is also highest. It is the least (4%) for long rotation under farm forestry followed by short rotation option (10%) under community forestry (Table 9). The benefit-cost ratio is greater than one for all mitigation options for the period 2005-2035. The mango orchards bear fruits from the fourth year and there is continuous flow of benefits for a period of 50 years. The yearly fluctuations in mango yield have also been taken into account in the model.

Investment required for the project: The investment for the various mitigation options at a discount rate of 8% is given in Table 10. The total investment for the six different mitigation options is Rs. 306 million for a total area of 14,000/ha. The average investment per ha for the project is about Rs. 21,860. The yearly investment spanned over 5 years ranges from Rs.96 million during the first year to Rs. 48 million during the fourth and fifth years (Table 10).

TABLE 10:

Investment for the project at 8% discount rate.

PLACE TABLE 10 HERE

The highest investment is required for the fruit orchard, as the area opted by the community is large and the investment per ha is higher compared to other mitigation options. The investment for bund plantation is the least though the area is large, as the tree density per ha is very low.

6.2 Alternative Carbon Price Scenarios

Afforestation and reforestation activities are examples of cost-effective means to stabilize GHG concentration. Credits that result from these projects for removing carbon from the atmosphere can be traded on a global market. The estimated price of a ton of carbon from a forest project could range from US$ 3 to US$ 57. The carbon price is still evolving.

In this study, financial benefit from sequestered carbon was estimated at different carbon prices – US$ 5 and 10. For each of the mitigation activity, the NPV with and without carbon prices is given in Table 11. At the lowest carbon price of US $5, at 8% discount rate, the incremental benefit per tC ranges from Rs. 127 for bund farm forestry to Rs. 945 for fruit orchard under community forestry for the period 2005-2035 (Table 11). The long rotation forestry option, even with carbon pricing at US$ 20 is not beneficial. At a rate of US $ 21/tC, at 6% discount rate it is a positive proposition. At 8% and 10% discount rates, the carbon price has to be US$ 35 and 47 per tC respectively for a positive NPV.

TABLE 11:

Net present value of benefits per tC with and without carbon pricing for various mitigation options.

PLACE TABLE 11 HERE

At 8% discount rate, the financial benefit from carbon credits for the project period 2005-2035 at US$5 and 10 is Rs. 193 million and Rs. 222 million respectively (Table 12). At a carbon price of US$ 5, the carbon price covers 63% of the investment cost and at US$ 10, it accounts for 72% of investment cost respectively.

TABLE 12:

Financial benefit from carbon price (Rs million) for the period 2005-2035 from the project area (14,000 ha).

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7. Leakage Estimation

Leakage is "the net change of anthropogenic emissions by sources of GHGs and removal by sinks, which occurs outside the project boundary, and which is measurable and attributable to the project activity". Leakage is failure to capture greenhouse gas changes outside the accounting system that result from project activities within the project boundary. Forestry projects are often assumed to lead to leakage, due to shift in extraction or land use change. In this study, an attempt was made to estimate leakage in both community forestry as well as farm forestry projects.

The leakage estimation was based on PRA exercise as well as household survey where the quantity of fuelwood and poles/small timber currently extracted from community grazing land, degraded forestland and farmlands proposed for the project were quantified.

Leakage is estimated to be equal to the current rates of extraction of fuelwood/small timber under baseline from the land proposed for the project. Thus, under community forestry project, extending over an area of about 8500 ha, the annual extraction or loss of biomass is insignificant at about 10 kg/ha/year. This accounts to about 0.025% of the total mean annual carbon stock change during project implementation (Table 13). Under farm forestry, there is insignificant extraction of biomass from the bund and block plantations in Gauribidanur.

TABLE 13:

Leakage estimates for community and farm forestry options.

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The leakage is absent or insignificant since the aboveground biomass recorded on the proposed lands for project activities in the baseline condition is quite low and therefore biomass extraction is low too. There is ample evidence to show that forestry projects, taken up on lands similar to the one proposed for this project have not led to leakage.

It is also essential to understand market leakage. Projects focused on local community needs may lead to positive leakage mainly because they aim to minimize the drivers and scale of potential leakage (Schwarze1 *et al.*, 2002). The proposed reforestation/afforestation projects will be virtually free of market-leakage risk. As the project generates products that are substitutes for others that come exclusively from natural forest sources (e.g. firewood for local use), this should tend to produce positive market-based leakage by creating a new supply of locally available resources (Schwarze1 *et al*., 2002).

Leakage mitigation measures: There are several options to minimize or avoid or mitigate leakage. Involvement of stakeholders and creation of long-term stake ensures no unplanned extraction or shifting of extraction occurs. Further, integration of biomass demands, particularly fuelwood will also avoid leakage. Creating buffer stocks and accounting rules such as using a discount factor are other options.

8. Transaction Cost Estimates

Transaction costs include; cost of planning, organizing, implementation, monitoring, verification and certification of a project. Transaction cost also refers to the time, effort, and resources needed to search out, initiate, negotiate, and complete a deal (Lile, Powell, and Toman 1998). Transaction cost will play an important role in determining the viability of forestry projects and the goal should be to minimize the transaction cost such that financial benefits to local stakeholders is maximized and forestry projects are made attractive to all the stakeholders, including investors.

Forestry projects have unique features such as; development of baselines, demonstrating environmental additionality, consultation and involvement of different stakeholders, intensive monitoring and verification, and a long negotiation process. In this study, the cost involved in baseline scenario development as well as for preparation of the project proposal has been estimated.

TABLE 14:

Transaction cost (in Rs.) estimates for baseline scenario developed Community Forestry.

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i) Baseline scenario development: The cost involved in baseline scenario development, that includes cost incurred for conducting field ecological studies, PRA exercises to generate information on land availability, compiling secondary information on area available, afforestation/reforestation rates of community as well as farm forestry projects, future plans etc., data entry, compilation and analysis, laboratory analysis of soil samples and other costs have been estimated. As can be seen from Table 14, the total cost of developing a baseline for community forestry is about 1.5 times more than that incurred for developing a baseline for farm forestry option. About 50% of the total cost incurred in developing a baseline for community forestry project is due to intensive sampling required for biomass and soil carbon studies and consultations with community members on various aspects of project development and implementation.

Conversely for farm forestry projects, consultation is with only the concerned farmer and also the biomass and soil carbon studies that need to be conducted are fairly simple as compared to community forestry option. However, the number of soil samples that are collected and analyzed for farm forestry option is more, to capture the wide variation in organic carbon content of cropland soils.

ii) Preparation of project proposal: This involves cost incurred in estimating and projecting the carbon stocks under the project scenario (Table 15). At project development phase also, the cost involved in ecological and PRA exercises is higher for community forestry option as compared to farm forestry. A household survey is conducted for the community forestry option to estimate fuelwood and other products that are extracted from the area proposed for the project, so as to enable estimation of leakage.

TABLE 15:

Transaction cost estimates for project proposal prepared.**PLACE TABLE 15 HERE**

The total cost of developing a project proposal, for farm forestry and community forestry projects is Rs. 250,000 and Rs. 285,000, respectively (Table 15). The cost per t of carbon is estimated to be Rs. 1.50 for community forestry and Rs. 3.75 for farm forestry option, which is less than 2% of carbon price (at US$ 5/tC).

9. Environmental And Socioeconomic Impact Assessment

9.1 Environmental Impact Assessment

There are potential synergies and tradeoffs between climate change mitigation activities (projects and policies) and the conservation and sustainable development objectives. Afforestation and reforestation activities can have negative impacts on biodiversity, if taken up in forest ecosystems rich in biodiversity. Conversely, if biodiversity is being promoted on land that is degraded, it will have a positive impact on biodiversity. It is therefore important to assess the environmental or ecological impacts of a project, particularly on biodiversity. Biodiversity was assessed using standard ecological methods and indices. The Shannon Wiener Diversity Index (H') was used for assessing biodiversity under baseline and project scenario.

An estimate of biodiversity under baseline as well as project scenarios both for community as well as farm forestry projects indicates that there is an improvement in biodiversity over the baseline in the project scenario (Table 16), as multi-species forestry is promoted, which is the choice of community.

TABLE 16:

Diversity estimates of baseline and project scenarios for community and farm forestry.

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9.2. Socio-Economic Impacts

All forestry sector activities are labour-intensive and create rural employment in establishing, protecting and maintaining forests or plantations and also provide diverse biomass products. The proposed project has multiple components, including promotion of long-rotation and short-rotation species and fruit orchards on a large-scale. Further, these species with varied gestation periods and end-uses would provide not only economic returns periodically but also in a sustained manner, as fruit orchards yield over many decades. Further, the various silvicultural operations and other plantation related activities especially on community lands would provide employment to the communities involved in project implementation apart from employment at the time of initiation of the project when various activities such as land preparation, pitting, nursery raising, transportation of seedlings and actual planting occur.

10. Conclusions And Implications For Methodological Issues

Climate mitigation through forest sector has been a contentious issue and has attracted a lot of attention of researchers as well as negotiators. This is because of the several methodological, technical, social and political issues, relevant to sink activities aimed to stabilize GHG concentration in the atmosphere.

The uncertainty of estimates of carbon emissions is presumed to be high in the LUCF sector, due to problems of definitions, biophysical variations that lead to varied estimates, limitations of methods or availability of multitude of methods to choose from, limitations of data and accounting issues involved. Here we discuss how these contentious issues have been addressed in this study with particular reference to methodological issues in forestry mitigation projects.

Carbon inventory techniques: The ideal approach is to measure all the C-pools. However, resource and time limitation will dictate selection of two or three dominant C-pools, considering the pools most likely to be impacted. The Marrakech Accord has also suggested reporting of changes in the stocks of five C-pools; AGB, BGB, litter, dead wood and SOC. The Revised IPCC 1996 Guideline focused on aboveground biomass, soil carbon and woody litter pools (IPCC, 1996). Standard and reliable field ecological methods were used for making estimates of carbon pools for aboveground biomass, soil organic carbon and woody litter. Default value for belowground biomass was used, as the cost involved in monitoring this carbon pool is high.

Database on growth rate of C-pools: *T*here are serious limitations with respect to availability of data on growth rates of different carbon pools for different forestry activities. Growth rates are available only for certain commercially or economically important forestry species and similar data for non-commercial forest and horticultural plantation species, naturally regenerating forests and agro-forestry species are lacking. Further, there is no database available for below ground biomass and woody litter. Thus, there is an urgent need to develop biomass estimation equations for the various species commonly opted by communities and farmers. Developing default values for different species across different ecological zones along with rate of change of soil carbon density under different situations – forests, plantation, natural regeneration and agro-forestry situations is an urgent requirement to enable cost-effective and successful development of forestry mitigation projects.

Baseline development: The past land-use or change is used to project future land use changes. Establishing baseline scenario requires knowledge of historical series of conventional practices in the project area, the local socio-economic situation, economic trends that may affect the carbon benefits of a project, and other policy relevant parameters (IPCC, 2000). Determining the land-use/land-cover change is critical to accurately estimating carbon benefits. Sound methods are necessary in order to state within a level of confidence, how well land-use/land-cover change is predicted. In Kolar, updated revenue records were not available to analyse the current land use. In many of the villages, the revenue records did not tally with ground reality, as the data was not updated. Participatory rural appraisal was found to provide reliable information with regard to past and current land use/land use change. Field visits give precise information with regard to land availability for mitigation options. Cross-sectional field studies yield reliable information during baseline development and the cost of such studies is not very high.

According to the Milan Accord, three options to a baseline methodology for a project activity has been suggested which are "(a) the natural emissions and removals that would otherwise occur; or (b) the net greenhouse gas removals by sinks due to use of the land that represents an economically attractive course of action, taking into account barriers to investment or other barriers or (c) the most likely prospective land use at the time the project starts, which may include for example, agriculture (pasture or crops), natural regeneration, forestry." For the current study, option c has been chosen, where the current land use i.e. community-grazing lands for community forestry and farmlands for farm forestry is assumed to maintain *status quo*.

Additionality: Additionality is not an issue for development of forestry mitigation project in Kolar as there are records available for understanding trends in A&R. Further, plan documents are available for projecting future rates of afforestation/reforestation activities. Further, as evident from the records, surplus land is available for taking up additional activities in addition to the ones already proposed. The biomass estimated on the baseline land categories is also low and therefore any mitigation project activity would lead to additional carbon sequestration.

Leakage: Leakage is not an issue for forestry projects in the semi-arid zone, especially when wastelands, with no or insignificant biomass are being considered as potential land categories for project implementation. This is also the case in Kolar wherein the lands proposed for the project are community-grazing lands and degraded forestlands with low or insignificant biomass. Further, the current dependence of communities or individual farmers on lands proposed for project implementation can be estimated through household survey or PRA, so as to incorporate the same in project design.

Permanence: The designing of the project when performed in consultation with communities or stakeholders, will not pose the problem of permanence. This is because, the initial consultation process will ensure that community choice of species as well as area is implemented and communities are also aware of the project. Further, agro-forestry trees, fruit orchards etc. are not harvested traditionally. Temporary carbon credits can also address the issue of permanence.

Biodiversity: A potential conflict exists between biodiversity conservation and fuelwood demand and demand for economically important timber species. However, consultation process with different stakeholders before the initiation of the project ensures that multi-species plantations are promoted to cater to the different requirements of the participating communities. On the bunds of farms where agro-forestry option is proposed, the baseline biodiversity is high and therefore project activities will further enhance the biodiversity. A multi-component project ensures biodiversity conservation.

Cost-effectiveness: The methods for estimating cost-effectiveness are well established and PROCOMAP provides estimates of various indicators. Incorporating carbon price into calculation of profitability is also feasible. Revenue from carbon is likely to improve the financial viability of projects.

Transaction cost: The transaction cost of preparing a baseline Project Design Document (PDD), consultations and other related activities is low. In this study the cost of post-PDD activities is not included, which could be higher than the cost of developing PDD.

Model limitations: In estimating the C-stock change, the limitations of PRO-COMAP model are:

- Below ground biomass, litter and dead wood not included under baseline.
- Non linear growth rates of biomass and soil C not considered

- Silvicultural interventions or intermediate harvest not incorporated, which is especially relevant for long rotation trees such as teak, which have direct relevance to the C stock changes in aboveground biomass.

Notes

[1] earthen embankment constructed to retain water or for separating one farm from the other.

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Table 1: Current and past land use pattern (in ha) in Bagepalli and Gauribidanur forest range for the period 1988-89 to 2001-02

Land category	88-89	94-95	97-98	99-00	00-01	01-02
			Bagepalli			
Total geographic area	90009	90009	90009	90009	90009	90009
Net sown area	37529	31462	33675	30733	30971	32531
Irrigated area	5918	5040	5178	2967	2697	6814
Rainfed area	31611	26422	28497	27766	28274	25717
Forest area	18458	18458	18458	18458	18458	18458
Wasteland	7498	7498	7498	7498	7498	7498
			Gauribidanur			
Total geographic area	86727	86727	86727	86727	86727	86727
Net sown area	47015	42079	42714	45999	43927	40378
Irrigated area	13823	17287	14192	11697	11697	11418
Rainfed area	33192	24792	28522	34302	32230	28960
Forest area	4332	4332	4332	4332	4332	4332
Wasteland	7375	7375	7375	7375	7375	7375

Table 2: Rate of afforestation – past and projected on degraded forestland (ha) in Bagepalli

YEARS	Forest area afforested		Surplus degraded land available after afforestation
	Total	Mean/year	
1995-2000	2492	498	9180
2001-2003	923	461	8257
2004-2008	1615	403	6642
2009-2012	1292	430	5350

Table 3: Farm forestry in Gauribidanur

YEARS	Area brought under farm forestry (ha)	Surplus land available after afforestation (ha)
1998-1999	1592	37771
1999-2000	3133	34638
2000-2001	3690	30948
2001-2002	2959	27989

Table 4: Socio-economic land potential for afforestation for community forestry in Bagepalli

Village	Technical potential (ha)	Socio-economic potential area (ha)	% of socio-economic to technical potential
Guraldina	120	60	50.0
Mallepalli	250	125	50.0
Babenayakanapalli	41.2	41	100.0
Vasanthapura	850	425	50.0
Pichallavarapalli	240	120	50.0
Singappagarapalli	39.2	16	40.8
Govinapalli	40	40	100.0
Boyinavarapalli	330	60	18.2
Devikunte	80	20	25.0
Gollapalli	40	20	50.0
Total	**2030.4**	**927**	**45.7**

Table 5: Land category and area proposed for different project activities and phasing under community forestry and farm forestry projects

Option	Land category proposed	Total potential area (ha)	Area proposed (ha)	Project activities	**Area (ha) dedicated for each option**	**Plantation Phasing (yrs)**	**Species opted by the community**
Community forestry	Community grazing land & Degraded forestland	15755[a]	8636[b]	Short rotation	2500 (29%)	5	*Eucalyptus* spp., *Acacia* spp.
				Fruit orchard	6125 (71%)	5	*Mangifera indica*, *Syzygium cuminii*, *Tamarindus indica*, *Azadirachta indica*, *Ficus* spp.
Farm forestry	Cropland bund planting	39363	3960	Long rotation + Fruit orchard	3960 (60% orchard & 40% teak)	3	*Tectona grandis*, *Grevillea robusta*, *Pterocarpus* spp. *Mangifera indica*, *Tamarindus indica*, *Azadirachta* spp., *Achras sapota*, *Artocarpus* spp.
	Cropland block planting		1420	Short rotation	228 (16%)	1	*Eucalyptus* spp.
				Long rotation	128 (9%)	1	*Tectona grandis*, *Grevillea robusta*, *Terminalia* spp., *Dalbergia* spp.
				Fruit orchard	1065 (75%)	3	*Mangifera indica*, *Tamarindus indica*, *Achras sapota*, Artocarpus, Neem, Guava, Syzygium

[a] *includes 7498 ha of community grazing land and 8257 ha of degraded forestland*
[b] *includes 3524 ha of community grazing land and 5112 ha of degraded forestland, based on community decision*
[c] *number in parenthesis indicates the percent area allocated for different options*

Table 6: Input data based on field studies for PRO-COMAP model

to assess the mitigation potential

Activity	Aboveground biomass growth rate (t/ha/yr)	Below ground biomass (t/ha/yr)*	Soil organic carbon uptake (tC/ha/yr)**	Rotation period (years)	Life of harvested product (years)***	***Litter decomposition*** t/ha/yr
COMMUNITY FORESTRY						
Short Rotation	4.00	1.04	0.51	8	5	0.22
Fruit orchard	1.41	0.36	0.40	-	-	0.25
FARM FORESTRY (Block Planting)						
Short Rotation	5.35	1.39	0.94	6	5	0.22
Long Rotation < 20 years > 20 years	 5.0 2.5	1.3	0.36	25	25	-
Fruit orchard	2.5	0.65	0.58	-	-	0.25
FARM FORESTRY (Bund Planting)						
Long rotation+fruit orchard	0.3	0.07	0.46	30	25	-

*below ground biomass is considered as 26% of the aboveground biomass based on Good Practice Guidance for LUCF sector (IPCC, 2003)

**accumulation period is considered as 7 years after planting.

***life of harvested product for short rotation (Eucalyptus) is pulp for paper-making and for long rotation (Teak) is sawn wood for furniture-making

Table 7: Carbon stock change under baseline and mitigation scenario (excluding harvested wood products) and the carbon increment per ha for various project activities for 2005-35 (tC/ha)

OPTIONS	2005	2010	2015	2020	2025	2030	2035
COMMUNITY FORESTRY							
SHORT ROTATION							
Baseline	37.62	37.64	37.66	37.68	37.71	37.73	37.75
Mitigation	39.03	53.16	50.35	58.56	53.55	48.95	56.88
Incremental	**1.41**	**15.52**	**12.69**	**20.88**	**15.85**	**11.22**	**19.13**
FRUIT ORCHARD							
Baseline	37.62	37.64	37.66	37.68	37.71	37.73	37.75
Mitigation	38.24	44.51	49.03	52.95	57.22	61.14	65.06
Incremental	**0.63**	**6.88**	**11.37**	**15.27**	**19.52**	**23.41**	**27.31**
FARM FORESTRY							
Short Rotation (Block)							
Baseline	36.27	36.27	36.27	36.27	36.27	36.27	36.27
Mitigation	38.28	58.37	57.60	55.10	52.91	50.42	47.92
Incremental	**2.01**	**22.10**	**21.33**	**18.83**	**16.64**	**14.15**	**11.65**
Long Rotation (Block)							
Baseline	36.27	36.27	36.27	36.27	36.27	36.27	36.27
Mitigation	37.87	53.84	68.56	82.73	96.20	46.50	64.33
Incremental	**1.60**	**17.57**	**32.29**	**46.46**	**59.93**	**10.23**	**28.06**
Fruit Orchard (Block)							
Baseline	36.27	36.27	36.27	36.27	36.27	36.27	36.27
Mitigation	37.29	47.53	55.39	62.38	69.72	76.70	83.69
Incremental	**1.02**	**11.26**	**19.12**	**26.11**	**33.45**	**40.43**	**47.42**
Fruit Orchard + Teak (Bund)							
Baseline	31.01	31.01	31.01	31.01	31.01	31.01	31.01
Mitigation	31.33	34.48	36.02	36.87	37.72	38.57	34.82
Incremental	**0.32**	**3.47**	**5.01**	**5.86**	**6.71**	**7.56**	**3.81**

Carbon stock change for project area: Overall the mitigation potential for community forestry from an area of 8,625 ha is 196,630 tC and for farm forestry with an area of 5,381 ha is 81,750 tC (Figure 1). Thus, the overall mitigation potential in Kolar for a total area of 14,000 ha under various mitigation options is 278,380 tC (Figure 1) at a rate of 20 tC/ha for the period 2005-2035, which is approximately 0.67 tC/ha/yr, which is inclusive of the harvest regimes under short rotation and long rotation mitigation options.

Table 8: ***Uncertainty associated with the measured carbon pools***

Location	Annual aboveground biomass growth rate (t/ha/year)	Soil organic carbon (tC/ha)	Rate of carbon uptake in soil* (t/ha/yr)
COMMUNITY FORESTRY			
Baseline (Wasteland)	0.01	36.26±7.12	-
Eucalyptus spp.	4.0±0.5	48.30	0.51
Mangifera indica	1.41±0.35	46.42±1.53	0.40±0.94
FARM FORESTRY (Block Plantation)			
Baseline	-	36.27	
Fruit Orchard (Mango + Tamarind)	2.50±0.86	44.49±4.18	0.58±0.72
Eucalyptus spp.	5.35±2.22	43.99±3.59	0.94±0.12
Tectona grandis	5.00	43.15	0.36
FARM FORESTRY (Bund Plantation)			
Baseline	-	31.01	-
Tectona grandis + Mango	0.3	41.82±1.72	0.46±0.08

**the soil organic carbon under mitigation option was subtracted with baseline soil organic carbon and divided by the age of the plantation to arrive at the rate of soil organic carbon uptake.*

Table 9: *Cost-effectiveness of mitigation options for the period 2005-2035 at 8% discount rate*

Option	Present value of initial cost		Life cycle cost		Net present value of benefits		Internal rate of return	Benefit cost ratio
	Rs/ha	Rs/tC	Rs/tC	Rs/ha	Rs/tC	Rs/ha		
Short Rotation (CF)	22661	1456	2013	31325	225	3505	9.72%	1.58
Fruit Orchard (CF)	30578	1187	4888	125885	8153	209953	29.65%	3.99
Short Rotation (FF)	22661	1945	4087	47620	2150	25044	16.60%	2.01
Fruit Orchard (FF)	30578	665	2973	136599	5073	233113	29.92%	4.06
Long Rotation (FF)	63716	2271	2800	78558	-1402	-39326	3.99%	2.87
Fruit Orchard + Long Rotation (FF-Bund)	4125	615	3423	22956	1973	13233	29.46%	1.79

- Initial costs include establishment cost for land preparation, nursery, planting, fencing, etc;
- operation and maintenance cost includes watering, protection etc; harvest and transport cost for activities involving harvesting; silvicultural cost pertaining to costs incurred for weeding, pruning, non-commercial thinning, marking for commercial thinning;
- recurring costs for administration, monitoring, management, etc; monitoring cost for monitoring biomass growth, soil carbon content, quantity of timber harvested, flow of benefits, etc. for baseline and mitigation scenario.
- Benefits include measurable and monetized benefits, such as timber – sawn logs, chip logs, pulp logs, poles, fuelwood, etc., and Non Timber Forest Products - fruits, seeds, etc.
- CF: Community Forestry; FF: Farm Forestry; 1US$ = Rs.45 (during 2005)

Table 10: ***Investment for the project at 8% discount rate***

Option and area proposed (ha)	Present value of initial cost (Rs/ha)	PV of investment cost needed (million Rs.)	Annual investment** (million Rs.)
COMMUNITY FORESTRY			
Short Rotation (2500 ha)	22661	56.65	11.33 (5)
Fruit Orchard (6125 ha)	30578	187.29	37.46 (5)
FARM FORESTRY (Block Planting)			
Short Rotation (228 ha)	22661	5.17	1.72 (3)
Long Rotation (128 ha)	63716	8.16	8.16 (1)
Fruit Orchard (1065 ha)	30578	32.57	32.57 (1)
FARM FORESTRY (BUND PLANTING)			
Long Rotation + Fruit orchard (3960 ha)	4125	16.34	5.45 (3)
Total for community and farm forestry (14006 ha)	21860*	306.17	Year 1: 96.69 Year 2: 55.96 Year 3: 55.96 Year 4: 48.78 Year 5: 48.78

**average investment/ha for all options*

***number in parenthesis is the number of phasing years for the mitigation option*

Table 11: Net present value of benefits per tC with and without carbon pricing for various mitigation options

Discount Rate	6%	8%	10%
Short Rotation (Community Forestry)			
Without carbon price	586	225	-31
With carbon pricing @US$5	746	370	100
With carbon pricing @US$10	906	515	232
Fruit Orchard (community forestry)			
Without carbon price	12148	8153	5541
With carbon pricing @US$5	12251	9098	7238
With carbon pricing @US$10	12353	9186	7316
Short Rotation (Farm Forestry)			
Without carbon price	3232	2150	1377
With carbon pricing @US$5	3498	2409	1627
With carbon pricing @US$10	3769	2671	1878
Long Rotation (Farm Forestry)			
Without carbon price	-885	-1402	-1700
With carbon pricing @US$5	-669	-1203	-1521
With carbon pricing @US$10	-451	-1005	-1340
Hurdle Rate	938 (US$21)	1623 (US$35)	2170 (US$47)
Fruit Orchard (Farm Forestry)			
Without carbon price	7470	5073	3491
With carbon pricing @US$5	7575	5759	4725
With carbon pricing @US$10	7679	5850	4804
Fruit Orchard + Long Rotation (Farm Forestry-Bund)			
Without carbon price	2748	1973	1435
With carbon pricing @US$5	2893	2100	1547
With carbon pricing @US$10	3038	2227	1659

Table 12: Financial benefit from carbon price (Rs million) for the

period 2005-2035 from the project area (14,000 ha)

Discount rate	6%	8%	10%
With carbon pricing @US$5	32.94	193.04	337.44
With carbon pricing @US$10	65.70	221.80	363.03

Table 13: Leakage estimates for community and farm forestry options

Option	Total project area (ha)	Annual extraction or loss kg/ha	Total leakage/year (t)	% of total mean annual carbon stock change
Community forestry	8625	10	86.25	0.025%
Farm forestry	5380	-	-	-

Table 14: Transaction cost (in Rs.) estimates for baseline scenario developed

Field Work		Laboratory work	Secondary data	Analysis	Total cost	Cost/tC
Ecological	PRA					
Community Forestry						
36000	2700	10500	600	27000	76800	0.45
Farm Forestry						
2700	300	18300	300	27000	48600	0.65

Table 15: Transaction cost estimates for project proposal prepared

Activity	Community forestry	Farm forestry
Ecological	33,000	24,000
PRA	7,500	3,000
Laboratory work	99,000	165,000
HH survey	16,000	
Land survey-farmer	5,500	3,000
Consultation process, analysis and proposal preparation	90,000	90,000
Total for project (Rs.)	**251,000**	**285,000**
Cost /t of carbon (Rs.)	***1.50***	***3.75***

Table 16: Diversity estimates of baseline and project scenarios for community and farm forestry

Community Forestry		Farm Forestry			
Baseline scenario	Project scenario	Baseline scenario		Project scenario	
		Bund	Block	Bund	Block
0.32-2.09	2.09	0.0-0.2	-	2.04	1.31

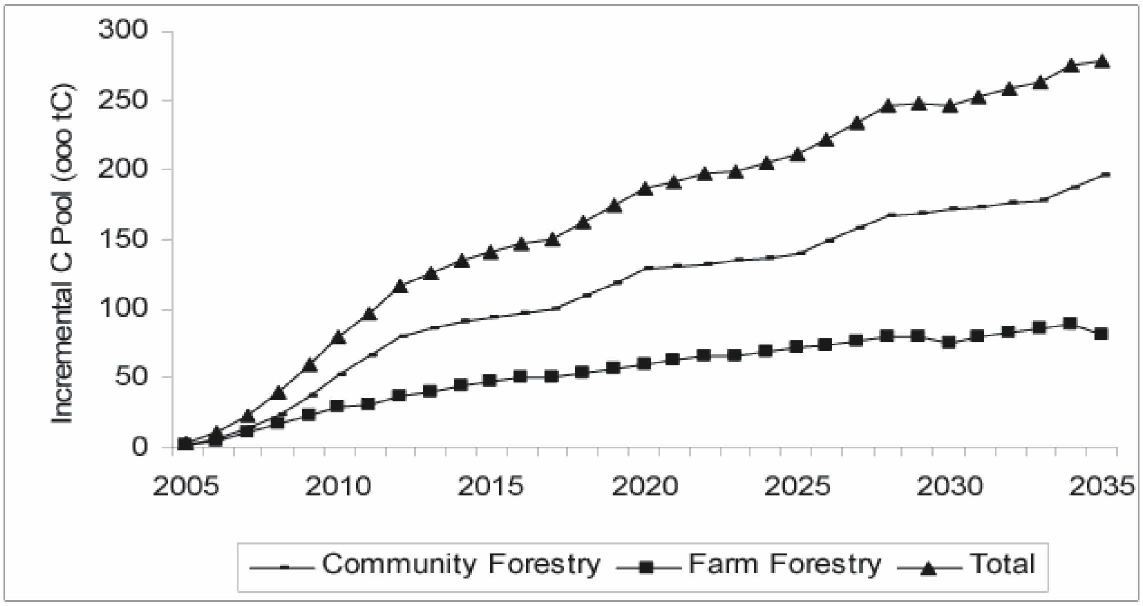

Figure 1: Total incremental carbon pool ('000 tC) for the project area in Kolar