CLEAN DEVELOPMENT MECHANISM AND LOCAL SUSTAINABLE DEVELOPMENT IN KARNATAKA, INDIA

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ABSTRACT

This Minor Field Study (MFS) has a focus on forest plantations in India and the prospects for including such activities in the Clean Developing Mechanism (CDM). To answer this question the study has had three different approaches. First the biomass and soil sampling and analysis, to establish the carbon stock in different forest types. Second, interviews were conducted as a way to establish the local people’s perception on forest and plantations and thirdly, mapping of the villages. Several methods have been used in this study, including mapping, biomass and soil analysis, and interviews. The field work was conducted in Uttar Kannada district in southern India and the study involved two villages, Huladevansara and Akkunji.

There exist a large carbon sequestration potential in forests in Huladevansara, results from this study shows that it is possible to sequester at least 40 tC/ha in biomass every 10th year. When the sequestration is measured it is important to establish the carbon in biomass that are thinned away from the plantation and include in the total carbon sequestered. The sequestration becomes even greater if the plantation is raised on wasteland where the soil carbon initially is low. These evaluations are made from an Acacia plantation. This doesn’t mean that the other forest types evaluated are less suited for an eventual CDM project. The study shows that the different forest types are valued differently by the people in the villages, but not so different that they can’t be combined with a CDM project. To establish a working CDM project different factors are also important, factors like sustainable development. This can mean that if the project is well received by the local people the project can function both as a carbon sink and as a way to sustain the development in a village.
PREFACE

This study has been conducted to complete a master degree (20 points, equal to 20 weeks work) in Physical Geography at the Department of Earth Science, Göteborg University, Sweden. The study was financed by the Swedish International Development Cooperation Agency (Sida) funded scholarship Minor Field Study (MFS). This is a grant program that allows students from Sweden to conduct a project in a developing country, with the aim to improve their knowledge and interest about developing countries. The fieldwork was conducted from October to December 2002 in at the Center for Ecological Sciences (CES) field station in Sirsi, Uttar Kannada, Karnataka, India. Some weeks was also spent at CES at the Indian Institute of Science, Bangalore, India.

Dr. Madeleine Ostwald supervised the work in Sweden and Prof. N.H. Ravindranath in India.
ACKNOWLEDGMENT

First of all I would like to thank my supervisors in Sweden, PhD Madelene Ostwald and in India, Prof. N.H. Ravindranath.

Madelene, thank you for all your help in designing, reading and modifying this study and for your endless support.

Dear Prof. Ravindranath, thank you for your never-ending support in field, all practical help and all improving discussions and for dealing with all my questions.

I would like to thank Mrs. Indu K. Murthy at CES in Bangalore for all information and knowledge you shared with me during my stay in India. A special thanks to Ass Prof. Göran Berndes, for all the time you spent reading and commenting my work, thank you for your constructive critic and your positive attitude.

In field I was receiving a great deal of help, mostly by the CES field station in Sirsi. I would like to thank Prabhakar, R. Bhat and C.M. Shastri for all help in establish contacts in the villages, ease my practical work and developing ideas. A special thanks to my friends, the staff at Sirsi fieldstation, that include G.T. Hege, Gopal Hegde, Deepak Shelti, D.M. Bhat and Rozario. M. Furtado. You gave me all the help I could ever need and I’m grateful for that.

I’m also grateful to:
Mats Olvmo, for all help in large and small matters and for good conversation.
Jon Norin and Fredrik Lindberg for help with my GIS work and for all your help with my questions.
Dr. G.S. Haripriya, for introducing me to her research that been very much helpful for me.
H. Khan and Heena, for your friendship, all your practical help and for your help with the laboratory work.

This work couldn’t be conducted without the help and cooperation from the people in the villages, Huladevansara and Akkunji. Thank you all, first the key informants spending hours with us in field, never ever complaining. Second, all the people that were interviewed, for giving me your time and finally all the families with their great hospitality.

A special thanks to my sister Adelina Palm for all her help with the figures, photos and visual design and finally also my family and friends for long distance support during the field work in India and never ending trust in me and my study.

This study was financed by:
Swedish International Development Agency (Sida) through Physical Environment institution at Earth Science Department. You made it possible for me to fulfill my dream of conducting field work in India, resulting in a masters thesis.
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1. INTRODUCTION

In all history, the climate has changed, but after the industrial revolution, in the middle of 19th century, there has been a clear trend both regional and global, in the climate. The climate is getting warmer, due to both natural and human induced processes. The process that human is responsible for are the increasing green house gas (GHG) emissions, in which the five most important are; CO₂ (carbon dioxide), CH₄ (methane), N₂O (nitrous oxide), CFC₅ (chlorofluoro carbon) and ozone (Ravindranath & Sathaye 2002). These gases work as a heat trap in the atmosphere; they impede the heat emission from the earth. A warmer climate near the earth surface has a global effect; it causes changes in sea level, affecting hydrological system and ecosystem, affecting crop production and human health, many times in a negative way. The climate change also causes changes in frequency, intensity and duration of extreme events such as floods, droughts, cyclones, storms and heat waves (Harvey 2000, Ravindranath & Sathaye 2002). All of these will potentially affect human welfare and biodiversity with substantial social, economic and environmental costs. The Intergovernmental Panel on Climate Change (IPCC) predicts the global warming to be between 1.4 to 5.8° C by the year 2100 (IPCC, 2003-04-04).

Even though the largest part of the worlds GHG emission is caused by the developed countries, the consequences and impacts will be most serious in the developing part of the world and upon the poor populations within these countries. This is mostly due to the low adaptive capacity in these countries, which is caused by poverty, absence of institutional condition and lack of necessary infrastructure to deal with such extreme events. This leaves countries badly prepared for effects of climate changes (Ravindranath & Sathaye 2002). To mitigate the effects of climate change, action has to be taken in the question of GHG emission. Even if the world decided to definitely stop all emission of GHG, the effects of the climate change will not end directly. We have with the past emissions started a process that will go on for several decades.

This thesis is dealing with one of the suggested flexible mechanism, the Clean Developing Mechanism (CDM) established as one of the flexible mechanisms within the Kyoto Protocol and subsequent climate negotiations. CDM is designed to help developed countries to meet their greenhouse gas emission limitation commitments (Quantified Emission Limitations and Reductions, QELR) and to assist developing countries to achieve sustainable development. CDM is based on the fact that mitigation of emissions can be done in a global scale. The basic idea is a project based mechanism, where developed countries or parties from developed countries invest in a project aimed to mitigate emission in developing countries. Project like this has two main goals: sustainable development and carbon sequestration.
1.1 OBJECTIVES

This thesis aims to investigate how CDM could be planned to work in the context of a forest planting project seen from the local perspective, and also to analyze how one could meet both carbon sequestration and sustainable development, both criteria in CDM. Another important part of this thesis is to estimate the carbon stock in different land-use systems, both standing biomass and soils, as a way to establish what kind of forest system that would be best suited for a CDM project, and to estimate the carbon sequestration potential. The result from this examination will be combined with the local villager’s perceptions concerning different forest types, forest management and projects aiming at carbon sequestration.

The study takes place in the southern part of India, in two villages, with different experience of plantation projects. India is a suitable area for this type of study, since it is a developing country with a large experience of plantation projects and also because India is a country where CDM projects may arise.

The scope of this study also includes a background study of CDM, forest and soil contra carbon sequestration. This part of the study is based on literature and not a practical investigation. To receive all the necessary background information to fully assimilate the result and discussion, this part is placed earlier in the thesis.

To receive knowledge of all above, several questions needed to be answered:

- What sort of plantation and what type of trees will best suit a CDM project in terms of local sustainable development and carbon sequestration?
- How could CDM and plantation project work in practice on local level?
- What parameters are important to sustainable development on local level?
2. BACKGROUND

2.1 CDM

A large part of the world has agreed that the world’s GHG emission has to slow down. This was manifested in the Kyoto Protocol in 1997. The Kyoto Protocol was adopted at the third Conference of Parties (COP). COP is held by the United Nations Framework Convention on Climate Change (UNFCC) as a way to gather the countries of the world and discuss climate change and measures. The agreement in the Kyoto Protocol was that the Annex I countries[^1] should lower their emission on an average of 5.2% from 1990 years level, the reduction should be achieved by the period of year 2008-2012 (the first commitment period). The non Annex I[^2] countries were not given any directions other than to measure the emission and to report the result (IPCC 2003-04-04).

The climate change will have global consequences, but there is no certain geographical correlation between specific emission and specific damage. Any emission (or emission reduction) is therefore equivalent, at least when the issue is climate change. This issue is important when it comes to cost of emission reduction, the price of the reductions can vary greatly in different situations. Some processes, like coal-fired electricity, are carbon intense in their very nature and an emission reduction here can be costly. On the other hand carbon sequestration through forest rehabilitation will be a very cost effective way to deal with the emission reductions (Stuart & Costa 1998). This economic argument allows for the emission improvements to occur in any country through any methodology.

The relative GHG inefficiency (in emission per unit of economic output) of many developing countries means that environmentally friendly investments can achieve greater relative GHG benefits than the same investments in an industrialized country. To make the investing part interested, the investor must be allowed to claim a large part of the emission credits created by the reduction or sequestration activity (Stuart & Costa 1998).

It is a fact that climate change will have global consequences and that there is no correlation between specific emission and specific damage. These arguments together initiated “the flexible mechanisms”, a way to mitigate emission where it is the most cost effective. During the negotiation of the Kyoto Protocol in 1997 the parties within the protocol agreed to the development and implementation of the “flexible mechanisms”.

The flexible mechanisms consist of:

- Clean Development Mechanism (CDM), a project based mechanism for international trading with greenhouse gases (article 12)
- Joint Implementation (JI), a project based mechanism described in article 6 of the protocol, which applies only to Annex B countries
- Emission Trading (ET), a way to trade with emission rights without being tied to a project

[^1]: Industrialized countries with emission reductions commitments, Annex I is an annex to the UNFCCC and Annex B is the annex to the Kyoto Protocol (IPCC, 2003-04-04)
[^2]: Non Annex I & non Annex B countries; Developing countries with no emission reductions commitments under the Kyoto Protocol for the first commitment period 2008-2012 (IPCC, 2003-04-04)
Article 12 of the Kyoto Protocol defines the CDM’s purpose as follows:

*The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3* (UNEP 2003-05-13).

CDM is designed to help developed countries to meet their greenhouse gas emission limitation commitments, QELR and to assist developing countries to achieve sustainable development. In practice this means that Annex B parties finance a project in a developing country, the Annex B parties take the credit for the emission lowering, and the developing country gets an inflow of capital and technology. The CDM contain also a demand for sustainable development.

**CDM in practice**

The first step when a CDM project will take place is to identify a potential project that both the Annex B country and the non Annex B country can come to an agreement about. Next thing is to require the project to be validated by an Operational Entity (OE) and after that to get it registered by the Executive Board (EB) of the CDM. The host country will ensure that the project will meet the criteria for sustainable development and that the project has undertaken environmental impact assessment (Ravindranath & Sathaye 2002).

To seek sustainable development is not an easy task since it is very unlikely that a certain criteria set would satisfy all involved. The project developers must also ensure that the project meets additionality condition and that the green house gas benefits are real, measurable and long term.

When the project is started it is up to the project developers to measure and report the greenhouse reduction benefits. These benefits can both be used for the investor to meet its country’s QELR: s and for the developers to use in emission trading. Since there is an interest for both the investors, the developers and the host country to receive a large reduction benefit, there must be an independent verification and appeal process to ensuring compliance.

CDM can work in a bilateral way, a multilateral way or a unilateral way, see below:

- The bilateral way would work pretty much as above, with one or more investor party and one host country.
- The multilateral way would allow the CDM Executive Board to bring together investors and projects, this can mean several investors to each project or that a larger organization creates a fund that will distribute the funds to different projects.
- The unilateral way to do a CDM project would contain only one country, both as a host and as an investor (Ravindranath & Sathaye 2002). This would give the country emission credits to sell and the country would gain market power.

It is important that the host country makes sure that the project fulfills all the CDM criteria and not be too focused on the financial benefits that a CDM project can bring to a country (Ravindranath & Sathaye 2002). One risk with the CDM mechanism is the buying selling situation that will occur (Repetto 2001). That the involved parties only focus on the benefits and not to fulfill the aims of CDM, sustainable development and carbon sequestration.
CDM and Forests

Forests play a critical role in the global carbon cycle accounting for 20% of the global CO₂ emissions at 1.6 ± 0.8 Gt C annually (during the 1990s) (Ravindranath & Sathaye 2002). The forest sector provides on the other hand mitigation opportunities to offset 10-20 % of the global CO₂ emission during the coming decades (Renewindia.org, 2003-04-10). Mitigation through forest sector has been a controversial issue during the COP meetings and for the purpose of the negotiations forestry activities are included under the category of Land Use, Land Use Change and Forestry (LULUCF). LULUCF were debated during several COP meetings and many of the developing countries as well as some Annex-1 countries opposed the inclusion of LULUCF activities under CDM due to several reasons:

- “Low hanging fruit”. This means that the developing countries are worried that the CDM would somehow give away the low cost options in emission limitation. This would leave only expensive options for green house gas limitation for the developing countries to manage in the future.
- There is a high uncertainty when it comes to measuring, monitoring and verification of carbon stock changes
- The “loophole” issue as feared by developing countries that carbon credits from LULUCF activities would encourage Annex1 countries to continue to emit CO₂ from fossil fuel

There are three key issues that have to be addressed for satisfactory accounting of carbon credits from LULUCF projects, baseline, leakage and permanence (Ravindranath & Sathaye 2002). To establish a baseline a scenario where no project under CDM has taken place must be evaluated. This is a hard task since all eventual future scenarios must be evaluated. This requires historical knowledge of the specific area, the local socio-economic situation and wider economic trends, which may affect the conventional outputs of a project.

If access to land, food, fuel and timber resources reduces without offering alternatives may result in carbon leakage when people find needed supplies elsewhere (Ravindranath & Sathaye 2002). The issue of permanence occurs if the activities that cause emission occur again after a period of time. The same problem can occur when an abandonment of sequestration activities may lead to a loss of the stored carbon, if the land is used for some other purpose. To come to turn with the leakage issue can be hard since monitoring leakage isn’t included in the project boundary. Permanence is also a tough issue, but the basic principle is to take a debit for the lost carbon at the time of its occurrence.

During COP6 in Hauge 2000, the inclusions of carbon sink projects, like reforestation³, in CDM was an issue, as well as if there should be a ceiling on how much of a countries emission reduction target that can be met through CDM. The ceiling was determined to 50% (TERI, 2003-04-10). During COP7 in Marrakech 2001, afforestation⁴ and reforestation project activities were included in CDM for the first commitment period. For the first commitment period, COP7 also limited the total credits from these two activities to not exceed one percent of the base year emission of a party.

³ Reforestation refers to the practice of reestablishing forest on a site that was recently harvested or maybe cleared some time ago (Sedjo et al. 2001)
⁴ Afforestation is a creation of forest land never before forested or not forested for a long time (Sedjo et al. 2001)
Discussions about LULUCF continued under COP8 in New Delhi October 2002. At least one country from Latin America declared that afforestation and reforestation is planned to be a part of their development plan. Other countries opposed to this uniting of environment and development some claimed that sink projects do not represent true development and could undermine the environmental integrity of the Protocol. This resulted in disagreement between parties at COP8 over the definition and modalities for sinks projects under the CDM (ECEN, 2003-05-13). The Climate Convention will most likely approve to the definitions and modalities to operationalize afforestation and reforestation activities under CDM during COP9, planned for December 2003 (Renewindia.org, 2003-04-10).

2.2 FOREST

Forest as a carbon sink
The global carbon is stored in different ways, where natural stocks include oceans, fossil fuel deposits, the terrestrial system, and the atmosphere. About two-thirds of the land-based carbon, exclusive of that sequestered in rocks and sediments, is sequestered in the world’s forests. Physical processes transfer carbon from the atmosphere to the ocean and biological growth involves the shifting from one stock to another. Plants fix atmospheric carbon in cell tissues as they grow; oxygen is released and thereby transforming carbon from the atmospheric to the biotic system. There are four components of carbon storage in a forest ecosystem. First there are the trees, then plants growing on the forest ground, detritus such as leaf litter and other material on the ground, and in the soils.

Forests have a great potential to function as a sink with the right management (Sedjo et al. 2001). Unlike many other plants and most crops, which have short lives or release much of their carbon in the end of their season, forest biomass accumulates carbon over decades and centuries. Forest can be managed strictly to sequester carbon, but such focus on biomass accumulation could reduce the amount of other forest ecosystem uses, such as biodiversity. A forest ecosystem focused on biomass accumulation would over time, if left alone, enhanced biodiversity.

The forests is not only a sink, it can also function as a source. Carbon can be released fairly quickly in the case of biomass reduction such as forest fires, tree decomposition or logging (Stuart & Costa 1998). Loss of forest cover means a reduction in global capacity to absorb growing industrial emission. Forests may again act as a sink as it is restored through forest regrowth (Toman 2001).

The use of forestry sector as a mitigation option is a subject of discussion. This is due to uncertainties, risks, potential for reversibility of carbon sequestered and leakage, potential for damage to biodiversity and livelihoods and perverse use of forestry for mitigation, such as clearing of forests and rising of plantations (Ravindranath & Sathaye 2002).

Even though there is a substantial potential for the forest to function as a carbon sink, there are several institutional and technical difficulties to manage forests for the sequestration of carbon. In India, for example, the demands on the forests are very high which results in an unsuitable use of forests hence the option of manage the forests in order only to sequester carbon may not be possible (Haripriya 2001). This is not a problem in most cases, forest
plantations as CDM usually has more than one purpose, both to sequester carbon, to satisfy the local needs or some other function.

Forest in India

India, situated in the south of Asia, is the second most populated countries in the world, following China, with a population of nearly a billion people. In India agriculture is the main occupation with a rural population of nearly 70% of the population and nearly half of the geographical area is under crop (Ravindranath et al. 1997). The population density is high, 257/km² and is growing at a rate of 1.6 % annually (Ravindranath et al. 2001).

22.8% of the geographically area is classified as forest land; observe this is not forests but forestland, i.e. land controlled by the Forest Department (Kadekodi & Ravindranath 1997). Satellite images from 1985-1987 show an actual area under forest of 63.91 Mha, 19.5%, with a crown cover over 10%. This measurement includes both natural forest and forest plantation.

Due to increased pressure on the forests to meet the biomass needs, India suffers form deforestation. The rate has changed during the last two decades and India has succeeded relatively well in reducing the deforestation (Ravindranath et al. 2001). In spite of the deforestation the area under forest remains stable at around 64 Mha. This is mostly due to the large afforestation programs implemented in India, one of the largest in the world. The programs where initiated during the 1980 under the social forestry programs.

Since 1980, India has afforested 27.6 Mha (Ravindranath & Sathaye 2002); over 90% of all forestation is afforestation on village commons, degraded revenue lands owned by the government and farm land (Ravindranath et al. 2001).

One other afforestation program that has contributed to slowing deforestation rates is the Joint Forest Management (JFM). The JFM was primarily initiated to regenerate the degraded lands with the help of local community, offering them a stake through sharing a portion of profit from the sales of the timber in the final harvest. JFM started in the early 1990 and had 2002 over 62.000 forest protection committees covering nearly 50% of the open forest in the country (Murthy et al. 2002). Both afforestation and JFM have the goal to meet the local biomass needs.

Plantation answers for a large part of the forest in India, accounting for almost half of the forest land, an area of 32.58 million hectare where 19.7% is different Acacia species. The plantations are except for rubber (1.7 % of the planted area) publicly owned (FAO 2003-04-04).

Indian forests, available land and carbon sequestration

A study made by Haripriya (2001) shows that Indian forests have a lot of potential to sequester carbon if they are appropriate managed. According to Haripriya, there are three possible ways to maintain a sustainable development and at the same conserve and sequester carbon. First, existing forests can be conserved more effectively, preventing loss of biomass and in some cases increase biomass. Secondly, new areas could be planted or regenerated and thirdly carbon emission could be reduced by the use of wood products received from the forest plantations instead of non renewable energy sources such as fossil fuel.

When forest plantation is discussed, it is important to establish what and how much land there is available. In India, the land that not has been put to use (degraded land or in India called
wasteland) (Ravindranath & Hall 1996) and which is technically suitable for raising trees can be seen as an option. In India, 23% of the geographical area this considered wasteland, this includes degraded forestland as well as crop and other privately owned non-crop land categories and pasture land (excluding the forest land with 10-40% crown cover and the area under roads and settlements).

According to Haripriya (2001) there are a few different types of plantation that will suit both carbon sequestration and sustainable development in India, some of them shown below:

- **Natural regeneration and enhanced natural regeneration:** Natural regeneration involves the protection of forest and enhanced natural regeneration involves protection, soil and water conservation measures and the planting of some desired tree species to enhance the biomass.
- **Rehabilitation of degraded land:** Degraded grazing land can be considered for rehabilitation to meet the diverse biomass needs of local communities in a sustainable way.
- **Afforestation and reforestation planting:** The area under degraded forestland with or without shrubs can be considered for afforestation and reforestation planting. The plantation should consider a mix of species so that the different needs of the people can be obtained.
- **Agroforestry:** The most common practice in agroforestry are, intercropping for the purpose of growing agricultural and forest products; boundary and contours planting for wind and soil protection as well as for the provision of agricultural and wood products.

The amounts of carbon that can be sequestered in Indian forests depend primarily on the amount of land that can be used for plantations and the productivity of the species planted. Haripriya (2001) points out that only the land remaining after catering for the future requirements of the local people can be dedicated to carbon sequestration.

**How to use a plantation most efficient**

So what will be the most efficient way to use this growing carbon stock in the plantations? Is it to leave the plantation alone and let the carbon stock grow larger and larger? This will generate a large carbon stock in both the actual biomass, in the litter on the ground and in the soil. Or will it be better to generate a carbon stock in a plantation and harvest it for biofuel, displacement for fossil fuel? This question can only be solved by looking at the efficiency of these two ways to lowering the CO2 in the atmosphere.

Carbon emission from different energy sources shows that the primary emission from fossil fuel goes way beyond the emission from biofuel. This is true if you establish a baseline year and start the calculations from that year. If a plantation is established in or after the baseline year the net emission to the atmosphere from biofuel is ±0, because all the carbon released when the biomass is used for energy originally is taken from the atmosphere. Compared to this fact the fossil fuel emit a whole lot more since the carbon stored in the fossil fuel is taken from the atmosphere way back in time and a release in the atmosphere today gives a net increase CO2.

A study by Schlamadinger and Marland (1996), shows that managing forest can be the key to a lowering of the atmospheric CO2. The study examines 16 different scenarios of land management under a time period of 100 years and shows how although there can be a
significant storage of carbon in standing trees, forest litter and soils, and wood products, all of these carbon pools achieve equilibrium at some level and then provides no further sequestration over time. If the management on the other hand use harvesting and displacement of fossil fuel for biofuel, the reduction in the net flux of carbon will go on for as long as fossil fuel are still available and are still in use and can be displaced. This strategy result in long-term benefits and for the best result there might be small or even negative benefits in the early stages.

The results from another study by Marland and Schlamadinger (1997) show how the cumulative carbon in the first 100 years for an afforestation project not harvested exceeds the cumulative carbon for a project harvested for fuelwood. This is a sign of the smaller benefits from this type of project in the beginning. If the diagrams where to followed up in say, 150 or 200 years the cumulative carbon in the project with harvesting would exceed the one with standing biomass.

One of these strategies doesn’t exclude the other. It is still a fact that standing biomass provides storage of carbon and this might be the best option for some projects. Another use for the biomass than biofuel, such as durable wood products like timber for houses and furniture, can also be a way to store carbon. This can be a lead in the biofuel process; first use the wood in durable products, when their lifetime is over, use them for biofuel.

2.3 SOIL

Soil as a carbon sink
The soil is one part of the carbon cycle, where the carbon transports from the atmosphere through photosynthesis into the biosphere. With biosphere means plants and animals and through these the carbon reaches the soil. When the carbon ends up in the soils, it can have a shorter or longer pause before it continues in the cycle. When the carbon leaves the plants and animals as dead waste material (litter, animal’s removal or dead animals) and ends up on the ground the decomposition starts, soil microbes carry out the decomposition of the plant residues, changing them into organic matter (Soil Organic Carbon, 2003-04-23).

The organic matter offers many benefits to soil, for example, it holds soil particles together and stabilizes the soil structure, making it less prone to erosion; it improves the ability of the soil to store and transmit air and water; it stores many nutrients needed for the growth of plants and soil organisms and it retains carbon from the atmosphere. The decomposing not only leaves carbon in the soil, it also gives back nutrients to the soil captured by the plants by its roots. The amount of organic carbon held in soil is the difference between how much is added to the soil (as crop residues, manure, sewage sludge) and how much is lost (through respiration, mineralization, or erosion).

So, it is possible for soil to work as a carbon sink? Practically the carbon has to pass through the biosphere to be captured in the soil, so it is quite a passive carbon sink depending on outside factors, not as the biosphere which has unlimited access to the carbon in the atmosphere. There are things that can be improved in soil management to increase the rate of carbon sequestration, mostly in the agricultural sector. These improvements can for example be to rotate the land with crops that contribute more biomass to the soil, increase the use of green fallow rotation, use natural fertilizer (green manure) and controlling erosion (Olsson & Ardö 2002). Controlling erosion and save waste biomass on the ground can also be used in
forest management and plantations. Carbon sequestration is not only a mitigation of \( \text{CO}_2 \) from the atmosphere, it is also a benefit for the agriculture.

The capturing of carbon in the soil can have less desirable effects. For example, amending soil with animal manure and green manure not only build up the soil carbon, it also contributes to the emission of nitrous oxide, which is a green house gas much more potent than carbon dioxide (Ravindranath & Sathaye 2002).
3. THE STUDY AREA

3.1 KARNATAKA, UTTAR KANNADA, SIRSI

This study has taken place in the southern part of India, in Karnataka state and more exact in Uttar Kannada district. The district is situated in the Western Ghats, which runs parallel to the west coast, pass through the district and divide it into two parts or two distinct zones, a wide upland country along the Ghats at an elevation of 675 m asl and a narrow costal strip (Murthy et al. 2002). The district is richly covered by forest and about 75% of the total area of 10.291 km$^2$ is forested. There are broadly four different categories of forest, tropical evergreen, semi evergreen, moist deciduous and dry deciduous. The district has an annual rainfall of 2742 mm and this is mainly from the southwest monsoon concentrated during the months of June to September. The district has been divided into four different forest divisions, Haliyal, Yellapur, Karwar and Honnavar and Sirsi. These forest divisions are further been sub-divided into ranges.

The field base of Indian Institute of Science, which was the field base of this project, is situated in Sirsi, one of the forest divisions. Sirsi is also the capital town of the forest division, a relative small town with a population of approximately 60 000. Scattered around Sirsi lie smaller villages with a populations where most people work in agricultural, either as landowners or employment of day-to-day basis. The main crop is rice and areca nuts and to a lesser extent coconut. Areca (*Areca catechu*) is a palm tree that give areca nuts, also called betel nut, which is chewed together with a leave and some lime paste as a digestive after a meal. The farming is mostly for household use, but also some for commercial use. The rice is grown in the valley with the areca nut gardens in the hillier areas. Since the yield from Areca nuts is higher than from rice it is getting more and more common that the farmers changes their crop to the more yielding Areca (Bath, oral communication, 2002).
3.2 HULADEVANSARA AND AKKUNJI

As seen in table 1, Akkunji covers a bit larger area than Huladevansara; apart from that the villages are quite similar in land use. Akkunji also has the larger population, more than double the population in Huladevansara. When the land use in %/total area, is compared between the villages, the large difference is the natural forest. Huladevansara has roughly 20% more natural forest than Akkunji. On the other hand does 21.8% of the area in Akkunji is rice fields, in Huladevansara the same land use only 13.2%. Akkunji has also far more plantations than Huladevansara, which partly can explain the smaller areas of natural forest in Akkunji. The plantations are mostly raised in degraded forest areas.

Table 1. Village information of Huladevansara and Akkunji, areas are measured in hectare.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Huladevansara</th>
<th>% of tot area</th>
<th>Akkunji</th>
<th>% of tot area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Forest</td>
<td>337.7</td>
<td>64.5</td>
<td>301.8</td>
<td>45.2</td>
</tr>
<tr>
<td>Beta</td>
<td>41.7</td>
<td>8.0</td>
<td>48.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Malki</td>
<td>28.3</td>
<td>5.4</td>
<td>50.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Rice</td>
<td>69.2</td>
<td>13.2</td>
<td>145.9</td>
<td>21.8</td>
</tr>
<tr>
<td>Areca</td>
<td>7.9</td>
<td>1.5</td>
<td>17.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Plantations</td>
<td>12.4</td>
<td>2.3</td>
<td>77.5</td>
<td>11.6</td>
</tr>
<tr>
<td>Other</td>
<td>26.3</td>
<td>5.0</td>
<td>27.0</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Total Area in ha</strong></td>
<td><strong>523.5</strong></td>
<td></td>
<td><strong>668.4</strong></td>
<td></td>
</tr>
</tbody>
</table>

5 (Hegde, S.N, oral communication, 2002)
6 (Census of India, 1981)
7 Grassland
8 Area of mixed land use, tanks and rivers, houses and gardens, former cultivated land (now wasteland), roads and temple area
24% of the population in Huladevansara owns an Areca garden and therefore also beta land. 22% are rice field owners and they can also have an Areca garden, usually raised as a part of the rice field. This group doesn’t own any beta land. 41% of the households are land less, which means that they doesn’t own any cultivated land of their own, however can they still have a kitchen garden (Hegde, oral communication, 2002). These figures come from the key informant in Huladevansara and there is no proof that Akkunji has the same relationship between different groups in the village.
Figure 3a and b. Maps showing land use in Huladevansara (a) and Akkunji (b).
Land use in Huladevansara and Akkunji

**Natural forest**
The natural forest is owned by the Forest Department (FD), but can be used by the village for non-timber forest products (NTFP). The department decides about logging and the timber and fuel wood is distributed where the FD finds best, i.e. it doesn’t have to be in the same village. The natural forest is divided into two different categories, the minor forest and the protected forest. The minor forest is forest that is available for the village in the purpose of collecting NTFP; they are not allowed to log trees for timber. The protected forest is forest area that is not available for the village. It is not allowed to disturb the forest in any way. In some cases the minor forest is encroached by the landless people and turned into either Areca gardens or rice fields. This is not allowed, but happens anyhow. From the natural forest the village get a great deal of what they need, fuel wood, green and dry leaves, small timber, fruits and nuts (Bhat & Shastri, oral communication 2002).

**Beta land**
Beta land is a kind of privileged land with the user right belonging to a specific farmer, a farmer that also owns an Areca garden. The beta land area is owned by the revenue department, the trees to the FD and the user right belongs to the farmer. The area was originally forested and belonging to the FD and the farmers who received it, have developed it to grassland with scattered trees, the trees were logged to make place and light for the grass. The area is not a monoculture, it contain many different tree species. This is to maintain the farmers need for the manure, which contains of mostly green leaves and cow dung and the manure need to contain different leaf types to give the best result. The beta land is also used for fuel wood, fodder (cut fresh grass), mulch (cut dry grass which is used for erosion protection) and grazing. The farmers also use the fertile soil in the beta land for their Areca garden (Bhat & Shastri, oral communication 2002).

*Figure 4a and b. (a) Beta land that has not been used for grazing. Photo: Baht November 2002. (b) Beta land that has been used for grazing. Photo: Palm November 2002.*
**Cultivated land**

Both the agriculture in Huladevansara and Akkunji is based on the rice fields, the Areca gardens with some limited areas with coconut palms. The rice fields covers the largest areas in the villages, except for the forest areas, and are located in the lowland, the Areca gardens lies in the slightly higher land around. The coconut palms are mostly planted as a border crop round the rice fields, but you can also find areas with only coconut gardens. The rice is planted in May and harvested during October to December. The Areca nuts and coconuts can be harvested all year around. The harvest is mostly used for the household needs, but if there is abundance it can also be sold to get an income. The Areca land can yield more than just the areca nuts, species such as cardamom, black pepper and occasionally green chilly are grown as an intercrop. As a protection of the young Areca plants banana trees are planted for shadow and they yield bananas even after the Areca trees has grown tall (Shastri, oral communication, 2002).

![Figure 5a and b. A typical Areca garden (a). An Areca tree showing the areca nut (b). Photo: Palm November 2002.](image-url)

**Plantations**

The plantations in the area of Huladevansara and Akkunji are mostly owned and planted by the Forest Department and contains mostly of Acacia (*Acacia arcuiformis*) and Teak (*Tectona grandis*). The plantations are planted on FD controlled land in more or less degraded forest areas and are in many cases only a short rotational plantation which means that after the trees are mature they are being logged and collected by the FD. Very often, since the forests in Uttar Kannada mainly are in a good condition, the logged trees are transported out of the region to fulfill the biomass needs in areas where forests are in a worse condition. This is not very beneficial for the local person since the plantations are raised in village land and the locals almost don’t get any benefits from them. Sometimes they are allowed to graze their cattle in the plantations. To protect the trees, grazing is not allowed when the plants are to small and when the trees are tall, the shade prevent the grass to grow and therefore grazing is not possible (Bhat & Shastri, oral communication, 2002).
The JFM program raises some of the plantations. This means that a village forest committee (VFC) is formed that is responsible for the protection of the plantation. The government still is responsible for the economy, such as planting, managing and harvesting (although these chores are often taken care of by the VFC or village people). After the trees have grown to a mature age they are logged and the harvest is shared between the VFC and the government (Murthy, oral communication, 2002).
4. DATA AND METHODS

The methods shall work as a way to reach the answer to the questions asked; in this case it is to evaluate how much carbon a specific tree species sequester and how sustainable development can be assured on a village level.

The sequestration of carbon in forests can be measured in three ways. The biomass, which is the actual stock of wood, is directly related to the amount carbon sequestered in the trees, the soil captured carbon and the litter on the ground. In many developing countries like India, the litter is collected as firewood or fodder, therefore the sequestered carbon is irrelevant in this case. That’s why that part is not an issue in this thesis. The biomass and the soil carbon must be measured in different ways since biomass is sequestered carbon above ground and soil carbon is sequestered carbon below ground. To receive information about sustainable development on local level, interviews were conducted.

The methods in this project can be divided into two parts:

- Data collections
- Data analysis

To receive enough information to answer the first question asked in the objectives, two different approaches have been used in this study, the biomass analysis and the soil analysis, both of them done to get an image of the carbon stock existing in different forest types. The result from the biomass collections was analyzed in EXCEL and the soil samplings analyzed through laboratory experiment.

To be able to answer the two last questions asked in the objectives the data has also been collected with two other methods, interviewing and mapping of the area. This approach was made to get the local peoples view and the common apprehension concerning different types of plantation projects, information about what the local people thought about sustainable development on local level and how an eventual CDM project could work in practice on local level. The interview material and the mapping was used as an input in the discussion and the conclusions where made.

To receive an accurate result the methods, biomass calculations and soil analysis, the mapping and the interviews were important.

4.1 DATA COLLECTION

Mapping

The mapping work was based on existing revenue village maps made by the Englishmen in the 1860s, received by the forest department. The Huladevansara map in scale 1:7920 and the Akkunji map in scale 1:3960. These maps were the only ones that were obtainable. They have been rewritten since that time, but no changes or new mapping work has been done. The map was showing the distribution of the village land, categorized by survey numbers. By these numbers it is possible to get information about ownership and land use from the Village accountant. Most of the information collected came from the key informants with their
enormous local knowledge. The information was also collected from walkabouts with local guidance and own observations.

In Huladevansara was the mapping work done more detailed than in Akkunji. This was depended on the contact with the key informant, and his large local knowledge. More time was also spent in Huladevansara and this resulted in more detailed information.

**Biomass**

The biomass can be defined as the weight of all the living organisms in a given area, population, volume or other units being measured (Ravindranath & Premnath 1997). When the biomass in this case was being measured the method of a *quadrate* was used. A quadrate is a way to decide how much actual stock of wood there is in a specific area. The quadrant is a square or rectangular plot of a particular dimension that is laid in replicates placed in the area of interest. The places for the quadrates were chosen consciously to get the most representative result.

The field worker can choose the dimension, but the most common is 25x25 meters or 50x50 meters (Murthy, oral communication, 2002). In this case the plot where 50x40 meters. The number of replicates can also be chosen, but a number of 3 or a larger number is better for the statistics (Murthy, oral communication, 2002). In an area with forest of different quality or an irregular forest cover, an area of totally at least one hectare is preferred, otherwise the representativity may not be covered (Murthy, oral communication, 2002). This also makes the calculations easier later on since the result should be presented in tons/ha.

In the quadrate, when size and number of replicates is decided, the measuring begins. All trees with a girth over 10 centimeters are considered trees and should be measured. The girth is measured in breast height, approximately 132 centimeters and a measure called GBH (girth at breast height).

For the shrub quadrate another measure is used, the DBH (diameter in breast height), this change in measure is done to ease the measurements in field. The shrub quadrates were laid in plots of 10x10 meters. The aim is to measure the shrub in breast height, although this is not always possible and when this occurs, the measurement is taken as high as possible. Instead of a measuring-tape as when to measure the GBH, a caliper is used.

Other parameters monitored are the species names, the number and an estimated height of individuals. If there are coppices in the quadrate, the largest, the smallest and one of middle size girth are measured and the number of trunks is also noted. This will help to calculate an average.
In the natural forest and in the beta land, 5 quadrates were laid and in the Acacia plantations one quadrate was laid in each plantation.

When the trees are all measured, shrub quadrates are laid inside the large quadrate, called a tree quadrate. The shrub quadrates are placed in two opposite corners of the four in the tree quadrate, randomly chosen. The shrub quadrates are laid to help the practical work since all the trees and bushes with a diameter in breast height between 1 centimeter to 3 centimeters, are to be measured. This is why the shrub quadrate has the smaller dimension of 10x10 meters. In the shrub quadrate the parameters monitored are species name, number and girth. It is not necessary to estimate the height. If the measurements should be very exact several herb quadrates of 1x1 meter can be laid inside the shrub quadrate, also in the corners. Although herb quadrates has not been measured for the scope of this study.

The biomass data was collected in Huladevansara, for two reasons. Huladevansara was situated in a more practical distance from the field station than Akkunji and all the necessary sampling sites could be found in Huladevansara. Even thought Huladevansara not had more than two plantations they were in good shape, they were not used by the local people and therefore not disturbed. They were a very good example of how plantations of their specific age should appear without any disturbance. The sampling sites in both the natural forest and in the beta land were chosen as sites with different forest quality.

**Soil sampling**

Since the carbon stock was calculate for a specific area and both carbon in biomass and soil carbon are included, the soil samples were taken in the same quadrate as the for the biomass measurements. The five samples in each quadrate were taken within the quadrate, one in each corner and one in the center.

A hole was dug in the ground at a depth of 30 centimeters and the sample was cut from the soil wall from the surface to the bottom, approximately the same thickness all the way and with the same amount from each depth. The number of quadrate and the forest type were taken down. When all the five samples were collected from one quadrate the samples was well mixed at a plastic sheet, roots and all organic matter were removed and finally one sample was taken with an approximate weight of 200 grams (Murthy, oral communication, 2002).

![Figure 7. Collecting soil samples. Photo: Palm November 2002.](image)

**Interviews**

The interviews were in this work used to broaden the gathered information and to get the community’s perspective and opinions on the local forest, existing and eventual plantations. This is a method that is based on communication between people and can lead to both quantitative and qualitative information (Mikkelsen 1998). Since this study used several
methods to get the most accurate result, the time was divided between the methods. Because of this the possibility to treat the interviewing result in a statistically way was limited. Despite this, with all three interview methods together, described below, the idea of the local people’s perspective became well documented. An interpreter from CES field station in Sirsi was present during all interviews.

**Informal interviews**
The fieldwork started with a general mapping and discussions that are called informal interviews. The idea was to have an interview situation without control or structure and without any specific questions prepared. In many cases in this study, this took place during the presentation of my work and me. During all discussion and conversation during the fieldwork, notes were taken and used as a foundation for the following interview result. Since the mapping work were taken place simultaneously while walking around the villages a large part of information where gathered during the informal interviews. The information was not only about forests and plantations, but also information about the general life in a small village in southern India, information that was very important for the rest of the fieldwork.

**Key informants**
To continue the collection of information a key informant were chosen in each village.

- In Huladevansara, the village elderly and his son was the given choice.
- In Akkunji, the president of a national forest program, JFM, was chosen.

The staff at Sirsi field station helped with the task of choosing the key informants. With the help of the key informants in each village, in-depth interviews were held to use the key informant’s local knowledge. The interviews starting point was to test and develop the questionnaires and proceeded to valuable discussions where a great deal of questions were answered.

**Questionnaires**
Two different kinds of questionnaires were developed with the help from the key informants and the staff from Sirsi field station (Bath, P.R & Shastri, C.M). The reason for the two different kinds was the different plantation experiences in the villages. The aim was to get the attitude and knowledge of the respondent about local forests, forests in general and plantations. The questionnaires were tested with the help from the key informants, and some questions were rephrased, some were excluded and some added to cover all the interest area. The respondents were chosen as a section of the villagers to cover different areas of the village, different social status and wealth. The intention was to use both women and men in the questionnaire, but this showed to not to be possible in practice. 30 questionnaires were conducted, 15 in each village. Of the total amount informants were only 2 women. This covers about one third of the households in Huladevansara and just a fraction of the households in Akkunji, which is a larger village. The decision was to conduct the same number of questionnaires in both villages not a percentage of the total number of households. The questionnaires in this case can be divided into two parts, one more strict where the respondent has to answer the question by yes or no, the second part is more free, with more free questions can the answers also be more free and open ended.
4.2 ANALYSIS

Mapping
The maps, which were received from the Range Forest Office, was scanned and then
digitalized in CARTALINX. The measuring system from the original map were in inches and
feet, it were recalculated into the metric system and a scale that were correct to the new
computerized map, a comparison between a specific distance on the original map and the
computerized map, were done. With the quotient a new scale was conducted. This new scale
was used to calculate the areas of different land use in both villages.

The data from the present study was noted in field and added to the old maps. When the old
maps were digitalized, the present data was added, also in the CARTALINX sheet. When the
resulting two maps were finished, a comparison was made and visible changes were noted and
analyzed.

Biomass
When the measurements were finished the aim was to find out the amount of carbon in tons
per hectare in the different forest types where the data was collected. All the information
gathered in field was taken down in the excel sheet, the tree species, the height, the GBH and
the number of coppice. Based on the data gathered, basic characteristics required were
calculated using formulas that were obtained from the field office in Sirsi.

The first thing was to calculate the basal area, which is the general section area of a tree. To
get the basal area from the trees with coppice a mean value was calculated.

\[
\overline{GBH} = \left( \sum \text{coppice girth} \right)^{\frac{1}{3}}
\]

With this mean value the basal area (BA) could be calculated. The calculations of trees and
shrubs differ a bit from each other. When the basal area of the trees is calculated the GBH or
mean GBH is used and with the shrub, the DBH is used. GBH and DBH were both in
centimeters.

For trees:

\[
BA = \frac{\overline{GBH}^2}{4\pi}
\]

For shrub:

\[
BA = \frac{\pi \times DBH^2}{4}
\]

The basal areas were used to calculate the volume of the trees and because of this the basal
area had to be mentioned in m² per hectare. To get this the basal area had to be multiplied
with the area in question. For the natural forest and the beta land this was already given since
the measurements were done in a full hectare, however divided into five different quadrates.
For the basal area from the Acacia plantations and the shrub some calculations had to be done.
The Acacia plantations were multiplied with 5 since only 2000 m² was measured in field. This could be done without large sources of error, since the trees in the plantations are planted after a specific pattern and there are no large differences in the area. The measurements of the shrub were done in an area of 10 by 10 meters twice in each quadrate, which gives an area of 200 m² in each 2000 m². Depending on how many quadrates that were measured, the shrub area was multiplied with different numbers to cover one hectare.

Standing woody biomass volume can be calculated from a general formula derived from published material wherein the actual estimate of biomass was determined from the basal area for tropical forest areas (Ravindranath et al. 2000). A simple linear regression coefficient was computed, considering basal area as an independent variable and the biomass as a depended variable. This results in a general formula as follows:

\[
\text{Biomass volume} = 50.66 + 6.52 \times BA
\] (4)

Where the regression coefficient is 6.52 and BA is the basal area in m²/ha (Ravindranath et al. 2000).

This formula is only estimated for forest with basal area more than 10 m²/ha, this means that the formula cannot usually be used to calculate the shrub biomass, nor can it be used for a single tree (Ravindranath et al. 1997). To be able to include the shrub biomass in the calculations the shrub basal area was added to the basal area of the trees and gave a basal area for the whole area including both trees and shrub.

By using a general formula to calculate the biomass volume, the height wasn’t used as a parameter. Although another calculation method was planned, but not used, and therefore the height was noted in field.

The formula results in the volume biomass per hectare forest or plantation. Mass in metric ton is counted for 50% of the volume (Haripriya 2003, Berndes, oral communication, 2003). This should in theory be dry biomass, but this is not possible in practice since the forest should remain where it is.

The carbon stock is estimated by taking 50% of the biomass as carbon and is accounted in tons per hectare (Ravindranath et al. 1997).

When the measurements were done, four different forest types were included. These were:

- **Natural forest**, five sampling sites of 2000 m² each, totally 1 hectare.
- **Beta land**, five sampling sites of 2000 m² each, totally 1 hectare.
- **Acacia plantation 5 years**, one sampling site of 2000m².
- **Acacia plantation 10 years**, one sampling site of 2000m².

**Soil**

To start the soil sample analyze, the samples was mixed together, to get a mean sample from the different forest types, until there are only one sample from each forest type, the same forest types as used for biomass calculations. This means that the five natural forest samples and the five beta land samples needed to be mixed together until only two samples remained.
All the samples from the same forest type were mixed together and laid in a circle (Murthy, 2002). The circle was cut in four pieces and one was removed. This process continued until there only were 200 grams left. This technique gives only one sample from each forest type.

The carbon amount in the soil was analyzed in laboratory experiments using the Walkley-Black method (Hesse 1971). 0.5 g of the soil sample was mixed together with 10 ml potassium dichromate solution, 20 ml concentrated sulphur acid and after 30 minutes left alone it was mixed with 10 ml ortho phosphoric acid and 100 ml distilled water. Diphymylamin indicator was added and the final solution was titrated with ammonium iron (II) sulphate solution until the first solution turned green at the end of the titration, resulting in an end-point. This end-point was used to find out the % organic carbon in the sample by using this formula

\[
%\text{OC} = \frac{(\text{blank titre} – \text{actual titre}) \times 0.003 \times M}{\text{Weight of dry soil in g}} \times 100 \quad (5)
\]

Where the actual titre is the endpoint, M is the concentration of the ammonium iron (II) sulphate solution, which is 0.5 M and 0.003 is the correction factor of organic carbon (Hesse 1971). The blanc titre is one titration of the solution without any soil sample and the actual titre is the ones with soil samples.

To get the result OC in ton/ha the bulk density (BD) for the samples was needed. The bulk density was calculated as the weight of 1 cm³ soil of the different samples.

\[
\text{OC} = %\text{OC} \times \text{depth} \times \text{BD} \times 100 \quad (6)
\]

Where %OC is % organic carbon, as depth was the sampling depth used, BD is the bulk density. 100 is used to get the percent figures into real numbers (Khan, oral communication, 2002).

**Interviews**

The questionnaires could be separated into several parts with different aim and different arrangement. Two parts, dependence of the forest and interest in a future plantation were arranged in yes or no alternatives and could be calculated into percent and put into diagrams for a better and easier analysis. The analysis of the rest of the questions in the questionnaire was conducted through a summarizing of arguments and opinions. The rest of the interview material, like informal interviews and key informants, were not treated in any statistical way, but used as qualitative data describing the attitudes of local people towards forests, plantations and land use in general.
5. RESULTS

5.1 MAPPING

When the mapping was completed the results showed that the earlier village maps still were surprisingly similar, surprisingly since the maps were constructed over hundred years ago. The old demarcations between cultivated, forest land and different ownership still existed with only small changes with divided fields and smaller encroached land areas, now cultivated, in the forestland (figure 8b). The division of fields can have many reasons; one is that since the price on rice is lower than the price of areca nuts, many farmers use some of the original rice land to grow the more income generating crop, the areca nut. The encroachment of the forest land is a natural process in the human aim to increase their living condition and is done by clearing a piece of forest land. This process with the encroachment is mostly done by the “on paper” landless villager as a way to lower the dependence on the “day to day” employment many of the landless villagers depend on. This way to get agricultural land is not legal and is not approved by the government, although the government realizes that the process is going on and has been so for several years so encroachment done earlier that 1978 will probably be legalized (Bhat, oral communication, 2002).

Other changes in land use are small divisions of cultivated land. Some areas that earlier contained only one crop, are nowadays divided into two or more crops. For example, a former rice field can now contain both a rice field and an Areca garden and even coconut as a border crop. Small changes like border crop are not considered in the mapping work since it is not relevant for the result. Since no data between 1860 and present has been available, the exact time for the changes can’t be accounted for.

Since the original map was made, several water tanks have been constructed. The explanation of this came when the interviews were conducted and several of the farmers brought up the fact, in their opinion, that the village in later years has been suffering from water shortage, both groundwater and drinking water. There are different opinions what has caused this, one farmer thinks that the Acacia plantation uses such a large amount of water that the groundwater is reduced, another that the plantations helps to keep the soil moist. To construct new tanks is a way to protect the village from water shortage in the future and some of the villagers are interested in construct even more tanks.

The results were mostly taken from the mapping work conducted in Huladevansara as seen in figure 8. Changes in forest condition hasn’t been noted and used in the mapping work. This is still an interesting observation, in Huladevansara there are just smaller changes, including partly degraded forest areas where there has been some logging of trees. In Akkunji on the other hand the forest land are in some places in really bad condition, in some places there are no trees left, only barren land. The forest in bad condition is often more grazed than other areas; they are more available for both the cattle and the herders. This in turn result in an even more degraded land with more erosion and in the end not enough soil to grow new trees. This can be a large problem and result in a wicked circle. In Huladevansara there are smaller areas partly degraded and as a way to deal with this in an early phase is to plant trees as a way to regenerate the forest, the planting contains seedlings, for example teak, planted scattered in the forest. This can also be a way to enlarge the biodiversity in a forest area. One explanation to this different forest condition in the two villages can be the population. Akkunji has more
than double the population of Huladevansara but not more than ca 150ha larger area. The pressure on the forest in Akkunji is therefore much higher than in Huladevansara.

Figure 8a and b. The figure shows the land use changes in Huladevansara between 1860 (a) until 2002 (b). Note the changes in plantations, tanks, households and encroached areas.
5.2 BIOMASS AND SOIL

In the natural forest the sampling sites was selected to cover different states of the forest, from very dense forest to partly degraded. In some of the quadrates there were traces from small scale logging and grazing of cattle. All quadrates were situated in the village Huladevansara. One large difference between the quadrates in the natural forest and the beta land was that the natural forest always contained shrub, in most cases very dense. The beta land on the other hand rarely contained shrub. The calculations (table 2) show that the natural forests contain approximately 10 times more shrub than all the other forest types examined.

The quadrates of beta land used for measurements in this study were located on different beta fields in the village Huladevansara. The fields differed in condition, three of them were used for grazing cattle, in one the grass was grown for fodder and the last one wasn’t in any specific use at the time. This gave a wide range of conditions and therefore a representative result.

The plantations in this case consist of the exotic *Acacia auriculiformis*, a foreign species imported and used for its fast growing and good timber value. Acacia has a rotational period of 10 years, when it is harvested for timber and fuel. The plantations examined in this case are one plantation of 10 years and one plantation of 5 years, half its rotational period. The amount shrub in the plantation quadrates depends on what is left from the clearing of trees and shrub before planting. Both the quadrates had traces from the former forest in the area, left scattered poles and some small shrub.

The carbon stock in different forest types depend on the basal area. The basal area in turns results in the standing biomass volume that in turns gives the standing biomass in metric tons, which is half the volume. In table 2, the soil carbon is also included to get the total carbon stock in all forest types.

<table>
<thead>
<tr>
<th>Table 2. Basal area and the results from the biomass and carbon analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA in m²/ha (trees)</td>
</tr>
<tr>
<td>BA in m²/ha (shrub)</td>
</tr>
<tr>
<td>BA/ha (trees + shrub)</td>
</tr>
<tr>
<td>Standing biomass volume m³/ha (trees + shrub)</td>
</tr>
<tr>
<td>Standing biomass t/ha</td>
</tr>
<tr>
<td>Carbon in standing biomass t/ha</td>
</tr>
<tr>
<td>Soil carbon t/ha</td>
</tr>
<tr>
<td>Tot t C/ha</td>
</tr>
</tbody>
</table>
Note that the natural forest has far more standing biomass compared to other forest types. The beta land follows and after that the Acacia plantation of 10 years. The Acacia plantation of 5 years has slightly more than half the amount standing biomass per hectare compared to the natural forest. Since the carbon content is calculated as 50% of the standing biomass the trend between the forest types continues here. Although the natural forest has a larger standing biomass than the other forest types, a larger standing biomass could be expected. The natural forest is so much denser than both the beta land and the plantation and contains so much more large trees, that it should have a larger standing biomass. This can depend on the general formula that was used in the calculations and it is suitability to use in natural forest, it seems more suitable for plantations. The trees used in plantations are often chosen because their biomass is focused in their steam, this makes things easier when they are harvested. The trees in the natural forest on the other hand often fight for the light with the other trees and develop a large crown. When the volume is calculated from GBH, the trees in plantations show a more accurate result than the trees in the natural forests.

The carbon in the soil in the different forest types shows a similar pattern as in the biomass carbon results. The natural forest has the highest value, shortly followed by the beta land. The difference from the biomass results is showed in the results from the Acacia plantations. The soil analysis resulted in a higher soil carbon value in the 5 year old plantation, than the 10 year old plantation. Note the large difference between the 10 year old plantation and the other forest types.

The relationship between the carbon in biomass and in soil is shown in figure 9. It shows that the carbon amount is approximately the same in both biomass and in the soil. The interesting part is that there is almost the same amount soil carbon in all the different forest types, except for the Acacia plantation of 10 years. This result indicates that the soil has been quite undisturbed and that the land use might have been of similar kind, for example natural forest. This makes sense since the former land use in the Acacia plantations were natural forest and this seems like the most likely former land use even in the beta land.

The result from the biomass calculations showed that the plantation of 10 years contain a larger amount of carbon than the 5 year plantation. This was expected since the older plantation has grown for twice the time the younger. However, the difference was not as high.
as expected. To examine the reason for this the amount trees per quadrate was calculated (table 3a). The result showed that the 10 year plantation only had half the amount trees compared to the younger and the fact that the 10 year plantation contain a lot fewer trees explains the small difference in tC/ha between the 5 year plantation and the 10 year old.

Table 3. Amount trees per quadrate in Acacia plantations, Natural forest and Beta land

<table>
<thead>
<tr>
<th></th>
<th>Amount trees per quadrate, 2000m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia 10 y</td>
<td>132⁹</td>
</tr>
<tr>
<td>Acacia 5 y</td>
<td>260⁹</td>
</tr>
<tr>
<td>Natural forest</td>
<td>194.4</td>
</tr>
<tr>
<td>Beta land</td>
<td>101</td>
</tr>
</tbody>
</table>

As a comparison are the amount trees per quadrate for natural forest and beta land also shown in table 3. The table shows a mean quadrate of dense natural forest and a thinner (less dense) mean beta land quadrate. The beta land contains fewer trees per quadrate than the natural forest and this can be explained by the way the beta land is used. The farmers are free to log and remove the trees that are of no use for them.

5.3 INTERVIEWS

The main part was the questionnaire, both because of the angle it gave the result and the time spent on this part, comparing to the informal interviews and key informants. To get the widest representation of people’s perception the questionnaires was given to three groups of villagers with different agricultural background. One group was the farmers that had and used beta land, the land that comes with the Areca garden. Group number two was the rice field owner and the third group was the landless people, people often working with day-to-day employment on other farmers’ fields.

When the diagrams that follows was analyzed its important to point out that there are no actual value in the different products received from the different forest types. The informants had no opportunity to validate the different products, nor did they have the opportunity to measure the intra related importance of the products.

The diagrams are all a result from questionnaires used in field (appendix 1 & 2) and the y-axis in all diagrams represents the percent interviewed farmers and their opinions.

Figure 10. An interview situation with two farmers in Huladevansara. Photo: Hegde S.G. November 2002.

⁹ This is excluded the left trees from the original natural forest and shrub
Dependence on the forest

The dependence from the forest, natural forest, beta land or plantations, is one of the results from the interviews. Figure 11 shows all products the farmers in both villages receive from the forests.

Natural forest

From the natural forest the fuel and timber products are the most obvious needs, shortly followed by grazing, fruits and nuts, dry leaves, green leaves and in Huladevansara, soil. The soil is used in the Areca gardens as a fertilizer. Soil from areas of relative untouched land contains more nutrients than soil from cultivated land; this soil is therefore dug up from the beta land and spread on the Areca fields.

The question “what forest products do you think is missing in the village” showed that all farmers are not satisfied with what they receive from the forest. Timber is one thing that the farmers feel is missing, mostly for constructing purposes, but even for commercial value. They are not allowed to log trees for timber in the natural forest and the farmers with no access to beta land, where logging is allowed, has no other legal option than buying timber at the market.

![Figure 11. Products received from the natural forest, 30 informants was interviewed, 15 in each village.](image)

The figure 11 still shows that the natural forest is used for timber purposes, but many farmers pointed out that this use is a smaller amount and for household use and practically never for commercial purpose. Other things concerned missing is fruits, spices and honey. The farmers tell that during time the honey has become more and more scarce in the forest and that everybody is missing it.

Beta land

When the beta land is considered, an important factor should not be forgotten. This is the fact that it is only the farmers with Areca gardens that possess beta land, which in this case means only 10 of 30 informants distributed in two villages, therefore only the beta land holders were asked in this matter. The importance of the beta land can’t be ignored.
Figure 12 show that the farmers with access to beta land, uses it in several ways. They use the beta land more than the natural forest except for the “other” category.

Figure 12. Products received from the beta land\textsuperscript{10}, 5 informants in each village was interviewed

Figure 13 shows the comparison between the natural forest and the beta land in receiving products. In this table the farmers from both villages are counted together. The result here shows that the beta land is preferred as a forest products resource and this can have several explanations. First of all is the beta land often more practically situated near the settlements and cultivated land (figure 8b), the farmers with access to beta land can modify their beta land in a way that are more suitable for the farmers. They can clear areas, remove non-useable trees and keep the useable ones, let the grass grow for fodder collection or let the cattle graze the area. The benefits the beta land has over the natural forest makes the choice easy for the farmers, they choose their beta land. The key informant in Huladevansara answered the question: Would you rather that the natural forest was turned into beta land? No, then we would miss benefits from the natural forest, like the wild animals, green leaves for the manure and groundwater. We would rather that the plantations, as they appear today, were more like the beta land.

\textsuperscript{10} Other: for example, fencing material, honey, food (wild animals and bamboo shoots)
Figure 13. The difference in what the farmers receive from the natural forest vs the beta land, 10 informants were interviewed, 5 in each village.

**Plantations**

The result from the plantation only considered Akkunji village, although there are two smaller plantations in Huladevansara they are not used in any larger scale.

Figure 14. Forest products received from the plantations for the village Akkunji, 15 informants were interviewed

From the plantations grazing, dry leaves and fuel are the most common products (figure 14). Since logging is not allowed in the plantation, many farmers point out that the fuel collected is fallen wood, twigs and leaves. The dry leaves from the Acacia plantation are not very popular for using in manure, but collected anyhow and maybe used as fuel. The grazing takes place in the plantations when the trees have reached an age of three years. The trees are then too high to be affected by the cattle, and continue for some years until the leaf layer on the ground is too thick for grass to grow. The farmers receive an income from the plantations when they gets employment. This employment is most attractive for the land less farmers in the village. The work in the plantations can be in soil conservation, planting seedlings, protecting the
plantation, thinning or in the harvesting. The employment is seen as a benefit since employment generating is poverty alleviation and gives the farmers a private income.

The figure 14 shows that the 27% of the Akkunji farmers uses the plantations for mulching material, this tendency showed already in the figure 11 and 12, where Akkunji farmers had a lower percent in collecting mulching material from both natural forest and beta land.

**Who benefits from the natural forest and plantations today?**

**Huladevansara**
Most of the informants, 93% feel like that the villagers are the ones that benefits the most from the natural forest, only one farmer thinks that the government shares the benefits today. On the other hand 60% of the farmers does think that smugglers, smugglers of timber mostly, are a large problem in the area when they use the village land for own benefits and all the farmers agrees that that is wrong and that this problem should be obstructed.

**Akkunji**
87% of the farmers think that the villagers receives benefits of different kind from the plantations (figure 14) but almost half, 47%, of the informants thinks that the government benefits more than the villagers. This is a system that most people finds reasonable since the government is the financier in most cases. Everybody agrees that the villagers should share a part of the benefits from the plantations and some thinks that this shared part could be bigger for the villagers vs. the government, say 50/50.

**Farmer’s perception to plantation**

**Huladevansara**
In Huladevansara is the perception regarding plantations of mixed character. The farmers realize that a lot of benefits can come out of a plantation project. Benefits like timber, fruits and nuts, green and dry leaves and also products of commercial value. Products that might be missing at present time. At the same time they all know that the eventual benefits all depend on what kind of project that can be in prospect. The villager’s earlier experience of plantation projects comes from two Acacia plantation of different age (the ones used for measures in this project) and the reactions from those are mostly negative and this of course influences their opinions regarding eventual future plantations.

The noted opinions regarding plantations follow:

- Plantations brings problems with the groundwater (male, 55 years old)
- Nothing will ever grow under an Acacia plantation and therefore no grazing (male, 67 years old)
- I don’t like monocultures, this is not beneficial for local species and the biodiversity (male, 60 years old)
- Monocultures only benefits the smugglers (male, 42 years old)
- We don’t need a plantation, there is enough natural forest in this area (male, 55 years old)
Akkunji

About today’s plantations
Through the questionnaire it is clear that the plantations in the village have had a positive impact. Almost every one of the informants agrees that the plantations have greeted the village with a lot of different benefits (figure 14). 27% of the informants see positive effects on the environment, improvements like a decrease of soil erosion and a rise in groundwater level near the plantations. Effects like a better air quality and more fertile land are also noticed. Every one of the informants agrees a conservation of barren land to a land overgrown by trees is a positive act. Despite this general positive perspective some negative opinions appeared during the interviews. Some of the informants also see negative effects for the village. One opinion is that wasteland used by the landless is taken for plantation, leaving the landless without land. Two of the farmers think that the plantations decrease the availability for grazing and that there is a lack of fodder because of the plantations.

Perception on future plantations
Most of the farmers are positive to a new plantation, mostly because of the benefits, benefits in forest products such as timber, fruits and nuts, dry and green leaves. Even eventual employment that might be available is considered as benefits. The farmers are concerned about the environment and welcome the environmental benefits that a plantation might bring. These are benefits such as a decrease of barren land and regenerating of degraded forest. The negative opinions about plantations in Akkunji village depend on priorities. A lot of the farmers emphasis other kinds of projects that the village needs and that maybe should be given priority above a plantation project. Projects proposed are; a new community hall, a housing project for the homeless, the building of a new school house or maybe areas for encroachment.

Areas available
80% of the informants in both villages are of the opinion that they have no available private land; however, several of the informants can point out smaller village areas that could be used for an eventual plantation. This is mostly barren or wasteland, in some cases degraded forest areas. The other 20% either had no opinion about available land or didn’t want to answer. When the question about interest in giving up a piece of private land for plantation the most common answer was, as noted above, that they had no available land. Many farmers also pointed out that they were not interested in changing agricultural land into forest land; they have been farmers for generations and want to stay that way. One farmer in Huladevansara pointed out that he doesn’t want a plantation near by his cultivated land, he means that it would attract wild animals and that they will eat his crop.
6. DISCUSSION

6.1 METHODS

Sources of error
Getting an objective impression of the result is only possible if the results are seen through the methods. The choice of methods have a crucial impact on the results and therefore also an impact on of the discussion and conclusion. By going through the sources of error the correctness of the results can be evaluated.

The sources of error can be divided into different categories. There is error in:

- measuring
- calculations
- translating

All of these sources of error are important for the result and by knowing them and try to come to terms with them; a more accurate result can probably be received in the end. Finding the sources can in some cases be hard since the basic meaning is to trust the method used, but to have a critical point of view and looking for cracks in the method is only beneficial for the results and continuing work.

The sources of error in measuring work are a common way to get a non accurate result. In this case, errors in measuring can be everything from a lack of accuracy when measuring the girt and problems in determine the right tree species. Errors on measuring can also occur in the lab when the soil carbon should be measured. When doing experiments the margin is small and mistakes are easily done.

The calculation is also a source of error. In this case a formula to calculate the biomass volume is used. There are formulas to use for a lot of different kinds of tree species for different areas in India. Those formulas were in this case not the best way to find out the biomass volume since there where things that didn’t fit into the pattern. There where small variations in the tree species, both local and regional, and for some species the formula were calculated for a different area and where not comparable. Because of all this variations, the more general formula was decided to be used. This formula is published in scientific material (Ravindranath et al. 2000) and has sufficient exactness. The possible source of error cannot be questioned. To be able to include the collected data of the shrub in the calculations, the basal area of the shrub was added together with the basal area of the forest. This gave a total basal area that resulted in the total carbon in biomass. Since the general formula is an estimation of a mean value of height and girth of different trees and since the shrub doesn’t have the same height or girth as a general tree the result from the shrub tend to be over valued. Since this was the only possible way to include shrub in the result, the choice was to use it anyway.

The translation error is most showed in the interweaving situations. When a project is taking place in a land where different language is spoken than the author have knowledge in, the author is depending to an interpreter. This means that the author is giving away a piece of the control of the result. The interpreter has a possibility to angle both the questions and the answers and give the author a different answer then the author might have gotten herself. This
can be of much importance for the result especially if the project is based on interviews. To get rid of this source of error the basic work with you and your interpreter is of most importance for the rest of your work.

There are other smaller sources of error that might not be able to be counted in these major categories. This is for example problems in interview situations. This can be situations during the questionnaire interviews were the meaning was that the interview should take place in private, but in most cases the whole family and neighbors joined the interview and the questionnaire became more of a focus group with a lot of opinions and help from everybody around. This might not always be a negative situation, the informant could be quiet and shy and the help from the family can be an asset, but just as likely can the situation and informant be disturbed by viewers. In this study the key informant was present at almost all interviews and since the key informant in both villages had a high status amongst the farmers. This fact that the key informants were present would most likely affect the informant’s answers.

The gender issue was also a hard thing to conquer. The aim from the start was to interview both men and women to get the best range of opinions. This was clear from the start of the fieldwork that topics were best discussed with the head of the house, usually the oldest man in the household. In some rare cases females could be interviewed, these were women who were single or whose husbands were not available. These were hard problems to overcome since the women themselves were convinced that they had no knowledge about the topics in question.

Although there are many possible sources of error in this study, they haven’t hopefully influenced the result in any large way. The results from the measuring and calculation are in this thesis since they are as correct as they can be, concerning the author’s knowledge. Although the interviews and the translation work could possible be more exact if more time were spent on it.

6.2 RESULTS

Biomass

Natural forest
The results from the measurements and calculations of the biomass show that the natural forest holds far more carbon stock than the other forest types. This seems like the obvious result, considering that the natural forest contains a mixture of different tree species and most important the natural forest is relatively old, compared to for example the plantations (Ravindranath, oral communication, 2002). Many of the trees have reached their mature state, the state when they no longer function as a carbon sink. The natural forest is also, compared to the beta land, quite untouched. Although the natural forest is the main source of both fuel and other necessities there are no large scale logging. The uses of the natural forest are large, but since there occur no felling of trees for timber in any large scale, the use doesn’t influence much on the carbon stock. To raise a CDM project with the intention to grow a natural forest as a carbon sink would be possible, but it will take a long time to receive a similar carbon stock (Ravindranath, oral communication, 2002). Regeneration with the intention to increase the quality of the forest would maybe work better than CDM in the natural forest.
The special report of the IPCC, Land Use, Land Use Change and Forestry (2000), shows a table of carbon stock from different forest management systems. The table shows that the carbon stock in primary and logged forest varies from 192 tC/ha, counted as low to 276 tC/ha, counted as high. This can be compared to the results from this study and the results are that all the forest types have a low carbon stock. The IPCC results are a summary of samplings of 116 sites, scaled from low to high, situated in the humid tropics. These results can therefore easily be compared with the results in this study, although they don’t match very well. This can be explained by the suitability of the formula used in this case. However, the results from IPCC don’t say what method has been used in collecting the data, nor does it say if the results include roots and shrub or something else that doesn’t match with the methods in this study.

*Figure 15. Natural forest in good condition. Photo: Palm, November 2002.*

Another study made by Haripriya (2001) estimate the mean carbon stock in Indian ecosystems to be 46 tC/ha in 1994. Of these 46 tC/ha is nearly 76% found in above ground biomass and the rest is found in fine and coarse root biomass. This leaves approximately 35 tC/ha in above ground biomass, the figure that can be compared to the results in this study. The result shows that the carbon in biomass in this study is slightly higher than Haripriyas (2001) estimation, but match well.

**Beta land**

The beta land on the other hand is used in another way. Much of the beta land are used for grazing and for growing fodder and this demands some logging of the trees to open up the land and ease the situation for the growing grass. It is not only the trees that gets logged, the shrub are also cleaned away. Some bushes can be left alone but mostly there are trees and grass.

The logging of the trees consider two things, first the remaining trees should be useful. This can for example be trees that they give fruits and nuts or it can be trees that have useful leaves. The leaves on the tree are used as manure; the leaves (fresh or dry) are mixed with cow dung and uses as fertilizer and the farmers have very good knowledge of which trees that gives the best leaves for manure. These trees are often left alone, except for thinning. The second consideration with the logging of the beta land is the biodiversity. The biodiversity gives a multiple use of the beta land, which many of the farmers prefer. The farmers are very aware of the fact of biodiversity and the positive benefits that comes with it. Of course there are range of looks and uses of the beta land since the farmer decides about his own land. Some beta lands are left totally alone and look more of natural forest, some are covered in high growing grass and some are just recently grazed.
These measurements took place in typical beta lands of these villages, mostly areas with scattered trees with or without grazing. This gives the explanation to the result of the biomass. If there are logging in an area, the total amount of biomass and the carbon stock can’t reasonably be as high as in the natural forest. It is although greater than in the plantations depending on, not the amount of trees, which is often lesser in the beta land, but the age and the maturity of the trees. The beta land is originally natural forest and because of that have a natural biodiversity and a maturity.

**Acacia plantations**

As can be seen on the results the 10 year old plantation has a larger biomass stock and therefore a larger carbon stock than the 5 year old plantation. The older plantation has been thinned during the years and contain therefore of fewer poles, only 50% of the poles remains after 10 years. The thinning is done on both separate poles, to get more space for the remaining trees and on coppice, leaving in most cases only one pole on each tree. Despite that it is not allowed some logging for fuel and timber by the people are taking place. The villagers don’t for certain do this; with the information from the villagers there is a lot of smuggling with timber going on. So the older plantation has thicker and taller trees, but less than the younger plantation.

*Figure 16. The acacia plantation 10 years (a picnic during biomass and soil sampling). Note that the trees are planted in strait lines. Photo: Palm, November 2002*

When studies of the standing biomass and carbon stock are done on plantations there is an interesting and important aspect that shouldn’t be forgotten. A comparison of the two plantations in this case shows that the 10 year old plantation holds the larger carbon stock. A larger, but not as large as could be expected. The rotational period of the Acacia plantation is 10 years and this should mean that the Acacia trees reaches it is maturity level at this age, i.e. most profitable for harvesting. The figures concerning the biomass per hectare in this study doesn’t give this result, they show that the 5 year old plantation almost has as large carbon stock as the 10 year old. If the numbers showed the whole picture the plantations could be harvested when they are 5 years with a larger yield. This isn’t exactly correct. The 10 year old plantation has been thinned and contains therefore lesser trees than the 5 year old plantation. The difference is actually almost 50% lesser trees. This gives a larger biomass per hectare, but because of the thinning the difference between 5 and 10 years isn’t as large as expected.

With the thinning also comes biomass. So to get the correct picture of the biomass amount in the 10 year old plantation you must count in both the actual standing biomass and the amount that was already harvested and taken away. This is the “hidden biomass”. In this case the
amount hidden biomass depends on at the age of the plantation when at the time the thinning took place.

Although if the plantations are raised as a CDM project the thinning is necessary to receive the largest carbon sequestration, with the thinning the trees grow faster and reaches its maturity age earlier. The trees need the extra space with more sun and water for each tree. It is important to remember the “hidden biomass” and to add the carbon sequestered here to the final carbon sequestered.

The result in this study with a standing biomass of 83 t/ha in the 10 year old plantation and 76.6 t/ha in the 5 year old plantation gives an mean annual growth of 8.3 t/ha/year in the 10 year plantation and 15.3 t/ha/year in the 5 year old plantation. This correlates well with figures from FAO (2000) where an *Acacia auriculiformis* plantation has a mean annual growth of 6-20 t/ha/year.

In the area, there has been some mixed plantation, with the relation, 25%: 75% where 75% is Acacia plantation, this is because of the high biomass demands (Bhat, oral communication, 2002). The other 25% can be a range of tree species, whatever suite the area in question best. It can be everything from fruit trees to valuable timber species. These mixed plantations have a bad survival rate, which is mostly due to the fact that the plantations are protected from grazing in approximately the three first years. When the grazing is free, the 25% other species than Acacia are grazed away, since the Acacia trees have a much higher growth rate. The other species are also disappearing because the Acacia trees are stealing the light.

**Soil**

To be able to compare the soil carbon values there is a need for a soil carbon baseline. Ravindranath (oral communication, 2002) suggested that this value can be calculated as a mean value from degraded forest land and dry land, i.e. cropland. This value represents a mean carbon value in all soils, the carbon the soil contains irrespective of the vegetation above. This value can be used to compare with the measured values from this project and can also be used to see the potential increase in soil carbon. Ravindranath (oral communication, 2002) suggested that the values that could be used in this case are for degraded forest land 42.7 tC/ha and for dry land 28.4 tC/ha. This gives the baseline value of 35.55 tC/ha.

When the baseline is compared to the results in this study, it is easily shown that all the forest types examined have a larger amount soil carbon than the baseline. The result is expected since all areas in this study are forested and not degraded, the different forest types show a similar pattern here as when the carbon stock in biomass was discussed. The natural forest has the largest amount, followed by the beta land. After that comes the 5 year old plantation and last the 10 year old plantation. The first two values gives no surprise, the soil contain more carbon in these two, since the forests are older and soil has been left alone for a long time and has not been disturbed by for example harvesting. The time in this case helps to accumulate the carbon in the soil. The last two is a surprise. How come the value of the 5 year old plantation is larger than the 10 year old and why is the gap between the 10 year old and the 5 year old so large? The explanation in this case is that 5 or 10 years of one specific land use is to short time to establish the soil carbon. The soil is still affected by the former land use in the area. It is clear that the soil carbon differ between degraded forest land, cultivated land and dense forest. So depending on the former land use in the area the plantation get different soil carbon values. The former land use in these cases, shown in figure 8a & b, has been natural
forest. The map doesn’t show in what shape the forest was, but most likely the forest was more or less degraded since it seems unnecessary to log not degraded forest just to raise a plantation in the same place. The soil carbon depends on the vegetation above, if the trees have grown for a long time and the soil has been left alone, the soil carbon value is much higher than if the soil is constantly disturbed by careless harvesting for example.

So, what about the idea of raising plantation in village wasteland? A study made in Lebanon (Moe 2003-05-05), shows a soil carbon baseline in wasteland of 20 tC/ha. The results from this study show larger soil carbon values in all the investigated forest types. The conclusions from this are that any kind of plantation on the wasteland would be beneficial in terms of the soil carbon. If the soil carbon can be raised at least up to the lowest level in this study, the total soil carbon in the wasteland (now planted) would be raised 200%.

Another study made by Haripriya (2003) shows a mean value for carbon in soils, calculated for the top 30 cm in the soil. The mean value here is 79.8 tC/ha and is counted for all India. When the mean value is calculated for the specific forest types common in Uttar Kannada (tropical wet evergreen, tropical dry evergreen, tropical semi evergreen, tropical moist deciduous and tropical dry deciduous) the value is even higher, 90.5 tC/ha. Compared with the results in this study, these numbers are much higher. One thing that need to be noted is that this study only considered one hectare or less of each forest type and that the results from Haripriya is a mean value for whole India. These differences can also depend on different methods used, in collecting and calculating.

These results from carbon in biomass and soil, shows that in a village like Huladevansara there is a possibility to sequester 41.5 tC/ha in biomass per rotational period with an Acacia plantation project. If the plantation is raised on wasteland the carbon stock in the soil can rise from 20 tC/ha to at least 40.53 tC/ha as in the 10 year old Acacia plantation. If the plantation is raised in an area with another former land use the carbon sequestration will be less. The potential carbon sequestration is high in a plantation project and even higher if the forest type is natural forest or beta land. However, the total carbon sequestration over time may be larger in plantation projects like Acacia since the rotational period only is 10 year, this means that every 10th year the carbon sequestration will double the amount carbon. The amount soil carbon sequestered may decrease every rotational period since the soil will be more and more saturated.

**Interviews**

The interviews give a good picture of how forest of any kind interacts with small communities and how important the forest is for local people.

What is interesting in the results from the interviews are that the two villages examined has two different opinions of the environmental effects of plantations. The people in Huladevansara are mostly negative, thinks that the plantation decreases the groundwater level and that plantations not are beneficial for local species. The people in Akkunji on the other hand think that the plantations deceases soil erosion and rise the groundwater level near the plantations. They also think that the plantation improves the air quality and gives a more fertile land.

These different opinions can seem odd but the fact is that both villages can be right. A study made by Sida in 1992 (Chaffey et al. 1992) on social forestry plantations in India, shows that
the environmental affects from plantation project can be many. As both villages points out the plantations affects the groundwater. It is true that trees consume more water that other kind of vegetation and therefore can decrease the groundwater level, but trees also provides a greater infiltration, both through its roots channels and through the litter on the ground and the hummus in the soil. Everything that lessen the surface runoff is beneficial for the infiltration and therefore also for the groundwater. The biodiversity can be a bad thing if the plantations are monoculture, which most plantations are in this area. A plantation can be a good thing for the biodiversity if local species are planted amongst the regular planted trees.

One large problem with making the farmers more interested in raising a plantation on their own land is that there is no available land. Most of the people are farmers in small scale; they own just the land area to support a family, to use land for forest plantations are not realistic. Many of the farmers interviewed in this study points out that they have been farmers for generations and that they are not interested in changing agricultural land for forest land. It is not a question of money, it is about tradition. One way to raise plantations could be to offer the farmers education about plantation and maybe start with agroforestry and use trees as a border crop.

Another way to make the farmers more positive towards plantations on their own land could be to ease the policy for the farmer. This can include making it easier to manage a forest, easier administrative work, make the laws and rules more adjusted to less educated people and allow foreign investors. This would also demand a change in the relationship between the industry and the farmers. There could be a support from the government to make it possible for the industry to give credit, longer lasting agreement, technology transferring and help with marketing. With this type of changes the basic starting help such as education and technology transferring could be much more efficient (Ravindranath et al. 2001).

CDM plantations should be used to fulfill the biomass needs of the local people (Bhat, oral communication 2002). A plantation could be raised and used to fulfill biomass needs, this will ease the pressure on the natural forest and there will be a net carbon sequestration, although harder to measure. The natural forest could still be used for non biomass needs, such as fruits, nuts and medicinal plants.

6.3 CDM

CDM is a very complex mechanism that will demand a lot from all involved parts, not impossible to manage, but it is a large scale project, that will work in practice on local level, with many parties involved. CDM will in practice influence parts on three levels all important, but very much different.

The first is the global level which basically started the whole thing. The CDM has multiple goals, not only must there be a reduction in emission or carbon sequestration, CDM must achieve a sustainable development, otherwise the project is a failure. At this global level the responsibility of baselines, additionality, monitoring, evaluating, reporting, verification and certification will lie. They will be decided and developed by COP/MOP (meeting of parties) and supervised by the Executive Board (EB). EB will also supervise CDM activities. The amount of countries involved in the decisions on this level can be a problem, not only because difficulties in agreement, but also because of the time it takes to agree.
The second one is the “party to party”. This often means country to country but can also include companies and non governmental organizations (NGOs). Each party will have a CDM-authority and it will establish a procedure that will ensure that CDM meet its criteria for sustainable development and other environmental requirements. The CDM-authority will select, approve and endorse CDM projects. Other important issues here are the economic transfer that maybe will occur. When money is involved a hierarchy is often evolved (in my opinion). The hierarchy system already exists between industrialized and developing countries and the money transferring could be yet another way to establish this world order.

The third is the local level, the level which will be affected in the daily life. At this level there are no routines evolved, and no clear guidelines established. This thesis shows how important local participation is for any kind of project and that theory not always match with reality. Without local participation – no working project. On the other hand, if a project reach a community and get the co-operation, a project may evolve in a very beneficial direction, both for investors, on governmental level and for the local participants. This co-operation can be reached in many ways; use the local knowledge, let people be involved, let it be worth it and always ask the local people. Use the theory combined with local perception to evolve a successful project.

6.4 ANSWERS TO THE QUESTIONS

*What sort of plantation and what type of trees will best suit a CDM project in terms of local sustainable development and carbon sequestration?*

When CDM and plantations are discussed, it is important to remember that the type of plantation depends on what the baseline scenario is for the specific place. If the area suffers from deforestation, regeneration or rehabilitation of the degraded forest might be an option. This might not enlarge the carbon stock in any large scale, but slowing deforestation is as well a mitigation of emissions and can be counted as a CDM project. On the other hand if the natural forest is in good condition, a plantation starting from scratch might be a good idea for the area. This will give a large carbon sequestration and hopefully a contribution to the local sustainable development.

When looking at the results from biomass, soil and interviews, in my opinion neither of the evaluated forest types is perfect for a CDM project, although combining them would make a suitable choice. All of the types would suit a CDM project in different ways. The natural forest is an excellent support to the local peoples needs; it holds a large carbon stock and is in all ways an important part of the daily life in the villages. The beta land on the other hand also supports the farmer with their needs, in a way that is more controllable for each individual. It holds a carbon stock, although not as large as the natural forest. The Acacia plantations is very suitable for carbon sequestration, they grow quickly and can be harvested in a short rotational period.

All the forest types have its negative sides. The natural forest is a complex mixture of different species of different age and since the species composition isn’t planned the natural forest grow slowly. It takes several decades for it to reach its maturity stage. The beta land first field of application is to support the farmers with what they need, not all the farmers, only the ones with an Areca garden. This means that the farmers modify the beta land in the most suitable way for them, with logging and thinning. This gives a carbon stock of nearly half the stock in the natural forest. The Acacia plantations are not only appreciated by the
farmers, in many cases they feel that they have no use for the plantation. The ways of looking at the plantations are different depending on the management system. For example, with the JFM projects where the farmers feel more as a part of the project and also shares the harvest, the attitude is more positive. Many plantations are also raised as monocultures, which makes the plantations more vulnerable for pests and diseases and this gives in turn a release of the sequestered carbon (Sathaye et al. 1999).

This is why a mixture of these forest types, in my opinion based on findings from this study, would suit a CDM project best. A plantation of fast growing trees with a short rotational time would with no doubt be the best for the actual carbon sequestration, but the local opinion on what trees that the project should contain is as important as the carbon sequestration. This part of the project must be designed from the local peoples view. It would be more preferable to plant trees that are highly valued by the local people since these are unlikely to be abandoned or mismanaged. This could for example be Areca gardens, fruit trees, trees that can be used in manure or for timber purposes. If a project will be integrated well in the village a certain benefit for the local people is essential. Areca could be a well suited tree species in a CDM project, it is a commercial crop highly valued by the villagers, the trees can be planted close together and the stumps are good fuel when they die. This would be a tree that the villagers would welcome as a planting project. This would however have a longer rotational period than for example Acacia plantations. The Areca trees need some years to start yielding the nuts, but on the other hand continue to yield nuts for approximately 40-50 years.

How could CDM and plantation project work in practice on local level?
One of the conclusions drawn from this project is that all villages are different. What could work for one village can be unsuitable for another village. One thing is important for everybody to make a project work and that is to involve the local people in designing a project and to take decisions. Nobody knows a certain village as well as its habitants. To make everybody feel involved a committee can be formed, where the members are chosen from and by the villagers. This committee could interact with the investing parties and other experts. How the decisions should be taken I’m not sure, but most important is that everybody has a say and that they get informed. It is not sustainable development to take decisions over somebody’s head and a project will never be well established if the people that will be affected by a decision cannot say their opinion.

What parameters are important to sustainable development on local level?
A sustainable development is a development that satisfies the needs of the present without compromising the ability of future generations to meet their needs. The Bruntland Commission (WEC 1987, Sited in Ravindranath & Sathaye 2002) suggested that sustainable development is “development that satisfies the needs of the present without compromising the ability of future generations to meet their needs”. This is the original definition, a bit vague, and therefore necessary to make concrete on local level and to define sustainable development by the host countries of a CDM project (Ravindranath & Sathaye 2002). Although this quote gives a very good image of what sustainable development should struggle for. Satisfy the needs of today without stealing from the future. So, what parameters are important to reach this goal? This quote basically says that if you satisfy the needs of today sustainable, sustainable development is achieved. How to know what the needs of today is? The needs keep changing. Isn’t it a fact that most people struggle for a better future? What about needs that the people had and still have, but not can satisfy today, like the honey from the natural forest? They had it before; still want it, but can’t have it.
The point must be that life should go on without any destruction of the life supporting systems, environment and economics for example. So changes are good as long as they are sustainable planned for the future. This can only be realistic when the decisions come from the outside or when it is about the village future. There can be no restrictions on how adults want to live their life. A CDM project demands sustainable development and to reach this investments for the project comes from the outside, a dialogue with suggestions and decisions develops together with both the village committee and the outside investors. If the village is interested in a CDM project they must agree to strive for sustainable development.

Theory doesn’t always match with reality!!!!
7. CONCLUSIONS

- Any forest type or tree species can function in a CDM plantation project. Depending on the expected result and what type of situation, both environmental and social, are some better suited that other. As long as the plantation functions as a carbon sink, sustainable development and are strongly supported by the locals involved it works.

- If plantations are raised and if it is thinned for a better final carbon stock, it is important to establish and measure the “hidden biomass”. This must be done as a way to establish the total carbon stock in the biomass and therefore also the right amount of eventual carbon credits the investors in the CDM project can collect.

- Soil carbon measurement can be difficult to include in CDM plantations. If the project has a short rotational period, the soil carbon in the first periods still is affected by the former land use and can not be measured for this specific plantation project. To include soil carbon in CDM can complicate the measurements of carbon sequestration.

- There exist a large potential for carbon sequestration in the examined villages. If the eventual CDM project includes an Acacia plantation with a rotational period of 10 years the carbon sequestration potential is 41.5 tC/ha in biomass per rotational period. The carbon sequestration in the soil can rise from 20 tC/ha to at least 40.35 tC/ha as in the 10 year Acacia plantation.

- A successful CDM project will, if it is well received by the local people, both can work as a carbon sink and as a way to sustain development in a village.

- Without local participation-no working project.
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APPENDIX 1

Questionnaire for interviews in Huladevansara

Name: Age:
Gender: Profession:
Family size: Land-use:

<table>
<thead>
<tr>
<th>Land-use</th>
<th>Paddy</th>
<th>Areca</th>
<th>Coconut</th>
<th>Beta</th>
<th>Dryland</th>
<th>Other</th>
</tr>
</thead>
</table>

1. What do you receive from the natural forest?

2. What do you receive from the beta land?

3. What do you like to get from the forest?

<table>
<thead>
<tr>
<th>Natural forest</th>
<th>Beta land</th>
<th>Like to receive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(manure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small timber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fodder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits/Nuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mulching material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seedling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicinal plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. What forest products do you think is missing or is lack of in this village?

5. Who benefits from the natural forest today, some special group or everybody?

6. Who do you think should benefit from the forest?

7. Who in your village has the right to take decision about common land and an eventually plantation?

8. Are there, in your opinion, any wasteland or common land that can be used in a plantation?
   - If yes, what area?

9. Are you positive to a plantation?
   - If yes, why?
   - If no, why?

10. Would you be interested in giving up a part of your land to a plantation?
    - If yes, what kind of compensation would you prefer?
• What type of trees would you prefer?

11. What would you like to recieve from an eventual future plantation?

<table>
<thead>
<tr>
<th>Future plantation</th>
<th>Future plantation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Nuts</td>
</tr>
<tr>
<td>Leaves</td>
<td>Seedling</td>
</tr>
<tr>
<td>Small timber</td>
<td>Manure</td>
</tr>
<tr>
<td>Fodder</td>
<td>Medicinal plants</td>
</tr>
<tr>
<td>Grazing</td>
<td>Private income</td>
</tr>
<tr>
<td>Fruits</td>
<td>Community income</td>
</tr>
<tr>
<td>Other</td>
<td>Biodiversity</td>
</tr>
<tr>
<td>Soil</td>
<td>Employment</td>
</tr>
</tbody>
</table>
APPENDIX 2.

Questionnaire for interviews in Akkunji

Name:                         Age:                        
Gender:                      Profession:                   
Family size:                 Land-use:                     

<table>
<thead>
<tr>
<th>Land-use</th>
<th>Paddy</th>
<th>Areca</th>
<th>Coconut</th>
<th>Beta</th>
<th>Dryland</th>
</tr>
</thead>
</table>

1. What do you get from the forest, plantation and beta land?

<table>
<thead>
<tr>
<th></th>
<th>Natural forest</th>
<th>Plantation</th>
<th>Beta land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry leaves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green leaves (manure)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small timber</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fodder</td>
<td></td>
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<tr>
<td>Grazing</td>
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<tr>
<td>Fruits/Nuts</td>
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<tr>
<td>Mulching material</td>
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<tr>
<td>Seedling</td>
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<tr>
<td>Soil</td>
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<td></td>
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<tr>
<td>Medicinal plants</td>
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<tr>
<td>Private income</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. What forest products do you think is missing in the village?

3. What connection do you have to the plantation?
   - Use it?
   - Work with it?

4. Who benefits from the planted forest, the poor, everybody or the wealthy?

5. Who do you think should benefit from the plantation?

6. Who in your village has the right to decide about the common land?

7. Are there, in your opinion, any wasteland or common land that can be used in a plantation?
   - If yes, what area?

8. In your opinion, did the plantation project help the village in some way?
   - In case of yes, why?

   - In case of no, why and what did you think did go wrong?
9. Are you positive to a new plantation?
   • If yes, why?
   • If no, why?

10. What would you want from a future plantation?

<table>
<thead>
<tr>
<th></th>
<th>Future plantation</th>
<th>Future plantation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Nuts</td>
<td></td>
</tr>
<tr>
<td>Dry leaves</td>
<td>Seedling</td>
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<tr>
<td>Small timber</td>
<td>Green leaves</td>
<td></td>
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<tr>
<td></td>
<td>(manure)</td>
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</tr>
<tr>
<td>Fodder</td>
<td>Medicinal plants</td>
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<tr>
<td>Grazing</td>
<td>Private income</td>
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<tr>
<td>Fruits</td>
<td>Community income</td>
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<tr>
<td>Other</td>
<td>Biodiversity</td>
<td></td>
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<tr>
<td>Soil</td>
<td>Employment</td>
<td></td>
</tr>
</tbody>
</table>

11. Would you be interested in giving up a part of your land to a plantation?
   • If yes, what kind of compensation would you prefer?
   • What type of trees would you prefer?