THE FINANCIAL FEASIBILITY OF TREE-PLANTING UNDER AGROFORESTRY: A CASE STUDY FROM THE GROUNDNUT BASIN OF SENEGAL

by

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(ABSTRACT)

Agroforestry is a new term for an old practice of resource management which includes the planting of trees and agricultural crops on the same piece of land, either simultaneously or sequentially. In Senegal, this new approach has been praised, mainly because it came along at a time when private participation in reforestation was badly needed. Since the early 1980s, the Snegalese government has been devoting money and personnel to the implementation of agroforestry projects, particularly in the Groundnut Basin. In spite of these efforts, small private farmers response to the suggested agroforestry systems has been slow in most parts of the region.

Assuming that financial return is the most viable mean for triggering large-scale adoption of agroforestry by private farmers, this study analyzes the financial attractiveness of the three agroforestry systems promoted in the Groundnut Basin, and compares them to the base case of growing groundnuts alone. The three agroforestry systems are: kad and millet, cashew and groundnuts, and a Eucalyptus block plantation. For each system, costs and benefits accruing to the farmer are identified and estimated. The financial attractiveness of each system is measured using two criteria: present net worth (PNW) and internal rate of return (IRR).

Using the criterion that a system with a PNW greater than zero is acceptable, the results indicate that all three agroforestry systems are acceptable at 10 and 15 percent discount rates. The kad and millet system is acceptable at rates nearing 50 percent. This is due mainly to the valuation of the crop loss avoided in the presence of kad trees. When this component was not internalized, the IRR

was found at only 15.8 percent. The cashew and groundnut system has the next highest IRR at 25.6 percent, followed by The Eucalyptus block plantation at 18.8 percent. The base case yields negative PNW at all three discount rates, and an IRR equal to 4.7 percent. This low return from the groundnut enterprise may be due to the valuation of family labor which does not generally constitute an out-of-pocket cost.

Some environmental benefits attributable to agroforestry systems and some socio-economic constraints that may be part of the farmers' reluctance to adopt the new systems are discussed. Finally, some recommendations are made to help improve the current approach to private involvement in reforestation. It is suggested that, in order to anticipate the loss in interest that follows most incentive programs once the incentives stop, the "cost sharing" program and other financial incentive programs should be limited to systems, which have strong favorable impacts on the environment but do not afford sufficient financial rewards by themselves for wide scale adoption.

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Chapter I

INTRODUCTION

1.1 Background

One of the most obvious factors affecting the economies of West Africa is undoubtedly the weather. The region has been the victim of unremitting series of drought since the late 1960s. The situation has been worsened in Senegal by the fact that, after more than two decades of independence, the country's economic health is still closely tied to the vissicitudes of the groundnut monoculture inherited from the colonial era. The size of the groundnut crop is the most important factor affecting the Senegalese economy (Delgado and Jammeh, 1991). Groudnuts generate two-thirds to three-fourths of rural monetary income, provide the raw material for the country's groundnut-processing industry, and, along with calcium phosphates -Senegal is the world's seventh-largest producer- constitute the leading export product. In 1990, Senegal's exports of Groundnuts and phosphates

accounted for roughly 26 percent and 19 percent of total merchandise export earnings respectively (U. S. Department of Commerce, 1991).

Senegal is overwhelmingly agricultural, with more than 70 percent of the labor force engaged in farming (U. S. Department of State). The current situation of Senegal's agricultural sector is best described by the U.S. Department of Commerce (1991:5):

> Poor rainfall patterns during the 1990/91 crop year kept the agricultural sector from repeating its strong performance of the year before. Total food crop production declined by 12 percent as output dropped from 1.1 million metric tons to 962,000 metric tons. A significant decline in millet production (down 125,000 metric tons) accounted for over 96 percent of the decline in food production. This fall in production is partially attributable to a 5 percent reduction in the land used to cultivate millet; however, the 11 percent decline in yield per hectare is strong evidence that less than ideal rain patterns are the principal culprit behind the downturn.

Farmland in Senegal is almost all held under customary tenure arrangements guaranteed under the *loi sur le Domaine National* and is cultivated on a rotational system. In some areas such as the Groundnut Basin, there is quite serious overcrowding and population pressure on farmland, which has led to a reduction in fallow periods and thus in soil fertility. Land holdings are very small, and farm incomes low. Most producers combine cash cropping with the production of grain for domestic consumption, and tend to switch from one to the other according to their needs.

The principal contribution of forestry to the Senegalese economy is in providing fuelwood. In major cities, charcoal constitutes the major domestic source of energy. Households find it more affordable than natural gas or electricity. In addition, there are a host of cultural practices such as tea making, incense burning, meat grilling and so forth, built around the use of charcoal and which, many believe, lose their "cultural flavor" when done using natural gas.

In rural areas, on the other hand, the use of noncommercial forest products, wood and fodder mainly, is still based on local people's user-rights, which were established when forest cover was more than adequate. The government did not view it necessary to plan to achieve a sustainable

flow of these noncommercial products. As a result, the country has become a net wood importer in recent years.

Each year, the country has to satisfy a national appetite for roughly four million cubic meters of firewood. In 1984, $34.5 million worth of forest products were imported (United States Agency for International Development (USAID), 1986). To reduce this high dependency on forests for domestic energy, the government decided to subsidize the price of gas, making it more affordable to the average family. However, the failure to provide enough information on the safe use of this material, new to most families, made this campaign a disaster.

In 1982, the lack of a well-defined energy policy associated with the cumulative effects of successive years of drought on natural resources forced the government to undertake a comprehensive strategy for forestry development in Senegal. The Multi-volume Forestry Development Master Plan (Plan Directeur Forestier), was designed to be the Bible of forestry development in Senegal for the coming years. The objective of the plan was to highlight and guide anti-desertification activities. An annual tree-planting rate of 14,000 hectares by the turn of the century has been projected (Groupe Protection de la Nature, 1989). The plan divided the national territory into six major ecological zones (*zone ecologique homogenes*); identified the ecological and socio- economic problems in each zone; and provided guidance for priority programs to be launched in the near future.

Though the social and economic impacts of the desertification process have been quite well known for sometime, it has been difficult for the government to find the right mix of human and financial resources to devote to generating solutions. With the help of the international community, technical assistance was provided as well as funds to launch what is today known as "first generation projects."

1.11 Characteristics of first generation projects

The approach of the first generation projects, was entirely non- participatory. Designated parcels were disk plowed with heavy machinery, planted by paid labor, fenced off, and guarded by watchmen hired to prevent damage to new plantations by animals or people.

In spite of the great care taken, success was extremely limited. Three reasons can be given for this failure:

1. The use of outside consulting agencies not often accompanied by collaboration with competent national agents from the Forest Service.

2. the projects were either too large, or so small and localized that their impacts on the environment were minor.

3. The areas designated for planting were cleared of natural tree vegetation and planted with exotic species such as the Bandia natural forest where Khaya senegalesis was decimated and replaced by Eucalyptus sp.

4. Lack of public involvement as farmers needs were not taken into account in the project design. In fact, participants in community reforestation efforts were rarely consulted about the choice of species to be planted, and were unsure as to who owned and would profit from plantation production.

These failures added to the cost of meeting the Forestry Master Plan targets of 14,000 ha per year, and made officials realize that plantings by the Forest Service needed to be complemented by plantings by rural communities.

1.12 Attempts to involve farmers in tree planting

By the end of the first generation projects, some of the inherent problems were beginning to become apparent. The government then began to look for more effective strategies. Anticipating greater local interest and participation, community forestry was started in the Groundnut Basin region. Villagers were asked to allocate pieces of land for tree planting. The Forest Service, via the Community Forestry Project in the Groundnut Basin (*Project de Reboisement Communautaire dans le Bassin Arachidier*), provided fencing and seeds. From the official point of view, this provided a cheaper way of establishing plantations. Project staff also assumed that the farmers would be interested in the trees as a source of fuel.

This move from conventional plantation forestry to a participatory approach, however, turned out to be more difficult than anticipated. Although the project succeeded in getting the farmers to do the planting, it failed to generate the promised large-scale popular participation in the activities. There were valid reasons for this lack of local interest:

1. The activities have been too closely associated with the fuelwood problem, failing to recognize that wood scarcity was not very perceptible to the average farmer who could gather wood relatively easily, either legally or illegally, from nearby forests.

2. Farmers had insufficient information and training about the variety and values of the exotic species they were asked to grow.

3. The complexity of policies and codes regulating the Forest Service were not designed to stimulate greater interest in tree planting. For example, in some areas, farmers were unwilling to grow certain valuable tree species because they are on forestry code lists of protected species and, therefore, could not be harvested for economic gain (Thompson, 1979; Foley, 1984; and Fortmann, 1985).

4. The Forest Service's lack of trust among farmers. In many areas, forest agents have repeatedly fined villagers and taken them to court for violating forest laws on "Classified Forests" and "Protected tree species".

5. The *"loi sur le Domaine National"* prevented land from being privately owned, so many farmers were unwilling to plant trees on public land with no assurance that the benefits would accrue to them or to their children. Planting trees without being sure to profit from them once they are grown is nonsense to farmers.

As can be seen, the revised approach has been successful only from the project's viewpoint because plantations could be achieved at a lower cost. Little or no attention was paid to the profitability of the activities from the point of view of farmers in the region. It was fortunate that agroforestry came along just in time, with this quick awareness of the farmers' interest, and helped set new directions.

1.13 New directions: Agroforestry projects.

Before these new directions were adopted, only a few local farmers were interested in tree planting. However, it was difficult to establish that trees were the main attraction of the old programs. Indeed, it was not clear whether tree planting was locally accepted by these farmers because they viewed it as a profitable and relevant farming activity. Two major incentives provided by tree planting projects to loyal farmers have led to these doubts:

1. Free food, provided by the World Food Program, was distributed to villages who agreed to add trees to their land use systems.

2. Expensive fencing, which is very effective in protecting crops from free-ranging domestic animals, was also distributed free to these same villages.

So, in recent years, the government has emphasized the development of agroforestry projects based on the two major recommendations made by forest officials as means of increasing widespread local farmers' participation in tree-planting programs. This new approach:

1. broadens the scope of forestry projects and promotes only those activities that are clearly relevant to the local population; and

2. motivates farmers and other private landowners to plant trees by proving the tangible financial gain and increased agricultural production that they can gain from agroforestry activities.

1.2 Study Area

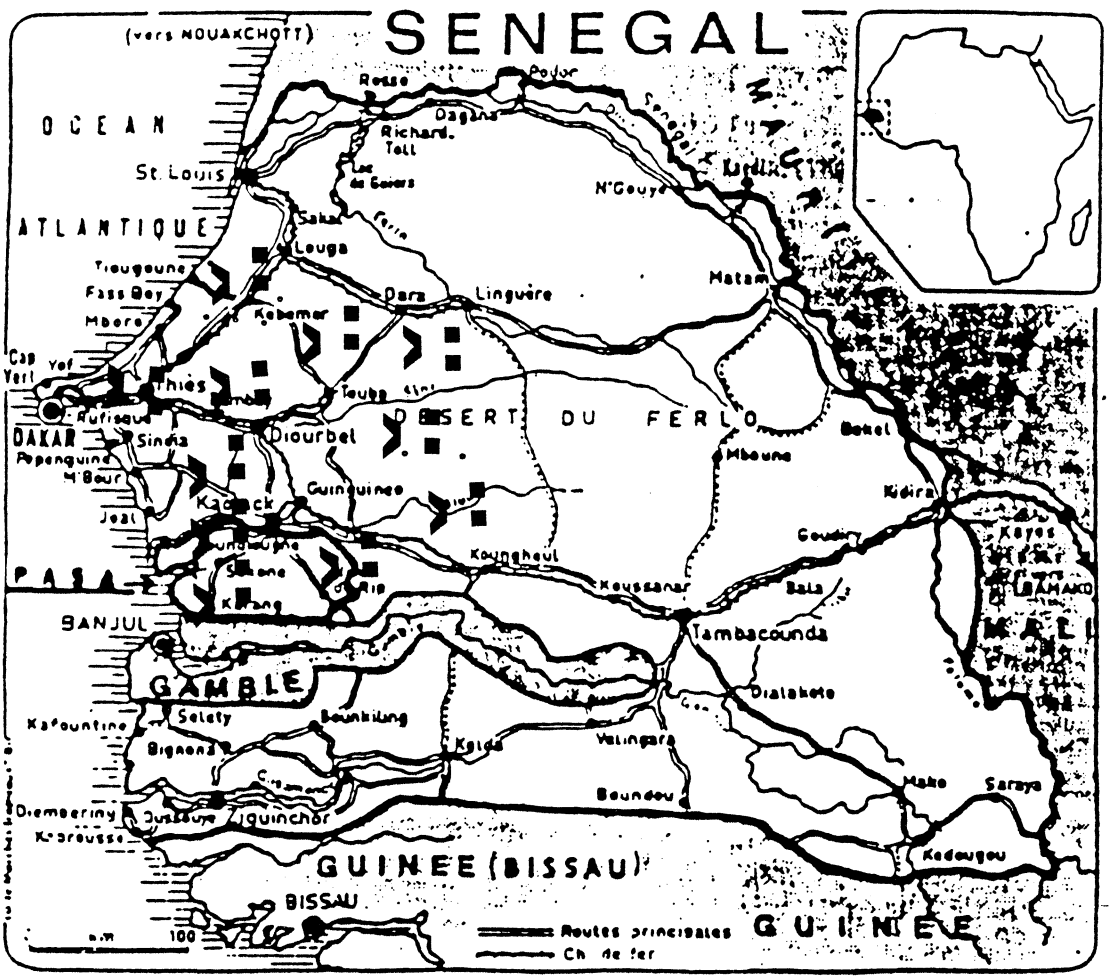
The Groundnut Basin is one of the six homogeneous ecological zones identifiedin the Senegalese Master plan for forestry development. The region lies behind the maritime belt, and extends from louga to the north of The Gambia (see map). There are four major characteristics that distinguish the Groundnut Basin from the other five homogeneous ecological zones:

1. The Groundnut Basin covers the greatest number of administrative regions (4 over 10);

2. major Senegalese agroforestry project are launched in the Groundnut Basin;

3. the Groundnut Basin accounts for some two thirds of the total area cultivated each year; and

4. The Groundnut Basin produces the bulk of Senegal's main crop, groundnuts, which are vital to the country's economy.



The Groundnut Basin

Source: Adapted from Busacker et al., 1990

Figure 1. Ecological boundary of the Groundnut Basin

The Forestry Master Plan prescribes three major anti-desertification actions for the Groundnut Basin. These are

1. Development of agroforestry practices across the region;

2. development of soil protection and restoration activities; and

3. development of integrated land -use systems involving both woody perennials, such as acacia species, and annual crop.

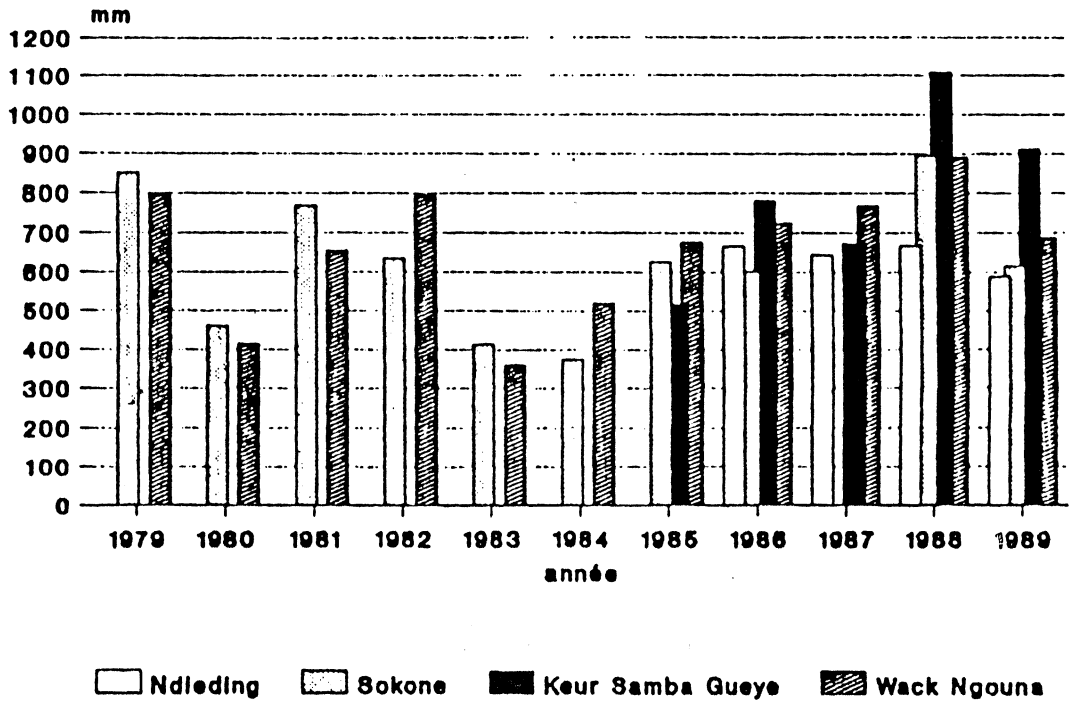
1.21 Climate

The region's climat is of the type sahelian in the northern part and sahelo-soudanian in the southern part. What characterizes both climate is the existence of only two major seasons

1. A long dry season lasting approximatly 8 to 9 months (from end October to June or July); and

2. a short rainy season lasting only 3 to 4 months (June to October).

The normal average rainfall is between 600 and 800 millimeters (Kone, 1987). Figure 1 gives the annual rainfall in the 1980s for the regions four major counties: Ndiending, Sokone, Keur Samba Gueye, and Wack Ngouna. It shows an unequal distribution of rainfall across the region. Southern regions such as keur Samba Gueye generally receive a higher rainfall. This results in low yields for the central and northern parts of the Groundnut Basin (Kelly and Delgado, 1991).



Source: Busacker et al., 1990.

Figure 2. 1979-89 annual rainfall for four counties in the Groundnut Basin

1.22 Soils

The region's soils are of the *tropical ferriginous* type with variable chemical properties (Kone, 1987). In most parts of the region, soils are washed out; however, they can be successufully farmed if appropriate protection measures against erosion are taken. The two dominant soil classes are

1. The *dior* soils; (sandy plains and dunes); and

2. the *deck* soils; (clayey soils found in swamps and between dunes).

1.23 Demography

A population density ranging from 50 to 100 inhabitants per kilometer square (Kone, 1987), higher than national average estimated at 9 to 10 inhabitants per kilometer square, puts the Groundnut Basin first among Senegalese regions referred to as *region de regroupement maximal de la population.* Also,while population density averages to only 49 inhabitants per cultivated square mile for Senegal as a whole, the same estimate for the Groundnut Basin averages 230 inhabitants per cultivated square mile (Nelson, 1974). As a result, there is a serious overcrowding in the region, and many authors, (Schumacker, 1975; Babou, 1987; and Kone, 1987) attribute the resource base and forest cover degradation in the region in part to the high population pressure.

1.24 Farming System

Groundnuts are the region's major agricultural crop. Most producers combine this cash crop with millet/sorghum and maize for domestic consumption. The region's crop yields depend greatly on rainfall and the level of inputs used (kelly and Delgado, 1991).

Cultivation methods are generally traditional, although the use of animals for ploughing and sowing has become widespread since the 1950's (Nelson, 1974). The preservation of kad natural regeneration on crop fields is the principal traditional agroforestry practice. Before the introduction of modern cultivation techniques, the practice of shifting cultivation with long years of fallow was well adapted to conserving soil fertility (Nelson, 1974). However, cash crop production led a large number of shifting cultivators to settle. As the population grew, the original rotation Groundnut-millet-fallow progressively gave way to a rotation in which the fallow period was greatly curtailed or abandoned. Although the use of fertilizers is well known to farmers, only few have the means to purchase it after the government ended providing subsidies for this commodity.

Kelly and Delgado, (1991) indicate that most equipment delivered to the Groundnut Basin was primarily used to increase the cultivated area, with no emphasis on improvement of tillage practices. In spite of the government's recent efforts to provide legislation that makes land available to *"those who use it for the benefit of the community"*, the average farmer land holding remains small and farm income is low. Small farmers have difficulty expanding their farmlands. This is mainly due to to the the existence of a parallel land tenure system, and the use of the *Loi sur le Domaine National* by the elites, civil servants and businessmen to acquire agricultural land, to the detriment of farmers. Gaye and Balde, (1991:198) quote the Senegalese Minister of Rural Development as saying: *"The day I solve this matter,* [land redistribution] *I will not need to be concerned about agriculture anymore. I will then go to Paris and other countries to discuss more important matters".*

Agroforestry, as a practice that integrates different farm activities on the same piece of land, has been promoted in order to avoid needed land reforms and their potential political consequencies. However, before the proposed agroforestry systems are well understood and accepted, their financial viability will have to be assessed.

1.3 Problem Statement

With increasing economic difficulties at the national level during the 1980s, the Senegalese government started to reduce its dominance of the rural and agricultural sector in favor of increased private initiatives. In the forest sector, this trend has been marked by a new reforestation program called "the matching grant program" in which the government promises to reimburse up to 50 percent of any private investment in reforestation after one year of tree survival. Like the United States' program providing incentives to private landowners for the reforestation of non-industrial private forests (NIPFs) (DeSteiguer,1984), this policy is based on the assumption that farmers are reluctant to invest their capital in the long-term wood production process, and thus, incentives are required to encourage them to undertake tree planting activities (Niang, 1991). It can be noted, however, that this program, which is still going on, has received very little response from farmers, particularly those living in the Groundnut Basin.

Niang (1991) gives five major reasons for this lack of involvement:

1. a lack of information about forest product markets;

2. a lack of training of potential market participants;

3. a lack of a consistent policy with respect to the distribution of seedlings;

4. inappropriate forest product taxes, pricing of forest products and permits; and

5. the lack of marketing services as part of the Forest Service's extension package.

The belief that the poor response is only because farmers in the region tend to be conservative, if not entirely against innovations, is misleading. Carr (1989), notes that there are times when agricultural officials believe that technology is available and blame farmers for the lack of adoption,

when in fact what is required is more penetrating research. In the past, Senegalese farmers have demonstrated their capacity to try a technology that helps them solve financial as well as environmental problems. As economic agents, they also want to put their efforts and funds only into what they see as productive activity. So far, no assessment has been made on the financial feasibility of the agroforestry schemes proposed by project staffs and the Forest Service. The lack of such analysis is likely the major constraint to agroforestry development in Senegal today.

A farmer's financial expectation, dictates to a large extend his willingness to adopt new crop patterns. Also, it is the farmer who makes the decision whether to utilize any particular agroforestry scheme. So he needs a means of comparing alternatives, which is meaningful to him and which he can interpret in his decision-making framework. Given the premise that farmers will react to market opportunities, information about how much the proposed agroforestry systems would contribute to their income then is crucial, and it is this study's goal to contribute answers to this question.

1.4 Research Objectives

The primary objective of this study is to estimate and compare the long term profitability of various interventions supported by the Senegalese Forest Service in the Groundnut Basin. A secondary objective is to provide a management tool to indicate the best opportunity for extension success in the region.

Three major agroforestry systems will be examined. These systems are associated with the three following species:

1. Acacia albida;

2. Anacardium occidentale; and

3. Eucalyptus sp.

The list of other trees most often planted in the context of agroforestry in Senegal is presented in Table 1.

Specifically, the study will:

1. identify and value all costs and revenues associated with the implementation of each system;

2. carry out a financial analysis, using Present net worth and internal Rate of Return criteria;

3. dentify and summarize the contribution of tree components on the microclimat; and

4. examine agroforestry investments within the current structure of farm in the region and identify the major constraints.

Table 1. Trees most frequently planted in agroforestry initiatives in Senegal.

Species	Wolof name
Eucalyptus	Khot butel
Anacardium occidental	DarKassu
Acacia albida	Kad
Azadiracta indica	Neem
Prosopis chilensis	Prosopis
Mangifera indica	Mango
Acacia nilotica	Nep-nep
Acacia senegal	Werek
Citruup3s lemon	Limon
Cassia siamea	Cassia
Psidium guayava	Goyave
Casuarina equisetifolia	Filao

Chapter II

LITERATURE REVIEW

2.1 What Is Agroforestry?

In recent years, agroforestry has generated a high level of enthusiasm among reseachers, developers, and policy makers concerned with tropical land-use systems. In the very beginning, the problem was to find a definition of agroforestry with which everyone could agree. This was not so much a question of terminology, but rather one of identifying the mandate, objectives and scope of agroforestry in the general context of land use (International Council for Research in Agroforestry, 1990). Various definitions have been suggested (Bene et al., 1977; Von Maydell et al., 1982; and Huxley, 1984); however, the following definition seems to be generally agreed upon (Nair, 1984:5):

> "Agroforestry represents an approach to integrated land use involving the deliberate mixture and retention of trees or other woody perennials, as part of the crop/animal production enterprises. Thus, it combines elements of agriculture, whether crop or animal based, with elements of forestry in sustainable production patterns on the same piece of land, either simultaneously or sequentially. The

> objective of most agroforestry systems is to optimize any beneficial effects of the interaction of woody components with the crop and/or animal components to obtain a production pattern that, in terms of total quantity, diversity of end products or sustainability, is preferable to what is usually obtained from the same resources under prevailing social, ecological and economic conditions."

The euphoria about the agroforestry concept, however, has led to a false belief that agroforestry is a completely new practice. Although it is true that the scientific principles of agroforestry are only now being examined, and hence understood, the practice, in some form or other, has been in existence since very early times among farmers in the Sahel. In the Groundnut Basin of Senegal, for example, maize, and peanut were often grown by farmers under a park of "Kad" (Acacia albida), precisely because farmers realize that they will reap a better harvest when they plant their crops in close proximity to these trees. In addition, local farmers often are willing to set a few corners aside for trees that are useful for their daily use. These are mainly trees that provide food, shade for the family compounds, wood for hut buildings or for the village market place. Weber and Hoskins (1983:8) also observe that

> "Ample evidence exists across the Sahel that many different species of trees in different farming or grazing systems have been deliberately managed and protected by the local people as part of their way of using the land. This practice was established long before the important contribution of trees to crop yields or range conditions were recognized and given full credit by development or government agencies ..."

Presumably, these considerations have led to the more simplified definition of agroforestry as "... a new term for the old practice of growing woody plants with agricultural crops and/or livestock on the same land ..." (Nair, 1984).

2.2 Agroforestry Systems

Hoekstra (1983a) describes three biological relationships between trees and agricultural crops when grown on the same piece of land. They may be:

1. competitive, wherein the output of one component can only be increased at the expense of the other; or

2. complementary, wherein an increase in the output of one component will also bring about an increase in the output of the other; or

3. supplementary, wherein the output of one component tends to be independent of the output of the other.

Huxley (1972) and Nair (1989) propose criteria and a structural basis for classifying agroforestry systems. MacDicken and Vergara (1990), DeTroyer (1986), and Advisory Committee on the Sahel (1984) describe the three main systems that constitute the primary land use strategies in agroforestry. These are:

2.21 Sylvo-pastoral systems.

These systems involve trees and livestock. They predominate in the northern part of the Sahel where there is little rainfall and where nomadic pastoralism is the main land use. In such systems, trees and shrubs supply a substantial part of livestock fodder needs (Diallo, 1985).

2.22 Agro-silvicultural systems

These systems combine trees with crop production. Usually, fertility on the agricultural land is maintained only by nutrients cycling through local trees (often leguminous). The land use systems under study in this project belong to this category.

2.23 Agro-silvo-pastoral systems

These systems combine crops, trees, and livestock in both space and time. Raintree (1983) states that neither biological nor economic methods are, in themselves, sufficient to the task of developing appropriate agroforestry cropping systems. He argues that the two approaches have to be combined in the form of an interdisciplinary bioeconomic approach in order to successfully generate the "genuinely adoptable technology."

2.3 Agroforestry Species

The tree species most commonly incorporated into agroforestry land use systems are from the wide range of leguminous trees or other nitrogen- fixing trees such as acacia species. Gregersen et al. (1989), note that when agroforestry tree components are well chosen, trees will increase agricultural productivity through the shelter effect; their leaf litter will raise the organic matter level in the fields; and their roots will tap nutrients from the deeper layers of the soil.

Okigbo (1980), also recommends the development of integrated land use systems involving both woody perennials and annual crops in order to solve the problem of low soil fertility in West Africa. It must be noted however, that some tree species compete directly with food crops, for example; when water availability is limited (Sanchez, 1987). A real challenge in agroforestry implementation is to determine the appropriate species?

So far, the ideal agroforestry species has not been identified. According to Lawrence (1982), such species should at least satisfy the following conditions:

1. They should be easy to establish;

2. they should be able to provide an evenly distributed shade within a short time after planting and throughout the year, especially during the dry season when shade is most needed;

3. they should compete as little as possible with the crops for soil nutrients and especially for moisture;

4. they should be easy to remove when no longer needed, and their removal should do as little damage as possible to the crop;

5. they should not be alternative hosts to insect pests and diseases of the crop; and

6. if possible, they should have a commercial value.

Huxley (1983), also develops some characteristics of trees that must be considered in agroforestry. In his study, these characteristics are noted in the form of a list of points to consider concerning germplasm, propagation, planting out, the juvenile phase of growth, mature growth and senescence and replanting. Following these works, O'Kting'Ati et al. (1984), conduct an inventory of plant species in the Kilimanjaro and identify their importance in the rural economy. Rachie (1983), also conducts research where preliminary observations from intercropping trials with leucaena leucocephala have shown some of the management needs for such systems. In the coming years more studies will be needed in order to identify all aspects of agroforestry species that will help to understand and enhance the value of agroforestry systems.

2.4 Agroforestry Potentials

A great deal has been written about the potential for agroforestry (Hall and Combs, 1981; Carlowitz, 1986; Monsoon Asia Agroforestry Joint Research Team, 1986; Gholz, 1987; and Nair, 1989). Essentially, the advantages fall into the following categories:

1. Increased variety and sustainability of food supplies;

2. sustainable supply of fuelwood;

3. increased availability of wood and a variety of other raw materials for construction and for farmer's subsistence;

4. improved productive potential of a given site and improved environmental conditions and carrying capacity;

5. sustainability through appropriate intensification of land use, and improved social and economic conditions in rural areas, by reducing risks and creating jobs and income; and

6. development of land use systems suitable for an optimal use of modern technologies and traditional local experience.

On the strength of this and amid high hopes, agroforestry projects have been started in many countries throughout the Sahel region with varying levels of success. However, despite the above-mentioned benefits of agroforestry, few attempts have been made to assess their financial value to farmers. Benefits have been more thoroughly discussed in ecological terms than in economic or financial terms.

Dykstra (1984) indicates that in many developing countries the primary use of woody plants is to provide fuelwood for cooking and poles for house construction. However, a study published by the Food and Agriculture Organization of the United Nations (FAO) (1989), shows a strong link between available perennial trees and local populations food security. Another joint study by FAO (Food and Agriculture Organization of the United Nations) and SIDA (Sweeden International Development Agency) (1990) shows that if agroforestry projects are to succeed in reducing rural poverty, rural women's needs must be taken into account in the design of agroforestry projects.

2.5 Economic Analysis versus Financial Analysis

Both economic and financial analyses provide an answer to the question whether or not a given project is attractive. Nevertheless, the two analyses differ totally in the perspective from which they approach the analysis (Gregerson and Contreras 1979).

Economic analysis examines an investment from a social perspective. In this case, the analysis is mainly designed to improve the resource allocation and overall welfare of citizens in the study area. Most economic analysis are done using the benefit-cost ratio.

The financial analysis, in contrast, examines the investment from the private investor's perspective; in the present case, farmers. Financial analysis is mainly concerned with assessing the commercial profitability of agroforestry investments. Many authors have discussed ways of identifying projects' financial attractiveness (Houghtaling and Gregerson, 1979; McGaughey, 1979; Gittinger, 1982; Gunt and Haney, 1984; Leuschner, 1984; Anderson, 1987; Gregory, 1987; and Duerr, 1988). Net present worth (NPW) and internal rate of return (IRR) are the most frequently proposed techniques.

In many countries, modern agroforestry projects have been designed mainly to help farmers increase crop production (Kerkhof 1990). However, in many areas, farmers continue to practice traditional agroforestry, and refuse to plant trees amid their crops. Hedge (1987) summarized farmers' attitude towards growing trees as follows:

1. Farmers do not generally consider growing trees unless alternative free supplies of fodder and fuelwood are exhausted;

2. Farmers like to grow trees to earn money rather than meet needs; and

3. Farmers like to grow products that can be sold easily.

In the past few years, there has been a growing demand for "hard facts" to demonstrate that agroforestry is indeed a financially viable form of land use. In Senegal as well as in the surrounding Sahelian countries, the real constraint on the large-scale acceptability of agroforestry revolves around this key issue. In the design of new agroforestry projects in the region and elsewhere, it will be increasingly important to consider the participating farmer's objective; which is to obtain a more attractive income from crop, livestock and labor activities within the land-use system than is possible from any alternative. Carlowitz (1986) indicates that agroforestry is not likely to be accepted, particularly by small farmers, unless it is proven superior to other forms of land use not only on ecological but also on financial grounds. So, in recent years, there have been attempts to develop approaches that address these issues.

2.51 Proposed approaches

Hoekstra (1983), first develops guidelines for the use of economic analysis in agroforestry. Flinn (1978), states that to assess agroforestry systems suitability as improved methods of crop production, the cropping patterns should be evaluated in terms of:

1. Their technical feasibility;

2. their profitability and dependability, when expressed in terms of the most limiting resources;

3. the compatibility of the innovation with the farmer's overall farming system;

4. social acceptability; and

5. whether the innovation is realistic, given the institutional and infrastructural realities in the target region.

Kronick (1984) demonstrates that agroforestry systems, when introduced into a region, are innovations that must be perceived as beneficial by the population before they will be adopted. He develops "temporal analysis" methods for assessing the likelihood of adoption of agroforestry systems. "Temporal analysis" is an approach which provides a common base for examining how both people's activities and agroforestry systems are structured in time. The author also observes that once these linkages are determined, changes induced by an agroforestry innovation in peoples' activity structure and their perception of these changes may then be easily anticipated.

Etherington and Matthews (1983), indicate that the profitability of agroforestry systems can be approached in a purely analytical fashion. The proposed method includes mathematical equations and diagrams explaining the principles of analysis.

The enthusiasm resulting from the exciting potential of agroforestry to increase products and improve services to farmers needs to be followed by solid evidence of financial profitability. However, there are major difficulties in assessing profitability in monetary terms.

2.52 Constraints.

The major difficulties in assessing an agroforestry system's profitability are the lack of basic data (Arnold, 1984), , and the following particular features that characterize these systems:

1) The tree component:

Trees in general present some features which make it difficult to incorporate in a financial analysis. Duerr (1960) identifies these features as:

1. The long-term production period of trees;

2. The fact that trees are both the production unit and the product;

3. The heterogeneity of the biological process; and

4. Trade-offs among output uses.

2) The production function:

Flinn (1978) identifies the following difficulties encountered when identifying the production function in an agroforesty system's financial analysis:

1. There are many products of value produced in the intercrop that may be harvested over an extended time period;

2. Some of the costs and benefits such as soil depletion and conservation aspects of alternative management strategies cannot be easily included in the analysis;

3. Experiments designed to provide the necessary data are complex, extremely expensive and time consuming to conduct; and

4. The farmers are operating in an uncertain environment. Their preferred use of inputs will usually be less than identified as desirable in a riskless situation.

3) The unit of measure:

The identification of the appropriate unit of measure for assessing the productivity and profitability of agroforestry systems has also been a major constraint. Hildebrand (1976), observes that the required unit must satisfy the following criteria:

1. it must be common to all products and inputs and provide a means of comparing different agroforestry systems;

2. it must be relatively easy to measure;

3. it must be capable of reflecting quality differences between the products; and

4. the unit of measurement must be meaningful to the farmer in such a way that it helps him allocate his resources between competing uses.

According to Flinn (1978), the only index that meets all criteria is the economic indicator of price or value, as reflected in the market price of inputs and outputs.

4) The discount rate:

Due to the multi-period nature of agroforestry land use systems, the valuation of costs and benefits over time has to be considered. However, the farmer's personal rate of discount is rather difficult to determine, since it can vary depending on the individual farmer's level of risk aversion and the relative scarcity of resources.

According to Flinn (1978), it is likely that:

1. poor farmers will have higher discount rate than rich farmers;

2. farmers with profitable investment alternatives, or stringent necessity, have higher discount rates than others; and

3. farmers who live in a natural environment that imposes high risk on them will have higher discount rates than others.

Hoekstra (1983), reports that most economists facing the discount rate dilemma either use several discount rates from which the future user of their analysis can select, or the internal rate of return. The major factor which will perhaps result in a low discount rate for agroforestry may be the general awareness of the need for tree planting in the Sahel region created by international and national bodies.

Despite these constraints, some researchers have made efforts to conduct financial analyses of agroforestry systems. Mathur et al. (1984) conduct a case study in India, and demonstrate that Eucalyptus hybrid raised at some suitable spacing and harvested at appropriate rotation can be a financially viable proposition to Indian farmers with large holdings.

Arnold (1983) discusses the financial benefits that can accrue to farmers from incorporating trees into the farm system, and the economic constraints and costs they may face in doing so. Gupta

and Mohan (1982) estimate returns from annual crops and livestock in comparison with the expected cost and returns of establishing a tree crop in Rajasthan (India). Depending on the species and rotation length, net annual returns from growing trees were considerably better than the expected returns from annual crops.

Garrett and Kurtz (1983) find the economic relationship of integrated forestry-farming using black walnut. This multicropping system is found to be an economically viable land use alternative.

Blandon (1985) analyzes the risk of hypothetical agroforestry systems using portfolio theory. He shows that the relationship of the returns of agroforestry system components, expressed in terms of the covariance or correlation of returns, is critical in correctly defining risk.

McCormick and Laarman (1988), compute the financial net present value (NPV) for six plantation species in Ecuador. In the study, they measure the elasticity of net present values with respect to some index of site quality and location. The results indicate a large variability in the elasticities from one case to another. Once analyses are implemented, it is useful to have criteria to select among competing alternatives.

2.53 Choice criteria.

Besides present net worth and the internal rate of return, there are several other choice criteria used to evaluate the potential of agroforestry systems. Several alternatives have been widely discussed in the literature. Banta (1978), argues that for a cropping pattern to have a clear advantage over existing systems, it should:

1. have a (discounted) net benefit at least 30 percent higher than the present pattern;

2. the return per unit of labor must exceed its opportunity cost; and

3. the (discounted) net benefit of the pattern should be sufficient to pay the cash costs of another cycle of that pattern.

Perin et al. (1976) use what they call the Marginal Rate of Return on Capital (MRRC); where:

$$MRRC = \{(NBNT - NBET)/(VCNT - VCET)\} * 100, \quad (1)$$

and where:

NBNT = Net Benefits of New Technology;

NBET = Net Benefits of Existing Technology;

VCNT = Variable Costs of New Technology; and

VCET = Variable Costs of Existing Technology.

The authors further argue that before a new technology can be judged superior to existing ones it should have a marginal rate of return on capital, in relation to the current practice, of at least 40 percent.

With the increasing interest in the financial profitability of agroforestry systems, one can expect financial analysis to have a positive contribution to the widespread acceptability of the enterprise by modern farmers in the coming decades. By helping determine the benefits that farmers receive from both present and new practices, and by means of comparison, financial analysis can be a useful tool in assessing the likely acceptability of new agroforestry patterns.

Chapter III

METHODS AND PROCEDURES

3.1 Field trips

Trips were made throughout the Groundnut Basin during the months of June and July, 1991. The purpose of these trips was to view first-hand the implementation of each of the three systems to be analyzed, and to discuss the management regimes with field agents.

3.2 Data

In most cases, data were obtained from research reports, primarily farming system studies implemented by the Senegalese Reforestation Project (PRS) under a Matching Grant Component. Data collection was primarily concerned with the following parameters: land, labor, time frame, prices, and discount rates.

3.21 Land.

In Senegal, other factors are often more limiting to farmers than land. Under the National Land Policy, *loi sur le Domaine National*, land can be made available to farmers free of charge, provided only that they will use it for their own benefit and for the benefit of the community. Individuals can also rent land from traditional land holders. Even in this case, however, the rental fee is only symbolic; usually it is the first fruit or seed harvested, and normally not significant. For the above reasons, land costs are not included in the financial analysis, as they often would be in an economic analysis.

3.22 Labor.

In the Groundnut Basin farming system, almost all farmland tasks are handled by family members; hired labor is seldom used. Conventionally, use of family labor does not constitute an out-of-pocket cost, given the lack of job opportunities for unskilled labor in the region. The analysis assumes however, that family members are not indifferent between working and not working.

Therefore, there is a leisure-time opportunity cost of working. This approach is consistent with the procedure used in many empirical applications of peasant household models (Singh et al. 1986). To establish a wage rate for family labor, labor is treated as though it were all hired.

For the labor cost of seedling production, the government rate of 1,500Fcfa per man-day is used. For other labor costs, however, the wage rate of 500Fcfa per man-day is used. This is an informal rate establish by farmers among themselves. It is also the labor rate used by Martin (1988) in his studies of Senegalese farming systems. A man-day is equivalent to a six-hour work day.

3.23 Time Frame.

Due to slow growth rates and severe climatic conditions that prevail in the region, a twenty-year time frame was used as the period it takes to cover one complete cycle of planting, harvesting and removal of trees.

3.24 Prices.

Both inputs and outputs are valued on a real price basis; that is, no allowance is made for price inflation. Inflation has been very low in Senegal in recent years, about two percent (U. S. Department of Commerce, 1991), and has not significantly affected the nominal price of items included in this analysis. As Vardaman, (1989:261), points out:

> ...using nominal rates produces unsatisfactory answers because it is hard to determine what the *current* inflation rate is. The best economists disagree to some extent, and even when they agree, the rate is changing all the time. But our biggest problem is that we need to know the *future* rate, not the current one, and no one can predict a second of the future. Many investors solve the problem as Wolfe did: By choosing the essential real rate and then figuring that timberland, by its nature, will protect them against inflation.

The low inflation rate observed in Senegal during the last few years may be explained by good harvests, stable domestic prices for key imports, and strict credit control (Landell-Mills and Ngo, 1991). Another reason may be that the Senegalese Franc is pegged to the French Franc. Thus, economic fluctuations are reflected largely in employment changes.

All unit costs for tree seedlings are estimated based on a 10,000 seedling nursery capacity. The reason is, no data about the per unit cost of seedlings produced in farmers' small capacity nursery were available.

All prices are in Francs cfa (*Communaute Financiere de l'Afrique*). At the time of data collection the average exchange rate was 300 Fcfa to 1 U.S. Dollar.

3.25 Discount Rates

Three discount rates were used in the analysis: 10, 15, and 25 percent. These are the rates used in agricultural analysis in Senegal by the World Bank and other donor institutions (Economist Intelligence Unit, 1986 and are based upon rather detailed studies by these institutions of Senegalese borrowing and lending practices.

3.3 Computation

For each system, direct inputs and outputs that is those which are traded in a market, for both forestry and agricultural components were identified. Values for these items are estimated using market prices. A year-by-year cash flow is developed over the analysis period. The financial

attractiveness of each system is measured using two criteria: present net worth (PNW) and internal rate of return (IRR).

Present net worth (PNW), also called present value, translates all investment cash flows back to the present (Davis and Johnson, 1987). Therefore, PNW provides a way of thinking not only about the magnitude of benefits and costs, but also about timing (Tietenberg, 1988). The interest rate gives a measure of the importance of the time element. The interest rate also measure the opportunity cost of money; that is, the benefit forgone by investing an amount of money in future returns as opposed to using it in the best alternative investment (Davis and Johnson, 1987). Present net worth is therefore dependent on and sensitive to the interest rate used. As shown in figure 2, all we are trying to do is to determine the value today of future costs and benefits from tree-planting.

PNWs were computed using the following formula; that is, costs and benefits generated under each system over time were discounted and summed up to obtain an overall figure. This formula is:

$$PNW = \frac{B_0 - C_0}{(1 + r)^0} + \frac{B_1 - C_1}{(1 + r)^1} + \ldots \frac{B_n - C_n}{(1 + r)^n} \quad (2)$$

or

$$PNW = \sum_{t=0}^{n} \frac{1}{(1 + r)^t} (B_t - C_t) \quad (3)$$

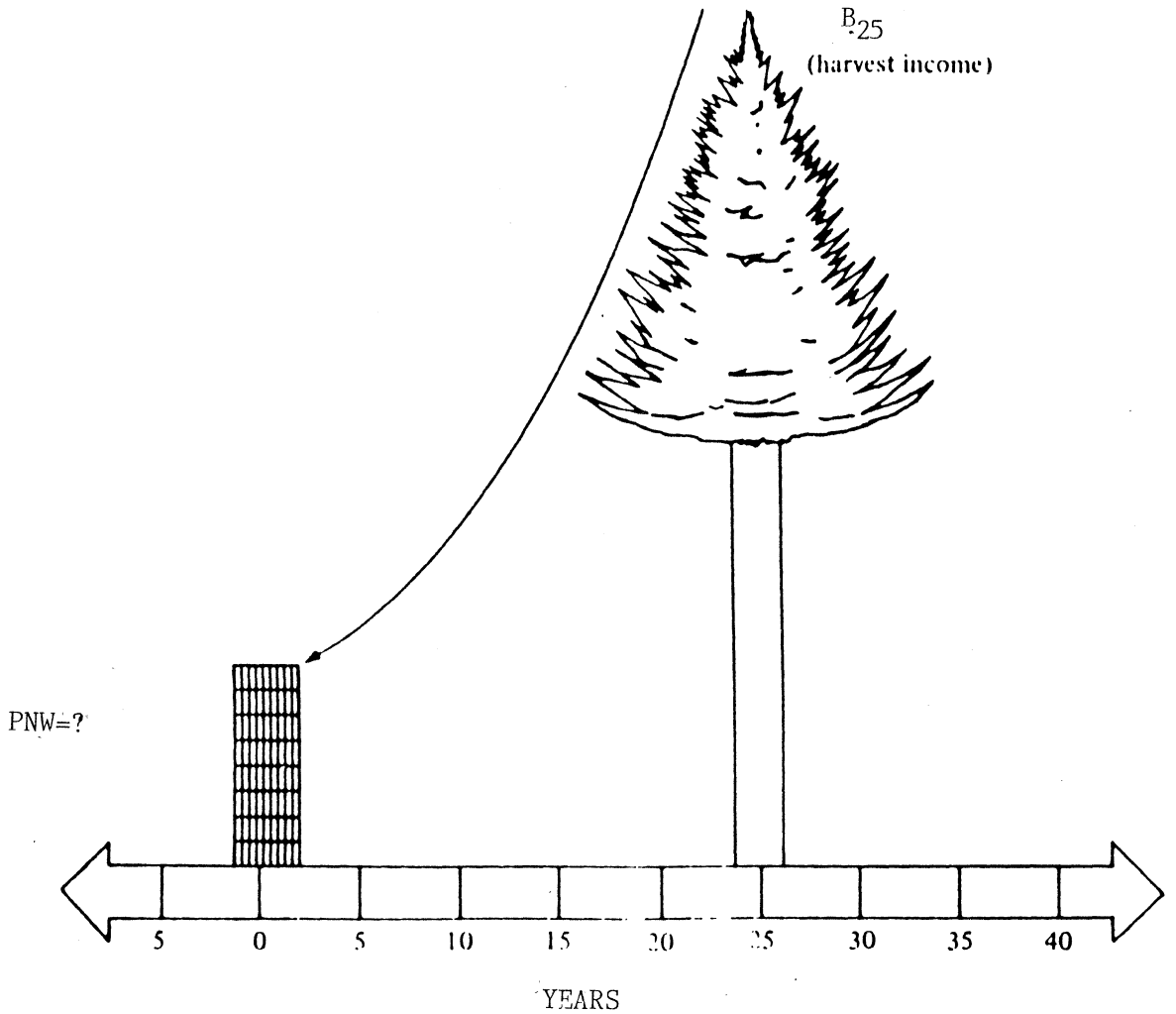
where

B_t = benefits from the system at year t

C_t = costs at time t

r = discount rate

n = time period



Source: Adapted from Davis and Johnson, 1987

Figure 3. Present net worth of tree planting.

Contrary to the present net worth criterion, the internal rate of return calculation does not require a guiding interest rate. Internal rate of return (IRR) is a relative measure of project worth, which gives the interest an activity actually earns on money invested (Gittinger, 1982). It is defined as the compound rate of interest that equates the present value of expected future returns with the present value of expected future costs (Gunter and Haney; 1984). It is therefore, the internal rate at which PNW is zero.

IRR is used, in contrast to PNW, for ranking projects in a situation where a limited budget is to be allocated among non-mutually exclusive alternatives (McGaughey, 1979). This is likely the case in the central and western parts of the Groundnut Basin, where all three systems are technically feasible.

The IRR was computed using the following formula:

$$\frac{B_0 - C_0}{(1 + x)^0} + \frac{B_1 - C_1}{(1 + x)^1} + \ldots \frac{B_n - C_n}{(1 + x)^n} = 0 \quad (4)$$

or

$$\sum_{t=0}^{n} \frac{1}{(1 + x)^t} (B_t - C_t) = 0 \quad (5)$$

where

B_t = benefits at year t

C_t = costs at time t

n = number of years

x = internal rate of return (unknown) which satisfies the equation

Results from the three cases were compared to the base case of growing groundnuts without an agroforestry practice in order to determine the net gain from adding tree crops to the typical agricultural operation.

Chapter IV

THE FINANCIAL ANALYSIS

The analysis makes two basic assumptions: First, a farmer's financial expectations, conditioned by his alternatives, dictates his willingness to adopt a particular agroforestry scheme, and second, he needs a means of comparing alternatives which he can use to make his best investment decision. After data were obtained, a commercial micro computer spreadsheet program was used to compute present net worth and internal rate of return.

4.1 Groundnut Cropping Without Agroforestry

Groundnut farming is the main cash crop in the study area and groundnut processing one of the leading industries. Groundnuts were introduced in Senegal as cash crop by French more than 120 years ago. The sharp fluctuations in groundnut production that have been experienced during the last 25 years, mainly attributed to drought and declining soil fertility, have caused severe problems

for farmers in the region. As mentioned earlier, the financial stresses resulting from these fluctuations is a primary reason for the interest in adding agroforestry species to existing systems. The hope is that the agroforestry system will both stabilize groundnut production and provide additional income to farmers.

Prior to 1985, most groundnut production was sold at a price set by the government; however, in 1985, the government decided to permit groundnut marketing by private traders, and substantially speeded up its disengagement from the agricultural sector. At the same time the farmers' credit program for seed and fertilizer was ended.

The shift in government policy has led farmer and rural development agencies to search for new ways to assure a more sustainable agriculture in the Groundnut Basin. This has led to the development of integrated land use systems in the region.

Groundnut cropping without agroforestry and under normal rainfall represents the base case; that is, the schedule of costs and returns with no agroforestry activity. Changes in costs and returns with the agroforestry adoption, compared with costs and returns without agroforestry, represent the net contribution of the agroforestry activity. Table 2 contains the base case's parameters. One hectare of groundnut cropping requires 90 kilograms of seed and 150 kg of fertilizer. Seed and fertilizer cost 110 and 77 Fcfa per kilogram respectively. Initial Groundnut yield is estimated at 1,200 kilogram per hectare and the farm gate price for groundnut is 80 Fcfa per kilogram.

Table 2. Parameters of the groundnut cropping without agroforestry

Item	Quantities (kg/ha)	Unit price (Fcfa/kg)
Seed	90	110
Fertilizer	150	77
Yield	1200	80

Source: Direction of Agriculture - Dakar (Senegal)

4.11 The cost stream

Under the circumstances described earlier, and using the parameters in table 2, estimated costs for farming one hectare (ha) of groundnuts with agroforestry intervention, are as follows:

4.11.1 Labor

Total labor requirement is divided among activities as follows (see table 3):

Land clearing. This consists of the clearance of unwanted vegetation from the site. All trash on the site has to be either burnt or carried away. This activity occurs in mid-June, and requires three man-days per hectare.

Sowing and harrowing. These activities are begun immediately after the first rain, usually beginning in July for the Groundnut Basin. Labor requirement is estimated at five man-days per hectare.

Table 3. Labor requirements for one hectare of groundnut (in man-days)

Operations	June	July	August	October
Land clearing	3	...	...	...
Sowing and harrowing	...	5	...	...
Fertilizing	...	2	...	...
1st weeding	...	7	...	...
2nd weeding	...	...	7	...
Harvesting				
-reaping	...	...	...	14
-gathering	...	...	...	7
-packing	...	...	...	6
-transporting	...	...	...	...
Total	3	14	7	27

...zero or negligible

Source: Unpublished data supplied by Abdou Niang, agronomist at the Direction of Agriculture, Dakar, Senegal.

Fertilizing. Fertilizers are applied as soon after germination (end of July). The application of fertiliers requires two man-days per hectare.

Weeding. The groundnut crop requires two weedings. The first weeding occurs in July, the second in August. The labor requirement for each weeding activity is estimated at seven man-days per hectare.

Harvesting. The groundnut crop cycle lasts about three months. Harvest activities begin at the end of September or beginning of October, and require a total of 27 man-days, distributed as follows: 14 man days for reaping, 7 for gathering and 6 for packing. Transportation costs are assumed to be negligible, since crop fields are usually located in close proximity to compounds if not part of them.

4.11.2 Materials

Beside labor, other expenses of groundnut farming include seeds, fertilizer and chemicals. These will be discussed in turn.

Seeds. To ensure variety purity and high quality seeds, the Senegalese Agricultural Service distributes seeds to farmers. The seed requirement is estimated at 90 kilograms per hectare at a price of 110 Fcfa per kilogram of seed.

Fertilizers. Since 1982, the government has ceased to distribute fertilizer free of charge. Farmers are now required to pay a subsidized price of 77 Fcfa per kilogram. It is estimated that 150 kilograms of fertilizer will be needed per hectare.

Chemicals. Chemical requirements include insecticides, fungicides and other substances needed to keep down weeds during the growing season. In contrast to fertilizer, chemicals are provided free of charge by the Direction la Protection des Vegetaux (DPV) whose agents also have the task to treat farm fields.

For small farmers no expense is accounted for tools. This is mainly because, tools used on groundnut fields are often home-made. Therefore, they become what Hymer and Resnick (1969) refer to as *Z-goods* in their model of an agrarian economy. Unfortunately, there are no data available for the monetary evaluation of these goods.

Table 4. **Total cost per hectare of groundnut production**

Item	Rate and quantity	amount (Fcfa)
(a) Labor operations		
Land clearing	500 Fcfa/MD[1] x 3 MD	1,500
sowing and harrowing	500 Fcfa/MD x 5 MD	2,500
fertilizing	500 Fcfa/MD x 2 MD	1,000
1st weeding	500 Fcfa/MD x 7 MD	3,500
2nd weeding	500 Fcfa/MD x 7 MD	3,500
reaping	500 Fcfa/MD x 14 MD	7,000
gathering	500 Fcfa/MD x 7 MD	3,500
packing	500 Fcfa/MD x 6 MD	3,000
transportation	...	500
(b) Materials		
seed	110 Fcfa/kg x 90 kg	9,900
fertilizer	77 Fcfa/kg x 150 kg	11,550
chemicals	...	...
tools	...	...
Subtotal		66,450
(c) Other charges		
contingencies[2]		3,322
Total		69,772

[1] MD = man-days
[2] Estimated as five percent of the sum of a plus b.
... zero or negligeable

Source: Direction of Agriculture- Dakar, Senegal.

Table 4 shows how the total cost per hectare of groundnut is obtained. The cost of labor operations and materials is evaluated. The total cost is estimated at 69,772 Fcfa.

4.12 Benefit Stream.

Revenues from the groundnut cropping base case come from groundnut sales and groundnut hay. In Senegal, there is an active market for groundnut hay as animal feed. However, reliable data on hay yields and prices were not available. Taking into account revenues from groundnut sales only, table 5 gives the gross year financial result of the operation: average groundnut yield in the Groundnut Basin is estimated at 1.2 tons per hectare (Busacker et al., 1990) and the farm gate price for the crop is 80 Fcfa per kilogram. This gives a first value of 96,000 Fcfa per hectare. Subtracting the total cost of 69,772 from Table 4 net first revenue is 26,228 Fcfa.

The total revenue of 96,000 Fcfa represents the maximum revenue in the first year of operation, when the land has just been brought into production after fallow and is at its maximum productive capacity. This value will be reduced each year to reflect the consequences of progressive soil degradation that would occur if the farmer does not adopt agroforestry or fallow practices to preserve the soil. Soil fertility will decline over the period of analysis since the organic material in the soil will disappear.

The decline in soil productivity results in a gradually declining farm income unless an agroforestry practice is adopted in order to increase soil productivity potential and reduce soil erosion by wind and rain. The erosion phenomenon that takes place in the "without agroforestry" base case may be the major cause of peanut yield declines observed in recent years in the Groundnut Basin, and wrongly attributed to the decline of rainfall only.

The analysis assumes that, without agroforestry, crop value declines by four percent each year up to year 10. This is the rate used by the Senegalese Reforestation Project in its recent attempt to assess the financial viability of the tree-planting activities the project is promoting (_____, 1991). Based on this assumption, the net revenue at any particular year between year 0 and year 10 can be obtained by using the following formula:

Table 5. First year net revenue from groundnut cropping without agroforestry

Item	Amount (Fcfa)
Total cost	69,772
Total revenue (80Fcfa x 1,200 kg)	96,000
Net revenue	26,228

$$NR_n = NR_o(1 - k)^n$$

where

NR_n = net return in year n,

NR_o = net return in year 0,

k = soil degradation rate, and

n = number of years -only up to year 10.

Results of the groundnut yearly revenue computed in this way are presented in Table 6. In year 10, crop value stabilizes at 63,824 Fcfa. This is due to the use of fertilizers. Also, cop fields in the Groundnut Basin are usually located in close proximity of compounds; therefore, they receive a certain level of organic matter from domestic animal dung and household wastes which can enhance soil "fertility". However, it must be pointed out that the use of animal dung on crop fields to maintain fertility also entails the assumption that farmers have access to an adequate supply of fuelwood, so that the animal dung will not be used as a fuel substitute. The IRR for the groundnut activity is found at 4.7 percent.

Table 6: Yearly net revenue from 1HA of groundnut without agroforestry intervention

Year>	0	1	2	3	4	5	6	7	8	9	10
Cost (Fcfa)	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772
Revenue (Fcfa)	0	96,000	88,474	84,935	81,537	78,276	75,145	72,139	69,253	66,483	63,824
Cash flow (Fcfa)	-69,772	26,228	18,702	15,163	11,765	8,504	6,373	2,3673	-519	-3,289	-5,948
PNW(10%) (Fcfa)	-69,772	23,844	15,456	11,392	8,036	5,280	3,033	1,215	-242	-1,395	-2,293
PNW(15%) (Fcfa)	-69,772	22,807	14,141	9,970	6,727	4,228	2,323	890	-170	-935	-1,470
PNW(20%) (Fcfa)	-69,772	21,857	12,987	8,776	5,674	3,417	1,799	661	-121	-637	-961

(Table 6 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Cost (Fcfa)	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	69,772	
Revenue (Fcfa)	63,824	63,824	63,824	63,824	63,824	63,824	63,824	63,824	63,824	63,824	
Cash flow (Fcfa)	-5,948	-5,948	-5,948	-5,948	-5,948	-5,948	-5,948	-5,948	-5,948	-5,948	
PNW(10%) (Fcfa)	-2,085	-1,895	-1,723	-1,566	-1,424	-1,294	-1,177	-1,070	-9,73	-9,487	-9,167
PNW(15%) (Fcfa)	-1,278	-1,112	-967	-841	-731	-636	-553	-481	-418	3,900	-14,377
PNW(20%) (Fcfa)	-801	-667	-556	-463	-386	-322	-268	-223	-186	-1,665	-18,528

IRR = 4.7 %

4.2 Acacia albida and millet

Acacia albida, better known as "Kad" by Senegalese farmers, is present throughout Senegal and is especially concentrated just inland from Dakar, where it often associates with post-cultivation vegetation (Giffard 1964). Densities of 10 to 50 trees per hectare have been recorded on these lands (Zung 1966). Kad trees occur in a wide range of habitats; ranging from the fringe vegetation on alluvial soils of perennial or seasonal water courses to open savannah woodland and cultivated lands, where the species may occur singly or gregariously and may either dominate the community or be an occasional constituent (Wickens 1969).

Kad species have been recorded in the Cape Verde Islands, but it is not known whether it is native or introduced (Wickens 1969). Many Sahelian foresters associate the presence of this tree with the activity of man. It is believed that Kad was spread into other parts of Africa by farmers or, perhaps more precisely, by domesticated livestock since propagation by animals is an important factor in species dispersal. The seeds, well protected by a hard coat, are believed to germinate much quicker after their passage through animal rumen.

4.21 Agroforestry Values

There is no doubt that Kad has extraordinary value as an agroforestry species. It allows the integration of pastoral and agricultural activities in an area of minimal and highly irregular rainfall (Cook and Grut, 1989). As a leguminous nitrogen-fixing tree, it has a deep taproot system that enables it to tap lower sources of water and nutrients inaccessible to agricultural plants. It is leafless during the agricultural season and therefore does not compete with agricultural crops for light.

Table 7. **Acacia albida multiple use table**

Use	Importance
Fuelwood	Minor use
Utility wood	Minor use
Fodder	Main use
Medecine	Minor use
Raw materials	Minor use
Protection and soil improvement	Main use
Village/urban plantation	Minor use
Cultural values	Main use

Source: Adapted from "Agroforestry in the West African Sahel," Advisory Committee on the Sahel (1984).

Table 7 gives the multiple uses of the species. The Kad tree produces large quantities of valuable forage in the form of leaves and pods, and provides ample shade for humans and livestock during the hot dry season. This phenomenon is known as "reverse foliation" (Advisory Committee on the Sahel 1984). Kad wood is used in local construction and as fuelwood, and the thorny branches are used as fence material. Many parts of the tree provide medicine for people and livestock.

Felker (1978:85) summarized major studies describing the effects of Acacia albida on the soil's chemical, physical, and microbiological characteristics. He also reported the species effects on crop yields-- the most important aspect in the context of this study--as follows:

> all four cases there was a valid average yield increase reported, but in cases where a large number of trees were included there were a few Acacia albida trees under which crop yields decreased ... The peanut yield depressions ... are most readily explained if one considers that excessive soil fertility can cause excessive vegetation growth at the expense of reproductive growth (grains or pods) ....

Wickens (1969:199) also reported:

> ... all found considerable increase in soil fertility, attributable to favorable conditions for leaf litter decomposition, since leaf fall coincided with the start of the rains ... Crop yields were increased two and half times, and protein content of the grain was three and a half times greater than in corresponding yields away from the tree ....

The major conclusion to draw from these statements is that density (number of trees per hectare) and adequate planting distance are essential for the economic productivity of any land use system involving Kad trees.

Guilloteau (1954), during his investigation in Senegal, concluded that with a stand of 15 trees per hectare, one year's fertilization by grazing animals every 80 years was sufficient to maintain soil fertility, permitting the land to be continuously cultivated without recourse to fallows.

The analysis uses the Kad and millet association, since the effect of the species is better documented for millet and sorghum (Martin 1988; Rodale 1989) than for groundnuts and other Senegalese agricultural crops. Yields and labor requirements for different activities are adapted from the management strategy developed by Seyler (1990). In that study, there were one hundred kad trees per hectare that were managed primarily for the production of fuelwood and fodder.

Table 8 gives the parameters used in the analysis. There are 10 meters between trees and a total of 125 kad trees per hectare. In average each tree is expected to produce 10 kilograms of forage and 10 kilograms of pods per year starting at year 10. Forage and pod prices are 25 and 50 Fcfa per kilogram respectively. Kad trees also produce poles and fuelwood. Poles and fuelwood prices are 200 Fcfa per pole and 2,500 Fcfa per cubic meter respectively.

Table 8. **Parameters of the kad and millet system**

Items	Quantity	Unit price
Spacing	10 x 10 mts.	
Number of trees	125/ha	
Forage	10 kg/tree/year	25 Fcfa/kg
Pods	10 kg/tree/year	50 Fcfa/kg
Poles[1]	100 poles/ha	200 Fcfa/pole
Fuelwood	0.2-0.5 cu. mt./ha	2500 Fcfa/cu. mt.

[1] Pole harvest starts in year 17.

Source: Adapted from "An Investigation of Internal and External Biophysical and Socio-economic Factors Relating to the Decline, Maintenance and/or Replication of the *Acacia albida* system in Senegal's North Central Peanut Basin" (Seyler, J. R. 1990).

4.22 The cost stream

The major cost items are: Establishment costs, maintenance costs, and harvesting costs. Each of these cost items will be discussed in turn.

4.22.1 Establishment costs

Kad plantations are usually established on crop fields. This is why there are no land clearing costs. Therefore, establishment costs only include the following items: seedling production, planting and fencing costs, and the cost of tools.

Seedling production Seedlings are produced in year zero, and the cost items involved are:

Seeds. Farmers can harvest fresh seeds from pods in April, using the traditional methods of mechanical scarification or boiling water to break dormancy; however, in order to guarantee higher germination rates, farmers are usually advised to buy seeds from the Forest Research Service. A kilogram of seeds costs 30,000Fcfa, and contains about 8,600 seeds.

Polyethylene bags. Once seeds are treated, they are sown in polyethylene bags 30 cm deep in mid-May, before being transplanted to the field in August. Polyethylene bags cost 7Fcfa each.

Nursery tools. Various kinds of tools are used in the nursery. The most important of these are: West African hoes, shovels, rakes, handforks, trowels, wheel barrows, watering cans, and spraying pumps. These tools are assumed to last two years and their total cost is estimated at 24,000Fcfa. However, the analysis does not include the full purchase price since tools last longer than the production period of seedlings. Instead, the value of that portion of tools used for one year in the nursery enterprise is estimated and reflected as a cost.

Table 9. Labor requirements for producing 10,000 kad seedlings

Activities	Number of hours
Nursery establishment	8.0
Seed pretreatment	1.5
Soil mixing	50
Filling polyethylene bags	200
Sowing	30
Watering	110
Weeding	72
Moving bags and cutting roots	135
Total	606.5

Source: Adapted from "Note Technique 88-1" (PARCE - Kaffrine).

Labor. The production of Kad seedlings is labor intensive, like the culture of most tree and agricultural crops in West Africa. Although there have been discussions about whether a number of operations could be economically mechanized, many of the operations have not been mechanized. For the production of 10,000 Kad seedlings, the labor requirements for different activities are as follows (see table 9):

Nursery establishment. This includes site clearing of all vegetation except that needed for shade, burning or carrying away all trash from the site and establishing fences around the designated area. It is estimated that a total of 8 man-hours will be needed for this operation.

Seed pretreatment. This operation is designed to induce early germination in dormant seeds before sowing them in polyethylene bags. The labor requirement is estimated at one-and-one-half man-hours.

Soil mixing. This operation is needed to prepare a fertile substrate. It consists of sieving sand from the nursery topsoil and raising its fertility by mixing it with farmyard manure or compost. Total labor requirement for this operation is estimated at 50 hours.

Filling polyethylene bags. Once the substrate from the soil mixing operation is ready, the polyethylene bags need to be filled. For a 10,000 seedlings capacity nursery, it is estimated that 200 man- hours will be needed for this operation.

Sowing. Once polyethylene bags are filled with substrate, they are watered in order to get the soil up to the desired moisture level for germination, and then sown with Kad seeds. It is estimated that this operation requires 30 man-hours.

Watering. Considering the high temperatures that prevail in Senegal during the dry season, success in the production of healthy seedlings depends to a great extent on supplying adequate water to the seedlings during the first weeks after planting in nursery. Water is usually extracted from wells and transported using watering cans. Total labor requirement is estimated at 110 hours.

Weeding. This is the removal of unwanted grass that grows along with seedlings during the germination period. Weeding frequency depends on the type of soil used as substrate. It is estimated that an average of 72 hours will be needed for the operation.

Moving polyethylene bags. One characteristic feature of Kad seedlings is that after germination, the primary root always elongates rapidly to reach a suitable moisture zone. Often, it penetrates the polyethylene bag and reaches the top soil. When this happens, the seedlings need to be removed and the primary root cut, in order to avoid its penetration in the soil outside the polyethylene bags. It is estimated that this operation requires 135 man-hours.

Chemicals. Chemicals include growth substances for inducing early germination in dormant seeds, and insecticides and fungicides for the prevention of disease and pests. The total cost of chemicals is estimated at 118,500Fcfa for the production of 10,000 seedlings.

Table 10 summarizes costs for seedling production. The total cost is estimated at 412,800 Fcfa, which corresponds to a unit cost of 41 Fcfa. This per unit cost is closed to the sale price of seedlings that most projects in the region charge to farmers. It is also the per unit cost of seedling that will be used in the analysis.

Table 10. Per hectare total establishment cost of Kad trees in the Kad and millet system.

Item	Rate and quantity	Amount (Fcfa/ha)
plantation	500 Fcfa/day x 8 days	4,000
Seedlings	40Fcfa/seedl. x 125 seedl.[1]	5,000
Fencing	25 Fcfa/mt.for 400 mts.	10,000
Fence improvement	...	...
Tools	6,760 Fcfa for 2 years	6,760
Contingencies[2]		1,288
Total establishment cost		27,048

...Zero or negligeable.
[1]Due to the low survival rate of kad seedlings (20%), it is assumed that 125 trees/ha would need to be planted in year 0 in order to obtain a mature density of 50 trees/ha by year 10. Seedling cost is from table 4.
[2]5% of total establishment cost.

Planting. It is estimated that eight man-days are needed for tree planting. This labor is paid 500 Fcfa/man-day.

Fencing. Local fences cost 25Fcfa per meter. For one hectare, a total of 400 meters of this fence will be needed.

Tools Tools are estimated to cost 3380Fcfa per year. Table 11 brings all the establishment cost items together. Adding 5 percent miscellaneous, per hectare establishment cost amounts to 27,048 Fcfa.

Table 11. Total cost of producing 10,000 kad seedlings

Items	Rate and quantity	Estimated cost (Fcfa)
Seeds	30,000 Fcfa/kg x 1.16 kg[1]	34,800
Polyethylene bags	7 Fcfa x 12,000[2]	84,000
Nursery tools	24,000 for 2 years	24,000
Labor	1.500 Fcfa x 101[3]	151,500
Chemicals		118,500
	Total cost	412,800
	Unit cost	41[4]

[1]It is estimated that there are 8,600 seeds in 1 kg of *Acacia albida* seeds; thus, 8,600 seeds/kg x 1.16 kg = 10,000 seeds.
[2]20% of polyethylene bags are lost by damage during filling and moving.
[3]From table 3: 606.5 hours/6 = 101 man-days
[4]The project PARCE charges 40 Fcfa to farmers for nursery grown *Acacia albida* seedlings. It is a subsidized price since it does notinclude administrative costs, tractor hours for sand transportation, fuel for the water pump, etc. Parce personnel estimate of the actual production cost of one *Acacia albida* seedling is closer to 300 Fcfa (Rodale 1989)

Source: Adapted from *"Estimation des couts de la campagne 88." Leccia F. and Ba L. PARCE, Kaffrine, Oct. 1988.*

4.22.2 Maitenance costs

Maintenance costs mainly include the cost of staking and pruning. The normal practice in the Groundnut Basin is to stake or support young plants with "tutors" (stakes or poles) in order to enhance growth rates. Pruning is usually carried out with the staking activity and involves removal of lower branches to improve tree form and enhance height growth. The cost of the activities is estimated to require about two man-days/ha, and needs to be done for five years, beginning in year 2.

4.22.3 Harvesting costs

Harvest pruning cost (for harvesting forage, firewood and poles) begins in year 10, and is estimated to require three man-days/ha in years 10, 11, and 12; five man-days/ha in years 13 through 15; and 7 man-days/ha in years 16 through 20. In year 20 however, more labor will be needed for pole harvest. It is estimated that an additional 6 man- days will be required for harvesting the total of 100 poles in year 20. This gives a total of 13 man-days.

Table 12 gives a summary of the cost stream. The three major cost items are shown and their value estimated. The undiscounted total value of the cost stream is equal to 69,548 Fcfa.

Table 12: The cost stream of an hectare of the kad and millet system

Year>	0	1	2	3	4	5	6	7	8	9	10
Establishment cost (Fcfa)	27,048	0	0	0	0	0	0	0	0	0	0
Staking & pruning (Fcfa)	0	0	2,000	2,000	2,000	2,000	2,000	0	0	0	0
Harvest pruning (Fcfa)	0	0	0	0	0	0	0	0	0	0	1,500
Total (Fcfa)	27,048	0	2,000	2,000	2,000	2,000	2,000	0	0	0	1,500

(Table 12 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Establishment cost (Fcfa)	0	0	0	0	0	0	0	0	0	0	27,048
Staking & pruning (Fcfa)	0	0	0	0	0	0	0	0	0	0	10,000
Harvest pruning (Fcfa)	1,500	1,500	2,500	2,500	2,500	3,500	3,500	3,500	3,500	3,500	32,500
Total (Fcfa)	1,500	1,500	2,500	2,500	2,500	3,500	3,500	3,500	3,500	3,500	69,548

4.23 The benefits stream

In the Kad and millet case, it is assumed that in year 10, the farmer will have 50 Kad trees per ha. These trees will be managed in such a way as to profit from all products provided by the species without jeopardizing crop yields. Specific benefits include:

4.23.1 Increased crop yield

This increase in crop yield has two components (see table 13):

1. The value of the yield decreases avoided; and

2. the value of net crop increase the farmer receives due to the better soil conditions and fertility levels directly caused by the presence of Kad.

The effects of Kad trees on millet yields has been well documented. Felker (1978) published a summary of studies in which these effects were examined. In the present analysis, millet yields will gradually increase due to the phenomenon described earlier. However, this does not take place the instant that Kad is planted. Rather, the crop yield improvement is distributed over a period of time. These gradual increases are shown on the incremental crop line on Table 13.

4.23.2 Increased service wood supply

It is estimated that a total of 100 poles can be removed by the end of year 20. The price for such poles in the Groundnut Basin is 200 Fcfa.

Table 13: The incremental crop yield stream

Year>	0	1	2	3	4	5	6	7	8	9	10
Crop loss avoided (Fcfa)	0	0	7,526	11,065	14,463	17,724	20,855	23,861	26,747	29,517	32,176
Net crop increase (Fcfa)	0	0	0	58	291	495	728	989	1,310	1,601	2,037
Total (Fcfa)	0	0	7,526	11,123	14,754	18,219	21,583	24,850	28,057	31,118	34,213

(Table 13 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Crop loss avoided (Fcfa)	32,176	32,176	32,176	32,176	32,176	32,176	32,176	32,176	32,176	32,176	505,694
Net crop increase (Fcfa)		2,619	3,201	4,074	5,238	6,693	8,439	10,186	11,641	12,514	13,096
85,210											
Total (Fcfa)	34,795	35,377	36,250	37,414	38,869	40,615	42,362	43,817	44,690	45,272	590,904

4.23.3 Increased fuelwood supply

The branches left after pole harvest are assumed to be used for fuelwood. Where fuelwood was the only management emphasis, Freeman (1982) estimated fuelwood yields to be 0.2 cubic meters, per hectare, in years 10-12 and 0.5 cubic meters/ha in years 13 through 20. However, for the multiple use approach taken in the analysis, it is assumed that only 0.5 cubic meters of fuelwood will be removed per hectare and as pole harvest residues in year 20. The price of fuelwood is 2,500 Fcfa/cubic meter.

4.23.4 Increased forage/fodder supply

During the latter part of the dry season, Kad trees are often the sole source of forage for cattle in the Groundnut Basin. Customarily, farmers prune Kad trees for this purpose during the months of April and May and sometimes into June. Forage yields adapted from the management regime developed by Seyler (1990) are as follows:

100 kg/year for years 10 to 12;
200 kg/year for years 13 to 15; and
300 kg/year for years 16 to 20.

In the same period, pods yield estimates are as follows:

50 kg/year for years 10 to 12;
100 kg/year for years 13-15; and
150 kg/year for years 16-20.

4.23.4 Salvage values

The value of 15,380 entered in this line (table 14) represents the total residual values of nursery tools (12,000Fcfa), and plantation tools (3,380Fcfa). These tools last two years but will be used only for one year in the analysis. Table 14 shows also the year-by-year pattern of all monetary benefits.

Table 14: The benefits stream for an hectare of the kad and millet system

Year>	0	1	2	3	4	5	6	7	8	9	10
Incremental crop yield (Fcfa)	0	0	7,526	11,123	14,754	18,219	21,583	24,850	28,057	31,118	34,213
Poles (Fcfa)	0	0	0	0	0	0	0	0	0	0	0
Fuelwood (Fcfa)	0	0	0	0	0	0	0	0	0	0	0
Forage (Fcfa)	0	0	0	0	0	0	0	0	0	0	2,500
Pods (Fcfa)	0	0	0	0	0	0	0	0	0	0	2,500
Salvage value (Fcfa)	0	15,380	0	0	0	0	0	0	0	0	0
Total (Fcfa)	0	15,380	7,526	11,123	14,754	18,219	21,583	24,850	28,057	31,118	39,213

(Table 14 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Incremental crop yield (fcfa)	34,795	35,377	36,250	37,414	38,869	40,615	42,362	43,817	44,690	45,272	590,904
Poles (Fcfa)	0	0	0	0	0	0	0	0	0	20,000	20,000
Fuelwood (Fcfa)	0	0	0	0	0	0	0	0	0	1,250	1,250
Forage (Fcfa)	2,500	2,500	5,000	5,000	5,000	7,500	7,500	7,500	7,500	7,500	60,000
Pods (Fcfa)	2,500	2,500	5,000	5,000	5,000	7,500	7,500	7,500	7,500	7,500	60,000
Salvage value (Fcfa)	0	0	0	0	0	0	0	0	0	0	15,380
Total (Fcfa)	39,795	40,377	46,250	47,414	48,869	55,615	57,362	58,817	59,690	81,522	747,534

The financial analysis is carried out in Table 15. All costs and benefits are discounted and summed to get an overall figure. The present net worth of the system is equal to 195,466 Fcfa at a 10 percent discount rate, 115,232 Fcfa at 15 percent, and 78,846 Fcfa at 20 percent.

Table 15: Summary table of the "kad and millet" financial analysis

Year>	0	1	2	3	4	5	6	7	8	9	10
Cost (Fcfa)	27,048	0	2,000	2,000	2,000	2,000	2,000	0	0	0	1,500
Revenue (Fcfa)	0	15,380	7,526	11,123	14,754	18,219	21,583	24,850	28,057	31,118	39,213
Cash flows (Fcfa)	-27,048	15,380	5,526	9,123	12,754	16,219	19,583	24,850	28,057	31,118	37,713
PNW (10%) (Fcfa)	27,048	13,982	4,567	6,854	8,711	10,071	11,054	12,752	13,089	13,197	14,540
PNW (15%) (Fcfa)	27,048	13,374	4,178	5,999	7,292	8,064	8,466	9,342	9,172	8,846	9,322
PNW(20%) (Fcfa)	-27,048	12,817	3,838	5,280	6,151	6,518	6,558	6,935	6,525	6,031	6,091

(Table 15 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Cost (Fcfa)	1,500	1,500	2,500	2,500	2,500	3,500	3,500	3,500	3,500	6,500	
Revenue (Fcfa)	39,795	40,377	46,250	47,414	48,869	55,615	57,362	58,817	59,690	81,522	
Cash flows (Fcfa)	38,297	38,877	43,750	44,914	46,369	52,115	53,862	55,317	56,190	75,022	
PNW (10%) (Fcfa)	13,423	12,387	12,673	11,827	11,100	11,342	10,656	9,949	9,188	11,152	195,466
PNW (15%) (Fcfa)	8,232	7,266	7,111	6,348	5,698	5,569	5,005	4,470	3,948	4,584	115,238
PNW(20%) (Fcfa)	5,154	4,360	4,089	3,498	3,010	2,819	2,428	2,078	1,759	1,957	70,846

IRR = 50.2%

4.3 Anacardium occidental and groundnuts

Anacardium occidental, commonly known as the cashew tree or *darcassou* by Senegalese farmers, is a member of the family Anacardiacae. The species is indigenous to Brazil. It crossed the Atlantic Ocean to the Old World with the trans-Atlantic trade and was brought to West Africa, to East Africa and to Southeast Africa (Lawrence 1982). The tree is of medium size with a spreading canopy and branches that often droop. The mature height is 10 to 11 meters. The species grows under a wide range of ecological conditions. It is reasonably tolerant of low soil moisture content, but growth is not adversely affected by high soil moisture content. The soil must however, be deep, freely drained and the terrain reasonably flat (Lawrence 1982). These factors have made cashew plantations well suited for the Groundnut Basin of Senegal.

Jacob (1971) stated that cashew plantations were reported to have been first established in Senegal in 1943, in the MBao National Forest in the district of Cap-Vert, now Dakar. At that time, little emphasis was placed on the utilization of its nuts and fruits, which were considered by-products. The main purpose of these plantations was to protect the area against the invasion of dune sands from the Atlantic coast.

Today, large cashew plantations of approximately 3,000 hectares (Busacker et.al 1990) exist in the Groundnut Basin of Senegal, particularly in the Sokone area where the *"Projet Anacardier Senegalo-Allemand"* (PASA) encourages farmers to plant cashew.

Table 16. The cashew multiple-use table

Use	Importance
Fuelwood	use indicated
Utility wood	no use
Food	main use
fodder	use indicated
Medecine	use indicated
Raw materials	use indicated
Protection and soil improvement	Main use
Village/urban plantation	no use
Cultural values	no use

Source: Adapted from "Agroforestry in the West African Sahel," Advisory Committee on the Sahel (1984).

4.31 Agroforestry values

The cashew tree has proven to be a good cash crop in areas where other tree crops produced little or nothing because of its tolerance of poor soils, low soil moisture content and low rainfall. As Table 16 shows, cashew plantations are established primarily for the production of its fruits and nuts, and as windbreaks to prevent soil erosion. The young tree also can be grown in rows with intercrops in the alley. Cashew trees are relatively free of diseases (Komolafe 1978).

The production of fuelwood as a result of occasional pruning and clearing of dense stands can be quite substantial. In addition, cattle, sheep and goats can be grazed with supervision, in cashew plantations since they do not normally relish cashew stem and leaves.

Sonna (1991) listed some useful knowledge concerning the use of the cashew by-products.

1. The burnt shells can be spread on the field to serve as weed control;

2. shells can also be used as fertilizer; and

3. the rotten nuts can be used to make soap.

The PASA project in the Groundnut Basin of Senegal reflects the general belief among Forest Service officials that the cashew has high potential as an income generating activity for rural dwellers. The species' production pattern is another factor which encouraged its adoption by some farmers. Fruit production occurs during the months of May and June, at a time when the need for money is relatively high among farmers, as their income generated from groundnut and millet has often been spent. This analysis, however, attempts to go beyond these socio- economic considerations and find out whether cashew plantations could indeed be considered as an option financially viable for private farmers.

Table 17 shows the parameters of the financial analysis. With a 5 x 20 meter spacing, it is estimated that 100 cashew trees will start producing at year four. Fruits and nut production varies yearly. In the Groundnut Basin, fruit and nut production stabilizes between the eleventh and twelveth years (Perry, 1991). Fruits and nut prices are 40 Fcfa and 125 Fcfa respectively.

Table 17. Parameters of the cashew plantation

Item	Quantity	Unit price
Spacing	5 x 20 mts.	
Number of trees	100/ha	
Polyethylene bags	120/ha	7 Fcfa/bag
Seeds	2 kg/ha	150Fcfa/kg
Production		
-fruits	varies yearly[1]	40Fcfa/kg
-nuts	varies yearly	125 Fcfa/kg

[1]The cashew nuts and apples yearly production is presented in table 21.

Source: Compiled from *"Calcul de TIR des plantations d'anacardiers"* Unreferenced document supplied by PASA/GTZ Assistant Director; Sokone, Senegal.

4.32 The cost stream

The major cost items involved in cashew plantations are: establishment costs, maintenance costs, harvesting costs, and crop losses due to the reduction of area available for the agricultural crop as trees develop.

4.32.1 Establishment costs

Establishment costs include: seedling cost, tools, planting cost, fencing cost, and fertilizer. These will be discussed in turn.

Seedling cost. Seedlings are produced in year zero, and their production requires the purchase of the following items:

Seeds. A kilogram of cashew seeds costs 150 Fcfa and contains about 160 seeds. Therefore, 63 kilograms of seed will be needed for a 10,000 seedling capacity nursery.

Polyethylene bags. The polyethylene bags needed for cashew plantations are sold to farmers at the subsidized price of 7 Fcfa a piece.

Tools. These are minor equipment needs for nursery activities, and are assumed to last two years. Their total cost is estimated at 25,000 Fcfa.

Mats. These are the covers needed to protect seedlings against intense sunshine. They are produced locally and cost 1,000 Fcfa each.

Labor. For the production of 10,000 seedlings, labor requirement is estimated at 472.5 man hours divided among the different activities as shown on table 18 : 9 man hours for nursery establishment;

50 for soil mixing, 200 for filling polyethylene bags; 1.5 for seed pretreatment; 30 for sowing, 110 for water, and 72 man hours for weeding.

Table 19 brings all seedling production costs together. The total cost is estimated at 260,950 Fcfa. This corresponds to the seedling unit cost of 26 Fcfa.

Tools. These are different from nursery tools and are used for planting and fencing. The total cost is estimated at 7,000 Fcfa.

Planting cost. It is estimated that 12 man days will be needed for the planting of one hectare of cashew. This labor is paid 500 Fcfa per man day.

Fencing cost. A solid fence is needed to protect young trees. Farmers under the project supervision can get these fences at a subsidized price of 17,500 Fcfa per 400 meters. The amount of money paid represents only 15% of the full cost. Farmers outside the project use the traditional hedgerow. PASA estimates of the cost of this type of fence, including labor, is 50,000 Fcfa per hectare. This is the cost used in the analysis. The cost for fence repair and improvement is considered negligeable.

Fertilizer. Fertilizer and other chemicals are sold to farmers at the subsidized price of 25 Fcfa per kilogram. For one hectare of cashew, it is estimated that 100 kilograms of fertilizer will be needed.

Table 18. Labor requirements for producing 10,000 cashew seedlings

Activities	Number of hours
Nursery establishment	9.0
Soil mixing	50.0
Filling polyethylene bags	200.0
Seed pretreatment	1.5
Sowing	30.0
Watering	110.0
Weeding	72.0
Total	472.5

Source: *"Couts de production des plants dans une pepiniere villageoise."* Unreferenced document supplied by PASA/GTZ Assistant Director; Sokone, Senegal.

Table 19. Total cost of producing 10,000 cashew seedlings

Item	Rate and quantity	Amount (in Fcfa)
Seeds	150 Fcfa/kg x 63 kg[1]	9,450
Polyethylene bags	7 Fcfa/bag x 12,000[2]	84.000
Tools	25,000 Fcfa for 2 years	25,000
Mats[3]	1,000 Fcfa/mat x 24 mats	24,000
labor	1,500 Fcfa/MD x 79 MD&sup4	118,000
	Total cost	260,950
	Unit cost	26[5]

[1]It is estimated that there are 160 seeds in 1 kg of cashew seed; thus, 160 seeds per/kg x 63 kg = 10,080 (rounded to 10,000 seeds).
[2]20% of polyethylene bags are lost by damage during filling and moving.
[3]mats are used to protect seedlings against sunburn. They last two years.
[4]From table 17: 472.5 hours / 6 hours = 78.75 (rounded to 79 man-days).
[5]The project PASA charges 30 Fcfa to farmers for nursery grown cashew seedlings.

Source: Compiled from *"Calcul de TIR des plantations d'anacardiers"* Unreferenced document supplied by PASA/GTZ Assistant Director; Sokone, Senegal.

Table 20 gives the total establishment cost for one hectare of cashew plantation. A 5 percent contingency is added to the sum of all expenses leading to plantation establishment. This gives the total cost of 72,187 Fcfa.

Table 20. Total establishment cost of 1 hectare of cashew trees

Item	Rate and quantity	Amount (in Fcfa/ha)
Plantation	500 Fcfa/MD x 12	6,000
Seedlings	26 Fcfa/seedling x 125[1]	3,250
Fertilizer	25 Fcfa/kg x 100 kg	2,500
Fencing		50,000[2]
Tools	7,000 for 2 years	7,000
Contingencies[3]		3,437
	Total	72,187

[1]The project PASA's estimate of survival rate on farm field is 80%; it is, therefore, assumed that 125 cashew seedlings/ha would need to be planted in year 0 in order to obtain a density of 100 cashew trees/ha by year 4, when the production starts.

[2]This is PASA's estimate of peasant hedgerow. No breakdown of the cost was available. The after taxe cost of the type of fence used by the project is 100,000 Fcfa/ha.

[3]5% of total establishment cost: 68,750 x 5% = 3,437.

4.32.2 Maintenance cost

These costs involve weed control, plant protection and other types of operations that will eventually be discontinued as the plantation becomes established. It is estimated that these activities will require 4 man-days during the first two years.

4.32.3 Harvesting costs

As fruits are near maturity, weeds in the plantation must be cut to facilitate the picking of fruits as they drop. Harvesting costs, therefore, include labor cost as well as the cost of all devices needed in the harvesting operation. First harvest occurs in year 4 and costs are estimated at 1,500 Fcfa. Throughout the period of analysis, total harvesting cost is expected to gradually increase as the plantation becomes more productive, and will stabilize at 13,000 Fcfa starting from year 13 (Table 21).

4.32.4. Crop loss

Though cashew trees are usually planted in rows with intercrops in the alley, the agricultural crop production is expected to decline over the years as tree crowns develop and the space available for the agricultural crops becomes reduced. Table 21 summarizes the cost stream. The loss in crop production is estimated at 350 Fcfa in year one. It is expected to increase gradually before stabilizing at 17,500 Fcfa in year 12 and throughout the rest of the period of analysis.

Table 21. The cost stream for an hectare of cashew plantation

Years>	0	1	2	3	4	5	6	7	8	9	10
Establishment cost (Fcfa)	30,187	0	0	0	0	0	0	0	0	0	0
Maintenance cost (Fcfa)	0	2,000	2,000	0	0	0	0	0	0	0	0
Harvesting cost (Fcfa)	0	0	0	0	1,500	3,000	5,500	6,000	6,500	8,000	9,000
Crop loss (Fcfa)	0	350	700	1,400	2,100	3,150	4,200	5,250	6,300	7,000	10,500
Total (Fcfa)	30,187	2,350	2,700	1,400	3,600	6,150	9,700	11,250	12,800	15,000	19,500

(Table 21 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Establishment cost (Fcfa)	0	0	0	0	0	0	0	0	0	0	30,187
Maintenance cost (Fcfa)	0	0	0	0	0	0	0	0	0	0	4,000
Harvesting cost (Fcfa)	9,500	11,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	164,000
Opportunity cost (Fcfa)	14,000	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	212,450
Total (Fcfa)	23,500	28,500	30,500	30,500	30,500	30,500	30,500	30,500	30,500	30,500	410,637

4.33 The benefits stream

When trees and agricultural crops are grown on the same piece of land under the agroforestry scheme, one normally expects the forestry component to improve the productive potential of the site, thus increasing crop yield above the case where no agroforestry practice is adopted. However, following our discussions with PASA technicians, no incremental crop value due to the presence of cashew trees was reported in the entire area covered by the project. Their explanation is that as the system develops, all benefits to the crop from reduced evapotranspiration or increased soil organic matter may be offset by root competition. Therefore, cashew fruits and nuts constitute the only contribution to the benefit stream.

Cashew trees in the Groundnut Basin come into production in the fourth year after field planting (Busacker et al, 1990). The per year production of cashew fruits and nuts and their monetary value for the hectare plantation are presented on table 22. The first crop is small, but, the production increases gradually up to the twelfth year when the plantation matures.

Table 22: The benefit stream for an hectare of cashew plantation

Year>	0	1	2	3	4	5	6	7	8	9	10
Fruit production (kg)	0	0	0	0	120	192	552	960	1,368	1,680	1,992
Value (Fcfa)	0	0	0	0	4,800	7,680	22,080	38,400	54,720	67,200	79,680
Nut production (kg)	0	0	0	0	12	19	55	96	137	168	199
Value (Fcfa	0	0	0	0	1,500	2,400	6,900	12,000	17,100	21,000	24,900
Total (Fcfa)	0	0	0	0	6,300	10,080	28,980	50,400	71,820	88,200	104,580

(Table 22 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Fruit production (kg)	2,184	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	30,648
Value (Fcfa)	87,360	96,000	96,000	96,000	96,000	96,000	96,000	96,000	96,000	96,000	1,225,920
Nut production (kg)	218	240	240	240	240	240	240	240	240	240	3,064
Value (Fcfa)	27,300	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	383,100
Total (Fcfa)	114,660	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	1,609,020

Table 23 gives the financial analysis results. All cost and benefits are discounted in each of the three chosen discount rates and for the appropriate number of years. The total present net worth of the system is equal to 274,385 Fcfa at 10 percent discount rate, 128,405 Fcfa at 15 percent, and 49,392 Fcfa at 20 percent. The internal rate of return is found at 25.6 percent.

Table 23: Summary table of the cashew plantation financial analysis

Year>	0	1	2	3	4	5	6	7	8	9	10
Cost (Fcfa)	72,187	2,350	2,700	1,400	3,600	6,150	9,700	11,250	12,800	15,000	19,500
Revenue (Fcfa)	0	0	0	0	6,300	10,080	28,980	50,400	71,820	88,200	104,580
Cash flow (Fcfa)	-72,187	-2,350	-2,700	-1,400	2,700	3,930	19,280	39,150	59,020	73,200	85,080
PNW(10%) (Fcfa)	-72,187	-2,136	-2,231	-1,052	1,844	2,440	10,883	20,090	27,533	31,044	32,802
PNW(15%) (Fcfa)	-72,187	-2,043	-2,042	-921	1,544	1,954	8,335	14,718	19,294	20,808	21,030
PNW(20%) (Fcfa)	-72,187	-1,958	-1,875	-810	1,302	1,579	6,457	10,926	13,726	14,187	13,741

(Table 23 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Cost (Fcfa)	23,500	28,500	30,500	30,500	30,500	30,500	30,500	30,500	30,500	30,500	
Revenue (Fcfa)	114,660	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	
Cash flow (Fcfa)	91,160	97,500	95,500	95,500	95,500	95,500	95,500	95,500	95,500	95,500	
PNW(10%) (Fcfa)	31,951	31,067	27,663	25,148	22,862	20,784	18,894	17,177	15,615	14,195	274,385
PNW(15%) (Fcfa)	19,594	18,223	15,521	13,497	11,736	10,206	8,874	7,717	6,710	5,835	128,405
PNW(20%) (Fcfa)	12,269	10,935	8,926	7,438	6,198	5,165	4,304	3,587	2,989	2,491	49,392

IRR = 25.6%

4.4 Eucalyptus sp.

Eucalyptus is a native of Australia. The eucalyptus have proven to be extremely successful in a large number of countries, where they constitute the most popular tree for fuelwood and other uses. In India, for example, Eucalyptus have proved to be the most useful trees in farm forestry programs (Foley and Barnard 1984).

According to the FAO (1955), the ability of the Eucalyptus to thrive in environmental conditions different from those of their natural range is a highly prized quality. In many areas however, recent field research has demonstrated the need to match the edaphic and climatic conditions of the site with the silvicultural requirements of the species (Mariani et al. 1978, Hillis and Brown 1984, Sharma et al. 1986).

In the Groundnut Basin of Senegal, Eucalyptus plantations were first established over a wide range of conditions by the "Projet d'Amenagement et de Reboisement du Centre-Est" (PARCE), financed by the World Bank. The purpose of these plantations was to create a future supply of electric poles in Senegal. Since the beginning of the 1980s, Eucalyptus has been widely planted on farmlands for the production of fuelwood reflecting the government's focus on agroforestry.

4.41 Agroforestry Values of Eucalyptus

Eucalyptus, an exotic highly adaptable to a wide range of sites, has been extensively planted throughout the Sahel, in order to promote large- scale agroforestry. Table 24 gives the species multiple uses. In agroforestry Eucalyptus is planted mainly for the provision of fuelwood. But, the

Table 24. Eucalyptus multiple use table.

Use	Importance
Fuelwood	Main use
Utility wood	Main use
Food	No use
fodder	Use indicated
Medecine	use indicated
Raw materials	No use
Protection and soil improvement	Use indicated
Village/urban plantation	Main use
Cultural values	no use

Source: Adapted from "Agroforestry in the West African Sahel," Advisory Committee on the Sahel (1984).

species is also excellent for planting on farmlands alone or in combination with agricultural crops (Poore and Fries 1985).

In many Sahelian countries, Eucalyptus has been chosen as plantation species for the following reasons (Keita 1981): (1) short rotation age (6 to 8 years); (2) high volume yield per hectare; and (3) wide range of uses. The species produces firewood, small timber and poles that can be used in house construction and for making crates for storing food grains in rural areas.

In Senegal, eucalyptus has been both praised and criticized. Some farmers have complained that it is difficult to plant any crop under the shade of eucalyptus. However, in the Groundnut Basin, some crops, such as manioc have been successfully grown in the first two or three years.

Eucalyptus species are usually planted in blocks of pure stands in the Groundnut Basin. In many cases, farmers grow cassava in young plantations in order to utilize available space and generate

Table 25. **Parameters of the Eucalyptus block plantation**

Item	Quantity	Unit price
Total area	1ha	
Spacing	4 x 4 mts.	
Number of trees	650/ha.	
Poles	6 mts./tree	100 Fcfa/mt.
fuelwood	10 cu.mts./ha	2,000 Fcfa/cu.mt
Average rotation	6 years	

Source: Senegalese Reforestation Project (PRS), Dakar, Senegal.

additional revenues. Neither fodder value nor incremental crop value has been ever reported for eucalyptus plantations.

The parameters of the Eucalyptus block plantation financial analysis are given on table 25. These data are supplied by the Senegalese Reforestation Project (PRS) in Dakar, and are obtained from field experiment. With an spacing of 4 x 4 meters between trees, a total of 650 seedlings were planted per hectare.

4.42 The cost stream

The Eucalyptus block plantation cost stream consists of three items. These are: establishment cost, maintenance costs, and harvesting costs.

4.42.1 Establishment costs

Establishment costs consist of three items : seedling production, planting cost, and the cost of fencing. These will be described in turn.

Seedling production: The production of Eucalyptus seedlings involves the following costs.

Seeds. The Forest Research Service price of Eucalyptus seedling is 75,000 Fcfa per kilogram. It is estimated that there are about 2 million grains in one kilogram of Eucalyptus seeds. This is why seeds are often sold in small packages of five grams.

Polyethylene bags. It is estimated that a total of 12,000 bags will need to be purchased for a 10,000 seedlings nursery. Because of the fragility of the type of bags used in Eucalyptus seedling production, the rest of the polyethylene bags will be wasted. The price of polyethylene bags is 5 Fcfa per bag.

Tools. Tools purchased for the nursery enterprise will cost 25,000 Fcfa and have a two-year life.

Crinting. These are locally made mats used during germination to create shade around young plants and avoid sun burns. The cost of a crinting is 1,000 Fcfa per unit.

Table 26. Labor requirements for producing 10,000 Eucalyptus seedlings.

Activities	Number of hours
Site preparation	9.0
Soil mixing	73.0
Filling polyethylene bags	110.0
Placement of pots	41.0
Sowing	69.0
Watering	39.0
Weeding	72.0
Total	413.0

Source: *"Estimation des couts de la campagne 88."*
Leccia F. and Ba L. PARCE, Kaffrine, Oct. 1988.

Labor. Total labor for producing 10,000 Eucalyptus seedlings is estimated at 413 manhours, paid at the government rate of 1,500 Fcfa per man-day. Labor is divided among nursery activities as follows (Table 26):

Site preparation	9.0 hours
Soil mixing	73.0
Filling polyethylene bags	110.0
Placement of bags	41.0
Sowing	69.0
Watering	39.0
Weeding	72.0

Seed trays. Seed beds are needed for Eucalyptus pre-germination. These seed trays sell 3,300 Fcfa per tray. For a 10,000 seedling nursery, it is estimated that a total of 15 trays will be needed.

Fungicides. Fungicides are chemical substances used in the nursery to prevent diseases and pests that can occur with the development of fungus. The total cost of fungicide is estimated at 11,425 Fcfa.

Cost items for seedling production are summarized on table 27. The total cost is estimated at 261,800 Fcfa, and the seedling unit cost at 26 Fcfa.

Planting costs. With a 4x4 meter spacing, a total of 650 seedlings will be needed per hectare. The total labor required to plant these seedlings is estimated at 30 man-days paid at the rate of 500 Fcfa per man-day.

Fencing. Soon after planting, the area must be fenced off. The type of fence in this case, costs 25 Fcfa per meter. 400 meters of fence will be needed in total.

Table 28 estimates the total establishment cost of an hectare of Eucalyptus block plantation. With 5 percent contingencies, this total cost is 43,962.

4.42.2 Maintenance Costs

Maintenance includes replanting dead trees and weeding. These costs are estimated at 5,000 Fcfa for the first two years. There will be no maintenance cost after the second year, due to the fast growth of Eucalyptus trees.

Table 27. Total cost of producing 10,000 Eucalyptus seedlings

Item	Rate and quantity	Amount (in Fcfa)
Seeds	75,000 Fcfa/kg x .005 kg	375
Polyethylene bags	5 Fcfa/bag x 12,000	60,000
Tools	25,000 Fcfa for 2 years	25,000
Mats	1,000 Fcfa/mat x 24 mats	12,000
labor	1,500 Fcfa/MD x 69 MD[1]	103,500
Seed trays	3,300 Fcfa/tray x 15 trays	119,500
Fungicide		11,425
	Total cost	261,800
	Unit cost	26

[1]From table 25: 413/6 = 69
Source: *"Estimation des couts de la campagne 88."*
Leccia F. and Ba L. PARCE, Kaffrine, Oct. 1988.

4.42.3 Harvesting Costs

Tree harvesting cost is estimated at 9,000 Fcfa per hectare at the end of each rotation period with the first harvest occurring seven years after planting, and the second and third harvests at five year intervals thereafter.

Table 28. Total establishment cost of one hectare of Eucalyptus block plantation

Item	Rate and quantity	Amount (in Fcfa/ha)
Plantation	500 Fcfa/MD x 30MD	15,000
Seedlings	26 Fcfa/seedling x 650	16,900
Fencing	25 Fcfa/mt. x 400 mts.	10,000
Contingencies (5%)		2,062
Total		43,962

Table 29 summarizes the cost stream for one hectare of the Eucalyptus block plantation. The total undiscounted value is 10,000 Fcfa for maintenance costs and 27,000 Fcfa for harvesting costs. These values, added to the initial establishment cost, give an undiscounted total cost of 80,862 Fcfa for one hectare of Eucalyptus block

Table 29: The cost stream for an hectare of Eucalyptus block plantation

Year>	0	1	2	3	4	5	6	7	8	9	10
Establishment cost (Fcfa)	43,962	0	0	0	0	0	0	0	0	0	0
Maintenance cost (Fcfa)	0	5,000	5,000	0	0	0	0	0	0	0	0
Harvesting cost (Fcfa)	0	0	0	0	0	0	0	9,000	0	0	0
Total (Fcfa)	43,962	5,000	5,000	0	0	0	0	9,000	0	0	0

(Table 29 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Establishment cost (Fcfa)	0	0	0	0	0	0	0	0	0	0	43,962
Maintenance cost (Fcfa)	0	0	0	0	0	0	0	0	0	0	10,000
Harvesting cost (Fcfa)	0	9,000	0	0	0	0	9,000	0	0	0	27,000
Total (Fcfa)	0	9,000	0	0	0	0	9,000	0	0	0	80,962

4.43 The benefit stream

Revenues from the Eucalyptus plantation block are from wood products only. Field experiments by the Senegalese Reforestation Project (PRS) at Thialle gave the following results that will be used in the analysis.

1. There was one six meter pole produced per tree in each coppice cut. The per unit market price of poles in the Groundnut Basin is 100 Fcfa per pole.

2. Small sized wood referred to as "piquet-rondin" was also produced. The total value of these items was estimated at 30,000 Fcfa/ha at each coppice cut.

3. There were 10 cubic meters of fuelwood per cut. This was made of branches, and top wood, that were not straight enough to make poles or piquets. Fuelwood price is 2,000 Fcfa per cubic meter. Table 30 summarizes the benefit stream for one hectare of the Eucalyptus block plantation. The total value of undiscounted benefits is estimated at 345,000 Fcfa. This comes from the sale of poles, piquets, and fuelwood.

Table 30: The benefit stream for an hectare of Eucalyptus block plantation.

Year>	0	1	2	3	4	5	6	7	8	9	10
Poles (Fcfa)	0	0	0	0	0	0	0	65,000	0	0	0
Piquet rondin (Fcfa)	0	0	0	0	0	0	0	30,000	0	0	0
Fuelwood (Fcfa)	0	0	0	0	0	0	0	20,000	0	0	0
Total (Fcfa)	0	0	0	0	0	0	0	115,000	0	0	0

(Table 30 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Poles (Fcfa)	0	65,000	0	0	0	0	65,000	0	0	0	195,000
Piquet rondin (Fcfa)	0	30,000	0	0	0	0	30,000	0	0	0	90,000
fuelwood (Fcfa)	0	20,000	0	0	0	0	20,000	0	0	0	60,000
Total (Fcfa)	0	115,000	0	0	0	0	115,000	0	0	0	345,000

The Eucalyptus block plantation last harvest occurs in year 17. In order to cover the 20 year-period of the analysis, it is assumed that the farmer grows groundnuts during the three years remaining. It is assumed also, that he will undertake good cultural practices in order to avoid yield declines during these years.

Table 31 shows the system's financial analysis results. The present net worth is equal to 62,511 Fcfa at 10 percent discount rate, 19,492 Fcfa at 15 percent, and 4,648 Fcfa at 20 percent. The internal rate of return is found at 18.8 percent.

Table 31: Summary table of the Eucalyptus block plantation financial analysis

Year>	0	1	2	3	4	5	6	7	8	9	10
Cost (Fcfa)	43,962	5,000	5,000	0	0	0	0	9,000	0	0	0
Revenue (Fcfa)	0	0	0	0	0	0	0	115,000	0	0	0
Cash flow (Fcfa)	-43,962	-5,000	-5,000	0	0	0	0	106,000	0	0	0
PNW(10%) (Fcfa)	-43,962	-4,545	-4,132	0	0	0	0	54,395	0	0	0
PNW(15%) (Fcfa)	-43,962	-4,348	-3,781	0	0	0	0	39,849	0	0	0
PNW(20%) (Fcfa)	-43,962	-4,167	-3,472	0	0	0	0	29,583	0	0	0

(Table 31 continued)

Year>	11	12	13	14	15	16	17	18	19	20	Total
Cost (Fcfa)	0	9,000	0	0	0	0	9,000	69,772	69,772	0	
Revenue (Fcfa)	0	115,000	0	0	0	0	115,000	0	96,000	96,000	
Cash flow (Fcfa)	0	106,000	0	0	0	0	106,000	-69,772	26,228	96,000	
PNW(10%) (Fcfa)	0	33,775	0	0	0	0	20,972	-12,549	4,288	14,270	62,511
PNW(15%) (Fcfa)	0	19,812	0	0	0	0	9,850	-5,638	1,843	5,866	19,492
PNW(20%) (Fcfa)	0	11,889	0	0	0	0	4,778	-2,621	821	2,504	-4,648

IRR = 18.8%.

Chapter V

DISCUSSION OF RESULTS

Three discount rates, (10, 15, and 20 percent) were used to evaluate each agroforestry system. The results are summarized in table 32.

These results indicate that the three agroforestry systems studied are financially more attractive than the base case. Using the decision criteria that an agroforestry system with a PNW greater than zero is acceptable, the results also indicate that all three agroforestry systems are acceptable at 10 and 15 percent discount rates. However, the kad and millet system is uneconomic at rates above 15.8 percent; and the Eucalyptus block plantation is uneconomic above an 18.5 percent rate of interest.

Table 32. Summary of the financial analysis.

Agroforestry system	PNW(10%)	PNW(15%)	PNW(20%)	IRR
Base case	-9,167	-14,377	-18,528	4.7%
Kad and millet	195,466	115,238	70,846	50.2%
Cashew and groundnut	274,385	128,405	49,392	25.6%
Eucalyptus block plantation	62,511	19,492	-4,648	18.8%

5.1 The Base Case

The base case assumes that a farmer plants groundnuts over the 20-year period of analysis, without any agroforestry practice. Due to land tenure constraints and the high population pressure, the recourse to new fallows is excluded. The use of fertilizers and domestic organic materials such as animal dung and domestic wastes are the only means available for improving soil fertility. These will prevent groundnut yield from reaching zero during the last years of soil impoverishment.

Under the conditions just described, groundnut yield will not remain constant over time. It is assumed that yield will decrease at a rate of four percent per year due to soil erosion, declining soil fertility and the loss of soil organic matter. However, the sensitivity of groundnut yearly net revenues to changes in the factor of soil degradation k should be pointed out. For example, the rate of 4 percent given to k in the analysis yields an IRR equal to 4.7 percent. But, if k is reduced to 3 and then 2 percent, everything being equal, the IRR becomes equal to 15.2 and 26.2 percent respectively. These values are in the same range as those later found for the three agroforestry sys-

tems. As a result, it can be assumed that, beside the production of fuelwood, fruits and nuts, The maintenance of soil quality is the major contribution of tree components in the farming system.

In spite of low farm revenues resulting from the high level of soil degradation, most farmers in the region continue to use family labor to grow groundnuts. The reason is, as Todaro (1977) indicates: " The main motivating force in a peasant's life may not be the maximization of income, but of survival...". In the Groundnut Basin, this attitude may be due to the lack of clear production alternatives and to the free use of an abundant family labor. Bonnefond and Couty (1991), indicate that from 1961/63 to 1982/84, total cultivated area in Senegal increased only by 15 percent, while the active agricultural population increased by more than 50 percent. When labor cost was not internalized, the results showed substantial "revenues" from the groundnut enterprise and throughout the period of analysis. Previous government agricultural policies also favored the monoculture of groundnuts as an export crop.

The current situation of groundnut production in Senegal is best characterized by Bonnefond and Couty (1991:37-38):

> Peanuts bought at the 1986 procurement price of CFAF 90/kg appear to be financially attractive to farmers. However, since three kilograms of peanuts are needed to produce one liter of oil worth only CFAF 200 at 1986 world prices ($600 U. S. per ton), "the production system of Senegalese peanuts is not profitable at the national level" (Gaulme 1986: 2784). The present move towards local grinding is economically justified but is not feasible for disposing of a high level of output. Peanut production was once profitable for both individual farmers and for Senegal as a whole, but that was the result of colonial preferences and subsidies, which came to an end in 1968.

The authors further illustrate these trades preferences as fallows:

> In 1933, France put a customs tax on imports of peanuts from countries other than Senegal, thereby protecting the Senegalese share of the market.... When France decided to pay for Senegal's peanut at lower world prices, the financial consequencies would be substancial for already impoverished Senegalese farmers.

5.2 Kad And Millet

Suppose a farmer plants fifty kad trees amid millet crops on each hectare of farm land. Kad trees will improve soil fertility and generate a gradual increase in crop yield.

The kad and millet case shows a positive PNW at all three discount rates. The internal rate of return is found at 50.2 percent. The reason for such a high rate is due to the value put on crop losses That the farmer avoids by implementing the system. When this value is not taken into account, the internal rate of return equals only 15.5 percent. The total value of crop losses avoided amounts to 590,904 Fcfa, almost 80 percent of the system's total benefits.

5.3 Cashew And Groundnuts

This case shows a positive PNW at all three discount rates. The high profitability of this system is apparently due to the production of high value products such as fruits and nuts, for which rural as well as urban markets exist. The cashew and groundnut case also shows the highest internal rate of return.

5.4 Eucalyptus Block Plantation

PNWs for this case are positive at 10 and 15 percent discount rates, but negative at 20 percent. The internal rate of return is 18.8 per cent.

The results indicate that planting by farmers is much more cost effective than planting by the government. The private planting cost is 43,962 Fcfa per hectare, substantially lower than the standard government cost estimate of 300,000 Fcfa. This may be due to the high cost of supervision associated with government reforestation activities, and to the high cost of heavy machinery used by the Forest service. As a result, it can be assumed that private planting by farmers could help the Forest Service achieve large scale reforestation at reduced cost.

Evidence indicates that earning income is one of the stronger incentives in triggering widespread local participation in agroforestry activities (Hildebrand, 1976; Laarman and Sedjo, 1990). The Senegalese Reforestation Project (PRS) is a good example of a program which builds upon an existing market incentive structure and local people's strong entrepreneurship to achieve significant and widespread local reforestation actions. However, with its major focus on financial viability and monetary benefits, agroforestry may seem to be far removed from the key issue facing Senegal and other Sahelian countries; namely, environmental degradation.

5.5 The Environmental Protection Connection

Deforestation, improper land use and the development of a large scale monoculture, notably involving groundnuts, have resulted in extensive damage in the form of erosion, loss of agricultural

productivity and water supply decline. In considering the importance of agroforestry activities in the Groundnut Basin, it is necessary to review briefly their environmental effects on the farming system.

Agroforestry systems are perceived to improve soil fertility and productivity, to promote soil conservation, reduce soil degradation and achieve sustainable production (Caborn 1956, Ingram 1990). These benefits are often attributable to the tree component of the system. They may be summarized as follows:

1. The use of trees may allow the planting of areas which are otherwise too exposed for agricultural crops;

2. The microclimatic conditions produced by trees provide a shelter that can help to retain moisture, which is a critical medium for crop growth under arid conditions such as exist in the Sahel;

3. The presence of trees reduces damage by strong winds;

4. Tree roots protect the soil from erosion and exploit deep soil layers where nutrients are available but beyond the reach of agricultural crops;

5. Leaf litter improves the soil organic matter and physical properties;

6. Finally, the ability to nodulate, possessed by woody perennial legumes such as the family of Acacia, offers great potential for augmenting the nitrogen status of agricultural soils.

At this point, one may ask: " in spite of agroforestry's financial and environmental potential, and in spite of the Senegalese Government's efforts in recent years to expand the practice primarily in the Groundnut Basin, why is the farmers' response to the suggested systems not always met the high expectations that underlined these actions?" The lack of basic data and financial analysis at the farmers' level, combined with farmers' risk aversion have been the most common explanation.

However, major constraints can also be found in the structure and socio-economic conditions of agricultural households in the region.

5.6 Socio-Economic Context and Constraints

The understanding of existing farming systems can help enhance the acceptability and adoption of new agricultural techniques, for it can help develop relevant methodologies. In Senegal, problems encountered with the first generation of projects were credited to the development of forestry programs not linked to the real world of farmers. The major constraints can be classified into two groups: social and financial. These will be discussed in turn.

5.61 Social constraints

Social constraints can be summarized in terms of the traditional attitude towards growing trees amid crops, issues of land tenure, and gender roles.

5.61.1 Attitude towards growing trees

Even with the pronounced tree scarcity in the Groundnut Basin, tree planting may be a low priority for the farmers, compared with the immediate, and often desperate, needs for water and food, healthcare, and employment. Furthermore, some indigenous people feel that tree growing is the work of Nature and God, and that human intervention is neither necessary nor appropriate. The

antipathy of growing trees amid agricultural crops may also be a result of practical reasons; some farmers cut down trees to reduce the population of crop-eating birds, to eliminate hiding places for thieves, and to get rid of snakes and other dangerous animals.

5.61.2 The land tenure system

In the Groundnut Basin, land tenure arrangements are characterized by the coexistence of two conflicting systems: traditional and modern. The modern land tenure system is based on the *Loi sur le domaine national* which stipulates that land can neither be bought nor sold but should belong to people who can make it profitable to themselves and to the community. This legislation also provides criteria for the optimum management level in land use. In contrast, the traditional land tenure system is based on the long-term occupation of agricultural land by some influential families who claim ownership over these lands and reserve to themselves the customary right to use it as they wish, or lease it to other members of the community on the basis of a contract renewable each season.

A recent land ownership survey in the region reveals that about 73.5 percent of the arable land falls into the traditional system of ownership (Busacker et. al 1990). This clearly demonstrates a weak application of the modern legislation by local authorities and explains the growing pressure on the government to undertake land policy reforms. The same survey also shows that only 44 percent of farmers in the Groundnut Basin "own" the land they farm. The remaining 56 percent are farming lands partly "owned" partly borrowed or totally borrowed.

The neglect of land problems may dimunish or even annihilate the financial and economic benefits of rural development projects (Falloux and Rochegude, 1988). With the growing population pressure as a result of migrants from less productive regions, current land tenure arrangements are becoming increasingly unsatisfactory. Competition between agricultural crops and trees for land

use is now more evident than ever, and government objectives such as large scale tree planting by farmers under agroforestry is not likely to occur without secure rights to land.

5.61.3 Gender roles

The design of agroforestry projects in the Groundnut Basin and other regions has seldom taken into account the needs of women and their role in household decision-making. Yet, it is the women who are often the local experts in key matters of farming (Hoskins 1984, Fortmann 1986), giving advice as to what portion of land to use for each purpose. This is mainly because they generally hold primary responsibility for family food and health. Some Senegalese agroforestry projects are now trying to overcome this failure of previous projects by recruiting women as professionals and technicians in the projects.

5.62 Financial Constraints

There is a general belief among rural experts that farmers are highly conservative, if not risk averse. As Laarman and Sedjo (1990) note, when people struggle even for their daily subsistence, they cannot afford to invest their meager resources on long term projects. With respect to agroforestry, there are two major financial constraints worth mentioning. These are: high establishment costs and the cash flow pattern.

5.62.1 Establishment costs

In the Groundnut Basin, the average household revenue is 30,000Fcfa ($100) per season which comes mainly from the sale of agricultural crops such as groundnuts and millet (Busacker et. al 1990). In addition, credit markets have failed to efficiently contribute to agricultural development. The preferential discount rate program, primarily designed for crop credit, was ended in 1989 (deZamaroczy, 1992). As a result, many farmers who are willing to adopt agroforestry practices may now find it difficult to cover the establishment costs of agroforestry systems. This of course, is the major reason why the government is providing subsidies for agroforestry activities. But, this approach has tended to attract people more interested in the cash payments than in agroforestry.

5.62.2 The cash flow pattern

The long term pay-off of agroforestry systems is another major constraint to their adoption by farmers. In addition, the pattern of the expected cash flow is unlikely to allow subsistence based farmers to make it between consecutive harvests without alternative sources of income. Table 30 is a typical illustration of this constraint: The farmer's initial investment (year zero) is estimated at 43,962Fcfa; but until the first harvest, in year seven, no cash flow will be available from tree components.

Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

With the severe drought that has affected Senegal in the past twenty years, Forest Service planting programs have so far accounted for a large share of government and foreign aid budgetary allocation. After the initial approaches to anti-desertification activities failed and their financing became a heavy burden to the government, "agroforestry" is now increasing in popularity as a means to encourage farmers to plant trees amid crops. This new practice is expected to support agricultural production, diversify farmers' source of income, and assure environmental protection.

In Senegal, the government is committing personnel and budgets to the large-scale adoption of agroforestry practices as part of a broader government objective to reduce its dominance of the agricultural sector in favor of increased private initiative. However, some farmers are still not motivated in getting involved in agroforestry on their own; some feel that the profit potential is too low, while others simply lack the necessary capital. This explains the subsequent government new reforestation program referred to as "cost-sharing" or "matching-grant" program initiated in 1988.

The present analysis has departed from the most popular explanation of the farmers reluctance to invest in agroforestry; namely, their aversion to risk. Assuming that the suggested systems will

likely be adopted only if they make financial sense to the farmer, this analysis has attempted to assess the profitability of the three agroforestry systems promoted by the Forest Service in the Groundnut Basin. In all cases, the initial investment required to cover establishment costs and the pattern of cash flows in the benefit stream appear to be the only major financial disadvantages. With available data and under prevailing farming conditions, the analysis indicates that these activities provide adequate compensation within the twenty-year period considered.

Beside financial benefits, the three systems studied have also proven to have some connection with the protection of the environment. In both instances, the use of land for an agroforestry enterprise proved to be justifiable. However, socio-economic conditions of agricultural households in the Groundnut Basin entail major constraints to agroforestry development. In addition, there are growing concerns among forest technicians that reforestation levels will drop sharply after the "cost-sharing" program ends, and therefore there is a need for a new approach that will take these concerns into account. Success in getting agroforestry moving will largely depend upon removing these constraints and adopting efficient policies with respect to monetary incentives. In considering these new perspectives, the following recommendations are made:

1. Long-term activities like tree planting under agroforestry are unlikely to be adopted on a large-scale without secure rights to land; therefore, the revision of laws that govern land use in Senegal will be needed;

2. Rights of access to trees have been overlooked by the prevailing "Forestry Code"; it is necessary that rules of use and access to trees by individuals be well defined, understood, and agreed upon;

3. Forest price systems, which fail to take full account of the real value of forest products, wood particularly, can have only negative effects. Therefore, it is of the utmost importance to improve the efficiency of fuelwood exploitation in conjonction with programs to drive up the price of wood.

4. The level of agroforestry adoption in regions such as the Groundnut Basin, may have been shaped by cultural attitudes towards trees; it is therefore necessary to undertake studies on the ecological, social, and socio-economic processes that govern the planting and use of trees at the local level. This could further be pursued with the use of social science in the training of future agroforestry professionals;

5. Rural women's needs should also be given adequate representation in the provision of incentives by current agroforestry programs;

6. Often times, farmers in some regions are confused by having two or more separate extension agents visit them with conflicting information and ideas; it is necessary that the extension activities of the three actors of rural development in Senegal namely, the Forest Service, the Agricultural Service, and the various Non-Governmental Organizations (NGO's), be centralized to facilitate coordination;

7. In Senegal, net farm income is low due to limited earning and saving potential of traditional crops; this constraint could be overcome by reorganizing the current "Agricultural Credit System" into a "Rural Credit System" that will provide needy farmers with adequate financial services;

8. Finally, once the above step is taken, "cost sharing" should be limited only to systems which have strong favorable impacts on the environment but do not afford sufficient financial rewards by themselves.

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