I Summary

The following Cost-Benefit Analysis compares the costs and benefits of land-use systems based on *Musa textilis* (Abaca) with rainforestation farming in Leyte, Philippines. Three different systems were selected for the economic analysis, namely Abaca with Coconut, Abaca with *Acacia mangium* and the establishment of a rainforestation site as third alternative. Since poverty is a major concern in Leyte, knowledge about the profitability of alternative land-use systems is essential for developing programmes. Further problems on Leyte are deforestation and soil erosion.

Coconut and Abaca are the main export products of Leyte. In 1999 Abaca was grown on 15,601 hectares, coconut on 203,017 hectares. This equals 2.73% and 35% of Leyte's total land area respectively. The extensive area of coconut plantations in Leyte explains why Abaca is mostly planted in combination with coconut and less often beneath a shade cover of fruit or timber trees like *Acacia mangium*. Interesting question for this CBA is whether the less common combination of Abaca – Acacia is more profitable than the commonly planted Abaca – Coconut system.

Forest Lands were once the most important natural resource in Leyte. Due to the depletion of forests from 42% in 1939 to 12% in 1987 soil degradation in terms of nutrient leaching and direct soil losses through erosion are a major problem in Leyte. An extensive establishment of rainforestation sites could slow down soil erosion or even restore some of Leyte's forests. Whether the introduction of 'rainforestation farming' on large scale will be successful depends to a high degree on its profitability.

Outcome of the present analysis is that the alternative of rainforestation is by far the most profitable land-use system. The net present value of this alternative was about 26,189 US$ per hectare. The alternative of Abaca beneath acacia ranked on second place with a NPV of 10,354 US$. The least profitable alternative is Abaca planted under coconut although this is one of the most common agricultural systems on Leyte. The NPV of this alternative is about 8,616 US$ or even 6,187 US$, in case coconut has to be planted first. These facts indicate that there is still a considerable potential for increasing the profitability of land-use in Leyte to face the problems of poverty, deforestation and soil erosion.

II Preface

The following Cost-Benefit Analysis about different land-use systems in Leyte is part of the programme of the Master course 'Tropical and International Forestry' 2002-2004 at Faculty of Forest Sciences and Wood Ecology of the Georg-August-University, Göttingen. The project began in October 2003 with a planning and literature research period, followed by a visit of the students at Leyte State University (LSU) and the Abaca Research Centre in Baybay, Leyte in December 2003. Aim of the visit was to gather information and literature about production systems with *Musa textilis*. Interviews with the staff of Leyte State University, the Abaca Research Centre besides various excursions and further interviews with local farmers were used to gain insight into agricultural and forestry practices and the economic situation on Leyte. Soon it became evident that the combination of *Musa textilis* with Coconut was the predominant practice. Besides coconuts *Acacia mangium* seemed to be a profitable alternative as shade trees. Therefore these two combinations, '*Musa textilis* and Coconut' and '*Musa textilis* and *Acacia mangium*' were selected for a financial analysis. One of the existing 24 rainforestation sites on Leyte has been established by the Institute of Forestry behind the campus of LSU. After a visit of this site, it was decided to take the alternative of rainforestation into account as third approach since the project seemed to be advantageous from an economic and ecological point of view. As a drawback of rainforestation farming can be considered that the only data available is from Dirksmeyer, 1998. At that time, rainforestation was only at an early development stage and data for future periods were based on assumptions. At present, these assumptions seem rather optimistic, which has to be taken into account when reviewing this evaluation. If new data would be available, the results of this Cost-Benefit Analysis could be fitted accordingly. The following CBA uses either information gathered during interviews, from the literature collection in Baybay or Göttingen and internet sources.

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1. Introduction

About two-thirds of Filipinos live from fishing, agriculture and forestry. The main products for export are coconuts (copra), Abaca (Manila hemp), tobacco, bananas, pineapples and cut flowers. The most important agricultural product is rice (Peters). The Philippines' population stood at 78 million in 2001, with an estimate of 85 million in 2005. Population growth rate is 2.3% annually (Lahmeyer). In the 1970s it was even at 3% (US Department of Commerce). 17.6 million People live on less than 1 US$ per day. The Philippines were the only country in South East Asia where the number of people living in poverty did not decline during the last decade (The World Bank Group).

Of the Philippines' total land area of 30 million hectares about 50% are currently classified as forest lands, under the direct administration of the State. Land with a slope of more than 18 % is classified by law as public forest land (Dirksmeyer). According to law, there should be no land tenure, no agricultural and no logging activities in these areas. However, only 56% of the total land area of the roughly 15 million hectares of declared forest land following this definition are significantly covered with trees. It is estimated that a third of the Philippines' population lives in such marginal areas and pursues farming activities there (World Bank Group). The areas with a slope smaller than 18% are officially declared as "Alienable and Disposable", thus suitable for agricultural purposes (Dirksmeyer). Further on, 31% of the land (9.4 million hectares) is classified as steep with a slope of greater than 30% and is considered as not being suitable for agricultural activities at all. Again, almost half of that is under cultivation by subsistence farmers (Dirksmeyer).

Just before Second World War, in 1934, the country had a total of around 17 million ha of forest cover. Indiscriminate logging, slash and burn cultivation, and a combination of socio-economic and political factors, contributed to the diminution of the country's forest cover to the present 5.39 million ha (Philippines Community Forestry). Due to excessive logging after Second World War and during the last decades, the Philippines are now among the most deforested nations in the tropics (Kummer, in Harrison). Since seven to eight million cubic meters of lumber are harvested annually within the Philippines it was predicted at the end of the 1980's that the primary forest mainly consisting of Dipterocarpaceae will disappear within a few years (The World Bank Group). To meet this projected dearth, the forestry sector embarked on massive reforestation programmes. Funds were made available from government appropriations, private sector initiatives, and loans from the World Bank, Asian Development Bank, and bilateral agreements with Japan and New Zealand (La Cruz).

Leyte island is the 8th largest of the Philippines islands, located in Region 8, Eastern Visayas. It comprises Leyte province and Southern Leyte province. Leyte's population was recorded at 1,592,336 in May 2000, with a population density of 280 persons per square kilometre. The island has an area of 568,469 hectares. The interior of Leyte is dominated by rough, mountainous terrain. (Philippines Geography). In the province of Leyte 49% (278,550 ha) of the land is classified as forestland with a slope of greater than 18 %. About one third of that area shows a slope between 30 % and 50 % and another 10 % can be classified as very steep having slopes of fifty percent and above. Approximately 25% of these steep areas suffer from severe erosion and 20% have shallow soils. Even though nearly half of the land of Leyte is classified as forestland based on its slope, only 10% was actually covered by trees in 1992. Most of the deforested area was used for coconut plantation. Shrub and grasslands covered nearly one third of the land, while rice reached 15 % (Dirksmeyer).

Settlement within forestland is illegal even though this area is not completely forested. Under the theoretical assumption that there are no illegal settlers within forestland, Leyte's population would live mainly on the remaining 51% within a narrow belt along the coast. This would lead to a corrected dramatic value for population density of 549 persons per square kilometre.

55% of the households in Leyte depend on agriculture and fishing to make their living. Only about 6% of households are primarily engaged in fishing, however, additional fishing activities for home consumption are common. Marine resources have been depleted due to dynamite and poison fishing (CATAD studies).

The average annual family income (1997) stands at PhP 66,000. Poverty is a major concern on Leyte: The poverty incidence of families is 41% (CATAD studies). The island belongs to the 44 poorest of the 77 provinces in the Philippines. Regarding the Gini Coefficient for Leyte the extend of poverty becomes even more obvious: Leyte ranks after the province Zamboagna del Norte on second place with a Gini Coefficient of 0.5220 (National Statistical Coordination Board). The average household is in urgent need of cash income to cover daily needs and other expenses, particularly the education costs of children. With all income spent on daily

needs, there are hardly any savings for investments or unforeseen expenditures. Those households receiving remittances from members working in Manila or abroad are usually better off. However, not all remittances arrive regularly (CATAD studies).
Limited availability of, and access to, suitable agricultural land are in many places the main reasons for people to adopt shifting cultivation practices on forestlands in Leyte. In addition, illegal logging is another way of mitigating income problems: Damage by illegal activities in forests also takes place on a larger scale and with the support of, and for the benefit of, government officials (CATAD studies). Institutional support for environmentally sound utilisation of natural resources is currently almost unavailable to the local population in Leyte (CATAD studies).

Leyte's main ecological problem is soil erosion (Philippines Geography). In Leyte the destruction of forests has caused erosion and soil degradation as well as the deterioration of watersheds. As a secondary effect of deforestation in Leyte off-shore siltation has to be mentioned (Dirksmeyer). In January 2004, landslides in Southern Leyte claimed more than 200 deaths. The severity of landslides has been blamed on illegal logging (Agence-France Presse). Together with a lot of other negative effects, deforestation is pointed out as one of the reasons. In November 1991 a flood following a typhoon in Ormoc, Leyte in November 1991 killed more than 6000 people and left more than 50.000 homeless.

Facing problems of overpopulation, poverty, deforestation and soil erosion means to improve the efficiency of agricultural and silvicultural systems and to invest into rainforestation programmes. Various facts indicate that there is still a considerable potential for increasing agricultural yields and reforested areas. This analysis compares the above mentioned types of land-use systems for their economic feasibility.

2 The Cost-Benefit Analysis: Basics

Cost-Benefit Analysis is an instrument for policy advice and is used to evaluate projects from the viewpoint of economic efficiency. It is intended for projects, which are not driven by price mechanisms on markets but by political decisions. A Cost-Benefit Analysis can be described as the public counterpart to the investment analysis of a private firm. A CBA either determines the advantages and disadvantages of one single public project or ranks various projects according to their advantageousness. In order to do this, all positive and negative effects of a project are summoned and made comparable by listing them in monetary terms. Finally the net-advantage of every project is calculated. Only those projects should be recommended that have a positive net benefit (Olschewski).

The theoretical background of a CBA can be found in welfare theory. While individual households or firms are forced to maximize efficiency due to scarce resources, this is not always true for a public project that is driven by political decisions. So a CBA has the purpose to check projects for efficiency against the background of economic scarcity.

Important differences between a market analysis of a private firm and a cost-benefit analysis are first the way resources are allocated and second the way of evaluating project effects: Decisions about resource allocation of a private firm are driven by market prices but the decisions of a public project are driven by other agents like political goals or commitments. Firms use market prices to calculate project effects; a CBA requires the determination of opportunity costs and shadow prices (Hanusch).

In developing countries the boundaries between the division of private and public project evaluation are sometimes not so strong. Here, a CBA is not only used to evaluate public projects but also projects that could be organized by private entities. Reasons are either lacking efficiency of market allocation mechanisms or and this is more often the case, extensive state activities as investor, for example when private initiative is supported through provision of plant material, financed by a development cooperation agency (Olschewski). Important for the result of a CBA is a) the selection of effects that are included in the analysis, b) the question which parties should be allowed to decide on resource allocation and finally c) the way in which economic welfare should be measured: Only project impacts, that effect humans, are included in the analysis. The evaluation of public projects has to be based exclusively on the opinion of the individuals concerned and not on the opinion of third parties. Project evaluation is based on an individualistic point of view. All individual positive and negative benefit estimations are summoned and the net welfare change of a project is calculated. This means that, e.g. fiscal and institutional aspects are considered as constraints and are not dealt with as project impacts. If a project is not realised due to this kind of constraints, project benefits would have to be considered as opportunity costs of the respective restrictions (see chapter 3).

The area within which a CBA is valid has to be determined in space and time. A CBA is more often conducted on national or regional than on international level. Normally a CBA is restricted to a determined period, although even the estimation of effects on future generations is possible (Hanusch). Finally one has to consider the 'With-and-Without-Principle' while determining project impacts. The effects of a project can be defined as the difference between the situation with and without project. Here it is important to take into account that a situation without project is likely to change over a longer planning horizon. For example ongoing soil degradation in a situation without project should be taken into account in order not to underestimate positive project effects. Effects that are not caused by the project should not be included in the analysis (Hanusch; Olschewski). This CBA about different land-use systems in Leyte follows the structure given by Hanusch (See Fig. 1). It includes a short theoretical introduction on the beginning of each section.

Structure of a Cost-Benefit Analysis:

1. **Identifying the relevant constraints**
2. **Selecting feasible alternatives**
3. **Determination of project impacts**
4. **Discounting costs and benefits**
5. **Comparing costs and benefits of the selected alternatives**
6. **Considering risk and uncertainty**
7. **Final ranking of the alternatives**

Fig. 1: Structure of a CBA (Hanusch)

3 Identifying the relevant constraints

Selecting the alternative projects, it has to be taken into account, that natural and social constraints can prohibit certain parts of a project or projects as a whole. These constraints can vary in time and from country to country (Olschewski). They are either natural or have their origin in political or social agreements or laws. Eckstein classified the most important constraints, namely physical, financial, juridical, administrative and political constraints (Hanusch).

3.1 Physical constraints

The term 'physical constraints' includes the production functions, i.e. the technical and natural relations between production factors and the goods produced. Production factors are labour and capital. It has to be taken into account, that restrictions due to a lack of production factors in the domestic economy might be reduced or overcome by imports from foreign countries (Olschewski). In this context natural constraints play a major role. Precondition for the establishment of *Musa textilis*, *Cocos nucifera*, *Acacia mangium* and Rainforestation sites is that the specific requirements of the involved plants and trees are met.

3.1.1 *Musa textilis*

Abaca is a plant of the hot and humid tropics. The present zone of successful cultivation lies between approximately 4°S and 14°latitude. In the Philippines it is usually grown in regions below 400 m with a well-distributed annual rainfall of 2000–2200 mm, an average temperature of about 28°C and a relative humidity of about 80%. Abaca is easily damaged by strong winds; in the Philippines windbreaks and cover trees are planted in typhoon-prone areas. It grows best on well-drained loams, rich in organic matter and potash, and is sensitive to water logging (Brink).

Further constraints that hindered many small scale farmers to establish Abaca plantations could be observed in Leyte: These constraints were based on availability of market outlets, planting material and a lack of knowledge about Abaca provenance and growth practices. Often farmers grow indigenous wild Abaca varieties which yield weak fibre that easily breaks when tuxying (Netfirms). The period until first harvest (18 months) is sometimes considered as a drawback of Abaca. Some farmers neglect their plantations to tend more profitable crops or even take another job, and only come back when the Abaca plants are ready for harvest

(Westphal and Jansen). Hence farmers often do not adopt improved cultural practices to accelerate growth and underbrushing and weeding of the farm is usually done only during harvesting time (Netfirms).

Due to the rugged terrain of Leyte, some farmers have to carry the product over a long distance from the farm to the road. Then they either bring the fibre to the bailing centre with a rented vehicle or the fibre is picked up from the buyer for a lower price per kg. The potential production sites are often very far from the trade centres and road conditions are still poor. This situation can reduce economic attractiveness because producers receive a lower net price for their products due to high marketing costs. The absence of market outlets and competitive product prices is one of the major problems that hinder farmers' interest in Abaca production.

Mass propagated seedling material with tissue culture is too expensive for the majority of farmers. Therefore, Abaca is mostly propagated by slashing the corms of younger plants into pieces. Planting material is shared among neighbours. But still many farmers in Leyte fear the lack of plant material when the rehabilitation of a whole plantation has to be done (Netfirms).

Depending on the appearance of a stand Abaca plantations need fertilizer application. 100 t of fresh stalks and leaves of Abaca remove per hectare: 280 kg N, 30 kg P2O5, 517 kg K2O and 124 kg CaO. In established plantations NPK fertilizer should be applied before and after the rainy season. Fertilizers are too expensive for small scale farmers in Leyte and many Abaca plantations become unproductive after 20 years (pers.comm. Guarte, Coconut Research Centre). In Central America for example sodium nitrate is applied 3-4 times per year at an annual rate of 450 kg/ha (Brink).

A further drawback of Abaca lies in the processing procedure: To extract the fibres, the leaf sheaths have to be peeled off the pseudostem. In a process called tuxying, the strips of the leaf-sheaths containing the fibre are torn off. The tuxies are stripped to pull off the non-fibrous material. This is done either manually or with the help of a stripping machine on a turning spindle. Stripping Abaca manually is very hard work and manually extracted fibre gets lower prices than spindle stripped fibre. A single farmer cannot afford such a stripping machine since it costs around 1200 US$. Some farmers in Leyte organized themselves into communities to share the investment, although the majority of farmers rent a machine from the landowner and pay a fixed amount per kg Abaca fibre for the service.

3.1.2 *Cocos nucifera*

Coconut requires an equatorial climate with high humidity. The ideal mean annual temperature is 27ºC with 5-7º diurnal variation. The palm does not withstand prolonged spells of extreme variations. A well-distributed rainfall of 1300-2300 mm per annum is preferred. Coconut is grown in different soil types such as strongly weathered, coastal sandy, alluvial, and also in reclaimed soils of the marshy lowlands. It tolerates salinity and a wide range of pH (from 5.0-8.0). It prefers sites with deep (not less than 1.5 m depth) well drained soils. Shallow soils with underlying hard rock, low-lying areas subject to water stagnation and heavy clayey soils are avoided (Kerala Agricultural University). Altogether *Cocos nucifera* has very wide amplitude of acceptable site conditions. It is not likely that coconut will not grow well in the lowlands of Leyte. A major problem linked with the Philippines' coconut resources is that the palm plantations are increasingly overaged: In 1983, 25 to 30% of coconut trees were estimated to be at least sixty years old; by 1988, the proportion had increased to between 35 and 40%. Planting material of high yielding varieties is scarce, also on Leyte (pers. comm. Dr. R.C.Guarte, Philippines Coconut Industry).

3.1.3 *Acacia mangium*

Acacia mangium occurs in areas along the boundary of the tropical warm and hot climatic zones, either humid or wet. The temperatures are high and equable throughout the year. The mean maximum of the hottest month is 21-23°C and the mean minimum of the coolest 14-22°C. Despite the high mean minimum, the daily maximum temperature rarely exceeds 28°C. The area is virtually frost free. The mean annual rainfall is between 1400-2000 mm. The seasonal distribution is monsoonal or shows a strongly-developed summer maximum with January-March very wet. The driest months are July-October, each averaging over 30 mm. *Acacia mangium* grows preferably on metamorphic, granitic, and acid volcanic formations of the foothills of coastal ranges and on sandy or loamy alluvium of coastal plains. The soils are acid grey-brown podzolics, red and yellow friable earths, and loams of moderate to low fertility. *Acacia mangium* is unlikely to grow well on sites where there is a severe period of drought, incidence of frost or high soil pH (Turnbull).

3.1.4 Rainforestation

The site demands for a rainforestation site are highly variable since they depend on the selected tree species. Precondition for the success of a forestation project is a suitable choice of trees adapted to climate and soil conditions. Some of the trees growing in the demonstration farm of Leyte State University are *Samanea saman, Artocarpus blancoi, Melai dubia, Swietenia mahagony, Casuarina equisetifolia, Dipterocarpus validus, Shorea contorta, Litsea leytensis, Sandoricum koetjape* and *Artocarpus heterophylla*. The foreign tree species *Gmelina ordorata* failed: In 1993, the demonstration farm site was damaged by a typhoon and mainly the exotic species like *Gmelina arborea* have been destroyed while the local species were more adjusted to strong winds and torrential rains. Foreign species are also more susceptible to damages by insects: a moth attacked the Gmelina plants. Hence the hypothesis was developed that a rainforestation farming system in the tropics is increasingly more sustainable the closer it is in its species composition to natural forest (Goelthenboth et al.).

Until now, the mass production of propagation material of native tree species is considered as being difficult; especially the seed availability and the seed storage of the recalcitrant Dipterocarp species give problems. Additionally there is still a lack of knowledge in nursery technique because of the large number of different tree species (Schulte).

3.2 Financial constraints

Political decisions determine the budget of public projects. One problematic issue is that statements regarding project costs might only be possible right after finishing the analysis. Nevertheless, projects have to remain within the budgetary framework given by the political decision makers. Should a CBA come to the result that the project exceeds the financial constraints but that it generates a particular high net benefit at the same moment politicians have to decide whether to increase the budget or not (Olschewski).

In this case the three alternative land-use systems are already implemented and a GTZ project to promote the most profitable alternative on a large scale is not yet planned. Hence there is no budged that has to be kept. This analysis just gathers information about the costs of the three systems. Regarding the role of small scale farmers, financial constraints play a major role for them. It seems that although the supply of Abaca cannot meet the demand and prices for fibre are still rising, the establishment of extensive Abaca plantations is hindered by the disability of the farmers to invest into seedling material and maintenance. Since establishment and maintenance costs are relatively high a plantation takes five years to pay off. This hinders small scale farmers to invest into plantations larger than 1 to 1.5 ha (Brink). This analysis could come to the conclusion, that a *Musa textilis* plantation is that profitable that financial support for farmers is strongly advised to overcome their financial constraints. In general, credit facilities for small scale farmers are not available on Leyte (CATAD studies).

3.3 Juridical constraints

When planning and implementing public projects, the legal framework of the particular country has to be obeyed. This framework consists for example of property rights, environmental protection laws, building regulations, etc. Projects violating national law have to be rejected (Olschewski).

In Leyte 52% of the total land area are officially classified as forestland (Eastern Visayas Sharing Network). Settlements or agriculture are prohibited within forestland. Settlement within forestland is illegal even though this area is not completely forested. Illegal settlers in Leyte suffer from constant uncertainty. Even legal settlers, for example tenants on non forest land are hesitant to engage in Abaca production since they are dependent on the decisions of the landowners (Networks).

A further juridical constraint strongly affects the profitability of the rainforestation project: Harvesting logs even on private land is only allowed for personal use and this requires a permit. The permit costs around 1 US$ per tree and half a US$ for one stem of coconut lumber. Here, a non-corrupt structure of the civil service issuing these permits is important, otherwise an additional administrative constraint would arise. The sale of logs cut in the forest is not allowed. This restriction is partially bypassed: Since it is possible to sell ‘second hand timber’, temporary houses are built, torn apart after a few weeks and the timber is finally sold (per. com. Ed Mangaoang). A better way for the adopters of rainforestation farming to legally harvest the trees they planted was to apply as an ‘Integrated Social Forestry Programme, ISF’. This was the stewardship agreement to meet certain criteria set by the Department of Environment and Natural Resources (DENR). The adaptors also had to register the reforested areas and the amount of planted seedlings or saplings at the DENR (Dirksmeyer). ISF does not exist anymore. It has been replaced by “Community based forest management agreement” (CBFMA), which is awarded to peoples organisations. This is a complex procedure involving a survey of the area, a forest inventory, forest management plans, annual workplans. It can then include "resource utilisation permits" RUPs, which determines annual allowable cuts. CBFMA is different from a certificate of stewardship contract (CSC) which is a contract with an individual with similar contents. Then again there is the possibility to register private forest plantations, which will then later entitle to cutting permits. This procedure is sufficient for rainforestation, if it is on private land (A&D), otherwise a CBFMA or CSC has to be obtained.

3.4 Administrative constraints

Constraints of this type are mainly related to the capacity and capability of adequate authorities. In this case the third alternative, the rainforestation project needs adequate training for the farmers since selection of tree species and the order in which these species should be planted decides over failure or success. This requires instructional work which has to be delivered by the local foresters or environmental and development agencies.

3.5 Political constraints

The goals aimed at by a specific project can differ from the goals formulated by politicians. A project could be rejected when its effects are not in line with these political aims. Considering public projects, certain qualitative and quantitative minimum requirements might be set by the political decision makers, with the result that projects, which do not fulfil those minimum conditions, have to be rejected during project planning (Olschewski).

Referring to the land-use alternatives in Leyte, none of these alternatives contradicts political guidelines. The only thing to be mentioned is the difference between approaches of the DENR as state institution, who promotes the use and planting of fast growing, exotic species for rapid reforestation; and the GTZ as foreign development aid organization, who follow tendencies of their own governments and focus more on close-to-nature approaches and the use of native species. Both approaches are accepted in the country and the two institutions tolerate the respective differences.

4 Selecting feasible alternatives

The quality of a cost-benefit analysis and its result depends strongly on the selected alternatives. Among the suggestions for project alternatives the ones which seem to be most profitable and which are not inflicting with the constraints should be selected for the analysis (Hanusch).

Table 1 gives a rough idea about the agricultural situation in the Eastern Visayas and presents production volumes of important agricultural products in Eastern Visayas in 1999.

Table 1: Volume of Production By Crops, Eastern Visayas (1999, in metric tons)

Crop	Volume (mt)
Coconut (nuts)	1,674,935
Sugarcane	625,432
Rice	461,397
Banana	127,110
Carnote	97,835
Cassava	59,464
Corn	45,813
Abaca fibre	31,783
Pineapple	4,842
Mango	176

Source: DA - 8, PMED & Bureau of Agricultural Statistics, Region – VIII (Da Amas)

In 1992 203,017 hectares of the land area of Leyte were covered with coconut plantation (Dirksmeyer). Since Leyte has a size of 571,280 ha, coconut plantations cover 35,5 % of the total land area (See table 2). In 1992 Abaca was grown on 15,601.4 hectares, this equals 2.73 % of Leyte's land area (FIDA).

Table 2: Land use in Leyte referred to area

Land use	Area [ha]	Area [%]
Coconut Plantation	203,017	35.5
Shrub and Grassland	165,555	29.0
Rice	84,277	14.8
Forest	59,450	10.4
Other Agriculture	44,754	7.8
Miscellaneous	14,227	2.5
Total	571,280	100.0

Source: Dirksmeyer

The extensive amount of coconut plantations in Leyte explains why Abaca is mostly planted under coconut. Abaca plantations beneath coconut are a common sight on Leyte, especially along the road from Baybay to Tacloban. Therefore this alternative was selected for the financial analysis of a CBA.

Using a mix of forest trees, mainly fruit trees, was also practiced fairly often. Concrete figures about the area planted with the various combinations between Abaca and shade trees are not available. Especially the alternative of Abaca in combination with *Acacia mangium* seemed to be highly profitable, although this combination seems to play a minor role in Leyte. It was also selected for the analysis. Interesting question for this CBA is whether the less important combination of Abaca – acacia is more profitable than the commonly planted Abaca – coconut alternative.

Forest Lands were once the most important natural resource in Leyte. Due to the depletion of forests from 42% in 1939 to 12% in 1987 soil degradation in terms of nutrient leaching and direct soil losses through erosion are a major problem in Leyte. Downstream this results in off-shore siltation and sudden temporary flood catastrophes like in Southern Leyte in January 2004. Figures from Southern Leyte province indicate that 76% of designated forest land is under agricultural production. Limited availability of suitable agricultural land and illegal logging are the main reasons for forest destruction on Leyte (CATAD studies). An extensive establishment of rainforestation sites could slow down soil erosion or even restore some of Leyte's forest. Whether the introduction of 'rainforestation farming' on large scale will be successful depends to a high degree on its profitability. Behind the campus of LSU the institute for forestry had successfully planted a rainforestation site 15 years ago. The project seemed not only advantageous from the ecological but also from the economic point of view. Hence a CBA of a rainforestation site was taken into account as third approach.

The following part gives an introduction on the plants and trees involved in the three different land-use systems, 'Abaca and coconut', 'Abaca and *Acacia mangium'* and the management of a rainforestation site. Dendrological facts about *Musa textilis*, *Cocos nucifera* and *Acacia mangium*, their distribution, propagation, and uses will be explained in detail. Emphasis is put on the amounts of production in the Philippines and Eastern Visayas. Further on, if available, the trends regarding these amounts and prices for products are given.

4.1 *Musa textilis* and *Cocos nucifera*

4.1.1 *Musa textilis*

Abaca belongs to the family Musaceae and is similar to banana in appearance except that the leaves are smaller, upright and narrower. Abaca provides an excellent source of fibre, cordage and pulp. Like banana, Abaca is also a major export good and plays a key role in strengthening the Philippines' economy (Bajet).

Origin:

Abaca (*Musa textilis*, Née) or Manila hemp in international trade is indigenous to the Philippines but has been introduced to Malaysia, Indonesia and Central America. The present zone of successful cultivation lies approximately between 5°S and 15°N latitude. Commercial cultivation is mainly concentrated in the Philippines and Ecuador and lately in Indonesia.

Trade and production, prices:

In the years between 1996 and 2000 the average annual world production of Abaca was about 98.000 t (Brink). The major producers were the Philippines with 72.000 t from 112.000 ha (Brink, Bajet). Ecuador produced 24.000 ha. In 1996-2000 an annual average of 33.000 t of Abaca fibre was traded internationally of which the Philippines exported 19.000 t, which equals 58% share on the world market. Ecuador exported 13.000 t. Main Importers of Abaca traded on the world market were the United Kingdom (15.000 t/year), the United States (8000 t/year), Japan (7000 t/year) and Spain (2000 t/year). The rest is shared by other countries like France, India, Korea, Canada, Italy, Belgium, the Netherlands, Egypt and Mozambique (Brink). The average annual export earnings of the Philippines from Abaca fibre and products in 1996-2000 were about 82 million US$. The domestic industry used 47,000 t of which 62 % were for pulp and paper making, 25 % for cordage and 13 % for fibre crafts. The production of Abaca fibre increased at the rate of 2.38% per annum (Da-Amas). The international and foreign demand for Abaca fibre is still increasing. This benefits the Philippines' economy, in particular with respect to foreign exchange earnings and employment (Westphal and Jansen). And the demand is expected to increase in the future even more: As technology evolves rapidly, more varied uses of Abaca are being discovered. In view of the growing environmental hazards posed by non–biodegradable materials, industrialized countries are beginning to consider more environment-friendly raw materials, such as Abaca (Brink).

At present the increasing demand is not met by the home industry of the Philippines (Brink). Table 3 gives prices per Abaca fibre. The grades 'S2', 'I', 'G' stand for high quality.

Table 3: Prices per kg of Abaca fibre by grade in Philippine Pesos

Grade	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
S2	17.81	23.34	26.58	28.09	26.97	27.83	29.38	26.54	27.98	32.76
I	17.76	23.32	26.60	28.31	27.14	27.36	27.39	26.67	27.80	32.69
G	14.72	18.09	20.33	23.26	22.95	24.66	25.27	22.35	23.60	26.92

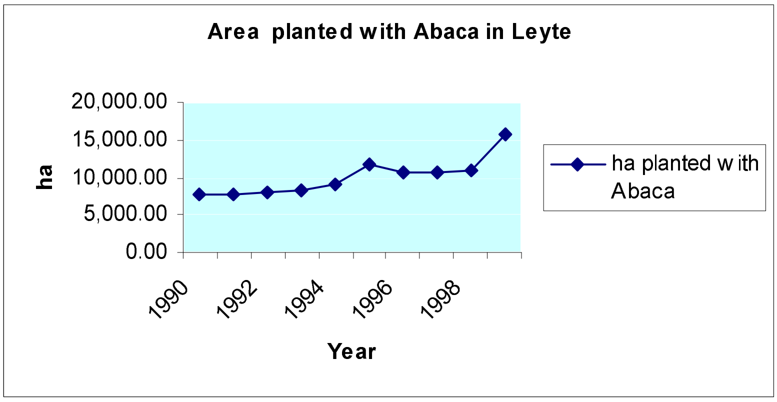
Source: FIDA

Eastern Visayas supplied the bulk of the product contributing 39% of the total production of the Philippines (Da-Amas). The next table shows the area planted in Leyte in hectares and the amount of production in metric tons.

Table 4: Area planted with Abaca and production in Leyte (ha and mt)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
(ha)	7,815.0	7,822.0	7,903.8	8,385.0	9,077.0	11,616.0	10,664.8	10,790.0	10,875.0	15,601.4
(mt)	8,251	7,296	6,068	7,198	5,209	4,798	5,995	6,751	7,265	6,922

Source: FIDA



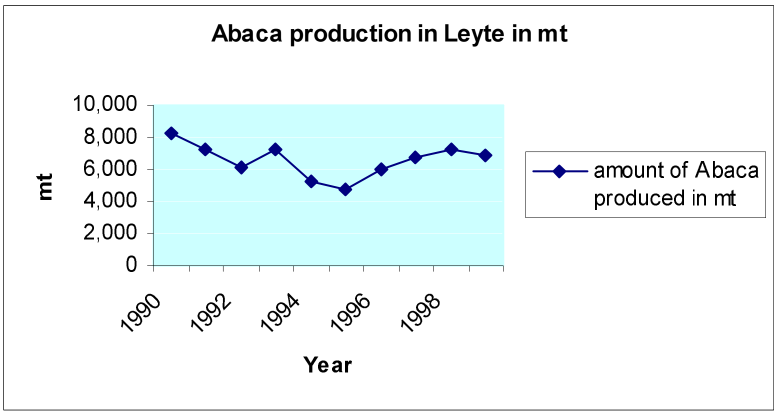


Fig. 2 and 3, area planted with Abaca and production in Leyte

Figures 2 and 3 illustrate the trends of production, based on the amounts given in Table 4. While the area planted with Abaca has doubled from 1990 to 1999, the amount of production stayed equal. Production sites lost in profitability. This is most probably due to a loss in soil fertility combined with a lack of financial resources for fertilizers and to some amount to the spreading Bunchy top disease.

Description:

Musa textilis is a tufted, perennial herb, up to 8 m tall, growing in a clump and looks very similar to *Musa musa* species. Its roots are all adventitious, arising from the corm. Pseudostems 2.5-6 m high, 15-20 cm in diameter at base, mostly green in colour, sometimes irregularly streaked deep brown, red, purple or even almost black towards the base, bearing up to 12 leaves. Inflorescence a drooping spike, consisting of bracts and flowers in axils of bracts. Fruit bunch horizontal, lax. Fruits narrowly ovoid or ellipsoid, 5-8 cm * 2-5 cm. Seeds are numerous and very irregular in shape, about 2-3 mm * 3-4 mm (Brink, 03).

Ecology:

Abaca is a plant of the hot humid tropics. In the Philippines it is usually grown in regions below 500 m with a well-distributed rainfall of 2000-3200 mm per annum, an average temperature of about 27°C and a relative humidity of about 80%. It grows best on friable well-drained loams, rich in organic matter and potash. It cannot stand waterlogging. It is easily damaged by high winds and windbreaks should be provided (Brink, 03).

Growth and propagation:

Emergence is completed 2-4 weeks after sowing, but vegetative development is very slow. Growth accelerates after 2-3 months. Flowering starts 18-24 months after planting. Time to fruit maturity ranges from 27-34 months under normal conditions but takes longer at higher altitudes. If not harvested before, the stem dies after the fruit has ripened.

Abaca can be propagated by suckers, corms or seed. Propagation by seed is not recommended because the plants take 1-2 years longer to mature and are not true to type, since Abaca is highly heterozygous. The use of suckers and corms (or corm sections: ‘seed pieces’) is recommended for commercial propagation of Abaca. In the preparation of corms, care should be taken not to destroy the bud eyes. Mass propagation of Abaca is now done through in vitro culture. Tissue cultured Abaca plants are used in replanting programmes, especially in Bicol. Matured suckers intended as planting material are used as replants in vacant spaces in already established plantations, especially when sources of alternative planting material are quite far away.

In large-scale operations it is advisable first to establish an Abaca nursery to produce the necessary planting material. An Abaca nursery one ha in seize, planted in double rows spaced (2+1) m * 1 m will produce approximately 40000 ‘seed pieces’ after one year. This is enough to plant 15 ha on the square at a spacing of 2m * 2m. ‘Seed pieces’ are planted in 40-50 cm deep holes spaced 2 m * 2 m for ordinary- sized cultivars and 2 (-3) m * 3 m for more vigorous cultivars. Depending on spacing, planting method (square, triangular, double row) and cultivar planting densities vary between 2500 to 3800 plants/ha. Planting is best done at the onset of the rainy season. Planting cover trees, such as *Erythrina fusca, Albizia falcata, Leucaena leucocephala, Durio zibethinus, Lansium domesticum, Artocarpus heterophyllus Acacia mangium* or *Cocos nucifera* is recommended to provide shade since Abaca is easily damaged by excessive heat and strong winds. Intercrops such as upland rice, mungbean or other leguminous crops may be planted for additional income and to reduce soil erosion. On small farms in the Philippines, Abaca is normally planted irregularly between felled trees.

Shallow cultivation and ring weeding is carried out at 2-3 month intervals for up to a year. Underbrushing weeds and cutting dried leaves is done during the succeeding years at quarterly intervals before applying fertilizer and before harvesting. Drainage canals should be constructed to allow better aeration because Abaca cannot withstand waterlogged conditions. Dry and hanging leaves, shrubs and grasses are periodically removed by ring weeding, strip weeding or general weeding. Pruning and thinning are done by removing excess young suckers, leaving about 8 suckers per hill to mature every year to avoid overcrowding.

Fertilization:

In established plantations NPK fertilizer is applied before and after the rainy season, depending upon the appearance of the stand. (See chapter 3.1 Physical constraints, *Musa textilis* for details) Compared with other crops, Abaca requires minimal care and in most cases the plants are just left to grow at their own rate until maturity. The duration of profitable production varies according to cultivar and growing conditions. In properly maintained areas production may not decline for over 20 years (Westphal and Jansen). The annual fibre yield of Abaca ranges from 0.31-1.71 t/ha, averaging 0.56 t/ha depending on cultivar and location.

Harvest, yield and processing:

Abaca pseudostems are considered mature and should be harvested when the flagleaf (a rudimentary leaf, much reduced in size) appears, which precedes the appearance of the inflorescence. The first harvest depends upon the cultivar used, the environmental conditions and the cultural methods employed. Abaca grown at higher altitudes usually takes longer to mature than that grown at lower elevations. Under normal conditions the first harvest takes place 18-24 months after planting. Subsequent harvests are done every 3-4 months in favourable areas and every 5-7 months under less favourable conditions. Harvesting Abaca consists of topping the plant by cutting the leaf crown at the base of the leaf blades, and tumbling the topped pseudostems with a slanting cut near ground level (Brink).

Abaca fibre is contained from the vascular bundles of the leaf sheaths that form a thick pseudostem. In cross-section each leaf sheath consists of three layers: an outer fibrous layer with long and strong fibres, a middle layer which has partitioned air canals and contains a small quantity of weak fibre and an inner layer which does not contain any fibre. The fibre from the outer layer is the so called primary fibre used for industrial purposes. Freshly cut plant stems contain 93% moisture and 1.5 to 3% fibre (Brink).

The leaf sheaths are peeled off the pseudostem. In a process called tuxying, the strips of the leaf-sheaths containing the fibre are torn off. The tuxies are stripped to pull off the non-fibrous material. This is hard manual work which can be lightened by fixing the fibres between two blades and pulling the fibres that are wrapped around a powered spindle through these blades. The clean fibre is dried in the sun or air-dried under a roof. Dried Abaca fibres are packed in bales and properly graded according to length, degree of cleaning and colour before marketing. Hand stripped fibres are traded for a lower price than spindle stripped fibres. Abaca fibres are an excellent raw material for paper and dissolving grade pulps due to their low lignin, ash, silica and extractive contents, and high total cellulose content, all of which contribute to high pulp yield and low consumption of chemicals in the pulping and bleaching treatments. It has also a high pentose content which contributes significantly to the high bursting, folding and tensile strength of its pulp handsheet. Abaca fibre is far more resistant to decomposition in salt water than most other vegetable fibres. It is three times stronger than cotton and twice as strong as sisal fibres. The fibres have a length of 1 to 3 metres, the fibre cells are in average 4 to 8mm long and 13 to 29 µm in diameter with a lumen of 7 to 14 µm (Brink).

Diseases:

The most fatal diseases of Abaca are Bunchy top disease, Mosaic virus and Vascular wilt. The impact of the Bunchy Top disease in the near future is still unknown. Befallen areas suffered losses of 90% of the plant material. Insecticides to fight the transmitter *Pentalonia nigronervosa* are too expensive for the farmers and a loss of regulations towards the transport of plant material from infected places to other areas allows unlimited contamination. Breeding immune cultivars has not been successful so far (Bajet) (see chapter risk and uncertainty for details).

Uses:

The uses of Abaca are plentiful. The main product is the fibre, but other parts of the plant are utilized as well:

1. The leaves are used for chlorophyll extraction to produce chlorophyll dye for food and toiletry products. The dried and hanging leaves can be used as bedding medium for mushroom culture and for compost.
2. The stalk is the source of fibres. The tuxies are extracted from the outermost portion of the leaf-sheath and the extracted fibres can be used for following purposes:
    - Production of non-woven textile by degumming.
    - Raw materials in pulping for the paper industry to produce high quality papers. Pulp is exported for the production of several industrial products such as bank notes, tea bags, cigarette filters, meat and sausage casings, coating for polls, hospital gowns and surgical masks, high capacitor papers and others.
    - Sinamay weaving, for handicraft products, novelty items, flower arrangements, interior decoration and for the fashion industry.
    - Abaca is used for handicrafts like bags, hats, coin purses, slippers, decors and others.
3. The dried outer leaf-sheath (bacbac) can be used for further handicraft products such as bags, hats, vases and others.
4. The stripping waste can be used in the production of alcohol, growing medium for mushrooms, raw materials for handmade paper and as organic fertilizer or compost. Likewise, the sludge from alcohol extraction can be processed into waxes or used as organic fertilizers.
5. The corms are used as planting material while the remaining portion of waste can be used in the production of starch for industrial purposes (Moreno).

4.1.2 *Cocos nucifera*

Origin:

The coco palm plays an important role on a global scale as it provides food for millions of people and its uses are multiple.

Origin:

The coconut's origin is shrouded in mysteries, vigorously debated. According to Purseglove, the centre of origin of cocoid palms most closely related to coconut is in north western South America. At the time of the discovery of the New World, coconuts (as we know them today) were confined to limited areas on the Pacific coast of Central America, and absent from the Atlantic shores of America and Africa. Coconuts drifted as far north as Norway are still capable of germination. The wide distribution of coconut has no doubt been aided by man and marine currents as well.

Trade and production, prices:

The Philippines is the world's second largest producer of coconut products, after Indonesia. In 1989 it produced 11.8 million tons. In 1989, coconut products, coconut oil, copra (dried coconut), and desiccated coconut accounted for approximately 6.7% of the Philippines' exports. About 25% of cultivated land was planted in coconut trees, and it is estimated that between 25% and 33% of the population was at least partly dependent on coconuts for their livelihood. About 80% of local coconut production goes to the export market with the remaining 20% to the domestic market. Coconut oil (crude and refined), copra, copra meal and desiccated coconut are the country's traditional coconut product exports. Coconut oil exports account for 85-95% of the total coconut exports by volume and 80% by value.

More recent figures from the Bureau of Agricultural statistics show that in 1999 the Philippines coconut production was slightly overtaken by India's production (See Table 5). Production from 1997 to 1999 showed a decline of 13.3%, this decrease in production may be due to the prolonged effects of the El Niño phenomenon. 1999 accounts to a total production volume of 10,503,000 metric tons, this figure is the lowest production figure on record (Coconut Industry Report).

Table 5: World Coconut production, 1995-1999 ('000 metric tons)

Country	1995	1996	1997	1998	1999
World	45,068	47,733	49,354	47,696	47,482
Indonesia	13,868	14,138	14,710	14,710	13,000
Philippines	12,183	11,368	12,118	10,905	10,503
India	8,000	9,649	9,800	10,000	11,100
Sri Lanka	1,997	1,935	1,999	1,999	1,850
Thailand	1,465	1,410	1,430	1,430	1,372
Vietnam	1,000	1,318	1,400	1,271	1,138
Mexico	1,201	1,179	1,234	1,102	1,302
Malaysia	1,043	967	967	967	711
PNG	700	777	734	734	734
Brazil	950	660	660	649	753
Others	4,544	4,382	4,367	4,341	4,522

Sources of Tables 5 and 6: Bureau of Agricultural Statistics (BAS-DA) in: Coconut Industry Report

Historically, the Southern Tagalog and Bicol regions of Luzon and the Eastern Visayas were the centres of coconut production. In the 1980s, Western Mindanao and Southern Mindanao also became important coconut-growing regions. On a per island basis, Mindanao accounts to a 58.48% share of the total production in 1999. The figures for Visayas and Luzon are 21.6% and 19.88% respectively. Top producing regions in 1999 are Southern Mindanao, Eastern Visayas and Southern Tagalog (Coconut Industry Report).

Table 6: Philippine Coconut Production, 1995 - 1999 ('000 metric tons)

Region	1995	1996	1997	1998	1999
Philippines	12,183	11,368	12,118	10,905	10,503
Ilocos Region	78	80	82	83	70
Cagayan Valley	31	42	43	37	32
Central Luzon	2	3	3	3	3
Southern Tagalog	1,791	1,571	1,943	1,853	1,522
Bicol Region	704	598	723	642	459
Western Visayas	229	264	274	246	280
Central Visayas	358	400	412	347	348
Eastern Visayas	797	806	1,113	1,228	1,645
Western Mindanao	1,560	1,379	1,431	1,329	1,257
Northern Mindanao	488	474	476	508	401
Southern Mindanao	4,472	4,168	4,038	3,097	2,818
Central Mindanao	504	447	417	374	340
ARMM	932	915	943	906	438
Caraga	236	221	219	253	889

Source: Coconut Industry Report

The average farm gate price for matured coconut from 1995 to 1998 exhibited an increasing trend from PhP 1.71 to 2.97 per nut. This uptrend is also the case at the wholesale and retail level (Table 7) (Coconut Industry Report).

Table 7: Yearly prices for matured coconuts in PhP per kg

Year	1995	1996	1997	1998	1999
Farm gate	1.71	2.42	2.43	2.97	na
Wholesale	4.73	5.52	6.50	6.89	na
Retail	5.14	5.85	6.11	6.94	na

Source: Coconut Industry Report

Description:

Cocos nucifera is a palm, up to 27 m or taller, bearing a crown of large pinnate leaves; the trunk is stout, 30-45 cm in diameter, straight or slightly curved, rising from a swollen base surrounded by a mass of rarely branched roots. The leaves are 2-6 m long, pinnatisect, leaflets are 0.6-1 m long, narrow, tapering. The inflorescence grows in the axil of each leaf as spathe enclosing a spadix 1.3-2 m long, stout, straw or orange coloured, simply branched. Female flowers are numerous, small, sweet-scented, the fruit is ovoid, 3-angled, 15-30 cm long, containing one single seed. Inside the wall of the endocarp is the testa with a thick endosperm, the coconut meat; the embryo is below one of the three pores at the end of the fruit, cavity of endosperm filled in unripe fruit with watery fluid, the coconut water, and only partially filled when ripe. Many classifications have been proposed for coconuts, none is wholly satisfactory. Variations are based on height, colour of plant or fruit; size of nut (some palms have very large fruits, others have large numbers of small fruits); shape of nuts, thickness of husk or shell; type of inflorescence; and time required to reach maturity. Many botanical varieties and forms have been recognized and named, using some of the characteristics mentioned above. Cultivars have been developed from various areas. Dwarf palms occurring in India are introductions from Malaysia, live about 30-35 years, thrive in rich soils and wet regions, flower and fruit much earlier than tall varieties, and come into bearing by the fourth year after planting. However, dwarf varieties are not grown commercially, and only on a limited scale because of their early ripening and tender nuts, which yield a fair quantity of coconut water. They are highly susceptible to diseases and are adversely affected by even short periods of drought. Tall coconuts are commonly grown for commercial purposes, 40-90 years, are hardy, and thrive under a variety of soil, climatic, and cultural conditions. They begin to flower about 8-10 years after planting (Duke).

Ecology:

Coconut has been reported to tolerate high pH, heat, insects, laterites, low pH, poor soil, salt, sand, and slope. (See chapter 3.1.2 Physical constraints, *Cocos nucifera*)

Growth and propagation:

Coconuts are propagated by seedlings raised from fully mature fruits. Seeds are selected from high-yielding stock with desirable traits. The yield of copra is the final criterion, based on size and number of nuts per palm. Seed-nut trees should have a straight trunk and even growth, with closely spaced leaf-scars, short fronds, well oriented on the crown, short bunch stalks, and from palms growing under normal rather favourable conditions. Also the inflorescence should bear about 100 female flowers, and the crown should have a large number of fronds and consequently of inflorescences. Seed-nuts should be medium-sized and nearly spherical in shape; long nuts usually have too much husk in relation to kernel. Because male parent is unknown and because female parent is itself heterozygous, seed-nuts from high-yielding palms do not necessarily reproduce same performance in progeny; so that character alone has limited value. Records are kept of fruits harvested from each mother palm, such as number of bunches, number of nuts, weight of husked nuts, estimated weight of copra (about one-third weight of husked nuts being considered favourable). After fully mature nuts are picked, and not allowed to fall, they are tested by shaking to listen for water within. Coconuts which are under-ripe, spoiled, those with no water, or with insect or disease damage are discarded (Duke). Nuts are planted right away in nursery or stored in a cool, dry, well-ventilated shed until they can be planted. Seeds planted in a nursery facilitate a selection of the best to plant in the field, as only half will produce a high-yielding palm for copra. Also, watering and insect control is much easier to manage in a nursery. Soil should be sandy or light loamy, free from waterlogging, but close to a source of water, and away from heavy shade. Nursery beds should be raised about 22 cm, and long, separated by shallow drains to carry away excessive water. In preparation of nursery beds, they should be dug and loosened to a depth of 30 cm. Nuts spaced in beds 22 x 30 cm, a hectare of nursery accommodating 100,000 seed-nuts. Nuts planted horizontally produce better seedlings than those planted vertically. The germinating eye is placed uppermost in a shallow furrow, about 15 cm deep, and soil mounded up around, but not completely covering them, leaving the eye exposed. Soaking nuts in water for 1-2 weeks before planting may benefit germination; longer periods of soaking are progressively disadvantageous. Bright sunlight is best for growing stout sturdy seedlings. Regular watering in nursery is essential in dry weather, amount and frequency depending on local conditions.

About 16 weeks after the nut is planted, the shoot appears through the husk, and at about 30 weeks, when 3 seed-leaves have developed, seedlings should be planted out in permanent sites. Rigorous culling of seedlings is essential. All late germinators and very slow growers are discarded. Robust plants, showing normal rapid growth, straight stems, broad comparatively short dark-green leaves with prominent veins, spreading outward and not straight upward, and those free of disease symptoms, are selected for planting out. Best spacing depends upon soil and terrain. Usually 9-10 m on the square is used, planting 70-150 trees/ha; with triangular spacing of 10 m, 115 palms/ha; and for group or bouquet planting, 3-6 palms planted 4-5 m apart. Planting holes of 1 m wide and deep should be dug 1-3 months before seedlings are transplanted. In India and Sri Lanka, 300-400 husks are burned in each hole, providing 4-5 kg ash per hole. This is mixed with topsoil. Two layers of coconut husks are put into bottom of hole before filling with the topsoil mixed ash. Muriate of potash, 1 kg per hole, is better than ash, but increases cost of planting. The earth settles so that it will be 15-30 cm below ground level when seedling is planted. In planting, soil should be well-packed around nut, but should not cover collar of seedling, nor get into leaf axils. As the plant develops, the trunk may be earthed up, until soil is even with general ground level. Young plantations should be fenced to protect plants from damage from cattle, goats, or other wild animals. Entire areas may be fenced in, individual trees, or, as in Sri Lanka and southern India, piles of coconut husks are placed around each tree. At the end of the first year after transplanting, vacancies should be filled with plants of same age held in reserve in the nursery. Also any slow-growers, or disease damaged plants should be replaced. During the first 3 years, seedlings should be watered during drought, an application of ca 16 litres/tree twice a week being recommended. Trees have to be kept clear of weeds, especially climbers. A circle 1-2 m in radius should be weeded several times a year (Duke).

Fertilization:

Usually the cheapest form of fertilizer materials for a given area is used. A recommended dosage of fertilization is for example 230-300 g N, 260-460 g P_2O_5, and 300-670 g K_2O per palm. Application of lime is not generally recommended. There is no evidence that salt is beneficial as is sometimes claimed. Coconuts can withstand a degree of salinity, about 0.6%, which is lethal to many other crops. Palms seem to need some magnesium, but are extremely sensitive to excess magnesium. Altogether the cultivation depends on soil type, slope of land, and rainfall distribution (Reed).

Harvest, Yield and processing:

Trees begin to yield fruit in 5-6 years on good soils, more likely 7-9 years, and reach full bearing fruit maturity in 12-13 years. The fruit ripens in 8-10 months. Nuts must be harvested fully ripe for making copra or desiccated coconut. Coconuts are usually picked by human climbers, or cut by knives attached to the end of a long bamboo pole, this is the cheapest method. With a pole, a man can harvest nuts from 250 palms in a day, by climbing, only 25. In some areas nuts are allowed to fall naturally, and collected regularly. Nuts are husked in the field, a good husker handling 2,000 nuts/day. Then the nut is split, (up to 10,000 nuts per working day). Copra may be cured by sun-drying, or by kiln-drying, or by a combination of both. Sun-drying requires 6-8 consecutive days of good bright sunshine to dry the meat. Drying reduces the moisture content from 50% to below 7%. Copra is stored in a well-ventilated, dry area. Extraction of oil from copra is one of the oldest seed-crushing industries of the world. Coconut cake is usually retained to feed domestic livestock. When it contains much oil, it is not fed to milk cows, but is used as fertilizer (Duke). For copra, an average of 6,000 nuts is required for 1 ton; 1,000 nuts yield 500 lbs. of copra, which yields 250 lbs. of oil. Average yield of copra per ha is 3-4 tons. Under good climatic conditions, a fully productive palm produces 12-16 bunches of coconuts per year, each bunch with 8-10 nuts, or 60-100 nuts/tree. Bunches ripen in about 1 year, and should yield 25 kg or more copra. Efficient pressing will yield from 100 kg of copra, approximately 62.5 kg of coconut oil, and 35 kg coconut cake, which contains 7-10% oil. The factor 63% is generally used for converting copra to oil equivalent. Yields of copra as high as 5 MT/ha have been reported, oil yields of 900-1,350 kg/ha (Duke).

Diseases:
Coconuts are subject to numerous fungal diseases, bacterial infections, and the most serious virus-like disease, cadang-cadang. Coconut trees are also attacked by numerous nematodes and some insect pests, the most damaging insect being the black beetle or rhinoceros beetle (*Oryctes rhinoceros*), which damages buds, thus reducing nut yield, and breeds in decaying refuse. Diseases and pests of a particular area should be considered and local agent consulted as to how to deal with them (Duke).

Uses: There are many uses for coconuts, coconut leaves or coconut lumber:

- The solid endosperm ('nut meat') is dried in the sun or in ovens fuelled by burning the husks, to produce copra which has been the main form in which coconut has been exported as it keeps well. It contains about 60-70% coconut oil, but the oil is slow to become rancid. Grated copra is used in confectionery.

- The liquid or solid endosperm is eaten or drunk raw, or used in a huge variety of recipes for cooked food.
- Coconut oil is extracted from copra and used in a variety of ways including in cooking, margarine and soaps. From about 1850 to 1950, coconuts were the main commercial source of vegetable oils. They were then overtaken by soybean and then by Oil Palm (*Elates*).
- Coconut milk is produced by mixing grated coconut with hot water, producing a milky-white liquid containing coconut oil and aromatic substances. The milk is used in a wide variety of Asian recipes. An acceptable easy solution to producing coconut milk in your kitchen is to mix desiccated coconut with hot water in an electric blender.
- Leaves are used for constructing shelters and are also used in weaving baskets, etc.
- Timber (called porcupine wood) used in buildings.
- Outer fibrous covering of the coconut (the mesocarp) used for producing coir matting and rope.
- Apical buds of old trees are canned as palm-hearts (cutting them off kills the tree).
- The axis of the inflorescence is tapped for palm juice, which when fermented produces palm wine, termed toddy (toddy is also produced from other palm genera as well). When evaporated, produces a crude sugar called jaggery (term also used for crude sugars produced from other palm species and from sugar cane). Toddy is distilled to produce the alcoholic spirit called arrack (Ethnobotanical leaflets).

4.1.3 Management of an Abaca and Coconut plantation

Managing Abaca beneath a shade cover of coconut is the same procedure as described above. There are no definite rules about the spacing of Abaca and coconut or the intervals of weeding or fertilization. This chapter serves to describe a system in an examplatory way for a better understanding of the calculations on in- and outputs in the next chapter. The way of management bases on suggestions of Mr. Diehl, GTZ office, Mr Mangaoang, Faculty of Forestry and Mr. Guarte, Coconut research Centre.

Since the land area of Leyte is already covered with Coconut by 35.5% there is most probably no need to plant Coconuts in the beginning. In case the Coconut-Abaca system is established on bare land, the area has to be cleared first. The spacing for coconuts should be 8 x 8 m, that corresponds to 156 trees per ha. The suggested spacing for Abaca is 2 x 2 m, corresponding to 2500 Abaca seedlings per ha. Coconut and Abaca can be planted at the same time. Copra can be harvested after 7 to 8 years, but it takes 12 years to reach full fruit maturity. The yield of coconut begins to decline after approximately 50 years, in the 60^{th} year the Coconut stems are harvested.

In the financial analysis it is assumed that Abaca has to be newly planted after 20 years, although in Leyte the process between harvest and planting reaches a constant flowing, steady state. Although first Abaca can be harvested one year after planting, a regular harvest to full extend is not possible before the 5^{th} year. Therefore farmers have to work somewhere else until significant revenues from Abaca are flowing in (Brink). This leads to neglect of the plantation. According to Brink, neglected farms produce lower yields of Abaca this is mainly due to a lack in weeding. The same problem exists in regard to fertilisation. Farmers in Leyte are too poor to pay for fertilizers and without fertilizer an Abaca plantation cannot be productive for longer than 20 to 25 years (pers. comm., Mangaoang). The financial analysis includes 30 working days annually for weeding and also costs for fertilizer.

4.2 *Musa textilis* and *Acacia mangium*

4.2.1 *Acacia mangium*

A. mangium has become a major plantation species in the humid tropical lowlands of Asia. Its success is due to its: extremely vigorous growth (annual wood volume increment of over 30 cubic metres per hectare on favourable sites); tolerance of very acid, low nutrient soils; ability to grow reasonably well where competition is severe, such as on Imperata grasslands; relative freedom from diseases; wood properties which potentially make it acceptable for a wide range of end uses; and ease of establishment (Forestry compendium).

Distribution:

Largely Australian with disjunctive distribution of small stands in New Guinea and the Moluccas, as well as in Cape York Peninsula. In Indonesia *A. mangium* occurs on Taliabu, the most western island, and Sanana, a southern island of the Sula Island Group and near Waesalan in the southwest of the main Ceran group. Introduced to Bangladesh, Cameroon, Costa Rica, Hawaii, Indonesia, Malaysia, Nepal, Papua, and the Philippines (Duke).

Trade and production:

On Leyte island, Paraclete community, a nursery was established and over 200 ha of acacias and eucalypts have been planted alone 1999 (Harrison). There are no data available about the total amount of *Acacia mangium* lumber produced in the Philippines nor worldwide.

Description:

Tree to 30 m tall, bole often straight, to over half the total tree height. Branchlets, phyllodes and petioles are glabrous or slightly scurfy. Phyllodes are 5–10 cm broad, 2–4 times as long as broad, dark green, chartaceous when dry. The phyllodes have (3–4) longitudinal main nerves which join on the dorsal margin at the base of the phyllode, secondary nerves fine and inconspicuous. Flowers in loose spikes to 10 cm long, solitary or paired in the upper axils. Flowers are pentamerous, the calyx 0.6–0.8 mm long, with short obtuse lobes, the corolla twice as long as the calyx. Pods linear, glabrous, 3–5 mm broad, ca 7.5 cm long when green, woody, coiled and brackish-brown when mature, depressed between the seeds. Seeds lustrous, black, ellipsoid, ovate or oblong, 3.5 x 2.5 mm, the funicle forming a fleshy aril beneath the seed. Dust from pods pounded during seed extraction causes a respiratory reaction in some people (Duke).

Ecology:

Often in grasslands and on margins of lowland primary forests at altitudes of 10–50 m. Probably capable of ranging from Tropical Very Dry to Moist through Subtropical Dry to Wet Forest Life Zones, this species has outperformed *Albizia falcataria, Gmelina arborea* (considered among the fastest-growing useful trees on earth, NAS, 1979), and *Pinus caribaea* on poor sites such as disturbed or burned sites, on degraded lateritic clay underlain with volcanic rock, on soils so worn out that even shifting cultivation had been abandoned, and on slopes infested with *Eupatorium* and/or *Imperata* species. Mangium apparently tolerates annual precipitation of 10 to 45 dm or more, mean maximum temperature of 31–34°C in summer, mean minimum temperature of 12–25°C in winter, and pH of 4.2–7.5 (NAS, 1983d). It is reported on entisols and ultisols. Hybridizes naturally with *Acacia auriculiformis*, producing hybrids which grow faster than either parent, but tending to retain the poor form of *A. auriculiformis* (Duke).

Growth and propagation:

Flowering and seeding commence at about two years of age under plantation conditions. One kg of seeds contains 80000 – 120000 seeds. Seeds must be pre-treated before sowing by immersing them in boiling (100°C) water for 30 seconds followed by soaking in cold water for 24 hours. The species is usually sown or transplanted at the 3-leaf stage into containers but may be amenable to direct sowing in the field if given weed control initially. Seedlings are ready for planting out after 16 weeks. Vegetative propagation of cuttings under mist has been successful although root formation is relatively slow. Preparation for planting may involve slashing Imperata grass or burning logging debris. Canopy closure without subsequent weeding will take about 2 years but will be more rapid if weeds are controlled during the first 6 months after planting and fertiliser is applied. Final spacing depends on variety: 7 x7 m to 10 x 10 m. (Turnbull).

Fertilizer:

Use of fertilizer at establishment varies. In Peninsular Malaysia, Mead and Miller (1991) recommended the application of 100 g of triple superphosphate (TSP)/tree at planting followed by a second application of 150 g TSP at 5-6 months on fertile sites and, on less fertile Imperata sites, N and trace elements in addition to TSP. On degraded soils deficient in N, P and K in South Kalimantan, Turvey (1995) found that the addition of NPK (180, 78 and 150 kg/ha was best) fertilizer was one of the keys to successful establishment of *A. mangium* (Duke).

Yield:

Soil depth and topographic position can influence yield in *A. mangium* as shown in the following table:

Table 8: Growth of *A. mangium* (8,7 years) on different soil classes at Jalan Lee, Sabah

	Mean height (m)	**Mean diameter (DBH)(cm)**
Skeletal	11	14,6
Hill creep	14,6	18,8
Sedentary	15,9	19,9
Hill wash	19,5	23,9
Alluvium	20,7	26,5

Source: Turnbull

The soil depth increases from the top to the bottom of the slope and although the altitudinal difference is only 100 m the volume production on the alluvium is almost double that on the skeletal catena (Turnbull). The following table shows the yield of *Acacia mangium* plantations in the Philippines.

Table 9: Predicted yields of *A. mangium* grown under industrial and farm silvicultural management regimes in the Philippines

Item	***A. mangium***	
	Industry	Farm level
Clear fall age	13	9
Total yield (m^3/ha)	322	76
MAI (m^3/ha/year)	25	8
Saw log yield (m^3/ha)	210	9
Rural house construction pole yield (m^3/ha)	91	51
Fuel wood yield (m^3/ha)	21	16

Source: Turnbull

Diseases:

There are problems with leaf insects. Specimens (ca 12%) in Sabah suffer from a heart rot and a "pink disease" (*Corticium salmonicolor*). Seedlings in Hawaiian nurseries are attacked by a powdery mildew (*Oidium* sp.). Three pinhole borers attack the tree in Sabah, especially on poorer sites. Carpenter ants (*Camponotus* sp.) form galleries in the heartwood of young trees. Wood borers of the genus *Xystrocera* may be a problem. Seedlings may be defoliated by *Hypomeces squamosus*. Scale insects and mealy bugs may also be problematic with young plants (Duke).

Uses:

Regarded first as a rather productive timber tree, secondly for firewood (specific gravity = 0.65). The hard, light-brown wood is dense, with narrow sapwood and a straight, close grain. It makes excellent particle board and could possibly be useful for furniture, cabinet making, and perhaps even pulp and paper. Capable of being directly sown, the tree appears quite promising for erosion control where adapted. Some success is indicated in the use of the species to correct the problem of the Imperata grasslands. Sabah foresters have converted 1,200 ha of degraded Imperata grassland into productive forest lands (Duke).

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4.2.2 Management of an Abaca and *Acacia mangium* plantation

Acacia mangium is initially planted with a spacing of 2 x 5 metres. Abaca is planted in the same year. Acacia has to be fertilized in the first and second year, in the 6th year the stand has to be thinned to a spacing of 6 x 5 metres. The harvested logs serve mainly for pulp production. For the following analysis it is assumed that acacia is harvested after 12 years. Some seed trees should remain on the plantation. Abaca is managed in the same way as explained before, again with a spacing of 2 x 2 metres.

4.3 Rainforestation

4.3.1 Rainforestation projects in Leyte

Since 1990 technologies have been developed at the Leyte State University (LSU), sponsored by the Philippine-German Applied Tropical Ecology Program, combining on local and community-based level the conservation and rehabilitation of the biodiversity of a given ecosystem with the need for food production and income generation (Goeltenboth et al.). The Tropical Ecology Program was founded to develop the techniques of 'Rainforstation Farming'. The concept behind the 'Rainforestation Farming' system aims "*...to replace the more destructive forms of kaining practices, form a buffer zone around the primary forest, protect their biodiversity, help maintain the water cycle, and provide farmers due to the continuously high production of fruits, root crops timber and other forest farming incomes with a stabile and higher income*" (Goeltenboth et al.).

At the beginning of the Tropical Ecology Program, a demonstration farm was established in the Forest Research Institute area in co-operation with the Department of Environment and Natural Resources and several departments at the Leyte State University, which contributed the experimental site. By the end of 1994, the concept was ready for implementation at the farmer's level, in 1995/1996 different plot sites in Baybay, Leyte could be developed following the concept of 'Rainforestation Farming'. So far, 'Rainforestation farming' has been developed in 24 'Rainforestation Farm' sites in the surrounding of Baybay and Ormoc with and average farm-size of about 1 ha. Excluding the exotic tree species, which were planted in the beginning of the project, the 'Rainforestation Farm' sites are planted with indigenous pioneer and light demanding tree species and after the first year of establishment, with shade-tolerant tree species e.g. trees of the Dipterocarpaceae. In the following part, the demonstration farm in the forest reservation of Leyte State University and another rainforestation site in Cienda are introduced.

The demonstration farm in LSU:

The demonstration farm is located inside LSU Forest Reservation and approximately 0.9 km from the highway in about 45 m height above see level. Before the ViSCA-GTZ Ecology program started to reforest this area it was used as coffee, cacao and banana plantation. The ground was mainly covered with grasses e.g. cogon grass (*Imperata cylindrica*) and some parts were used as pasture land for carabaos (Kolb). Before planting, the area was cleared completely except for banana plants, which were left for shade. The planting activities began in 1991 with initially planting only seedlings of such species, which could be risen in the nursery. Because of the very dense grass cover, firstly pioneer and light demanding tree species such as *Gmelina arborea*, *Samanea saman*, *Swietenia mahagoni*, *Melia dubia* were planted. A strong typhoon in December 1993 has broken many trees belonging to the pioneer species and it has been recognized that this affected mainly the exotic tree species, while the local species seemed to be more adjusted to strong winds and torrential rains. This led to a modification in the theory of the "Rainforestation Farming" project. It was decided to plant only indigenous tree species. The total area of the former "Closed canopy and high diversity forest farming" project, which included nursery areas, so called "gene bank areas" as well as so called "extension areas", is about 2.6 ha in size. The initial tree spacing was 1 x 1 m, since the mortality rate was about 50%, 5010 trees are left per ha. with about 901 different tree species per ha, composed of 431 pioneers, 349 shade lovers and 121 fruit tree species. Since some species are only represented by one or two individuals they will die out sometime. The slope corresponds to 5 to 10% and the elevation of the site is 90 m above see level. Rainfall is about 2621 mm per year with a monthly temperature of 27° Celsius in average; the drainage of the soil is well. The soil belongs to the group of Haplic Alisols. Erosion had been a problem before 1992, now there is little evidence. Domination pioneer trees are: *Samanea saman, Artocarpus blancoi, Melai dubia, Swietenia mahagoni and, Casuarina equisetifolia.* Dominating shade lovers are *Dipterocarpus validus, Shorea contorta and Litsea leytensis.* Dominating fruit trees are *Sandoricum koetjape and Artocarpus heterophylla.*

The rainforestation farming site in Cienda

The planting activities in Cienda started in March 1996 when 2.506 forest tree seedlings were planted on 0.97 ha. Out of this, 191 mortalities were reported. In July 2001, further trees were planted on the site. Up to know there are 5158 plants per ha, with 1316 different tree species. The slope is about 5%, the elevation is about 50 m above see level. Rainfall is 2621 mm per year, monthly average temperature is 27.4°Celsius. The initial tree spacing was 2 x 2 m, shade loving trees were added later with a spacing of 2 x 1 m. Dominant pioneer species are *Vitex parviflora, Terminalia microcarpa, Polyalthia glandulosa, Cratoxylum arboreum and Albizia lebbekoides.* Dominating shade loving trees are *Shorea contorta, Litsea leytensis, Parashora malaanonan and Podocarpus philippinensis.* Dominating fruit trees are *Artocarpus odoratissima and Psidium guayava.*

A critical aspect to both sites is the high amount of different tree species planted. with a high financial input. Many individuals are represented by one or two individuals and will die out later. Both sites are demonstration farms, therefore the high number of species served the purpose to gather knowledge about the performance of these species. When introducing a rainforestation site on farm level a reduced number of tree species would be more advantageous.

4.3.2 Management of a rainforestation site

The order in which trees should be planted depends on their growth class. Five different growth classes have been identified: the slow and the fast growing sun demanding trees, the slow and the fast growing shade requiring trees (e.g. Dipterocarpus) and medium growing shade demanding tree species (e.g. durian). The increment in diameter breast height of the fast and the slow growing sun demanding trees is assumed at 1 7 cm/year and 0.7 cm/year respectively (Whitmore, 1993), while it is also 0.7 cm/year for the fast growing shade demanding trees and 0.35 cm/year for the slow growing shade demanding trees. The annual increment of durian is assumed with 0.55 cm/year in diameter breast height (Dirksmeyer).

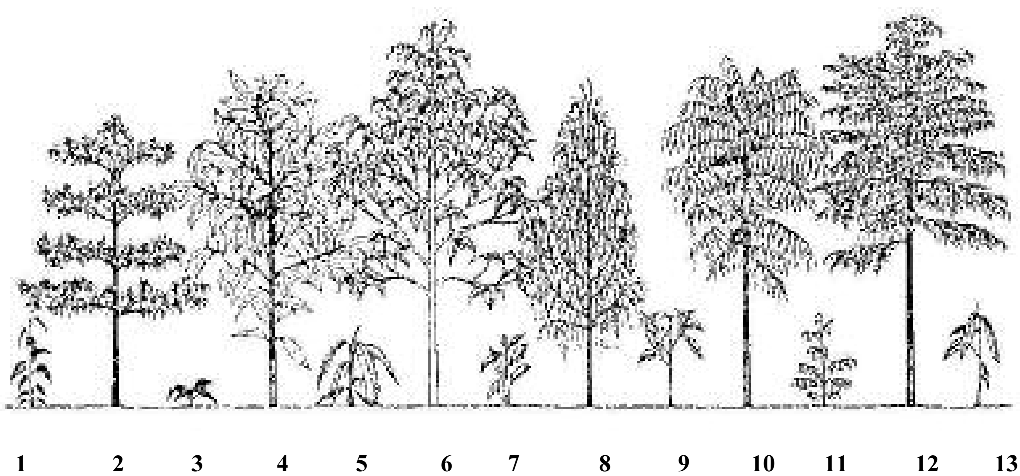
Before planting a rainforestation site, a nursery has to be established and the future rainforestation site has to be cleared of *Cylindrica imperata* for example. In the first year, fast growing and light demanding tree species (local species as well as exotic species (e. g. *Gmelina arborea*) are planted with a spacing of 2 x 2 m to close the canopy and to shade out the grass. The most important activity during the first years is the cutting of vines.

In the second year, shade-tolerant species as well as high priced hardwoods and fruit tree species are planted with a spacing of 2 x 1 m under the pioneer trees. Since non timber products, are playing an important role in the economics of rural people an enrichment with rattan, fruits, nuts or crops like e. g. bananas, cassava, sweet potatoes and vegetables in the second year after planting is recommended. The addition of shade-tolerant crops, e.g. climbing ubi, pineapples or Abaca and others is possible after the canopy has closed in the eighth year (Goeltenboth). Thereby the possibility and time of interplanting crops is strongly depending on the soil type and the growth performance of the trees. The yields of the intercrops may decrease depending on the density and the cropping scheme of the original stands of the crops and their light and space demands as well as on the light and space demands of the rainforestation farming seedlings.

In the third year shade demanding trees can be planted in-between at a distance of 3 x 3 m, for example 125 slow growing shade demanding and 375 fast growing ones. Additionally, 60 fruit trees, e.g. 30 mangosteens and 30 durians, will be planted at the same time. This results in 560 shade requiring trees. Depending on their availability seedlings of different species were added, at random arrangement in a way that each neighbouring tree was of a different species to build up a maximum diversity (Kolb).

In the fifth year approximately 50% of the fast growing trees will be cut and sold as firewood; so that the slow growing, sun demanding trees will get enough sun to develop good growth. Brach cutting should be done when fruit trees or trees with high value timber a suppressed. Otherwise it should be avoided; shade suppresses weeds and accelerate growth of trees Thereby the Dipterocarps and fruit trees should not get scarves. The remaining fast growing, sun demanding trees will be harvested 12 years after planting and sold as lumber. Fruits like Mangosteen and Durian can be sold on the market. (*Durio zibethinus* bears fruits after 8 years, Mangosteen 15 years.) Harvesting should be done when the trees reach a size of 40-50cm dbh. The first of the faster growing Dipterocarps can be harvested when they are five years old, which means in the eighth year after establishing the farm. Over a period of twenty years around 5 % of the initially planted faster growing Dipterocarps will be harvested per year Then the first 50 % (=62 trees) of the slow growing Dipterocarps will be harvested in the 18th year. The healthiest trees of each species should remain as seed trees. Only 10% of total trees should be cut per year and the gaps have to be replanted with seedlings immediately. Planting and harvesting activities should be done in a never ending chain after the system is established.

Fig. 4: Species composition of a “Rainforestation Farming” system with pioneer and light demanding trees planted in the first year as well as shade tolerant and fruit tree species planted in the second year,



1: Hopea malibato
2: Terminalia microcarpa
3: Garcinia mangostana
4: Calophyllum blancoi
5: Dipterocarpus validus
6: Vitex parviflora
7: Dipterocarpus kerii
8: Casuarina equisetifolia
9: Nephelium lappaceum
10: Dracontomelon dao
11: Shorea contorta
12: Melia dubia
13: Durio zibethinus
Source: Kolb

5 Determination of project impacts

The central issue of a cost-benefit analysis is the determination of project impacts. Hence the positive and negative project impacts have to be reported. This is a difficult task because there is a wide range of project impacts to be considered. One way is to regard the price changes or the quantity changes for certain goods caused by the project impacts. It is important to consider that every input of production factors in the project can be interpreted as a factor withdrawal and thereby decline of production elsewhere. The question is in which way the shortfall of production on the one side and the extra production on the other side can be evaluated. Because preferences of the effected population are considered to be of importance, the concepts of the consumer surplus (used in case of price changes) and the maximal marginal willingness to pay (used in case of quantity changes) can be used to value the altered production (Olschewski).

Large scale projects may have effects on market prices. In that case, project evaluation can be based on changes in consumer's surplus. Effects of smaller projects are minimal; they only have impacts on the quantity, but not on the market price for a particular good. A slight increase in Abaca, coconut or timber production in Leyte alone for example is unlikely to change the prices for these goods. In this case, the maximal marginal willingness to pay for a product is represented by the market price generated at the market equilibrium (Bergen et al.). Thus, individual economic subjects decide independently about demanded quantities (concept of consumer's sovereignty) within the scope of their possibilities. By doing so, they compare the price of a specific good with their marginal willingness to pay and accommodate the quantity demanded. Therefore, it is permitted to interpret the market price as a measure of utility and cost in the CBA, the latter in case of reduced quantities as a result of project measures. A problematic aspect linked with the consumer's surplus as a measure for utility is, that an equivalent transformation of monetary units in utility units is only possible under the assumption of a constant marginal utility of income. To determine the marginal utility, the intensity of individual utility changes has to be determined, and this is not possible. A second problem is that due to the ordinal character of utility summing up the individual positive and negative effects is also not possible. This problem can be avoided by choosing a constant utility level as reference standard (Olschewski).

5.1 Maximal marginal willingness to pay and consumer's surplus

The concept of maximal marginal willingness to pay and consumer's surplus is based on the assumption that households act in order to maximize their utility, always trying to draw the maximum utility out of a given budget. The maximal price households are willing to pay for a specified quantity is indicated on the demand curve which represents a price-quantity relationship.

Initially, regarding the first unit of a good, the willingness to pay is highest, and decreases for every additional unit. To determine the value of a particular good for the sum of all households, the situations with and without that good have to be compared. The situation without the good corresponds to an instance where the price of the good is perceived to be too high by the households, leading to renunciation regarding the consumption of that good (here, the actual quantity consumed equals zero (Point P_2^{max} in figure 5). The question arises, how the aggregate of all households values the difference between the situation without the good and the actual situation with the good X_2^0 in monetary units. Consequently, that particular amount of money is sought-after, which denotes the difference between the highest price P_2^{max}, the households are willing to pay for a good X_2, and the actual price P_2^0 of the good X_2, consumed by the households (see figure 5) (Bergen et al.).

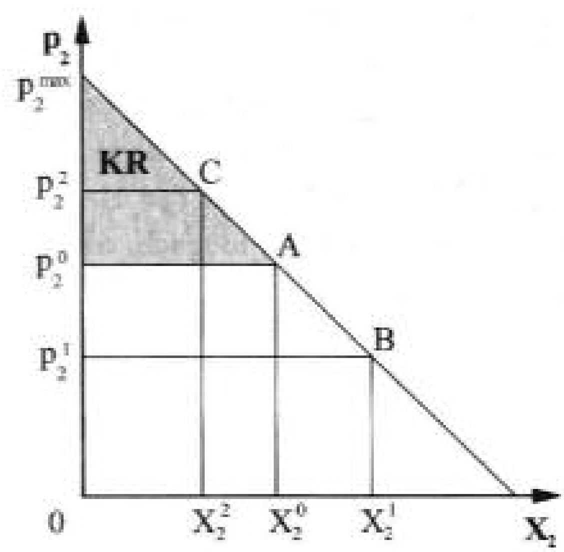


Fig. 5: Demand curve of maximal marginal willingness to pay and consumer's surplus (KR) Source: Bergen et al.

5.2 Market price

On the other hand producers have to be considered. They are assumed to act as profit maximizers, adjusting the supplied quantity by comparing marginal cost of production and product price. The supply of various enterprises aggregates horizontally to a single supply curve on the market. The supply curve, like the demand curve, represents a price-quantity relation. The variable of interest is the price, which coordinates demand and supply. If the market demand is confronted with the market supply, the market equilibrium is where the amounts of supplied and demanded goods are equal. This is represented in point E on the supply curve (see figure 6). At this particular point, demanders and suppliers agree to buy and sell the quantity X^* at the price P^*, respectively. At P^*, both sides of the market draw maximum advantages out of the trade, representing the reason why P^* is the prevalent market price.

The market price (P^*) at the market equilibrium (E) can be consulted for the assessment of the costs of various project alternatives, which reduce the available amount of the product X. A distinction between goods that are sold and goods that are consumed for subsistence needs is not necessary, which is justified by the assumption that self consumed goods could be sold or bought at the same market price (P^*) (Bergen).

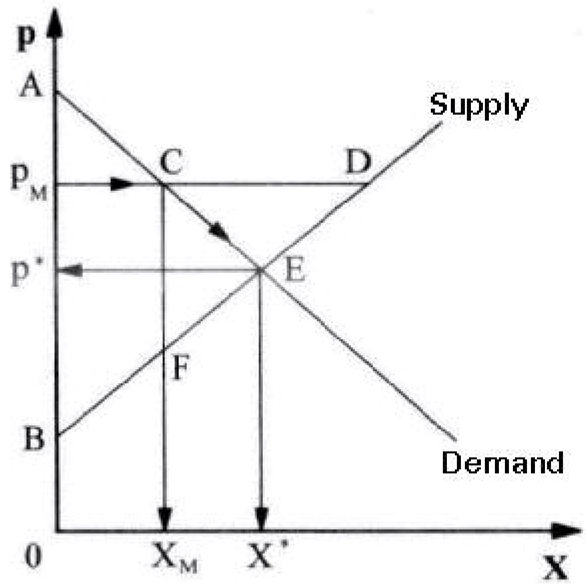


Fig. 6: Market equilibrium
Source: Bergen et. al.

5.3 Project effects through factor withdrawal and provision

Project evaluation in monetary terms can be problematic, if production factors are partially withdrawn or provided at preliminary production stages. Consequently, these preliminary products or inputs are not directly entering the production of consumer goods. This hinders an accurate assessment of the impacts of withdrawal or provision of production factors.

A possible option to render opportunity costs for production factors that are not traded on consumer-good markets is represented by the factor price. In order to be able to understand this approach, it is necessary to remember how profit-maximizing enterprises act on factor markets (Bergen et al.). Their profit maximizing condition is:

Factor price = marginal product in terms of value:

$$\mathbf{q = p \cdot \delta X_1/\delta V}$$

The factor price q can be seen on the left side, while the right side contains the product price p and the marginal productivity. The marginal productivity $\delta X_1/\delta V$ indicates how a change of one unit in the amount of input of production factor V affects the quantity produced of X_1. If the marginal productivity is multiplied by the price p, the result is the marginal product in terms of value.

The produced quantity of X_1 will diminish if one unit of the production factor V is withdrawn from the production. Contrariwise, the produced quantity is enhanced, if an additional unit of production factor V is used. The consumers' evaluation is included into this calculus via the price p, because consumers would have been willing to buy the amount of X_1 for the market price p. If the production factor V is paid according to the profit maximization condition represented above, then the factor price q represents the opportunity costs emerging from the factor withdrawal (Bergen et al.). That is why the marginal product in terms of value of a production factor is of importance for the assessment of its opportunity costs.

5.4 Production factor labour

Likewise, manpower represents a production factor and has to be evaluated using opportunity costs. In this context it has to be determined, how the production factor labour with given skills is to be evaluated on the labour market. This can be problematic if people are employed in the project, who were unemployed before. In the latter case, an accurate calculation of opportunity costs has to be based on the marginal product in terms of value. Because employers have not been withdrawn from other productions, the marginal product in terms of value is very low or equals zero. Accordingly, opportunity costs will be low and assume values below the factor price (Bergen et al.).

Although unemployment rate in the Philippines is about 12.7 percent (Asia Times) for this analysis it is assumed that in Leyte officially unemployed rural population would work within the agricultural sector, for example shifting cultivation. Hence opportunity costs correspond to the average wage for non skilled workers, namely 100 PhP per day and per worker.

5.5 Production factor capital

The term capital comprises production factors that are not used up in the production process during the lifetime of a project. Examples are represented by permanent constructions, soil and inventory items (such as for example chainsaws and other tools). Because capital is bound during the lifetime of the project and cannot be used for alternative investments, this production factor has to be valued using its market price. The forgone returns of an alternative use have to be calculated by means of the interest rate.

The soil value was not taken into account for the calculations of project impacts of the different land-use systems in Leyte. To include the soil value into the CBA would change the single outcome of each alternative but it would not change the final result of the CBA because the ranking in terms of advantageousness of each alternative in regard to the others stays the same.

5.6 External effects and public goods

Public projects can cause positive or negative external effects. Example: A rainforestation project stops soil erosion on a site. This is a positive external effect that has to be evaluated from the point of view of the effected individuals and included in the analysis as not to underestimate the overall benefit of the project. In this case an evaluation of the positive effects of the rainforestation alternative was not possible due to a lack of data.

Public goods have the characteristic that they are spread among the entire community, whether or not the individuals desire to purchase these goods. Hence, these goods are characterized by non-excludability and non-rivalry in consumption, which is the reason that these goods are not traded on markets. Therefore, market prices does not exist and other economic evaluation techniques have to be used (Olschewski).

5.7 Foreign exchange effects

Whenever production factors, needed for the realization of a project, have to be imported from abroad, or export goods are produced by a particular project, it generates changes in foreign currency earnings or expenditures. In the course of the CBA, these foreign currency effects have to be considered by appropriate conversion into domestic currency. However, many governments of developing countries tend to control own exchange rates, frequently resulting in overvaluation of domestic currencies. An underestimation of project costs will take place if foreign factor input is needed and the arising costs are calculated on the basis of these a fixed, official exchange rates which underestimate the value of foreign currencies. Thus, by using an overvalued exchange rate project costs regarding imported production factors are underestimated. The same applies regarding the benefit side of projects, where revenues from the export of manufactured goods are expressed using an overvalued exchange rate. For correct estimation of project efforts, a higher shadow exchange rate has to be used in case of domestic currency overvaluation (Bergen et al.).

Referring to this CBA about different land-use systems in Leyte there is no need for foreign production factors, stripping machines for Abaca or chainsaws for the rainforestation project are produced in the Philippines. For the calculation of the output domestic prices for products like Abaca, timber or coconut were used. An exchange rate of 54.2033 Pesos for one US$ was used in this analysis. According to the Bangko Sentral Filipinas this rate corresponds to the average rate of 2003, the basis period for the following calculations. In general, there is no fixed exchange rate for the Philippine Peso.

5.8 Determination of costs and benefits of the project alternatives

In the following part, the costs and benefits of the project alternatives are determined. They are discounted with a discount rate of 6.5%, (see chapter 6.7 'selected discount rates for this CBA'). Time horizon is 25 years, basis period, the so called 'year 0' is 2003, 'year 25' is 2029 respectively. Hence all prices and costs used for the calculations are from 2003. Since the alternatives have to be made comparable, all inputs and outputs are referred to one hectare. The calculations are made in Excel with figures accurate to ten decimal places although no decimal places are shown. Costs are calculated in Philippine Pesos.

Labour costs are 100 PhP for unskilled workers. This is the usual wage paid to unskilled labour in Leyte in 2003. Land values are not taken into account, (see chapter 5.5). A time horizon of 25 years was selected although one cycle of Abaca lasts 20 years. Hence the analysis puts the alternative of rainforestation with its cycle of 25 years into a favourable position. It is assumed that Abaca has to be planted again in year 21 and the main part of revenues from the newly planted Abaca is cut off after the last year of the time horizon. The alternative '*Acacia mangium* - Abaca' gains an advantage over '*Cocos nucifera* – Abaca': *Acacia mangium* can be harvested twice and there are no new establishment costs in the year 25 since one cycle of acacia lasts 12 years; coconut lumber is harvested after 60 years and these revenues are not included in the analysis.

But even though a selection of 25 years instead of a longer time horizon seemed to be reasonable since soils with Abaca loose in fertility and outputs will be reduced after 25 to 30 years. As far as fertilizer is needed, costs are taken into account for each alternative, but under normal conditions farmers are too poor to afford fertilizers in Leyte. Therefore most Abaca plantations loose in productivity after 20-25 years (pers. comm. Mangaoang).

Calculations of costs and revenues for Abaca are based on data provided by Diehl (GTZ project Leyte) and Predo (Abaca Research Centre, Leyte). Costs and revenues for coconut are also based on data of Diehl from 2003. The cash-flow tables are compiled by using further information from Mangaoang and Guarte, both LSU. The figures for *Acacia mangium* are from Harrison and were initially calculated for 1997 and referred to 2003 with a factor for inflation rate of 1.37770. This factor is calculated by the inflation rates from 1998 to 2003 according to Bangko Sentral, Manila. The same was done with the costs and benefits for the rainforestation site. These figures were compiled by Dirksmeyer for the year 1996 and referred to 2003 with a factor of 1.458. All amounts given in the text are not discounted. The same is true for the amounts in the cash flow tables, except of course the given net present value in the last row. Those tables that contain the summoned costs and revenues of the single items also show the discounted amounts in Philippine Pesos for each item.

The cash flow charts based on data from Dirksmeyer, Harrison and Diehl can be found in the digitalized appendix. All cash flow tables contained in the following text are extracted from these charts. These charts reflect the situation of well-managed farms with relative high net revenues. Real farming systems in Leyte may differ from this ideal situation in several aspects, as, in general, farmers are not able to pay for fertilizers. Furthermore, ring weeding of Abaca is not done, at least not to the extent of working days assumed in the cash flow tables. Additionally, fruit trees in the rainforestation system are supposed to be harvested in the last project period although the long term income generated by fruits is higher than that of the timber. Finally, the impact of diseases is not considered. Nevertheless, the ideal situation was taken as reference scenario. Later some of the aspects mentioned above where taken into account by conducting a sensitivity analysis.

5.8.1 Abaca – Coconut

Since 35.5% of Leyte's land area is covered with coconut plantations it is most likely, that there is no need to plant coconut on the beginning. Hence in relation the costs for the establishment of an Abaca – coconut system will be lower than the costs for an Abaca-acacia plantation. To get a better comparison between the land-use systems Abaca-coconut and Abaca-acacia the costs for a newly established coconut plantation were also taken into account.

5.8.1.1 Abaca – planted Coconut

Establishing Abaca:

- **Production factor labour:** The labour consumption of one hectare Abaca plantation is as follows: Most processes are done by 'non skilled workers' which earn 100 PhP per day. The stripping is done by 'skilled workers' which earn 150 PhP per day. The additional 50 PhP include the costs for the stripping machine. The single processes and the time needed is listed in an additional chart (Table 10). The workload of year five and the following years until year 20 corresponds to the amount in year four. Since the time horizon of this CBA is 25 years the whole process begins again in year 21 although then the working steps 'clearing' and 'tumbling unnecessary' trees are excluded.

Table 10: Workload over the years for one hectare Abaca plantation

Workload Man-Days Abaca plantation Years	**0**	**1**	**2**	**3**	**4**
Land preparation					
Clearing (underbrushing)	30				
Tumbling unnecessary trees and filing of debris	10				
Preparation of stakes, lay outing, staking	6				
Digging of holes and planting	30				
Replanting	5				
Maintenance					
Underbrushing	60	60	45	30	30
Ring weeding	15	15	15	15	15
Fertilization	10	10	10	10	10
Harvesting, stripping, bundling and marketing					
Topping, tumbling piling (150 stalks per MD)		17	25	33	42
Tuxying and hauling (80 stalks per MD)		31.3	46.9	62.5	78.1
Stripping (machine, 100 kg fibre per day for skilled labour @ 150 P per day)		9	14	19	23
Hauling and drying		9	13.5	18	22.5
Bundling & marketing		3	4.5	6	7.5
simple workload Man-Days	166.0	144.9	159.9	174.8	204.8
skilled workload Man-Days	0	9	14	19	23
Total workload Man-Days	166	141.9	155.9	169.8	197.8

- **Other Inputs:** Other inputs are fertilizers and planting material. Since one seedling costs two pesos and for planting and replanting 2750 plants are needed, the costs for planting material is about 5,500 PhP. Costs for fertilizers are 2000 PhP in the basis period and year one. In the following years only 1600 PhP for fertilizer are needed annually.
- **Outputs:** One hectare of Abaca yields 750 kg in year one, 1,125 kg in year two, 1500 kg in year three and 1,875 kg in year four and the following years. The price of one kg fibre is 30 PhP. Hence the yield for fibre is about 56,250 PhP annually from year four on. The yield from the leaf sheath reaches 781 kg in year four and since the price of one kg leaf sheath is 5 PhP the income from leaf sheaths are 3,905 PhP from year four on.

The following table presents the summoned costs and revenues for 25 years, discounted and non discounted.

Table 11: Costs for the single production factors and revenues, Abaca, 25 years

Item	Amount (PhP)	Discounted amounts 6.5% (PhP)	
simple Workload	493,747		249,025
skilled Workload	74,700		36,530
Seedlings and hauling of seedpieces	13,750		13,330
Fertilizer	43,200		22,099
Total Costs	625,397		316,360
Revenues (PHP)			
Fibre	1,215,000		594,088
Outer leaf sheet	84,378		41,257
Total Revenues	1,299,378		635,345
Cash Flow	673,980	NPV Abaca:	318,984

Establishing Coconut:

- **Production factor labour:** When establishing a coconut plantation, the area has to be cleared, layouted and holes for the coconuts have to be dug. Finally the seedlings have to be transported to and into the plantation site and planted. For these activities 75 working days are needed in the basis period, which will cost 7500 PhP. Ring weeding and underbrushing has to be done every year, this will consume 25 working days or 2500 PhP annually. Fertilization of the area will take 4 man days annually, this sums up to 400 PhP. Harvesting and handling of coconuts, including the production of copra begins in year seven with 19 working days. The workload for harvest increases from year to year and reaches full extend in the year eleven when time consumption for harvest sums up to 76 working days.

- **Other Inputs:** The costs for fertilizer sum up to 3,575 PhP annually, composed of 1,625 PhP for Ammonium Sulphate and 1,950 PhP for Muriate of Potash. With a spacing for coconut of 8 x 8 meters and costs of 13 PhP per seedling, seedling costs will be 2000 PhP.
- **Outputs:** In year seven the first coconuts can be harvested. Fruit maturity is reached in year eleven when one coconut palm produces 60 nuts. The coconut yield is calculated the following way: In the year seven 15 nuts per tree can be harvested, there are 156 trees per hectare and one coconut yields 270g copra, hence the total yield is about 632 kg. One hectare coconut plantation in full maturity produces annually 2,527 kg copra which can be sold for 10 PhP per kg. In case the coconut stems are harvested in the year 60, the income is about 14,820 PhP with 120 PhP per stem minus 25 PhP for the permit to harvest the tree. Income through coco lumber is not taken into account in this analysis: The year 60 is not included in the time horizon. The revenues of 14,820 PhP for coco lumber are surmounted by the annual income of copra production.

The following table presents the summoned costs and revenues for a newly established coconut plantation, discounted and non discounted.

Table 12: Costs for the single production factors and revenues, new Coconut, 25 yrs

Item	Amount (PhP)	Discounted amounts 6.5% (PhP)
Costs		
Clearing the area	1,500	1,500
Lay outing and Digging	3,000	3,000
Hauling and planting	3,000	3,000
Cost of seedlings	2,000	2,000
Ring weeding/underbrushing	65,000	32,995
Fertilizer	92,950	47,182
Fertilization	10,400	5,279
Harvest, copra making	130,783	47,720
Sum of Expenses	308,633	142,676
Revenues		
Copra	435,942	159,067
Sum of Revenues	435,942	159,067
Cash flow	127,309	NPV new Coconut 16,391

The following table shows costs, revenues and cash flow of one hectare 'Abaca- planted coconut' plantation beginning in year 2003 and ending in 2029. From the year eight on until year 24 only average costs and revenues are given.

Table 13: Cash flow table for newly established Abaca-Coconut plantation (PhP)

Year	0 (2003)	1	2	3	4	5	6	7	Ø 8-24	25
Costs Abaca										
simple Workload	16,600	14,491	15,988	17,483	20,479	20,479	20,479	20,479	19,223	20,479
skilled Workload		1,350	2,100	2,850	3,450	3,450	3,450	3,450	3,009	3,450
Seedlings & hauling	6,875								404	
Fertilizer	2,000	2,000	1,600	1,600	1,600	1,600	1,600	1,600	1,647	1,600
Total Costs Abaca	25,475	17,841	19,688	21,933	25,529	25,529	25,529	25,529	24,283	25,529
Costs Coconut										
Clearing the area	1,500									
Lay outing &Digging	3,000									
Hauling and planting	3,000									
Cost of seedling	2,000									
Weeding/underbrush	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Fertilizer	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575
Fertilization	400	400	400	400	400	400	400	400	400	400
Harvest								1,895	7,136	7,582
Total Costs Cocos	15,975	6,475	6,475	6,475	6,475	6,475	6,475	8,370	13,611	14,057
Total Costs	41,450	24,316	26,163	28,408	32,004	32,004	32,004	33,899	37,894	39,586
Revenues Abaca										
Fibre		22,500	33,750	45,000	56,250	56,250	56,250	56,250	48,971	56,250
Outer leaf sheet		1,563	2,344	3,125	3,906	3,906	3,906	3,906	3,401	3,905
Total Rev. Abaca		24,063	36,094	48,125	60,156	60,156	60,156	60,156	52,372	60,155
Revenues Coconut										
Copra								6,318	23,785	
Total Rev. Cocos								6,318	23,785	25,272
Total Revenues		24063	36094	48125	60156	60156	60156	66474	76,157	85427
Cash flow	-41,450	-254	9,931	19,717	28,152	28,152	28,152	32,575	38,263	45,841
Discounted Cash Flow (6.5%)	-41,450	-238	8,756	16,322	21,883	20,548	19,294	20,962	No value	9,495
NPV	**335,375**									

5.8.1.2 Abaca – old growth Coconut

In this case Abaca is simply planted beneath an already existing shade cover of coconut trees. The establishment costs are the same as described in the previous chapter. The costs for production factors for coconut are lower and the revenues are higher under the assumption that coconut has reached full fruit maturity in the base year. The changes in the cash flow table for coconut are as follows:

- **Production factor labour:** There are no costs for the establishment of the plantation. Time consumption for ring weeding and underbrushing is still the same with 25 working days annually. Also the labour for fertilization stays the same with 4 man days annually. Harvesting and handling of coconuts, including the production of copra sums up to 76 working days from the base year on.
- **Other Inputs:** The costs for fertilizer do not change and sum up to 3,575 PhP annually.
- **Outputs:** Fruit maturity is already reached in the base year. Hence 2,527 kg copra are produced each year. Revenues from coco lumber are not included since it is assumed that harvesting time still lies outside the time horizon of the analysis.

Table 14 presents the summoned costs and revenues for the single items during 25 years, discounted and non discounted. Table 15 gives the cash flow over the years for an old growth Abaca - coconut plantation.

Table 14: Costs for the single production factors and revenues, old Coconut, 25 years

Item	Amount (PhP)	Discounted amounts 6.5% (PhP)
Costs		
Clearing the area	0	0
Lay outing and Digging	0	0
Hauling and planting	0	0
Cost of seedlings	0	0
Ring weeding/underbrushing	65,000	32,995
Fertilizer	92,950	47,182
Fertilization	10,400	5,279
Harvest, copra making	197,121	100,061
Sum of Expenses	365,471	185,517
Revenues		
Copra	657,072	333,537
Sum of Revenues	657,072	333,537
Cash flow	291,600	NPV old Coconut 148,019

Table 15: Cash flow table for Abaca – old growth Coconut plantation (PhP)

Year	0	1	2	3	4	5	6	7	Ø 8-24	25
Costs Abaca										
simple Workload	16,600	14,491	15,988	17,483	20,479	20,479	20,479	20,479	19,223	20,479
skilled Workload		1,350	2,100	2,850	3,450	3,450	3,450	3,450	3,009	3,450
Seedlings & hauling	6,875								404	
Fertilizer	2,000	2,000	1,600	1,600	1,600	1,600	1,600	1,600	1,647	1,600
Total Costs Abaca	25,475	17,841	19,688	21,933	25,529	25,529	25,529	25,529	24,283	25,529
Costs Coconut										
Weeding/underbrush	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Fertilizer	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575
Fertilization	400	400	400	400	400	400	400	400	400	400
Harvest	7,582	7,582	7,582	7,582	7,582	7,582	7,582	7,582	7,582	7,582
Total Costs Cocos	14,057	14,057	14,057	14,057	14,057	14,057	14,057	14,057	14,057	14,057
Total Costs	39,532	31,898	33,745	35,990	39,586	39,586	39,586	39,586	38,340	39,586
Revenues Abaca										
Fibre		22,500	33,750	45,000	56,250	56,250	56,250	56,250	48,971	56,250
Outer leaf sheet		1,563	2,344	3,125	3,906	3,906	3,906	3,906	3,401	3,905
Total Rev. Abaca		24,063	36,094	48,125	60,156	60,156	60,156	60,156	52,372	60,155
Revenues Coconut										
Copra	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272
Total Rev. Cocos	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272	25,272
Total Revenues	25,272	49,335	61,366	73,397	85,428	85,428	85,428	85,428	77,644	85,427
Cash flow	-14,260	17,437	27,622	37,407	45,843	45,843	45,843	45,843	39,304	45,841
Discounted Cash Flow (6.5%)	-14,260	16,373	24,353	30,967	35,634	33,460	31,417	29,500	No value	9,495
NPV	**467,004**									

5.8.2 Abaca – Acacia

Costs and revenues for one hectare Abaca plantation are again the same as described above. The cost of production factors and revenues for one hectare Acacia mangium plantation are as follows:

- **Production factors:** The cash flow table from Harrison gives amounts in PhP to single items like 'Fertilization'. There is no information on how much money is spent on working hours and how much on other production factors. According to the author seedling production costs are 2,204 PhP in the base year and again 2,204 PhP in year 13. This figure is most likely determined by working hours spent on collecting the small *Acacia mangium* seeds. In the base year there are labour costs for the land preparation of 6,957 PhP for gaining access and digging fire ponds and land preparation like burning, hole digging and back filling. In the year 13 these costs are reduced to 5924 PhP. There are further costs for pest control and ground spraying of 579 and 3,031 in the base year. Planting production species will cost 4,546 PhP in the basis period and 4,546 PhP in year 13. Fertilisation and strip spraying will consume 8,404 and 3306 in the first two years. Blanking in the first year costs 689 PhP. Labour costs for thinning operations are 331 PhP in year one, 496 PhP in year two, 689 PhP in year three and the same amounts during the second cycle respectively. Costs for protection are about 689 PhP annually. All costs linked with harvest are about 65,468 PhP in year six and 218,227 PhP in year 13, the same again in the second cycle. These costs are spent on logging, loading, cartage, roading and commission for sale.
- **Outputs:** The thinning operation in year six yields pulp logs with a market price of 132,259 PhP. In year 13 553,835 PhP are earned for pruned, branched and pulp logs.

The following chart (table 16) presents the costs and benefits for the single production factors over a planning horizon of 25 years. Table 17 on the following pages shows the cash flow of an Abaca – acacia plantation.

Table 16: Costs for the single production factors and revenues, Acacia, 25 years

Item	Amount (PhP)	Discounted amounts 6.5% (PhP)
Cost:		
Seedling production	4,409	3,176
Access and fire ponds	689	689
Land preparation-burning	344	344
Land preparation-hole digging	5,786	4,169
Land preparation - back filling	6,062	4,368
Pest control	579	579
Land preparation - ground spray	3,031	3,031
Planting - production species	9,093	6,551
Fertilisation	16,808	11,650
Strip spraying	6,613	4,619
Blanking (if required)	689	689
Form prune	661	447
Second prune	992	630
Thin to waste	1,378	822
Protection	17,910	9,091
Logging and loading	277,744	104,267
Cartage	198,389	73,302
Roading and skid formation	39,678	15,482
Sales commission/management	51,581	19,305
Total cost	642,434	263,212
Revenues:		
Pruned logs (100m3/ha)	462,907	156,652
Branched logs (150m3/ha)	446,374	151,058
Pulp logs (50m3/ha)	198,389	67,137
Pulp log thinning	264,518	130,616
Total revenues:	1,372,187	505,463
Cash flow	729,753	NPV: Acacia mangium 242,251

Table 17: Cash flow table for Abaca –acacia plantation (PhP)

Year		1	2	3	4	5	6	7	Ø 8-24	25
Costs Abaca										
simple Workload	16,600	14,491	15,988	17,483	20,479	20,479	20,479	20,479	19,223	20,479
skilled Workload		1,350	2,100	2,850	3,450	3,450	3,450	3,450	3,009	3,450
Seedlings & hauling	6,875								404	
Fertilizer	2,000	2,000	1,600	1,600	1,600	1,600	1,600	1,600	1,647	1,600
Total Costs Abaca	25,475	17,841	19,688	21,933	25,529	25,529	25,529	25,529	24,283	25,529
Costs Acacia mangium										
Seedling production	2,2 40								130	
Access and fire ponds	689									
Land preparation-burning	344									
Land prep.-hole digging	2,893								170	
Land prep. - back filling	3, 310								178	
Pest control	579									
Land prep - ground spray	3, 310									
Planting	4,546								267	
Fertilisation	1,653	2,618							251	
Fertilisation	1,515	2,618							243	
Strip spraying	1,653	1,653							194	
Blanking (if required)	689									
Form prune		331							19	
Second prune			496						29	
Thin to waste				689					41	
Protection	689	689	689	689	689	689	689	689	689	689
Logging and loading							33, 65		8,169	105,807
Cartage							19,839		5,835	79,355
Roading &skid formation							6,613		1,167	13,226
Sales commission/manag.							5,952		1,517	19,839
Total Cost Acacia	23,517	7,908	1,185	1,378	689	689	66,157	689	18,900	218,916
Total Cost	48,992	25,749	20,873	23,311	26,218	26,218	91,686	26,218	43,184	244,445

Table 17 (continued): Cash flow table for Abaca –acacia plantation (PhP)

Year		1	2	3	4	5	6	7	Ø 8-24	25
Total Cost Abaca & Acacia mangium	48,992	25,749	20,873	23,311	26,218	26,218	91,686	26,218	43,184	244,445
Revenues Abaca										
Fibre		22,500	33,750	45,000	56,250	56,250	56,250	56,250	48,971	56,250
Outer leaf sheet		1,563	2,344	3,125	3,906	3,906	3,906	3,906	3,401	3,905
Total Rev. Abaca		24,063	36,094	48,125	60,156	60,156	60,156	60,156	52,372	60,155
Revenues Acacia										
Pruned logs (100m3/ha)									13,615	231,453
Branched logs (150m3/ha)									13,129	223,187
Pulp logs (50m3/ha)									5,835	99,194
Pulp log thinnings							132,259		7,780	
Total Rev. Acacia							132,259		40,358	553,835
Total Revenues		24063	36094	48125	60156	60156	192415	60156	92,730	613990
Cash flow	-48,992	-1,686	15,221	24,814	33,938	33,938	100,729	33,938	49,546	369,544
Discounted Cash Flow (6.5%)	-48,992	-1,584	13,420	20,542	26,381	24,771	69,033	21,840	No value	76,547
NPV	**561,236**									

5.8.3 Rainforestation

The financial analysis of a rainforestation system follows the suggestion of Dirksmeyer. Costs and revenues are based on the management plan described in chapter 4.3.2 'Management of a rainforestation site'. It has to be kept in mind however, that the data Dirksmeyer provided stems from a young Rainforestation site and benefit estimations may be rather optimistic.

- **Production factor labour:** The following part about labour costs will give the figures in PhP instead of working days. Dirksmeyer also assumed 100 PhP per working day, but it is unclear in which way the labour days (and costs) are distributed among weeding, planting and harvesting for his model calculation. He just gives examples from different reforestation sites, like 13 labourers for 35 days for clearing and weeding and 13 labourers for 25 days for planting in the first year in the rainforestation site Cienda. Labour costs for harvest include the needed tools like axes or chainsaws. Dirksmeyer does not describe explicitly how harvesting shall be done.

  In the model calculation on which this CBA is based the workload is distributed exclusively on weeding, planting of tree seedlings and planting of intercrops until year four. In the first year 20,298 PhP per hectare will be needed, in the second even 95,215 PhP due to intense weeding and planting of intercrops. Year three will cause 76,381 PhP for weeding and planting and from then on the figure declines to steady 42,981 PhP in year seven to year 12. The first harvest has to be done in year 13 and further seedlings are planted into the gaps, this brings the figure for labour costs up to 274,593 PhP. In the following years approximately 54,000 PhP will be needed and in the last year 132,122 PhP mainly for harvest.

- **Other Inputs:** Neither fertilizers nor pesticides will be used at all. 9716 PhP are spent on the production of seedlings in the first five years, further 402 PhP in the years 13, 14 and 15. Costs for production of each seedling vary between 1.9 to 30 PhP, depending on tree species. It is assumed that plant material for intercrops is gained for free from neighbours or existing stocks. Costs for chainsaws are included into working costs.

- **Outputs:** Due to the logging ban, markets for the timber species grown in Rainforestation Farming do not exist. Therefore it is not possible to get market prices for the calculations. Since the main product of Rainforestation Farming is lumber, price determination is crucial for the financial viability of the system. For this reason, Dirksmeyer used a second best indicator after market prices, which was in this case interviews with furniture producers who buy the needed timber on still existing black markets. Depending on quality wood was classified into five categories (See table 18). Prices are given in PhP. The calculations for revenues for lumber are based on these amounts.

Table 18: Prices for lumber in Leyte, 1997 in PhP

Class	**I**	**II**	**III**	**IV**	**V**
Price Range					
[P/W]	12-20	21-30	31-40	41-50	>50
Example	Antipolo	White Lauan	Dao	Yakal-Kaliot	Narra
	Gumihan	Red Lauan		Yakal-Malibato	

Source: Dirksmeyer

Outputs from trees begin to flow in during year three with 316 PhP when first firewood is cut. The thinning in year 13 and 14 yields the first significant revenues with 1,904,754 PhP for lumber and 3,249 PhP for poles. Poles are also harvested in the following years. In year 25 459,453 PhP will be earned, when mainly the slow growing, sun demanding trees are cut. Altogether the profit from lumber of rainforestation trees is 2,713,307 PhP. This includes the revenues from fruit tree lumber.

The following chart (Table 19) summons the costs for production factors and the revenues for each single item, discounted and non discounted. Table 20 shows the cash flow for a reforestation site.

Table 19: Costs for the single production factors and revenues, Rainforestation, 25 years

Years	Amount (PhP)	Discounted amounts 6.5% (PhP)
Costs		
Trees, seedling costs:		
slow-gr, sun-dem.	*241*	*239*
fast-gr., sun-dem.	*3,273*	*3,255*
slow-gr. shade-dem.	*303*	*250*
fast-gr. shade-dem.	*3,173*	*2,448*
Fruit trees	*3,128*	*2,575*
Total plant material	10,118	8,767
Labour (trees)	1,543,645	740,072
Intercrops		
Labour (intercrops)	55,759	25,633
Total labour cost	1,599,404	765,706
Total Costs	1,609,523	774,472
Revenues		
Trees:		
slow-gr, sun-demanding, lumber	*146,730*	*30,393*
Fast-gr, sun dem., firewood	*3,373*	*2,482*
Fast-gr., sun dem., lumber	*2,092,878*	*917,931*
slow-gr., shade-dem., poles	*33,088*	*6,854*
Fast-gr., shade dem., poles	*203,969*	*53,609*
lumber	*214,287*	*44,387*
Fruits	*941,038*	*247,367*
Fruit trees, poles	*18,981*	*3,932*
Revenues trees	3,654,345	1,306,954
Intercrops:		
Banana	*95,890*	*48,820*
Pineapple	*844,710*	*398,798*
Other Fruits	*145,841*	*71,158*
Tacudo	*395,520*	*177,667*
Camote	*143,836*	*73,292*
Abaca	*256,607*	*117,293*
Revenues Intercrops	1,882,404	887,028
Total Revenues	5,536,749	2,193,983
Cash Flow	3,927,226	1,419,511

Table 20: Cash flow table for a rainforestation site (PhP)

Years	0 (2003)	1	2	3	4	5	6	7	Ø 8 - 24	25
Costs										
Trees, seedling costs:										
slow-gr, sun-dem.	*219*	*22*								
fast-gr., sun-dem.	*2,975*	*298*								
slow-gr. shade-dem.				*274*	*29*					
fast-gr. shade-dem.				*2,516*	*255*				24	
Fruit trees				*2,844*	*284*					
Total plant material	3,194	319		5,634	569				24	
Labour (trees)	20,298	93,793	74,959	42,829	17,055	47,019	42,596	40,573	60,871	129,714
Intercrops:										
Labour (intercrops)		1,422	1,422	1,422	1,422	1,915	2,408	2,408	2,408	2,408
Total labour cost	20,298	95,215	76,381	44,251	18,477	48,934	45,004	42,981	63,279	132,122
Total Costs	23,492	95,534	76,381	49,885	19,045	48,934	45,004	42,981	63,303	132,122
Revenues										
Trees:										
slow-gr, sun-demanding, lumber										*146,730*
Fast-gr, sun dem., firewood				*316*	*31*	*2,753*	*273*			
Fast-gr., sun dem., lumber									123,110	
slow-gr., shade-dem., poles										*33,088*
Fast-gr., shade dem., poles									9,271	*46,366*
lumber										*214,287*
Fruits									47,419	*134,917*
Fruit trees, poles										*18,981*
Revenues trees				316	31	2,753	273		179,800	594,370
Intercrops:										
Banana		*6,563*	*5,469*	*3,646*	*3,646*	*3,646*	*3,646*	*3,646*	3,646	*3,646*
Pineapple		*10,501*	*29,168*	*35,002*	*35,002*	*35,002*	*35,002*	*35,002*	35,002	*35,002*
Other Fruits		*5,834*	*5,834*	*5,834*	*5,834*	*5,834*	*5,834*	*5,834*	5,834	*5,834*
Tacudo		*7,000*	*7,000*	*7,000*	*10,501*	*14,001*	*17,501*	*17,501*	17,501	*17,501*
Camote		*10,938*	*7,110*	*5,469*	*5,469*	*5,469*	*5,469*	*5,469*	5,469	*5,469*
Abaca		*6,198*	*6,198*	*6,198*	*6,198*	*8,678*	*11,157*	*11,157*	11,157	*11,157*
Revenues Intercrops		47,034	60,779	63,149	66,649	72,629	78,608	78,608	78,608	78,608
Total Revenues		47,034	60,779	63,466	66,680	75,382	78,881	78,608	258,408	672,978
Cash Flow	-23,492	-48,501	-15,602	13,581	47,635	26,448	33,877	35,627	195,106	540,857
Discounted Cash Flow (6.5%)	-23,492	-45,541	-13,756	11,243	37,027	19,304	23,217	22,926	No value	112,032
NPV	**1,419,511**									

6 Discounting costs and benefits

6.1 Temporal homogenization

When costs and benefits occur during a single period all evaluated advantages and disadvantages can simply be added up and the result can be compared directly (Bergen et al.) But most projects last over a longer time horizon. This is especially true for forestry projects with costs and benefits occurring at different points of time. To enable a comparison between costs and benefits, they have to be “homogenized” in time (Hanusch). This is usually done by discounting the advantages and disadvantages of different time periods to a basic period (for example the initial year of the project, here the year 2003). To calculate the so-called present value, financial mathematic formulas are used. Through discounting, costs and benefits occurring in the future get lower values.

Formulas for the calculation of the present values for costs (PV(C)) and benefits (PV (B)) are given below:

$$PV(C) = C_0 + \frac{C_1}{(1+d)} + \frac{C_2}{(1+d)^2} + \ldots + \frac{C_T}{(1+d)^T} = \sum_{t=0}^{T} \frac{C_t}{(1+d)^t}$$

$$PV(B) = B_0 + \frac{B_1}{(1+d)} + \frac{B_2}{(1+d)^2} + \ldots + \frac{B_T}{(1+d)^T} = \sum_{t=0}^{T} \frac{B_t}{(1+d)^t}$$

Different time periods within the planning horizon are termed t = 0,1,2,….,T, where t = 0 denotes the basis period and d stands for the discount factor. The estimation of the present value is in accordance to the procedure used in dynamic investment calculation. One problem of evaluating projects is due to the fact, that no “right” discount rate can be identified. Depending on different viewpoints, several discount rates are preferable (Bergen et al.). Therefore, different arguments about discount rates are presented and explained in the following part.

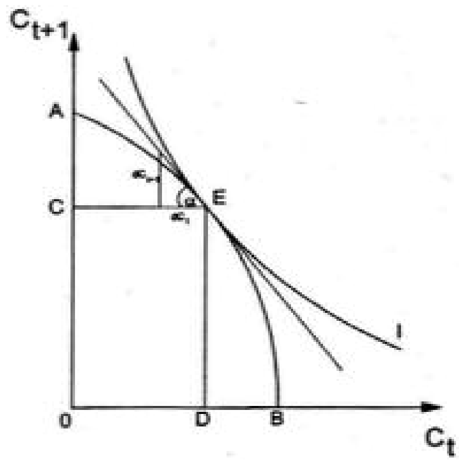
6.2 Individual time preference rate

Due to uncertainty of the future, individuals have normally a positive time preference rate (ITP). The application of the ITP is in consistence with the postulate of consumer's sovereignty, thus fitting into the concept described for the CBA up to this point (Bergen et al.). The behaviour of households on the capital market can be analyzed in order to assess the appropriate level of the ITP. On a perfect market only one interest rate for saving as well as borrowing appears and brings the market into equilibrium. This particular interest rate could then be used as a discount rate for the calculation of present values (Bergen et al.). In reality, however, the conditions for a perfect capital market are not fulfilled and a variety of different interest rates exists (for example difference between interest on borrowing and saving). Thus, the problem of selecting the accurate interest rate persists.

6.3 Opportunity cost rate

This concept focuses on the possibilities to enhance consumption in the future through forgone consumption at present. This can be illustrated with the help of figure 7.

Fig. 7: Consumption distributions: Possibilities and Preferences Source: Olschewski



The horizontal axis displays the present consumption C_t, while the vertical axis indicates the future consumption C_{t+1} in the next period. The possible combinations of consumption at present and in the next year can be identified by the transformation curve AB. If OD is consumed today, DB will remain as saving for investment purposes and provides the consumption of OC in the next period. Thus, point E on the transformation curve can be attained. The marginal rate of transformation is determined by the equation $|dC_{t+1}/dC_t| = |dC_t(1+r)/dC_t| = 1 + r$. The amount of additional units that can be consumed in the future, if one unit of consumption is withdrawn at time t, is indicated by the opportunity cost rate r. Another synonym for r is the marginal productivity of the capital unit used.

The curve I denotes the indifference curve of the households. An indifference curve for a two-commodity model (here present and future consumption) is mathematically defined as the location of all particular points where different combinations of the two commodities give the same level of satisfaction to the consumer. Thus, the curve displays all combinations of today's and future consumption, to which the household is indifferent. This implies that all the combinations provide the same level of welfare, with the household perceiving them to be equal. The marginal rate of substitution is determined by the equation $|dC_{t+1}/dC_t| = |dC_t(1+i)/dC_t| = 1 + i$. The interest rate at which households are willing to postpone consumption from period t to t+1 is indicated by the time preference rate i. The location at which the marginal rate of transformation $(1+ r) = \text{tg}\ \alpha$ equals the marginal rate of substitution $(1+ i) = \text{tg}\ \alpha$, is indicated by point E. In this point, r equals i, meaning that the opportunity cost rate of investments equals the time preference rate of the households.

According to the "law of one price", at a certain point of time only one interest rate would bring the market into equilibrium, but as mentioned earlier, in reality the conditions for a perfect capital market are not fulfilled. That is the reason why in reality, the opportunity cost rate differs from the time preference rate, leading to the problem of selecting an accurate interest rate for the appropriate determination of project related cost.

6.4 Synthetic discount rates

In case that ITP and OCR differ and production factors are withdrawn from consumption and investment, using one discount rate only would lead to distortions. Thus, the adoption of a synthetic discount rate, incorporating opportunity cost rate and individual time preference rate, has been suggested (Bergen et al).

6.5 Social time preference rate

Supporters of the social time preference rate presume that households are generally short-sighted. The result is a relatively high discount rate with an insufficient recognition of future generations. This is supposedly the case for long-term forestry and infrastructure projects, where the individual time preference rate is too high, thus future revenues are not taken adequately into account. In this case, a lower "social" time preference rate could be used (Bergen et al.). This approach can be justified by the fact, that society as a whole, unlike its individuals, has an infinite time horizon. Still, the questions arise of who should determine the level of a social time preference rate and based on which criteria.

6.6 Conclusion

One conclusion that can be drawn from the concepts explained above is that the "right" discount rate does not exist. The individual time preference rate of households cannot be determined explicitly, so an interest rate for long-term, fixed-interest state securities is often taken as a substitute, representing a second best indicator (Bergen et al).

A further problem exists, if the opportunity cost rate and the individual time preference rate differ to a large extent. This is often the case in developing countries. The individual time preference rate can be very high, when for example projects for the production of basic food are to be evaluated and the opportunity cost rate can be very low because of low capital productivity (Götz, cited in Olschewski). Sensitivity analysis, using different discount rates to survey impacts on the result of the CEA, should be carried out in order to overcome the problem of making wrong decisions.

Another vital aspect of consideration is the difference between nominal and real values. When real prices are selected for a CBA, also the interest rate must be calculated in real terms. Real values exclude inflation rates. It is important to avoid a mixture of nominal and real variables when calculating the NPV. For example: A nominal rate of return of 8%, with a 3% rate of inflation, implies a real rate of return of 4,85%. (Bergen et al.). The real interest rate can be calculated by applying the equation below:

$$i^r_t = \frac{i^n_t - \pi_t}{1 + \pi_t}$$

i^n_t nominal interest rate

π_t rate of inflation

6.7 Selected discount rates for this CBA

Forestry projects have normally a large time gap between the occurrence of costs and benefits. Therefore it becomes essential to find the appropriate discount rate.

For the CBA about different land-use techniques in Leyte a real discount rate of 6.5% was selected. This rate corresponds to the average rate for 'long-term bank loans for all maturities' in 2003 (Bangko Sentral). The second best yardstick, to take an interest rate for long-term, fixed-interest state securities was not possible in this case because long-term, fixed-interest state securities are not available in the Philippines.

As described before finding the 'right interest rate' is rather difficult, especially in developing countries. For this CBA it was decided to conduct a sensitivity analysis with the discount rates of 3% and 9%. These rates were selected because with values of 3, 6.5 and 9% one gets a wider spectrum from a very low to a relatively high discount rate. The sensitivity analysis overcomes the problem of making a wrong decision when selecting a wrong rate because the result of the sensitivity analysis states how strong changing discount rates influence the result of a CBA.

6.8 Discounting costs and benefits

The following charts show discounted costs and benefits. For the calculation the formulas of the present values for costs (PV(C)) and benefits (PV (B)) were used (See chapter 6.1 Temporal homogenization). A sensitivity analysis was done with the discount rates of 3% and 9%.

Table 21: Discounted costs and benefits of alternatives with different discount rates (in PhP)

Abaca-new Coconut	**6.5%**	**3%**	**9%**
Discounted costs	459,037	652,016	371,739
Discounted benefits	794,412	1,177,677	620,629

Abaca-old Coconut	**6.5%**	**3%**	**9%**
Discounted costs	501,877	701,662	410,541
Discounted benefits	968,881	1,374,829	781,637

Abaca-Acacia	**6.5%**	**3%**	**9%**
Discounted costs	579,572	853,340	459,110
Discounted benefits	1,140,808	1,748,645	873,848

Rainforestation	**6.5%**	**3%**	**9%**
Discounted costs	774,472	1,111,176	623,804
Discounted benefits	2,193,983	3,521,652	1,617,462

In the next chapter these results will be used to apply different decision criteria.

7 Comparing costs and benefits of the selected alternatives

Next step in a Cost Benefit Analysis is the comparison of cost and benefits. In case several projects are available that exclude each other, one has to be selected. In the following, four criteria of decision will be presented, that have their origin in private investment analysis: Net present value, benefit-cost ration, internal rate of return, and annuity.

7.1 Net Present Value

The net present value is defined as the difference between the discounted benefits and the discounted costs of a project. For the calculation of the NPV, the already explained formulas of PV(B) and PV(C) can be combined as follows:

$$NPV = PV(B) - PV(C) = \sum_{t=0}^{T} \frac{B_t}{(1+d)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+d)^t} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+d)^t}$$

A positive value means that the project can be recommended. The amount of the net welfare effect is given by the NPV. If projects exclude each other, the NPV is the superior criterion, because it is uninfluenced by different cost and benefit interpretations and has a definite result that corresponds to the net welfare effect of a project.

7.2 Benefit-Cost Ratio

The ratio of discounted benefits and discounted costs of a project is called benefit-cost ratio (BCR):

$$BCR = \frac{PV(B)}{PV(C)} = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+d)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+d)^t}}$$

A benefit-cost ratio higher than 1 indicates that the project is advantageous. A problem linked with the BCR is that this criterion is vulnerable to differing interpretations of costs and benefits. Taking into account that costs might be characterized as negative benefits and benefits as negative costs, it can be shown that the BCR is sensitive to these changes. NPV is not influenced by different classifications of costs and benefits (Olschewski).

7.3 Internal Rate of Return

Another investment criterion is the internal rate of return (IRR). It is calculated by setting the NPV equal to zero, changing the discounted rate for z and solving the equation for z. The IRR gives that interest rate at which discounted costs and benefits are equal. A project can be recommended if the calculated IRR is higher than the level of a certain reference interest rate. Otherwise one would be better off investing money in the more attractive alternative. This criterion of decision can lead to doubtful results due to its algebraic form (Olschewski). Furthermore, this concept cannot avoid the problem of choosing the 'right interest rate'.

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+z)^t} = 0 \qquad \text{respectively:} \qquad \sum_{t=0}^{T} \frac{B_t}{(1+z)^t} = \sum_{t=0}^{T} \frac{C_t}{(1+z)^t}$$

7.4 Annuity

The net present value calculates the discounted sum of all net benefits occurring in different time periods t = 0,1,2..T. This value can be distributed into equal parts to be received in each period.

$$A_N = NPV \cdot ((1+i)^T \cdot i) / ((1+i)^T - 1)$$

One of these equal parts is called annuity A_N, which can be used for comparison of different projects. Discounting all annuities within the project period leads back to the net present value.

7.5 Comparison of the project alternatives

When comparing the net present values of all alternatives, Abaca - coconut has the lowest value, even under the assumption that coconut has not to be planted first. The alternative of Abaca – acacia has a higher NPV than Abaca – coconut. Rainforestation farming produces by far the highest value. The ranking of the project alternatives is uninfluenced by different discount rates. Interesting additional information was gathered when discounting alone the cash flow of a newly established coconut plantation with a discount rate of 9%: In this case the NPV was even at -826 PhP. Hence establishing a coconut plantation is not profitable at a high discount rate when regarding a time horizon of 25 years.

Table 22: Criteria of decision at different discount rates

Abaca and planted coconut	6.50%	3.00%	9.00%
NPV	335,375	525,661	248,891
Annuity	27,495	30,188	25,339
Benefit Cost Ratio	1.73	1.81	1.67

Abaca and old growth coconut	6.50%	3.00%	9.00%
NPV	467,004	673,168	371,096
Annuity	38,286	38,659	37,780
Benefit Cost Ratio	1.93	1.96	1.90

Abaca and Acacia mangium	6.50%	3.00%	9.00%
NPV	561,236	895,305	414,739
Annuity	46,011	51,415	42,223
Benefit Cost Ratio	1.97	2.05	1.90

Rainforestation	6.50%	3.00%	9.00%
NPV	1,419,511	2,410,475	993,658
Annuity	116,374	138,428	101,161
Benefit Cost Ratio	2.83	3.17	2.59

NPV, CBR and annuity lead to the same ranking of alternatives. The calculation of the IRR brings ambiguous results with Abaca and old growth forest. This is due to the fact that the algebraic sign in the cash flow changes twice: it was negative in the basis period and once again in the year 21, when Ababa has to be replanted.

8 Considering risk and uncertainty

8.1 Risk

"In general, perfect information about all project impacts is not available" (Olschewski). Therefore the determination of costs and benefits is based on uncertainties. Uncertainties may have two characteristics: In case all the states are known and the probabilities have a sense of being objective, e.g. based on accurate past observations, then we have a situation that might be called pure risk. This actually implies that appropriate data is available, allowing the calculation of probabilities for the occurrence or non-occurrence of certain project effects (Bergen *et al*). If a situation is considered to be close to pure risk then expected values of variables can be calculated for a variable X at time t (Bergen):

$$E(X) = P(1)*X(1) + P(2)*X(2) + P(3)*X(3) + P(4) *X(4) + \dots$$

where $P(1) + P(2) + P(3) + P(4) + \dots = 1$

For example: The probability that an Abaca plantation is befallen with the Bunchy top disease is 0.2. (That means that in the past 20% of all Abaca plantations were befallen). In this case the project output are 0 US$. The probability, that and Abaca plantation is not befallen is 0.8 and the output is 1000US$. Then the expected value is:

$$EV= 0.2 \cdot 0 + 0.8 \cdot 1000 = 800 \text{ US\$}$$

8.2 Uncertainty

If on the other hand not all the states are known, then the probabilities are unknown and we are in a situation of uncertainty. In this case literature provides a wide range of decision rules (Hanusch):

- Maximax rule: asks for the maximum achievable benefit of each alternative and then chooses the one with the highest maximum benefit.
- Minimin-rule: compares the minimum benefits to be reached by alternative projects and recommends the one with the highest minimum benefit.
- Hurwicz rule: here the two former concepts are combined. The highest and lowest benefits are weighted by numbers between 0 and 1 and then aggregated to an overall measure. Here the analyst involves a parameter that indicates his optimism or pessimism.
- Laplace rule: According to the principle of insufficient reason all events have the same probability. Then the decision becomes the same as in a situation with risk.
- Savage-Niehans rule: In case that one decides falsely for a project with a lower benefit than the optimal solution, a certain amount of utility is lost. That amount is calculated for each project alternative. Finally the project with the lowest amount of 'lost utility' or 'regret' is chosen.

The choice for one of these decision rules depends on the costs that are caused by a decision for a wrong project. If these costs are high, one should choose a more pessimistic decision criterion like Savage-Niehans or Laplace rule, which is of course an arbitrary approach.

8.3 Incorporating risk and uncertainty into the land-use systems in Leyte

All three alternatives, namely Abaca-coconut, Abaca-acacia and rainforestation site are already practised in Leyte. The majority of Leyte's farmers are small scale farmers. These farmers have often such a small budget, that the failure of their plantation would inflict serious financial difficulties. Uncertainties related to coconut, acacia and rainforestation can become determining factors for these land-use systems. The permit for harvesting timber depends on policy making but it is not likely that the existing regulations towards timber harvest will be tightened even more. The risk linked with the failure of tree species in the rainforestation site can be reduced by choosing domestic tree species. Abaca is easily damaged by strong winds and highly susceptible to various diseases. These diseases spread to such an extent that Abaca production is seriously influenced. The following part will go into detail about Abaca diseases, the situation in Leyte and the influence of typhoons on Abaca.

8.3.1 Diseases of Abaca

Abaca is highly susceptible to various diseases. To date, some 17 diseases have been recorded, 9 of which are caused by fungi, 2 by bacteria, 2 by viruses and 4 by nematodes. The importance of a disease varies from one area to another but generally, the most serious and dangerous are (Westphal and Jansen).

- **Abaca diseases in general** Bunchy top virus (transmitted by *Pentalonia nigronervosa*) The origin of Abaca bunchy top (AbaBT) in the Philippines is not clear. Some researchers claim that AbaBT may have been present in the country as early as 1910. Although reports indicate that AbaBT is mostly confined in the Bicol Region, at present, it thrives as well and makes similar havoc in other major Abaca-producing provinces. The first noticeable symptom is the presence of indefinite, yellowish-white, chlorotic areas on the blade of the youngest furled leaf. These symptoms also occur on the margins and on the lamina of the youngest unfurled leaf. When these symptomatic leaves have expanded, their blades become dark green, stop growing, and curl upward, or tear along the margin. Delicate, thin, and transparent areas or streaks of various sizes and shapes may develop from the midrib to the margin. These streaks disappear as they reach the yellow borders. However, in a more advanced stage of infection, the streaks remain along the secondary veins on the nether surface of the foliage. The leaf showing the first symptoms of infection is stiffer, shorter and narrower than the leaf that appears before the plant is infected. As the disease progresses, the petioles begin to rise from nearly the same plane at the upper end of the pseudostem. As a result, the leaves form a rosette arrangement or a bunch. During the advanced stage of infection, the new leaves that appear become progressively narrower, shorter, and stiffer than the ones immediately below. Their margins become chlorotic. Discoloration extends towards the midrib in the form of irregular diffused streaks with their long axes lying parallel with the veins. Starting from the edge, the thin chlorotic areas along the margin become necrotic. Infected Abaca plants may remain alive for more than two years, but they gradually become smaller and smaller, until finally, all of the leaves and leaf sheaths run brown and die. These plants produce numerous undersized suckers with small and stiff leaves with curled up margins. Thus far, none of the observed bunchy top infected Abaca plants have borne fruit. Abaca bunchy top virus is spread by aphids, *Pentalonia nigronervosa*. One aphid can transmit the virus but transmission is more consistent and efficient with a higher number of aphids. Plants that were seized with aphids showed first symptoms after 20 days. At present, experts have not yet developed Abaca varieties that can resist bunchy top infection. To control bunch top, they recommend the use of healthy planting materials. Sanitation through rouging of infected plants and application of herbicides is also recommended. In addition researchers recommend the practice of quarantine procedures to prevent the movement of infected banana or Abaca and their parts (Bajet, 02).

- Mosaic virus (transmitted by Aphis spp). Abaca mosaic is caused by the Abaca mosaic virus (AbMV), a potyvirus transmitted by aphids such as corn aphids (*Rhopalosium maidis*) and cotton aphids (*Aphids gossypii*). The onset of Abaca mosaic is characterized by mottling of the leaves, consisting of dark to pale green or yellowish streaks, which extend from the midribs to the margins; mottling also occurs on other parts of the plant. Affected plants do not grow to full size. The use of disease-free planting material, eradication of infected plants, and elimination of alternate hosts such as maize (*Zea mays* L.) and the weeds *Cyperus compressus* L., Paspalum *conjugarum* Bergius and *Senna tora* (l.) Roxb., are necessary for effective control of Abaca mosaic (Brink, 03).
- Vascular wilt (*Fusarium oxysporum f. cubensis*) An important fungal disease is Vascular wilt, also Fusarium wilt, caused by *Fusarium oxysporum f.sp. cubense*. It starts with rotting at the base of the pseudostem, with the rot moving upward until it reaches the leaf blades; plants will become yellowish and eventually wilt. When

pseudo-stems of wilted plants are cut crosswise, the reddish-violet colour of the vascular bundle becomes evident. The first noticeable symptoms of the disease are the inward curling of the leaf blades at or near the tip of the lower leaves and the slow growth of the plants. Vascular wilt, which, in contrast to the virus diseases, spreads in the soil or by rainwater, can be controlled by digging out infected plants and burning them, and by strict implementation of quarantine measures. Some cultivars, e.g. 'Linawaan', seem less susceptible than other ones (Brink and Escobin, 2003).

The situation in Leyte:

The impact of Bunchy top disease and Mosaic Virus in Leyte is catastrophic:
Bunchy top virus and Mosaic virus got completely out of control in the year 2003. According to an article in Ormoc News in June 2003 5,708 hectares of Abaca farms in Eastern Visayas are infected which equals 15% of the area planted with Abaca. The same article summons the infected plantations on the West coast of Leyte even at 41% (Ormoc News). In the same month Cebu Daily News writes that in Southern Leyte alone, at least 1,500 hectares were infected with the virus, affecting some 2,000 residents dependent on Abaca.

Two months later News Philippines states that in Eastern Visayas even 16,737 ha are infected. That means that 45% of all abaca plantations in Eastern Visayas are infected. According to the article the country's Abaca and banana industry is severely threatened by bunchy-top disease – the most widespread and prevalent disease of the industry. Further on the same article says that the Fibre Industry Development Authority (FIDA) has not publicized extensive statistics about the extent of the disease. For the time being farmers in Leyte are encouraged to plant other crops.

These figures and headlines indicate that planting Abaca in Southern Leyte cannot be recommended at the moment. However, large areas in the north are still unaffected by the disease and will probably remain so for quite some time. Abaca and banana strains that are resistant to the bunchy top virus have not been developed so far. Thus it is unclear what will happen to the fibre industry in the Philippines at all. The spreading of the disease is completely uncontrolled, up to now there are no regulations towards the handling of befallen Abaca material. Infected Abaca plantations suffer losses around 80% and it takes nine months to two years before an affected field recovers from the damage caused by the bunchy top virus.

Referring to this CBA the question is, whether the occurrence of Abaca diseases ranks under risk or uncertainty: According to newspaper articles the size of infected area of Abaca plantations has shot up from 15% to 45% in the last year. This is either due to an extremely vast spreading of the disease or and this is more likely the case it is due to an underestimation of the disease in June 03. Either way the probability for the occurrence of Bunchy top or Mosaic virus cannot be estimated. Thus the event of an infected Abaca plantation ranks under uncertainty.

8.3.2 Typhoons

Abaca is easily damaged by strong winds; complete plantations can be destroyed by typhoons. This is similar for acacia and especially coconut, because it does not root deeply. Typhoons are annual occurrences in the Philippines. An average of 9.2 typhoons cross the Philippines annually. The typhoons occur mainly in the period from July to December and affect all parts of the country, although the southern part of the country is slightly less affected (Disaster Management Philippines). The event of destruction of an Abaca plantation due to wind could theoretically rank under risk: An average of yearly frequency and intensity of strong winds is known. But there are no data available about extend of damage in relation to sovereigns of a storm. Further the risk of a damaged Abaca plantation strongly depends on the individual site: Planting Abaca on sites that are less prone to strong winds and planting cover trees helps to reduce the risk.

Since there are no sufficient data available the event of windbreaks has to be classified as uncertainty. As concluding remark it should be mentioned that typhoons and extensive Abaca plantations coexist in the Philippines since nearly 100 years.

8.3.3 Sensitivity Analysis

Within this part, we considered two possible scenarios that might occur to the different land-use systems. About none of those scenarios definite statements can be made. To get a concrete idea about the effects, a sensitivity analysis has been conducted for each system.

The first sensitivity analysis deals with the Bunchy top disease in case of the Abaca systems and the second one with the necessity of a logging permit in case of the rainforestation system. In the Abaca systems we assumed a 100 % loss of Abaca plants due to the virus in the tenth year of the cutting cycle. In year eleven of the cutting cycle, the farmer has to start again with Abaca and replant the area.

In case of the Rainforestation system it is assumed that the farmer does not get permits to harvest any of the Rainforestation trees. Consequently, the farmer is only allowed to sell his intercrops and fruits from the fruit trees. The following tables show the results of these two assumptions.

Table 23: NPV taking risk into account (6.5% discount rate)

	Rainforestation	Coconut old with Abaca	Coconut new with Abaca	Acacia with Abaca
Bunchy top Virus infection at age 10 (PhP)	1,419,511	400,869	269,240	495,100
Bunchy top Virus infection at age 10 (US $)	26,189	7,396	4,967	9,134
No lumber licences for Rainforestation farming (PhP)	612,097	467,004	335,375	561,236
No lumber licences for Rainforestation farming (US $)	11,293	8,616	6,187	10,354

The result of this sensitivity analysis shows how the net-benefit may vary due to different natural and political factor impact. In case of Rainforestation, the logging ban results in the alternative being a lot less beneficial. The net present value is 11,281 dollars which is only 43 % of the result with the permission to harvest the trees.

The overall revenues also decrease in case of the Abaca systems. In detail, the net present value of the Abaca-*Acacia mangium* system is 88 % of the disease free variant, the Abaca system with old grown coconut generates 86 % and Abaca with planted coconut gives 80 %.
Finally it can be stated, that even by taking these uncertainty aspects into account, the ranking of the systems does not change.

9 Final ranking of the alternatives

Comparing the net welfare contributions of different projects makes it possible to put them into a ranking. A CBA also allows a statement, whether a certain project is sensible at all. The result of this Cost-Benefit Analysis shows that none of the projects can be rejected from the economic point of view. The rainforestation system has by far the highest NPV of 26,189 US$. The advantageousness of rainforestation is that significant that it is advisable to overcome the juridical and administrative constraints linked with rainforestation. However, two caveats have to be mentioned here: The calculations of Dirksmeyer for the rainforestation system, which have also been adopted for this study, have been made at a time when the plantations were still young and hence, figures on revenues of crops, fruits and timber were based on assumptions and not on real data. At present, these data are still not available and it is recommended to intensify research in this area before promoting rainforestation farming at large scale. Furthermore, it has to be considered that farmers have to overcome the high rainforestation establishment costs in the first years. Here, the implementation of micro finance systems might be one means in order to achieve a wider application of this land-use alternative. Abaca with *Acacia mangium* ranks on the second place, followed by Abaca within an established coconut plantation and by Abaca under newly planted coconut. Due to the spreading Abaca diseases, it is unclear whether planting Abaca in the study region is advisable at the moment. The impact of the disease still seems to be unclear. To combine Abaca with acacia instead of coconut is a sensible means to increase the profitability of an Abaca plantation and to reduce the overall losses in case Abaca becomes infected. Regarding the NPV of an Abaca and acacia plantation, 57% of the revenues (318,984 PhP) are obtained by Abaca. In the case of old growth coconut-Abaca plantation even 68% are due to Abaca. In a newly planted coconut plantation with Abaca there are even losses of 95% in case Abaca fails.

Table 24: Final ranking of the alternatives

	NPV (PhP)	NPV (US$)
1. Rainforestation	1,419,511	26,189
2. Abaca and Acacia mangium	561,236	10,354
3. Abaca and old growth coconut	467,004	8,616
4. Abaca and planted coconut	335,375	6,187

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