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University of Applied Sciences Van Hall Larenstein

Topic: The Potential of Illipe nut production for small holders in Kalimantan, Indonesia. A comparison between Illipe nut cultivation and Palm oil cultivation by small holders in Kalimantan.

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Preface and Acknowledgements

This report is written as a final thesis to obtain the Bachelor Degree for the study of tropical forestry and nature conservation at van Hall Larenstein, University of Applied Sciences. I chose the subject, because I was very interested in the potential of the Illipe nut production as a way of subsistence for forest communities and as an alternative source of vegetable oil. Especially because the Palm oil industry in Indonesia proved itself to be extremely devastating for tropical ecosystems and forest communities the last three decades.

This study was commissioned by Dr. Ir. Willie Smits, founder of the Masarang foundation (see chapter1.1), in order to obtain information on the economic and ecological differences of palm production and Illipe nut production by independent smallholders in West Kalimantan. I would like to thank Dr. Ir. Willie Smits for providing the possibility to conduct this study under his leadership. I also want to thank Ir. Jaap de Vletter for his structural advice and accompaniment during the thesis research. Likewise, I would like to thank Dr. Peter van der Meer who taught me report writing skills during previous periods. Furthermore, I feel privileged having experienced the culture and hospitality of the Dayak community in Tembak. I would also like to thank Pak. Apui for his patience and understanding during all the interviews we had. I'm also grateful for the assistance of Pak. Najau and Pak. Nyat ensuring that all field data was well-directed. Moreover, I would like to thank Melvin Houtman, a third year Tropical Forestry student at van Hall Larenstein, for his cooperation and assistance during the fieldwork.

Yours faithfully,

Bram Groen

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List of Abbreviations

ABG= Above ground

Ba= Basal area (m2)

C = Carbon

CBR= Cost Benefit Ratio

CRAS=Clay-rich Alluvium Soils

DBH= Diameter Breast Height

EGS=Environmental Goods & Services

FFB= Fresh fruit bunch

Ha=Height average (m)

IDR=Indonesian Rupiah

NPV= Net Present Value

NTFP=Non-Timber Forest Product

SLS= Sandy Loam Soils

SSRM=*Shorea stenoptera* Regeneration Model

V= Volume (m3)

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Summary

This thesis has compared two different oil producing land use systems: the Illipe nut production and the Palm oil production. This comparison was made from the objective of the producer/smallholder. The research was commissioned by the Masarang Foundation (See chapter 1.1), because there is very little known about the economic and ecological aspects of the Illipe nut production viewed from the perspective of the producing small holders. At first the significance of the Illipe nut industry in Kalimantan's past was assessed, then the problems of the industry were analyzed to provide the context of the Illipe nut production in the history of Kalimantan.

In order to compare the Illipe nut production with the Palm oil production, a planting model has been designed for the Illipe nut production (See chapter 1.3.2). In order to make suitable predictions for the designed planting model, field research was conducted in existing Illipe nut regeneration stands. This study has conducted field research in West Kalimantan, Indonesia where interviews were conducted among Illipe nut producers. The results were compared with existing literature in order to execute statistically supported conclusions.

On the economic plan, both Illipe and Palm oil production by small holders were compared on the basis of a Costs and benefit analysis. The necessary information considering the Costs and benefits of Palm oil production by small holders was assessed through literature sources. In order to analyze the Costs and benefits for the Illipe nut production, many interviews were conducted to obtain the required parameters. On the ecological plan, both systems were compared on the basis of floristic diversity/ha and carbon storage/ha. In order to obtain the required information, literature was analyzed regarding the Palm oil production. For the Illipe nut production existing Illipe nut stands were investigated in the field and the outcomes compared with existing literature.

The comparison on the economic differences between both systems was performed on the basis of commonly used financial indicators. It appeared that the Illipe nut production according to the planting model is compatible with Palm oil production on the aspect of the Net Present Value. According the Benefit Cost ratio, the Illipe nut production performs even better than the Palm oil production. Looking at Internal Rate of Return it was unclear if the calculations from the Palm oil study were done considering the current inflation in Indonesia.

On the ecological plan, it appeared that the floristic diversity in both systems decreases as rotation age increases. It became clear that in the open stage of both stands the floristic diversity were nearly identical, but in the closed stage, the diversity in the Palm oil plantations decreases a lot faster than in the Illipe nut stands. Regarding the carbon stocks it became clear that the Illipe nut stands sequester more carbon on the Clay rich alluvium soils than Palm oil plantations. On Sandy loam soils, however, the Illipe nut stands capture less carbon than the Palm oil plantations. Overall the Clay rich alluvium soil proved to be more suitable for the SSRM production and thereby most compatible with Palm oil production by the small holders in Kalimantan.

1.1 General introduction

This thesis was conducted on request of the Masarang foundation which was founded by Dr. Ir. Willie Smits in 2001(Masarang, 2013). This foundation is committed to nature conservation in Indonesia whose head office is located in Tomohon, North Sulawesi, Indonesia. The Foundation cooperates with several local communities throughout Indonesia to assist them with the preservation of their livelihood and environment. In 2011, this foundation began assisting a Dayak community in West Kalimantan who asked for help in their endeavors against Palm oil companies who tried to encroach on their land(Masarang, 2013). This community already has a long history with various companies who have tried to convince them to sell their land or resources. Nevertheless, this community has always remained loyal to their culture and is not willing to sell their ancestral grounds.

They approached the Masarang foundation hoping to find sustainable alternatives that could create a stable income from their own land. One of the plans of the Masarang foundation is to regenerate the Illipe nut industry in this region by establishing an Illipe nut processing plant, whereby, the extensive Illipe nut stands in this region could be utilized once again.

The Masarang foundation asked me to conduct a study about the potential of Illipe nut production by small holders requesting economic and ecological information so this land use could be compared to other common land uses. Due to the lack of information on the Illipe nut production by small holders, it was necessary to conduct field research in the region of Tembak (see paragraph 2.1).

1.2 Background

The name "Illipe nut" refers to the seeds produced by several Shorea species (Dipterocarpaceae). The seed kernels contain edible oil with chemical properties that are remarkably similar to cacao butter. In the past the trees were planted by local communities as an inheritance for future generations. The oil is locally used as cooking oil, medicinal salve and fish fodder. On the international markets the oil is being used to manufacture cosmetics, chocolate, soap and candles (Peters, 2003). The Illipe nuts have been commercially traded since the middle of the eighteenth century (Wong, 1988). For many years the Dayak in West-Kalimantan earned a good income from the production and export of the illipe nuts. In 1987 alone almost 14000 tons of illipe nuts with an estimated value of over US $ 5 million were exported from West-Kalimantan (BiroPusatStatistik, 1987). In spite of the obvious economic importance of illipe nuts in West-Kalimantan, the industry was very unstable and unpredictable. One of the main reasons is the irregular seed production of Illipe nut trees. Like many Shorea species the seed reproduction occurs at intervals of 2-10 years, also known as "mast-flowering" (Ashton et al, 1988). Obviously, it is extremely difficult to create a stable export market from a resource that has such unreliable supply characteristics (Peters, 2003). At Mast-flowering years processing plants frequently received an oversupply of Illipe nuts, which resulted in high losses due to rehydration.

The former processing plant, that processed the Illipe nut of West Kalimantan, is located in Pontianak. This plant processes cacao butter as well, but nowadays mainly Palm oil. Due to the unpredictable supply of Illipe nuts, the factory has shifted to processing predominantly Palm oil. Presently, they only accept Illipe nuts during mast years. This is done because all machinery needs to be cleaned and adapted in order to process the Illipe nuts and this is only worthwhile when processing large quantities. During these mast years there is frequently an oversupply due to poor communication between the factory and the supply chain. As a result, the Illpe nuts of many traders and cultivators are spoiled. The location of the processing facility is also problematic considering the Illipe nut production in West Kalimantan. The areas that contain the largest populations of Illipe nut are in the vicinity of Sintang and Putissibau in West Kalimantan, which are located 400-800km from Pontianak (Peters, 2003). This creates a problem simply because the Illipe nuts need to be processed within 4-5 days before they start to putrefy.

Due to the unpredictability of these risks, cultivators, investors and processing plants have made a strong transition to the Palm oil industry the last three decades. In addition to the production of oil seeds, illipe nut trees are also a valuable source of the light red Meranti (Kartasujana, 1973). Unfortunately, due to the unstable market and the decreasing value of Illipe nuts many local people have sold their Illipe trees to loggers in order to obtain a quick and frequently large cash income. However, with the disappearance of the Illipe nut trees, the locals lose their land rights as well. These trees are officially recognized and used as land markers, therefore it is officially forbidden to sell them. However, many companies try to pursue local communities to sell these trees, in order to get access to their land, whereby they can start concessions. Wherein, the local people lose their independence and are often forced to work on the concession under conditions established by the concession holders.

Given these problems, there is a great urge to regenerate the value of the Illipe nut stands. The Masarang foundation wants to achieve this by the establishment of a specialized processing plant in the village of Tembak, Tempunak (See chapter 2.1). The Tempunak district contains the largest remaining Illipe nut stand of Kalimantan. Therefore the factory will be located amidst the remaining stands in the Tempunak district. The foundation intends to establish fixed prices for the Illipe nuts, in order to minimize the risks for the cultivators. After processing the Illipe nuts, oil can be stored over 30 years. The foundation wants to generate a reliable supply by creating a guaranteed and fixed stock of Illipe nut oil close to the factory. In doing so, the Masarang foundation aims to create a reliable industry in Tempunak and draw the interest of both cultivators and investors for the Illipe nut production.

This study aims to collect information about the economic and ecological aspects of Illipe nut production by small holders. This information should enable small holders to compare the Illipe nut production with other land uses. This study compared the Illipe nut production with the Palm oil production from the small holder's perspective.

1.3 Problem analysis

Although much literature is available about the general role of Illipe nut production in the past of Kalimantan, there is no comparative information available about the long term economic and ecological effects of Illipe nut production from a producers point of view. Despite the fact that Illipe nut cultivation was always practiced by independent small holders, there is no solid and applicable information whereby they can predict and compare the effects of Illipe nut production with other land uses.

The lack of this information is mainly the result of the irregular characteristics of seed production due to mast flowering. Another reason is the large variety of Illipe nut species being exploited, which all have their own specific characteristics.

In order to overcome these obstacles, this study designed a model that is solely based on the *Shorea stenoptera* (see paragraph 1.2.1). The model assumes an average mast flowering interval of 4 years and 16 *Shorea stenoptera's* per hectare (see paragraph 1.2.2)

Will this study provide new information in the field of Illipe nut production by small holders, whereby the Illipe nut production can financially and ecologically be compared with other land uses?

1.2.1 The Shorea stenoptera

There are at least 20 different Illipe nut species in West-Kalimantan with around 10 of these species being commercially viable (Soewanda et al, 1978). However, this study only investigated the *Shorea stenoptera*. Due to the relative large seeds and high quantity of production, the *S. stenoptera* is one of the most common and utilized Illipe nut tree in Kalimantan (Ashton, 1982) The *S. stenoptera* is a shade-tolerant primary species that is endemic to Borneo. The trees have an affinity for alluvial soils along river banks and can be grown at an elevation less than 800m (Anderson, 1975).

Like all Illipe nut species, the Shorea stenoptera flowers and fruits according to mast flowering characteristics which occur at intervals of 3-5 years (Schulte. A, 1996). This study assumed an average mast flowering interval of 4 years.

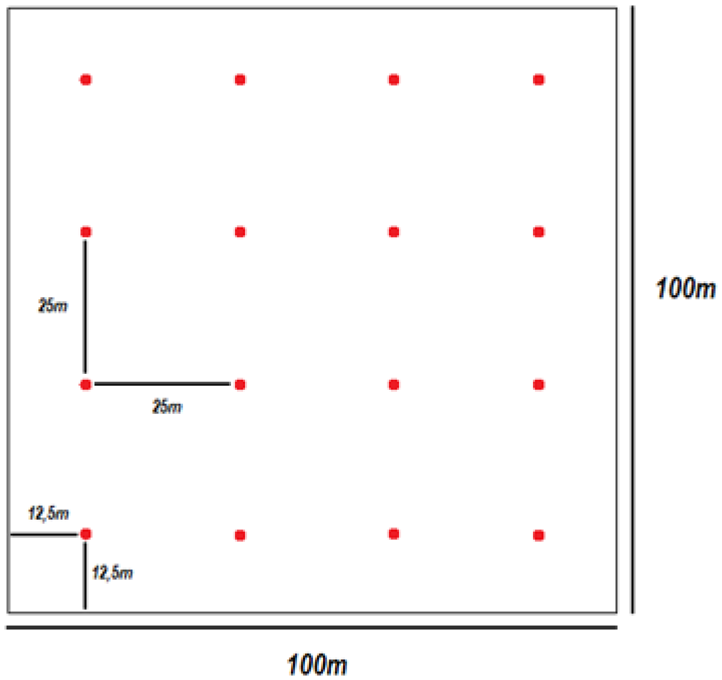
1.2.2 Design of the SSRM (Shorea Stenopetera Regeneration Model)

A planting model has been designed in order to estimate the economic and ecological potential of a *Shorea stenoptera regeneration model (SSRM)*. The study is based on 1ha planting design with 16 *S. stenoptera/*ha (see figure 1). The planting model is designed on the basis of the recommendations of three Illipe nuts experts (see appendix 1). Cited: "*Maximum fruit production and tree growth can only be achieved when the branches have the space to grow long stretching horizontal branches*." The study is based on the assumption that the fields are open at the planting stage, where after the *S.stenoptera* trees grow without management along with the natural regeneration. This circumstance frequently occurs in West Kalimantan, when the Dayak plant *S.stenopetera* trees on old rice plots. This planting model was investigated for two soil types: Clay-rich Alluvium soils (CRAS) and Sandy loam soils (SLS)(See annex 2)

Table 1. Basic assumptions used for the estimations with the SSRM

Basic assumptions of the SSRM	
Mast flowering interval	4 year(See paragraph 1.2.1)
Production at Non-Mast year	3,5 %
Length lifecycle SSRM	0-60 yr

Figure 2. The planting design of the" *Shorea stenoptera regeneration model(SSRM)*"



1.4 Objective and Research questions

The present report assesses the potential value Illipe nut cultivation could offer to small holders in Kalimantan. In order to place these findings in the appropriate context a comparison was made with Palm oil cultivation, a common land use practice for small holders in Kalimantan. The comparison is focused on the economic and ecological differences between these two land uses. The study is designed as an exploratory research that defined the economical values trough a financial analysis. Financial indicators were provided whereby the general economics of both land uses could be compared. The ecological values were compared on the basis of floristic diversity and carbon quantification.

Objective: Comparative information on the Net present Value, Internal rate of Return, Benefit Cost Ratio and ecological data on Floristic diversity and Carbon stocks of Illipe nut and Palm oil production by small holders in West-Kalimantan, Indonesia.

The main research question of this study is:

> **"What are the economic differences on the aspects of NPV, IRR and BCR and what are the ecological differences on the aspects of floristic diversity and carbon stocks of a SSRM and a conventional Oil palm monoculture by independent small holders?"**

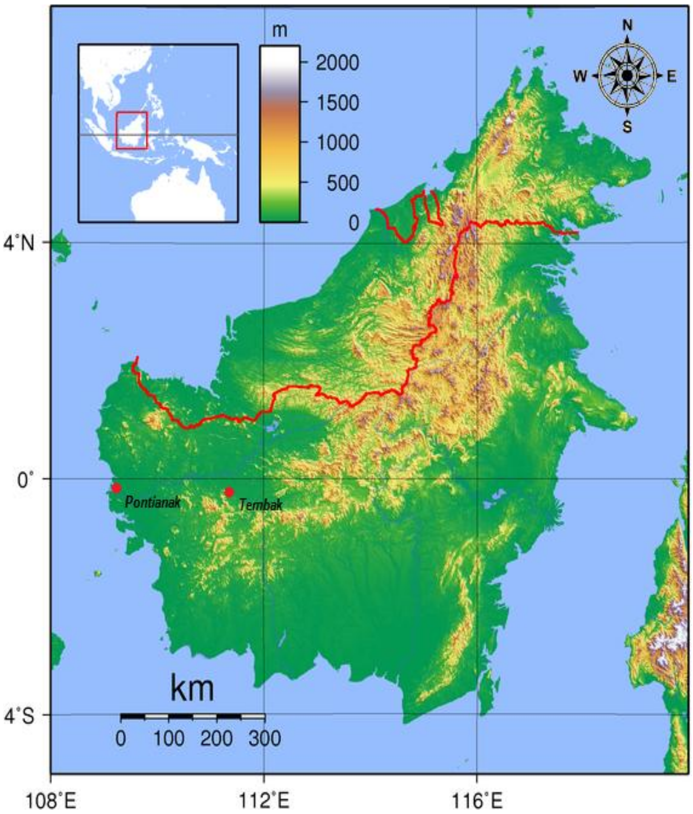
The main research question is answered through the following sub-questions:

1. What is the potential fruit production of the SSRM model
2. What are the differences in NPV, IRR and BCR between a of the SSRM compared with Palm oil monoculture?
3. What is the potential timber value of *Shorea stenoptera* throughout the lifecycle of the SSRM?
4. What is the difference in floristic diversity/ha between a palm oil plantation and a SSRM.
5. What is the difference in Carbon stock/ha in the lifecycles of a palm oil plantation and a SSRM

1.5 Study area

Research has been conducted in the Dayak community of Tembak (S 0°18.045 , E 111° 18.132), Tempunak district, South-West-Kalimantan, Indonesia. The region has an elevation 60-65m, average temperature is 26.9 C with an average monthly range of 1 C (Climatemps,2012). The area predominantly contains fluvial soils that are covered primarily with tropical forests, interspersed with secondary forests and rubber plantations. The region receives on average of 3181mm precipitation annually or 265 mm each month. The Dayak who inhabit this region are of the "Seberuang" tribe. This tribe practices shifting cultivation to grow Upland rice (Oryza sativa) with their main source of income consisting of rubber farming. In the past however, all men were Illipe nut cultivators

Figure 2. Map of Kalimantan, Indonesia[1:1000.000](Sadalmelik, 2007)



Sampling sites

All sampling sites were located in Illipe nut regeneration forests which were formerly rice fields. After the second rice yield, the Dayak still plant *S. stenoptera* trees on the fallow plots. Thereafter, these trees will grow without any maintenance and will grow along with the natural regeneration. This makes these spots ideal to determine the natural regeneration of biomass and floristic diversity after planting. These regeneration stands are found on the two most common soil types in this region: Clay-rich Alluvium soils (CRAS) and Sandy loam soils (SLS)(see appendix 2). This study assesses the performance of the S.stenoptera under both soil conditions so a proper comparison can be made.

2. General Methodology

Due to the diverse nature of topics, this chapter gives a detailed overview of the methods and parameters used to answer each sub-question separately. This gives a clear and chronological overview of the methods used to answer the main question of the study; thereby the elaboration of the research can be understand and reproduced

In order to obtain the required information, both field research and literature study was conducted. Regarding the Palm oil production, all required information was available in existing literature sources. However, regarding the Illipe nut production, there was no existing literature available for small holders to compare the Illipe nut production with the Palm oil production. Therefore, it was necessary to conduct field research in the village of Tembak (see paragraph 1.5)

Interviews

Tembak has a population of 266 people. There is still a lot of expert knowledge about Illipe nut cultivation especially among elderly men over 40, almost all of whom were Illipe nut farmers in the past. Due to the large number of former Illipe nut farmers, a compilation was made to select the most suitable interviewees (See annex 1). Eventually three men were chosen based on their specific and complementary knowledge. Interviews were conducted on the subjects of Fruit production (See paragraph 2.2) and production costs and practices (See paragraph 2.3) with the SSRM being designed in conformity with the results.

Field research

In the surroundings of Tembak are large populations of *S.stenoptera* regeneration stands. Survey's and measurements were conducted in these stands, in order to predict the potential carbon stocks and floristic diversity that could regenerate during the production cycle of the SSRM. In total, 4 plots (900m^2) were established in these stands to estimate the carbon quantities for the SSRM (see paragraph 2.5). To estimate the floristic diversity another 4 plots (900m^2) were sampled(see paragraph 2.6). In order to estimate the *S.stenoptera* timber volumes during the rotation of the SSRM, 188 *S.tenoptera's* ranging between 0-60 yr were measured in existing regeneration stands(See paragraph 2.3). For each of these subjects, the field data was compared with extensive studies that focused on each subject specifically. These studies were based on statistical tests and were used to verify the reliability of the field data in this study.

Literature study

With regard to the Palm oil production all required data was available in existing studies. These studies were used to evaluate the differences between Illipe nut production and the Palm oil production by small holders..

2.1 Potential fruit production of the SSRM

2.1.1Interviews

The potential FFB production for the SSRM is determined through interviews with three Illipe nut experts (see appendix 1)consisting of open and direct questions. These men were asked to estimate the minimal and maximum FFB production at "Mast flowering" years for a *S. stenoptera* tree at fixed ages between 0-60 yr. Both for CRAS and SLS.

2.1.2 Pebble stone method

Per interviewee, an average FFB production was determined based on the estimated min-max production at "Mast flowering" years. This resulted in three graphs for both CRAS and SLS. Subsequently, 36 former illipe nut cultivators were invited in the church of Tembak so that each could divide 5 stones over the three graphs in order of likelihood. This was done for CRAS and SLS. The most chosen graphs were used for the calculations of the FFB production in the lifecycle of the SSRM

2.2 Cost and benefit analysis of the SSRM and Palm oil Plantations

There are Costs and Benefits analysis available on Palm oil plantations in Kalimantan, managed by independent small holders, but for the SSRM there is no similar data available. Therefore, this study has conducted a Cost and Benefit analysis in order to obtain the financial indicators so the SSRM production can be compared with Palm oil production.

2.2.1 Interviews

Open and direct questions were elaborated among 4 Illipe nut experts (see appendix 1). Questions were directed to obtain all required parameters needed to conduct a financial analysis. The following parameters were determined for the SSRM; wages, labor hours, harvest practices etc (see table 2). The Masarang foundation asked to conduct the Cost and Benefit analysis for the prices shown in table 2.

Table 2. Parameters used for the Cost and benefit analysis of the SSRM

ITEM	VALUE
Interest rate	0,15
Growth rate(Inflation rate)	0,08
N-Seedlings/Ha Shorea stenoptera	16
Planting seedlings/Piece in Rupiah	3000
Wage/Hour per person in Rupiah	12500
Collection capacity Fresh fruit/Hour/Person in Kg	62,5
Price of fresh fruit/kg in Rupiah	1000
Price of fresh fruit/kg in Rupiah	2000
Price of fresh fruit/kg in Rupiah	3000
Collecting seedlings/hour	16
Cleaning field/Ha in Rupiah	800000

2.2.2 Cost benefit analysis

Based on the fruit production for the SSRM, a cost and benefit analysis is conducted to obtain the financial indicators whereby the SSRM can be compared with a Palm oil monoculture. These were the main financial indicators whereby both land uses were compared: Net Present Value/ Ha, Internal Rate of Return, Benefit/Cost ratio. All calculations were based on the actual Indonesian inflation rate of 8% (Trading economics, 2013). The used discount rate (interest rate) is 15%. This was done for three potential price levels for the FFB/kg for the Illipe nuts of the *S.stenoptera*. 1000IDR/kg, 2000IDR/kg, 3000IDR/kg

2.2.3 Literature study

Several financial reports on Palm oil production by independent small holders in Indonesia have been assessed. The reports were valued for their suitability to conduct a comparative study on the basis of common financial indicators. A study on Palm oil production by independent small holders in Central-Kalimantan proved to be the most appropriate (Boer, 2012).

2.3 Potential timber increment of *S.stenoptera*

2.3.1 Field research

A measurement of 188 S.stenopetera's (of which the age was known) was taken from within existing regeneration stands. The age of these stands corresponds with the S.stenoptera's on it because the *S.stenoptera's* were planted directly after the second rice yield (see paragraph 2.1). Age, Stem height (m), total height (m) and DBH at 1.30m was noted for all individual stands. This was done for N=95 on Clay-rich Alluvium soils and N=93 on Sandy loam soils. Measurements were conducted for ages ranging from 0-60 yr

Calculations

For each ***age class*** these parameters were determined;

-N trees
-Average DBH
*-Average Stem height (*Measured from ground height to the point were the trunk start to bifurcate)

These parameters were used to calculate the V/tree/Age of the *S.stenoptera*.

V(m³)=Ba*Stem height*0.7

$$V(m^3)=Ba*Stem\ height*0.7$$

Were;

Ba:	Basal area *(m^2)*
Stem height:	Measured from ground height to the point were the trunk start to bifurcate*(m^2)*
Form factor(0.7):	Form factor of 0.7 used for bole wood volume(Schulte,1996)

The estimated volume per tree is multiplied by 16 to calculate the timber Volume (m^3) per hectare in the SSRM. The timber volume was calculated with the stem height in order to indicate merchantable timber volume per hectare during the lifecycle of the SSRM

2.3.2 Literature study

Literature study was conducted to verify the reliability of the field data. A study was used that had measured N=2448 *S.stenoptera's* varying from 0-30 (Sudiono,1967). On the basis of the mathematical mean of the DBH, this study was compared to the field data (see paragraph 4.3).

2.4 Carbon quantification

In order to estimate the potential regeneration of ABG carbon in living biomass for the SSRM, existing *S.stenoptera* regeneration stands were investigated.

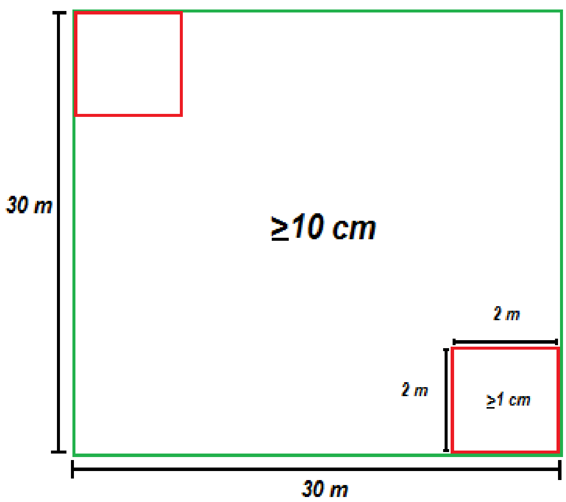
2.4.1 Plot selection

To estimate the potential ABG Carbon stocked by natural regeneration in the SSRM, 4 stages of Illipe nut regeneration forests have been sampled (see appendix. 3). A plot size of 900m^2 was used to achieve a 10% cover considering the 1/ha SSRM model. In total 4 plots were selected and sampled, 2 on Clay-rich Alluvium soils with the age 16 and 58 yr and 2 on Sandy loam soils with the age 20 and 47 yr. The ages of 16 and 20 yr, are corresponding with the mature stage in the life cycle of Palm oil plantations. The age stages of 47 and 58 yr are approximately two life cycles of Palm oil plantations (25-30yr) and are intended to indicate the difference of the C-stock overtime in the two land uses.

2.4.2 Plot sampling

Biomass was measured according to sample plot design in figure 3. In the 30m x30m plot the tree layer (Dbh>10cm) was measured. In the 2 sub-plots the understory (Dbh >1cm) was measured. DBH was measured at 1.30m using a diameter ribbon, Height measurements were conducted from the ground base towards the crown top using a laser range meter. Furthermore, for each plot, general plot features were assessed, such as date, geographical coordinates, elevation, age, soil samples, photo's etc.

Figure 3. Plot design carbon estimations



2.4.3 Calculations and formulas

To calculate the ABG Carbon (t/ha C), first the volume of the understory (Dbh>1cm) and the volume of the tree layer (Dbh>10cm) were determined. Consequently, you need to converse V/ha in m^3 to biomass/ha in kg. This is done with the specific wood density factor used for Asian tree families (FAO, 2012). Finally biomass/ ha in kg is conversed to Carbon/ha in kg by the specific Carbon conversion factors for the understory and the tree layer (Syahrinudin, 2005).

Volume/Ha in m^3

V=Ba*Ha*0,49

Where;

V: Above ground Biomass(Tree & undergrowth layers)(m3/Ha)
Ba: Basal area(m2/Ha)
Ha: Average height(m)
0,49: Form factor(Latifah, 2005)

Ba=N*$(0,25*\pi*Da^2)$ (in m2/ha)

Where;

Da: Diameter(m)

N: Number of trees

First all the data per plot is categorized in diameter classes. The number of trees (N) per diameter class is converted to N/Ha. Than the Ba/Ha per diameter class has been calculated with the formula for Ba. Then the height per diameter class is determined from a regression graph corresponding to the diameter classes. Finally all the parameters are entered in the formula V=Ba*Ha*0.49. This results in all the Volumes/ha for all the diameter classes. These Volumes are all summed to provide the total standing Volume/ha (m^3) for the tree layer and understory. The false form factor is applied, which uses DBH at 1.3 m as a reference point (S.Latifah, 2005)

Biomass/Ha in kg

The total biomass/ha in kg was derived from the V/ha in m^3 through conversion with the specific wood density factor. It is referred to as biomass density when expressed as mass per unit area, e.g., tons per hectare. For tropical trees in Asia this factor is 0.57 (Reyes et al, 1992)

Carbon/Ha in kg

The total Carbon content was calculated from the biomass/ha in kg of both the tree layer and understory and were converted with a carbon conversion factor. For the understory 39% of the biomass consists of carbon (Syahrinudin, 2000). For tropical trees 46.75% of the biomass consist of carbon (Thomas, 2012).

2.4.4 Literature study

In order to verify the reliability of the field data, the data was compared with statistically based information on the Carbon stocks of Illipe nut regeneration stands (see paragraph 4.4). The outcomes for the SSRM were compared with ABG C-stocks in Palm oil plantations on fluvial soils in East-Kalimantan (Syahrinudin, 2005). In order to place these findings in a broader perspective, these stocks are compared to other planting patterns such as; rubber plantations, agro forests and native Tropical moist forests(see paragraph 3.4)

2. 5 Floristic diversity

In order to compare the potential floristic diversity of the SSRM with the floristic diversity in Palm oil plantations, the potential floristic diversity in the SSRM needed to be estimated. In order to estimate the potential floristic diversity of the SSRM, existing illipe nut regeneration stands were investigated. These regeneration stands provide a good representation of the floristic diversity that could regenerate in the SSRM.

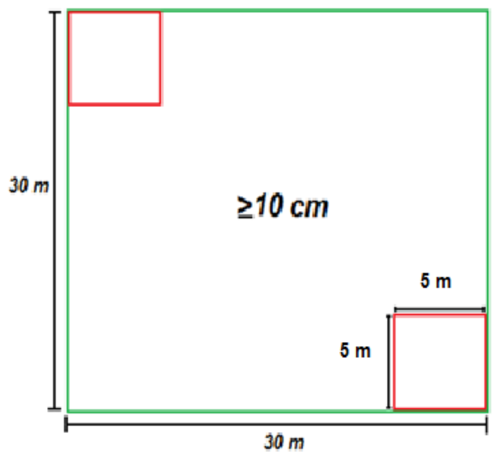
2.5.1 Plot selection

To assess the potential regeneration of floristic diversity in the SSRM, 4 plots ($900m^2$) were inventoried in Illipe nut regeneration forests. A distinction was made into two successive stages: The "open stage" (0-20yr) and the "closed stage" (40-60yr). 2 plots were conducted in the "open stage" and two in the "closed stage". A plot size of $900m^2$ was used to achieve a 10% cover considering the 1/ha SSRM model .In total 4 plots were established on fluvial soils to record the floristic diversity in the tree layer, understory and the herb layer

2.5.2 Plot sampling

The floristic diversity was determined using the plot design in figure 4. In the main plot all plant species of the tree layer (Dbh ≥ 10cm) were recorded. The understory (Dbh ≥ 1cm) and herb layer were recorded in the two 5x5m sub-plots, excluding tree ferns and epiphytes. Although most of the species could be determined by the local and scientific name, many could not, therefore only the numerical differences were measured(see paragraph 3.5). Furthermore, for each plot, general plot features were assessed, such as date, geographical coordinates, elevation, age, soil samples, photos etc.

Figure 4. Plot design floristic diversity estimations



2.5.3 Literature study

Two studies on the floristic diversity throughout the lifecycle of Palm oil plantations were used to compare with the potential floristic diversity of SSRM. These studies investigated the difference in floristic diversity in the open stage and the closed stage of Palm oil plantations. The open stage represented the first 1/3 of the lifecycle. The closed stage represented the last 2/3 of the lifecycle. These studies determined the floristic diversity on 900 m^2 as well (Sauerborn, 2003), excluding tree ferns and epiphytes

3. Results

Due to the comparative nature of the study, the results section shows the processed field data concerning the potential production of the SSRM, together with the comparative literature regarding the Palm oil production. This should provide a good overview on how the results of the SSRM and the Palm oil production relate to each other. Furthermore it's intended to provide clear insight into the structure of the study.

3.1 Fresh fruit bunch production of the SSRM

Figure 5. shows the difference of the Illipe nut production on clay-rich alluvium soils between mast flowering and Non-Mast flowering years. The production in the Non- Mast years corresponds to 3.5% of the production of a mast flowering. The potential production in the SSRM is based on an average mast flowering interval of 4 years (see figure 6)

Figure 5. Fresh fruit bunch production on Clay-rich Allivium soils

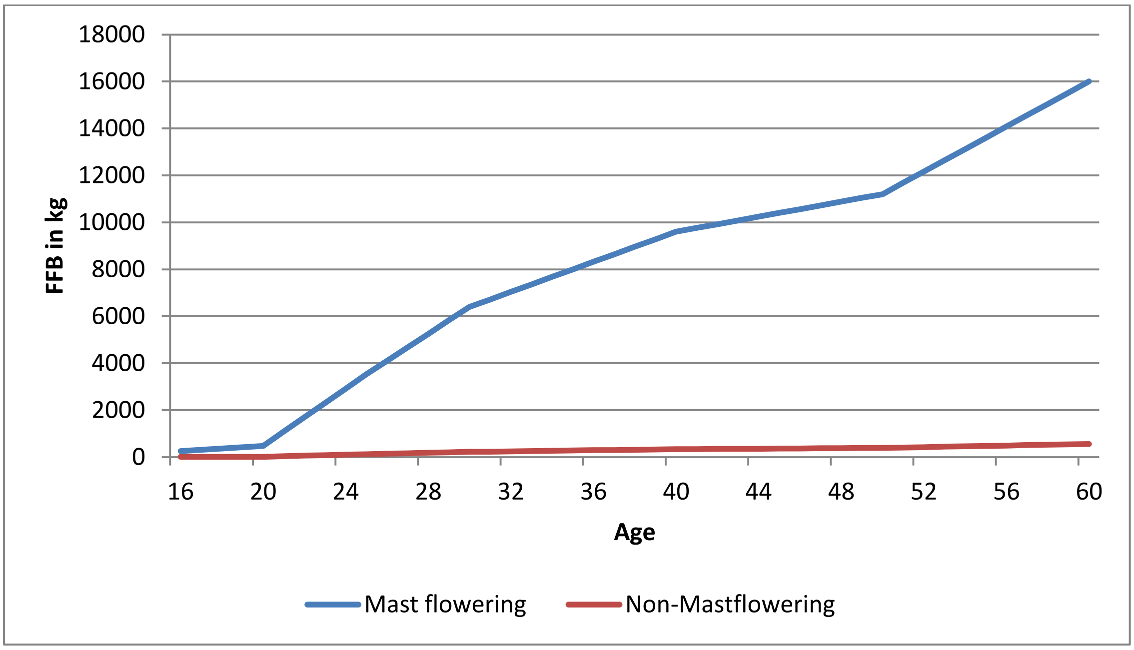
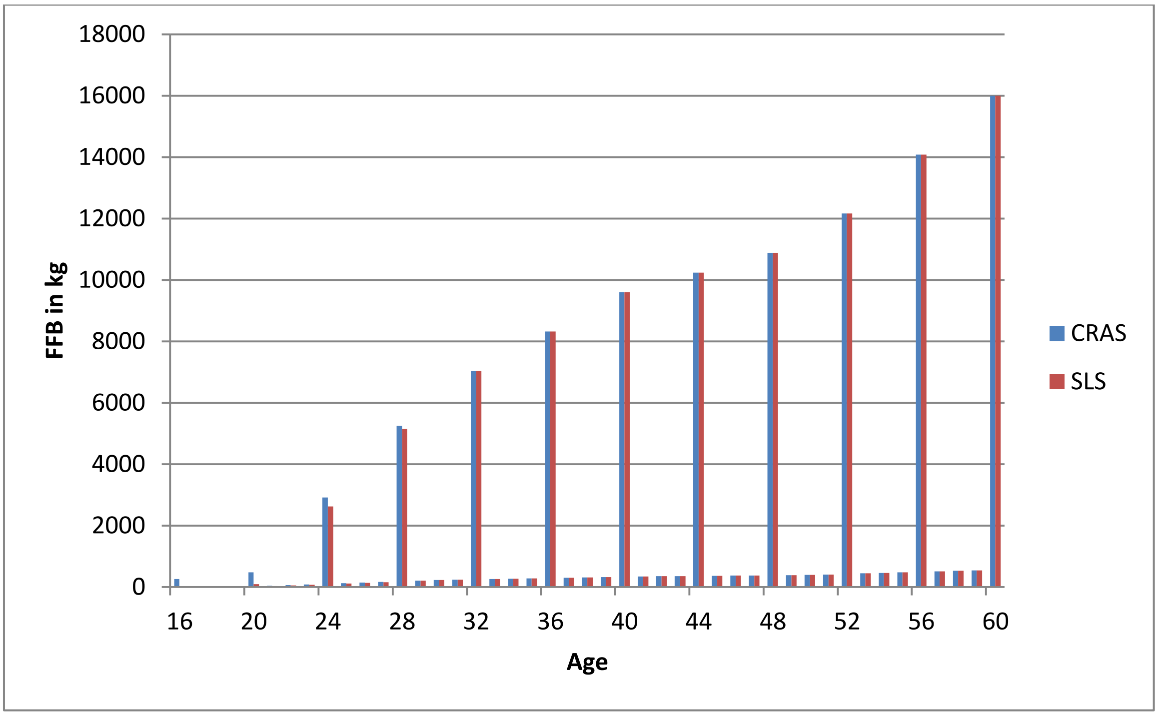


Figure 6 Shows the estimated fresh fruit production of the SSRM on CRAS and SLS at an average mast flowering interval of 4 years. The *S.stenoptera* starts producing illipe nuts at age 16yr on CRAS. On SLS the fruit production starts at age 20yr. In between the Mast flowering there is still annual fruit production. The production in the non-mast years is 3.5% of the production which the *S.stenoptera* generates at mast flowering. In the first 30 years there is a difference in fruit production between the CRAS and the SLS. At age 30 years the *S.Stenoptera* fruit production is even on both soils.

Figure 6. Production of Fresh fruit bunches in kg/ha on CRAS and SLS



3.2 Cost and benefit analysis of SSRM and Palm oil Plantations

Before starting to invest in a certain land use system, there are many factors to consider. Through a financial analysis, important financial indicators of the SSRS are determined. Indictors such as IRR/ha, NPV/ ha and BCR are assessed (see paragraph 3.2). These financial indicators are commonly used to compare the reliability and profitability of different land use systems. This chapter compares and discusses the general economics for independent smallholders in an SSRS and in Palm oil plantations. Independent smallholder or *"petani mandiri"* means a farmer who is managing, financing, and operating his farm by himself (Boer, 2012).

Production cycles

In a monoculture stand, oil palms start there productive cycle on average at 3-4 years (FAO, 2012). The SSRM on CRAS start to produce at the 16 yr and on SLS at 20 yr. In the study on Palm oil plantations (Boer, 2012), calculations were done with a labor wage of 37.800/day, where the SSRM uses a fixed minimum labor wage of 100.000IDR/day. There are on average 30-40 Labor days/ha/yr in the 25 yr lifecycle of an oil Palm plantation of an independent smallholder (Boer, 2012). In the SSRM there are on average 4-6 Labor days/ha/yr in a 60yr lifecycle. This is mainly due to the difference in plant care (see table 3). In the SSRM there are no management practices after planting, such as weeding, pruning, applying of fertilizer and pesticides. In the SSRM the labor days consist mainly of cleaning field for harvesting and harvesting itself (see table 3) which results in low total costs over the 60 yr production cycle in the SSRM (see table 3). The start-up costs in the SSRM are 860500IDR compared to 16.195.500IDR on the Palm oil plantation. In the SSRM the small holders already owned the land. Also the planting costs are much lower in the SSRM due to the relatively low number of trees per hectare.

Table 3. Overview of the total costs in the production cycles of Palm oil plantations and SSRM(Boer, 2012)

	Ind. Farmer Palm oil (IDR/ha/25yr)	***Ind. Farmer SSRS, Fertile Clay (IDR/ha/60yr)***	***Ind. Farmer SSRS, Sandy loam (IDR/ha/60yr)***
Land acquisition	2,500,000	NA	NA
Planting	13,695,500	60500	60500
Plant care(4-25yr)	98,053,950	NA	NA
Cleaning field	NA	15,675,040	15,546,421
Harvesting	14,099,120	22,286,272	21,070,464
Total	128,348,570	36,806,004	36,677385

Financial indicators

The NPV determines the present value of an investment, taking into account costs and benefits, subject to inflation and the discount rate used through the whole production cycle. Table 4 shows a NPV of 10.707.906 IDR/ha in a Palm oil plantation of an independent smallholder. Table 5 shows that in the SSRM that NPV/ha is reached at a FFB price of 2000IDR/kg. The IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. Table 4 shows an IRR of 47.94% in the Palm oil plantation of a small holder. Looking at Internal Rate of Return it was unclear if the calculations from the Palm oil study were done considering the current inflation in Indonesia. The IRR in the SSRM was calculated considering current inflation. The Benefit Cost Ratio is a financial indicator that is used in Cost and benefit analysis to assesses the value for money. For example a BCR value of 1.3 indicates that for every $1 invested (costs) $1.3 will be gained. Table 4 and 5 show the BCR's for small holders in Palm oil production and the SSRM.

Table 4. NPV, IRR and BCR in Palm oil plantations of small holders

Independent smallholder/ha	**Palm oil Plantation**
NPV	10.707.906 IDR
IRR	47,94%
BCR	1,29

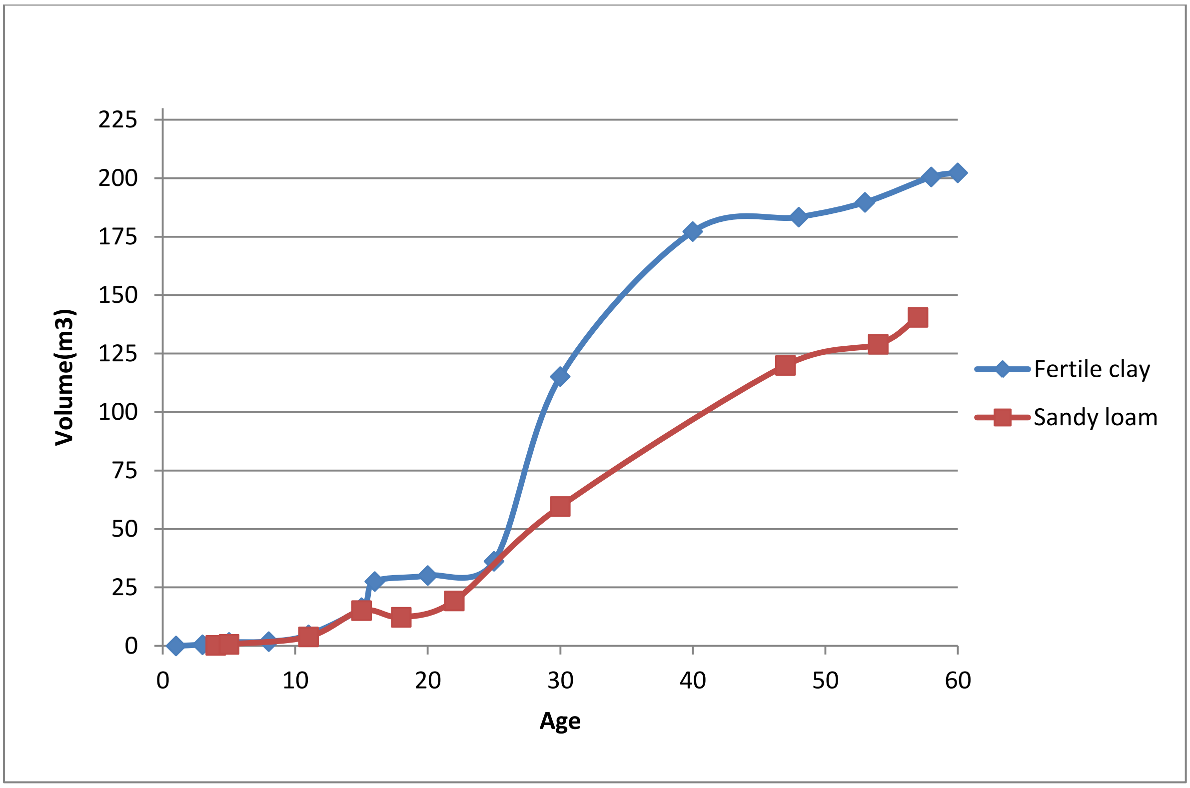
Table 5. NPV, IRR and BCR in the SSRM for SLS and CRAS

Price FFB/kg	**1000 IDR**	**2000 IDR**	**3000 IDR**	**Soil**
NPV	4.263.838	11.474.840	18.927.628	CRAS
NPV	4.104.546	10.996.559	18.150.152	SLS
IRR	21	25	27	CRAS
IRR	21	24	26	SLS
BCR	2.68	4.36	6.47	CRAS
BCR	2.72	4.33	6.42	SLS

3. 3 Potential Timber increment *S.stenoptera*

Figure 7 shows a clear dissimilarity between the timber increment on SLS and CRAS. The same trend was seen in the biomass on both soils (see paragraph 3.4). What is notable is the initial slow growth on both soils until 23-25 years. These growth curves are characteristic for shade-tolerant primary trees. The reliability of this data was verified by the comparison of the mathematical mean of the DBH's with existing literature (see paragraph 4.3).

Figure 7. Timber Volume(m^3)/ha in the SSRM



3.4 Carbon stocks of SSRM and Palm oil plantations

In order to estimate the potential Carbon the SSRM could store, existing *S. stenoptera* regeneration were investigated. This chapter is meant to clarify the differences in C-stocks between the SSRM and Palm oil plantations. Furthermore this data could be used to assess the feasibility for participation in Carbon schemes. In order to place these findings in a broader perspective, these stocks are compared to other planting patterns such as; rubber plantations, agro forests and native Tropical moist forests.

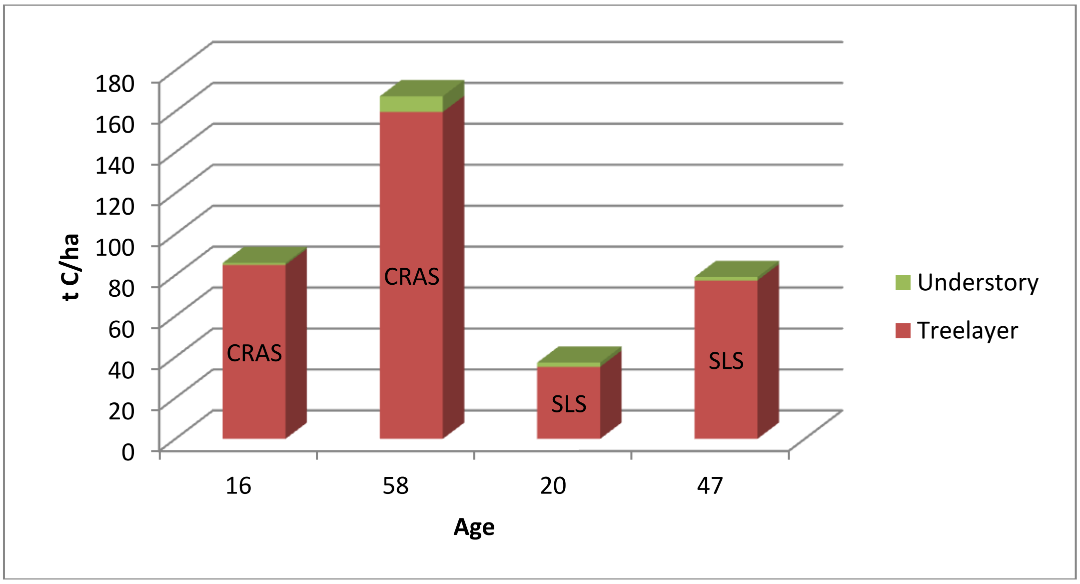
Carbon stocks in the SSRM

The C-stocks in the SSRM differ greatly between both soil classes (see figure 8). The graph shows a clear dissimilarity between the C-stock on CRAS and the SLS. As shown in table 6, 1 ha SSRM on CRAS (16 yr.), stocks 2.3 times as much carbon as 1ha SSRM on SLS (22 yr) and even 5 tons more than the SSRM (47yr) on SLS. Despite the fact that N. trees/ha is slightly higher on the SLS, the Ba/ha is much higher on the CRAS. This indicates the influence of the soil types on Carbon sequestration and biomass in the SSRM

Table 6. Characteristics of the SSRM on Clay-rich Alluvium soils and Sandy loam soils

	Clay-rich Alluvium	Sandy loam	Sandy loam	Clay-rich Alluvium
Age	16	20	47	58
T C/Ha	85.9	37.2	79.1	167.4
N/Ha	867	889	400	378
Ba/Ha(m2)	40.4	22.3	31.4	53.9

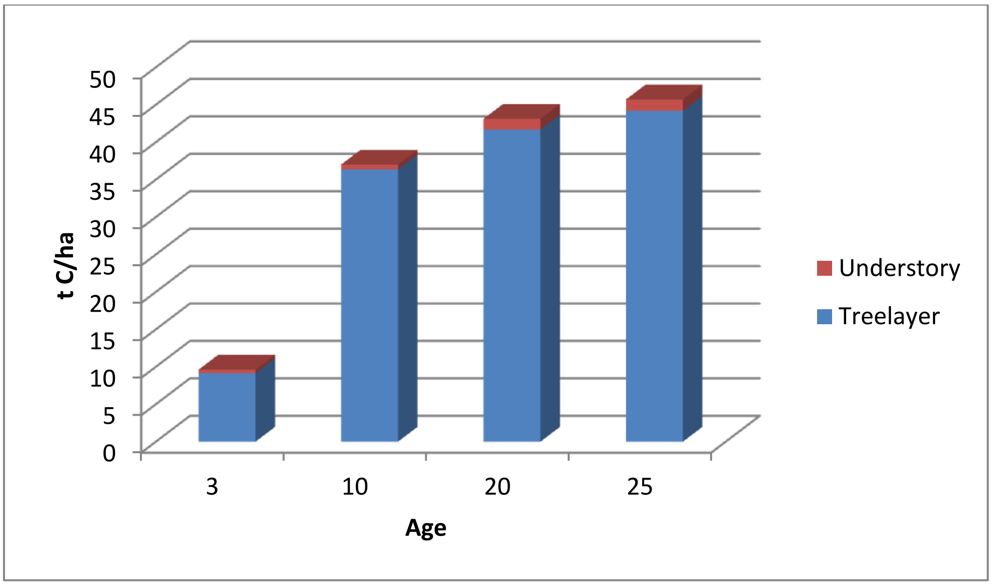
Figure 8. ABG C-stocks in SSRM on SLS and CRAS



Carbon stocks in Palm oil Plantations

The average ABG C-stock of oil palm plantations based on a typical replanting cycle of 25 years is (35)-40-(45) t C/ha(Implying a measured range of 30-45 and a mean of 40)(World agroforestry, 2012). Figure 9 shows the results of the research conducted on the AGB C-stocks of Palm oil plantations on mineral soils in East-Kalimantan (Syahrinudin, 2005). The ABG C-stock is determined by the C in the understory and tree layer. This makes this source more appropriate for a comparison with the ABG C-stocks in the SSRM.

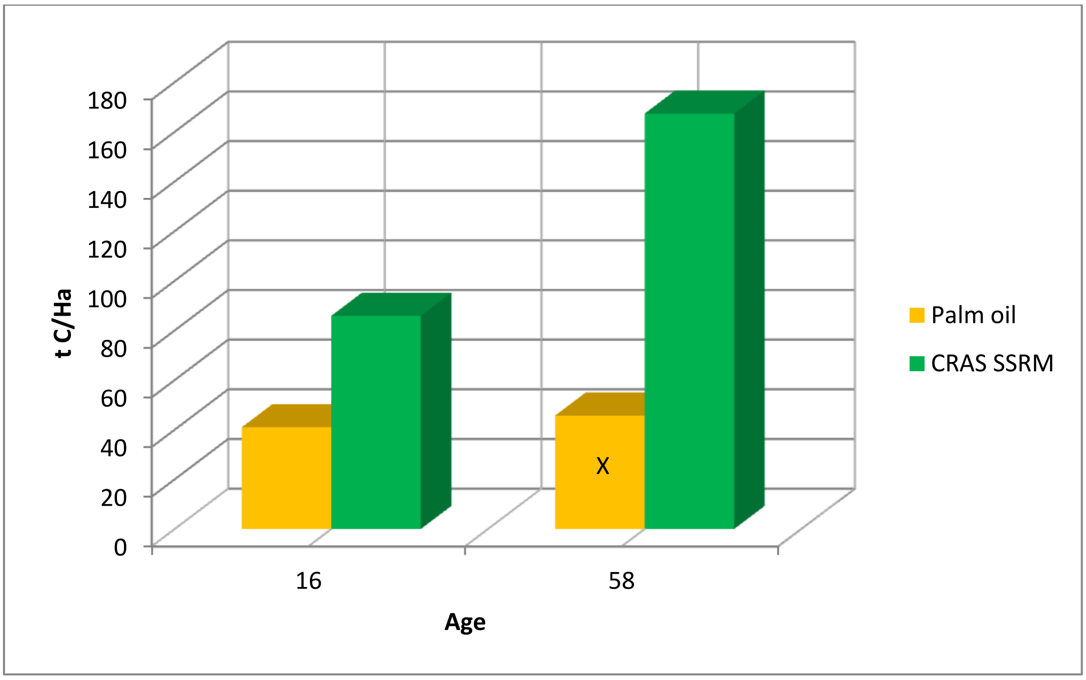
Figure 9. Carbon stocks of Palm oil plantations in East-Kalimantan(Syahrinudin, 2005)



Carbon stocks in the SSRM and Palm oil Plantations

Figure 10 shows the total ABG C-stocks from the study in East-Kalimantan (Syahrinudin, 2005), combined with the C-stocks in the SSRM on CRAS. At the age of 16 yr the Palm oil plantation stores 48% of the C-stock that the SSRS on CRAS stores. At 16 yr the Palm oil plantation stores 41(t C/Ha) and the SSRM 85.9 (t C/Ha). At age 58 the SSRM stores 167.4 (t C/Ha)

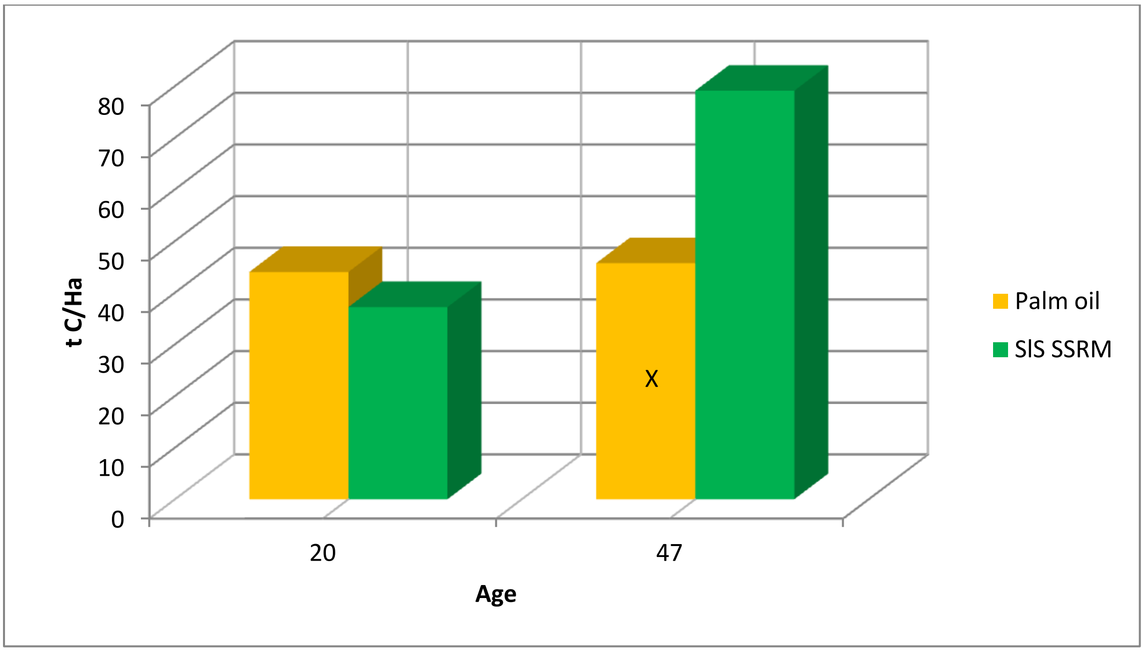
Figure 10. C-stock stocks in the SSRM on CRAS vs C-stock in Palm oil plantations(Syahrinudin, 2005)



X: This bar shows the maximum C-stock in the Palm oil rotation cycle(25yr)

Figure 11 shows the Carbon stock of the SSRM on SLS is lower at age 20. The C-stock in the SSRM is 85% of the C-stock in the Palm oil plantation at age 20. The SSRM stores 37.2(t C/Ha) and the Palm oil plantation 44(t C/Ha) at age 20. At age 47 the SSRM stores 79.1(t C/Ha)

Figure 11. C-stocks of the SSRS on SLS vs C-stocks in a Palm oil Plantations(Syahrinudin, 2005)

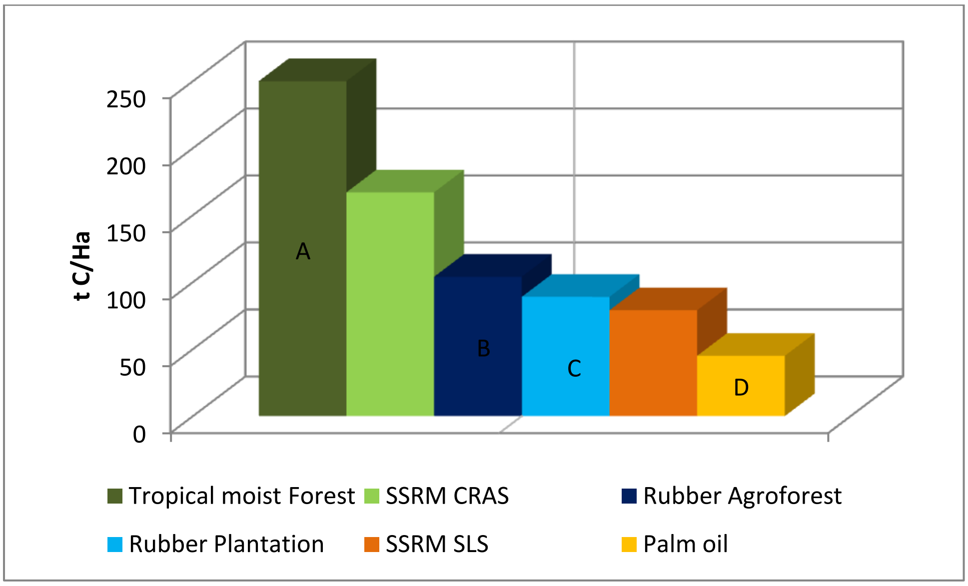


X: This bar shows the maximum C-stock in the Palm oil rotation cycle(25yr)

Carbon stocks of land uses in Kalimantan

The natural vegetation in this region is mostly comprised of tropical moist dipterocarp forests with other common land uses being Palm oil and rubber plantations. In general, tropical forests store 150–250 tons of carbon per hectare (t C/ha). Tree based forest systems 50–150 t C/ha for tree-based systems and non-tree-based systems less than 50 t C/ha (FAO, 2012). The graph in figure 12 shows the maximum ABG carbon stocks of different land uses in Kalimantan. The estimated carbon stocks for the SSRM are showed on SLS en CRAS.

Figure 12. Maximum ABG carbon stocks of land uses in Kalimantan



Sources:
A: FAO(2012)
B: Situmpul(2000)
C: Palm(1999)
D: Syahrinudin, (2005)

3.5 Floristic diversity of the SSRS and Palm oil plantations

The floristic diversity of Palm oil plantations and the SSRM was compared on the basis of two stages in the lifecycles of these systems, the open stage and the closed stage. This distinction was made to explore the diversity present in the open stage of these two systems and the change in diversity that occurs after crown closure. The open stage represents the first 1/3 of the lifecycle and the closed stage represents the last 2/3 of the lifecycle in both systems. In the SSRM the open stage was inventoried at the 16th yr. and 20 th yr. The closed stage was inventoried at the 47th yr. and 57th yr. (see table 7). In the Palm oil study, the open stage was inventoried at the 6th year and 7th yr (Sauerborn, 2003). The closed stage was inventoried at 17 th year and 20th yr. (Chen *et al*. 1978; Wan Mohammad 1986; Hassan and Abdullah 1991)

Table 7. Shows the potential floristic diversity of the SSRM in the open and the closed stage

	Open stage				**Closed stage**			
	Plot 1. 16 yr		**Plot 2. 20 yr**		**Plot 3. 47 yr**		**Plot 4. 57 yr**	
	N	%	N	%	N	%	N	%
Tree layer	36	52	25	40	20	36	13	30
Understory	12	17	9	15	9	16	7	16
Herb layer	21	31	28	45	27	48	24	54
Total	***69***	***100***	***62***	***100***	***56***	***100***	***44***	***100***

Table 8. Stand structure of the floristic diversity for the SSRM in the open and closed stage

	SSRM. 16 yr		**SSRM. 20 yr**		**SSRM. 47 yr**		**SSRM. 57 yr**	
	N/ha	Ba/ha(m^2)	N/ha	Ba/ha(m^2)	N/ha	Ba/ha(m^2)	N/ha	Ba/ha(m^2)
Tree layer	867	38.22	889	17.98	400	27.93	867	41
Understory	15000	2.18	8750	4.33	10000	3.46	15000	12.83

Figure 12 shows the regeneration of floristic diversity in Illipe nut regeneration stands on fluvial soils. This data provides a good indication for the potential floristic diversity of the SSRM model on fluvial soils. In the open stage (measured for 16,20yr) the stands have a higher diversity than in the closed stage (47,57yr) Especially the diversity in the tree layer decreases.

Figure 12. Potential floristic diversity of the SSRM

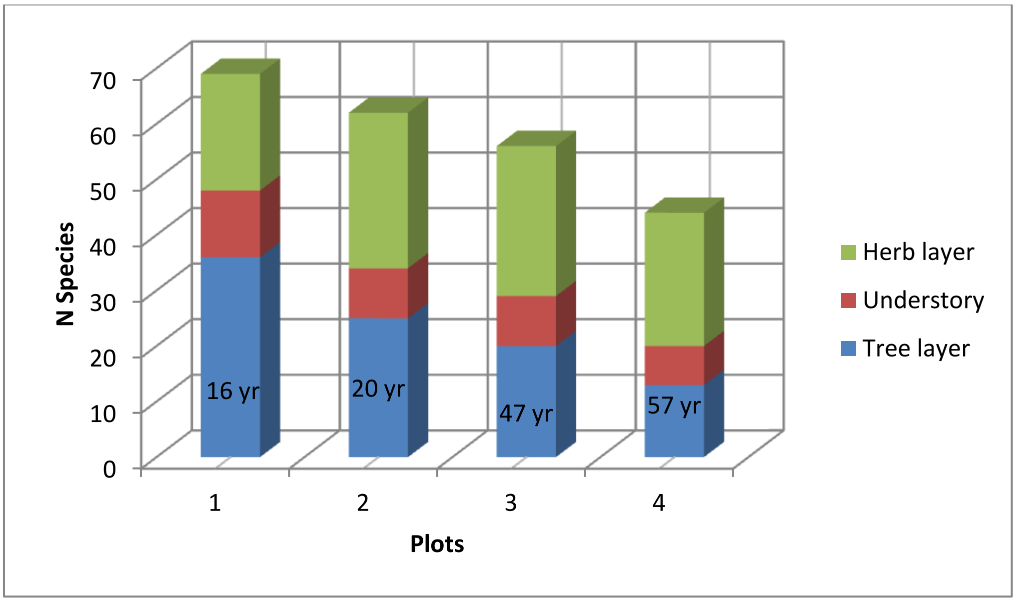
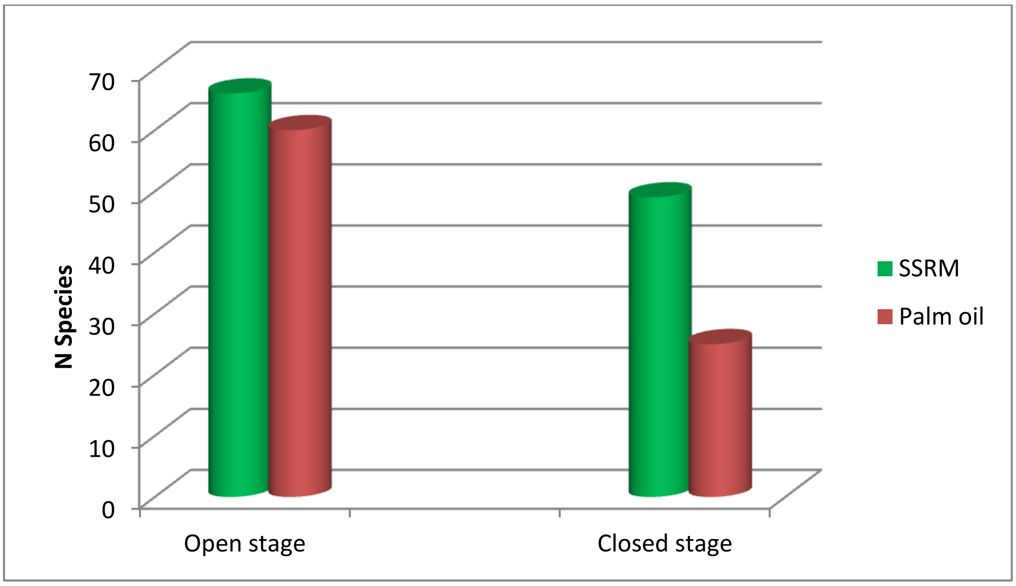


Figure 13 shows the findings of the potential floristic regeneration in the SSRM, compared to the floristic diversity in Palm oil plantations. In the open stage the difference in diversity is marginal, but in the closed stage the SSRM comprise 49% more species than in the Palm oil plantations

Figure 13. The Floristic diversity of the SSRM and Palm oil plantations in the open and



4. Discussion

4.1 Potential fruit production of the SSRM

The design of the SSRM made it possible to estimate the fruit production per hectare during a 60 yr cycle of the Illipe nut production. Subsequently, this data provides the required parameters in order to conduct a Cost and benefit analysis. Nevertheless, mast flowering is a phenomenon that remains difficult to predict. Therefore this estimation is only useful for long term predictions, such as the 60 yr production cycle in the SSRM. The fruit production in the CRAS and SLS differ predominantly in the beginning phase of their production cycles. The fruit production on the CRAS start at the age of 16, were the production on the SLS starts at 20 yr. In the 60th yr. the production of the SSRM reaches its maximum production of approximately 1000kg FFB per tree. This continues for another 80-100 yrs. That is the reason why the Illipe nut trees were usually planted as a future supply for the next generation.

4.2 Cost and benefit analysis of SSRM and Palm oil plantations

Through the designed SSRM production model it was possible to perform a financial analysis. This resulted in financial indicators, whereby the Illipe nut production can be compared to Palm oil production and other land uses. There are some clear differences between the production of Palm oil and Illipe nuts by small holders. One of the main differences is the length of the production cycles. The Illipe nut production is a long rotation system (60yr), whereas the Palm oil production is a medium long rotation system (25yr). The production and revenues start at the age of 3-4 years in a Palm oil plantation (FAO, 2012), wherein the SSRM production starts after 16-20 years depending on the soil type. Yet, in terms of investment capacity the SSRM is more accessible for small holders. The initial startup costs for small holders are 860500IDR/ha in the SSRM versus 16.195.500IDR/ha a Palm oil plantation (Boer,2012). Furthermore, the total costs over the entire production cycles are much lower in the SSRM with 36 million IDR over 60 years versus 128 million IDR during 25 years in the Palm oil plantation. This is despite the fact that the daily wage is 2.6 times higher in the SSRM. This huge difference is predominantly caused by the dissimilarity in man hours and therefore labor costs. The SSRM is a production system which doesn't require any maintenance after planting in year 1, were Palm oil production requires extensive maintenance throughout the production cycle. This is clearly seen in the average days of labor per year in both systems (see paragraph 3.2). During the 25 year cycle, the Palm oil plantation requires on average 40-60 working days per year (Boer,2012). The SSRM requires 4-6 working days a year during the production cycle of 60 yr. The in the SSRM are consist of planting and harvesting practices, were a Palm oil plantation requires a lot more maintenance such as; weeding, pruning, applying of fertilizer and pesticide etc. In equation the SSRM is more accessible for small holders with limited financial resources and time. When comparing the SSRM to the Palm oil plantation, you have a longer waiting period before you see revenues which is a clear disadvantage.

In order to compare the profitability of both systems, financial indicators were analyzed that translate the cash flows of both production cycles to current financial values. In terms of the Net Present Value the SSRM is competitively at a price of 2000IDR/kg FFB. The Internal Rate of Return is much higher in the Palm oil plantation, only it is not clear whether the IRR in the Palm oil study was calculated taking into account the current Indonesian inflation. Therefore, it was not possible to compare both systems on the aspect of the IRR. Nevertheless, the IRR in the SSRM was determined considering current inflation and therefore is still a valuable financial indicator for comparisons with other land uses. Regarding the Benefit Cost ratio the SSRM performs very well. In this study the BCR ranges from 2.7-6.5 depending on soil type and assumed price (see paragraph 3.2). In the Palm oil plantation the BCR is 1.29. The relatively high dissimilarity on the BCR between both systems can be explained by the low total costs during the production cycle of the SSRM compared to Palm oil production.

In short, this financial analysis compared two very different production systems on the basis of creditable financial indicators. Previously, financial comparisons based on general CBA indictors could not be conducted regarding the Illipe nut production. Furthermore, the cash flow during the entire production cycle of Illipe nut production was clarified. The financial comparison has shown that on the long term the SSRM production can be compatible with Palm oil production. Nevertheless, the SSRM is probably most suitable as a secondary land use, due to the late upcoming revenues. The SSRM should be seen as a depth investment, wherein the short term Palm oil production is financially more attractive.

4.3 Potential Timber increment S.stenoptera

The results considering the Timber increment of the S.stenoptera give a clear indication of the standing timber volumes throughout the life cycle of the SSRM. Notable is the initial slow growth of the *S.stenoptera* on both soils. At the age of 23-25 years the growth of the trees starts to accelerate. This phenomenon is characteristic for shade-tolerant primary trees and a well known process in vegetation dynamics of regeneration forests. After approximately 20-25 years there is a high mortality of long-lived, shade-intolerant pioneer trees, which stimulates the canopy recruitment and reproductive maturity of shade tolerant primary canopy species (Chazdon, 2008).

On the CRAS N=95 *S. stenoptera's* were measured between the age of 0-60yr. On the SLS N=93. Because on both soils N is too low to execute statistical tests, the results were compared with a study were N was 2448 *S.stenoptera's* (Sudiono, 1967) The results were compared on the basis of the mathematical mean of the DBH classes. The mathematical mean of the DBH measured for the *S.stenoptera* on SLS and CRAS were slightly higher than the mathematical mean that was calculated in the study conducted at Hourbentes, Java (Sudiono, 1967). This was probably caused by the relatively high N/ha in the stands at Hourbentes, Java, nevertheless the growth curves were similar.

There was a great difference between the Timber volume of the *S.stenoptera* on CRAS and SLS. At the end of the assumed production cycle (60 yr.) this variance was more than 60 m^3/ha. The dissimilarity between these two soils was also recognized in the carbon stocks on both soils (see paragraph 3.4).

Even though the timber in the SSRM is not intended as a commercial source, it still adds value to the land and it could serve as a kind of surety. It is a long term investment which prevents farmers from changing the land use and thereby reduces the pressure on these forest stands. During the aging of the stand, the land increases in value, were in Palm oil plantations the soil gets depleted overtime and the land gets qualified as degraded after 25 years (Nelson, 2011). This in turn, decreases the value of the land. This redemption of the land value was not reflected in the financial comparisons.

4.4 Carbon stocks of the SSRM and Palm oil Plantations

Countries and organizations are reducing carbon emissions by using forests as CO2 sinks, where formally the focus was mainly on natural forests, now forest plantations have been recognized as important carbon sinks (Dallinga, 2013). Today, the Carbon in forest stands is often determined by airborne investigations. These investigations make use of long-wave length radar and LIDAR to determine the ABG biomass/Carbon in temperate and tropical forest zones. For the SSRM the ABG carbon stocks were estimated on the basis of ground based inventories in existing *S.stenoptera* regeneration stands. Ground based inventories are still the most accurate method to estimate carbon stocks in forests, but are expensive and time consuming (Houghton, 2005). Because the SSRM is an unknown planting system, the estimated ABG carbon stocks were compared to other land uses in order to place the findings of this study in a broader perspective.

Notable is the large difference in ABG carbon stocks between the SSRM on CRAS and SLS (See paragraph 3.4). This fluctuation was caused by the variance in soil fertility. The CRAS is more fertile than the SLS, which was also reflected by the higher *S.stenoptera* timber volumes on CRAS (see paragraph 3.3). Soil fertility is recognized as an important determinant in the ABG carbon storage capacity of forests (Ghazoul, J, 2010). This conclusion was also strengthened by the N.trees/ha that hardly differed on both soil types, but the Ba/ha on the CRAS was higher by a factor of 1.8.

Regarding the Carbon stocks in Palm oil plantations, this study showed that there is no Carbon sequestration advantage of the SSRM on SLS compared to the Carbon stocks in Palm oil plantations. However, the SSRM on CRAS sequesters approximately twice as much carbon as Palm oil plantations(see paragraph 3.4).

The potential Carbon stocks of the SSRM were compared to a study that assessed the carbon stocks of Illipe nut stands in Nepal(Magar, 2012). This study came to an average Carbon stock of 148 t C/ha for stands >20y(Magar, 2012). Furthermore, the estimated carbon stocks of the SSRM were compared to carbon stocks of other common tree based land uses in Kalimantan. This was done on basis of the maximum carbon stock of each land use. In general, tropical forests store 150–250 tons of carbon per hectare (t C/ha). Tree based forest systems 50–150 t C/ha and non-tree-based systems are less than 50 t C/ha(FAO,2012). The SSRM on CRAS stored a maximum of 167.4 t C/ha and can be classified in the carbon class of tropical forests. Because the SSRM is a regeneration model, it develops very similar as a tropical rainforest. The SSRM in SLS stored a maximum of 79.1 t C/ha and can thereby be classified within the carbon class of tree based forest systems (FAO,2012). Of all the tree based systems compared, Palm oil plantations stored the lowest maximum carbon storage capacity. However it should be noted that the lifecycle of the Palm oil plantations is the shortest. In general information on the maximum carbon stocks of different land uses is crucial to estimate the carbon stocks of vast areas with different land uses. The estimates of ABG carbon stocks in the SSRM is valuable information when considering participation in Carbon credit schemes.

4.5 Floristic diversity

A comparison was conducted on the potential floristic diversity in the SSRM and the floristic diversity of Palm oil plantations in Kalimantan. Due to the different structure and rotation length in both systems, a distinction was made into two succession stages. The open stage, accounting for the first 1/3 in each lifecycle and the closed stage, accounting for the last 3/3 in each lifecycle(see paragraph 3.5). In both systems there were more species present in the open stage as in the closed stage. This phenomenon is caused by the expanding crowns, that compete for space and light. Hereby the overall floristic diversity decreases. This phenomenon was also recognized in the Palm oil plantations. However, due to the monotonous stand structure of Palm oil plantations, the floristic diversity decreases faster than in the SSRM. The tree layer of a Palm oil plantation consist solely of the Oil palm and the understory layer is absent. In the closed stage the species in the herb layer are reduced, due to the decrease of light reaching the ground. In the Illipe nut regeneration stands, the floristic diversity was reduced as well in the closed stage, but far less drastic as in Palm oil plantations. This dissimilarity is caused by the difference in stand structure between both land uses. In Illipe nut regeneration stands, the succession of the stand structure is similar to the succession of tropical forests. In this study this stand structure was simplified by the division of the tree layer, understory and the herb layer. In the closed stage the tree layer still contained 13-20 species and the understory 7-9 species(3.5). In short, the SSRM is likely to accommodate a higher biodiversity than Palm oil plantations.

5. Conclusion

This study has provided new information in the field of Illipe nut production by small holders. Information whereby the Illipe nut production can be compared to other land uses. This report focused on the comparison with the Palm oil production by small holders in Kalimantan. These two land uses were compared on economic and ecological aspects . On the economic front both systems were compared on the basis of financial indicators provided by cost and benefits analysis. The main indicators used for this comparison are the NPV, IRR and BCR. Furthermore the cash flows during the production cycles were analyzed in both systems. On the ecological plan, a comparison was made on the basis of the floristic diversity and carbon sequestration during both lifecycles.

From an economic viewpoint the SSRM is merely suitable as a long term investment project. Palm oil production is financially more attractive on a short term. One the one hand, this is caused by the late start of the reproductive cycle in the SSRM. On the other hand this is a result of the mast flowering characteristics. However, an important advantage of the SSRM for small holders is the low investment capacity needed to start an SSRM. Furthermore the low maintenance throughout the lifecycle makes the SSRM very suitable as secondary livelihood. Besides, the SSRM proved to be compatible with Palm oil production on the aspects of NPV and the BCR, despite the higher wages in the SSRM(see paragraph 3.2). An additional benefit of the SSRM is the increment of valuable timber during the lifecycle of the SSRM, which ensures an increasing value of the land. In contrast to the SSRM, the land value of Palm oil plantations decreases, due to erosion and soil depletion(Nelson, 2012)

Regarding the carbon quantities of both systems, it appeared that only on CRAS the SSRM stores more carbon than Palm oil plantations. On SLS the SSRM stored less carbon than in Palm oil plantations. Depending on the soil type, the maximum carbon capacity of the SSRM can be classified in two carbon classes as determined by the Food and Agricultural Organization. On CRAS the maximum carbon storage of the SSRM was 167.4 t C/ha. These carbon stocks are also found in original tropical moist forests(FAO, 2013). On SLS the SSRM stores a maximum of 79.1 t C/ha. This carbon quantity is conventional in tree-based forest systems(FAO, 2013).

The floristic diversity in Palm oil plantation consists predominantly of the herb layer. In the SSRM the floristic diversity is distributed over the herb layer, understory and the tree layer(see paragraph 3.5). In the open stage the floristic diversity of both systems is almost similar, but in the closed stage, Palm oil plantations lose 58% of their floristic diversity, while the diversity in SSRM only decreases by 25%(see paragraph 3.5).

Although Palm oil production and Illipe nut production are very different systems, this study provided comparative information regarding both land uses. This was done from the small holders perspective. Over all the aspects investigated by this study, the SSRM performs best on CRAS.

6. Recommendations

The recommendations of this study are based on the previously discussed results and are intended to give potential measures to improve on the economical and ecological aspects for the SSRM.

- Establishment of information networks and platforms, whereby small holders can exchange information with policy makers on the SSRM production. Information such as; carbon schemes, subsidies etc.

- Obtain Illipe nut varieties with annual fruiting characteristics. Two species should be examined: The S.stenoptera from the Hourbentes plantation in Java(Suzuki, 1989) and the Shorea atrinervosa(Symington, 1943; Wood and Meijer 1964; Ashton, 1982)

- Pruning of the *S.stenoptera* trees could lead to an increase in timber increment and benefit the overall growth of the trees.

- The SSRM should be used for various intercropping combinations. The effects and benefits should be discussed among the information networks

- For future comparisons on the SSRM and Palm oil plantations, the redemption of the land value in Palm oil plantations should be considered. Not to mention the rehabilitation costs of the land.

- There should be experiments with larger N/ha *S.stenoptera* trees. Thinning practices should be considered.

- Research should be conducted in order to examine the potential of the SSRM for Carbon schemes and environmental subsidies.

-Asses the potential of the SSRM as a forest regeneration system, to restore degraded environments.

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8. Appendixes

Appendix 1. Selection interviewees

Four interviewees were approached to ask for their know-how on the subjects of illipe nut cultivation, production and trading. Three elderly man were chosen based on their extensive experience with the illipe nut cultivation. Furthermore they helped to clarify the environmental goods and services and the actual and potential biodiversity within the SSRS.

Pak Apui, Medicine man

Pak. Apui; is 62 years old. He is the medicine man and head of culture in Tembak. He has been an illipe nut appraiser for around thirty years. His profession was to estimate the hanging fruit in kg/tree from the ground. According to his estimation the hanging fruit was sold to a buyer. After the fruit had been collected, it was weighted and the estimation was verified. He was also a producer and trader in illipe nuts. He is known as the most knowledgeable man in the Seberuang tribe in West-Kalimantan on the subject of environmental goods and services. Knowing more than 2000 plants species and their uses. He shared his knowledge on the differences in environmental goods and services between SSRS and Palm oil plantations. Furthermore he gave much information about the potential flora, with their uses, that can be found or planted within the SSRS

Pak Nyat; Is 64 years old and the Head of law in Tembak. He has been trader and producer of the illipe nuts for more than 35 years. He knows very much about the required growth conditions such as; planting distances, soil requirements, soil indicators, symbioses with fungi and other plant species. Furthermore he shared his knowledge on collecting practices, seedling collection, planting practices, Mast flowering characteristics, labor hours and wages. He explained a lot about soil characteristics and flora that he used as soil indicators.

Pak Nyat, Head of law.

Pak Najau; Is 42 years old and is head of administration in Tembak. He has been a producer of illipe nuts for 25 years. He still knew all the dates when the trees were planted, even of trees his grandfather had planted. This was very use full for the Individual tree measurements, to relate age to diameter, stem height, total height, volume and fruit production.

Pak Najau, Head of administration

Dr.ir.Willie Smits; provided extensive information on the environmental goods and services the SSRS provide. He told a lot the about the consequences of Palm oil plantations on the socio-economic existence of the Dayak. Moreover, he explained the effects of Palm oil plantations on water retention, fruiting patterns, human health, soil, biodiversity, the global and microclimate and many other environmental good and services. Furthermore he advised on the broad methodology of this research. Such as interviewing techniques, plot selection and about the broad context of the Shorea stenoptera for the Dayak.

Willie Smits

Appendix 2. Soils

Both soils are Alluvial soils. The soil on the left is a Clay-rich alluvium soil. The soil on the right is a Sandy loam soil. The Clay rich alluvium soils are more fertile compared to the Sandy loam soil. In total 14 of these soils were sampled during plots and inventories. N=7 on SLS and N=7 on CRAS

Appendix 3

These photos were taken in the plots used to determine the Floristic regeneration of *S.stenoptera* regeneration stands.

Plot 1. Age 16

Plot 2. Age 20

Plot 3, Age 47

Plot 4, Age 57

Appendix 4.

Plot Nr.	Date:
Plot size	Coordinates
Soil type	Elevation

DBH>=10cm

Tree Nr	DBH(cm)	Height(stem/total)	Remark

DBH>=10 cm

Tree Nr	DBH(cm)	Height(stem/total)	Remark

Appendix 5. Fruit production on CRAS

	Mast flowering	Non-Mastflowering
16	256	8,96
17	312	10,92
18	368	12,88
19	424	14,84
20	480	16,8
21	1088	38,08
22	1696	59,36
23	2304	80,64
24	2912	101,92
25	3520	123,2
26	4096	143,36
27	4672	163,52
28	5248	183,68
29	5824	203,84
30	6400	224
31	6720	235,2
32	7040	246,4
33	7360	257,6
34	7680	268,8
35	8000	280
36	8320	291,2
37	8640	302,4
38	8960	313,6
39	9280	324,8
40	9600	336
41	9760	341,6
42	9920	347,2
43	10080	352,8
44	10240	358,4
45	10400	364
46	10560	369,6
47	10720	375,2
48	10880	380,8
49	11040	386,4
50	11200	392
51	11680	408,8
52	12160	425,6
53	12640	442,4
54	13120	459,2
55	13600	476
56	14080	492,8
57	14560	509,6
58	15040	526,4
59	15520	543,2
60	16000	560

Appendix 6. Plot locations