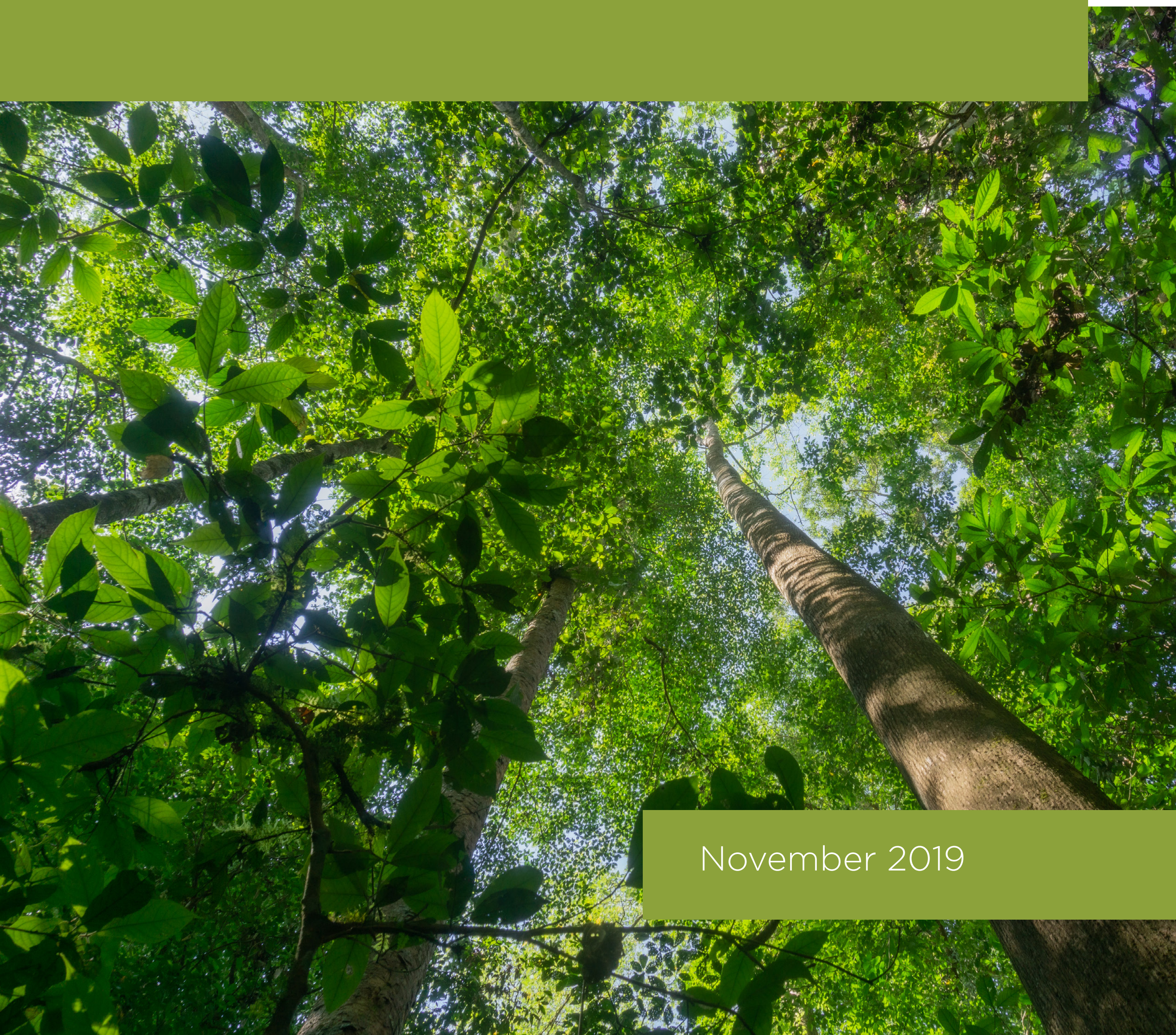
Building Out a Toolkit for Restoration: Economic Assessments from Peru, Indonesia and Cambodia



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FINAL REPORT

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Building out a Toolkit for Restoration: Economic Assessments from Peru, Indonesia and Cambodia

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PREFACE

Pedro Gasparinetti, Diego Brandão

This study seeks to build a "Restoration Toolkit" - a database of restoration models with key information on investment costs and benefits based on real cases from three countries: Peru, Indonesia and Cambodia. The study discusses alternative restoration methods for these regions, their potential bottlenecks and opportunities related to economic returns, local regulations, policies and technical capacities. The literature on forest restoration costs and benefits is still limited for Peru, Cambodia and Indonesia. Consequently, the studies conducted may have shown the first economic records of forest restoration initiatives in these countries.

The selection of models followed three main goals: to provide sustainable ecological gains to the landscapes in the long term; to generate positive economic returns to the necessary investments; and to be suited to local contexts (technical, political, economic and social), focusing on the scalability of the models.

The models were developed based on data collected in the field from actual initiatives, combined with projections about how the models could be developed, adapted and scaled up in the long term to yield better economic results. This means, for example, that costs related to technical assistance and hired labor, that might not have been necessary on the actual properties visited, were also included in cases in order to make the cases replicable.

The data is synthesized and described by some key variable, such as: Biome; Property area (size); Main productive activity; Biophysical conditions (slope, soil); Restoration Model; List of species used; Initial Investment required; Investment per hectare; Net Present Value (NPV); Internal Rate of Return (IRR); Enabling factors and bottlenecks; Technical Capacity Availability; Logistics; Regulation and Law enforcement. We expect the toolkit to provide valuable insights on how to implement restoration initiatives, supporting decision making processes and the prioritization of investments that will be able to provide ecological gains with economic feasibility - potentially attracting private investiments and generating income generation to local communities.

The selected cases indicate that restoration models were implemented in degraded and underused areas. Farmers and restorers tend to prefer to use species with economic potential combined with non-commercial native species for ecological purposes. However, restoration models in the field were implemented without a prior economic assessment, being still in incipient stages.

The study indicates that differences in the previous state of the soil are an important factor in determining the restoration economic feasibility. Additional investments are necessary in places with poor soil conditions. On the other hand, degraded areas with fertile soil not only require less investment but also present higher productivity. Therefore, restoration models that demand lower investments due to soil conditions, showed to be economically promising, while models with high initial investments, as presented by the cases in Cambodia, tended to be less economically feasible.

There are similarities in the profile of stakeholders involved with forest restoration in the different countries. The study indicates that there is a strong participation of non-governmental organizations in partnership with rural producers. Non-governmental organizations tend to subsidize investments aimed at ecological, rather than economic, gains. The governments operate mainly in protected areas without economic objectives and often support the partnership between non-governmental organizations and rural producers.

It was shown that there are different legal issues related with forest restoration in the profiled countries. Local legislations often do not clearly detail the percentage of land that should be conserved or restored on each property, or the accepted combination of native and exotic species that might be used for that objective. Thus, because the lack of legal definitions, forest restoration in these countries are often carried out on a voluntary basis, or incentivized by non-governmental projects. In other cases, such as in Indonesia, the government has clearer restoration targets and policies that might incentivize restoration initiatives.

Finally, the studies have indicated that landowners and communities, in general, are inexperienced in conducting forest restoration. Thus, a potential large-scale action plan would depend heavily on the provision of technical assistance, essential for this kind of initiative to evolve successfully.

The report is organized as follows: The first chapter is a summary of the results from the three countries, discussing financial results, enabling factors, bottlenecks and differences and similarities among countries. The following chapters present the in-depth descriptions for each country's contexts and results. These core chapters are developed as follows: (i) a literature review on potential restoration models for the regions; (ii) a discussion of the local context and the characteristics of landowners that could be engaged in restoration initiatives; (iii) a discussion on the selection of the most promising restoration models from an economic perspective; (iv) the economic assessment of the two restoration cases, plus a seeds dispersion model; (v) a discussion on enabling factors and bottlenecks for economic restoration in the selected region; (vi) final remarks.

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SUMMARY OF RESULTS

CHAPTER 1 – SUMMARY OF RESULTS

Pedro Gasparinetti, Diego Brandão, Victor Araújo

Regional Context and Characterization of the "standard restorers"

In Peru, Indonesia and Camboja the demand for forest restoration is mainly associated with agricultural degradation and illegal logging. In Peru, the main causes of deforestation are associated with the expansion of coffee, cocoa, rice, livestock, illegal felling and land trafficking. In Indonesia, particularly in North Sumatra, the rapidexpansion of palm oil extraction has been cited as the main threat to long-term natural forests. In Cambodia deforestation is currently related to illegal logging and the expansion of agriculture.

There is a similarity in the profile of agents involved with forest restoration in the different countries. There is a strong participation of non-governmental organizations in partnership with rural producers. Non-governmental organizations tend to subsidize investments aimed at ecological rather than economic results. On the other hand, governments act by creating legal provisions and supports initiatives between non-governmental organizations and farmers.

Non-governmental forest restoration organizations include, for example Conservation International, World Wild Life Fund - WWF, and United Nations Development Program - UNDP. In general, non-governmental organizations partner with farmers and community members to implement experimental initiatives in areas smaller than 10 hectares. The state, in turn, is primarily responsible for forest restoration in areas protected by law. In Indonesia, the state still grants degraded areas for private economic use, but without an ecological purpose.

Selection of Restoration Models

Nine forest restoration models were selected, three for each country, with two for economic and ecological purposes, and one only for ecological purposes (seeds dispersion method) (Table 1). The basic assumption of this selection is that the nine models fulfill ecological functions and are better land use alternatives for degraded areas. These models are described in detail below. More detailed information on these forest restoration models can be obtained from the original documents.

Economic Assessment of Forest Restoration Models

For each country and region, we found three restoration models that meet the objective of this assignment.

Table 1 - Restoration Models Area and Species

Models		Area (ha)
Peru		
1	Cacao and silvopastoral (with native and exotic trees)	5.8
2	Coffee, cacao, guaba and jacaranda	3.0
3	Seed dispersal	1.0
Indonesia		
4	Sea cypress and ketapang	2.0
5	Durian, mangosteen and coconut	2.0
6	Seed dispersal	1.0
Cambodia		
7	Turmeric, ginger and lemon grass as forest farming crops	1.0
8	Rattan and Bamboo as forest farming crops	1.0
9	Taungya	1.0

Cases from Peru

The selected models in Peru are variations of agroforestry models, based on native perennial species with annual harvests, such as cacao and coffee. It is important to highlight that the soil conditions for the selected models were very favorable, demanding little investment to enrich or correct its composition, also yielding good production. Other examples with more degraded soil were found, demanding larger investments and having worse productivity, which led to unfeasible economic results.

Model 1 - Peru: Cacao and silvopastoral (native and exotic trees)

This model was based on a property located in the Gepelacio District, Moyobamba Province, San Martin Department. The area has an extension of 17.5 hectares and was previously dedicated to agriculture and livestock. The site has an inclined topography of approximately 45°, and therefore, erosion is more likely to cause problems in the area. Based on the owner's previous bad experiences, and with the help of CI technicians, a silvopastoral system[1] of 0.75 ha was implemented in order to prevent soil erosion. It consists of species of economic and ecological importance such as: Pino Chuncho (*Schizolobium amazonicum*), Bolaina (*Guazuma crinita*), Capirona (*Calycophyllum spruceanum*) and Shaina (*Colubrina glandulosa*) and introduced species such as the Cedro de la India (*Acrocarpus fraxinifolius*). They were planted at a distance of 4m x 4m, resulting in 468 plants, associated with cattle grass (*Brachiaria brizantha*). They have also planted cocoa (monoculture) on 5 hectares at a distance of 3m x 3m, in another plot.

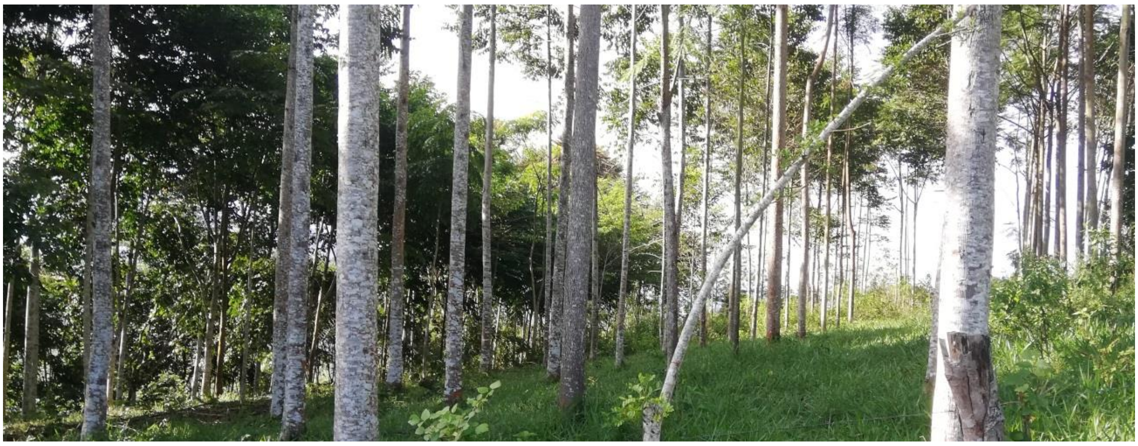


Figure 1 - The Silvopastoral System with 5 forest species of ecological relevance

The agroforestry system was implemented for economic purposes, so that the owner could have an income and pay for the costs generated by the restoration. Furthermore, he planned to plant some timber plants within the system, so that they could cover in the area once the cycle of cocoa is completed.

[1] The economic results considered only the production from trees - therefore cattle breeding is not included in the analysis.

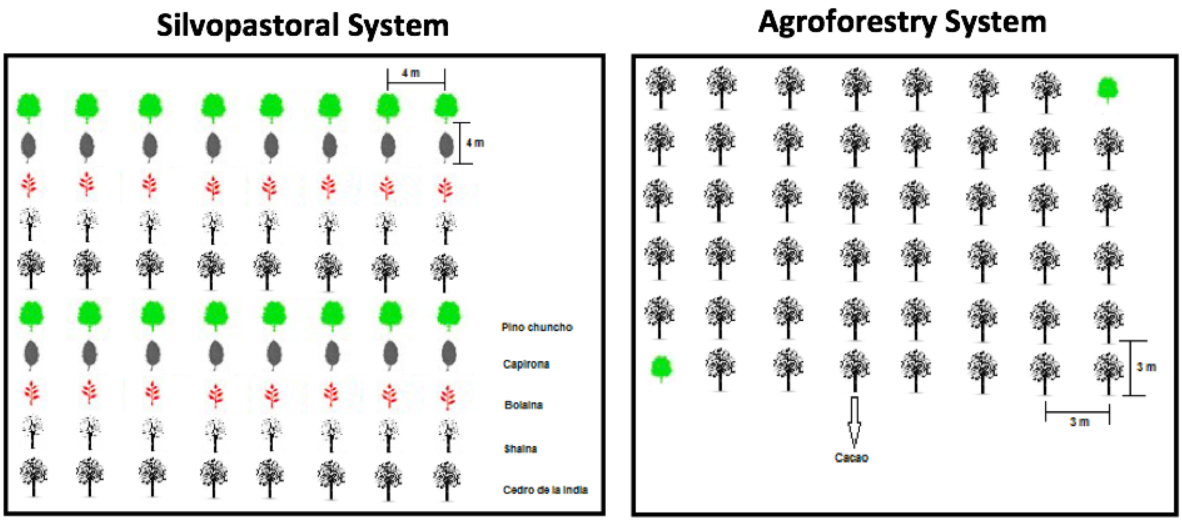


Figure 2 - Sketch of Model 1: On the left the Silvopastoral System with 5 species of ecological importance, on the right the Agroforestry System with Cocoa.

The annual production yield of the 5 hectares increases from Year 3 to Year 8. Also, the income stabilizes from Year 9 to Year 30, due to cocoa's maximum production (average annual production of 5 hectares is 3750 kg). The price is USD 2.12 per kg. The simplified cash flow is presented in the following table:

Table 2 - Cash flow of Model 1 – Peru - Cocoa

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	2,600.0	- 2,600.0	-	- 2,600.0
2	-	-	783.0	- 783.0	-	- 783.0
3	212.0	-	1,200.0	- 988.0	-	- 988.0
4	1,060.0	-	1,201.5	- 141.5	-	- 141.5
5	2,120.0	-	1,201.5	918.5	-	918.5
6	4,240.0	-	1,201.5	3,038.5	-	3,038.5
7	6,360.0	-	1,201.5	5,158.5	-	5,158.5
8	7,950.0	-	1,201.5	6,748.5	-	6,748.5
9	7,950.0	-	1,588.5	6,361.5	-	6,361.5
10	7,950.0	-	1,588.5	6,361.5	-	6,361.5
11	7,950.0	-	1,588.5	6,361.5	-	6,361.5
12	7,950.0	-	1,588.5	6,361.5	-	6,361.5
13	7,950.0	-	1,588.5	6,361.5	-	6,361.5
14	7,950.0	-	1,588.5	6,361.5	-	6,361.5
15	7,950.0	-	1,588.5	6,361.5	-	6,361.5
16	7,950.0	-	1,588.5	6,361.5	-	6,361.5
17	7,950.0	-	1,588.5	6,361.5	-	6,361.5
18	7,950.0	-	1,588.5	6,361.5	-	6,361.5
19	7,950.0	-	1,588.5	6,361.5	-	6,361.5
20	7,950.0	-	1,588.5	6,361.5	-	6,361.5
21	7,950.0	-	1,588.5	6,361.5	-	6,361.5
22	7,950.0	-	1,588.5	6,361.5	-	6,361.5
23	7,950.0	-	1,588.5	6,361.5	-	6,361.5
24	7,950.0	-	1,588.5	6,361.5	-	6,361.5
25	7,950.0	-	1,588.5	6,361.5	-	6,361.5
26	7,950.0	-	1,588.5	6,361.5	-	6,361.5
27	7,950.0	-	1,588.5	6,361.5	-	6,361.5
28	7,950.0	-	1,588.5	6,361.5	-	6,361.5
29	7,844.0	-	1,588.5	6,255.5	-	6,255.5
30	7,844.0	-	1,588.5	6,255.5	-	6,255.5

Table 3 - Cash flow of Model 1. Installation, management, harvest and sales of Cocoa plantation

Operation	Costs during X years (USD)	Cost per hectare
Initial investment activities	USD 452.00	Purchase cocoa seeds (USD 24.00) Purchase of seedlings (USD 30.00); Instalation and maintenance of temporary nursery (USD 54.00) Land preparation (USD 36.00) Plantation (USD 72.00) Technical assistance (USD 20.00) Weeding (USD 216.00)
Maintenance activities	USD 150.00	Weeding and preparation (USD 85.00) Fertilization (USD 18.00) Pruning management (USD 47.00)
Harvest & sale activities	USD 1,754.00	Harvest 750 kg (USD 120.00) Dry 750 kg (USD 44.00) Sales 750 kg (USD 1,590.00)
TOTAL	USD 2,356.00	

The costs considered in table 3 are for an initial investment and maintenance, harvest and sales of 1 hectare of cocoa plantation throughout the life of the crop.

The investment for this area was $ 2,600.00, with an IRR of 40% and an NPV of $ 15,552.00. For this reason, the financial indicators show that this restoration model is feasible under the established parameters. Also, this model doesn't include the livestock profits, which could increase the viability of this project.

Table 4 - Financial indicators of Model 1 – Perú – Cacao and Silvopastoral

Item	Value (USD)
Area (hectares)	5.8
Investment	2,600
Investment/ha	452
IRR	40%
NPV	15,552
NPV/ha	2,705
Benefit/Cost ratio	2.6

In the Alto Mayo Basin, there are areas with flat or sloping topographies, typical of a high forest. In some cases, there are species that need certain conditions, such as high altitude, higher humidity and precipitation, soils rich in organic matter, among others. These may alter investment costs when implementing a restoration plot.

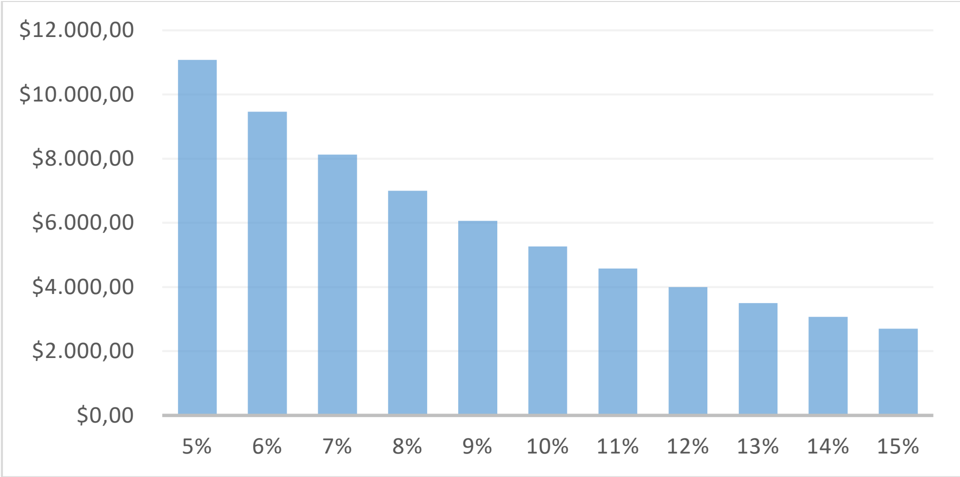


Figure 3 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 1 – Cacao and Silvopastoral

Model 2 - Peru: Coffee, cacao, guaba and jacaranda

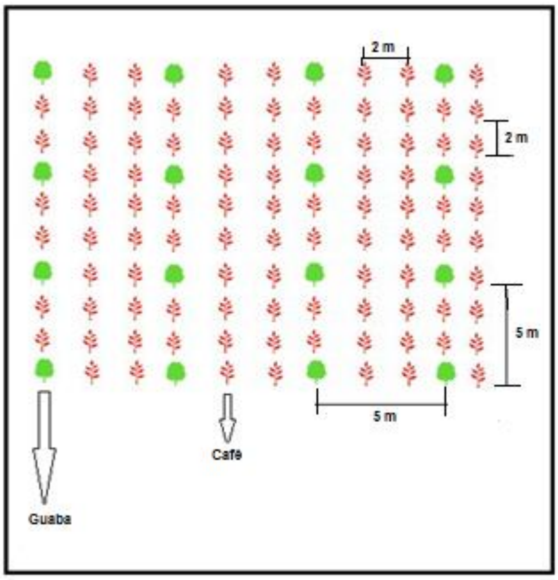
This model was based on a property located in the District of Calzada, Moyobamba Province, San Martin Department. It has a total area of 3.5 hectares and, 30 years ago, was dedicated to agriculture. However, it now has the capacity to produce its own seedlings, compost and fertilizers. The owner has been managing 2.5 hectares of coffee (*Coffea arabica*), grown with Guaba (*Inga edulis*) plants to provide shade to Coffee plantation and 0.5 hectares of cocoa planted with jacaranda trees (*Jacaranda copaia*) that grew on a natural regeneration process. Initially, 6,250 coffee seedlings were planted on 2.5 hectares at a distance of 2m x 2m, with guaba, for permanent shade at a distance of 5m x 5m. Cocoa has been planted at a distance of 3m x 3m and it is combined with jacaranda trees that grew naturally, due to the dispersion of seeds from neighboring forests to the area.

The restoration model of cocoa and jacaranda showed over time that the association of both species is interesting, proving to be beneficial for both of them, since the coca plants needs shade in the first two years of the cycle, and this shade is provided by Jacaranda. In addition, jacaranda is a fast-growing native species of important ecological value, since it is an important resource to many wildlife species.

The annual production yield of this plot is similar to Model 1. The production increases from Year 3 to Year 10. It then stabilizes from Year 11 to Year 30, with an average annual production of 400 kg in ½ hectare. The price is the same as indicated in Model 1 ($ 2.12 per kg).

Agroforestry System – Part 1

(Coffee + Guaba)



Agroforestry System – Part 2

(Cocoa + Jacaranda)

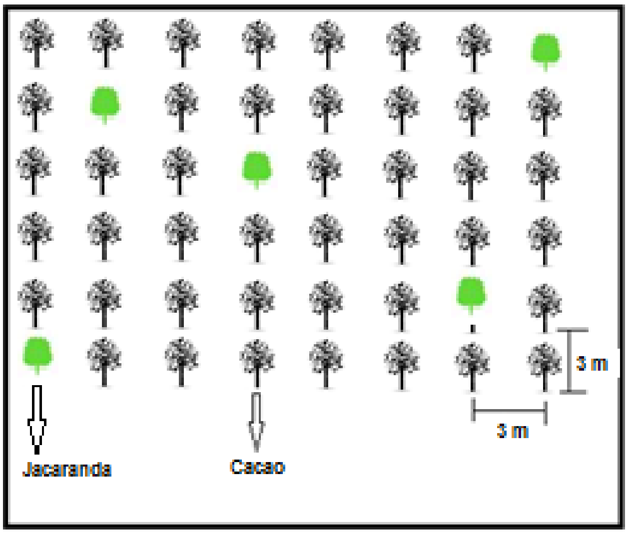


Figure 4 - Skectch of Model 2. On the left, the Coffee and Guaba system, and on the right the Cocoa and Jacaranda system.

The simplified cash flow is presented in the following table:

Table 5 - Cash flow of Model 2 – Peru - Coffee and Cocoa

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	620.0	- 620.0	-	- 620.0
2	1,095.0	-	859.0	236.0	-	236.0
3	1,502.4	-	1,003.0	499.4	-	499.4
4	1,931.0	-	1,553.0	378.0	-	378.0
5	2,767.0	-	1,258.0	1,509.0	-	1,509.0
6	2,979.0	-	1,247.0	1,732.0	-	1,732.0
7	3,191.0	-	1,265.0	1,926.0	-	1,926.0
8	3,297.0	-	1,274.0	2,023.0	-	2,023.0
9	3,360.6	-	1,274.0	2,086.6	-	2,086.6
10	3,403.0	-	1,274.0	2,129.0	-	2,129.0
11	3,403.0	-	1,274.0	2,129.0	-	2,129.0
12	3,403.0	-	1,274.0	2,129.0	-	2,129.0
13	3,403.0	-	1,274.0	2,129.0	-	2,129.0
14	3,403.0	-	1,274.0	2,129.0	-	2,129.0
15	3,403.0	-	1,274.0	2,129.0	-	2,129.0
16	3,403.0	-	1,274.0	2,129.0	-	2,129.0
17	3,403.0	-	1,274.0	2,129.0	-	2,129.0
18	3,403.0	-	1,274.0	2,129.0	-	2,129.0
19	3,403.0	-	1,274.0	2,129.0	-	2,129.0
20	3,403.0	-	1,274.0	2,129.0	-	2,129.0
21	3,403.0	-	1,274.0	2,129.0	-	2,129.0
22	3,403.0	-	1,274.0	2,129.0	-	2,129.0
23	3,403.0	-	1,274.0	2,129.0	-	2,129.0
24	3,403.0	-	1,274.0	2,129.0	-	2,129.0
25	3,403.0	-	1,274.0	2,129.0	-	2,129.0
26	3,403.0	-	1,274.0	2,129.0	-	2,129.0
27	3,403.0	-	1,274.0	2,129.0	-	2,129.0
28	3,403.0	-	1,274.0	2,129.0	-	2,129.0
29	3,403.0	-	1,274.0	2,129.0	-	2,129.0
30	3,403.0	-	1,274.0	2,129.0	-	2,129.0

Table 6 - Cash flow of Model 2 - Coffee and Cocoa

Operation	Costs during X years (USD)	Cost per hectare (Café y Cacao)	
Initial investment activities	USD 1,240.00	Purchase of coffee seeds (USD 30.00) Purchase of guaba seeds (USD 40.00) Purchase of cacao seeds (USD 30.00) Purchase and aplication of fertilizers (USD 180) Instalation and maintenance temporary nursery (USD 306.00) Land prpeparation (USD 32.00) Plantation (USD 72.00) Technical advice (USD 240.00) Weeding (USD 144.00)	
Maintenance activities	USD 519.00	Weeding and prearation (USD 360.00) Tehnical advice (USD 60.00) Fertilization (USD 27.00) Pruning management (USD 72.00)	
Harvest & sale activities	USD 1,705.00 en Café USD 1,719.2 en Cacao	Harvest 20 Quintales of coffee (USD 200.00) Dried out of 20 Quintales of coffee (USD 45.00) Sales of 20 Quintales of coffee (USD 1,460.00) Harvest - 760 Kg cocoa (USD 72.00) Dried out - 760 Kg cocoa (USD 36.00) Sales of 760 kg cocoa (USD 1,611.20)	
TOTAL	$ 5,183.20		

The costs considered in table 6 represents the initial investment and maintenance costs, harvest and sales of 1 hectare of coffee and cocoa plantations throughout the plant cycle. (01 quintal =100 Kg)

The site visited is reported to have fertile soil, and low input costs, such as labor (USD 9/day) and seedlings (USD 1 each), which is cheaper than purchasing seeds. Therefore, the initial investment costs are low, and productivity is high. The relatively low installation cost of $620.00 generates an NPV of USD 2,494 per hectare in 30 years, indicating its highly profitability[2].

[2] We also visited another coffee plantation (Coffee arabica) associated with Guaba (*Inga edulis*), similar to Model 2, with the same spacing of coffee and guaba. This property had an area of 1 hectare, where the owner added 60 plants of Tornillo *(Cedrelinga catenaeformis)* and 40 Sinami *(Oenocarpus mapora)* in a dispersed way.

Table 7 - FInancial indicators of Model 2 - Peru – Coffee & Cocoa

Item	Value (USD)
Area(hectares)	3.0
Investment	620
Investment/ha	207
IRR	88%
NPV	7,482
NPV/ha	2,494
Benefit/Cost ratio	5.9

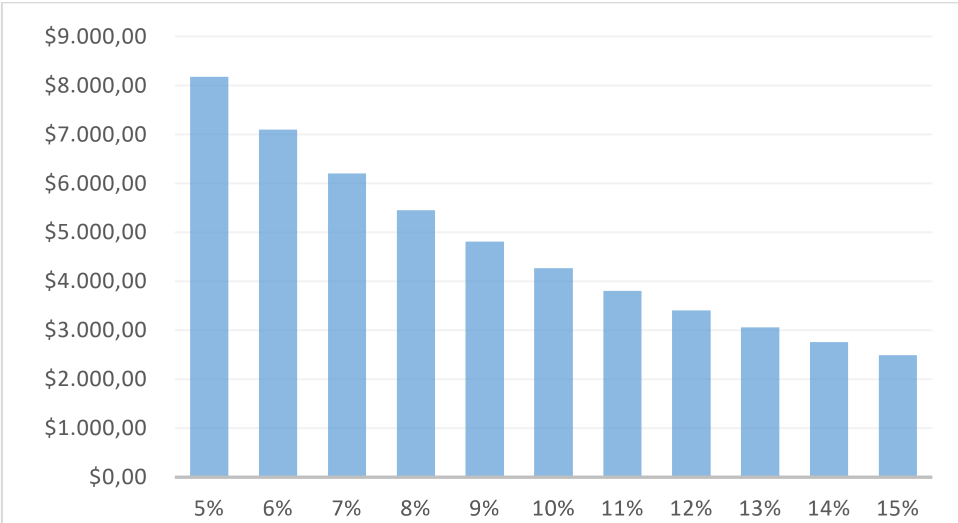


Figure 5 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 2 – Peru – Coffee & Cocoa

Model 3 - Peru: Seed dispersal

This model was designed only for ecological purposes, therefore profitable species were not included. This model was based on a 5 hectare property and a discount rate of 15%. The highest costs are related to planting and maintenance, since the management of the seeds lasts until Year 3. The total cost for the restoration of 5 hectares is about USD 3,350 (USD 2,240 for installation and USD 1,110 for maintenance), resulting in a total cost of USD 670 per restored hectare (including maintenance).

Table 8 - Costs of Model 3 – Peru - Seed dispersal – 5ha

N°	Components	Price (USD)
1	Seeds (1000 x @ USD 1.00)	1,000.00
2	Inputs and tools	480.00
3	Planting and maintenance	1,710.00
4	Technical assistance	160.00
	TOTAL COST	3,350.00

Cases from Indonesia

The selected models in Indonesia are divided by two different focus landscapes: lowlands and highlands. Lowlands encompass coastal and peatland areas. In highlands, the proposed restoration model seeks to tackle issues related to the main degradation driver in the country – the expansion of the palm oil industry. Here we present the models with what is considered to yield the greatest ecological gains and diversity. In the following chapter that details the local context, variations of the models that also proposes, for example, enriching palm trees areas with other species, are also presented.

Model 1 – Indonesia, Lowland: Coconut, Ketapang and Cemara Laut

The lowlands restoration model is a combination of native sea cypress (*Casuarina equisetifolia*) and ketapang (*Terminalia catappa*). The restoration is done in two ecosystems: coastal and peatland areas. This model targets the protection of endemic species, especially penyu belimbing (*Dermochelys coriacea*)[3], a native turtle. The model is outlined under a local village regulation (Peraturan Desa)[4] that regulates areas 100m towards the mainland (which is calculated from the shoreline during tides session) are classified as protected areas. The first 50 meters from the shoreline is restrict to general activities, except for those related to turtle management. The remaining 50m are authorized to be managed by the community for agricultural activities. It is common to cultivate coconut trees, cemara laut or sea cypress (*Casuarina sp*p.), species that are planted close to each other in this area. The 2nd 50 m part with agriculture is primarily aimed to guard the 1st 50 m and also to fortify large waves and seawater abrasión.

This model attempts to restore the peatland that is threatened by palm oil plantations, back to its natural condition, as a mechanism for water management and carbon sequestration. Under this scenario, the oil palm, that must be cut down at the end of its natural cycle, generally 20-25 years, could be replaced by native species under this agroforestry system and be used as a restoration alternative to recover the peatland ecological functions.

Palm trees is planted by companies (mostly) and communities (a small portion). The age of palm tree is 5 years and 12 years. Not all community lands have been planted with palm tree. The restoration will be carried out on community land and coastal land (under a local village regulation). The planting method in this model can be done either with or without shade at the initial phase, for the three species. Planting is done after the oil palm has been removed. As shown in the sketch below, the planting distance between the coconut seedlings is about 15m x 15 m resulting in 44 coconut trees per hectare. Native plants are arranged in a way that form plant rows or windbreaks, between cocunt plantations, Communities have done it/activity.

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[3] Of the 7 types of sea turtles in the world, 6 species are in Indonesia, 5 species can be found on the coastal area of Muara Upu. (https://rakyatsumutnews.com/2019/04/25/5-jenis-penyu-kekayaan-hayati-pantai-muara-upu/) retrieved July 30 2019

[4] Peraturan Desa Muara Upu No. 01/2015 – a village regulation regarding Muara Upu Marine and Coastal Management

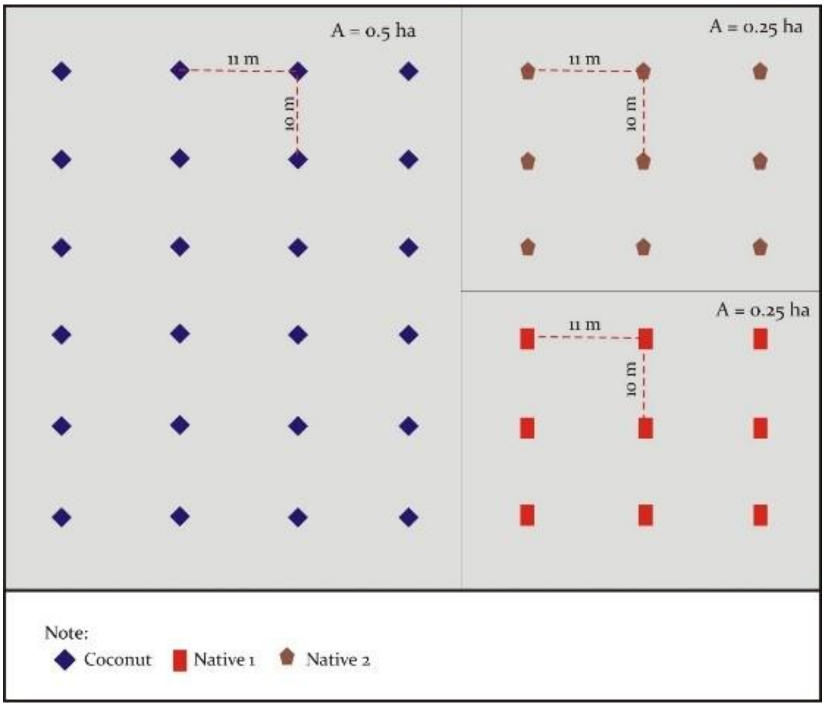


Figure 6 - Sketch of Model 1 – Indonesia - Sea cypress and ketapang

The simplified cash flow is presented on the following table:

Table 9 - Cash flow of Model 1 – Indonesia – Coconut, Ketapang and Cemara Laut

Year	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	208.3	-208.3	-	-208.3
2	-	-	45.5	-45.5	-	- 45.5
3	-	-	45.5	-45.5	-	- 45.5
4	105.6	10.6	37.2	57.8	1.4	56.4
5	116.2	11.6	55.2	49.4	1.2	48.1
6	147.8	14.8	57.8	75.2	1.9	73.4
7	190.1	19.0	61.3	109.7	2.7	107.0
8	211.2	21.1	63.1	127.0	3.2	123.8
9	211.2	21.1	63.1	127.0	3.2	123.8
10	211.2	21.1	63.1	127.0	3.2	123.8
11	211.2	21.1	63.1	127.0	3.2	123.8
12	211.2	21.1	63.1	127.0	3.2	123.8
13	211.2	21.1	63.1	127.0	3.2	123.8
14	211.2	21.1	63.1	127.0	3.2	123.8
15	211.2	21.1	63.1	127.0	3.2	123.8
16	211.2	21.1	63.1	127.0	3.2	123.8
17	211.2	21.1	63.1	127.0	3.2	123.8
18	211.2	21.1	63.1	127.0	3.2	123.8
19	211.2	21.1	63.1	127.0	3.2	123.8
20	211.2	21.1	63.1	127.0	3.2	123.8
21	211.2	21.1	63.1	127.0	3.2	123.8
22	211.2	21.1	63.1	127.0	3.2	123.8
23	211.2	21.1	63.1	127.0	3.2	123.8
24	211.2	21.1	63.1	127.0	3.2	123.8

Year	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
25	190.1	19.0	61.3	109.7	2.7	107.0
26	169.0	16.9	59.6	92.5	2.3	90.2
27	147.8	14.8	57.8	75.2	1.9	73.4
28	137.3	13.7	56.9	66.6	1.7	64.9
29	116.2	11.6	55.2	49.4	1.2	48.1
30	105.6	10.6	-	95.0	2.4	92.7
TOTAL	1,260.50		2,226.94			

The assessment results indicate that this model needs an investment of about USD 104.15 per ha, in the first year. Therefore, the model presents an NPV of US$224.50 per ha, over a 30 year period. Also, the IRR of 22.2% implies that the project is financially feasible.

The cost of Model 4 detailed by operation category is shown below .

Table 10 - Cost of Model 1 – Indonesia – Coconut, Ketapang and Cemara Laut

Operation	**Costs during 30 years (USD)**	**Cost per hectare**	
Initial investment activities	178,07	Supplies for seed (durian and palm)	71,25
		Fertilizer for investment in first year	42,66
		Hole digging	18,00
		Labor - planting	46,16
Maintenance activities	1.979,42	Annual (29 year)	68,26
		Fertilizer for second-last year	1.237,14
		Labor for second-last year	742,28
Harvest & sale activities	105,20	Annual (27 year for harvest)	3,90
		Labor for harvest	105,20
TOTAL	2.262,69*		

**No taxes included*

Table 11 - Financial indicators of Model 1 - Indonesia – Coconut, Ketapang and Cemara Laut

Item	Value (USD)
Area(hectares)	2.0
Investment	208.30
Investment/ha	104.15
IRR	22.2%
NPV	449.01
NPV/ha	224.50
Benefit/Cost Ratio	1.66

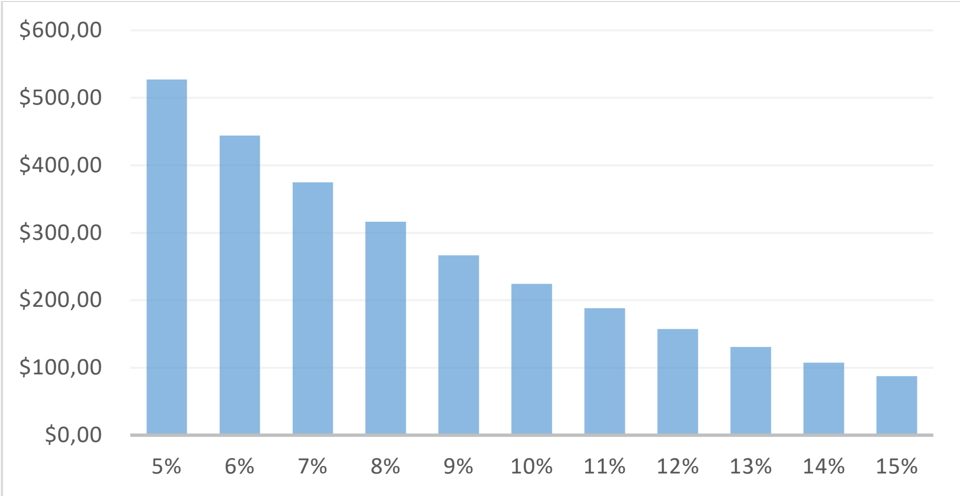


Figure 7 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 1 - Indonesia – Coconut, Ketapang and Cemara Laut

Model 2 – Indonesia, Upland: Durian, Manguis, Coconut

This model consists of three species that were chosen because they are popular in the area and have high economic value in the region of Tapanuli Selatan. In particular, the combination of these species with a native timber could accelerate the development of this model, since they are shade tolerant in the early planting period. This model was designed so that it could be implemented during the palm oil cycle. From Year 5 to Year 10 on, the palm oil trees can be replaced by the three commercial species and the native plants. During the field visit, the palm trees are already 10 and 15 years. Communities could plant the restoration species under the palm trees. After palm trees are 20/25 year old, community could remove it.

Costs related to the installation were not included in our economic calculation due to limited data and information

The plant composition of this model was suggested by the local community during field visits, presented in the sketch below.

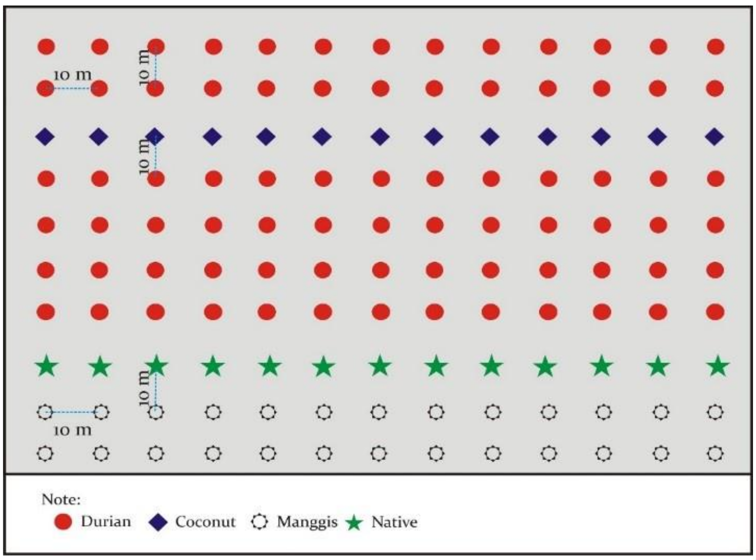


Figure 8 - Sketch of Model 2 – Indonesia - Durian, mangosteen and coconut

The simplified cash flow is presented on the following table:

Table 12 - Cash flow of Model 2 – Indonesia - Durian, mangosteen and coconut

Year	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Taxon Income	Cash Flow after taxes
1	-	-	434.2	-434.2	-	-434.2
2	-	-	136.5	-136.5	-	-136.5
3	-	-	136.5	-136.5	-	-136.5
4	123.2	12.3	145.3	-34.4	-	-34.4
5	135.5	13.6	146.2	-24.2	-	-24.2
6	172.5	17.2	148.8	6.4	0.2	6.2
7	221.8	22.2	152.4	47.2	1.2	46.1
8	246.4	24.6	154.1	67.6	1.7	66.0
9	547.4	54.7	154.1	338.5	8.5	330.1
10	830.4	83.0	154.1	593.2	14.8	578.4
11	1,131.4	113.1	154.1	864.1	21.6	842.5
12	1,176.4	117.6	154.1	904.6	22.6	882.0
13	1,468.4	146.8	154.1	1,167.4	29.2	1,138.3
14	1,486.4	148.6	154.1	1,183.6	29.6	1,154.1
15	1,787.4	178.7	154.1	1,454.5	36.4	1,418.2
16	1,823.4	182.3	154.1	1,486.9	37.2	1,449.8
17	2,124.4	212.4	154.1	1,757.8	43.9	1,713.9
18	2,292.9	229.3	154.1	1,909.5	47.7	1,861.8
19	2,461.4	246.1	154.1	2,061.1	51.5	2,009.6
20	2,726.4	272.6	154.1	2,299.6	57.5	2,242.2
21	552.4	55.2	108.6	388.6	9.7	378.8
22	1,383.3	138.3	108.6	1,136.4	28.4	1,108.0
23	1,356.8	135.7	108.6	1,112.5	27.8	1,084.7
24	1,277.3	127.7	108.6	1,041.0	26.0	1,014.9
25	1,157.5	115.8	106.8	934.9	23.4	911.5
26	746.2	74.6	59.6	612.0	15.3	596.7
27	653.0	65.3	57.8	529.8	13.2	516.6
28	606.3	60.6	56.9	488.7	12.2	476.5
29	513.0	51.3	55.2	406.6	10.2	396.4
30	466.4	46.6	8.8	411.0	10.3	400.7
TOTAL	5,946.11		6,918.08			

For the first year of restoration, the cost of this model is about USD 217.11 per ha. Thus, the model has an NPV of about USD 1,819.55 per ha, over a 30 year period. The IRR of 26.74% indicates that this restoration model is financially feasible as it is also confirmed by its Benefit Cost Ratio of 3.13. Compare to regular palm oil plantation in Indonesia, where IRR was about 14,83 during 25 yrs plantation cycle (Svatonova et al, 2015), the IRR of this model is significantly higher. IRR values are very high in just one palm tree species. In some plantation areas such as Sulawesi, the value reaches more than 25% (Defidelwina 2013), and in Sumatra and Kalimantan even more than 500% (eg: Hutabarat 2011, Sarasvati 2018).

The cost of Model 5 detailed by operation category is shown below.

Table 13 - Cost of Model 2 – Indonesia - Durian, mangosteen and coconut

Operation	**Costs during 30 years (USD)**	**Cost per hectare**	
Initial investment activities	164,75	Supplies for seed (manggis and durian)	97,75
		Fertilizer for investment in first year	28,44
		Hole digging	18,00
		Labor - planting	20,56
Maintenance activities	978,34	Annual (2-25 year)	42,54
		Fertilizer for second-last year	611,46
		Labor for second-last year	366,88
Harvest & sale activities		For manggis and durian, the price of fruit	
TOTAL	1.143,09*		

No taxes included

Table 14 - Financial indicators of Model 2 – Indonesia - Durian, mangosteen and coconut

Item	Value (USD)
Area (hectares)	2.0
Investment	434.21
Investment/ha	217.11
IRR	26.74%
NPV	3,639.10
NPV/ha	1,819.55
Benefit/Cost Ratio	3.13

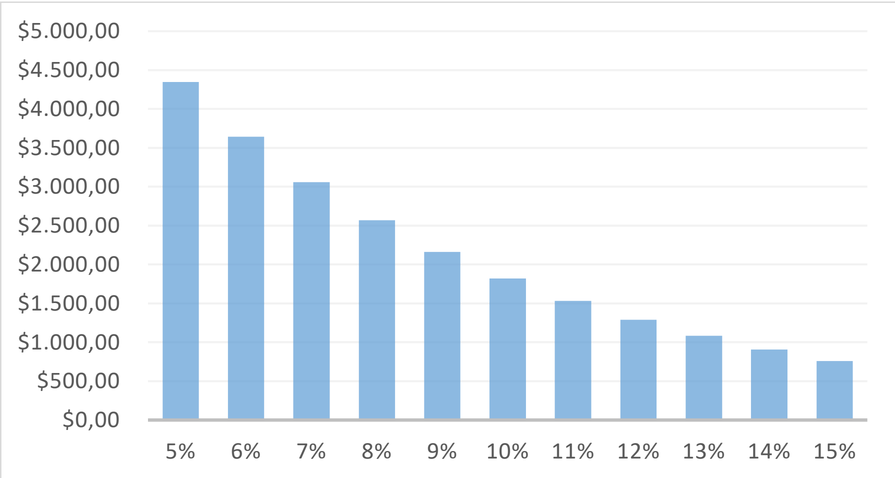


Figure 9 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 2 – Indonesia - Durian, mangosteen and coconut

Model 3 - Seed dispersal model[5]

This model was designed for ecological purposes only, meaning that species with economic value were not included. Moreover, the management of this kind of restoration is simple and does not demand many costs over time.

The implementation of this model (Table 11), however, has several costs. This restoration is presented in a 1-hectare base calculation, with a plant spacing of 4m x 4m (the density is about 625 plants per hectare). The price of the native seeds is USD 2.13 (per seed), similar to Model 5 and 6. Furthermore, the cost of the planting holes is about USD 0.36 per hole, and planting is about USD 0.07 per seed planted. With this, the total cost of this restoration is about USD 1,600.00 per hectare. The assumption, the community will get the seeds by buying it.

Table 15 - Costs of Model 3 – Indonesia - Seed dispersal

Components	Cost (USD/ha)
Seed from native trees (625 x @ USD 2.13)	1,331.25
Hole of native trees (625 x @ USD 0.36)	225.00
Planting native trees (625 x @ USD 0.07)	43.75
TOTAL COST	1,600.00

Table 16 indicates the cost detailed more by category of operation

Table 16 - Cost of Model 3 - Indonesia - Seed dispersal model

<table>
<tr><th>Operation</th><th>Costs during 30 years (USD)</th><th colspan="2">Cost per hectare</th></tr>
<tr><td rowspan="3">Initial investment activities</td><td rowspan="3">1,600.00</td><td>Supplies for seed (native)</td><td>1,331.25</td></tr>
<tr><td>Hole digging</td><td>225,00</td></tr>
<tr><td>Labour - planting</td><td>43.75</td></tr>
<tr><td rowspan="2">Maintenance activities</td><td rowspan="2">-</td><td>Annual (2-29 year)</td><td>-</td></tr>
<tr><td>Fertilizer for second-last year</td><td>-</td></tr>
<tr><td rowspan="2">Harvest & sale activities</td><td rowspan="2">-</td><td>Annual (4-30 year)</td><td>-</td></tr>
<tr><td>Labor for harvest</td><td>-</td></tr>
<tr><td>TOTAL</td><td>1,600.00</td><td></td><td></td></tr>
</table>

[5] In Chapter 3, it appears as Model 5.

Cases from Cambodia

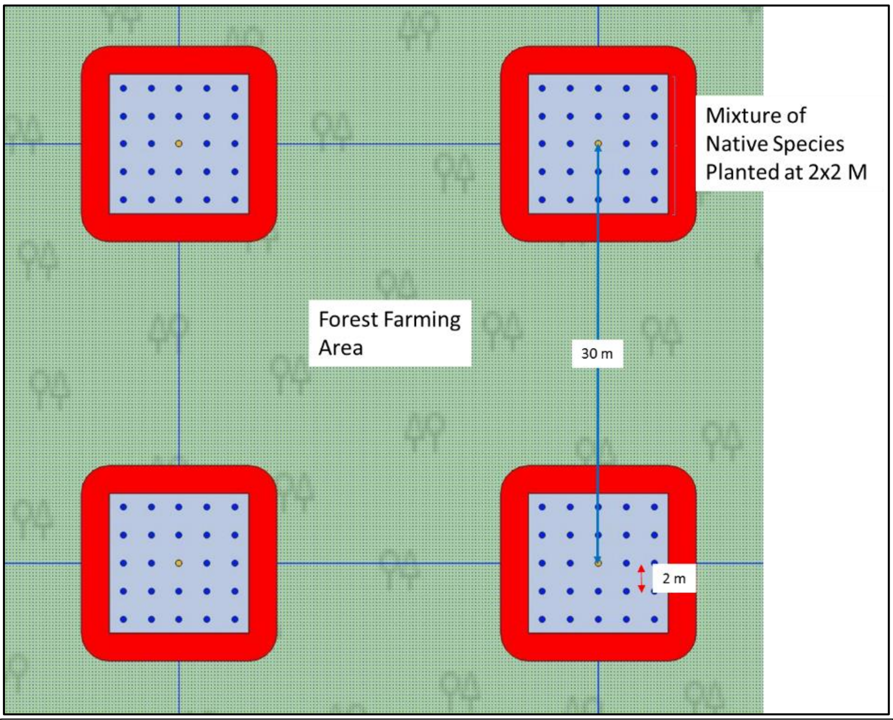
The models selected in Cambodia seek a combination of local traditional agricultural activities with annual crops, combined with restoration using native species with ecological functions. Soil preparation and mechanical hole digging showed to be important cost components that were necessary for the proposed restoration models.

Model 1 - Turmeric, ginger, lemon grass and clusters of native species

This model has two components: (1) clusters for forest restoration and (2) crop/forest farming. Forest restoration involves the planting of timber species to rehabilitate the area, while crop farming is the production and revenue-generation component of the design (ginger, lemon grass and turmeric). In farming, crops with economic value are intercropped underneath the sapling that grows in between the clusters. The site visited is comprised of a mix of early succession deciduous forest. The trees are mostly in the sapling stage with low density. Due to low canopy cover, grasses thrive underneath the trees –the *Shorea obtusa* being the main species.

Enrichment planting is the main approach of the restoration site in Ou Baktra. The site is a degraded second growth forest and remnants of a logged over area. After the forest concession folded up, some people established clandestine farms until the area was covered by a Community Forestry. Thereafter, the forests gradually start to recover. Enrichment planting is implemented in combination with the following planting design and principles: (1) planting in clusters that will serve as plant recruitment points; (2) use of framework species; (3) using a mix of as many species as possible following the Miyawaki technique; and (4) using indigenous species, following the Rainforestation approach. Cluster plots measuring 10m x 10m will be established 30 meters apart and, in each cluster, 25 trees pioneer and climax species will be planted at 2m x 2m as shown below[6].

[6] During the field visit, CARITAS Switzerland had not yet completed the planting in the cluster plots



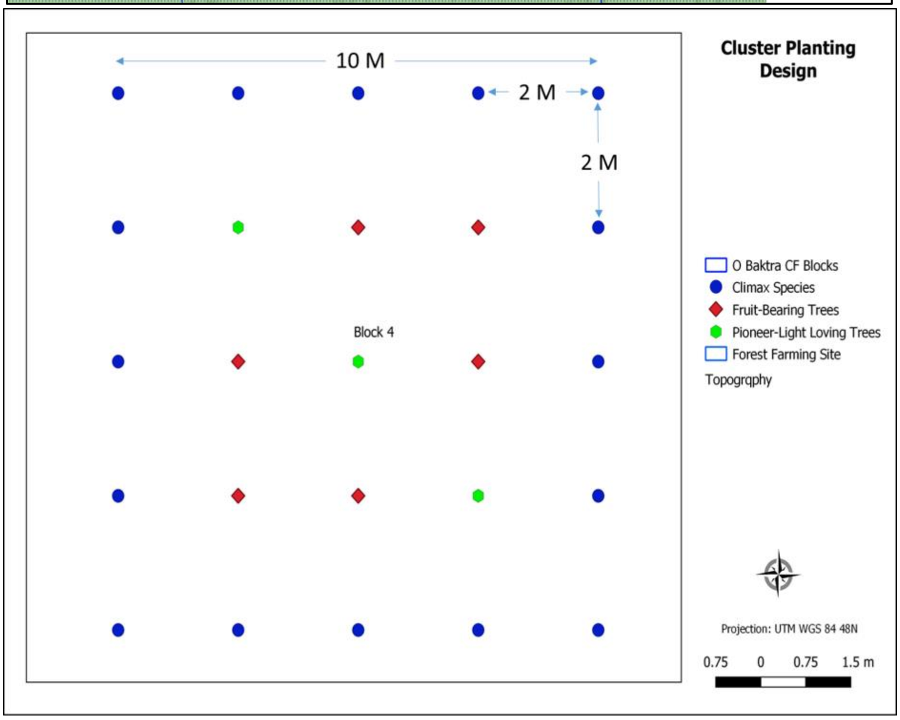


Figure 10 - Sketch of Model 7: Relative position of the cluster planting plots and Forest Farming area (top) and close up of the cluster planting plot detailing the species planted in each cluster plot (bottom)

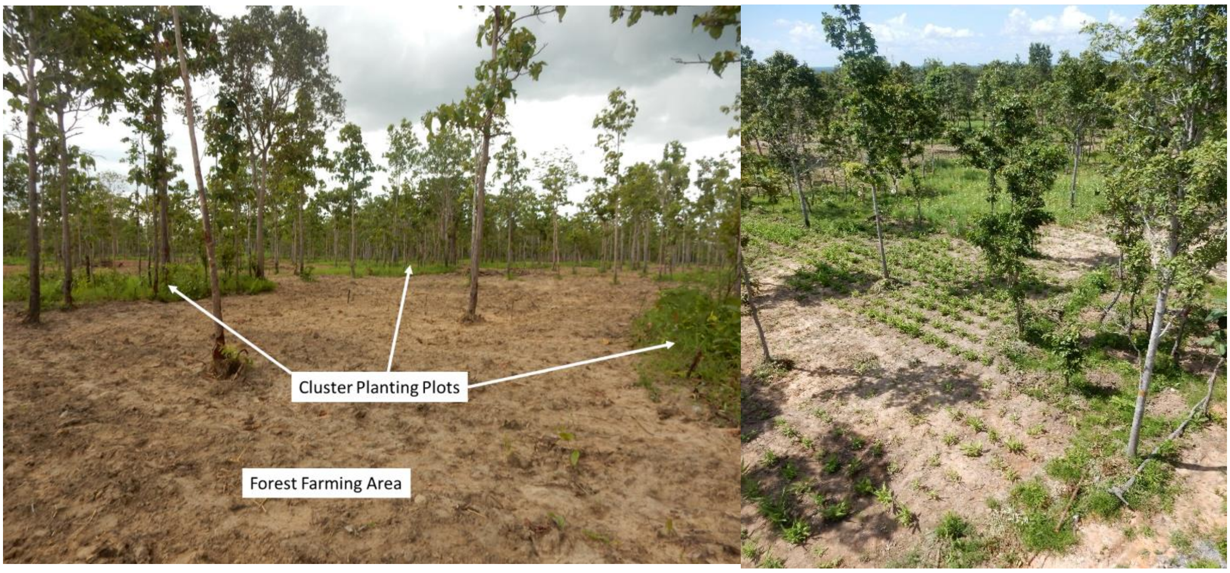


Figure 11 - Site preparation conducted in the Caritas Switzerland demonstration site in OU Baktra CF

Figure 12 - Turmeric and ginger planted in the forest farming plot in Ou Baktra CF

Figure 13 - Plants planted in the cluster plot. Top left is a picture shows the close up of a fruit tree Syzygium spp. and Luxury tree Pterocarpus macrocarpus planted in the cluster plot in Ou Baktra CF

The estimated costs for the cluster planting component only consider the development costs (i.e. covering the cost of seedlings and planting, and does not consider harvesting), since the trees planted are intended for conservation and restoration.

Forest farming involves the cultivation and management of understory crops within an established or developing forest.[7] Unlike other agroforestry practices, such as alley cropping, where trees are introduced into an agricultural system, forest farming intentionally integrates agricultural techniques into existing or newly established forests to farm Non Timber Forest Products (NTFPs).[8] Forest farming may take place in a natural forest setting or in a more organized plantation and can be a sustainable production system. The canopy of the forest is modified and maintained to provide the correct micro-conditions and protection for quality production of the understory or non-timber forest crops.[9]

Three crops (ginger, turmeric and lemon grass) (Table 12) were recently planted by farmer cooperators in Ou Baktra CF.[10] The selection of species was influenced by the existence of buyers especially turmeric and ginger. These crops also have well-established local and national markets as they are used for cooking and are traded in volume.

The costs and assumptions used in the financial analysis are expressed in the financial indicators. The assumptions were mostly based from interviews in Ou Baktra although some information was not available during the interview, such as the cost of hole digging using a mechanical hole digger. In such cases, information from other provinces was used as proxy costs.

The hole digging activities using a mechanical hole digger will be done only during the first 2 years. It is assumed that thereafter, the soil will be friable and can easily be planted with turmeric. Mulching, one of the important features of Conservation Agriculture, will also control weeds, making weeding and brushing unnecessary. Finally, the costs of this model included technical assistance.

Table 17 - Cash flow of Model 1 – Cambodia - Turmeric, ginger and lemon grass as forest farming crops

Year	Gross Revenue (US$)	Tax on Sales (US$)	Cost & Investments (US$)	Cash Flow before income tax (US$)	Tax on Income (US$)	Cash Flow after taxes (US$)
1	3,663.00	-	7,736.00	-4,073.00	-	-4,073.00
2	3,663.00	-	7,476.00	-3,813.00	-	-3,813.00
3	3,663.00	-	3,190.00	473	-	473
4	3,663.00	-	2,655.00	1,008.00	-	1,008.00
5	3,663.00	-	2,655.00	1,008.00	-	1,008.00
6	3,663.00	-	2,655.00	1,008.00	-	1,008.00
7	3,663.00	-	2,655.00	1,008.00	-	1,008.00
8	3,663.00	-	2,655.00	1,008.00	-	1,008.00
9	3,663.00	-	2,655.00	1,008.00	-	1,008.00
10	3,663.00	-	2,655.00	1,008.00	-	1,008.00
11	3,663.00	-	2,655.00	1,008.00	-	1,008.00
12	3,663.00	-	2,655.00	1,008.00	-	1,008.00
13	3,663.00	-	2,655.00	1,008.00	-	1,008.00
14	3,663.00	-	2,655.00	1,008.00	-	1,008.00
15	3,663.00	-	2,655.00	1,008.00	-	1,008.00
16	3,663.00	-	2,655.00	1,008.00	-	1,008.00
17	3,663.00	-	2,655.00	1,008.00	-	1,008.00
18	3,663.00	-	2,655.00	1,008.00	-	1,008.00
19	3,663.00	-	2,655.00	1,008.00	-	1,008.00
20	3,663.00	-	2,655.00	1,008.00	-	1,008.00
21	3,663.00	-	2,655.00	1,008.00	-	1,008.00
22	3,663.00	-	2,655.00	1,008.00	-	1,008.00

[7] https://articles.extension.org/pages/64919/forest-farming-and-non-timber-forest-products-defined
[8] http://www.centerforagroforestry.org/academy/2015/chp7-ForestFarming_2015.pdf
[9] https://articles.extension.org/pages/64919/forest-farming-and-non-timber-forest-products-defined
[10] The technical description of the three species is shown in Annex 3.

Year	Gross Revenue (US$)	Tax on Sales (US$)	Cost & Investments (US$)	Cash Flow before income tax (US$)	Tax on Income (US$)	Cash Flow after taxes (US$)
23	3,663.00	-	2,655.00	1,008.00	-	1,008.00
24	3,663.00	-	2,655.00	1,008.00	-	1,008.00
25	3,663.00	-	2,655.00	1,008.00	-	1,008.00
26	3,663.00	-	2,655.00	1,008.00	-	1,008.00
27	3,663.00	-	2,655.00	1,008.00	-	1,008.00
28	3,663.00	-	2,655.00	1,008.00	-	1,008.00
29	3,663.00	-	2,655.00	1,008.00	-	1,008.00
30	3,663.00	-	2,655.00	1,008.00	-	1,008.00
TOTAL	34,530.80		81,897.30			

Table 18 - Assumptions and basis in developing the cash flow (Model 7 - Cambodia) analysis for forest farming using turmeric, ginger and lemon grass*

Outputs / Key Activities	**Total Cost per Ha. over a period of 30 years**	Computation**
1.0 Initial Investments	**69,215**	
1.1 Fencing	**0**	No need to fence
1.2 Forest Farming	**68,831**	
1.2.1 Brushing and Pruning of Saplings and Mulching the Site	**2,400**	
Labor Cost (Package)	**2,400**	@ 30 Ha. x 80 $/Ha.
1.2.2 Hole Digging	**8,433**	
Labor Cost (Package)	**4,167**	@ 556 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**4,167**	@ 3333 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.2.3 Seedling Transport and Planting	**57,998**	
Labor Cost (Package)	**900**	@ 1 Ha./Yr.; 30 Has. x 30 $/Ha.
Cost of Planting Materials: Turmeric	**18,750**	@ 9,375 kgs. x 2 $/kg.
Cost of Planting Materials: Lemon Grass	**848**	@ 1,785 kgs. x 0.475 $/kg.
Cost of Planting Materials: Ginger	**37,500**	@ 18,750 kgs. x 2 $/kg.
Fertilizers	**0**	Will not apply fertilizers
1.3 Cluster Planting	**384**	
1.3.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.3.2 Hole Digging	**26**	
Labor Cost	**26**	@ 3.4375 person-day x 7.5 $/Person-day
1.3.3 Seedling Transport and Planting	**278**	
Labor Cost (Package)	**3**	@ 0.11 Has. x 30 $/Ha.
Cost of Seedlings	**275**	@ 275 seedlings x 1 $/seedling
2.0 Maintenance and Technical Assistance	**11,762**	
2.1 Forest Farming	**2,378**	
2.1.1 Maintenance Weeding Using Grass Cutter	**1,440**	
Labor Cost (Package)	**1,440**	@ 18 kgs. x 80 $/Ha./Weeding Pass

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
2.1.2 Fertilizer Application	**938**	
Cost of Cow Dung	**938**	@ 37500 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**0**	None
2.2 Cluster Planting	**984**	
2.2.1 Maintenance Weeding	**106**	
Labor Cost	**106**	@ 0.22 Ha. x 80 $/Ha. x 6 Brushings/Yr.
2.2.2 Replanting (Yr. 2 and 3)	**87**	
Labor Cost	**4**	@ 2 replantings x 2 $/replanting
Seedling Cost	**82**	@ 82 seedlings (for 2 years) x 1 $/seedling
2.2.3 Fireline and Firebreak Construction and Maintenance Around the Periphery of Plot	**792**	
Labor Cost	**792**	@ 79, 200 sq.m. x 100 $/10000 sq.m.
2.3 Technical Assistance	**8,400**	
Technical Assistance Cost	**8,000**	@ 320 person-day x 25 $/person-day/Ha.
Gasoline	**400**	@ 320 li. x 1.25 $/li./Ha.
3.0 Harvesting Cost (for Forest Farming)	**9,141**	
3.1 Harvesting and Processing	**900**	
Labor Cost	**900**	@ 30 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**8,241**	
Transport Cost (7.5% of Value of Products)	**8,241**	
TOTAL EXPENSES	**90,118**	

*Turmeric = 0.25 Ha.; Lemon Grass = 0.25 Ha.; Ginger = 0.5 Ha.

**Annual development = 1 Ha. Over 30 year period, some costs, like planting, will be equivalent to 30 has. (i.e. 1 Ha./Year x 30 years)

Table 19 - Financial indicators of Model 1 – Cambodia - Turmeric, ginger and lemon grass as forest farming crops

Item	Value (USD)
Area (hectares)	1.0
Investment	7,786
Investment/ha	7,786
IRR	10.78%
NPV	536
NPV/ha	536
Benefit/Cost Ratio	1.01

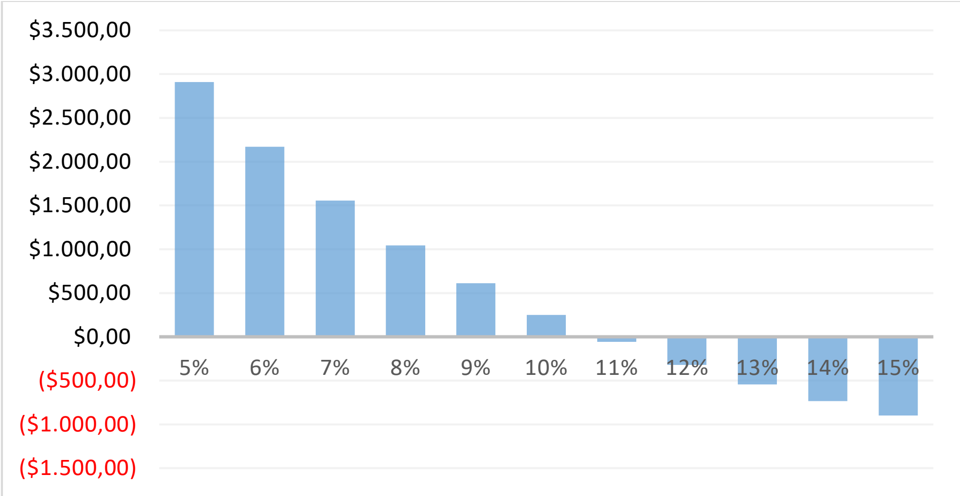


Figure 14 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 1 (Cambodia: Turmeric, ginger and lemon grass as forest farming crops)

Model 2 - Rattan and Bamboo as Forest Farming Crops

This model represents a variation of forest farming, shown in Model 7, and considers the use of rattan and bamboo instead of turmeric, ginger and lemon grass, maintaining the concept of using forest clusters between the crops. The potential rattan and bamboo species that will be used for planting are listed in Annex 2. Although the design is similar, rattan and bamboo will be planted at 5m x 5m. The data for the planting, maintenance, harvesting and yield were based on the information collected from Sre Ambel District in Koh Kong province.

It is noted that the price of rattan and bamboo are very low. Also, the bamboo and rattan species considered are small in size, used mainly as garden trellises or other lesser value products.

The costs of this model included technical assistance. Unlike in forest farming using ginger, turmeric and lemon grass, the process of planting these crops is done only once. Harvesting starts after 6 years for rattan and after 5 years for bamboo. The cash flow analysis showed that using the cost estimate and prevailing yield and prices of rattan and bamboo cannot offset the expenses incurred in developing the forest farm.

Table 20 - Cash flow of Model 2 – Cambodia - Rattan and Bamboo as Forest Farming Crops

Year	Gross Revenue (US$)	Tax on Sales (US$)	Cost & Investments (US$)	Cash Flow before income tax (US$)	Tax on Income (US$)	Cash Flow after taxes (US$)
1	-	-	1,548.00	-1,548.00	-	-1,548.00
2	-	-	990	-990	-	-990
3	-	-	871	-871	-	-871
4	-	-	816	-816	-	-816
5	-	-	336	-336	-	-336
6	568	-	379	189	-	189
7	770	-	394	376	-	376
8	777	-	394	383	-	383
9	785	-	395	390	-	390
10	793	-	395	398	-	398
11	800	-	396	404	-	404
12	808	-	397	411	-	411
13	816	-	397	419	-	419

Year	Gross Revenue (US$)	Tax on Sales (US$)	Cost & Investments (US$)	Cash Flow before income tax (US$)	Tax on Income (US$)	Cash Flow after taxes (US$)
14	823	-	398	425	-	425
15	831	-	398	433	-	433
16	838	-	399	439	-	439
17	846	-	399	447	-	447
18	854	-	400	454	-	454
19	861	-	401	460	-	460
20	869	-	401	468	-	468
21	877	-	402	475	-	475
22	884	-	402	482	-	482
23	892	-	403	489	-	489
24	900	-	403	497	-	497
25	907	-	404	503	-	503
26	915	-	405	510	-	510
27	922	-	405	517	-	517
28	930	-	406	524	-	524
29	938	-	407	531	-	531
30	945	-	407	538	-	538
TOTAL	4,506.70		13,225.50			

Table 21 - Assumptions and basis in developing the cash flow (Model 2) analysis for forest farming using rattan and bamboo in Ou Baktra CF*

Outputs / Key Activities	**Total Cost per Ha. over a period of 30 years**	Computation**
1.0 Initial Investments	**1,262**	
1.1 Fencing	**-**	No fencing is needed
1.2 Forest Farming	**878**	
1.2.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.2.2 Hole Digging	**168**	
Labor Cost (Package)	**38**	@ 5 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**30**	@ 24 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.2.3 Seedling Transport and Planting	**630**	
Labor Cost (Package)	**30**	@ 1 Has. x 30 $/Ha.
Cost of Planting Materials: Rattan	**200**	@ 200 sdlngs x 1 $/seedling
Cost of Planting Materials: Bamboo	**400**	@ 200 sdlngs x 2 $/seedling
Fertilizers	**-**	Will not apply
1.3 Cluster Planting	**384**	
1.3.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.3.2 Hole Digging	**26**	
Labor Cost	**26**	@ 3.4 person-day x 7.5 $/Person-day
1.3.3 Seedling Transport and Planting	**278**	
Labor Cost (Package)	**3**	@ 0.11 Ha. x 30 $/Ha.

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
Cost of Seedlings	**275**	@ 275 seedlings x 1 $/seedling
2.0 Maintenance and Technical Assistance	**11,748**	
2.1 Forest Farming	**2,378**	
2.1.1 Maintenance Weeding Using Grass Cutter	**1,440**	
Labor Cost (Package)	**1,440**	@ 18 weeding x 80 $/Ha./Weeding Pass
2.1.2 Fertilizer Application	**938**	
Cost of Cow Dung	**938**	@ 37,500 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**-**	None
2.2 Cluster Planting	**971**	
2.2.1 Maintenance Weeding	**106**	
Labor Cost	**106**	@ 0.22 Ha. x 80 $/Ha. x 6 Brushings/Yr.
2.2.2 Replanting (Yr. 2 and 3)	**73**	
Labor Cost	**4**	@ lump sum
Cost of Seedlings	**69**	@ 69 seedlings x 1 $/seedling
2.2.3 Fireline and Firebreak Construction and Maintenance Around the Periphery of Plot	**792**	
Labor Cost	**792**	@ 79200 sq.m. x 100 $/10000 sq.m.
2.3 Technical Assistance	**8,400**	
Technical Assistance Cost	**8,000**	@ 320 person-day x 25 $/person-day/Ha.
Gasoline	**400**	@ 320 li. x 1.25 $/li./Ha.
3.0 Harvesting Cost (for Forest Farming)	**2,486**	
3.1 Harvesting and Processing	**900**	
Labor Cost	**900**	@ 30 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**1,586**	
Transport Cost (7.5% of Value of Products)	**1,586**	
TOTAL EXPENSES	**15,496**	

*Rattan = 0.50 Ha.; Bamboo = 0.50 Ha.

*Annual development = 1 Ha. Over 30 year period, some costs, like planting, will be equivalent to 30 has. (i.e. 1 Ha./Year x 30 years)

Table 22 - Financial indicators of Model 2 – Cambodia - Rattan and Bamboo as Forest Farming Crops

Item	Value (USD)
Area (hectares)	1.0
Investment	1,548
Investment/ha	1,548
IRR	6.07%
NPV	(1,511)
NPV/ha	(1,511)
Benefit/Cost Ratio	0.72

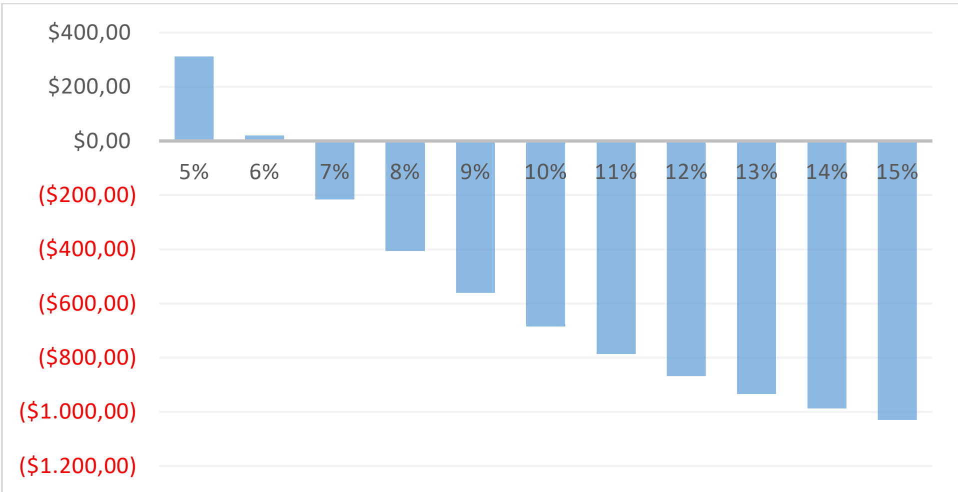


Figure 15 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 2 – Cambodia - Rattan and Bamboo as Forest Farming Crops

Model 3 - Taungya Model

Several plantations are established by the government, NGOs and Economic Land Concessions in Cambodia. The latter are developing large tracts of land for rubber and industrial tree plantations. Some rubber plantations are intercropped during early stages of development. The planting of profitable crops between spaces has the potential to contribute to food security in the country.

The Taungya model was done in the seed orchard established by the Institute of Forest and Wildlife Research and Development (IRD) in Chansor Research Station. The spacing of the seed orchard is 5m x 5m, which is enough space between the planted timber for the crops. In this model, peanuts were planted between native trees. The primary purpose of planting the legume is to enrich the soil by intercropping leguminous species, and to control weeds, meeting the restoration purpose.

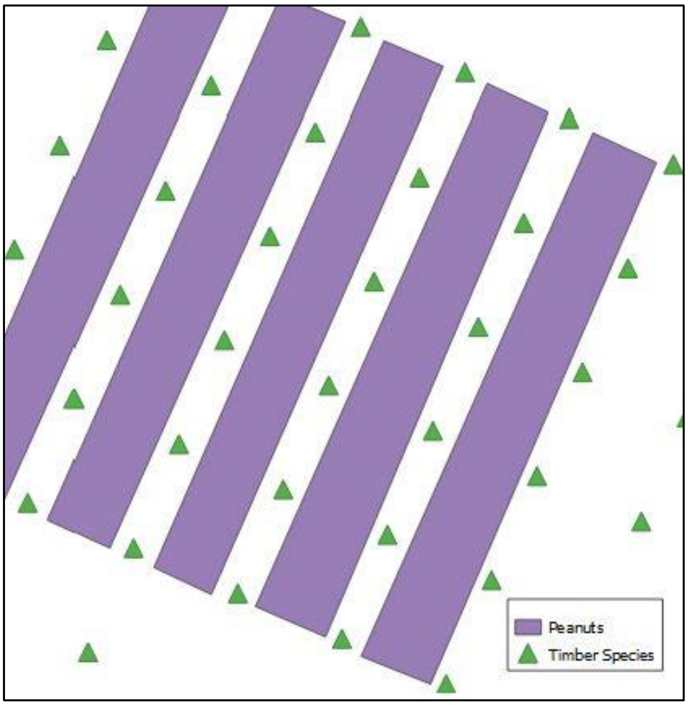


Figure 16 - Sketch of Model 3 (Taungya) located in the seed orchard of Institutre of Forest and Widlife Research and Development in Chansor Research Station in Siem Reap province

Figure 17 - Newly planted peanuts interplanted in a one-year-old grafted Dalbergia seedlings in a Seed Orchard in Chansor Research Station

In this analysis, the Taungya model will integrate Conservation Agriculture (i.e. no tillage). The period of peanut harvest, in this model, is 6 years. Due to the canopy closure the site will no longer be suitable for growing of peanuts after year 6, and will no longer provide income.[11] Considering this, the period of analysis of this model is 6 years.

[11] When the canopy starts to close, other shade tolerant crops may be planted instead of peanuts and will resemble forest farming practices. This option is not included in the analysis, being beyond the scope of this work.

Table 23 - Cash flow of Model 3 - Cambodia - Taungya

Year	Gross Revenue (US$)	Tax on Sales (US$)	Cost & Investments (US$)	Cash Flow before income tax (US$)	Tax on Income (US$)	Cash Flow after taxes (US$)
1	3,500	-	12,650	(9,150)	-	(9,150)
2	3,500	-	6,724	(3,224)	-	(3,224)
3	3,500	-	244	3,256	-	3,256
4	3,500	-	244	3,256	-	3,256
5	3,500	-	244	3,256	-	3,256
6	3,500	-	244	3,256	-	3,256
TOTAL	15,243		18,500			

Table 24 - Cost assumptions for Taungya Model (Model 3) Cambodia

Outputs / Key Activities	Total Cost per Ha. over a period of 6 years	Computation*
1.0 Initial Investments	**13,385**	
1.1 Fencing	**-**	
1.2 Brushing and Mulching the Site	**480**	
Labor Cost (Package)	**480**	@ 6 Ha. x 80 $/Ha.
1.3 Fireline and Firebreak Construction and Maintenance	**127**	
Labor Cost (Package)	**127**	@ 1.58 Ha. x 80 $/Ha.
1.4 Hole Digging	**12,100**	
Labor Cost (Package)	**6,000**	@ 800 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**6,000**	@ 4800 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.5 Seedling Transport and Planting	**678**	
Labor Cost (Package)	**180**	@ 6 Has. x 30 $/Ha.
Cost of Planting Materials	**498**	@ 6 Ha. x 83 $/Ha.
Fertilizers	**-**	Will not apply
2.0 Maintenance and Technical Assistance	**13,951**	
2.1 Maintenance Weeding Using Grass Cutter	**960**	
Labor Cost (Package)	**960**	@ 12 weeding x 80 $/Ha./Weeding Pass
2.2 Fertilizer Application	**31**	
Cost of Cow Dung	**31**	@ 1250 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**-**	None
2.3 Technical Assistance	**12,960**	
Technical Assistance Cost	**7,200**	@ 288 person-day x 25 $/person-day/Ha.
Gasoline	**5,760**	@ 5760 li. x 1 $/li.
3.0 Harvesting Cost (for Forest Farming)	**180**	

Outputs / Key Activities	Total Cost per Ha. over a period of 6 years	Computation*
3.1 Harvesting and Processing	**180**	
Labor Cost	**180**	@ 6 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**-**	
Transport Cost	**-**	None, Sold on Farm
TOTAL EXPENSES	**27,516**	

*Annual development = 1 Ha. Over 6 year period, some costs, like planting, will be equivalent to 6 has. (i.e. 1 Ha./Year x 6 years)

Table 25 - Financial indicators of Model 3 - Cambodia - Taungya Model

Item	Value (USD)
Area (hectares)	6.0
Investment	8,965
Investment/ha	1,494
IRR	-
NPV	(7,247)
NPV/ha	(1,207)
Benefit/Cost Ratio	0.70

Overall results

In order to compare the results among the models, the overall results and perceptions of each restoration proposal are organized in Table 18. The models with the highest economic viability were observed in Peru. Even though they presented problems related to selling the products, the NPV of those models were higher than US$ 2,700 per hectare, with one model reaching up to US$ 30,000 per hectare, which indicates the country's potential for this kind of initiative. In contrast, the models in Cambodia presented the lowest financial indicators values due to larger investment values.

Furthermore, the seeds dispersion models presented a cost of USD 670 and USD 1,600 per hectare. These results indicate that restoration models using this technique have a relatively high initial investment. However, these models have the lowest costs over time, which compensates the implementation expenses.

The following table presents a summary of results for models assessed, and also addresses some contextual/qualitative questions.

Table 26 - Overall results and perceptions on the restoration models

Country	Case	Restoration Model	Species 1 (name)	Species 2 (name)	Species 3 (name)	Species 4 (name)	Species 5 (name)	% of native vegetation and productive species	Property Total Area (ha)	Restoration/ Agroforestry Area	Main productive Activity	Secondary Activity	Biophisical conditions (slope, soil)	Investment / ha (US$/ha)	NPV / ha (US$)	IRR	Technical Capacity on Restoration in the Region (low/high)	Logistics / Access to Markets	Regulation issues	Legal obligation to restore? (yes /no)
Cambodia	1	Modified Caritas Model - Cluster Planting	Lemongrass	Turmeric	Ginger			100%	0,32	0,32	Forest Farming	Management of the Community Forest	Flat-Gently rolling; Clayey	$7.786,00	$ 536,00	10.78%	Low	Limited	Cultivating the community forests will likely encounter objection from the Forestry Administration	No
Cambodia	2	Modified Caritas Model	Bamboo	Rattan				100%	0,32	0,32	Forest Farming	Management of the Community Forest	Flat-Gently rolling; Clayey	$1.548,00	$(1.511,00)	N/A	Low	Limited	None	No
Cambodia	3	Taungya Model	Peanuts	Timber Species				100%	3	3	Peanuts and Timber Species	Seed Orchard Management	Flat; Sandy to Sandyloam	$ 1.494,00	$(1.207,00)	N/A	High	Limited	Forestry Administraiton may not allow the villagers to access to the reforestation areas to do the intercropping	No
Indonesia	1	Lowland Restoration	Coconut (*Cocos nucifera)*	Ketapang (*Terminalia catappa*)	Cemara Laut (*Casuarina equisetifolia*)			50% and 50%	500	500	Farmer and/or fisher	Labor to palm plantation	Coastal area and peatland, mosty flat	$ 104,15	$ 224,50	22,20%	low; need more skill and capacity building	little, potential to be improved	available but not fully executeable	yes
Indonesia	2	Highland Restoration	Meranti (*Shorea sp.)*	Durio (*Durio zibethinus*)	Manggis (*Garcinia mangostana*)	Coconut (*Cocos nucifera)*		25% and 75%	100	100	Farmer	Labor to farm and off-farm	Hilly and mountanious	$ 194,35	$ 1.799,58	29,33%	low; need more skill and capacity building	little, potential to be improved	available but not fully executeable	yes
Peru	1	Agroforestry system	Coffee	Guaba	Caoba	Tornillo		93% coffee 6% Guaba 0.5% Caoba 0.5% Tornillo	13	0,5	Coffee	Ecotourism	Clayey and flat surface	$ 600,00	$ 689,00	86%	High (permanent training of C.I technicians.	There is a big demand of companies that buy coffee beans (06 identified companies at least)		Yes (Conservation agreement)
Peru	2	Agroforestry system Sistema Silvopastoril	Cocoa	Pino chuncho	Bolaina	Capirona	Cedro de la india	86% Cocoa 8% Pino chuncho 2% Bolaina 2% Capirona 2% Shaina 2% Cedro de la india	17,5	5,75	Cocoa	Cattle	Clayey rock surface with 45° slope	$ 400,00	$ 85,00	30%	High (permanent training of C.I technicians.	There is a big demand of companies that buy cocoa beans.		Yes (Conservation agreement)
Peru	3	Agroforestry system	Coffee	Cocoa	Guaba	Jacaranda		84% coffee 8% Guaba 7% Cocoa 1% Jacaranda	3,50	3,00	Coffee	Cocoa	Clayey and flat surface	$ 100,00	$ 277,00	55%	High (permanent training of C.I technicians.	There is a big demand of companies that buy cocoa and cofee beans.		Yes (Conservation agreement)

Final Remarks

The literature review identified almost no information about forest restoration costs in the profiled countries, corroborating other studies indicating the lack of economic information worldwide (Wortley et al. 2013)[12]. This gap in knowledge is being addressed here, in an effort to encourage the implementation of large-scale initiatives such as the Bonn Challenge and demand indicated by the IPCC (IPCC 2014)[13] to stabilize anthropogenic climate change.

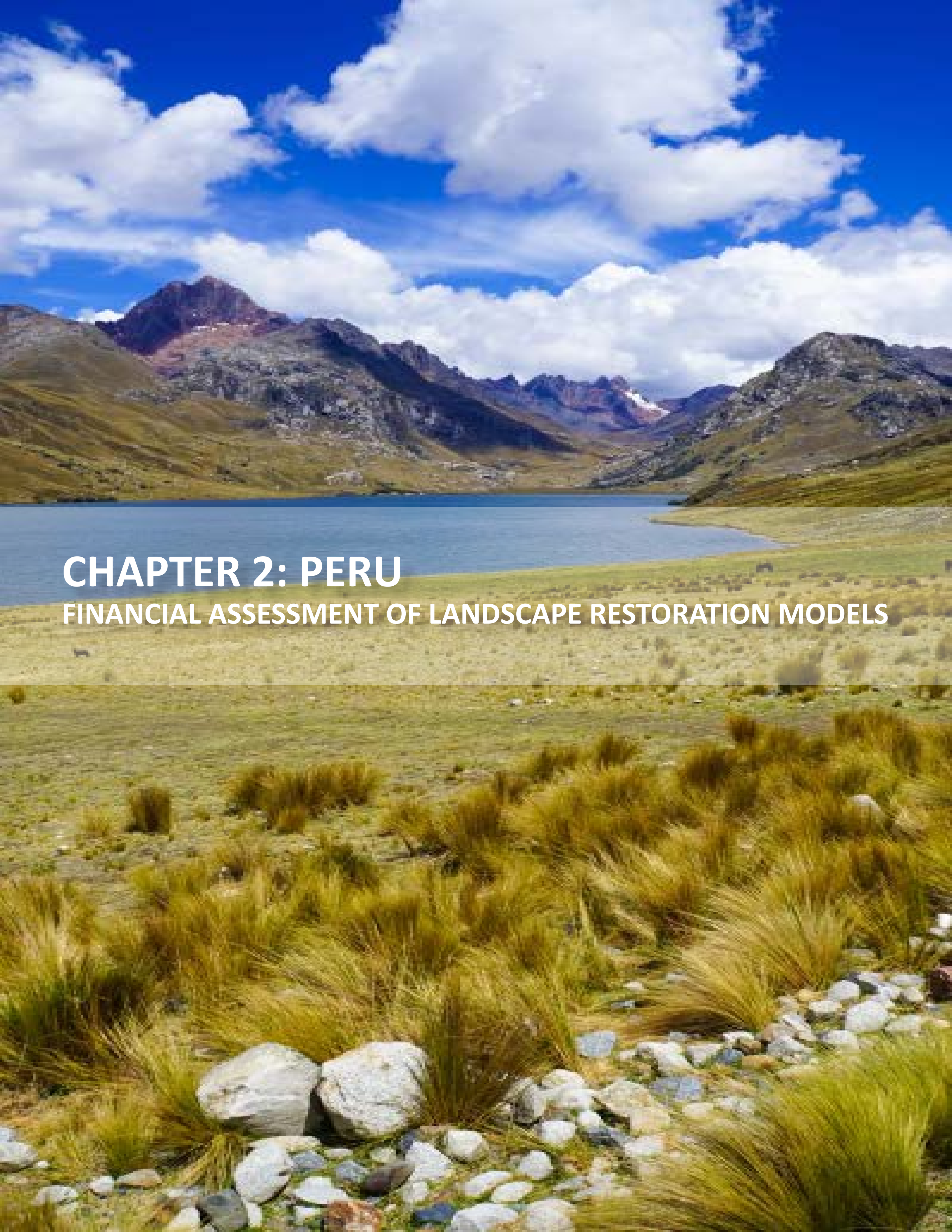
Regarding restoration public policies, it was apparent there is a lack of legislation clearly determining what percentage of properties should be conserved or restored, meaning that forest restoration is mainly a voluntary initiative in the profiled countries. In the case of Indonesia, for example, the government has ambitious restoration targets, and is seeking to incentivize these initiatives. However, in other countries, establishing a legal framework for forest restoration is still a challenge.

This study found that the forest restoration initiatives are mostly conducted by non-governmental organizations and in some places, they have also support from the government. However, in both cases, restoration models are not chosen based on economic performance. Some of these initiatives might be implemented in protected areas, to generate income to local communities, while others refer to ecological improvements in private or communal farms. In general, farmers have little theoretical and practical experience in forest restoration. Thus, the models included technical assistance costs to ensure the engagement of farmers without technical knowledge and the proper replication of the proposed models.

The study identified average forest restoration total deployment costs per hectare and approximately to one year period, vary from around USD 515 in Peru, to USD 640 in Indonesia, and USD 3,642 in Cambodia – with an overall average of UDS 1,600. Five out of the 6 restoration models with economic goals (not considering the seeds dispersion models) yielded Internal Rates of Return larger than the discount rate, which means they are capable of paying back initial investments, inputs and labor costs with positive net economic returns. Regarding the selected models, Model 2 implemented in Peru, including coffee and cocoa as the main species, had the highest returns, which suggests a high potential for plant agroforestry systems in degraded areas with very low investment costs and a promising market for the selected species.

[12] Wortley, L., Hero, J.M. & Howes, M. Evaluating Ecological Restoration Success: A Review of the Literature. Restoration Ecology. V21 n5 pp 537-543. 2013.

[13] Intergovernmental Panel on Climate Change – IPCC. Climate Change 2014: Impacts, Adaptation and Vulnerability. IPCC Working group II contribution to AR5. Available at https://www.ipcc.ch/report/ar5/wg2/. 2014.



CHAPTER 2: PERU

FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

CHAPTER 2 – PERU: FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

France Cabanillas, Jhon Farfan, Francisco Roman

Restoration models - Literature review

The restoration of degraded ecosystems is both a necessity and an opportunity in Peru. The National Forestry and Wildlife Service (SERFOR), an office attached to the Ministry of Agriculture and Irrigation (MINAGRI), is responsible for promoting restoration at the national level. However, the concept of restoration still needs to be strengthened.

In April 2018, the "Guidelines for the Restoration of Forest Ecosystems and other Ecosystems of Wild Vegetation" was issued (SERFOR, 2018), guiding restoration actions in national territories. The document defines the restoration and rehabilitation of ecosystems as follows:

- Restoration: Process to help the recovery of an area, ecosystem, or degraded landscape, damaged or destroyed, in order to resume its ecological trajectory, maintain resilience, conserve biological diversity and restore the functionality of ecosystems and landscapes.
- Rehabilitation: Any attempt to recover structural or functional elements within a degraded ecosystem. Unlike restoration, rehabilitation can help restore some, but not necessarily all, of the flora and fauna that were originally present in an ecosystem.

According to the current regulation, there are 3 modalities for restoration:

Qualifying land titles and administrative acts forest and wildlife. Restoration initiatives can be developed within the framework of the enabling titles and administrative acts that imply the intervention or withdrawal of forest cover, granted in the framework of *Ley N°29763, Forestry and Wildlife Law and its Regulations*, as well as those titles granted under the revoked *Ley N°27308.*

As part of Environmental Management Instruments. Within the framework of *Ley N°27446, Law of the National Environmental Impact Assessment System*, taking into account, as appropriate, the guidelines for environmental compensation and other complementary regulatory instruments; as well as what is established in the guidelines for restoration.

As public or private initiatives. Restoration initiatives can also be developed by: public institutions, within the framework of their competencies, which have budgetary programs or public investment projects for restoration or recovery actions at the national, regional or local level; private company; associations; academy; among others, within the framework of its policies, lines of action and particular interest.

Principles of restoration

These guidelines adopt 5 principles of restoration based on scientific evidence and practice, which are mentioned below:

- Restoration increases biotic integrity in ecosystems and landscapes.
- The restoration is sustainable in the long term.
- The restoration is based on knowledge.
- The restoration benefits and commits society.
- The restoration contributes to mitigate the effects and reduce the vulnerability of climate change**.**

In Peru, there are different restoration models and projects, described below:

The Sustainable Landscape Project for the Amazon (El *Proyecto Paisaje Sostenible para la Amazonia*), whose focus was to increase the capacity to mitigate and adapt to climate change while improving ecosystem services and socio-economic benefits for farmers in Yurimaguas, Loreto, Peru; using more sustainable productive alternatives such as agroforestry, reforestation, Silvopastoral System and forest enrichment (Cited by SERFOR, 2018).

In the Piura region, Peru, the NOSBOSQUE project promotes forest development, based on the conservation and sustainable use of the forest resources. Restoration serves as a tool to promote sustainable development, especially of rural populations through agroforestry systems, forest plantations and reforestation of the middle and upper parts of Piura with reintroduction of native forest species and protection of natural regeneration.

The National Institute of Agricultural Innovation (El Instituto Nacional de Innovación agraria) (INIA) developed various restoration projects in the Coast, Sierra and Jungle with multi-layer systems (distribution of treetops according to plant species), agrobosque system (mix of annual and perennial crops) and silvopecuary systems, or also called silvopastoral systems.

The “Recovery of areas degraded by mining activity” project was initiated in Madre de Dios in 2015. This initiative was implemented by Wake Forest University (WFU), the Amazon Scientific Innovation Center (*Centro de Innovación Científica Amazónica*) (CINCIA), the United States Agency for International Development (USAID) and the World Wide Fund for Nature (WWF), which is supported by the Ministry of Environment, the National Forest and Wildlife Service (*Servicio Nacional Forestal y de Fauna Silvestre* (SERFOR), the Regional Government of Madre de Dios and provincial, local municipalities. It began with the installation of experimental reforestation plots with an initial goal to recover around 42 hectares. However, in 2018 the goal was extended by 140 hectares, through reforestation with more than 155,000 trees, in the district of Inambari and the province of Manu, where the most degraded areas from mining are located. Thanks to this initiative, the soils that had completely lost their fertility, are starting to recover their constitution. (Andina, 2017).

2. Regional context and characterization of "standard restorers"

The San Martin Region presents a high vulnerability to the effects of climate change in Peru (Andersen et al., 2009). The provision of water, in quantity and quality, constitutes a problematic situation, caused mainly by the loss of forest cover, decreasing the amount of water available during the dry season and affecting water quality due to the increase in the sediment load in the rivers (Lapeyre et al., 2004).

In the Alto Mayo Region, due to deforestation linked to agriculture, mainly coffee, cocoa, rice, livestock, illegal felling, land trafficking and illicit crops (coca, amapola), water provision is becoming a problem (Concha et al., 2007). This situation increases soil erosion due to rainfall, sediments in rivers and decreases the water retention in the forest, affecting the quantity and quality of water. It is aggravated by the lack of knowledge of the rules established for the management and use of water resources, and the perception that the management structure is weak (Chuquizuta et al., 2016).

The Alto Mayo basin is located to the north of the departments of San Martín and Amazonas, and it forms part of the Huallaga river basin, at an altitude that varies from 300 to 3,800 meters above sea level, covering an area of 9,792.4 km². The North borders the lower area of the Marañón River basin, the East with the basins of the Huallaga, Shanushi and Caynarachi rivers, the South with the basins of the Sisa, Saposoa, Huayabamba and Utcubamba rivers, and the West with the basins of the Imaza and Nieva rivers, belonging to the Amazon Region. Furthermore, the San Martín region stands out for its geo-economic importance and population concentration. It shares its territory (859.9 km², which is equivalent to 8.8% of the area of the basin) with the department of Amazonas (MINAM, 2009).

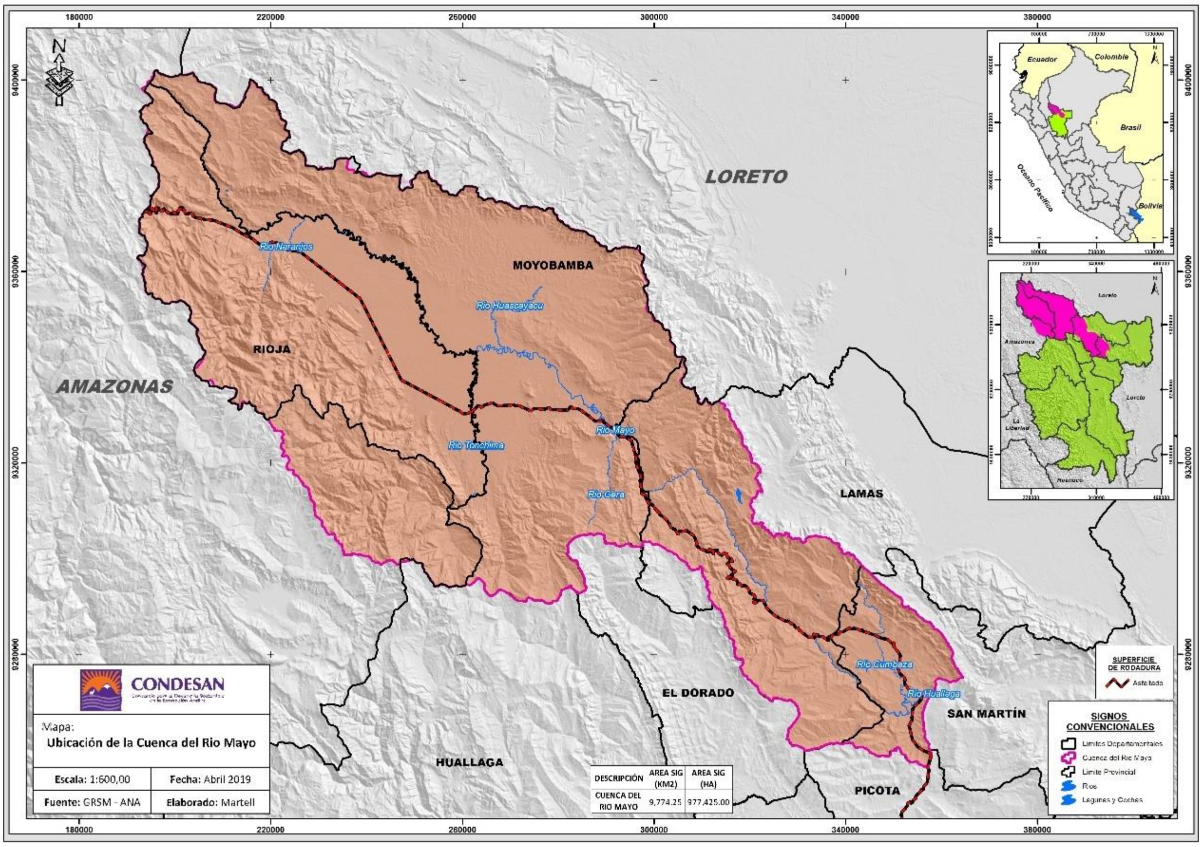


Figure 18 - Location Map of the Alto Mayo Basin

Source: Forestry Zoning of the Regional Government of San Martín, 2018

Politically, the Alto Mayo basin forms part of the administrative scope of the departments of San Martín and Amazonas. Within the department of San Martín, it includes the provinces of Rioja, Moyobamba, Lamas and San Martín, which represent 29 districts in the basin, and the provinces of El Dorado and Rodríguez de Mendoza within the department of Amazonas, as detailed in Table 1 .

Table 27 - Provinces and districts located within the Alto Mayo basin

Provinces	Districts
Rioja	Awajún, Elías Soplín Vargas, Nueva Cajamarca, Pósic, Pardo Miguel, Rioja, San Fernando, Yorongos, Yuracyacu
Moyobamba	Calzada, Habana, Soritor, Jepelacio y Yantaló
Lamas	Alonso de Alvarado, Cuñumbuque, Lamas, Pinto Recodo, Rumizapa, San Roque de Cumbaza, Shanao, Tabalosos y Zapatero
San Martín	Cacatachi, Juan Guerra, Banda de Shilcayo, Morales, San Antonio, Shapaja y Tarapoto

Source:"Socioeconomic Characterization of the Mayo River Basin", July 2008. It does not include the provinces of El Dorado and Rodríguez de Mendoza, because it belongs to the department of Amazonas."

In the Alto Mayo basin, various productive activities converge as already mentioned. Thus, the efforts of the government (central, regional and local), as well as the private ones, are aimed at reducing the pressure in forest areas. This has been done mainly through conservation, but also with different mechanisms, such as payment for ecosystems services, REDD projects, sustainable tourism, management of non-timber forest resources such as beekeeping, restoration for riparian protection purposes, the compensation mechanism for ecosystem services (MERESE), among others.

In this case, restoration can be included in these new tools, as part of an integral management of the landscape, and those landowners who can execute the restoration initiatives in a more effective way. In most cases, they are those that sign conservation agreements or that formally commit themselves in said processes.

There are also restoration initiatives led by indigenous peoples, such as the Awajun Community. This community, 10 years ago, rented their land to outsiders for monoculture plantings, such as papaya and coffee. The usage of synthetic fertilizers and herbicides throughout those 6 years, contaminated and altered the soil structure. As a result, most of those lands are covered with pastures (herbaceous). However, thanks to an initiative of SERNANP and CI, some community members are now recovering small plots, such is the case of Gilberto Nugkuag that has 1 hectare of coffee (*Coffea arabica*), intercropped with guaba (*Inga edulis*) and native trees like Tornillo (*Cedrelinga catenaeformis*) and Sinami (*Oenocarpus mapora*).

3. Selection of restoration models with economic potential

CI supports many restoration plots in the Alto Mayo Basin, most of these are replicas of the same "Coffee + Guaba and Cocoa" model. The first restoration model with Agroforestry Systems and tourism entrepreneurship to attract and protect wildlife; the second restoration model with Agroforestry Systems and Silvopastoral systems to reduce soil erosion; third restoration model with Agroforestry Systems associated with natural regeneration and the fourth restoration model with Agroforestry Systems where previously the soil structure was altered by herbicide and synthetic fertilizer use, and is also located in an indigenous town (the objective was to plant trees to attract wildlife and also create shade for the community members).

Table 28 - Restoration iniciatives in Alto Mayo

Land onwer	Restoration Model	UTM Coordinates	Altitude
Norbin Becerra	Agroforestry Systems and tourism entrepreneurship.	207987 9371400	1050 m.a.s.l
Mauro Fernández Medina	Agroforestry Systems and Silvopastoral systems	296414 9315824	950 m.a.s.l
Armando Marchena	Agroforestry Systems	269581 9336905	846 m.a.s.l
Gilberto Nugkuag	Agroforestry Systems	235156 9359261	895 a.s.l

Four properties with different agroforestry configurations were visited in order to select the two most promising models.

Property 1: Restoration with Agroforestry Systems (Coffee + Guaba: ½ hectare) and tourism entrepreneurship

This is an agricultural property located in the Pardo Miguel Naranjo District, Province of Rioja, Department of San Martin; the landowner is Mr. Norbin Becerra. It has a total area of 13 hectares and was previously dedicated to migratory agriculture; however, with the experience, he saw another potential within his estate, which was to plant trees to attract birds like hummingbirds and partridges. To the date, it has 0.5 hectares of coffee intercropped with Guaba, and he also planted some trees such as Tornillo and Caoba.

Property 2: Restoration with Agroforestry Systems (Cocoa: 5 hectares) and Silvopastoral (native and exotic trees, area: 0.75 hectares).

This is an agricultural property located in the Gepelacio District, Moyobamba Province, San Martin Department; the landowner is Mr. Mauro Fernández Medina. It has a total area of 17.5 hectares and was dedicated to migratory agriculture and livestock. The property has an inclined topography of approximately 45° and therefore erosion is common place. With the technical assistance of CI, 8 years ago they installed a plot of 0.75 hectares with Silvopastoral system with trees like Pino chuncho, Bolaina, Capirona, Cedro de la India, to avoid soil erosion, and 5 hectares of cocoa.

Property 3: Restoration with Agroforestry Systems (Coffee + Guaba: 2.5 hectares) and (Cacao + Jacaranda: ½ ha).

This is an agricultural property located in the District of Calzada, Moyobamba Province, San Martin Department; the owner of the land is Mr. Armando Marchena Núñez. It has a total area of 3.5 hectares. About 30 years ago, it was dedicated to migratory agriculture. As a results of various trainings the landowner has attended, the land now has the capacity to produce its own seedlings, compost, fertilizers, and silvicultural treatments, among others. For the past 5 years, it has been managing 2 hectares of coffee intercropped with Guaba and 0.5 hectares of cocoa intercropped with jacaranda trees that grew with natural regeneration.

Property 4: Restoration with Agroforestry Systems (Coffee + Guaba + Tornillo + Sinami)

This model is located in the Indigenous Community of Awajun, Awajun District, Province of Rioja, Department of San Martin. Ten years ago, the community leased their land to outsiders for the planting of monocultures such as papaya and coffee. For 6 years, synthetic fertilizers and herbicides were used, contaminating and completely altering the soil structure. Much of these lands are now covered with pastures. However, thanks SERNANP and CI, some community members have been recovering small plots, such as Gilberto Nugkuag that has a 1 hectare plot of coffee intercropped with Guaba and native trees such as Tornillo and Sinami.

As a result of the visits to these four properties and interviews with the owners, enough information was collected to conduct the financial analysis on the most efficient restoration models. Property 2 and Property 3 financial data allowed considering hypothetical profitable models of a silvopastoral system for economic purposes (including fence installation), and another model based on seeds dispersal. A vast literature exists regarding the volume per hectare of trees of economic importance in plantations, for example in the case of the Tornillo (Cedrelinga cateniformis) it can reach 1247 m^3/ha 30 years (INIA, 2016), and others timber species of rapid growth can reach greater volume. This information allowed the calculation of the volumes per hectare of each hypothetical model.

4. Economic assessment of restoration models - Basic parameters

Installation of restoration plots

The plots in the Alto Mayo Basin that are part of the Protection Forest do not have large areas, due to the conservation agreements they have signed with SERNANP. Normally they are smaller than 2 hectares, having no needs for fences.

Maintenance

The maintenance of the restored plots is typically done 4 times a year (weed clearing), in the traditional way with a machete. For coffee, pruning is done once a year starting in the 2^{nd} year, and when the coffee plantations are affected by a pathogen. For cocoa, pruning is done once a year starting in the 4^{th} year, to prevent its growth in height and to stimulate a higher yield. Some also fertilize their plots by preparing and applying compost and organic foliar fertilizers (Biol) once a year.

Harvest

Harvesting is usually done in the dry season, from April to July of each year. In the case of coffee, it is first harvested and then peeled. It is then dried in the shade, which can take 2 days or more, depending on the volume and area where it dries. For cocoa, the seeds are taken out of the fruit, and placed in a wooden box for 5 to 7 days them to undergo a fermentation process that allows it to be dried. Cocoa can also be sold fresh, after it is removed from the fruit, but is purchased at 30% discount to account for the moisture of the seed.

Taxes

According to the *Ley de Promoción de la Inversión en la Amazonía Ley N° 27037*, taxpayers of the Amazon engaged in primarily agricultural activities and/or the transformation or processing of products qualified as native and/or alternative crops in said area, will be exempted from income tax, to promote sustainable activities. For this reason, we did not consider sales taxes or income taxes.

Discount Rate

The discount rate used for the economic assessments in Peru was 15%, based on the cost of capital (interest rates) that landowners would have to pay to access to loans.

Model 1 - Cacao with Silvopastoral system

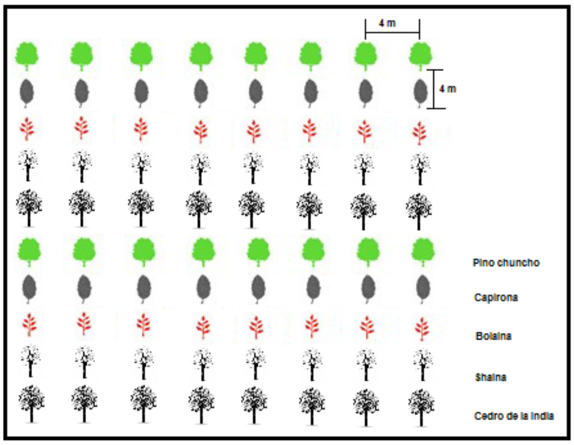
This model was based on a property located in the Gepelacio District, Moyobamba Province, San Martin Department. The area has an extension of 17.5 hectares and was previously dedicated to agriculture and livestock. The site has an inclined topography of approximately 45°, and therefore, erosion is more likely to cause problems in the area. Based on the owner's previous bad experiences, and with the help of CI technicians, a silvopastoral system[14] of 0.75 ha was implemented in order to prevent soil erosion. The system has species of economic and ecological importance such as: Pino Chuncho (*Schizolobium amazonicum*), Bolaina (*Guazuma crinita*), Capirona (*Calycophyllum spruceanum*) and Shaina (*Colubrina glandulosa*) and introduced species such as the Cedro de la India (*Acrocarpus fraxinifolius*) at a distance of 4m x 4m, which resulted in 468 plants, associated with cattle grass (*Brachiaria brizantha*). Furthermore, in another plot the owner had also planted cacao, on 5 hectares, at a distance of 3m x 3m.

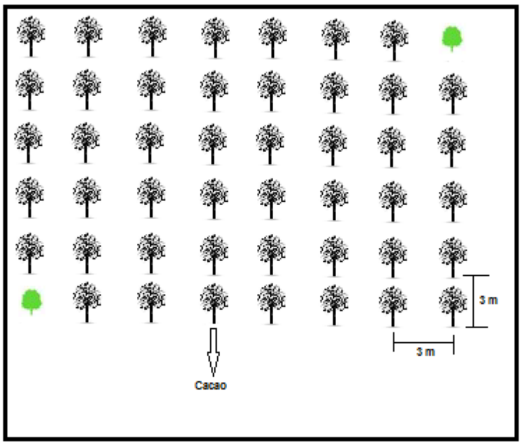
Figure 19 - Silvopasture and Cacao

[14] The economic results considered only the production from trees - therefore cattle breeding is not included in the analysis.

The agroforestry system was implemented for economic purposes, so that the owner could have an income and pay for the expenses generated by the restoration process. Furthermore, he planned to plant some timber plants within the system, in order to cover the area once the cycle of the cocoa plants is completed.

Silvopastoral System **Agroforestry System**





The annual production yield of the 5 hectares increases from Year 3 to Year 8. Also, the income stabilizes from Year 9 to Year 30, due to cocoa's maximum production (the average annual production of 5 hectares is 3750 kg). The simplified cash flow is presented in the following table:

Table 29 - Cash flow of Model 1 – Peru - Cocoa and Silvopastoril

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	2,600.0	- 2,600.0	-	- 2,600.0
2	-	-	783.0	- 783.0	-	- 783.0
3	212.0	-	1,200.0	- 988.0	-	- 988.0
4	1,060.0	-	1,201.5	- 141.5	-	- 141.5
5	2,120.0	-	1,201.5	918.5	-	918.5
6	4,240.0	-	1,201.5	3,038.5	-	3,038.5
7	6,360.0	-	1,201.5	5,158.5	-	5,158.5
8	7,950.0	-	1,201.5	6,748.5	-	6,748.5
9	7,950.0	-	1,588.5	6,361.5	-	6,361.5
10	7,950.0	-	1,588.5	6,361.5	-	6,361.5
11	7,950.0	-	1,588.5	6,361.5	-	6,361.5
12	7,950.0	-	1,588.5	6,361.5	-	6,361.5
13	7,950.0	-	1,588.5	6,361.5	-	6,361.5
14	7,950.0	-	1,588.5	6,361.5	-	6,361.5
15	7,950.0	-	1,588.5	6,361.5	-	6,361.5
16	7,950.0	-	1,588.5	6,361.5	-	6,361.5
17	7,950.0	-	1,588.5	6,361.5	-	6,361.5
18	7,950.0	-	1,588.5	6,361.5	-	6,361.5
19	7,950.0	-	1,588.5	6,361.5	-	6,361.5
20	7,950.0	-	1,588.5	6,361.5	-	6,361.5
21	7,950.0	-	1,588.5	6,361.5	-	6,361.5
22	7,950.0	-	1,588.5	6,361.5	-	6,361.5
23	7,950.0	-	1,588.5	6,361.5	-	6,361.5
24	7,950.0	-	1,588.5	6,361.5	-	6,361.5
25	7,950.0	-	1,588.5	6,361.5	-	6,361.5
26	7,950.0	-	1,588.5	6,361.5	-	6,361.5
27	7,950.0	-	1,588.5	6,361.5	-	6,361.5
28	7,950.0	-	1,588.5	6,361.5	-	6,361.5
29	7,844.0	-	1,588.5	6,255.5	-	6,255.5
30	7,844.0	-	1,588.5	6,255.5	-	6,255.5

Table 30 - Cash flow of Model 1 - Installation, management, harvest and sales of Cocoa plantation (1 ha)

Operation	Costs during X years (USD)	Cost per hectare
Initial investment activities	USD 452.00	Purchase cocoa seeds (USD 24.00) Purchase of seedlings (USD 30.00); Instalation and maintenance of temporary nursery (USD 54.00) Land preparation (USD 36.00) Plantation (USD 72.00) Technical advice (USD 20.00) Weeding (USD 216.00)
Maintenance activities	USD 150.00	Weeding and preparation (USD 85.00) Fertilization (USD 18.00) Pruning management (USD 47.00)
Harvest & sale activities	USD 1,754.00	Cosecha de 750 kl (USD 120.00) Secado de 750 kl (USD 44.00) Ventas de 750 kl (USD 1,590.00)
TOTAL	USD 2,356.00	

The costs considered represents the system initial investment and average maintenance, harvest and incomes of 1 hectare of cocoa plantation throughout the crop cycle.

The investment for this area was $ 2,600.00, with an IRR of 40% and an NPV of $ 15,552.00. For this reason, the financial indicators shows that this model is feasible under the established parameters. Also, this model doesn't include the livestock profits, which could increase the viability of the project.

Table 31 - Financial indicators of Model 1 – Peru – Cocoa and Silvopastoril

Item	Value (USD)
Area (hectares)	5.8
Investment	2,600
Investment/ha	452
IRR	40%
NPV	15,552
NPV/ha	2,705
Benefit/Cost ratio	2.6

In the Alto Mayo Basin, there are areas with flat or sloping topographies, typical of a high forest. In some cases, there are species that need certain conditions, such as high altitude, higher humidity and precipitation, soils rich in organic matter, among others. These may alter investment costs when implementing a restoration plot.

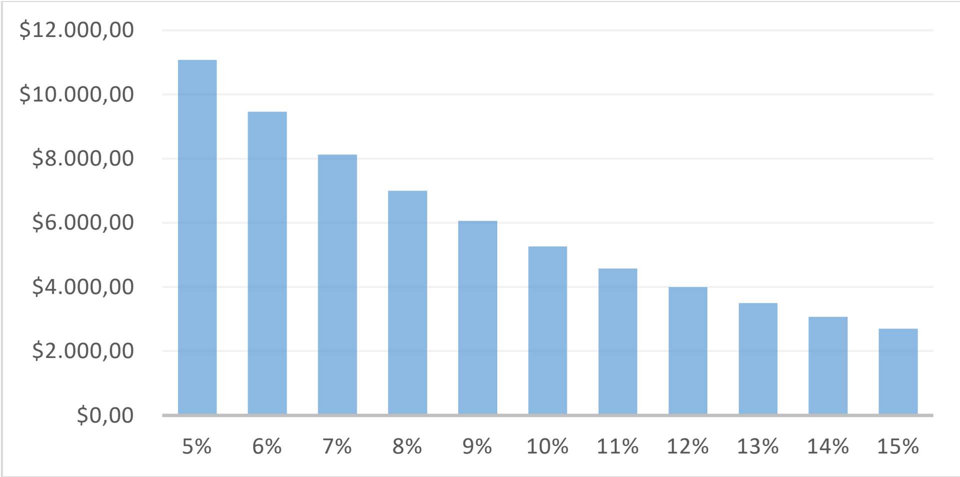


Figure 20 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 1

Model 2 - Coffee + Guaba and Cocoa + Natural regeneration of Jacaranda

This model was based on a property located in the District of Calzada, Moyobamba Province, San Martin Department. It has a total area of 3.5 hectares and, 30 years ago, was dedicated to agriculture. However, nowadays it has the capacity to produce its own seedlings, compost, fertilizers, and other treatments required. The owner manages 2.5 hectares of coffee (*Coffea arabica*), associated with Guaba (*Inga edulis*) plants, in order to provide shade for the Coffee plantation, and 0.5 hectares of cocoa associated with jacaranda trees (*Jacaranda copaia*), that grew in a natural regeneration process. Initially, 6,250 coffee seedlings were planted on 2.5 hectares, at a distance of 2m x 2m, and associated with guaba for permanent shade, at a distance of 5m x 5m. Finally, Cocoa has been planted at a distance of 3m x 3m and it is combined with jacaranda trees that grew naturally, due to the dispersion of seeds from neighboring forests to the area.

Figure 21 - Restoration site of Model 2.

The restoration model of cocoa and jacaranda showed over time that the association of both species is interesting, proving to be beneficial for both of them, since the coca plants requires shade in the first two years of the cycle (which is provided by Jacaranda). In addition, jacaranda is a fast-growing native species of important ecological value, since it is an important resource to many wildlife species.

The annual production yield of this plot is similar to Model 1. The production increases from Year 3 to Year 10. Then, it stabilizes from Year 11 to Year 30, with an average annual production of 400 kg in ½ hectare. The price is the same as indicated in Model 1 ($ 2.12 per kg).

Agroforestry System (Coffee + Guaba) **Agroforestry System (Cocoa + Jacaranda)**

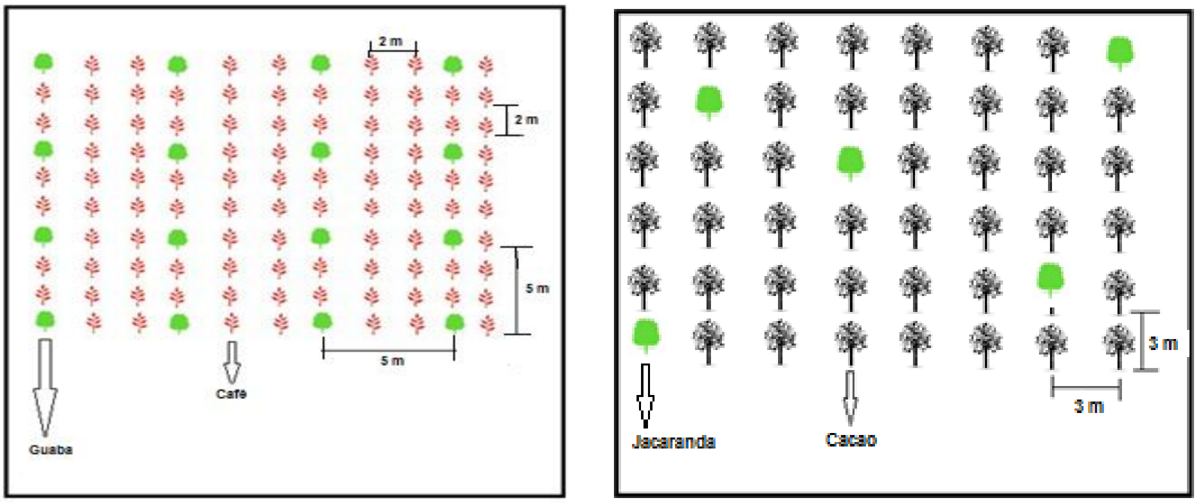


Figure 22 - Sketch of Model 2 - on the right, Coffee and Guaba system, and on the left side, Cocoa and Jacaranda system.

The simplified cash flow is presented in the following table:

Table 32 - Cash flow of Model 2 – Peru - Coffee and Cocoa

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	620.0	- 620.0	-	- 620.0
2	1,095.0	-	859.0	236.0	-	236.0
3	1,502.4	-	1,003.0	499.4	-	499.4
4	1,931.0	-	1,553.0	378.0	-	378.0
5	2,767.0	-	1,258.0	1,509.0	-	1,509.0
6	2,979.0	-	1,247.0	1,732.0	-	1,732.0
7	3,191.0	-	1,265.0	1,926.0	-	1,926.0
8	3,297.0	-	1,274.0	2,023.0	-	2,023.0
9	3,360.6	-	1,274.0	2,086.6	-	2,086.6
10	3,403.0	-	1,274.0	2,129.0	-	2,129.0
11	3,403.0	-	1,274.0	2,129.0	-	2,129.0
12	3,403.0	-	1,274.0	2,129.0	-	2,129.0
13	3,403.0	-	1,274.0	2,129.0	-	2,129.0
14	3,403.0	-	1,274.0	2,129.0	-	2,129.0
15	3,403.0	-	1,274.0	2,129.0	-	2,129.0
16	3,403.0	-	1,274.0	2,129.0	-	2,129.0
17	3,403.0	-	1,274.0	2,129.0	-	2,129.0
18	3,403.0	-	1,274.0	2,129.0	-	2,129.0
19	3,403.0	-	1,274.0	2,129.0	-	2,129.0
20	3,403.0	-	1,274.0	2,129.0	-	2,129.0
21	3,403.0	-	1,274.0	2,129.0	-	2,129.0
22	3,403.0	-	1,274.0	2,129.0	-	2,129.0
23	3,403.0	-	1,274.0	2,129.0	-	2,129.0
24	3,403.0	-	1,274.0	2,129.0	-	2,129.0
25	3,403.0	-	1,274.0	2,129.0	-	2,129.0
26	3,403.0	-	1,274.0	2,129.0	-	2,129.0
27	3,403.0	-	1,274.0	2,129.0	-	2,129.0
28	3,403.0	-	1,274.0	2,129.0	-	2,129.0
29	3,403.0	-	1,274.0	2,129.0	-	2,129.0
30	3,403.0	-	1,274.0	2,129.0	-	2,129.0

Table 33 - Cash flow of Model 2 – Peru - Coffee and Cocoa

Operation	Costs during X years (USD)	Cost per hectare (Coffe & Cacao)	
Initial investment activities	USD 1,240.00	Purchase of coffee seeds (USD 30.00) Purchase of guaba seeds (USD 40.00) Purchase of cacao seeds (USD 30.00) Purchase and aplication of fertilizers (USD 180) Instalation and maintenance temporary nursery (USD 306.00) Land prpeparation (USD 32.00) Plantation (USD 72.00) Technical advice (USD 240.00) Weeding (USD 144.00)	
Maintenance activities	USD 519.00	Weeding and prearation (USD 360.00) Tehnical advice (USD 60.00) Fertilization (USD 27.00) Pruning management (USD 72.00)	
Harvest & sale activities	USD 1,705.00 Coffee USD 1,719.2 Cacao	Harvest 20 Quintales of coffee (USD 200.00) Dried out of 20 Quintales of coffee (USD 45.00) Sales of 20 Quintales of coffee (USD 1,460.00) Harvest de 760 Kg de cocoa (USD 72.00) Dried out de 760 Kg de cocoa (USD 36.00) Sales of 760 kg de cocoa (USD 1,611.20)	
TOTAL	$ 5,183.20		

The costs considered in table 3 represents the system initial investment and average maintenance, harvest and incomes of 1 hectare of cocoa and coffee plantation throughout the crops cycle. (01 quintal =100 Kg)

The site visited is reported to have fertile soil, and low input costs, such as labor (USD 9/day) and seedlings (USD 1 each), which is cheaper than purchasing seeds. It resulted in low initial investments. The relatively low installation cost of $620.00 generates an NPV of USD 2,494 per hectare in 30 years, indicating the project high viability[15].

[15] We also visited another coffee plantation (Coffee arabica) associated with Guaba (*Inga edulis*), similar to Model 2, with the same spacing of coffee and guaba. This property had an area of 1 hectare, where the owner added 60 plants of Tornillo *(Cedrelinga catenaeformis)* and 40 Sinami *(Oenocarpus mapora)* in a dispersed way.

Table 34 - Financial indicators of Model 2 – Peru – Coffe and Cocoa

Item	Value (USD)
Area(hectares)	3.0
Investment	620
Investment/ha	207
IRR	88%
NPV	7,482
NPV/ha	2,494
Benefit/Cost ratio	5.9

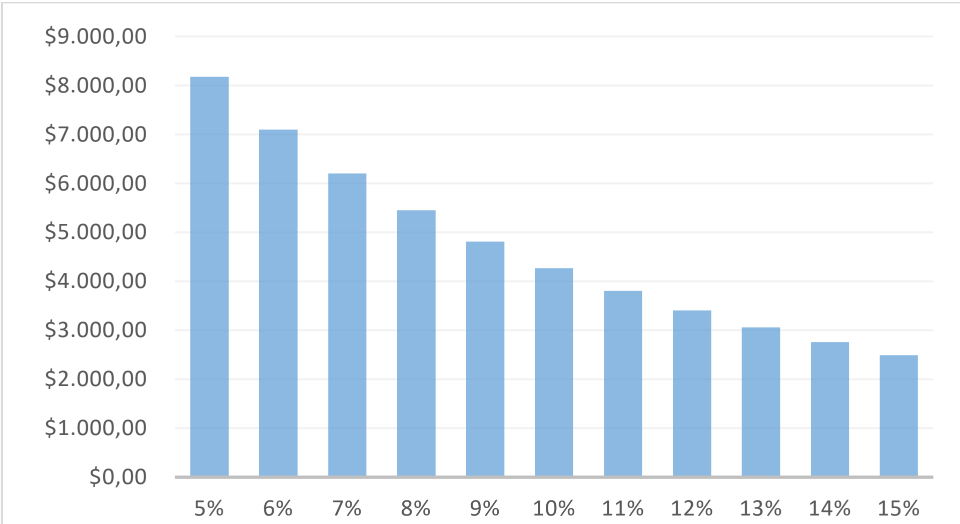


Figure 23 - Sensitivity Analysis – NPV/ha x Discount Rate – Model 2 – Peru – Coffee and Cocoa

Model 3 - Seeds Dispersal Model

This model was designed only for ecological purposes, therefore profitable species were not included. This model was based on a 5 hectare property and a discount rate of 15%. The highest costs are related to planting and maintenance, since the management of the seeds lasts until Year 3. The total cost for the restoration of 5 hectares is about USD 3,350 (USD 2,240 for installation and USD 1,110 for maintenance), resulting in a cost of USD 670 per restored hectare (including maintenance).

Table 35 - Costs of Model 3 (5 ha of Seed dispersal)

N°	Components	Price (USD)
1	Seeds (1000 x @ USD 1.00)	1,000.00
2	Inputs and tools	480.00
3	Planting and maintenance	1,710.00
4	Technical assistance	160.00
	TOTAL COST	3,350.00

5. Overall Results

In order to compare the results among the models, the overall results and perceptions of each restoration proposal are organized in Table 18. The models with the highest economic viability were observed in Peru. Even though they presented problems related to the products sale, the NPV of those models were higher than US$ 2,700 per hectare, with one model reaching up to US$ 30,000 per hectare, indicating the country's potential for this kind of initiative. In contrast, the models in Cambodia presented the lowest financial indicators values due to larger investment values.

Furthermore, the seeds dispersion models presented a cost of USD 670 and USD 1,600 per hectare. These results indicate that restoration models using this technique have a relatively high initial investment. However, these models have the lowest costs over time, which compensates the implementation expenses.

The following table presents a summary of results for models assessed, and also addresses some contextual/qualitative questions.

Table 36 - Overall results and perceptions on the restoration models

Country	Case	Restoration Model	Species 1 (name)	Species 2 (name)	Species 3 (name)	Species 4 (name)	Species 5 (name)	% of native vegetation and productive species	Property Total Area (ha)	Restoration/ Agroforestry Area	Main productive Activity	Secondary Activity	Biophisical conditions (slope, soil)	Investment / ha (US$/ha)	NPV / ha (US$)	IRR	Technical Capacity on Restoration in the Region (low/high)	Logistics / Access to Markets	Regulation issues	Legal obligation to restore? (yes /no)
Cambodia	1	Modified Caritas Model - Cluster Planting	Lemongrass	Turmeric	Ginger			100%	0,32	0,32	Forest Farming	Management of the Community Forest	Flat-Gently rolling; Clayey	$7.786,00	$ 536,00	10.78%	Low	Limited	Cultivating the community forests will likely encounter objection from the Forestry Administration	No
Cambodia	2	Modified Caritas Model	Bamboo	Rattan				100%	0,32	0,32	Forest Farming	Management of the Community Forest	Flat-Gently rolling; Clayey	$1.548,00	$(1.511,00)	N/A	Low	Limited	None	No
Cambodia	3	Taungya Model	Peanuts	Timber Species				100%	3	3	Peanuts and Timber Species	Seed Orchard Management	Flat; Sandy to Sandyloam	$ 1.494,00	$(1.207,00)	N/A	High	Limited	Forestry Administraiton may not allow the villagers to access to the reforestation areas to do the intercropping	No
Indonesia	1	Lowland Restoration	Coconut (*Cocos nucifera)*	Ketapang (*Terminalia catappa*)	Cemara Laut (*Casuarina equisetifolia*)			50% and 50%	500	500	Farmer and/or fisher	Labor to palm plantation	Coastal area and peatland, mosty flat	$ 104,15	$ 224,50	22,20%	low; need more skill and capacity building	little, potential to be improved	available but not fully executeable	yes
Indonesia	2	Highland Restoration	Meranti (*Shorea sp.)*	Durio (*Durio zibethinus*)	Manggis (*Garcinia mangostana*)	Coconut (*Cocos nucifera)*		25% and 75%	100	100	Farmer	Labor to farm and off-farm	Hilly and mountanious	$ 194,35	$ 1.799,58	29,33%	low; need more skill and capacity building	little, potential to be improved	available but not fully executeable	yes
Peru	1	Agroforestry system	Coffee	Guaba	Caoba	Tornillo		93% coffee 6% Guaba 0.5% Caoba 0.5% Tornillo	13	0,5	Coffee	Ecotourism	Clayey and flat surface	$ 600,00	$ 689,00	86%	High (permanent training of C.I technicians.	There is a big demand of companies that buy coffee beans (06 identified companies at least)		Yes (Conservation agreement)
Peru	2	Agroforestry system Sistema Silvopastoril	Cocoa	Pino chuncho	Bolaina	Capirona	Cedro de la india	86% Cocoa 8% Pino chuncho 2% Bolaina 2% Capirona 2% Shaina 2% Cedro de la india	17,5	5,75	Cocoa	Cattle	Clayey rock surface with 45° slope	$ 400,00	$ 85,00	30%	High (permanent training of C.I technicians.	There is a big demand of companies that buy cocoa beans.		Yes (Conservation agreement)
Peru	3	Agroforestry system	Coffee	Cocoa	Guaba	Jacaranda		84% coffee 8% Guaba 7% Cocoa 1% Jacaranda	3,50	3,00	Coffee	Cocoa	Clayey and flat surface	$ 100,00	$ 277,00	55%	High (permanent training of C.I technicians.	There is a big demand of companies that buy cocoa and cofee beans.		Yes (Conservation agreement)

6. Enabling factors and bottlenecks for economic restoration of forest

Deforestation in the Alto Mayo is high due to unsustainable human activities, associated with the limited information of successful restoration work. Despite this, in recent years restoration work is growing thanks to the technical assistance and strengthening of the capacities of the farmer and the field technicians of public (SERNANP) and private (CI, ACAC) institutions. Likewise, a good strategy was to consider the stage of production and commercialization (added value and presentation of the product) that guarantees you a good supply and demand of the product produced such as coffee and cocoa. **In the short term, with the cultivation of coffee, and in the medium-term with cocoa, agroforestry is capable of generating income that the landowners did not have before - in this way, landowners improve their quality of life and believe in restoration.**

There are several risk factors associated with forest restoration and these risks are directly related to political, economic, environmental, land tenure, efficient technical assistance, and other issues.

Political Scope

The Alto Mayo Basin Protection Forest (BPAM), located in the department of San Martín, has been deforested and degraded through land invasions within the buffer zone and the Protected Forest itself, protected by the state through SERNANP. At the same time, there are many problems related to land title overlaps that have not been resolved to date by the unstable political environment, which encourages this disorder and land colonization. All these problems accelerate the deforestation and degradation of ecosystems, and it discourages farmers to access some loans to start restoration projects, much less if can they can even participate in public investment and international cooperation projects in the first place, since the titles of property are a basic requirement for any project.

This situation would be different if there was stability of public officials and inter-institutional articulated work, since they are responsible for supporting farmers with sustainable and conservation projects such as restoration for the benefit of farmers.

Another problem is the inter-institutional lack of coordination since many times there are duplicate efforts due to lack of partnerships. A clear example in the area of Alto Mayo in the restoration work there is only the presence of the aforementioned institutions, but not an accompaniment of the San Martin Regional Government through its Natural Resources and Economic Development Managements, the Agriculture Directorate, Production Management, the National Agricultural Health Service, among others.

Economic Scope

The Alto Mayo Basin Protection Forest (BPAM), in recent years, managed to reduce the deforestation rate by 24%, thanks to a series of strategic interventions articulated by CI. One of the most important interventions was to create a coffee cooperative. In 2017, it managed to export seven containers of organic coffee to the United States and Europe. In the coming years, the organization plans to increase its sales abroad by 50%. It is also promoting other economic activities such as the tourism of birds and orchids, the cultivation of pitahayas and the production of vanilla and honey, which will be able to diversify the economy of the approximately 1,500 families that live in this protected area. In this way, the pressure on forest species is reduced and sustainable use is given to forest soils by promoting restoration practices (Diario La República, 2018)

Environmental scope

Climate change is affecting natural landscapes worldwide, altering the dynamics of ecosystems. It is necessary to preserve our forests to reduce environmental problems. Deforestation not only destroys forests and alters soils, but is also a bad agricultural practice. Monocultures attract pests, makes them more resistant to biological controllers and can harm traditional crops. An important role in this work is the specialized technical assistance that permanently strengthens the capabilities of the rural people. It is necessary to continue with these practices as they ensure you proper handling and a good product.

Technical assistance

It is important to have a qualified team that offers adequate and constant technical assistance to beneficiaries in the field. Even though the visited restorers had good expertise on restoration, other landowners do not. To scale up these initiatives, technical assistance should be provided – and its costs were included in the proposed models.

7. Final Remarks

The literature review identified almost no information about forest restoration costs in the profiled countries, corroborating with other studies that indicates the lack of economic information worldwide (Wortley et al. 2013)[16]. This gap is being addressed here, in an effort to encourage the implementation of large-scale initiatives such as the Bonn Challenge and collaborate with the demand indicated by the IPCC (IPCC 2014)[17], to stabilize anthropogenic climate change.

Regarding restoration public policies, there is a lack of legal tools that determines the percentage of properties that should be conserved or restored, meaning that forest restoration is mainly a voluntary initiative in the profiled countries. In the case of Indonesia, for example, the government has ambitious restoration targets, and is seeking to incentivize these initiatives. However, in other countries, establishing a legal framework for forest restoration is still a challenge.

This study found that the forest restoration initiatives are mostly conducted by non-governmental organizations and, in some places, they have also support from the government. However, under these conditions, restoration models are not chosen based on economic performance. Some of these initiatives might be implemented in protected areas, to generate income to local communities, while others refer to ecological improvements in private or communal farms. In general, farmers have little theoretical and practical experience in forest restoration. Thus, the models included technical assistance costs to ensure the engagement of farmers without technical knowledge and the proper replication of the proposed models.

The study also identified average forest restoration total costs per hectare and approximately to one year period, vary from around USD 515 in Peru, to USD 640 in Indonesia, and USD 3,642 in Cambodia – with an overall average of UDS 1,600. Five out of the six restoration models with economic goals (not considering the seeds dispersion models) yielded Internal Rates of Return larger than the discount rate, which means they are capable of paying back initial investments, inputs and labor costs with positive net economic returns. Regarding the selected models, Model 2 implemented in Peru, including coffee and cocoa as the main species, presented the highest returns, which suggests a high potential for plant agroforestry systems in degraded areas with low investment costs and a promising market for the selected species.

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Annex 1 – Overview of restoration options and definitions

To define the most appropriate options, consideration is given to the resilience of the ecosystem, the history of disturbances and the landscape context, depending on the objectives and resources of the initiative. It can be aimed at eliminating or modifying a specific alteration and allowing the ecological processes to recover on their own. When the level of degradation is very high and the probabilities for natural regeneration are scarce or null, the restoration requires a greater intervention (assisted restoration). Depending on the scale of the initiative (area, ecosystem and / or landscape) and the level of affectation that the area has, the following options can be included:

Prevention and Control. Preventing degradation is fundamental to any restoration initiative regardless of the stage of degradation that is being faced. This implies taking into account two basic elements: 1) preventing further damage, and 2) removing existing barriers against natural regeneration. For these purposes, the following measures can be taken:

- Set firewall curtains.
- Carry out livestock management.
- Protect wildlife to promote seeds dissemination.

There are several alternatives to promote natural regeneration and Management of Natural Regeneration:

- Reduce competition from non-native invasive species.
- Fertilize.
- “Ralear” or selective felling.
- Boost with species of social or ecological value.
- Establish infiltration ditches.
- Manage grasslands.

Establishment of Plantations. It is developed according to the *Regulation for the Management of Forest Plantations and Agroforestry Systems*, approved by *Decreto Supremo No. 020-2015-MINAGRI*. The following types of plantations and considerations should be considered:

- Restoration plantations. They are aimed at restoring the natural ecosystem using native species of the place and complementing the protection and natural regeneration. They usually contain species of different mixed successional phases so that interactions of complementarity can be favored between and those interactions that cause the exclusion of individuals or species due to competition for resources are minimized. It is very important to consider what characteristics would be desirable, as well as the spatial arrangement.
- Protection plantations. They are oriented to soil protection against erosion and to the preservation of water sources and courses, favouring the use of native species and being able to incorporate introduced species depending on the ecological characteristics of each area. In these plantations, additionally, collecting fruits and other products other than wood can be done, as well as the management of wildlife. Plantations producing other products than wood. The production plantations of products other than wood are installed in partially degraded areas, with still fertile soils that allow optimum development of the species for the supply of non-timber forest products, including wildlife and environmental services. They can also play protective, recreational, and scenic functions, among others, not excluded by the extraction of products. These plantations can be considered as a rehabilitation.

In the Plantations of Restoration and Protection the use of timber resources is not allowed.

Agroforestry systems. Their purpose is to maintain or recover the provision of goods and services from ecosystems located in special treatment areas for agroforestry or silvopastoral production. They can be used as an alternative in fragmented areas to improve the structural connectivity of the landscape. Like plantations for purposes other than wood, these systems focus on the recovery of productivity, so they can be considered as a form of rehabilitation.

CHAPTER 3: INDONESIA
FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

CHAPTER 3 – INDONESIA: FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

Azis Khan, Adi D. Bahri

1. Restoration Models – Literature Review

In Indonesia, restoration is included in the policy of forest and land rehabilitation outlined by government regulations. Under such a policy perspective, forest and land rehabilitation is framed through three stakeholder involvement schemes, namely (1) government on forest lands in state forests areas that have no utilization permits, (2) private sector concessions (in forestry and mining) and forest restoration permits called Izin Usaha Pemanfaatan Hasil Hutan Kayu – Restorasi Ekosistem (IUPHHK-RE), and (3) communities both in community forestry and social forestry approaches.

The first scheme is carried out in 2 areas: watershed areas and conservation areas. In watershed areas, the Forest Management Unit (FMU or KPH) conducts rehabilitation to recover the degraded land into its former function and condition as a forest ecosystem. Meanwhile, ecosystem recovery activities in conservation areas are carried out by the National Park authority as a nature of National Park's main task and function in general – through field activities on ecosystem maintenance through natural succession, planting and restoration in degraded areas. So that the restoration of forest ecosystems in conservation areas restores not only forest functions, but also creates a balance of biological natural diversity and its ecosystem (KLHK 2018).

In the second scheme, restoration of forest ecosystems is also carried out in forests areas where concession permits are located. Every permit holder is required to restore forest functions based on their activities that have made negative changes to the forest ecosystem. The obligation to restore ecosystems is carried out by planting timber plants in the area at their own cost. The intended concession permits are (1) license to use forest area called *Izin Pinjam Pakai Kawasan Hutan* (IPPKH), such as mining companies that take mining materials in forest areas which are obliged to carry out reclamation and rehabilitate watersheds under their own costs; (2) logging concessions called *Izin Usaha Pemanfaatan Hasil Hutan Kayu – Hutan Alam* (IUPHHK-HA); and (3) forest plantations called *Izin Usaha Pemanfaatan Hasil Hutan Kayu –Hutan Tanaman* (IUPHHK-HT), as well as special forms of permits for the ecosystem restoration concessions in production forests, namely IUPHHK-RE.

Under the third scheme, the Government of Indonesia (GOI) accommodated the community to manage (state) forests with a social forestry scheme (Environment and Forest Minister Regulation No.P.83 / MenLHK / Setjen / KUM.1 / 10/2016 concerning Social Forestry and No.P.39 / MenLHK / Setjen / KUM.1 / 6/2017 concerning Social Forestry in the Perum Perhutani Working Area). As a scheme, Social Forestry covers areas of (1) village forest in the form called *Izin Hak Pengusahaan Hutan Desa* (IHPHD) or village forest concession permit, (2) community forestry permit called *Izin Usaha Pemanfaatan Hutan Kemasyarakatan* (IUP-HKm) (3) community forest plantation permits called *Izin Usaha Pemanfaatan Hasil Hutan Kayu-Hutan Tanaman Rakyat* (IUPHHK-HTR) (4) Customary Forest which the tenure is the Determination of the Recognition of Customary Forests, and (5) Forestry Partnership called *Pengakuan Perlindungan Kemitraan Kehutanan* (Kulin KK) and Social Forestry Utilization Permit called *Izin Pemanfaatan Hutan Perhutanan Sosial* (IPHPS) on Java Island. The community runs a social forestry program by planting plant species through an agroforestry system. In principle, this social forestry scheme provides more legality for people's access to use state forests area with several obligations. One of the key obligations is restoring land and forest ecosystems by rehabilitating forests onto sustainable forests paths in terms of conditions, and economic and ecological functions.

Regarding the IUPHHK-RE, it is specifically regulated under the Minister of Forestry Regulation No.SK.159 /Menhut-II / 2004 concerning Ecosystem Restoration in Production Forests (IUPHHK-RE). This is actually targeted to production forest areas, which conditions require restoration mainly due to former commercial timber concession related activities. Such a restoration is carried out by private-corporations as a "restoration concession holder". This could be the closest concept/approach to the restoration framework in general/global terms or definition. At present, 16 companies hold the IUPHHK-RE concessions with total area of 623,100 ha which are specifically licensed for ecosystem restoration as shown in Table 39. This table indicates that there is no single such a restoration concession holder in North Sumatra.

Table 37 - The Recent Progress of Ecosystem Restoration Concessions (2017)

No	Company	Province	Area (ha)
1	PT. Restorasi Ekosistem Indonesia	West Sumatra	52.170
2	PT. Restorasi Ekosistem Indonesia	Jambi	46.385
3	PT. Restorasi Habitat Orangutan Indonesia	East Kalimantan	86.450
4	PT. Ekosistem Khatulistiwa Lestari	West Kalimantan	14.080
5	PT. Gemilang Cipta Nusantara	Riau	20.265
6	PT. Sipef Biodiversity Indonesia	Bengkulu	12.672
7	PT. Rimba Makmur Utama	Central Kalimantan	108.255
8	PT. Rimba Raya Conservation	Central Kalimantan	37.151
9	PT. Gemilang Cipta Nusantara	Riau	20.450
10	PT. Karawang Ekawana Nugraha	South Sumatra	8.300
11	PT. Sinar Mutiara Nusantara	Riau	32.830
12	PT. Global Alam Nusantara	Riau	36.850
13	PT. The Best One Unitimber	Riau	39.412
14	PT. Alam Bukit Tigapuluh	Jambi	38.665
15	PT Alam Sukses Lestari	Central Kalimantan	19.520
16	PT Rimba Makmur utama	Central Kalimantan	49.620
		TOTAL	623.075

Source: Directorate General of Sustainable Production Forest Management). (2017) – presentation material

It is quite difficult to obtain data and information on restoration costs in Indonesia. Possibly because most of the restoration is done soley by companies or restoration concession holders through a restoration permit, such as IUPPHK-RE as described above. Costs incurred by companies to carry out restoration are usually confidential, and not available to the public, so it is not easy to obtain detailed costs. Alternatively, some schemes for ecosystem improvement such as forest and land rehabilitation, and reclamation of ex-mining forests (Table 40) could be relevant examples that are similar.

Table 38 - Cost of Ecosystem Improvement

Model of restoration	Cost(USD/Ha)	Location	References
Forest rehabilitation in forest production by government	43–7,320	Forest production	Nawir et al (2008)
Land and forest rehabilitation Movement by communities	335	Community forestry	Prasetyo et al (2005)
Rehabilitation by donor institution	366-15,221	State and private forest	Nawir et al (2008)
Rehabilitation by private companies or state companies	115-8,500	Another used land (APL), state forest by CSR program in their concenssion	Nawir et al (2008)
Rehabilitation in watershed area	552.99	Protected forest in Forest Manajemen Unit (FMU) Tapanuli Selatan	KPH X Tapanuli Selatan (2018)
Average of 16 units Ecosystem Restoration Concession (ERC) (Table 1)	25.68*)	Sumatra and Kalimantan (see Table 1 for details)	Kartodihardjo (2019)

** The investment value for 16 units ERC during the first 6 years is estimated at USD 14 million to USD 18 million*

2. Regional Context

Indonesia is facing serious problems regarding forest and land degradation. The highest rate of deforestation in Indonesia happened from 1996-2000 (KLHK, 2018). As per Indonesia Forestry Statistics, the area of degraded land in Indonesia in year 2006, 2011 and 2013 accounted for 30.2 million ha, 27.3 million ha, 24.3 million respectively (Dephut 2008; Kemenhut 2012; KLHK 2016). The vast amount of degraded land and forest requires the government to restore the forest close to its initial form and function with its both economic and ecological value. In this regard, the government has determined to do forest and land rehabilitation.

North Sumatra Province in eastern Indonesia faces these challenges of forest and land degradation. It is reported that the deforestation rate ranges between 3-6% annually[18]. Based on Ministry of Environment and Forestry decree No.1076/2017 forest area of North Sumatra is about 3.01 million ha. It is about 41.25% of the total North Sumatra area which is 7.3 million ha. Out of 3.01 million ha, the forest cover area is about 2.23 million ha. It is also reported that the agriculture area is about 2.34 million ha or 32.09% of the total North Sumatra area. North Sumatra province is widely known to be a home for peatland and major biodiversity areas with key species including Tapanuli orangutans, Sumatran tigers, tapirs, and elephants. In terms of commodities, North Sumatra is also known as a producer of (natural) rubber, coffee, cocoa, and palm oil. Current high expansion of palm oil has become so rampant it has put serious pressure on the existence of natural forests, from both corporations as well as smallholders. Financial incentives and less intesive management leading to lower productivity have become a strong driver for small holders

[18] CI Indonesia, presentation materials – The discussion on it was made in CI Jakarta Office on 2 July 2019

to encroach more into the forest area. The rate of deforestation could be strong indication related to this phenomenon.

As of December 2016, North Sumatra has 25 districts, and 8 cities/municipalities (BPS, 2018). In terms of population BPS (2018) reported that North Sumatra is the fourth most populous province in Indonesia after West, Central, and East Java. Based on the 2010 population census, the population of North Sumatra is about 12.98 million people with 188 people/km2 density. Population growth during 2000-2010 is reported to be 1.22 % per annum (BPS 2018).

In North Sumatra, CI is working in four districts, namely Pakpak Barat, Tapanuli Utara, Tapanuli Selatan and Mandailing Natal or Madina (Figure 27). The total area of the four is 1.72 million hectares. With this, CI committed to help achieve the SDGs in North Sumatra by targeting a moratorium on new palm oil licenses toward “no deforestation spatial (development) plan”. CI then focus partly on helping (a) implementing such plan; (b) improving productivity of both existing plantation and small holders; (c) transforming natural resource extraction to be oriented more towards services like ecotourism; and (d) promoting sustainable production, restoration, protection, and conservation.

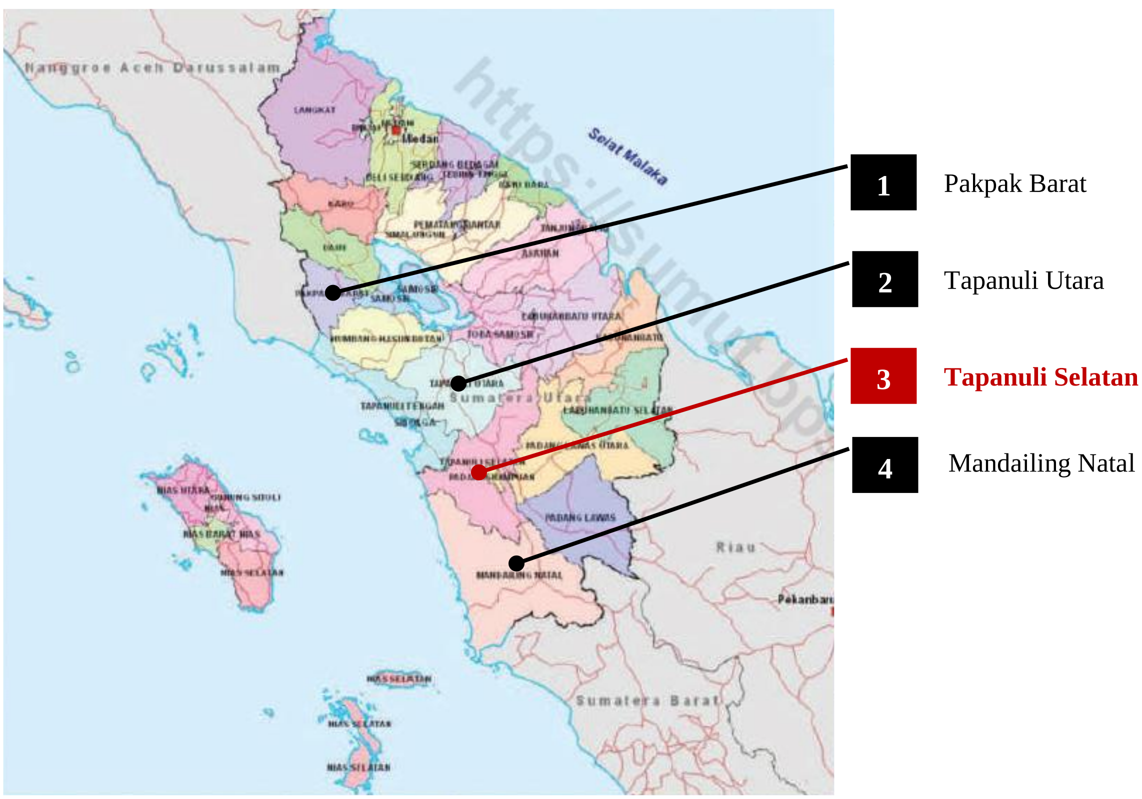

Figure 24 - North Sumatra and the Four Districts where CI Works

Tapanuli Selatan – at a Glance

Tapanuli Selatan would be the most appropriate district to focus on restoration projects. Tapanuli Selatan district has also similar field problems and the phenomenon as described above, facing sustainability issues related to the fact that (a) the deforestation rate has reached 12% of terrestrial areas or 77.3

thousand ha[19], (b) more than 50% of deforestation occurred in the designated forest area because of a significant expansion from small holder palm oil plantations (CI 2019).

In 2013, primary forest in Tapanuli Selatan has forest cover approximately about 190 thousand ha or 45% of the total forest area (CI 2014). This percentage of forest cover is greater than that of Sumatra, which is only 30% (Margono et al. 2012). Tapanuli Selatan has lost about 2,050 ha (1.57%) of forest each year during 2010-2013 period (CI 2014).

Tapanuli Selatan district is geographically located between 0°58'35 "- 2°7'33" North Latitude and between 98°42'50 "- 99°34'16" East longitude. In the north its boundaries are Tapanuli Tengah and Tapanuli Utara districts. In the east it is bordered by Padang Lawas district and Padang Lawas Utara and Labuan Batu District. While the southern boundary is Mandailing Natal district. The total area of Tapanuli Selatan district is about 433,540 ha (BPS 2018)[20] with an altitude of between 0 to 1,985 meters above sea level. Tapanuli Selatan district has 14 sub-districts and about 212 villages as well as 36 cities (kelurahan).

Table 39 - Total Area by Sub district in Tapanuli Selatan District, 2017

Sub District	Total Area (ha)	Percentage (%)
1. Batang Angkola	*36,105.97*	*8.29*
2. Sayur Mutinggi	29,511.20	6.78
3. Tantom Angkola	21,030.10	4.83
4. Angkola Timur	23,516.28	5.40
5. Angkola Selatan	49,656.83	*11.4*
6. Angkola Barat	10,452.31	2.40
7. Angkola Sangkunur	25,476.95	5.85
8. Batang Toru	33,004.19	8.73
9. Marancar	8,911.41	2.05
10. Muara Batang Toru	*30,801.12*	*7.07*
11. Sipirok	40,936.52	9.4
12. Arse	26,590.28	6.11
13. Saipar Dolok Hole	54,057.00	12.41
14. Aek Bilah	4,048.47	9.3
TOTAL	435,535.00	100.00

Source: Tapanuli Selatan in Figure (BPS, 2018)

[19] In a personal communication with Bappeda Tapanuli Selatan, 26 July 2019, an average annual deforestation rate of 5% was mentioned - instead of the peak of 12%.

[20] Under CI analysis it is 435,810 ha. We use BPS number for our reference

Tapanuli Selatan conditions indicate that out of its total area of 435,810 ha, about 82.3% (359,300 ha) of the area is of high conservation value (HCV/HCS) (CI 2019). This area is considered to be majority *No Go Area*, especially for further palm oil expansion. Instead, this has to be conserved and some areas need to be restored very soon. About 35% out of total *No Go Area*, (125,750 ha), have lost its forest cover making restoration actions in this area a necessity. The rest, (about 76,660 ha (17.7%)), has been considered as *Can Go Area* which could be a bit "open" for any use[21].

3. Selection of Restoration models with Economic Potential

The process of selection was a two stages process: The first stage consisted in defining the priority locals and landscapes[22], and second stage was to define which restoration models were more appropriate for each region. Two different landscapes were selected, here called Upland and Lowland.

Upland Restoration

The selected areas for restoration assessment in the uplands is a small plot of 200 ha located in **Binasari,** Pardomuan Village, Angkola Selatan Sub-district. This area is actually under CI facilitation with support from Forest Management Unit (FMU X) as well as the local community under their agreement to protect Angkola Selatan Protection Forest (ASF) as part of Batang Angkola Forests (BAF). Binasari is itself inside the ASF. The ASF is itself under FMU X jurisdiction.

Under the agreement, they all agree to (1) protect and improve the Angkola Selatan Protection Forest ecosystem conditions by trying to conduct forest ecosystem restoration which will be carried out in damaged forests in its buffer and riparian areas[23]; mainly by (2) improving agricultural practices on (sustainable) agriculture that now exist in the area, and (3) through community development under regional development approach.

Furthermore, BAF is an important forest to Tapanuli Selatan with an area of 10,154 ha which connects to Batang Gadis National Park (TNBG, 72.150 ha). BAF experiences many crucial issues, deforestation, wildlife trade, loss of biodiversity and degradation of ecosystems. This is due to the expansion of palm oil, rubber plants, and coffee as well as rice cultivation. According to the Center for Statistical Agency (BPS) 2018 data, production value for palm oil in 2015 and 2017 for Tapanuli Selatan are respectively 53.99 tons and 55.76 tons. For rubber plantation these are 5.48 tons (2016) and 5.76 tons (2017). Whilst, the production value of coffee are 823.30 tons (2016) and 964.34 ton in 2017 (BPS, 2018). In the local community, productivity level of agricultural cultivation is so small mainly due to lack of knowledge and information about cultivation by itself, market information and so forth[24]. As a result, the community continues to expand their cultivation area and pressure the forest area in higher place mostly by doing illegal activities including those of logging and land clearing.

The restoration in Binasari then focuses on improving low productivity agroforestry areas. This is not only aimed at improving livelihoods, but also provides a legal pathway for smallholders who have established already palm oil farms in state forest areas (*Kawasan hutan*). This is a sort of transition actions covering

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[21] Need to be further checked with CI for more specific and detailed information as well as related rule of law, if any

[22] For details on the selection of restoration places, please see the annex.

[23] This actually refer to Binasari site which geographically has buffer function to Angkola Selatan Protection Forest

[24] Per discussion with some farmers during field observation, community oil palm production is less than one third of corporate palm oil production

those (1) from low productivity agroforestry areas to high productivity agroforestry areas and 2) low productivity crop production to a productive agroforestry system. By establishing Binasari's role as a buffer zone to Angkola Selatan Protection Forests (ASF), the planned restoration is also considered a solution to address forest encroachment practices.[25]

This Binasari restoration site is widely known by local people as part of former natural forest landscape for years far before, with many types of native species. The native species partly cover meranti (*Shorea sp*), kapur (*Dryobalanop sp*), pulai (*Alstonia sp*), merbau (*Intsia bijuga*), and resak (*Vatika sp*). All these species are now disappearing in this area and changing to palm oil. This happened especially when PT Austindo Nusantara Jaya (ANJ), a big corporation, first came in 2004 following the end of forest concessions. This is followed by a massive expansion by community-owned palm oil plantations. This caused much more serious pressure on forest areas. Figure 28 shows one of the old remaining stumps of native plants in the middle of the current oil palm plantation. The stumps appears likely to be meranti, as also confirmed by some local informants. Figure 29 indicates that many logs of merbau (*Intsia sp*) have been used for building and road construction. Overall, current conditions of this site indicates that the area is still mostly in monoculture of palm oil.

Figure 25 - A stump of former meranti (Shorea sp) in the middle of existing palm oil *Photo By AK*

Photo By AK

Figure 26 - Log of Merbau (Instia sp) used for road (left) and building (right) construction

[25] There is an earlier draft of this forest encroachment solutions, which is developed into government (KLHK) policy

Lowland Restoration

The lowland restoration site is called **Muara Upu** village, sub-district Muara Batang Toru. Located close enough to the beach - around hundred meters – and mostly flat, Muara Upu is in a lowland area. As confirmed by local people, the length of the coastline around here is about 18 km. Not so far away from this area is a peatland area, mostly shallow, which is now dominated by palm oil and monoculture. The palm oil is planted and cultivated mostly by local communities. This area is about 275 ha. Next to this are palm oil concessions managed by big concessions, namely PT Maju Indo Raya (MIR), PT Samukti Karya Lestari (SKL) and PT Ondo Perkasa Makmur (OPM).

Like the ones in Binasari, Muara Upu is widely known by the local community as formerly natural forests with various native plant like ketapang, waru, bakau, cemara, and cemara laut. There are two frames of restoration here. One is a beach conservation program (Program Perlindungan Pantai). The other is focused on the peatland[26] area (275 ha) located not far from the beach and beach conservation area. It is currently already planted with monoculture palm oil and mostly owned by the community. Some of this area is also currently cultivated by coconut trees. Cemara laut (*Casuarina sp*) species are also already planted close to the beach.

Drone Photo By Audrie of CI Jakarta

Figure 27 - Cemara laut (Casuarina sp) planted in the beach (left), close to palm oil (right)

Restoration could improve productivity of lowland peat from a low productivity farm/crop (mainly palm oil) production to a more productive agroforestry (or Silvo-fishery) system. In terms of climate change targets, the lowland peat restoration will hopefully provide a higher carbon benefits through emission reductions and carbon sequestration. In this regard, the protected peatlands area (*Kawasan lindung gambut*) is another important consideration of the restoration, especially to turn the main peat ecosystem function back.

In both lowland and upland restoration areas, it is possible to apply agroforestry systems with a combination of fruit crops, such as durian and mangosteen.[27] The two types of plants have high

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[26] A shallow peatland, as it was stressed repeatedly by Head of Village of Muara Upu, and some informal leaders as well as other local community members who all participated in the FGD on 25 July 2019.

[27] Confirmed also by CI Tapanuli Selatan Office.

productivity values in Tapanuli Selatan. In 2017 durian total area is about 677.09 ha with 7,110 ton of total productivities. While total area of mangosteen is about 528.26 ha with total product no less than 4.67 ton (BPS 2018). Forest restoration in Binasari upland may use an agroforestry approach by using this mixed composition. Another possible composition will be those between wood plants (timber or fruits) and coffee. The selection of these two fruit plants is due to their significant economic value, that can provide income for local people and so for government in Tapanuli Selatan. The location of the two restoration sites are shown in the Figure below.

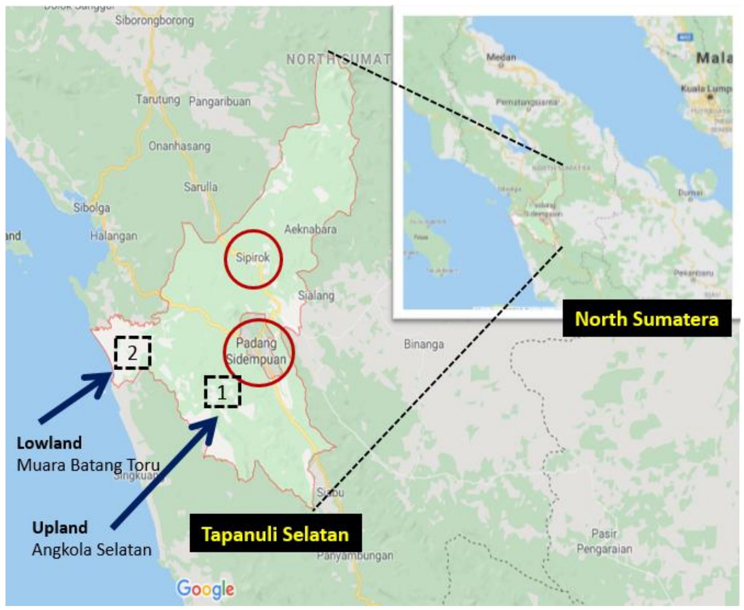

Figure 28 - Upland and Lowland Restoration in Tapanuli Selatan, North Sumatra.

4. Economic Assessment

This study analyzes 4 restoration models, from which the two most promising were selected. The four models are a form of restoration with an **agroforestry** system. The four consist of (1) Palm oil and durian; (2) Native tree combined with durian and mangosteen; (3) Native trees combined with durian, mangosteen and coconut; and (4) coconut combination native trees. The restoration model is applied in the Binasari upland area (models 1; 2; and 3) and the Muara Upu lowland area (model 4). Model 1 and 4 are ongoing and in initial steps. Models 2 and 3 are options to Model 1, specifically by replacing the exiting palm oil plant with native tree species.

According to the Minister of Forestry regulation No.P.70 / Menhut-II / 2008, specifically in Chapter 2 it is stipulated that the composition of forest rehabilitation plant species is a minimum of 60% wood plants and 40% are Multi Purpose Tree Species (MPTS) plants. In fact, in the field, this proportion of the plant cannot be fully applied. Problems related to tenurial issues encourage the community to greatly prefer to plant exotic plants, especially those with significant economic value. Communities usually carry out rehabilitation and restoration of forests with agroforestry or intercropping. All 4 models are framed to closely follow this stipulation by also considering local communities' experiences and their relevant aspirations drawn from field observations.

The community in upland area usually plants meranti, cypress as native species. In lowland they plant ketapang as a native plant. The community also plants other MPTS like durian, mangosteen and coconut as an economic buffer. Observation of the restoration model was carried out at a location with average area of 2 hectares. With this, structure and trees composition of the 4 restoration models and their species combination are shown in the Table below.

Table 40 - Restoration Models Area and Species in Indonesia

No	Model	Species	Area (ha)
1	Model 1	Palm oil dan durian, no native	2
2	Model 2	Native: meranti MPTS: durian dan manggis	2
3	Model 3	Native: meranti MPTS: durian, manggis dan kelapa	2
4	Model 4	Native: cemara, ketapang MPTS: kelapa	2

Basic Financial Parameters

- **Investment in Security**. The security of the forest area is carried out by patrolling. The patrol was carried out by officers from the Forest Management Unit (KPH), the community and assisted by CSOs like CI.
- **Maintenance**. Maintenance costs are very much linked to operating costs during the maintenance period including that of initial investment when the business is started.
- **Discount Rate**. The discount rate used in this study is a financial model calculated on the WACC (weighted average cost capital) model. The intended discount rate applying in this study is 10%.
- **Taxes**. In Indonesia, income tax and sales tax are widely known. According to regulations, that income tax is 2.5% of gross income. Sales tax is adjusted to the types of goods and services that are required to pay tax. The sale tax to be paid is 10% for agricultural products. In fact, farmers, as taxpayers, usually will not think about the tax matters in regard to agricultural products they harvested. However, this study use 2.5% income tax and 10 % sales tax.

5. Upland Restoration Model

Here the ecosystem has changed for three times. First, forest ecosystems with meranti species. The second is mixed forest (agroforestry) by communities. Finally, the existing, the oil palm plantation ecosystem. This palm oil was built by large companies very dominant and the community at small scale in the form of community gardens.

Plant Species

Palm Oil. Palm oil is a type of plant that mostly produces fruit as raw material for cooking oil. Palm oil is a global market crop with a significant market demand. Because of the large demand, various parties, including those of local community want to plant due to the promising economic value palm oil could provide. As such, in many cases across the country, this had been a serious driver for forest encroachment and forest degradation.

However, current conditions are slightly different. In a fairly long time, the basic price of palm oil fruit or Tandan Buah Segar (TBS) has decreased sharply. Not only big companies, but farmers who plant palm oils have suffered losses. This was also experienced by farmers in Binasari, Pardomuan Village, Tapanuli Selatan.

Communities and companies in Tapanuli Selatan have cleared many forest lands to be converted into palm oil plantations. Palm oil cultivation need large trcts of land, so that until now the practice of clearing forest land and transforming it into palm oil monoculture farms continues to happen.

Durian. Durian (*Durio zibethinus*) is a fruit with a high demand in Tapanuli Selatan market. The productivity of durian per ha in one time of harvest could reach about 183 fruits (BPS, 2017). In this case, durian, besides providing additional economic benefits, also plays a role in enhancing ecological functions. Durian, like any other wood plants, has the properties to grow and live for a long time. Tapanuli Selatan people have known durian for quite a long time. Durian cultivation and its silviculture is relatively easy for them, and are even accustomed to growing it in their backyard.

Mangosteen. Mangosteen (*Garcinia mangostana*) produces fruit that is very popular and well liked so that it has a high economic value (price). Mangosteen plant areas in Tapanuli Selatan has decreased to 105 ha in 2015. Previously, it reached 366 ha in 2011 (BPS 2017). The decrease in mangosteen land area is due to the community converting forest and mangosteen land into palm oil monoculture gardens.

Mangosteen lives and grows well in Tapanuli Selatan. Mangosteen grows optimally in the highlands (Agricultural Research and Development 2007). Until now the mangosteen has become a fruit that has high prices and high demand. Mangosteen is very suitable as a restoration plant, because this plant is a type of plant that requires shade at the beginning of planting. Mangosteen plants have high economic potential and are included in the types of plants that live in a long period of time which is good for maintaining ecological function.

Coconut. Coconut (*Coconus nucifera*) has been the main crop for rural communities. Far before the existence of cooking oil from palm oil fruits, the community processed coconuts for cooking oil sugar. Sugar is obtained from processing its coconut juice water.

Coconut plants became the main commodity for people living in coastal areas in Muara Upu, Tapanuli Selatan. Here, the community has use dcoconut production as their main income Like in Binasari highlands, coconut has a role as an additional monthly income for the community in Muara Upu.

How a combination of various plants described above forms a restoration model, is explained in the following section.

The restoration model will generaly produce fruits and plant products. The products will be sold mostly at the market, regret commonly via middle man. It is unavoidable that farmer are usually price takers.

Model 1 - Palm Oil and Durian

In this model, most farmers plant their land with palm oil and combine it with durian. Actually, at present, community lands are palm oil monocultures. It is possible for the community to do thos combination as durian is a type of plant that need a shade at the beginning of its growing. Figure 31 indicates the combination.

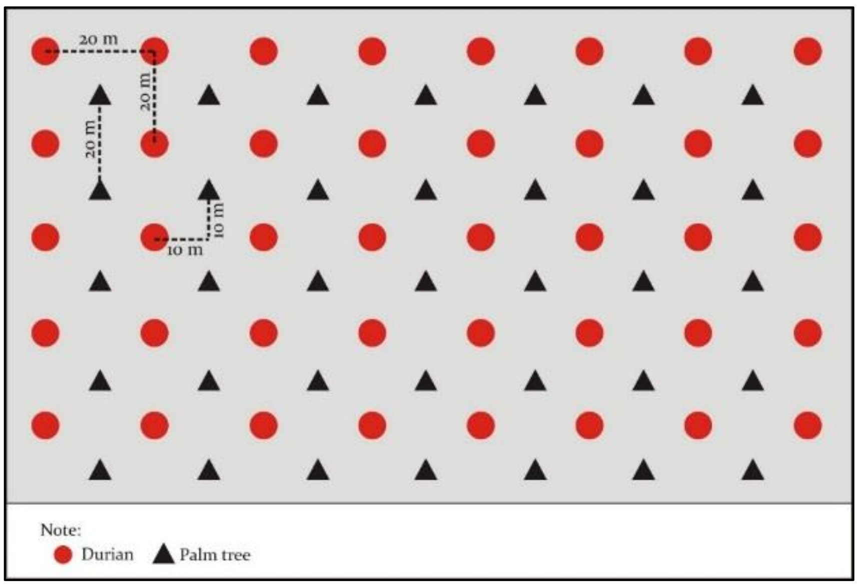

Figure 29 - Restoration Model 1 - Indonesia - Durian and Palm Oil

Ecologically, the combination is a form of restoration with minimal ecosystem improvement. However, it potentially has a higher economic value than that of only planting the palm oil monoculture system. This restoration model needs various costs as detailed in Table 43.

Table 41 - Cost of Inputs and Services of Model 1 - Indonesia - Durian and Palm Oil - Investment and annual maintenance for 1 period of plant (30 years)

No	Items	Input price (unit) (USD)	Total (USD) for 2 hectares
Inputs			
1	Hole of planting for durian (50)	0.36 (every unit)	18.00
2	Hole of planting for palm (50)	0.36 (every unit)	18.00
3	Seed of palm oil (50)	1.07 (every unit)	53.50
4	Seed of durian (50)	1.78 (every unit)	89.00
5	Planting durian (50)	0.07 (every unit)	3.50
6	Planting palm (50)	0.07 (every unit)	3.50
7	Fertilizer (NPK) for palm oils (180 box for 30 y)	14.22 (every box)	2,559.60
Services			
8	Distribute the seed of palm oil (3)	5.69 (one day)	17.06
9	Distribute the seed of durian (3)	5.69 (one day)	17.06
10	Fertilizing for palm oil (270 day for 30 y)	5.69 (one day)	1,535.76
Harvesting			
11	Harvesting for the palm fruit	0.01 (one stem of the palm fruit)	
Total (Inputs+Services)			**4,314.98**

Note: this is an example of agroforestry with a 2 ha area consisting of palm oil and durian with 50 steams each

The table above illustrates that the capital investment costs during the current palm oil cycle (assuming 30 years) and durian (20 years) without harvesting costs is about USD 4,314.98 for two hectares. This become USD 6,067.5 for two hectares when cost and investment – including that the costs of harvesting the palm oil up to the age of 30 years, are calculated.

Table 42 - Cash flow of Model 1 - Indonesia - Durian and Palm Oil

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	356.1	-356.1	-	-356.1
2	-	-	136.5	-136.5	-	-136.5
3	-	-	136.5	-136.5	-	-136.5
4	27.0	2.7	141.0	-116.7	-	-116.7
5	42.0	4.2	143.5	-105.7	-	-105.7
6	54.0	5.4	145.5	-96.9	-	-96.9
7	54.0	5.4	145.5	-96.9	-	-96.9
8	54.0	5.4	145.5	-96.9	-	-96.9
9	319.0	31.9	145.5	141.6	3.5	138.0

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
10	587.0	58.7	146.0	382.3	9.6	372.7
11	852.0	85.2	146.0	620.8	15.5	605.3
12	852.0	85.2	146.0	620.8	15.5	605.3
13	1,120.0	112.0	146.5	861.5	21.5	840.0
14	1,120.0	112.0	146.5	861.5	21.5	840.0
15	1,382.0	138.2	146.0	1,097.8	27.4	1,070.3
16	1,379.0	137.9	145.5	1,095.6	27.4	1,068.2
17	1,644.0	164.4	145.5	1,334.1	33.4	1,300.7
18	1,775.6	177.6	145.4	1,452.7	36.3	1,416.4
19	1,907.2	190.7	145.2	1,571.3	39.3	1,532.0
20	2,165.0	216.5	144.0	1,804.5	45.1	1,759.4
21	51.0	5.1	145.0	-99.1	-	-99.1
22	410.8	41.1	144.3	225.4	5.6	219.8
23	384.3	38.4	143.8	202.1	5.1	197.0
24	349.8	35.0	143.1	171.7	4.3	167.4
25	331.3	33.1	142.8	155.4	3.9	151.5
26	291.5	29.2	142.0	120.3	3.0	117.3
27	265.0	26.5	141.5	97.0	2.4	94.6
28	265.0	26.5	141.5	97.0	2.4	94.6
29	265.0	26.5	141.5	97.0	2.4	94.6
30	265.0	26.5	141.5	97.0	2.4	94.6

The cost of Model 1 detailed by operation category is shown below.

Table 43 - Cost of Model 1 detailed by category of operation, data collected in Binasari (upland) during field visits

Operation	Costs during 30 years (USD)	Cost per hectare	
Initial investment activities	178,07	Supplies for seed (durian and palm)	71,25
		Fertilizer for investment in first year	42,66
		Hole digging	18,00
		Labor - planting	46,16
Maintenance activities	1.979,42	Annual (29 year)	68,26
		Fertilizer for second-last year	1.237,14
		Labor for second-last year	742,28
Harvest & sale activities	105,20	Annual (27 year for harvest)	3,90
		Labor for harvest	105,20
TOTAL	2.262,69[28]		

[28] *No taxes included.*

The calculations described above are based on a 2-hectare area. Durian is planted with a plant spacing of 20m x20 m so its density is about 25 plants/ha. Likewise for palm oil which the density is similar to that of durian.

Model 1 needs cost and investment total about USD 3,033.75 per hectare for 30 years. At the 1st year of restoration it is about USD 178.07 per ha. With this, the restoration model will obtain net present value (NPV) of about USD 925.99 per ha over 30 years period. The number of IRR (21.09%) indicate that running this restoration model is financially feasible enough as it is also confirmed by its BCR number (2.15).

Since no native plant species will be planted then the initial ecological function and condition of the site could not be fully restored. However the financial assessment on this site also indicate that this model could help securing the BAF and Angkola Selatan Protection Forest (ASF) as planned, because then people will have additional income and options to staying at the site, instead of encroaching on forests as happened before. In other words, to run the model is feasible in the sense that to make it the site more productive which could decrease people's motivation to go and encroach the intended forests area.

Table 44 - Overall Assessment Indicator - Model 1 - - Indonesia - Durian and Palm Oil

Item	Value
Model	1
Area (hectares)	2.00
Investment	356.14
Investment/ha	178.07
IRR	21.09%
NPV	1,851.98
NPV/ha	925.99
Benefit/Cost Ratio	2.15

Model 2 - Native Trees, Durian and Mangosteen

This model has combination of three types of commodities, namely native plant commodities combined with durian and mangosteen. The native plant is intended to replace the existing palm oil at the end of its current cycle. The choice of this combination is based on the need to improve ecological conditions and at the same time have better financial and economic figures creating better, more regular incomes for the community. This model could provide more shade space (under the auspice of mangosteen and durian) giving farmers more opportunity to do the planting with types of vegetables for their daily needs. Figure 9 is a sketch illustrated this model based on the local community perspective confirmed during the field observation.

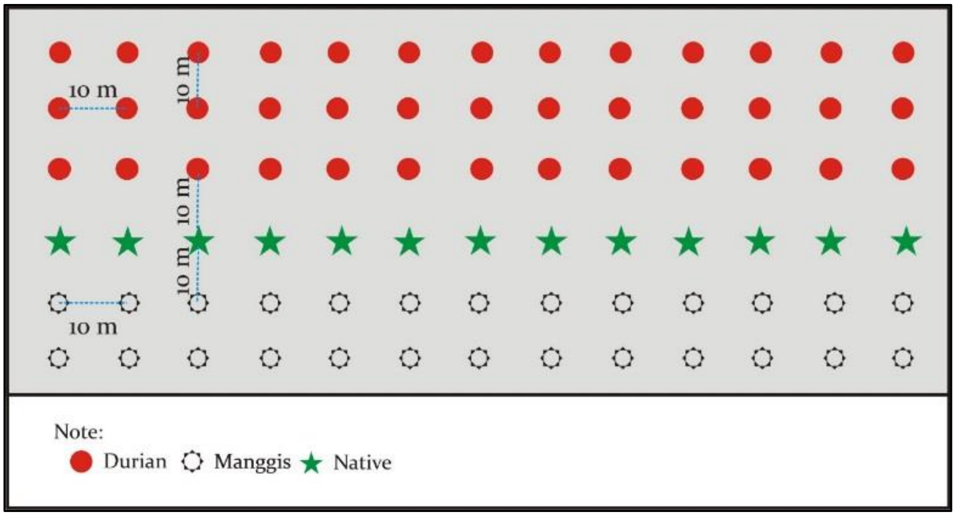

Figure 30 - Restoration Model 2 – Indonesia – Durian, Mangosteen and Native Trees

Both types of plants (mangosteen and durian) need shade at the beginning of the planting, as well as the natives plants, Meranti. To solve this, farmers can carry out this model when the land is still in the form of a palm oil monoculture landscape. They can plant mangosteen seeds, durian and meranti under the sidelines of oil palm plants. When these restorations are 5-10 years old, and palm oil plants are no longer productive then it can gradually be cut down.

Using 2 ha as a basis for calculation, this model needs expenditure cost total about USD 2,286.18 for 2 ha during a 25 year period. This become USD 4,135.6 for 2 hectares when the costs and investment (Table 45) are included.

Table 45 - Cost of Inputs and Servies - Model 2 – Indonesia – Durian, Mangosteen and Native Trees

No	Cost of Modal	Input price (unit) (USD)	Total (USD) for 2 hectares
Inputs			
1	Hole of planting for durian (50)	0.36 (every unit)	18.00
2	Hole of planting for manggis (50)	0.36 (every unit)	18.00
3	Seed of manggis (50)	2.13 (every unit)	106.50
4	Seed of durian (50)	1.78 (every unit)	89.00
5	Planting durian (50)	0.07 (every unit)	3.50
6	Planting manggis (50)	0.07 (every unit)	3.50
7	Fertilizer (NPK) for durian (40 box for 20 y)	14.22 (every unit)	568.80
8	Fertilizer (NPK) for manggis (50 box for 25 y)	14.22 (every unit)	711.00
Services			
9	Fertilizing for durian (60 day for 20 y)	5.69 (one day)	341.28
10	Fertilizing for manggis (75 day for 25 y)	5.69 (one day)	426.60
Total (Inputs+Services)			**2,286.18**

Note: this is an example of agroforestry with a 2 ha area consisting of palm oil and durian with 50 steams each

Table 46 - Cash flow of Model 2 - Indonesia – Durian, Mangosteen and Native Trees

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	329.5	-329.5	-	-329.5
2	-	-	91.0	-91.0	-	-91.0
3	-	-	91.0	-91.0	-	-91.0
4	-	-	91.0	-91.0	-	-91.0
5	-	-	91.0	-91.0	-	-91.0
6	-	-	91.0	-91.0	-	-91.0
7	-	-	91.0	-91.0	-	-91.0
8	-	-	91.0	-91.0	-	-91.0
9	301.0	30.1	91.0	179.9	4.5	175.4
10	584.0	58.4	91.0	434.6	10.9	423.7
11	885.0	88.5	91.0	705.5	17.6	687.9
12	930.0	93.0	91.0	746.0	18.6	727.3
13	1,222.0	122.2	91.0	1,008.8	25.2	983.6
14	1,240.0	124.0	91.0	1,025.0	25.6	999.4
15	1,541.0	154.1	91.0	1,295.9	32.4	1,263.5
16	1,577.0	157.7	91.0	1,328.3	33.2	1,295.1
17	1,878.0	187.8	91.0	1,599.2	40.0	1,559.2
18	2,046.5	204.7	91.0	1,750.8	43.8	1,707.1
19	2,215.0	221.5	91.0	1,902.5	47.6	1,854.9

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
20	2,480.0	248.0	91.0	2,141.0	53.5	2,087.5
21	306.0	30.6	45.5	229.9	5.7	224.1
22	450.5	45.1	45.5	359.9	9.0	350.9
23	424.0	42.4	45.5	336.1	8.4	327.7
24	344.5	34.5	45.5	264.5	6.6	257.9
25	318.0	31.8	45.5	240.7	6.0	234.7
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-

The cost of Model 2 detailed by operation category is shown below.

Table 47 - Cost of Model 2 detailed by category of operation, data collected in Binsari (upland) durang field visits

Operation	Costs during 30 years (USD)	Cost per hectare	
Initial investment activities	164,75	Supplies for seed (manggis and durian)	97,75
		Fertilizer for investment in first year	28,44
		Hole digging	18,00
		Labor - planting	20,56
Maintenance activities	978,34	Annual (2-25 year)	42,54
		Fertilizer for second-last year	611,46
		Labor for second-last year	366,88
Harvest & sale activities		For manggis and durian, the price of fruit	
TOTAL	1.143,09*		

**No taxes included*

This Model needs a costs and investment total of about USD 2,067.8 per hectare for 30 years. At the 1st year of restoration, the cost and investment is about USD 164.75 per ha. With this, this restoration model will obtain net present value (NPV) of about USD 1,263.79 per ha over 30 years period. The number of IRR (24.75%) indicate that running this restoration model is financially feasible enough as it is also confirmed by its BCR number (3.3).

Since native timber species will also be planted to replace palm trees, then the initial ecological function of the site can be restored close to its original condition. Besides, this site could help saving the BAF and ASF, providing income alternatives to people – which is a bit higher than Model 1 NPV - which will keep more people staying at the site instead of encroaching the forests, as happened in the past. This model will be recommended and considered as option to the Model 1 as here the palm trees are replaced by natives timber species. Replacing palm trees will not be a serious issue to the local community, as local people stressed that income from palm oil plantation does not fulfil their monthly basic needs.

Table 48 - Overall Assessment Indicator - Model 2 – Indonesia – Durian, Mangosteen and Native Trees

Item	Value
Model	2
Area (hectares)	2.0
Investment	329.51
Investment/ha	164.75
IRR	24.75%
NPV	2527.58
NPV/ha	1263.79
Benefit/Cost Ratio	3.30

Model 3 - Native, Durian, Mangosteen and Coconut

This model consists of three plant species, namely durian, mangosteen and coconut. These three are chosen because they are popular and widely well liked as well as have high economic value in Tapanuli Selatan. As already explained in the description of each type of plant outlined above, a combination of the 3 with a native timber plant is expected could accelerate the implementation of this model. The four types of plants are tolerant of shade in the early planting period. Farmers can plant it when the land still have palm oil on it. In the next 5 to 10 years afterward, all the palm oil plants can be immediately replaced by the three and the native plants. Figure 10 is a sketch to illustrate the plant composition of this model as suggested by the local community during the field visit.

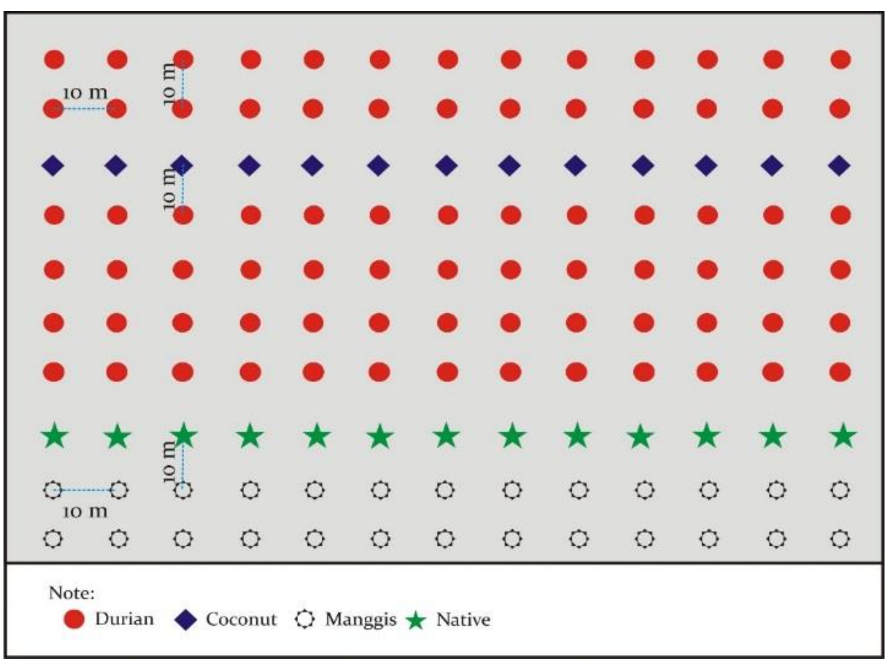

Figure 31 - Restoration Model 3 – Indonesia – Durian, Coconut, Manggis and Native Trees

Table 49 - Cost of Inputs and Services - Model 3 – Indonesia – Durian, Coconut, Manggis and Native Trees

No	Cost of Modal	Input price (unit) (USD)	Total input (USD) for 2 hectares
Inputs			
	Hole of planting for durian (50)	0.36 (every unit)	18.00
	Hole of planting for manggis (50)	0.36 (every unit)	18.00
	Hole of planting for coconut (32)	0.36 (every unit)	11.52
	Seed of manggis (50)	2.13 (every unit)	106.50
	Seed of durian (50)	1.78 (every unit)	89.00
	Seed of coconut (32)	1.42 (every unit)	45.44
	Planting durian (50)	0.07 (every unit)	3.50
	Planting manggis (50)	0.07 (every unit)	3.50
	Planting coconut (32)	0.07 (very unit)	2.24
	Fertilizer (NPK) for durian (40 box for 20 y)	14.22 (every unit)	568.80
	Fertilizer (NPK) for manggis (50 box for 25 y)	14.22 (every unit)	711.00
	Fertilizer (NPK) for coconut (58 box for 30 y)	14.22 (every box)	824.76
Services			
8	Fertilizing for durian (60 day for 20 y)	5.69 (one day)	341.28
9	Fertilizing for manggis (75 day for 25 y)	5.69 (one day)	426.60
10	Fertilizing for coconut (87 day for 30 y)	5.69 (one day)	494.86
Fix Cost (Inputs+Services)			**3,665.00**

Note: this is an example of agroforestry with a 2 ha area consisting of palm oil and durian with 50 steams each and 32 stems of coconut

Under a 2 ha basis, the total expenses of this model for various components is about USD 3,665.00 for 2 hectares in 30 years as shown by the table. This become USD 6,918.08 for 2 hectares and for the same period when the costs and investment are elaborated.

Table 50 - Cash flow of Model 3 - Indonesia – Durian, Coconut, Manggis and Native Trees

Year	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Taxon Income	Cash Flow after taxes
1	-	-	434.2	-434.2	-	-434.2
2	-	-	136.5	-136.5	-	-136.5
3	-	-	136.5	-136.5	-	-136.5
4	123.2	12.3	145.3	-34.4	-	-34.4
5	135.5	13.6	146.2	-24.2	-	-24.2
6	172.5	17.2	148.8	6.4	0.2	6.2
7	221.8	22.2	152.4	47.2	1.2	46.1
8	246.4	24.6	154.1	67.6	1.7	66.0
9	547.4	54.7	154.1	338.5	8.5	330.1
10	830.4	83.0	154.1	593.2	14.8	578.4
11	1,131.4	113.1	154.1	864.1	21.6	842.5
12	1,176.4	117.6	154.1	904.6	22.6	882.0
13	1,468.4	146.8	154.1	1,167.4	29.2	1,138.3
14	1,486.4	148.6	154.1	1,183.6	29.6	1,154.1
15	1,787.4	178.7	154.1	1,454.5	36.4	1,418.2
16	1,823.4	182.3	154.1	1,486.9	37.2	1,449.8
17	2,124.4	212.4	154.1	1,757.8	43.9	1,713.9
18	2,292.9	229.3	154.1	1,909.5	47.7	1,861.8
19	2,461.4	246.1	154.1	2,061.1	51.5	2,009.6
20	2,726.4	272.6	154.1	2,299.6	57.5	2,242.2
21	552.4	55.2	108.6	388.6	9.7	378.8
22	1,383.3	138.3	108.6	1,136.4	28.4	1,108.0
23	1,356.8	135.7	108.6	1,112.5	27.8	1,084.7
24	1,277.3	127.7	108.6	1,041.0	26.0	1,014.9
25	1,157.5	115.8	106.8	934.9	23.4	911.5
26	746.2	74.6	59.6	612.0	15.3	596.7
27	653.0	65.3	57.8	529.8	13.2	516.6
28	606.3	60.6	56.9	488.7	12.2	476.5
29	513.0	51.3	55.2	406.6	10.2	396.4
30	466.4	46.6	8.8	411.0	10.3	400.7

The cost of Model 3 detailed by operation category is shown below.

Table 51 - Cost of Model 3 detailed by category of operation, data collected in Binsari (upland) during field visits

Operation	Costs during 30 years (USD)	Cost per hectare	
Harvest & sale activities	217,11	Supplies for seed (manggis and durian)	120,47
		Fertilizer for investement in first year	42,66
		Labour - planting	30,22
		Hole digging	23,76
Maintenance activities	1.615,39	Annual (2-30 year)	59,83
		Fertilizer for second-last year	1.009,62
		Labor for second-last year	605,77
Harvest & sale activities	209,00	Annual (4-30 year)	7,74
		Labor for harvest	209,00
TOTAL	2.041,50*		

**No taxes included*

This model has costs and investment about USD 3,459.04 per hectare along its 30 years. At the 1st year of restoration, the cost and investment is about USD 217.11 per ha. With this, this restoration model will obtain net present value (NPV) of about USD 1,819.55 per ha over 30 years period. The number of IRR (26.74%) indicate that running this restoration model is financially feasible as it is also confirmed by its BCR number (3.13).

Similar to Model 2, native plant species will be planted replacing the existing palm oil and there is additional species plant (coconut) to be added. Hence the initial ecological function and condition of the site could hopefully more restored. Such a financial and ecological performance under this model could more help securing the intended forest, BAF and ASF, as targeted, because then people will have more other income options to keep much more people staying at the site, instead of come to and encroaching the intended forests as happened previously. In short, to run the model is feasible in the sense that to make it the site much more productive which could decrease much more people motive to go and encroach the intended forests.

Table 52 - Overall Assessment Indicator - Model 3 - – Indonesia – Durian, Coconut, Manggis and Native Trees

Item	Value
Model	3
Area (hectares)	2.0
Investment	434.21
Investment/ha	217.11
IRR	26.74%
NPV	3,639.10
NPV/ha	1,819.55
Benefit/Cost Ratio	3.13

6. Lowland Restoration Model

Model 4 – Coconut and Native Species

Here, the ecosystem has changed at least twice. First, forest ecosystems on peatlands, with several types of plants: coconut and cypress (cemara laut). At present, peat forests change to become the palm ecosystems. The palm plantations-ecosystem have changed almost all peatlands. This become the essential reason behind current on going restoration efforts.

The lowland restoration model is considered as Model 4 with a combination of native sea cypress (*Casuarina equisetifolia*) and ketapang (*Terminalia catappa*). The restoration in this model is a special form of restoration in the lowlands with two ecosystems- coastal and peatland areas. In the coastal there is a beach conservation program (Program Perlindungan Pantai) partly by replanting sea cypress for protecting sea wave and avoiding sea abrasion. At the same time it is targeting to protect endemic species of turtle, especially penyu belimbing (*Dermochelys coriacea*)[29]. This is already outlined under local village regulation (Peraturan Desa)[30] as a multistakeholder agreement. With this, it is regulated that, among other things, 100m towards the mainland, which is calculated from the shoreline during tides, as a protected area. The first 50 m from the shoreline is outlined to be zero/minimum activity unless for turtle management related activities. On the remaining 50m, the community is able to manage and utilize for various cultivation activities, mostly coconut. Therefore, some of this area is currently already cultivated by coconut trees. Cemara laut or sea cypress (*Casuarina sp*) species are planted close to beach between these two 50 m-parts. (Figure 32)

The peatland area (275 ha) is located not far from the beach and beach conservation area. This peatland is a shallow peatland area. It is currently already planted with monoculture palm oil and owned by the community. This is considered as Model 4 in this assessment. The model is framed trying to turn the peatland – especially its hydrological function – back into or close to its natural condition as a natural instrument for water management and potential for carbon sequestration. Under this frame, the existing palm oil has to be cut away at the end of its current cycle and replaced with native species under agroforestry system. Consistent with this, it is also targeted to ensuring that there will be no new palm oil plantations. [31]

The planting procedure in this model can be applied either with or without shade at the beginning of the age or the planting year for all three types of plants. As shown in the sketch, the planting distance between one coconut seedling with another is about 15m x 15m so that in one hectare there will be 44 coconut trees. Whereas native plants are arranged in such a way as to form plant lines or green borders.

[29] Of the 7 types of sea turtles in the world, 6 species are in Indonesia, 5 species can be found on the coastal area of Muara Upu. That is the uniqueness of Muara Upu beach (https://rakyatsumutnews.com/2019/04/25/5-jenis-penyu-kekayaan-hayati-pantai-muara-upu/) retrieved July 30 2019

[30] Peraturan Desa Muara Upu No. 01/2015 – a village regulation regarding Muara Upu Marine and Coastal Management

[31] Actually the peat ecosystem is so wide and currently in the form of a monoculture landscape of oil palm plantations. Here, the land is already utilized by large-scale corporations and small-scale plantations managed by the community. The area of plantation managed by companies is more than 5,000 ha, while those managed by small holder is only about 275 ha.

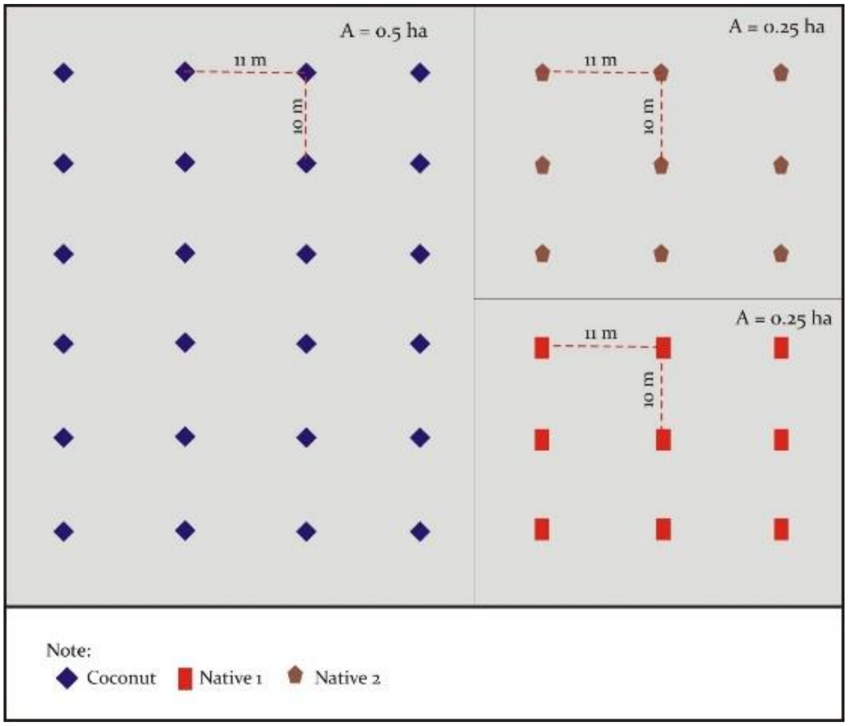

Figure 32 - Restoration Model 4 – Indonesia - Coconut and Native Trees

As shown below, the total cost for various inputs and services is about USD 1,482.42 per 2 ha for 30 years. If the costs and investment as shown in Table 52 was included hence the total cost of this model is about USD 2,226.94 per 2 ha in 30 years.

Table 53 - Cost of Input and Services – Model 4 – Indonesia - Coconut and Native Trees

No	Cost of Modal	Input price (unit) (USD)	Total input (USD) for 2 hectares
Inputs			
	Hole of planting for coconut (88)	0.36 (every unit)	31.68
	Seed of coconut (88)	1.42 (every unit)	124.96
	Planting coconut (88)	0.07 (every unit)	6.16
	Fertilizer (NPK) for coconut (58 box for 30y)	14.22 (every unit)	824.76
Services			
	Fertilizing for coconut (87 day for 30y)	5.69 (one day)	494.86
	Harvesting for the coconut fruit	0.01 (one of the coconut fruit)	
Cost (Inputs+Services)			**1.482,42**

Note: this is an example of agroforestry with a 2 ha area consisting 88 stems of coconut per ha

Table 54 - Cash flow of Model 4 - – Indonesia - Coconut and Native Trees

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	208.3	-208.3	-	-208.3
2	-	-	45.5	-45.5	-	- 45.5
3	-	-	45.5	-45.5	-	- 45.5
4	105.6	10.6	37.2	57.8	1.4	56.4
5	116.2	11.6	55.2	49.4	1.2	48.1
6	147.8	14.8	57.8	75.2	1.9	73.4
7	190.1	19.0	61.3	109.7	2.7	107.0
8	211.2	21.1	63.1	127.0	3.2	123.8
9	211.2	21.1	63.1	127.0	3.2	123.8
10	211.2	21.1	63.1	127.0	3.2	123.8
11	211.2	21.1	63.1	127.0	3.2	123.8
12	211.2	21.1	63.1	127.0	3.2	123.8
13	211.2	21.1	63.1	127.0	3.2	123.8
14	211.2	21.1	63.1	127.0	3.2	123.8
15	211.2	21.1	63.1	127.0	3.2	123.8
16	211.2	21.1	63.1	127.0	3.2	123.8
17	211.2	21.1	63.1	127.0	3.2	123.8
18	211.2	21.1	63.1	127.0	3.2	123.8
19	211.2	21.1	63.1	127.0	3.2	123.8
20	211.2	21.1	63.1	127.0	3.2	123.8
21	211.2	21.1	63.1	127.0	3.2	123.8
22	211.2	21.1	63.1	127.0	3.2	123.8
23	211.2	21.1	63.1	127.0	3.2	123.8
24	211.2	21.1	63.1	127.0	3.2	123.8
25	190.1	19.0	61.3	109.7	2.7	107.0
26	169.0	16.9	59.6	92.5	2.3	90.2
27	147.8	14.8	57.8	75.2	1.9	73.4
28	137.3	13.7	56.9	66.6	1.7	64.9
29	116.2	11.6	55.2	49.4	1.2	48.1
30	105.6	10.6	-	95.0	2.4	92.7

The cost of Model 4 detailed by operation category is shown below.

Table 55 - Cost of Model 4 detailed by category of operation, data collection in Muara Upu (lowland) during field visits.

Operation	Costs during 30 years (USD)	Cost per hectare	
Initial investment activitites	104,15	Supplies for seed (coconut)	62,48
		Hole digging	15,84
		Labour - planting	11,61
		Fertilizer (NPK) (palm) to first year	14,22
Maintenance activities	398,16	Annual (2-29 year)	7,11
		Fertilizer for second-last year	398,16
Harvest & sale activities	204,60	Annual (4-30 year)	3,93
		Labor for harvest	204,60
TOTAL	706,91*		

**No taxes included*

The assessment results indicate that this restoration needs investment of about USD 104.15 per ha in the first year (Table 56). With this, the model will obtain present value (NPV) of about USD 224.50 per ha over 30 years period. The number of IRR (22.20%) implies that running this restoration model is financially feasible enough. The BCR (1.66) confirms this. In other words, running this model is so feasible in the sense that in addition to such financial performance, to restore the site close to its initial function and condition is also potentially possible.

Table 56 - Overall Assessment Indicator - Model 4 -– Indonesia - Coconut and Native Trees

Item	Value
Model	4
Area(hectares)	2.0
Investment	208.30
Investment/ha	104.15
IRR	22.20%
NPV	449.01
NPV/ha	224.50
Benefit/CostRatio	1.66

Model 5 - Seed Dispersal

This model is considered dispersal as it plants only species which have ecological functions and hence it is intended only for ecological purposes. Plant species having economic values like those planted in Model 1-4 are not considered to be planted in this dispersal model. This model is assumed to be carried out in a truly traditional manner with very minimum or almost sterile management.

The implementation of this model, however, requires several cost components as shown below. This will be presented in 1 hectare base calculation with a plant spacing of 4m x 4m, so the density is about 625 native plants. The price of the native plants is similar to those in the Model 2 to Model 4, at USD 2.13 per seed. While the cost of making planting holes is about USD 0.36 per hole and the cost of planting is about USD 0.07 per seed planted. With this, the total cost of this model is about USD 1,600.00 per hectare (Table 57).

Table 57 - Cost of restoration to seed dispersal case

No	Components	Price (USD)
1	Seed from native trees (625 x @ USD 2.13)	1,331.25
2	Hole of native trees (625 x @ USD 0.36)	225.00
3	Planting native trees (625 x @ USD 0.07)	43.75
	TOTAL	1,600.00

Table 58 indicates the cost detailed more by category of operation

Table 58 - Cost of Model 3 detailed by category of operation, data collected in Muara Upu (lowland) during field visits.

Operation	Costs during 30 years (USD)	Cost per hectare	
Initial investment activities	*1,600.00*	*Supplies for seed (native)*	*1,331.25*
		Hole digging	*225,00*
		Labour - planting	*43.75*
Maintenance activities	-	*Annual (2-29 year)*	-
		Fertilizer for second-last year	-
Harvest & sale activities	-	*Annual (4-30 year)*	-
		Labor for harvest	-
TOTAL	*1,600.00*		

From the observation and discussion in the field, it is very rare for local people to implement this type of restoration model. Instead, they prefer to have monoculture plantations mostly by clearing the forests. This is a confirmation that one main driver behind forest degradation and deforestation is the lack of agricultural land to support families' livelihood. Therefore, restoration efforts based on seeds dispersal aimed only for the ecology purposes itself would not generate incentives for the community as they would be able to use land fit to agriculture.

7. Overall Results

All the assessment results are shown in the table below. This table indicates that overall, all restoration models show good financial figures. With these figures, the ultimate goal and mission of restoration can potentially be achieved; either for site restoration by itself, or within a restoration framework of protecting a stretch of forest, such as BAF and ASF.

The table below also suggests that all restoration scenarios in the upland site have good financial performance, which is good for the purpose of protecting the BAF. Yet, even though Model 1 indicates good financial performance, and then has the potential to protect BAF, it is probably ecologically unable to restore the site by itself. One of the reasons is that its scheme will keep the existing palm trees in place. Alternatively, it is recommended to CI to take into account Model 2 or Model 3, which replace palm trees by relevant native forestry/timber species - in this case it is meranti (*Shorea sp*). Both models have better financial figures compared to Model 1. Among these two models, Model 3 seems to be much better in terms of both financial figure and expected ecological benefit, i.e. can hopefully restore the site much better while at the same time having more buffer function to protect much better the BAF. In terms of value for money figure, Restoration Model 3 also indicates the highest value, namely 8.38 – meaning that per 1 USD investment per ha in this restoration site will resulted in USD 8.38 NPV, also per ha, during a 30 year period.

Table 59 - Financial and Ecological Figure of the Four Restoration Models - Tapanuli Selatan

Model	Description	Investment*	NPV*	IRR	BCR	Potential Ecological Benefit
Model 1	Upland – Palm Oil with Durian	178.07	925.99 *[5.2]***	21.09%	2.15	BAF and ASF protected, site not enough restore as palm oil is still in the sites; less function as buffer to protect the BAF
Model 2	Upland – Native, Durian, Manggis	164.75	1,263.79 *[7.67]*	24.75%	3.30	BAF and ASF more protected, no more palm oil in the site, replace by native, having more function to protect the BAF
Model 3	Upland – Native, Durian, Coconut, Manggis	217.11	1,819.55 *[8.38]*	26.74%	3.13	As above, but having much more as buffer function to protect the BAF and ASF
Model 4	Lowland – 2 timber native with Coconut	104.15	224.50 *[2.16]*	22.20%	1.66	The site restored close to its initial ecological function, no more palm oil in the site, replace by native, but still productive with coconuts
Model 5	Seed dispersal with timber native only	1,600.00	-	-	-	Intended to be aimed for ecological gain and purposes

**in USD/ha; ** Value for money*

In the lowland restoration sites, even though they indicate good financial figures, overall it is not as good as those in upland. However, the site will potentially be more fully restored – because it will have no more palm trees in the site, replaced by agroforestry native species mixed with kelapa (coconut). At the same time it will discourage people to come and encroach the forest and its vicinity.

Out of the five models, Restoration Model 3 is the most promising, followed by Model 2. In regard to investment opportunities, these two models can possibly use private sector funding sources, as all investment results confirm their potential benefits - for both financial and ecological criteria. This could likely be in line with the idea to frame of having sustainable funding resources, for instance by inviting private sectors. And this might use such a scheme as IUPHHK-RE.[32] The seeds dispersal model, as stated above, could be another ideal option if the ecological gain is the only objetive. Even though the per hectare investment of this model is much higher than those of the Model 3 and 2.

Table 60 - Financial and Ecological Figure of Model 2, 3 and Dispersal - Tapanuli Selatan.

Model	Description	Investment*	NPV*	IRR	BCR	Potential Ecological Gain
Model 2	Upland – Native, Durian, Manggis	164.75	1,263.79 *[7.67]*	24.75%	3.30	BAF and ASF more protected, no more palm oil in the site, replace by native, having more function to protect the BAF
Model 3	Upland – Native, Durian, Coconut, Manggis	217.11	1,819.55 *[8.38]*	26.74%	3.13	As above, but having much more as buffer function to protect the BAF and ASF
Model 5	Dispersal with timber native only	1,600.00				The highest ecological gain as it is aimed

**in USD/ha; ** Value for money*

Considering that the restoration initiatives in both upland and lowland landscapes is still in very initial steps[33], most of the assessment results illustrated above should be read as "potential" rather than actual results.

In the upland site (Binasari), CI is working with participatory patrol for BAF; partly with FMU team, local community, and other partners; and preparing nursery for durian, which is planned to be planted as agroforestry durian-palm oil in Binasari. Likewise, in the lowlands, CI is implementing an engagement processes to assess perspectives on what native and other species would be useful and beneficial to the local community. Here what CI is doing very much in line with The Global Partnership for Forest and Landscape Restoration (GPLR) definition on forest and landscape restoration.[34] To make it a reality,

[32] In line with this, CI invited Unilever and ADM as stated in their Financial Sustainability Plan Conservation Agreement in Binasari, South Angkola sub-district. Both Unilever and ADM are private sector actors who have committed to provide funding support to CI's conservation agenda.

[33] Most of the CI team in Padang Sidempuan strongly confirm this, and amplified by the local communities during field observation in the sites.

[34] The GPFLR defines the forest and landscape restoration as "an active process that brings people together to identify, negotiate and implement practices that restore an agreed optimal balance of the ecological, social and economic benefits of forests and trees within a broader pattern of land uses". (FAO and UNCCD, 2017).

especially in terms of economic and ecological balance, there will be precondition and enabling factors as well as potential bottlenecks which all need to be addressed as discussed in the following section.

8. Enabling factors and bottlenecks for Economic Forest Restoration

By taking Model 3 as the most promising model as well as Model 2 as the second-best, and to make it more actionable, several points need to be considered and anticipated, as outlined below. These points are also relevant for the dispersal model.

Public Policy: Text and Practice

The issuance of PMK No. 159/2004 concerning Restoration in Production Forests, as discussed above, has been considered by Kartodihardjo (2019) as a discretion step - it is called discretion given that the "ecosystem restoration" term has never existed in legislation product before. With this and given that neither the central nor local government do not yet have the capacity to carry out forest management much better across the country, the forest ecosystem restorations (IUPHHK-RE) are expected to be able to address this weak point. By focusing the restoration on the production forest ecosystems, it can hence also explore various benefits of production forests besides timber products.

As confirmed by Kartodihardjo (2019), in practice current ecosystem restoration management is so far similar to other usual forest management. It still covers by conflicts and claims of forest/land use (tenure problems), government-related policies that are partly too technical and not really in line with field conditions and realities. There are also inconsistent changes in spatial planning over time. Furthermore, illegal logging is currently still so rampant. Another important issue,is that of the low level of local government support. As a result, the ecosystem restoration business has so far been positioned more like a commercial permit holder similar to natural forest and plant concessions. In other words, the discretion carried out in 2004 is still limited to accommodate the permitting mechanism, and has not yet determined the unique position of the restoration. Classified as IUPHHK-RE, the letter "K" (K for *kayu* or wood) causes all forest management discourse to be carried out (such as having to make blocks, plots, and silvicultural systems) and all based on wood. In addition, the substance of the policy imposes administrative burdens with little room for improvisation in different field conditions.

Deforestation

Forests are under serious pressure, including that of Tapanuli Selatan and especially the forests around the upland restoration site. The high deforestation rate and forest degradation level are strong indicators for this pressure. This is an essential motivation to key stakeholders over there to continue pushing the restoration agenda. Political buy-in expressed by the local Tapanuli Selatan government could be a good enabler, and also the existence of multi stakeholders plans and agreements to do restoration.

Forest Management Unit (FMU) as key important player

The existence of FMU X as the jurisdictional holder of the area where the site is located could also be enabling factor, in the sense that they can bridge national policy on the restoration to be grounded in the site. In other words the existing gap between policy texts and its practical realities could be filled it out under FMU X's role and function. As such, national policy and its target on the ecosystem restoration across the country could be another potential enabler.

National Target on Reforestation

At the national level, there is a target of about 5.5 million ha forest area to be rehabilitated and restored within 5 years. The total budget for this is about IDR 39 trillion (USD 2.9 billion) - this resource is an important enabling factor. However, the available government budget is only able to carry out rehabilitation actions for about 200 thousand ha per year. (KLHK 2018). In the 2015-2019 Long Term National Plan (RPJMN) road map it is outlined a target of adding 500, 000 ha. However, in reality the realization until Oct 2018 only reached 107,608 ha (21.56%)

This is clearly a serious bottleneck. It implies that a non-state budget and external support are absolutely needed. By taking this into account, the national policy of having a permit mechanism to do the restoration by inviting private sectors could be one of a potential way out; one of them might be executed through ecosystem restoration concession (ERC) called IUPHHK-RE. For smallholders or community level, social forestry can be the other way possible to adopt. This could be combined, for instance with corporate social responsibility (CSR) fund by optimizing it under FMU X coordination and other local NGOs relevant to restoration agenda.

Capacity of the Community

At the community level in general, there is also a sort of classical problem in regard to current capacity. Learning from Tapanuli Selatan, however, there might be some key issues which could be considered to be limiting or bottleneck factors. This could consist of partly – but not limited to (a) community lack of capacity in terms of cultivation knowledge and skill, especially in improving their productivity level, (b) very limited access to both market and financial capital, (c) not enough innovation and creativity, and (d) lack of ability to get out of the price taker position. The quality of basic physical infrastructure around the site and its vicinity, such as roads, bridges, and markets, to and from the site could be other limiting factors that can possibly make the problem of implementing the restoration even more challenging.

Another point of urgency is that of improving the local community economy. It could be another good opportunity for the restoration to be better implemented in a way that the restoration has indeed to have financial and economic benefits to the local community, especially those in the site. Only the local community with a much better economy – and hence their wellbeing – will be able to support achieving the ultimate goals and mission of the restoration, mainly in restoring the degraded forest and peatland and also in securing other intended forests around the sites[35].

Issues on Coordination and Synergy

Current landscape policy and governance might be another essential bottleneck factor for the restoration to be fully and perfectly implemented. This includes the lack of coordination and synergy between the center and the provincial government as well as between the province with district government or even inter-district government, for instance in implementing and enforcing regulations and permits – more specific on forestry, agriculture estate, mining, and environmental-related authorities. As a result, there are many uncertainties issues in the field partly regarding land use governance and its boundary, spatial plan, forest, and land allocation, and its tenurial aspects. The case of the existence of land-based multi-dimensional conflict could be a good indicator to show this phenomenon. And so the fact that some forests area are most likely open access resources.

In Muara Upu as a lowland restoration site, for instance, some deep peatland with a significant area has been a palm oil concession since 2004. This is an example of how the rules related to the prohibition of

[35] This is also confirmed by a CIFOR researcher during a conversation on 3 September 2019 at CIFOR HQ in Bogor

conducting cultivation activities on the deep peatland (Government Regulation PP 71/2014 jo PP No. 57/2016, and Ministerial decree SK KLHK 130/2017) have long been ignored. It likely becomes worst, since until this study was conducted, there has been no significant attempt to resolve this case.

9. Final Remarks

While all the restoration models in Tapanuli Selatan are still in very early stages, they all indicate positive economic figures. They also show potential benefits from an ecological point of view, especially in helping to secure the forests around the sites which are actually under pressure.

Out of the 4 models, Models 2 and 3 – both in upland areas – are very promising. Most of the financial indicator ssuggest that Model 3 is the most promising one. This model consists of 3 plant species, namely durian, mangosteen and coconut as well as native species which could hopefully accelerate the ecological restoration process with no direct and instant economic value. Under this model the latter would be compensated by the other three species which are widely known to have good economic value in the short run. Also, that is one of the reasons expressed by the local community when selecting the appropriate species for this model. In other words, this model, as any other, is oriented to be a non-timber model.

The statement above is actually not too exaggerated as it is amplified by the financial indicator of this model. This model has costs and investment of USD 3,459.04 per hectare along the 30 year timeframe. At the 1st year the cost and investment is about USD 217.11 per ha. With this, the model will obtain net present value (NPV) of about USD 1,819.55 per ha over 30 years period. The number of IRR (26.74%) indicate that running this model is financially feasible as it is also confirmed by its BCR number, which is 3.13.

The above results could be good incentives for many related key actors to soon materialize this model and – if necessary – to think the further about a plan for replication and scaling up. Given the existing conditions, however, first materializing the restoration concretely seems a better priority for all the key stakeholders. However, as stated above, if the ecological gain is the only main purpose of the restoration agenda, then the dispersal model could be the best option.

The above results can also be used to attract the investors' interest to ascertain which restoration model to be finally decided according to the scheme legally prepared by the government. This point is important since the given studied model is still unclear, especially from a legal basis. However, in practice, as per discussion during the field observation the social forestry scheme could be the closest model. With this, one of the implications would be that FMU X and the local community as producers as well as other relevant NGOs have to increase their engagement in order to make it this model work. During the engagement, such issues as those on getting cost investment, technical assistance, legality procedure and other formalities steps could be discussed and solved. And so those related to technicalities like having technical assistance, providing seedlings, equipment and labor for forest restoration.

Another important issue is the need for law enforcement improvements, landscape governance, and policy - for instance on loans arrangement, market, technical assistance and conflict resolution mechanism, especially on tenurial.

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Annex 1- Selection of Priority Regions for Restoration

Based on Tapanuli Selatan's existing conditions, and by using what they called multi-criteria decision model (MCDM), they come up with a restoration plan. Under this plan, Tapanuli Selatan has been divided into four categories. Under multi-criteria decision model, the main decision are mostly based on biophysical criteria covering map of slope, peat, beach border, lake and river border. All these maps are superimposed with flora-fauna criteria covering key biodiversity area, HCV on distribution of endangered species, on protected animal habitat, and on temporary animal habitat. The results are then further superimposed with another three criteria: priority for improving management of palm oil incompatibility, distribution of palm oil plantations based on the manager, and (forest) area status.

As a result of the multi-criteria decision model, Tapanuli Selatan has finally four categories with each area as shown in Table 3. Map of the four category is shown in Figure 2.

Table 61 - Four Restoration Categoriel for Tapanuli Selatan.

Category	Percent of Criteria	Total Area (ha)
I	> 75%	25.175,89
II	65% < criteria < 75%	217.526,10
III	50% < criteria < 65%	124.265,00
IV	< 50%	88.848,20

Source: CI (2019) – discussion and its presentation materials

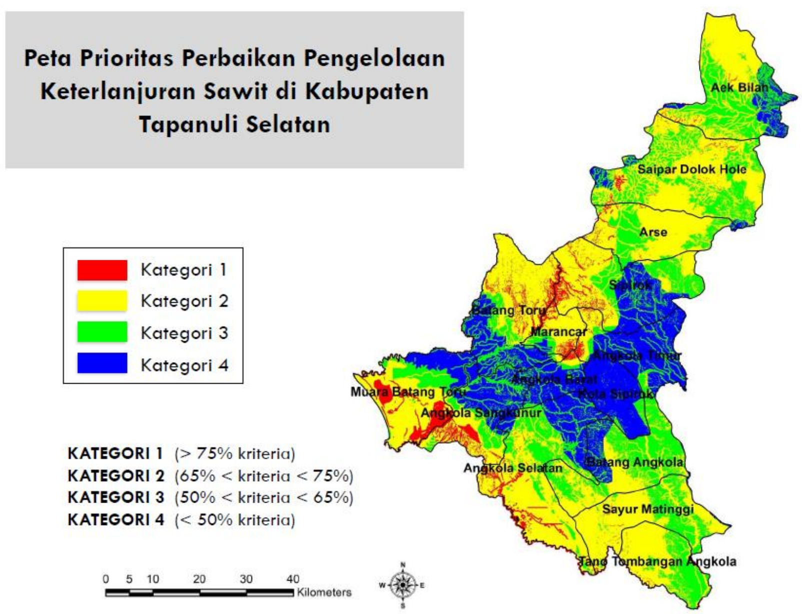

Figure 33 - Four Restoration Categories for Tapanuli Selatan

(CI, 2019)

By using the four categories, all sub-districts area in Tapanuli Selatan actually all have category I area, meaning that not even one sub-district is sterile from this category, as shown in Figure 3. This could be a strong indicator highlighting and consistent with the majority of Tapanuli Selatan having *No Go Area*.

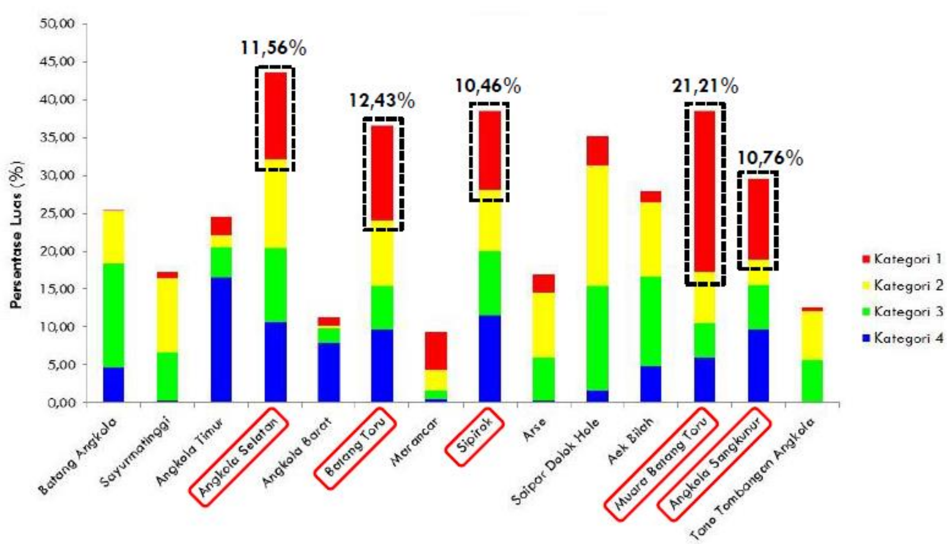

Figure 34 - Distribution of all category to each all sub-district area (%).

(CI, 2019)

Figure 36 also indicates five sub-districts with the largest area of Category I out of the 14 sub-districts in Tapanuli Selatan. It is also indicates that the area under the highest first category is Muara Batang Toru sub-district namely 21.21% or 5.34 thousand ha. While Sipirok is in the fifth with 10.46% or 2.63 thousand ha. Besides, as also shown in the figure 3, a sub-district with smallest area of Category I is Batang Angkola[36].

Partly by considering the need to have its best understanding on economic, CI both Jakarta and Tapanuli Selatan Office and CSF consultant team decided to visit and assess restoration related works in both upland and lowland area which are under CI facilitation supports.

[36] As it is confirmed by CI on discussion on July 2 2019 in CI Jakarta Office

CHAPTER 4: CAMBODIA
FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

CHAPTER 4 - CAMBODIA: FINANCIAL ASSESSMENT OF LANDSCAPE RESTORATION MODELS

Edward V. Maningo, Dul Ponlork

Deforestation in Cambodia intensified during the civil war in 1965, and in 1969-1970, with the heavy bombing by the U.S. destroying almost 2 million hectares of forests. The destruction of the forest further escalated during the Khmer Rouge regime who seized power from 1975-1979 when the people were forcibly moved to the western part of the country and converted large tracts of lands for agriculture. In the post-civil war era, after the Khmer Rouge regime was toppled, more forestlands were converted to agriculture as a means of livelihood and to address the increased demand for construction timber for rebuilding damaged houses. Illegal logging became rampant and shipping of logs to neighboring countries like Vietnam and Thailand intensified. The expansion of agriculture, illegal logging, the construction boom and increasing demand for lands associated with growth in Foreign Direct Investments became a significant driver of deforestation in the country (FA and FAO, 2010).

Early restoration involved supplementary plantings carried out in the natural forests to assist in the replenishment of valuable tree species in logging areas. Forest concessionaires were not required to carry out any rehabilitation work as they paid a reforestation tax to the government for this purpose (Gilmore et al., 2000). Plantations were also developed using fast growing species like Acacia, Eucalyptus, Tectona and Pinus. Most of the planted areas however had been destroyed either by fire or by illegal cutting (Carle, 1998). The Forestry Administration (FA), Ministry of Environment (MoE) and Fishery Administration (FiA) struggled to conduct forest planting due to budget limitations in a bid to meet the National Forest Programme target of increasing the forest cover to 60% by 2029 (RGC, 2010).

Due to limited funds allocated for restoration, international NGOs and development partners provided assistance to restore degraded sites. The CBNRM[37] communities undertake restoration activities supported by international funding mostly through the government, local NGOs and development partners. Large scale plantation developments are undertaken by private investors, mostly by Economic Land Concessionaires (ELCs) who developed large areas for rubber and exotic fast-growing species. However, conservation NGOs frowned upon ELCs' land developments contending that second growth forests were cleared to pave way for rubber and industrial tree plantations (Swift, 1998).

The Cambodian laws have not explicitly defined forest restoration despite mentioning it repeatedly. Article 30 of the Protected Areas Law provides: *Extensive programmes for education and dissemination, involving all means of communications, shall be developed for individual protected area on the protection and conservation of natural resources, the <u>rehabilitation and restoration of biodiversity and degraded and lost ecosystems</u>.* Under Section D.8 of National Forest Programme of Cambodia (Strategic direction for objective 8: Forest management regimes), has the following provision:

Rehabilitation/afforestation particularly focuses on restoration, enhancement and re-establishment of natural like forest*. Plantations by communities and government will typically be of* <u>multi-species</u>*, for multiple purposes for livelihood improvement and environmental services, such as protection of agriculture and fisheries. To date, the state has been an actor in plantation development though primarily of exotic monocultures.*

[37] List of Acronyms in the Annex

Although the above-cited provisions do not explicitly define restoration, several elements can be discerned:

- The plantings in degraded areas favor a diverse species composition to develop natural like forests (i.e. tropical forest); and
- Favoring the use of multispecies in plantation establishment instead of monoculture.

1. Restoration Models: Literature Review

Restoration usually employs various techniques (Wagner *et al*., 2000). What is important is the final outcome: to alter the degraded ecosystem so that the resulting natural processes will lead to the desired function (Stanturf *et al*., 2014). Several restoration approaches have evolved in the recent years.

Rainforestation. In this approach, native or indigenous species has been recommended for restoring degraded landscapes with emphasis on NTFP species in Community Protected Areas (CPAs)and economic timber species (Li *et al.*, 2018). Planting of indigenous species, popularly called rainforestation, gained prominence as a means of restoring degraded habitats and improving the structural habitat to support wildlife (Milan, 2014). In Cambodia, the Song Saa Foundation piloted the approach in Banteay Srei to accelerate the recovery of forests (Song Saa Foundation, undated).

Enrichment Planting, Reforestation and Afforestation Practices. Enrichment planting is the interplanting of desired species on degraded forest sites to improve ecological conditions of the forest (Prill, 2016; Lamb, 2014a). Through the years, the technique of restoration and enrichment planting has expanded to different approaches.

Conventional Planting. Conventional planting refers to the use of monoculture and fixed planting distance. Most of government restoration programs involve the use of monoculture and regular planting distance, either using exotic or indigenous species. Timber plantations are often established as monoculture using exotic species (Lamb and Gilmour, 2003). In Cambodia, *Dalbergia cochinchinensis,* currently used in many restoration projects, are mostly planted in monoculture plantations.

Framework Species. The framework species method is designed to restore diverse forest ecosystems on degraded forestland for biodiversity conservation or environmental protection (Wangpakapattanawong and Elliott, 2008; ICEM. 2014). The framework species method was developed in Queensland Australia (Betts, 2013), that employs high density planting (not less than 1,000 trees per ha) of a small number of indigenous timber and fruit-bearing species to be able to attract seed-dispersing birds (Wangpakapattanawong and Elliott, 2008; Lamb and Gilmour, 2003; Prill, 2016; ICEM, 2014). Framework species are fast growing indigenous species with dense shading crowns that rapidly shade out competing weeds, and are attractive to seed dispersing wildlife, especially bats and birds (Elliott *et al*., 2003; ICEM. 2014). Seed-dispersing wildlife re-establishes biodiversity and the original tree species composition of the forest (Wangpakapattanawong and Elliott, 2008; ICEM. 2014). In Cambodia, the Framework species approach was recommended in a meadow area in the Banteay Srei by Song Saa Foundation (Song Saa Foundation, undated).

Cluster Planting. Cluster planting or scattered planting involves planting of small number of scattered, single trees or clumps or rows of trees, which serve as perching areas for birds and will be the starting point for accelerated successions. The cluster of planted seedlings will eventually expand from the grown planted trees and become new bird perching trees (Lamb and Gilmour, 2003). In Cambodia, cluster planting was used in the planting of an imperata-dominated restoration plot of the APFNet-funded project implemented by the Institute of Forest and Wildlife Research and Development (IRD). Clusters of 9 plants (planted at 1m x 1m) at 5m x 6m between cluster was used in the demonstration plot. The established cluster of plants may expand and colonize nearby areas (Maningo, 2014).

Miyawaki Method. The Miyawaki Method (or maximum diversity approach) consists of planting seedlings of maximum possible number of tree species representing pioneer to late-successional species (Miyawaki, 2014). The salient feature of Miyawaki method is the application of the concept of "contemporary succession." When native species normally associated with different successional stages are planted simultaneously generate an "assisted succession" that allows the development in a few decades of the relatively stable late-successional stage and become part of a rapid succession (Miyawaki, 2014). After the first phase of rapid growth, there is a natural selection of species best suited to microsites, and the plantation will evolve into a late-successional stage mimicking a natural plant succession (Miyawaki, 2014). The Miyawaki Method was recommended in the Song Saa Reserve located in Banteay Srei, Siem Reap (Song Saa Foundation, Undated).

Assisted Natural Regeneration. Assisted Natural Regeneration aims to enhance the establishment of secondary forests by protecting and nurturing mother trees and their offspring already present in the area (Thomas, 2014). A key component of this model is the protection aspect. ANR is very suitable in areas with remaining trees or patches of natural forest within a wider degraded landscape, as these trees provide propagation material or attract dispersal agents like birds, bats, mammals, etc. (Thomas, 2014). In Cambodia, most of the CBNRMs simply protect the community forests without doing anything. Pagbag-o Foundation, the main proponent of ANR, considered this practice as part of ANR. Which is also called passive restoration. Lamb and Gilmour (2003) described passive restoration as protecting the site from further disturbances and allowing natural colonization and successional processes to restore ecosystem biodiversity and structure. The approach is especially advantageous when there are limited financial resources available to land owners and one of the few approaches that can be introduced in large areas (Lamb and Gilmour, 2003) as in the case of many CBNRMs in Cambodia.

The Project TCP/RAS/3307 is the first FAO-assisted project in Cambodia specifically aimed at implementing and promoting Assisted Natural Regeneration (ANR). The project was implemented at a community forestry (CF) project site (BPF, 2012). ANR was also recommended at the Songsaa Reserve located in Banteay Srei, Siem Reap (Songsaa Foundation, Undated).

Agroforestry Approach. Agroforestry has emerged as a practice that can greatly increase farm productivity and quality of life for poor smallholder farmers in the developing world (International Center, Undated). Agroforestry is the collective term for land-use systems and technologies in which woody perennials are used deliberately on the same land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence (Hillbrand *et al.*, 2017; Lamb and Gilmour, 2003; International Center, Undated; Hillbrand *et al.*, 2017). Several agroforestry models have been implemented in Cambodia albeit only recently.

Taungya Approach. Under this design, newly established forest plantations will be intercropped with food crops or medicinal plants until the canopy of trees will cover the ground (Rao *et al.*, 2004). There are very few cases of agronomic crops planted on tree plantations. A Taungya-like scheme was observed in the rubber plantations managed by ELCs in Mondul Kiri, where peanuts were planted between spaces of a young rubber plantation. The Institute of Forest and Wildlife Research and Development (IRD) also piloted intercropping of rice and cassava in a Dalbergia plantation. The financial analysis conducted in Lao PDR shows that intercropping crops such as cassava in the Eucalyptus plantation increased the profit to the plantations (Phimmavong *et al.*, 2019). The study also concluded the benefits of integrating local food production in timber plantation models in avoiding potential conflicts over land allocation for plantations, build local engagement and supporting food security.

Rainforestation Farming, Conservation Agriculture, *In-situ* and *Ex-Situ* Planting of NTFPs. Pornchai (Undated) described the importance of the forests in the production of jungle tea for the upland indigenous people in Chiang Mai province in Thailand. Some of the medicinal plants grow in forests since they require (or tolerate) partial shade, moist soils high in organic matter, high relative humidity and mild temperatures (Rao *et al.*, 2004).

A variant of rainforestation, called Rainforestation Farming (RF) originated from the Philippines, has recently caught interest. It is an agroforestry system that integrates annual crops, fruit trees and native timber trees planted within the forest. No distinction will be made between Rainforestation and Forest Farming since the approach is very similar to a well-known agroforestry model called Forest Farming.

Growing NTFPs and commercial crops under the forests like rattan, medicinal plants or food crops that can be harvested in a shorter time than it would take for trees to reach harvestable size, could make tree-growing attractive to landholders (Lamb, 2014). The cultivation and domestication of plants is being applied in a number of species such as cardamom and paper mulberry, orchids, mushrooms, etc. (ICEM, 2014). In rainforestation farming, native or indigenous tree species are used in combination with agricultural crops and fruit trees. The rainforestation farming system, when appropriately understood and implemented, can replace the destructive form of slash and-burn farming, allowing upland farmers to continuously crop even a small area. By incorporating fruit trees and other crops, rainforestation farming can provide farmers with additional income (Milan, 2014).

Although the term Rainforestation Farming is not popularly known in Cambodia, several communities are practicing it. For instance, NGOs, notably WWF, have been planting rattan and bamboo. HARVEST also conducted trial planting of pineapple in a thinned natural forest while IRD piloted planting of pineapple in Ou Soam and Tbeng Lech community forests (Maningo, 2014). Except for the rattan and bamboo, intercropping of pineapple did not show promising results.

Multistory Model. This model aims to maximize farm productivity by utilizing vertical space or canopies. CARITAS Switzerland recently implemented this model in Ou Baktra CF (Maningo, 2019) and the Ministry of Environment also promoted this technology in its Adaptation Fund project. Cassava and pineapples are sometimes intercropped with fruit trees like cashew, mangoes and jackfruit. For peanuts that are interplanted in timber and rubber plantations, these are appropriately described under the Taungya method.

Swidden Farming-Fallow Method. Swidden Farming is also called slash and burn farming or shifting cultivation. Under this method, the farmers clears the forest for planting of agricultural crops for a certain period or when the crop start to decline after exhausting the soil nutrients. The farmers let the cultivated lands stay idle to recover. Meantime the farmers will move to their other areas that have been idle for 4 years (and now colonized with trees) and start clearing the land. This traditional practice is still observed in Phnum Kulen, Siem Reap and by some Indigenous People in Mondul Kiri province.

Conservation Agriculture. FAO defined Conservation Agriculture as a farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance (i.e. no tillage) and diversification of plant species.[38]

Conservation agriculture has been implemented in Cambodia and implemented in Banan, Battambang funded by USAID. Five Technology parks were established in Battambang, Siem Reap, Kampong Thom, Kampong Cham and Phnom Penh to promote the concept (Edralin *et al*., 2017; Reyes *et al*., 2018). The features of Conservation Agriculture have high potential of complementing the Rainforestation Farming method. This method can be used in the planting of crops and NTFPs in the forest or in Taungya and multistory models.

CARITAS-Switzerland Restoration Model. The CARITAS-Switzerland model combines several models over the same piece of land. CARITAS Switzerland tested the model with the community forestry in Ou Baktra in Pursat. A portion of the community forest was developed for cluster planting (spaced at 30m x 30m) and intercropped with turmeric, considered a shade-tolerant crop. Each block (measuring 30m x 30m was assigned to an interested farmer, who are members of the Community Forest (CF) to plant cash crops. The cluster plot, measuring 10m x 10m will be planted with a mix of fast growth species, fruit trees and climax species. The original concept of the model was to conduct only spot clearing and hole digging for the planting of the cash crop the (a concept of conservation agriculture). However, the farmers were skeptical and believed that turmeric will not grow under this scheme. It was finally decided to plow the land using hand tractor as part of the land preparation.

2. Regional Context and Characterization of Standard Restorers

The restorers in Cambodia include government agencies, NGOs and community organizations and the farmers implementing Community-Based Natural Resource Management (CBNRM) projects. The restoration projects are mostly done collaboratively among restorers.

CBNRM: Community Forestry (CF), Community Protected Area (CPA) and Community Fishery (CFi). CBNRM in Cambodia was institutionalized by Cambodian law. Local communities are encouraged by NGOs and the government to apply for Community Forest (Mulcahy and Boissière, 2014). The Royal Government of Cambodia has supported the organization of Community Forestry (in areas under the jurisdiction of the Forestry Administration), Community Protected Areas (CPAs) in areas under the jurisdiction of the Ministry of Environment and Natural Resources, and Community Fisheries, under the jurisdiction of the Fishery Administration.

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[38] FAO. http://www.fao.org/conservation-agriculture/en/

In Ou Baktra Community Forestry (CF) conducted sporadic planting and regular patrol of the community forests especially during summer. At the same time, during patrol work, they also collect non-timber forest products such as mushrooms, medicinal plants and wild fruits. Most of the NTFPs collected are for consumption.[39] Almost the same activities are conducted by CF members in Sre Ambel except that they use bamboo and rattan. They also collected bamboo and rattan for commercial purposes. The planting of rattan and bamboo in Sre Ambel is supported by World Wide Fund for Nature (WWF).

Non-Governmental Organizations. Several conservation NGOs had been working in Cambodia providing support to the community, to the Forestry Administration and Local Authorities on natural resource management and conservation. Among the prominent international NGOs who worked directly or indirectly on landscape restoration, conservation or management include Conservation International (CI), World Wide Fund for Nature (WWF)-Cambodia, PACT-Cambodia, Fauna and Flora International (FFI), NTFP-EP and several others. CI has helped the Cambodian government to develop the legal frameworks and on-ground strategies needed for effective, long-term conservation of the area. CI also works directly with the communities in and around the forest to develop livelihoods that allow them to benefit from the rich resources of the Cardamoms while encouraging their preservation. CI has pioneered the conservation agreements with communities to protect natural ecosystems and halt destructive activities in return for incentives that support sustainable development. WWF-Cambodia is working for a strong participation and support from all people to conserve the country's rich biological diversity.[40] WWF-Cambodia mostly works in the eastern plains landscape and the Mekong Flooded Forests and supported the planting of rattan and conservation of several NTFPs. NTFP-EP on the other hand is involved in supporting community-based enterprise. NTFP-EP involves setting up agroforestry pilot or testing site, rehabilitation of NTFP species and raising awareness of the agroforestry concept. PACT works with local communities and governments to forge effective management systems and build responsible nature-based enterprise allowing people to benefit from their natural environment. Among the landscape restoration projects supported by PACT is the Oddar Meanchey REDD+ project which is a partnership with the local villages, the national Forestry Administration (FA), Terra Global Capital (TGC), and Community Forestry International (CFI). The project, located in the northwestern part of Cambodia, is one of the country's REDD+ demonstration projects for national REDD+ roadmap. Fauna & Flora International (FFI) has been supporting the government's conservation work across the country, and was one of the first international conservation organizations on the ground. The field activities of FFI are focused on community engagement and empowerment, food security, biodiversity monitoring and research with the aim of conserving critical forest and marine habitat and protecting flagship species of global importance. The International NGOs mostly work in partnership with local conservation NGOs, such as Mlup Baitung, NTFP Cambodia, Culture and Environment Preservation Association (CEPA) and community-based organizations who are involved in community based natural resource management.

Restorations in Cambodia are mainly carried out by two ministries: the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Ministry of Environment (MoE). MAFF has jurisdiction over the permanent forest estate, which comprise Permanent Forest Reserves, including Community Forests, Concession

[39] Group interview with the CF members in OU Baktra

[40] http://www.wwf.org.kh/wwf_cambodia/our_mission_in_cambodia/

Forests, Protection Forests, and Conversion Forests (State Public Property), and Private Forests (State Private Property)[41]. MAFF has implemented the following landscape restoration projects:

Collaborative Management for Watershed and Ecosystem Service Protection and Rehabilitation (CoWES) Project. The project, funded by UNDP, aims to reduce pressures on upland watershed areas from competing land uses by demonstrating collaborative management and rehabilitation of agricultural lands and forest areas by promoting a sustainable land management and stabilizing watershed catchment functions in degraded areas of upper Prek Thnot watershed in Kampong Speu Province. Among the expected results of the project include the improvement of on-farm soil conservation and agroforestry practices, and suitable management of the community forests in the upstream areas of Prek Thnot watershed.

Greater Mekong Sub-Region Biodiversity Conservation Corridors Project. The project, funded by ADB, includes the following interventions related to landscape restoration: agricultural production, forestry, and land based natural resources management. One of the expected results is a sustainable management of biodiversity corridors in Koh Kong and Mondul Kiri provinces. The project targets the rehabilitation and conservation of approximately 9,000 hectares of forests in Mondul Kiri province.

Under the MAFF are two agencies that have implemented restoration: The Fishery Administration (FiA) and Forestry Administration (FA). The FiA is responsible in the rehabilitation and restoration of the coastal and flooded forests, including the riparian areas. The Forestry Administration is in charge of managing the Permanent Forest Estate (Permanent Forest Reserves and Private Forests) including community forestry. The IRD is one of the agencies under the FA that implemented several pilot restoration and agroforestry projects. The FA has developed in Siem Reap province a large monoculture plantation of *Dalbergia cochinchinensis,* one of the flagship reforestation species of Cambodia while IRD has implemented several restoration trials in Kampong Speu, Siem Reap and Kampong Thom provinces, and includes testing the intercropping of agricultural crops in the seed orchard and second growth forests. The agency also tested direct seeding and cluster planting using mixed indigenous species in its research site (Maningo, 2014).

The Ministry of Environment (MoE) is the key agency responsible for environmental protection and natural resources conservation and responsible for Protected Areas, flooded forests and mangroves inside Protected Areas. The MoE is co-implementer of the ADB-funded Greater Mekong Sub-Region Biodiversity Conservation Corridors Project. It also implemented a project with UNEP under the Adaptation Fund where eco-agriculture approach was promoted to the communities living around the five community protected areas (CPA) (Maningo and Yim, 2017).

3. Selection of Restoration Models with Economic Potential

The selection of the more appropriate models was made using a Multi-Criteria Decision Analysis (MCDA) (Annex 1). There were 11 selection criteria used in evaluating the different restoration models where each criterion is given a weight ranging from 1 – 10. Higher scores were given to criteria that were more relevant. The weighed sum was derived by multiplying the weight of performance scores for each model (10 point is assigned if the model is perceived to perform best and 1 if worst). The selection of the technology is based on the Total Weighted Scores of each model.

[41] http://www.wepa-db.net/policies/structure/chart/cambodia/maff.htm

As a result of this process, the following models were selected: Modified CARITAS Switzerland Model (first priority) and Taungya model (second priority). Both models were combined with Conservation Agriculture. The Modified CARITAS model came in as third priority. Rainforestation was dropped out since there is no rainforestation farming model that can be visited in Cambodia. Besides, this model was already integrated as part of the CARITAS Switzerland model. The Multistory Cropping method was also dropped when it was found during the field visit that the farmer was using fruit trees as upper story plants instead of timber species. The original CARITAS Switzerland model came in fourth, but this has to be dropped, since the plowing of the forest floor may encounter objection from the Forest Administration (FA) or from the Ministry of Environment (MoE). Taungya is fifth in the ranking.

Modified CARITAS Switzerland Model. The model was identified to be appropriate for the community forests or in degraded forests. It combines important features of several approaches such as Rainforestation Farming, Frameworks Species and Miyawaki Method. The method involves planting in clusters in the degraded forest and each cluster measuring 10m x 10m was established at 30m x 30m. In between the clusters, shade-tolerant crops or NTFPs will be planted. The CARITAS Switzerland model will have two variations:

Using intercropping with turmeric, ginger and lemon grass; and intercropping with bamboo and rattan.

Taungya Method Combined with Conservation. In this model peanuts[42] were intercropped in the government-managed seed orchard[43] project. The planting of peanut will be conducted until the seed orchard closes its canopy, at approximately 6 years.

The current CARITAS Switzerland model allowed the farmers to plow the forest floor using a hand tractor. The reason being the soil is too compacted- the crops (turmeric, ginger and lemon grass) will not grow and it is difficult to plant. Conservation Agriculture (no tilling method) will be incorporated in both CARITAS Switzerland and Taungya Method. Instead of plowing, a mechanical hole digger (used for installing posts) will be used (Figure 15). Hole digging will be done only

Figure 35 - Mechanical hole digger used for the installation of posts.

[42] During the field visit, the Project Coordinator also used upland rice as an intercropping crop on their other lot, but we adopted peanuts in our case since it can be easily replicated to various sites.

[43] A seed orchard is a plantation established for the purpose of supplying seeds and propagules, in this case, of three timber species: *Dalbergia cochinchinensis*, *Pterocarpus macrocarpus* and *Diptercarpus intricatus*. The three spcies were collected from the plus trees all over Cambodia. Usually, the planted seedlings are grafted seedlings are planted in the seed orchard to have a true copy of the genetic characteristics of the parent trees. But in the the project of IRD, only D. cochinchinensis and P. macrocarpus were grafted (hence called clonal seed orchard). Grafting of D. intricatus was unseuccessful, so D. intricatus was planted using seedlings (hereafter called seedling seed orchard).

in the first and second year since the soils are expected to be softer after continuous mulching.

4. Economic Assessment of Forest Restoration Models

The sites were visited to collect information needed for the cost-benefit analysis (CBA). Meetings were held with the farmers and interviews with some key informants in the field (Figure 2).[44] The following sites were visited during the field work from July 24 to 30, 2019:

- Community Forestry in Ou Baktra
- Community Forestry in Bos Thom, Siem Reap Province
- Restoration project in Bos Thom, Siem Reap
- Seed Orchard in Chansor Forest Restoration Site, Siem Reap Province
- Dalbergia Plantation in Khun Ream Research Station, Siem Reap Province
- Rattan and Bamboo Plantation of Community Forestry in Sre Ambel District, Koh Kong Province

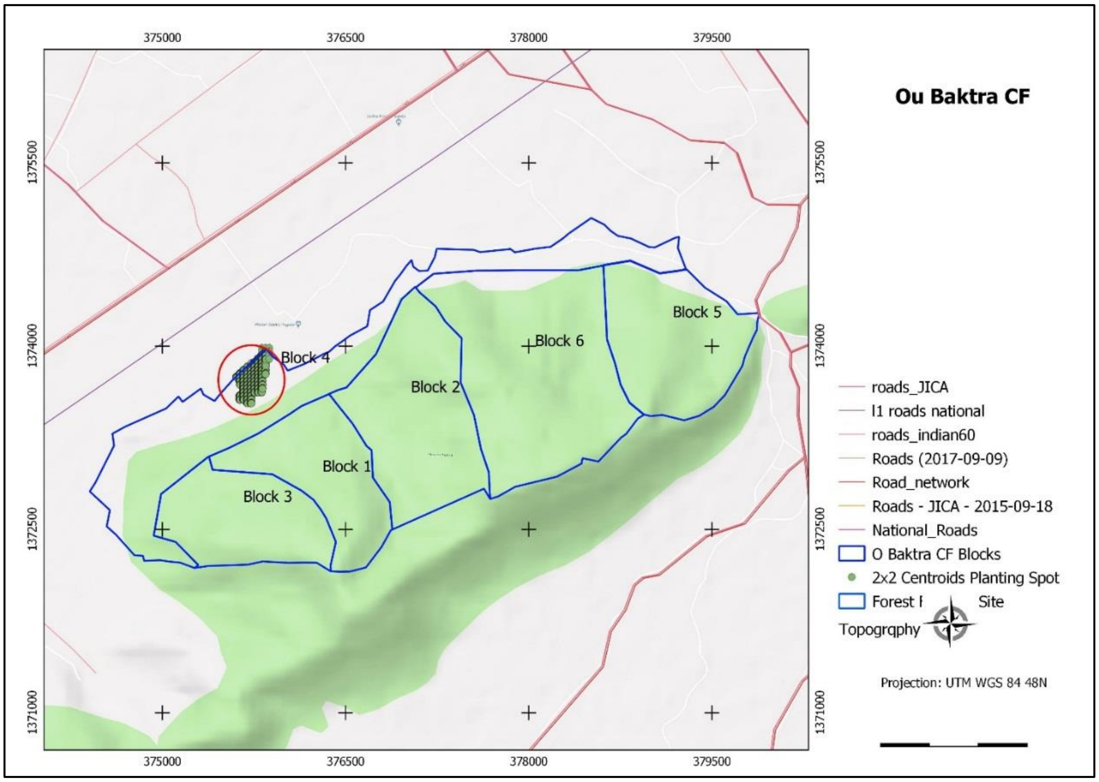
Figure 36. Meeting with the farmer cooperators in Ou Baktra community forestry

Basic Parameters

Ou Baktra CF is part of an abandoned forest concession. After the forest concession closed its operation, the area became open access and has been subjected to illegal cutting and sporadic cultivations. The community then decided to establish a Community Forestry to halt further conversion of many areas to further degradation. The Ou Baktra CF covers a total area of 849 hectares (Figure 37). Within this community forest, CARITAS Switzerland delineated approximately 9 hectares for forest restoration. The

[44] The list of people that were interviewed or met with during the field visit are listed in Annex 3.

area for forest farming covers only 12,800 sq.m. (16 blocks) that was allocated to 4 farmer partners. The forest farming is intended for commercial purposes.



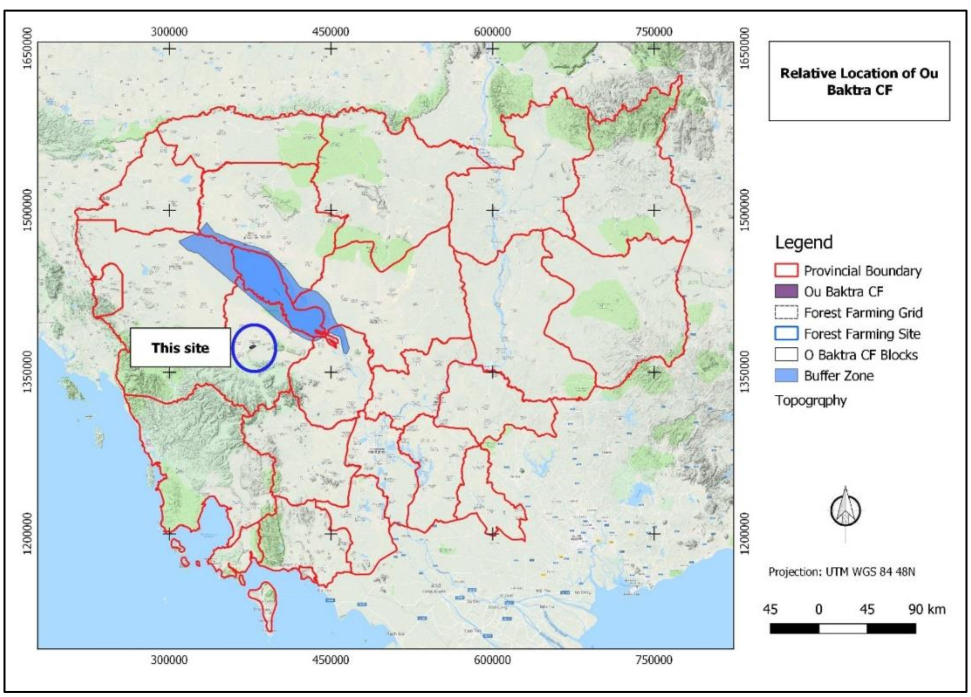


Figure 37. Location of restoration site. Above: Location within Ou Baktra CF; Below: Relative location within Cambodia

CARITAS Switzerland identified 3,200 sq. to each farmer equivalent to 4 blocks (i.e. each block has a net plantable area of 800 sq.). Three crops were used for planting on the forest farm: (1) Turmeric (1 block or 800 sq.); (2) lemon grass (1 block); and (3) ginger (2 blocks covering 1,200 sq.). In the proposed modified model, the following species were also proposed in lieu of the spices: (1) rattan (1,600 sq.); and (2) bamboo (1,600 sq.).

Chansor Seed Orchard, where Taungya was located, covers three hectares (1 hectare each for *Dalbergia cochinchinensis*, *Pterocarpus macrocarpus* and *Diptercocarpus intricatus*). The three hectares were intercropped with peanuts. Although the intention of planting peanuts is for site amelioration, the Project Management also intends to sell it as an income generating activity of the project.

The economic analysis involves determining the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) of the different restoration alternatives. The CBA follows a 30-year time frame. In determining the NPV, a discount rate of 10% was used based on the estimated obtainable returns from alternative investment opportunities.[45] The assumptions used in the analysis (i.e. labor cost, materials, yield, etc.) were based on the interviews.

In Ou Baktra, the farmer cooperators use family labor in the planting and tending of their farms. In Sre Ambel, it is the member of the Community Forestry who is doing the planting of rattan and bamboo as part of their CF activities whereas in Chansor, the project coordinator contracted out the planting of peanuts in the seed orchard on a per hectare basis, a common working arrangement in the area. The labor costs vary in each location, and depending on the type of work. For example, in Sre Amble, the labor cost is more expensive since there are only very few labors available. Most of the people migrate to neighboring Thailand to seek for seasonal labor causing labor shortages and high labor costs.

In this economic analysis, some of the costs are estimated on a per output or hectare basis ($100-$200 per hectare for plowing and construction of water well at $1,600 and paying a daily rate of $5-$7 per day). One of the major components of the development cost is hole digging during planting. It is estimated that using a mechanical hole digger makes 70-100 holes a day.

There was no actual data for harvesting and processing of the crops since the development has just started. In Chansor, peanuts were only recently planted as replacement of previously intercropped mung bean. The project was not able to harvest mung beans after the crop was damaged by successive rains. The use of mechanical hole digger will be done only in the first year of operation. It is assumed that the soils will be more friable in the succeeding cropping years and mechanical hole diggers will no longer be needed. There is no actual data on the cost of hole digging for planting, thus, the daily output using hole digging machine for installing posts was used as proxy. The specific cost for each model is described in each design.

[45] Economic analysis of small NRM projects, Cambodia. http://www.crdt.org.kh/OLD%20uploads%20(before%20Wordpress)/file/EconomicAnalysisofSmallNRMProjects.pdf

Model 1 - Modified CARITAS Switzerland Model Using Turmeric, Ginger and Lemon Grass as Forest Farming Crops

The proejct in Ou Baktra was funded by CARITAS Switzerland who had been in the coutrny since 2001. The organziaiton focuses on the fields of Migration and Climate Change and Disaster Risk Reduction, both consicered as strongly interrelated, as climate change is a key push factor for migration. The programme of CARITAS Switzerland in 2017-2020 focuses on safe migration and in building the resilience of communities to disasters. Cambodia became the focus of CARITAS Switzerland considering that Cambodia remains one of the poorest countries in Asia with around 90% of the poor living in the countryside. Agriculture contributes about one third to GDP and the country is also ranked among the top ten countries most vulnerable to climate change. Weather extremes have increasing impacts at community level due to poor water management, obsolete agricultural techniques, lack of infrastructure and limited institutional capacity to respond to hydro-climatic variability. In environmentally stressed areas, migration has become an established livelihood strategy. People migrate in the hope of escaping poverty by seeking employment either in urban areas or abroad.[46] Poverty is more pronounced among the communities living in the periphery of the forests, who exploit the forests as a fallback during economic shocks.

Ou Baktra Community Forestry, is located in Pursat province, who formed their organization with the help of the government. Since the establishment of their CF, the CF has brought very limited economic benefits to the CF members who are mostly subsistence farmers. CARITAS Switzerland considered this community a priority for piloting poverty alleviation through agroforestry technology (i.e. Forest Farming model). The community welcomed the intervention of CARITAS Switzerland.

The CF Management Plan of Ou Baktra states that the goal of the CF is to develop the community forest for ecotourism and increase the evergreen forest composed of mix species that can be sources of timber and NTFP products that will support livelihoods and contribute to the protection of ecosystem, biodiversity and increase resilience to climate change.

The demonstration site is composed of a mix of early succession deciduous forest. The trees are mostly in sapling stage with very low density trees. Due to very low canopy cover, grasses thrive underneath the canopy. The dominant species are *Shorea obtusa*. The soils are sandy to clayey with very thin soil. The site belongs to Red Yellow Podzols. The CARITAS Switzerland model has two components: (1) the forest restoration and (2) forest farming. Forest restoration involves the planting of timber species to rehabilitate the area while forest farming is the production and revenue-generation component of the design. In forest farming, cash crops will be intercropped underneath of the sapling that grows in between the clusters.

Forest Restoration Component (restoration using cluster planting)

Enrichment planting is the basic approach of restoring the site in Ou Baktra CF. Enrichment planting will be implemented in combination with the following planting design and principle: (1) planting in clusters that will serve as plant recruitment points; (2) use of framework species; (3) using a mix of as many species as possible following the Miyawaki technique; and (4) using indigenous species, following the

[46] https://www.caritas.ch/en/what-we-do/worldwide/country-programmes/country-programme-of-cambodia.html

Rainforestation approach. Cluster plots measuring 10m x 10m will be established 30 meters apart (Figure 38) and in each cluster, 25 trees of framework and climax species will be planted at 2m x 2m (Figure 39)[47].

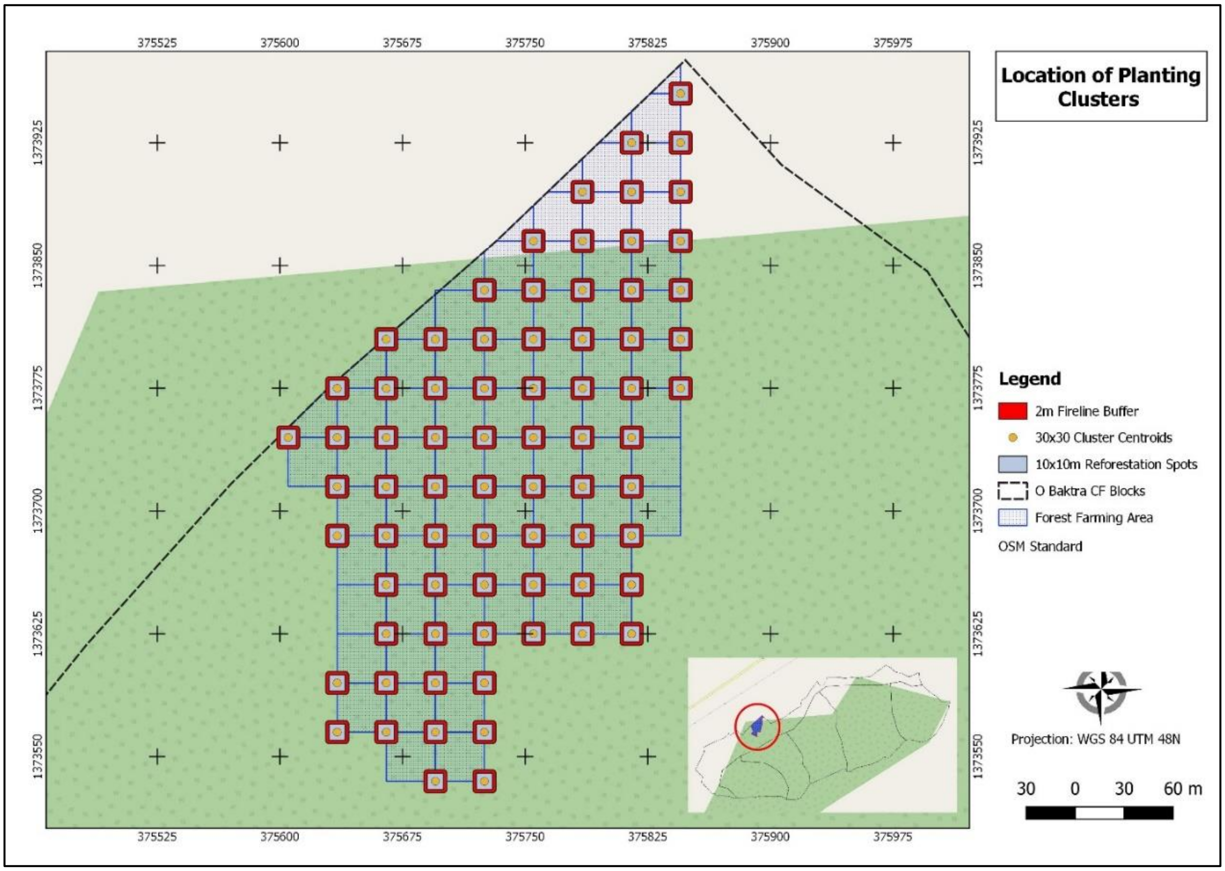


Figure 38. Location of cluster plots for enrichment planting in Ou Baktra CF

The location of clusters plots was draped over a base map with green indicating second growth degraded forests, and gray areas are open and cultivated lands.

Pioneer, climax and framework species will be planted in the cluster plots. Framework species include fruit-bearing species that serve as foods for wildlife or pollens for honey bees. The community will plant *Dalbergia cochinchinensis, Melanorhea laccifera, Dalbergia bariensis, Pterocarpus pedatus Aquilaria crassna, Pterocarpus macrocarpus*; *Xylia Xylocarpa*; and *Sindora siamensis*. The planting design in the cluster plot is shown in Figure 39.

[47] During field visit, CARITAS Switzerland had not yet completed the planting in the cluster plots

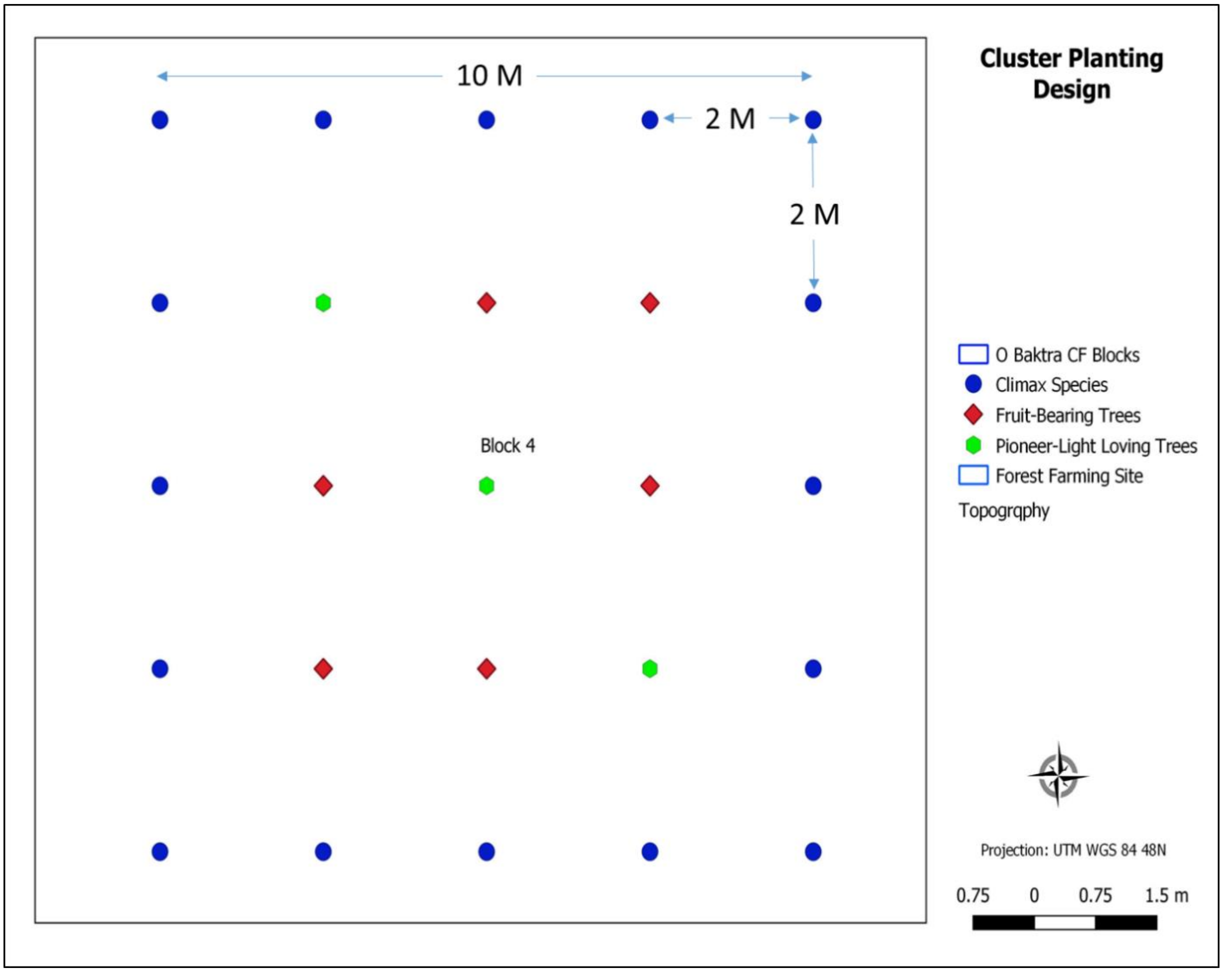


Figure 39. Enlarged view of a cluster planting plot showing the detailed planting design of seedlings in the cluster plot

The assumptions and estimated costs for the cluster planting component are shown in the Table 28. The expenses only cover the development costs since the trees planted are intended for conservation and restoration. The assumption was based on field interviews.

Forest Farming Component

Forest farming involves the cultivation or management of understory crops within an established or developing forest.[48] It is a type of agroforestry that integrates agriculture and forestry on the same landscape. Unlike in other agroforestry practices such as alley cropping, where trees are introduced into an agricultural system, forest farming intentionally integrates agricultural techniques into existing or newly established forests to farm NTFPs.[49] Forest farming may take place in a natural forest setting or in a more organized plantation and can be a sustainable production system. The canopy of the forest is

[48] https://articles.extension.org/pages/64919/forest-farming-and-non-timber-forest-products-defined

[49] http://www.centerforagroforestry.org/academy/2015/chp7-ForestFarming_2015.pdf

modified and maintained to provide the correct micro-conditions and protection for quality production of the understory or non-timber forest crops.[50] The location of the forest farming area in relation to the cluster planting plots is shown in Figure 40.

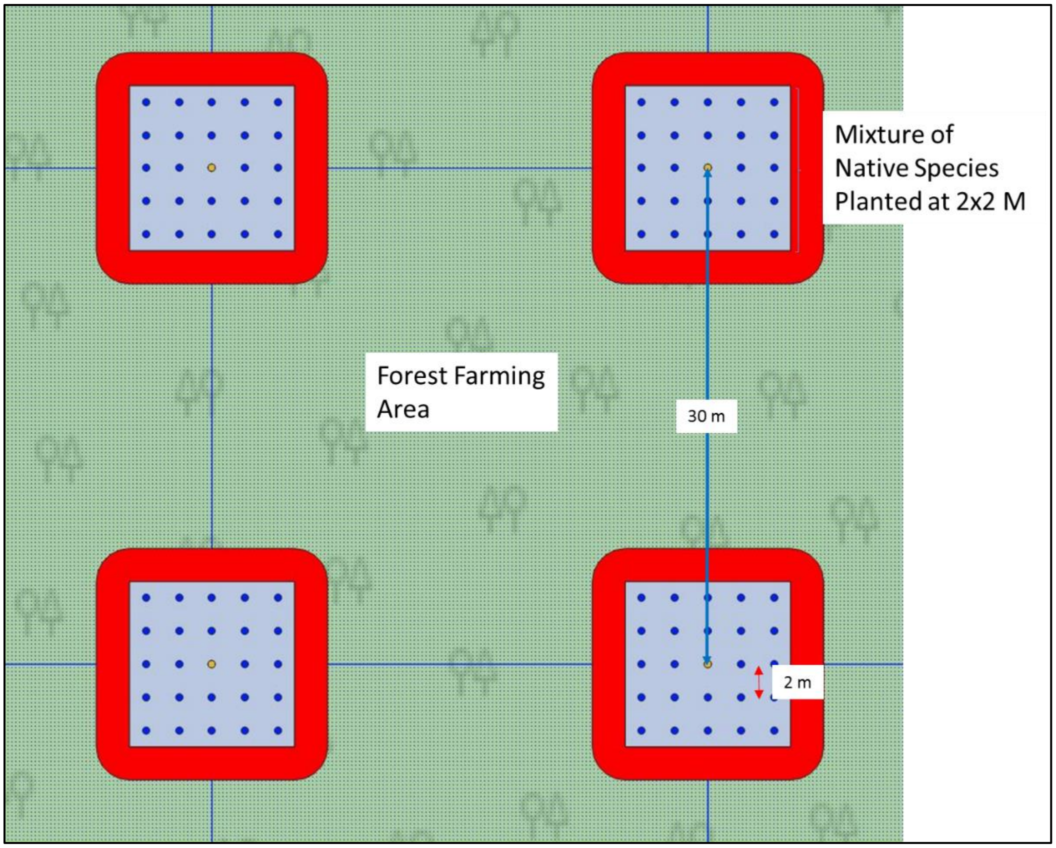


Figure 40. Cluster planting plots for enrichment planting

There are two options proposed under the forest farming method: (1) planting of lemon grass, ginger and turmeric; and (2) planting of rattan and bamboo. In Ou Baktra, the communities did not plant bamboo and rattan, therefore the information collected from Sre Ambel District, in the southern part of Cambodia, was used in developing the cash flow analysis for forest farming using rattan and bamboo. CARITAS Switzerland provided support to the community in terms of technical assistance and infrastructure, such as a water system (Figure 21) which will be delivered to the forest farming area through plastic pipes.[51]

[50] https://articles.extension.org/pages/64919/forest-farming-and-non-timber-forest-products-defined

[51] The cost of the water system was not included in the financial analysis

Figure 41. On-going construction of water tank in Ou Baktra CF

Ginger, Lemon Grass and Turmeric Intercrops

Three crops (ginger, turmeric and lemon grass) were recently planted by farmer cooperators in Ou Baktra CF (Figure 42).[52] The selection of species was influenced by the market of the products (i.e. ginger, lemon grass and turmeric) and the existence of buyers especially turmeric and ginger. These crops also have well-established local and national markets as they are used for cooking and traded in volume.

[52] The technical description of the three species is shown in Annex 3.

Figure 42. Newly planted lemon grass and turmeric (*Curcuma longa*) in Ou Baktra Community Forestry

The costs and assumptions used in the financial analysis are shown in Table 62. The assumptions were mostly based from interviews in Ou Baktra although some information was not available during the interview, such as the cost of hole digging using mechanical hole digger. In such case, information from other provinces was used as proxy cost.

Table 62 - Assumptions and basis in developing the cash flow analysis for forest farming using tumeric, ginger and lemon grass planted in Ou Baktra CF. *

Outputs / Key Activities	**Total Cost per Ha. over a period of 30 years**	Computation**
1.0 Initial Investments	**69,215**	
1.1 Fencing	**0**	No need to fence
1.2 Forest Farming	**68,831**	
1.2.1 Brushing and Pruning of Saplings and Mulching the Site	**2,400**	
Labor Cost (Package)	**2,400**	@ 30 Ha. x 80 $/Ha.
1.2.2 Hole Digging	**8,433**	
Labor Cost (Package)	**4,167**	@ 556 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**4,167**	@ 3333 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.2.3 Seedling Transport and Planting	**57,998**	
Labor Cost (Package)	**900**	@ 1 Ha./Yr.; 30 Has. x 30 $/Ha.
Cost of Planting Materials: Turmeric	**18,750**	@ 9,375 kgs. x 2 $/kg.
Cost of Planting Materials: Lemon Grass	**848**	@ 1,785 kgs. x 0.475 $/kg.
Cost of Planting Materials: Ginger	**37,500**	@ 18,750 kgs. x 2 $/kg.

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
Fertilizers	**0**	Will not apply fertilizers
1.3 Cluster Planting	**384**	
1.3.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.3.2 Hole Digging	**26**	
Labor Cost	**26**	@ 3.4375 person-day x 7.5 $/Person-day
1.3.3 Seedling Transport and Planting	**278**	
Labor Cost (Package)	**3**	@ 0.11 Has. x 30 $/Ha.
Cost of Seedlings	**275**	@ 275 seedlings x 1 $/seedling
2.0 Maintenance and Technical Assistance	**11,762**	
2.1 Forest Farming	**2,378**	
2.1.1 Maintenance Weeding Using Grass Cutter	**1,440**	
Labor Cost (Package)	**1,440**	@ 18 kgs. x 80 $/Ha./Weeding Pass
2.1.2 Fertilizer Application	**938**	
Cost of Cow Dung	**938**	@ 37500 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**0**	None
2.2 Cluster Planting	**984**	
2.2.1 Maintenance Weeding	**106**	
Labor Cost	**106**	@ 0.22 Ha. x 80 $/Ha. x 6 Brushings/Yr.
2.2.2 Replanting (Yr. 2 and 3)	**87**	
Labor Cost	**4**	@ 2 replantings x 2 $/replanting
Seedling Cost	**82**	@ 82 seedlings (for 2 years) x 1 $/seedling
2.2.3 Fireline and Firebreak Construction and Maintenance Around the Periphery of Plot	**792**	
Labor Cost	**792**	@ 79, 200 sq.m. x 100 $/10000 sq.m.
2.3 Technical Assistance	**8,400**	
Technical Assistance Cost	**8,000**	@ 320 person-day x 25 $/person-day/Ha.
Gasoline	**400**	@ 320 li. x 1.25 $/li./Ha.
3.0 Harvesting Cost (for Forest Farming)	**9,141**	
3.1 Harvesting and Processing	**900**	
Labor Cost	**900**	@ 30 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**8,241**	

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
Transport Cost (7.5% of Value of Products)	**8,241**	
TOTAL EXPENSES	**90,118**	

*Turmeric = 0.25 Ha.; Lemon Grass = 0.25 Ha.; Ginger = 0.5 Ha.

**Annual development = 1 Ha. Over 30 year period, some costs, like planting, will be equivalent to 30 has. (i.e. 1 Ha./Year x 30 years)

Model 2 - Modified CARITAS Switzerland Model Using Rattan and Bamboo as Forest Farming Crops

A variation of forest farming is considered where rattan and bamboo will be planted instead of turmeric, ginger and lemon grass. The potential rattan and bamboo species that will be used for planting are listed in Annexes 4 and 5. Although the design is still basically the same, rattan and bamboo will be planted at 5m x 5m. The data for the planting, maintenance, harvesting and yield were based on the information collected from Sre Ambel District in Koh Kong province. WWF-Cambodia supported the community in the planting and harvesting of bamboo and rattan (Figure 43). The assumptions and basis for cost-benefit analysis is shown in Table 63.

Figure 43. Rattan planted in Sre Ambel District, Koh Kong province, Cambodia

Table 63 - Assumptions and basis in developing the cash flow analysis for forest farming using rattan and bamboo in Ou Baktra CF*

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
1.0 Initial Investments	**1,262**	
1.1 Fencing	**-**	No fencing is needed
1.2 Forest Farming	**878**	
1.2.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.2.2 Hole Digging	**168**	
Labor Cost (Package)	**38**	@ 5 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**30**	@ 24 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.2.3 Seedling Transport and Planting	**630**	
Labor Cost (Package)	**30**	@ 1 Has. x 30 $/Ha.
Cost of Planting Materials: Rattan	**200**	@ 200 sdlngs x 1 $/seedling
Cost of Planting Materials: Bamboo	**400**	@ 200 sdlngs x 2 $/seedling
Fertilizers	**-**	Will not apply
1.3 Cluster Planting	**384**	
1.3.1 Brushing and Pruning of Saplings and Mulching the Site	**80**	
Labor Cost (Package)	**80**	@ 1 Ha. x 80 $/Ha.
1.3.2 Hole Digging	**26**	
Labor Cost	**26**	@ 3.4 person-day x 7.5 $/Person-day
1.3.3 Seedling Transport and Planting	**278**	
Labor Cost (Package)	**3**	@ 0.11 Ha. x 30 $/Ha.
Cost of Seedlings	**275**	@ 275 seedlings x 1 $/seedling
2.0 Maintenance and Technical Assistance	**11,748**	
2.1 Forest Farming	**2,378**	
2.1.1 Maintenance Weeding Using Grass Cutter	**1,440**	
Labor Cost (Package)	**1,440**	@ 18 weeding x 80 $/Ha./Weeding Pass
2.1.2 Fertilizer Application	**938**	
Cost of Cow Dung	**938**	@ 37,500 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**-**	None
2.2 Cluster Planting	**971**	
2.2.1 Maintenance Weeding	**106**	
Labor Cost	**106**	@ 0.22 Ha. x 80 $/Ha. x 6 Brushings/Yr.
2.2.2 Replanting (Yr. 2 and 3)	**73**	

Outputs / Key Activities	Total Cost per Ha. over a period of 30 years	Computation**
Labor Cost	4	@ lump sum
Cost of Seedlings	69	@ 69 seedlings x 1 $/seedling
2.2.3 Fireline and Firebreak Construction and Maintenance Around the Periphery of Plot	**792**	
Labor Cost	**792**	@ 79200 sq.m. x 100 $/10000 sq.m.
2.3 Technical Assistance	**8,400**	
Technical Assistance Cost	**8,000**	@ 320 person-day x 25 $/person-day/Ha.
Gasoline	**400**	@ 320 li. x 1.25 $/li./Ha.
3.0 Harvesting Cost (for Forest Farming)	**2,486**	
3.1 Harvesting and Processing	**900**	
Labor Cost	**900**	@ 30 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**1,586**	
Transport Cost (7.5% of Value of Products)	**1,586**	
TOTAL EXPENSES	**15,496**	

*Rattan = 0.50 Ha.; Bamboo = 0.50 Ha.

*Annual development = 1 Ha. Over 30 year period, some costs, like planting, will be equivalent to 30 has. (i.e. 1 Ha./Year x 30 years)

It was noted that the prices of rattan and bamboo are very low. The marginal buying prices of products could be due to the kind of species that were harvested. The bamboo and rattan are small in size (Figure 44) which are used mainly for garden trellises and other lesser value products.

The prices were adjusted based on the Consumer Prices Indices of Cambodia:

- CPI_{2009}=96.717
- CPI_{2010}=138.25
- CPI_{2019}=174.54
- Average Price of Rattan in 2008 = $0.75/cane
- Average Price of Bamboo in 2010 = $2.25/culm

Figure 44. Bamboo and rattan harvested by the communities in Sre Ambel District, Koh Kong province. (A) Bamboo growing in the field; (B) Close-up of bamboo ready solid in the market; and (C) Naturally growing rattan in Sre Ambel

Model 3 - Taungya Model

Several plantations are established by the government and NGOs in Cambodia (see Section 2.0) and ELCs. The latter are developing large tracts of land for rubber and industrial tree plantations. Some rubber plantations intercropped in between spaces during early stages of development (please see the Taungya experience in Section 1). The planting of cash crops in between spaces will have potential to contribute to the food security in the country.

In Chansor Restoration Site, a seed orchard was established and managed by the Institute of Forest and Wildlife Research and Development (IRD) a government agency under the Forestry Administration (FA) of Cambodia. Since the spacing of the seed orchard is 5m x 5m, there is enough space in between the planted timber for the planting of crops. Peanuts were planted in between trees (Figure 25). The original purpose of planting the legume is to enrich the soil through by intercropping of leguminous crop and to control weeds.

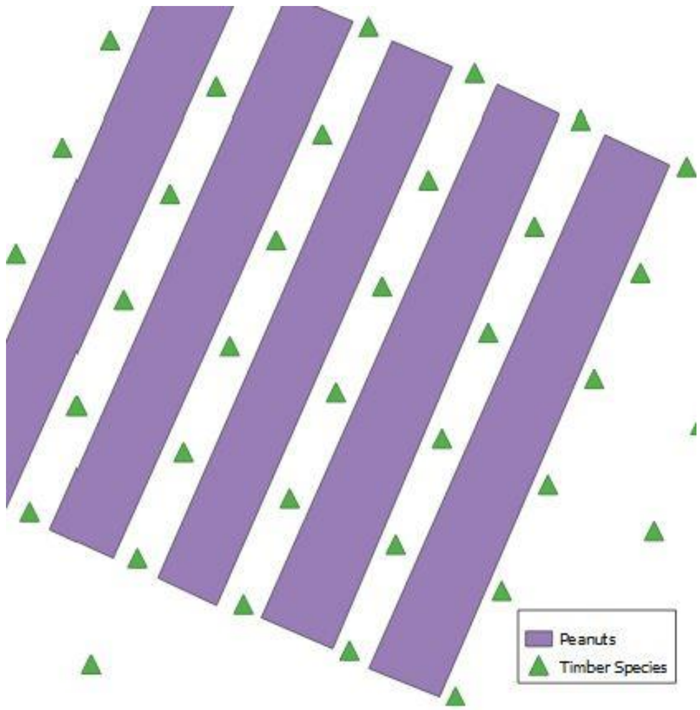


Figure 45. Planting arrangements of peanuts intercropped in the Dalbergia cochinchinensis, Dipterocarpus intricatus and Pterocarpus macrocarpus seed orchard in Chansor Research Station

Figure 46. Newly planted peanuts interplanted in a one-year-old grafted Dalbergia seedlings in the Seed Orchard of Chan Sar Restoration Site

The next table shows the assumption used in the cost-benefit analysis of Taungya system in Chansor Seed Orchard. In this analysis, the Taungya model will integrate Conservation Agriculture (i.e. no tillage). The period of analysis will be 6 years since by this time, it is estimated that the canopy will start to close and will no longer be suitable for growing peanuts.[53]

[53] When the canopy starts to close, other shade tolerant crops may be planted instead of peanuts and will resemble forest farming practices. This option is not included or in the analysis.

Table 64 - Cost assumptions for taungya Model in Chansor Research Station.

Outputs / Key Activities	Total Cost per Ha. over a period of 6 years	Computation*
1.0 Initial Investments	**13,385**	
1.1 Fencing	**-**	
1.2 Brushing and Mulching the Site	**480**	
Labor Cost (Package)	**480**	@ 6 Ha. x 80 $/Ha.
1.3 Fireline and Firebreak Construction and Maintenance	**127**	
Labor Cost (Package)	**127**	@ 1.58 Ha. x 80 $/Ha.
1.4 Hole Digging	**12,100**	
Labor Cost (Package)	**6,000**	@ 800 person-day x 7.5 $/Person-day
Gasoline for Hole Digging	**6,000**	@ 4800 li. x 1.25 $/li.
Rental for Hole Digging Eqt.	**100**	@ 2 days x 50 $/day
1.5 Seedling Transport and Planting	**678**	
Labor Cost (Package)	**180**	@ 6 Has. x 30 $/Ha.
Cost of Planting Materials	**498**	@ 6 Ha. x 83 $/Ha.
Fertilizers	**-**	Will not apply
2.0 Maintenance and Technical Assistance	**13,951**	
2.1 Maintenance Weeding Using Grass Cutter	**960**	
Labor Cost (Package)	**960**	@ 12 weeding x 80 $/Ha./Weeding Pass
2.2 Fertilizer Application	**31**	
Cost of Cow Dung	**31**	@ 1250 kgs. x 2.5 $/100 kgs.
Labor Cost (Package)	**-**	None
2.3 Technical Assistance	**12,960**	
Technical Assistance Cost	**7,200**	@ 288 person-day x 25 $/person-day/Ha.
Gasoline	**5,760**	@ 5760 li. x 1 $/li.
3.0 Harvesting Cost (for Forest Farming)	**180**	
3.1 Harvesting and Processing	**180**	
Labor Cost	**180**	@ 6 Ha. x 30 $/Ha.
3.2 Transport of Harvested Products	**-**	
Transport Cost	**-**	None, Sold on Farm
TOTAL EXPENSES	**27,516**	

*Annual development = 1 Ha. Over 6 year period, some costs, like planting, will be equivalent to 6 has. (i.e. 1 Ha./Year x 6 years)

5. Overall Results

A cash flow was developed for the two models: Modified CARITAS Switzerland model and Taungya method based on the information collected from the field. The financial analysis used the Net Present Value (NPV) approach, Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) in determining the profitability of the forest investments. A 10% interest rate was used as a discount factor in the NPV and BCR analysis.

Model 1: Modified CARITAS Switzerland Model Using Turmeric, Ginger and Lemon Grass as Forest Farming Crops

The modified CARITAS Switzerland model combined forest farming and cluster planting as restoration approach. There are two variations under this model: (1) using ginger, turmeric and lemon grass as forest farming crops; and (2) using rattan and bamboo as forest farming crops.

Table 32 shows the cash flow of the Modified CARITAS Switzerland model using turmeric, ginger and lemon grass. The cash flow covers a 30-year period, although some development activities are confined only in the early stage of development. The hole digging activities using a mechanical hole digger will be done only during the first 2 years. It is assumed that thereafter, the soil will be friable and can easily be planted with turmeric. Mulching, one of the important features of Conservation Agriculture, will also control weeds, making weeding and brushing unnecessary.

Table 65 -Cash flow – Model 1 – Cambodia - Turmeric, ginger and lemon grass

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	3,663.00	-	7,736.00	-4,073.00	-	-4,073.00
2	3,663.00	-	7,476.00	-3,813.00	-	-3,813.00
3	3,663.00	-	3,190.00	473	-	473
4	3,663.00	-	2,655.00	1,008.00	-	1,008.00
5	3,663.00	-	2,655.00	1,008.00	-	1,008.00
6	3,663.00	-	2,655.00	1,008.00	-	1,008.00
7	3,663.00	-	2,655.00	1,008.00	-	1,008.00
8	3,663.00	-	2,655.00	1,008.00	-	1,008.00
9	3,663.00	-	2,655.00	1,008.00	-	1,008.00
10	3,663.00	-	2,655.00	1,008.00	-	1,008.00
11	3,663.00	-	2,655.00	1,008.00	-	1,008.00
12	3,663.00	-	2,655.00	1,008.00	-	1,008.00
13	3,663.00	-	2,655.00	1,008.00	-	1,008.00
14	3,663.00	-	2,655.00	1,008.00	-	1,008.00
15	3,663.00	-	2,655.00	1,008.00	-	1,008.00
16	3,663.00	-	2,655.00	1,008.00	-	1,008.00
17	3,663.00	-	2,655.00	1,008.00	-	1,008.00
18	3,663.00	-	2,655.00	1,008.00	-	1,008.00
19	3,663.00	-	2,655.00	1,008.00	-	1,008.00
20	3,663.00	-	2,655.00	1,008.00	-	1,008.00
21	3,663.00	-	2,655.00	1,008.00	-	1,008.00
22	3,663.00	-	2,655.00	1,008.00	-	1,008.00
23	3,663.00	-	2,655.00	1,008.00	-	1,008.00
24	3,663.00	-	2,655.00	1,008.00	-	1,008.00

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
25	3,663.00	-	2,655.00	1,008.00	-	1,008.00
26	3,663.00	-	2,655.00	1,008.00	-	1,008.00
27	3,663.00	-	2,655.00	1,008.00	-	1,008.00
28	3,663.00	-	2,655.00	1,008.00	-	1,008.00
29	3,663.00	-	2,655.00	1,008.00	-	1,008.00
30	3,663.00	-	2,655.00	1,008.00	-	1,008.00
TOTAL	34,530.80		81,897.30			

The result of the cost-benefit analysis for planting of ginger, turmeric and lemon grass shows a net positive cash flow of $19,771 over a 30-year period before discounting. After discounting all the costs and revenues at 10%, the analysis shows a positive NPV (i.e. NPV=536). The analysis also shows that the IRR is lower than the preferred interest rate (IRR = 10.78% > 10%). The benefit cost ratio (BCR) also shows that at 10% interest rate, the BCR = 1.01 > 1 (Table 66). An analysis was made without considering the technical assistance showed that the net cash flow increased to $29,071 (NPV=$3,751; IRR = 15.56%; and BCR=1.11).

Table 66 - Result of the cost-benefit analysis – Model 1 - Ginger, turmeric and lemon grass

Area (Ha.)	1.00
Turmeric (0.25 Ha.)	0.25
Lemon Grass (0.25 Ha.)	0.25
Ginger (0.5 Ha.)	0.50
First Year Investment (US$)	7,786
First Year Investment/Ha.	7,786
Total Investment for 30 years (US$)	90,104
Total Revenues (US$)	109,875
▪ Turmeric (delivered to the village market or collection center)	27,000
▪ Lemon Grass (delivered to the village market or collection center)	28,875
▪ Ginger (delivered to the village market or collection center)	54,000
Net Cash Flow (US$)	19,771
Net Cash Flow (US$) without Technical Assistance	29,071
Total Discounted Cost @10%	37,442
Total Discounted Revenue @10%	37,979
NPV @10%	536
NPV @10% without Technical Assistance	3,751

NPV/Ha.	536
IRR	10.78%
IRR without Technical Assistance	15.56%
BCR @10%	1.01
BCR @10% without Technical Assistance	1.11

Model 2: Modified CARITAS Switzerland Model Using Rattan and Bamboo as Forest Farming Crops

The cash flow analysis for rattan and bamboo similarly used a 30-year timeline. However, unlike in forest farming using ginger, turmeric and lemon grass, the planting of these crops will be done only once. Harvesting started to be realized after 6 years for rattan and after 5 years for bamboo. The cash flow analysis showed that using the cost estimate and prevailing yield and prices of rattan and bamboo cannot offset the expenses incurred in developing the forest farm (Table 67).

Table 67 - Cash flow – Model 2 – Cambodia - Rattan and bamboo

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	-	-	1,548.00	-1,548.00	-	-1,548.
2	-	-	990	-990	-	-990
3	-	-	871	-871	-	-871
4	-	-	816	-816	-	-816
5	-	-	336	-336	-	-336
6	568	-	379	189	-	189
7	770	-	394	376	-	376
8	777	-	394	383	-	383
9	785	-	395	390	-	390
10	793	-	395	398	-	398
11	800	-	396	404	-	404
12	808	-	397	411	-	411
13	816	-	397	419	-	419
14	823	-	398	425	-	425
15	831	-	398	433	-	433
16	838	-	399	439	-	439
17	846	-	399	447	-	447
18	854	-	400	454	-	454
19	861	-	401	460	-	460
20	869	-	401	468	-	468
21	877	-	402	475	-	475
22	884	-	402	482	-	482
23	892	-	403	489	-	489
24	900	-	403	497	-	497
25	907	-	404	503	-	503

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
26	915	-	405	510	-	510
27	922	-	405	517	-	517
28	930	-	406	524	-	524
29	938	-	407	531	-	531
30	945	-	407	538	-	538
TOTAL	4,506.70		13,225.50			

Table 68 shows that all using rattan and bamboo generated a positive net cash flow of $6,591 for a 30 year period. However, at 10% interest rate, the project shows a negative NPV ($1,511). The IRR is lower than the interest rate used in determining the NPV (IRR = 6.07% < 10%) and BCR of 0.77 < 1.0. Without considering the technical assistance, the net cash flow of the plantation increases to 14,991 (NPV=1,392; IRR=13.93%; and BCR=1.39).

Table 68 - Result of the cost-benefit analysis – Model 2 – Cambodia - Rattan and bamboo

Area (Ha.)	1.00
Rattan (0.50 Ha.)	0.50
Bamboo (0.50 Ha.)	0.50
First Year Investment (US$)	1,548
First Year Investment/Ha.	1,548
Total Investment for 30 years (US$)	14,558
Total Revenues for 30 years (US$)	21,149
▪ **Rattan** (delivered to the village market or collection center)	5,245
▪ **Bamboo** (delivered to the village market or collection center)	15,904
Net Cash Flow (US$)	6,591
Net Cash Flow (US$) without Technical Assistance	14,991
Discounted Cost @10%	6,469
Discounted Revenue @10%	4,957
NPV @10%	(1,511)
NPV @10% without Technical Assistance	1,392
NPV/Ha.	(1,511)
IRR	6.07%
IRR without Technical Assistance	13.93%
BCR @10%	0.77
BCR @10% without Technical Assistance	1.39

Model 3: Taungya Model Using Peanuts in Chansor Research Station

The Taungya model uses peanuts as the main plants intercropped in the seed orchard. The period of analysis is only 6 years to coincide with the estimated closure of the canopy. Like in Forest Farming, Conservation Agriculture will be applied in the Taungya model (i.e. there will be no tilling and will use hole digging only). The cash flow analysis indicates a positive cash flow (Table 69).

Table 69 - Projected cash flow of peanuts planted using Taungya method in Chansor Research Station.

YEAR	Gross Revenue	Tax on Sales	Cost & Investments	Cash Flow before income tax	Tax on Income	Cash Flow after taxes
1	3,500	-	12,650	(9,150)	-	(9,150)
2	3,500	-	6,724	(3,224)	-	(3,224)
3	3,500	-	244	3,256	-	3,256
4	3,500	-	244	3,256	-	3,256
5	3,500	-	244	3,256	-	3,256
6	3,500	-	244	3,256	-	3,256
TOTAL	15,243		18,500			

The cost-benefit analysis shows that the intercropping peanuts in the seed orchard have negative net cash flow (-$6,516) for a 6-year period (Table 10). All of the economic parameters (NPV, IRR and BCR) also showed unfavorable results. One of the causes for the losses is the relatively high overhead, when the cost accounted for the time of the Forestry Staff who is managing the site which accounts for 47% of the total investment cost. Without considering the cost of the Forest Staff, the net cash flow increased to $14,556 (NPV=$3,101; IRR =26.7% and BCR=1.23). The cost of overhead is expected to decrease as the area being managed will increase.

Table 70. Results of the cost-benefit analysis – Cambodia – Model 3 - Taungya

Area (Ha.)	1.00
First Year Investment (US$)	8,965
First Year Investment/Ha.	8,965
Total Investment for 6 years (US$)	27,516
Annual Revenues for 6 years (US$) (from the sale of peanuts) (the products are sold on-farm)	21,000
Net Cash Flow for 6 years (US$)	(6,516)
Net Cash Flow for 6 years (US$) without considering Technical Assistance	$14,556
Discounted Cost @10%	24,015

Discounted Revenue @10%	16,768
NPV @10%	(7,247)
NPV @10% without considering Technical Assistance	$3,101
NPV per Ha.	$3,101
IRR	-
IRR without considering Technical Assistance	26.70%
BCR @10%	0.70
BCR @10% without considering Technical Assistance	1.23

6. Enabling Factors and Bottlenecks for Economic Forest Restoration

Viability of Forest Restoration Activities

The financial analysis indicates that the proposed model (Modified CARITAS Switzerland Model) and Taungya can provide financial benefits to the farmers. Using turmeric, ginger and lemon grass can provide a net present income of $536/ha. Rattan and bamboo did not show positive net income in the analysis. However, without considering the cost of technical assistance, the net present income for bamboo and rattan will have a potential present income of $1,392, and $3,751 for ginger, turmeric and lemon grass. The Taungya model also shows a potential net present income of $3,101/Ha if the technical assistance is not considered in the financial analysis.

Program of Managing the Landscape

Management at the landscape level has only recently started in Cambodia, with the implementation of the Commune Land Use Plans. Several programs were also implemented like the APFNet funded development of the Integrated Watershed Management Plan (IWMP) for Prek Thnot; the UNDP-funded Collaborative *Management for Watershed and Ecosystem Service Protection and Rehabilitation (CoWES) Project*; and the ADB-funded *Greater Mekong Sub-Region Biodiversity Conservation Corridors Project* that works on the landscape level. Focusing restoration at the landscape level will provide a more effective approach to restoration by considering all the stakeholders in the landscape instead of focusing on the forest ecosystem only. The landscape approach considers both the ecological and the economic aspects of restoration.

Market Conditions

The limited profitability of using rattan and bamboo as crop for forest farming demonstrates the need for further study. The revenues are found to be very low owing to the low prices of these products in the market. The value chain of forest products is still poorly developed, particularly in Sre Ambel where most of the rattan and bamboo are sold in raw form. There is no processing to add value to the products and the government or the NGOs should spearhead in product development of NTFPs. Value adding of bamboo and rattan including the use of high value species in planting must be considered.

Limited Experience of Farmers and Government Field Staff on Agroforestry

Agroforestry is recognized as a practical approach to addressing drivers of deforestation and issues in rural areas such as hunger and food security and among forest-dependent communities. Farmers and Community Forestry members, continue to subsist on hunting and gathering (e.g. collecting NTFPs, hunting wildlife, cutting timber, etc.). Farmers have limited experience in implementing agroforestry techniques. This is partly due to the limited capacity of government field staff in extending technical assistance to the farmers since most of them are trained on regulatory functions instead of providing technical services.

Importance of Assisting NGOs and Government Staff to Forest Restoration

There is a need for the government and research institutions to provide technical support to the farmers. Forest farming (or farming in the forest) is still something new - the reason only few farmer cooperators participated in the trial. The farmers have no experience growing the crops (ginger, turmeric and lemon grass) in the forest or partially shaded environment.

Importance of Foreign Investment to Structure Forest Restoration Initiatives and Technology Dissemination

Promoting agroforestry technology to farmers requires upfront costs to demonstrate its potential of improving land productivity and farmers' income. Despite the improvement of the Cambodian economy, the forest sector only receives a marginal share of the government budget and does not match the huge restoration targets. Cambodia still heavily depends on development partners and foreign investments for restoration activities.

Ineffective Diffusion of Agroforestry and Restoration Technology

The success of promoting agroforestry together with the restoration is affected by the interest and adoption of the technology by the farmers. Mostly, poor farmers are averse to adopt new technologies. Demonstrating that innovative agroforestry and restoration will work is very critical in influencing the farmers' decision. It is thus important that farmers should be exposed to demonstration sites and observed that the technology works. The government and the development NGOs will play a very important role in establishing demonstration sites showcasing the agroforestry and restoration technologies. The demonstration sites can also serve as learning sites for other farmers who want to adopt the technologies.

Weak R&D Programs for Agroforestry and Sustainable Forest Utilization

Several trials and demonstration projects on forest restoration has been conducted by government agencies. Several NGOs had been working on sustainable utilization of the forest by the communities. Despite successful demonstration of effectively restoring degraded areas, the government is still lagging behind in testing agroforestry models that will contribute to the household income. Most of the agroforestry models are implemented only recently and it still difficult to find cases of agroforestry providing sustainable income. There is still no enough documentation and information on the performance of the crops planted under the canopy and the suitability of the crops under a partially shaded environment remain to be observed.

The main limiting and potential factors in implementing the landscape forest restoration in Cambodia are shown in Table 38. Some of these provide an enabling factors analysis for the successful implementation for the forest landscape restoration while others pose challenges in the implementation of the forest landscape restoration.

Table 71. Main limiting and potential factors for the implementation of landscape forest restoration (FLR) in Cambodia

Strengths	Weaknesses	Opportunities	Threats
Demonstration sites have been implemented Cambodia still has considerable intact forest areas The government has implanted various restoration project	Agroforestry is only new and there are still no major demonstration sites that showcase a major success in agroforestry models Limited budget to support the restoration works Significant land areas are managed by the Economic Land Concessions. But the ELCs do not readily cooperate with the communities on the ground	Some of the ELCs are abandoned and can be an ideal target for agroforestry Competent staff at the national level who are knowledgeable on forest restoration and agroforestry	There are still some issues related to the conflicts between the communities and the Economic Land Concessions There is a slow process of accessing security of tenure There are more forests that are being converted to agriculture

7. Final Remarks

Agroforestry is still in nascent stages of development in Cambodia. It is difficult to find agroforestry technology that has been practiced by the community for considerable period. The modified CARITAS Switzerland model, despite the unfavorable results of the economic analysis, may still be a good model of integrating conservation and crop developments. CARITAS Switzerland has just only started testing the agroforestry model. The profitability may still improve by using high value species that command better prices and improving the market connection of the products.

The Taungya method that has been implemented by the Institute of Forest and Wildlife Research and development (IRD) of the Forestry Administration (FA) has potential to meet the objectives of restoration and address local food security.

The integration of conservation agriculture (CA) needs to be promoted and more trials need to be done in the forest. The economic feasibility of conservation agriculture still needs field testing to validate whether the benefits (e.g. increased yield) that was observed by the farmers in the agroecosystem will also have the same result in the forested environment. Conservation agriculture was reported to be successfully implemented in several demonstration sites in Cambodia (e.g. Battambang Province). The Forestry Administration staff is also wary that the mulches, one of the main features of Conservation Agriculture, may increase the risk of forest fires.

Many forests are prone to forest fires. The site in Ou Baktra where forest farming was implemented frequently experienced forest fires due to the carelessness of people (e.g. throwing of cigarette butts; slash and burn farming; embers blown off during cooking in the field, etc.). The Forestry Administration is trying to minimize forest fuels, sometimes by controlled burning, as a means of minimizing forest fires. But in ecoagriculture, mulching using forest litters and plant debris, is part of the practices. Risk of forest fires needs to be managed and minimized to make conservation agriculture acceptable to the Forestry Administration. There is a need for continuous documentation and monitoring of various agroforestry practices in the country that may further improve the model and provide better financial benefits to the farmers.

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Annex 1. Multi-criteria Scoring for different models in Cambodia

Model	Performance Score												Remarks
	Criteria												
	Economic Consideration			Acceptability to Restorers						Flexibility and Area Specificity of Technology	Contribution to Environmental Conservation	Total Weighted Score	
	Restorers' Investment	Potential for Income Stream and Benefits	Gestation Period	Compatibility with Culture and Traditional Practices	Aligned to Government's Approach	Technological Simplicity	Ease of Diffusion/Replicating to Other Provinces	Extent the Technology Being Practiced	Length of Time the Technology Being Practiced				
Weight	10	10	2	8	10	4	2	4	2	10	10		
Rainforestation Farming Combined with Conservation Agriculture	5	10	8	4	10	3	7	7	8	5	10	518	Will give this as third priority. This can be captured in the forest recommendation sans cluster planting.
Multistory Cropping Agroforestry Model Using Timber Species as Upper story Species	8	10	8	4	8	5	8	2	3	10	5	508	Will give this as second priority due to its simplicity and applicability for a cultivated farm. It can be readily upscale.
CARITAS Switzerland Model Combined with Conservation Agriculture	8	8	8	2	10	2	4	2	4	8	10	504	We will give this as first priority since the model is very flexible in restoring second growth forests and can adopt multi-objectives. The model is the first of its kind which captures features of several restoration techniques. But we have to modify (or do away with cultivation (i.e. use Conservation Agriculture) to avoid criticisms from conservation NGOs. It is unimaginable if we let the farmers plow underneath eh forest covering hundreds of hectares if we will upscale the model.

Model	Performance Score												Remarks
	Criteria												
	Economic Consideration			Acceptability to Restorers									
	Restorers' Investment	Potential for Income Stream and Benefits	Gestation Period	Compatibility with Culture and Traditional Practices	Aligned to Government's Approach	Technological Simplicity	Ease of Diffusion/Replicating to Other Provinces	Extent the Technology Being Practiced	Length of Time the Technology Being Practiced	Flexibility and Area Specificity of Technology	Contribution to Environmental Conservation	Total Weighted Score	
Weight	10	10	2	8	10	4	2	4	2	10	10		
CARITAS Switzerland Model	8	8	8	2	10	3	6	3	3	8	8	494	We forego this model since this will be captured in the model above.
Taungya Approach for CBNRM, ELCs and Government Reforestation Projects	8	8	10	6	8	7	8	1	2	5	6	470	Will give this as fourth priority
Rainforestation Using Conventional Planting (using either reforestation, afforestation or enrichment planting) as planting design, and either seeds or seedling as plating materials	5	5	2	3	10	5	5	9	8	5	10	460	
CBNRM Protection-Passive Restoration	10	2	1	8	1	10	10	10	10	10	1	426	
CBNRM Protection Combined with Assisted Natural Regeneration	9	2	2	2	10	2	6	9	6	5	5	398	
Framework Species Approach	1	2	2	2	10	1	2	5	5	10	10	388	
Miyawaki Method	1	2	2	2	10	1	2	5	5	10	10	388	
Pure Plantation Using Conventional Planting	1	2	2	1	5	10	8	10	10	10	7	378	
Swidden Farming (Fallow Method)	10	5	10	10	1	8	4	9	6	1	1	368	

Annex 2. Persons and Farmers visited or contacted

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Annex 3. Information of recommended cash crops for Forest Farming in Cambodia

Species	Site Requirement and Cultivation Method	Use
Lemon grass	▪ Climate: warm humid, sunny area, ▪ Rainfall 2000-2500 mm ▪ Soil: wide range of soil type but not water logged soil. ▪ pH 5.0 – 8.4 ▪ Seed rate 2.5kg/ha OR 25,000 slips/ha with 0.6x0.8 m ▪ Fertilization: FYM 10t/ha, 450-100-125 kg/ha. ▪ Harvest: up to 6years, 1st harvest is 3 MAP and subsequently 45-60days intervals. ▪ Yield 15t/ha or 400kg oil/ha.	Herbal products, detergent, insect repellent, perfumery, cosmetics, and beverages.
Ginger	▪ Climate: morning sunlight and stippled shade, not exceeding 32.5^{o}c. ▪ Planting: by rhizomes 15cm between plants. ▪ Harvest: 8-9 MAP	Fresh, dried, oil, and powder. brandy, wine, beer, flavoring, medicine.
Turmeric	▪ Climate: Tropic, humid climate, 20 – 30^{o}c, in shade but not too dense, however, it produces larger and better rhizomes in open ground exposed to the sun. ▪ Soil: Loams and sandy loam. ▪ Planting: By rhizomes and fingers, rhizome is planted as such or split into pieces, each piece must have at least one sound bud. It is planted between May and August on beds of 15cm height and 1m width, 50cm between beds, 15 – 20cm between plants. ▪ Fertilization: 4– 6t/ha cattle dung. ▪ Harvest: 7 – 9MAP when leaves turn yellow and start drying up. ▪ Yield 16 – 20t/ha.	Fresh and powder. Source of Vitamin C, Magnesium, and Potassium. Anti-inflammatory and anti-oxidant.

Annex 4. Commercially Important Rattan Species in Cambodia

Calamus salicifolius Becc

- Use: handicrafts, such as baskets, matting and rope, bringing a good source of income for local communities. Its shoot is also collected and eaten as a vegetable.
- Trade (2008): a cane of 4-5 m costs 100-150 riel. Its cane is collected for domestic handicraft production only. No export record of this species exists.

Calamus erinaceus (Becc.) J. ransf.

- Cane: 0.8-1.5 cm diameter; internode 10-25 cm long; not flexible; durable.
- Location: found only along a sea estuary in Koh Kong province.
- Use: its canes are used for the production of furniture, in combination with other products such as wood. However, the flexibility of the cane is poor, and is not used much by handicraft artisans.
- Trade (2008): its cane is 200 riels for 4-5 meters. It is reported that it used to be exported to Thailand

Calamus palustris Griff.

- Cane: 0.8-2 cm diameter; internode 10-25 cm long; durable and flexible.
- Location: this species is sparsely scattered throughout Cambodia.
- Habitat: semi-evergreen forest, evergreen forest and sometimes riparian forest.
- Use: its cane is classified as a small good quality rattan for handicraft and furniture. It is used to make bookshelves and for weaving chairs
- Trade: its canes are collected for either domestic use or international trade. A four to five-meter cane costs between 180 and 350 riels.

Calamus rudentum Lour.(Local Name: Phdao Doumbong)

- Uses: the cane is used for making frame and support for furniture, as well as bookshelves, beds, chair etc. It has a large diameter and is of good quality for furniture production. The demand is high and there is over-harvesting.
- Market: In Phnom Penh, the cane 4-5m is 4000 riel and village level 500-3300 riel. It is the most expensive species of all rattan. Export to Vietnam and Hong Kong have been reported but volumes are unknown.

Calamus tetradactylus Hance

- Cane: 0.35-0.5 cm diameter; internode 10-15 cm long.
- Use: there are very few records on the use of this species. Some local communities reported that its cane is used for weaving baskets and ropes.
- Trade: there is no record on the trade of this species in Cambodia, besides the collection for household use. However, neighboring countries like Lao PDR and Vietnam use this species extensively for crafts.

Calamus viminalis Willd

- Cane: 0.7-1.7 cm diameter; internode 10 to 30 cm long.
- Location: widespread across the country.
- Habitat: this species prefers dry conditions. It is found in semi-evergreen forest, mixed deciduous forest and on termite hill of deciduous dipterocarp forest.
- Use: it is a good species for handicraft and furniture making. A range of products made from this species includes basket handles, baskets, and mattresses. It is also used for walls and floors of bookshelves, beds, chairs and sofas.

- Trade: 220-350 riel for a cane of 4-5 m length. Its cane is extensively collected across the country for both domestic and international markets and thus this species is generally over-harvested.

Calamus rudentum Lour.

- Cane: 1.8-3.5 cm diameter; internode 12-20 cm long and durable.
- Use: its cane is used for making frames and supports for kinds of furniture including bookshelves, beds, chairs etc. It is a large diameter, good quality rattan for furniture that is in high demand and therefore over-harvested.
- Trade: a 4-5 m cane is around 4,000 riels in Phnom Penh, but its local price varies from 500 to 3300 riel. It is the most expensive species of all rattan. Exports to Vietnam and Hong Kong have been reported but volumes are unknown.

Calamus sp. (Local name: Phdao Toeuk Khmom)

- Cane: 1-2.3 cm diameter; internode 12-30 cm long; durable and flexible.
- Use: due to its durability and flexibility, the cane is preferably used to make the base in furniture like bookshelves, beds and chairs.
- Trade: it is extensively collected for commercial trade to Thailand and therefore over-harvested. A cane of 4-5 m long was worth 700 riels in Battambang province and 900-1,100 riel in Kravanh district, Pursat province.

Calamus godefroyi Becc.

- Cane: 1-1.3 cm diameter; internode 10-15 cm long; not durable and flexible.
- Use: it is used mainly by local communities for basketry and matting for local use.
- Trade: 150 - 250 riel for 4-5-meter-long cane. This species is at present extensively collected for basket waving at Krabei Real commune, Siem Reap province.

Daemonorops jenkinsiana (Griff.) Mart)

- Cane: 1-1.7 cm diameter; internode 10-25 cm long; durable and flexible.
- Use: its palm heart (shoot) is edible and eaten by local communities as vegetable. Larvae that live in the rattan shoot are also collected for food and sale. One larvae are 2000 to 4000 riel at local market or village, and up to around 8000 riels at urban market. Its cane is flexible and durable, and thus preferred for bending as a decoration of furniture production.
- Trade: it is heavily collected for either domestic or international trade but its harvesting volume is not known. A raw cane of 4-5 m long is 300-500 riel, and the price is up to 1200 riel a cane of the same length after first stage processing.

Korthalsia laciniosa Mart.

- Cane: 1.4-2.5 cm diameter; red; durable and poorly flexible. Usually categorized as a large diameter cane.
- Use: it is used for the frames of furniture.
- Trade: it is extensively collected for trade and exportation. A 4-5 m cane is 450-1000 riel, and rarely up to 1800 riel.

Myrialepis paradoxa (Kurz) J. Dransf.

- Cane: 1.2-2.1 cm diameter; internode 12-27 cm long; core soft; poorly flexible.
- Use: the cane has a soft core and hard bark which cannot be bent. It is used as a frame for lower quality furniture (mainly for local use).
- Trade: in the southwestern part of Cambodia, it is collected for sale to local handicraft artisans for the production of furniture. It is not suitable for export. A 4-5 m cane is 600-1000 riel, and rarely 300 riel or up to 1300 riel.

Myrialepis paradoxa (Kurz) J. Dransf. (Phdao Chhnour)

- Uses: The cane has a soft core and a hard bark; it cannot be bent. It is used as a frame of lower quality furniture (local use).
- Market: In the southwestern of Cambodia, it is collected for sale to local furniture and handicraft. But it is not suitable for export. For a cane of about 4-5 m the price is 600-1,000 riel, and rarely 300 riel or up to 1300 riel.

Plectocomia elongata Mart. & Blume

- Cane: 3-5 cm diameter, internode 10-25 cm long, poorly durable and flexible.
- Use: its cane is rarely used except for frames of chairs, tables, beds etc., for local communities.
- Trade: a 4-5 m cane is 1500 riel at Veal Renh rattan factory. It is collected mainly for local use and not for export.

Annex 5. Commercially Important Bamboo Species in Cambodia

Thyrsostachys siamensis (Kurz ex Munro) Gamb. (Local Name: Russey Pingpong)

- Description: Densely tufted bamboo, Culm dark green, erect or with arching tips, 8- 14m tall, 4-8 cm diameter; internodes 20-40cm long. Leaf blade oblique- oblong, 7-15 cm long, 2-4 cm wide, green above, light green underneath.
- Uses: Culm used for construction in communities, fishing material, household equipment; many kinds of basket. It is an important bamboo for local cash income.
- Market: The culm of 8-10 m long is sold 8,000-10,000 riels ($2-$2.5) (as of 2010), and it is for domestic trading only not for export

Bambusa bambos (L.) Voss ex Vilm (Local Name: Russey Prey)

- Description: Densely tufted bamboo, Culm erect, dark green, 15-25 m tall; 10-15 cm diameter; internodes usually 20-40 cm long, branches, and many thorns. Leaf blade oblique-oblong, 10-30 cm long, 3-5 cm wide, green above, light green underneath.
- Ecology: This species is distributed in deciduous forest, semi-evergreen forest in Cambodia and in some South-East Asia countries.
- Uses: This species is used for: fishing material, ladder for climbing the sugar palm tree. It is also used as a tool and as many kind of baskets as well. It is considered as the main source of local income.
- Market: It is sold at 8,000-10,000 riels ($2-$2.5) (as of 2010) and traded domestically.

Annex 6 - Acronyms

ADB	Asian Development Bank
ANR	Assisted Natural Regeneration
APFNet	Asia-Pacific Network for Sustainable Forest Management and Rehabilitation
BCR	Benefit Cost Ratio
CA	Conservation Agriculture
CBA	Cost-Benefit Analysis
CBNRM	Community-Based Natural Resource Management
CEPA	Culture and Environment Preservation Association
CF	Community Forestry
CFi	Community Fishery
CI	Conservation International
CoWES	Collaborative Management for Watershed and Ecosystem
CPA	Community Protected Areas
ELC	Economic Land Concession
FA	Forestry Administration
FAO	Food and Agriculture Organization
FFI	Fauna and Flora International
FiA	Fishery Administration
IRD	Institute of Forest and Wildlife Research and Development
IRR	Internal Rate of Return
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCDA	Multi-Criteria Decision Analysis
MoE	Ministry of Environment
NGO	Non-Government Organization
NPV	Net Present Value
NTFP	Non-Timber Forest Products
NTFP-EP	Non Timber Forest Products Exchange Programme
RF	Rainforestation Farming
TGC	Terra Global Capital
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WWF	World Wide Fund for Nature