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Asia-Pacific Network for Sustainable Forest Management

and Rehabilitation

COMPLETION REPORT

Reconstruction and sustainable management of degraded forest based on the combination of inter-planting nitrogen fixation rare tree species and thinning (2018P4-CAF)

01/01/2019-30/06/2022

Supervisory Agency

Experimental Center of Tropical Forestry, Chinese Academy of Forestry

Executing Agency

Institute of Forest and Wildlife Research and Development, Forestry Administration of Cambodia

08/2022

BASIC INFORMATION

Project Title(ID)	Reconstruction and sustainable management of degraded forest based on the combination of inter-planting nitrogen fixation rare tree species and thinning (2018P4-CAF)		
Supervisory Agency			
Executing Agency	Experimental Center of Tropical Forestry, Chinese Academy of Forestry (ECTF)		
Implementing Agency	Institute of Forest and Wildlife Research and Development, Forestry Administration of Cambodia (IRD)		
Date of Project Agreement: [dd/mm/yy] 14/11/2018			
Duration of implementation: [01/2019-12/2021], 36 months (extended by 6 months, to June 2022)			
Total project budget(in USD)	503,000	APFNet assured Grant (in USD)	378,000
Actual project cost(in USD)	317,291.45	APFNet disbursed Grant(in USD)	321,889

Disbursement Status	Date of disbursement	Amount(in USD)
First disbursement	[02/2019]	166,783
Second disbursement	[04/2020]	78,624
Third disbursement	[06/2021]	76,482

Reporting Status	Schedule implementation[1]	Project progress status[2]
Annual Project Progress Report (01/2019-12/2019)	track schedule	satisfactory
Annual Project Progress Report (01/2020-12/2020)	track schedule	satisfactory
Annual Project Progress Report (01/2021-12/2021)	Behind schedule	satisfactory
Annual Project Progress Report (01/2022-06/2022)	track schedule	satisfactory

[1] Schedule implementation status could be on track/behind/ahead of schedule
[2] Project progress status could be ranked as satisfactory, dissatisfactory, moderately satisfactory, moderately dissatisfactory

List of Project Steering Committee and Project Team

Table 1. Project team of ECTF

No.	Name/Title	Expertise	Responsibilities	Email
1	Prof. Daoxiong Cai	Forest Management	Design the project activity, ensure the completion of the project tasks within the project budget and validity period	rlzxcdx@126.com
2	Ms. Dongjing Sun	Forest Ecology	Make coordination and communications among different parties	happysdj@163.com
3	Mr. Hongyan Jia	Forest Management	Provide training and guidance for demonstration forest establishment and management	rlzxjhy@163.com
4	Prof. Wenfu Guo	Silviculture	Provide training and guidance for demonstration forest establishment and management	wenfuguo@163.com
5	Prof. Lihua Lu	Forest Ecology	Evaluate forest ecological and economic benefits, and provide technical support on establishing home gardens	07718526136@sina.com
6	Dr. Angang Ming	Forest Ecology	Assess non-forestry livelihood, and draft the evaluation report	mingangang0111@163.com
7	Dr. Lin Chen	Soil Science	Make coordination and communications among different parties, and prepare the work plan and reports	daqiqiu@163.com
8	Mr. You Nong	Plant Taxonomy	Set up plots, conduct field investigation and data analysis	343182947@qq.com
9	Mr. Shengjiang Pang	Silviculture	Set up plots, conduct field investigation and data analysis	rlzxpang@126.com
10	Mr. Ruiling Lan	Accountant	Ensure rational uses of project funds, assisting in funding transfer to IA, and providing financial materials required by	913299025@qq.com

No.	Name/Title	Expertise	Responsibilities	Email
			APFNet	

Table 2. Project officer of IRD

No.	Name/Title	Expertise	Responsibility	Email
1	Mr. Chan Ponika	Project Manager	Manage the project	ponikachan18@gmail.com
2	Mr. Prak Marina	Project Coordinator	Provide technical support and coordinate with local authorities and relevant	prakmarinafa@gmail.com
3	Mr. Seab Kimsrim	Central Project Staff	Manage the project	kimsrim71@gmail.com
4	Mr. Kong Boravuth	Provincial Coordinator	Coordinate and lead the project team, prepare the work plan and reports	kongboravuth79@gmail.com
5	Mr. Ros Tharoth	GIS specialist	Implement field activities and provide technical support on GIS-related matters	tharoth.ros168@gmail.com
6	Mr. Sum Onn	Field Project Staff	Implement field activities	N/A
7	Miss Hieng Sokny	Accountant	In charge of administrative and financial matters	hiengsokny.ird@gmail.com

Table 3. Steering Committee

No.	Name/Title	Expertise	Responsibility	Email
1	Prof. Shirong Liu	Chair	Review and endorse annual work plans and reports, make major decisions	Liusr9311@163.com
2	Prof. Yuanchang Lu	Forest Management	Provide technical guidance on forest management	ylu@caf.ac.cn
3	Mr. Hongyan Jia	Forest Management	Review annual work plans and reports and reports	rlzxjhy@163.com
4	Dr. Sokh Heng	Representative from IA	Review annual work plans and reports and reports	sokhhengpiny@yahoo.com
5	Mr. Tea Kimsoth	Representative from MAFF	Review annual work plans and reports and reports	kimsothtea@gmail.com
6	Mr. Vorn Monin	Representative from local authority	Review annual work plans and reports and reports	vornmonin@gmail.com
7	Mr. Ruiling	Accountant	Review budget plan and	913299025@qq.com

No.	Name/Title	Expertise	Responsibility	Email
	Lan		expenditure	

Executive Summary

This project was conducted in Bos Thom village, Khna Por commune, Soth Nikum, Siem Reap province, Cambodia. The community forest was established in 1997. The forest is a mix of evergreen and deciduous forest, and protected by the farmers for naturally regeneration. The growth of forest is slow and some important species have been lost. Some parts are degraded with only a few trees left. This project is to accelerate forest resource restoration and improve livelihood of local farmers in Cambodia through establishment of demonstration forests and holding technical training. Since the launch of the project, project activities were implemented as planned, in accordance with the tasks and schedule of the Project Documents and Annual Work Plans. A demonstration forest, covering 50 hectares, was established, maintained and rehabilitated. The demonstration forest included 5 ha of severely degraded forest, 20 ha of moderately degraded forest, and 25 ha in slightly degraded forest. A total of 16,598 seedlings of nitrogen-fixed valuable species were planted in severely and moderately degraded forest. Silvicultural treatment was conducted to the target trees (20 species) in the slightly degraded forest to promote their growth. A total of 19.94 ha of home garden was established by planting fruit trees and short-term crops. Each of 20 households was provided with a set of solar system to provide electricity energy. Moreover, our project supported some poor villagers with revolving fund of USD 7,840 to help them improve their livelihood activities. To date, the revolving fund has increased to USD 8,950. In order to assess the effect of project implementation on livelihood improvement, the project team selected 37 households and conducted a livelihood assessment every year. At the end of the project, we evaluated the ecological and economic benefits of the converted degraded forests. To share the best knowledge and experiences on tropical degraded forest restoration, we held an international seminar, compiled a technical manual, made a promotional video and issued leaflets, and wrote news. The villagers of the local community are very active in participating in the project activities, therefore the forest quality has been significantly improved, and livelihoods have also been greatly improved.

However, due to Covid-19 epidemic and international travel restriction, some activities have been canceled or delayed. The project team made the following adjustments: 1) a six-month extension; 2) project director was changed from Prof. Cai Daoxiong to Jia Hongyan, because Prof. Cai Daoxiong retired in 2021; 3) Sample plots measurement (Activity 1.2.1) was entrusted to IRD, and ECTF made the survey plan; 4) International seminar in China (Activity 3.2.1) was changed to an online seminar; 5) ECTF team provided technical guidance through online communications instead of flying to Cambodia (Activity 3.2.2); 6) Forests ecological and economic benefits evaluation (Activity 1.3) and technical manual compiling (Activity 3.3) were postponed to 2022; 7) Increased budget of project dissemination (brochures,

short video, and publish fees for technical manual) and project extension (forest thinning and tending, field monitor, alternative energy sources, revolving fund and labor cost) were resolved by the project team, and did not request extra budget from APFNet.

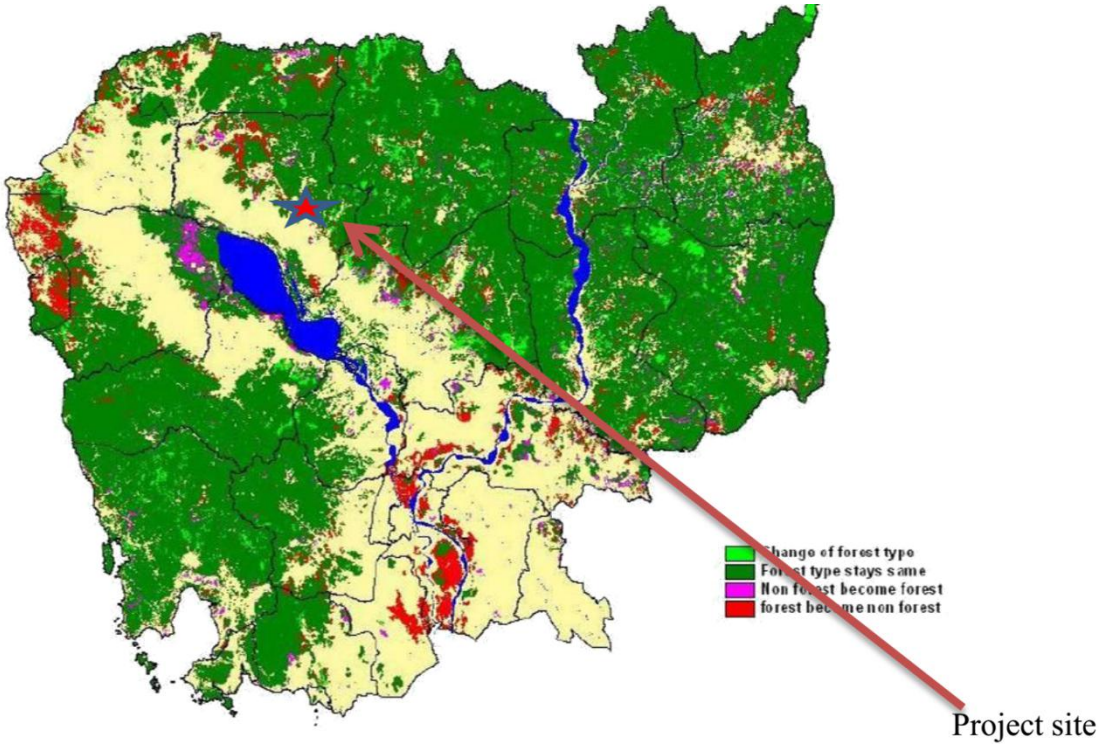
CONTENTS

1. BACKGROUND AND INTRODUCTION

1.1 Project context

After years of continued over-exploitation and deforestation, Cambodia faced forest degradation and decline of the forest resources. The project established a pilot demonstration in the degraded forests in Bos Thom village, Khna Por commune, Soth Nikum, Siem Reap province to demonstrate the restoration techniques. The goal of the project is to increase the level of forest restoration and promote forest sustainable management in Cambodia through the establishment of demonstration forests and technical personnel training, and also improving the livelihoods of local people through non-forestry livelihood activities.

The following shows the maps of the project site.



1.2 Project goal(s) and objectives

The objectives of the project are:

(1) To demonstrate effective approaches on degraded forest transformation to improve the growth and quality of the forest stand and enhance ecological services by enhancing forest restoration and sustainable forest management. About 50 hectares of demonstration forest will be restored by thinning and replanting with nitrogen-fixing tree species.

(2) To improve the livelihood of the local forest dependent poor people by establishing 10 hectares of home garden with short-term economic benefits of fruit trees or crops with high economic value and setting up 16 small solar

equipment to provide adequate electricity.

(3) To share information and knowledge of best practices on forest restoration and rehabilitation by organizing a technical training course for the local people and holding an international seminar on restoration and reconstruction of tropical forest, to improve the awareness of forest restoration and sustainable forest management; a technical manual will be compiled and distributed to share the best practice and experience of the project.

1.3 Project expected outputs and outcomes

The expected outputs in Project are:

(1) Through the thinning of non-target species and group inter-planting in gaps with rare tree species of biological nitrogen fixation ability, 50 hectares of deforestation demonstration forests will be established.

(2) Establishing 10 hectares of home garden with commercial trees/crops with high economic benefits in the short-term, and develop alternative energy by installing 8 small solar equipment;

(3) Hold a training courses and on-site practice for local people, to improve the awareness of forest restoration and forest restoration and sustainable forest management at the demonstration sites and local villagers.

2. PROJECT IMPLEMENTATION

2.1 Project schedule and implementation arrangements

Output 1: To explore and demonstrate effective approaches on degraded community forest, optimize the forest structure, and improve forest ecosystem services.

Activity 1.1 Forest status inventory and species screening

Activity 1.1.1 Forest status inventory

Activity summary

The initial forest inventory was carried out using the sample plots conducted in December 2018. The forest inventory data will provide a technical guidance for the selection of artificial supplementary tree species and forest management in local communities. An inventory team, led by Guo Wenfu (ECTF) and supported by qualified professionals from the ECTF, IRD, local FA staffs, and villagers, was organized to conduct the inventory. The characteristics of forest structure, productivity and soil fertility for each forest type was investigated.

Methods

The target area of this project is a community forest covering a total area of 445 hectares (194 ha fully stock, 207 ha saplings/poles, 44 ha grassland/open). The forests are mainly composed of evergreen and

deciduous forest. Based on plant community appearances and internal species compositions, the community forest is classified into three types (i.e. Severely Degraded forest, canopy<20%; Moderately Degraded forest, canopy 20%-60%; and Slightly Degraded Forest, canopy ≥ 60%). Three sample plots of 600 m^2 are selected randomly for investigation in each forest type.

The data collected from the sample plots include: (1) species name, DBH and height of each tree (DBH ≥ 5cm) in the tree layer; (2) species name, height, number and coverage in the shrub and herb layers. Soil samples from 0-20cm, 20-40cm, and 40-60cm, respectively in each of the plots in different forest types. The soil samples were sent to a laboratory in Phnom Penh to determine bulk density, water holding capacity, texture, N, P, K, Ca, Mg contents.

Results

Forest status

Based on the investigation results, tree number, density and volume were significantly different among three degraded forest types. In Severely Degraded forests, the density of the forest was 139 trees per hectare, with a canopy of 0.2; in Moderately Degraded forest, the density was higher, 656 trees per hectare and canopy of 0.6; and in Slightly Degraded forest, the density was 1,328 trees per hectare with canopy of more than 0.9. There was no significant difference in the average DBH and height between Severely Degraded and Moderately Degraded forests. However, the DBH, height and stock volume in Slightly Degraded forest was higher than those in the other two types (Table 1).

Table 1. Tree growth in three forest types

Indicators	Severely Degraded forest	Moderately Degraded forest	Slightly Degraded forest
Number of trees per ha	139c	656b	1328a
Avg. DBH (cm)	10.69b±6.55	8.8 b±4.74	12.28a±7.41
Avg. Height (m)	8.38b±3.62	8.11b±3.37	13.85a±4.90
Avg. stock volume (m^3/ha)	5.77c	18.64b	115.73a

Diameter class distribution

The forest was mostly composed of small-diameter trees in all forest types. Even in the Slightly Degraded forests with less human disturbance, quality and productivity of the forests were quite low (with a stock volume of 115.73m^3/ha). There was a high proportion of small diameter poles (avg. DBH of 12.28 cm) and few large diameter trees (Table 1). It was expected that there will be few commercial and harvest-able trees in the next 20 years.

Plant diversity of forest community

Plant diversity indexes in the tree and shrub-herb layers were investigated in three forest types, respectively (Table 2). The results showed that there were significant differences in the species richness index and Shannon-Wiener index among three forest types. Slightly Degraded forests had a more stable and reasonable community structure, and the dominant tree species could regenerate well with good potential for long-term succession. The stability, plant diversity and natural resilience of Severely Degraded forests were lower due to higher number of invasive species.

Table 2. Plant diversities in three forest types

Forest types	Severely Degraded forest		Moderately Degraded forest		Slightly Degraded forest	
Layer	Tree layer	shrub-herb layer	Tree layer	shrub-herb layer	Tree layer	shrub-herb layer
Species richness index	11	12	26	22	34	31
Shannon-Wiener index	2.21	0.7039	2.84	2.0462	2.94	2.7337
Simpson index	0.87	0.2669	0.92	0.8153	0.93	0.8878
Evenness index	0.92	0.2833	0.87	0.6620	0.83	0.7961
Species richness index	3.11	1.7378	5.24	2.9827	6.03	5.9715
Ecological dominance	0.09	0.7326	0.07	0.1840	0.07	0.1063

Forest soil condition

Soil physical properties. Average content of silt clay in 0-40 cm soil was 26.1-30.2%. The soil texture was sandy loam and loamy. The average soil water content was 7.1-8.3%. There were no significant differences in texture and moisture content among three forest types.

Soil chemical properties. Soil pH, organic matter, total nitrogen, total phosphorus, available phosphorus contents, and other soil properties were analyzed. Total N content in the Slightly Degraded forest was significantly higher than those in other two forest types (Table 3).

Overall, there was a similar characteristic of the forest soil in the tropical monsoon forest. It was a strong acid forest soil (pH4.5-5.5), sandy loam or light loam in its texture. The soil was relatively dry since soil sample was taken in dry season, but the plants and trees could still grow well.

Table 3. Soil physical and chemical properties in three forest types

Properties	Severely Degraded forest	Moderately Degraded forest	Slightly Degraded forest
Silt clay content (%)	30.2±7.59	25.6±5.19	25.9±6.67
Water content (%)	8.3±0.40	7.1±0.61	7.7±0.39
pH	5.05±0.22	4.97±0.20	4.76±0.10
Organic Matter (%)	3.01±0.37	2.26±0.26	3.03±0.29
Total Nitrogen (%)	0.1233b±0.0076	0.1250b±0.0087	0.1583a±0.0104
Total Phosphorus (%)	0.0357±0.003	0.0262±0.0127	0.0300±0.0035
Available Phosphorus (ppm)	31.81±6.31	28.00±0.86	28.50±0.50

Activity 1.1.2 Screening out suitable species

Activity summary

A small workshop was held in Siem Reap in December 2018. Project members from the ECTF, IRD and local FA participated in the workshop to discuss and select suitable species for artificial planting in the degraded forest. The principle for species screening was nitrogen-fixed local tree species with strong adaptability and high economic value. Based on the available Cambodian Species List as well as the field investigation, the team had screened out 4 suitable tree species for planting: Dalbergia cochinchinensis Pierre ex Laness, Pterocarpus macarocarpus Kurz, Afzelia xylocarpa (Kurz) Craib and Cassia siamea Lam. D. cochinchinensis and P. macarocarpus were considered priority tree species, while A. xylocarpa and C. siamea were alternate tree species. If the priority tree species had poor survival rate or bad performance during the first planting year, the alternate tree species would be used for enrichment planting in the next year.

Activity 1.2 Demonstration forests establishment by thinning, inter-plantation and tending

Activity summary

The ECTF team had designed three approaches of restoration measures for different degraded forests in December 2018. A detailed implementation plan was provided by ECTF as a field work instruction and guideline. The IRD team and 40 trained villagers had conducted the field work since March 2019.

A 50 hectares of demonstration forest was established in the project area. A total of 2,534 future crop trees with high value and good growth potential were selected and tended in 25 ha slightly degraded forest. A total of 16,598 N-fixed and high value seedlings (i.e. 9,6500 D. cochinchinensis, 1,598 A. xylocarpa, 4,000 P. macrocarpus, and 1,350 C. siamea) were planted in 5 ha severely degraded forest and 20 ha moderately degraded forest. New plantations were tended two or three times each year by removing the

surrounding weeds three months after planting.

Implementation details

Activity 1.2.1 Sample repetitive measurement

According to the degrees of human disturbance, plant community structure and composition of the forest, the demonstration forest was divided into severely degraded forest, moderately degraded forest, and slightly degraded forest. Three plots from each type and a total of 9 fixed sample plots were set up for measurement. The sample plot was circular in shape, with a radius of 13.8 m and an area of 600 m^2. PVC pipe was inserted in the center of the sample circle as a mark.

Growth of replanted seedlings and remaining trees, stand structure and diversity, and soil physical and chemical properties were investigated in December 2018 and January 2022, respectively. Due to the Covid-19 epidemic and international travel restrictions, the ECTF team canceled the flying to Cambodia to do the sample repetitive measurement. The second sampling was conducted by IRD team with technical support from ECTF.

Activity 1.2.2 Site preparation and planting

① Five (5) hectares of Severely Degraded forest (open forest land) were selected for afforestation conducted using the "Belt Planting"method.

Fires often occurred in the weedy areas in the dry season, resulting in slow growth of trees and depleted nutrients in soils. Considering this issue, the project team designed a "Belt Planting" model for restoration. Planting Belt of 4 meters and Control Belt of 3 meters were repeated alternatively (Figure 1). All vegetation in the Planting Belt were cleared out, while those in the Control Belt were remained. The screened-out N-fixed tree species (i.e. Dalbergia cochinchinensis, Pterocarpus macarocarpus, Afzelia xylocarpa and Cassia siamea) were planted in the Planting Belt at the space of 2 m × 2 m (i.e. at 1,430 seedlings/ha). A total of 7,150 N-fixed seedlings were planted in the 5 sites separately (Site 1 = 1.592 ha; Site 2 = 0.741 ha; Site 3 = 1.318 ha; Site 4 = 1.15 ha; and Site 5 = 0.246 ha), and a total of 5 hectares of demo-sites was established in Severely Degraded forest in June, 2019 (Figure 2). A survival rate was conducted by the ECTF team in early July, 2019 (20 days after planting), and the survival rate was found to be 99%.

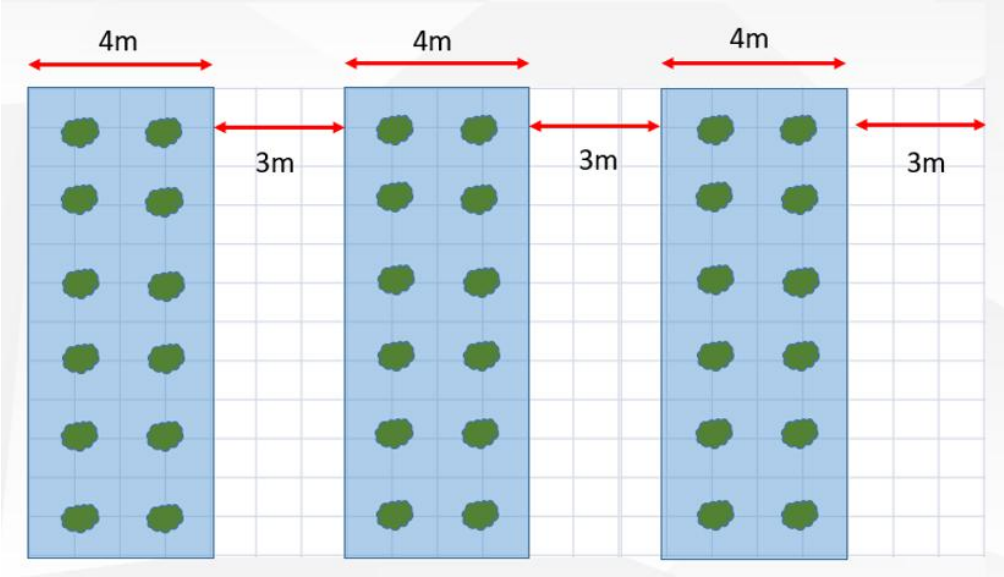


Figure 1. Belt Planting mode in Severely Degraded forest

Figure 2. Site preparation (left) and new plantation (right) in Severely Degraded Forest

② Twenty (20) hectares of Moderately Degraded forest were selected for inter-planting using the “Cluster Planting” model.

In early 80’s to 90’s, the forest was severely damaged by settlements, logging, land encroachment, shifting cultivation, etc. In 1998, the community forestry was established to protect and restore natural resources, so that the area now became a moderately degraded forest.

With technical support from ECTF, 20 hectares of demo-sites was

established in Moderately Degraded forest at the end of June 2019 and 2020 (Figure 4). The planting plot was 6 meters in diameter, and the distance between the plots was around 10 meters, and therefore there would be 90-120 gaps or plots per hectare (Figure 3). Four planting holes (50 x 50 x 30 cm) were dug in each plot, and 4 N-fixed seedlings were planted in each plot at a space of 2 × 2 m, with a cluster planting mode (i.e. at 400 seedlings/ha). Thinning and clearing were conducted two or three times each year by removing the shrubs and low-quality trees. Dominant trees with straight trunks and valuable tree species were retained, while the low-quality trees, shrubs, liana and weeds were cleared. Most of the thinned trees and shrubs were used for firewood. A survival check was conducted by the ECTF team in early July 2019 (20 days after planting), and the survival rate was 100%.

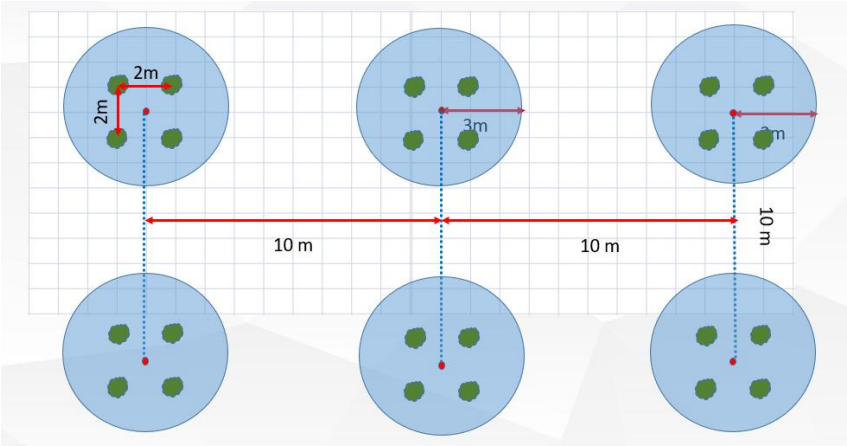


Figure 3. Cluster Planting mode in Moderately Degraded Forest

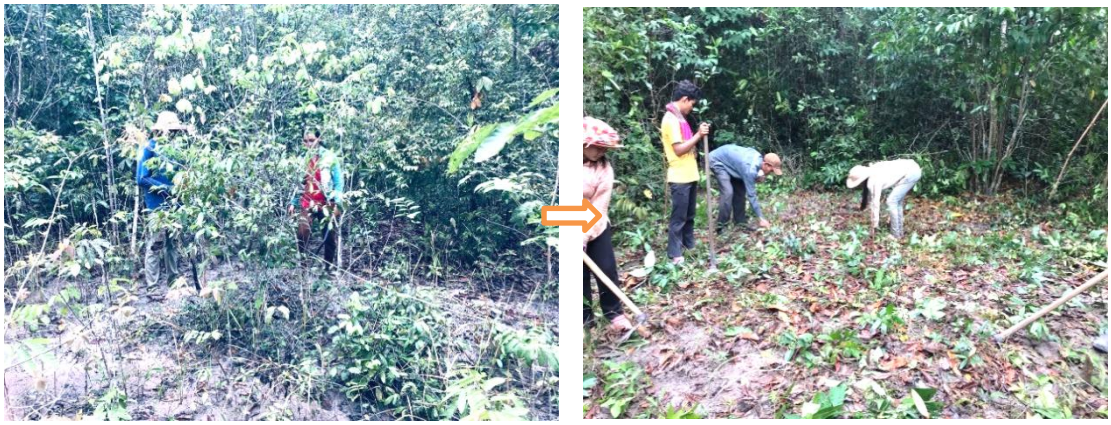


Figure 4. Site preparation in Moderately Degraded Forest

Activity 1.2.3 Plantation maintenance

The project team together with a group of villagers visited the field monthly, to checked the growth of planted seedlings and protected them from cattle and other unnecessary plants, such as vines, weeds, etc (Figure 5).

Figure 5. Check the survival rate of seedlings

Activity 1.2.4 Thinning and tending

① Five (5) hectares of severely degraded forest and twenty (20) hectares of moderately degraded forest

Tending/weeding was conducted three (3) times in the 25 ha of new plantation, including 5 ha of severely degraded forest and 20 ha of moderately degraded forest which were planted in 2019 and 2020. Grass, weeds and vines were cut in a 1-meter circle area and placed around the seedlings. In addition, removing the poor sprouts and kept the best one for the multi-rod

seedlings. The nearby shrubs those interfering the growth of seedlings were fell down. This would help provide a favorable environment for seedlings and conserve soil water availability (Figure 6). During tending, some dead seedlings were found and replaced in time. About 845 seedlings were replanted in moderately degraded forest and 470 seedlings in severely degraded forest.

Figure 6. Before (left) and after (right) weeding

② Twenty five (25) hectares of slightly degraded forest

After conducting field survey, the team from ECTF and IRD decided to select the slightly degraded semi-evergreen forest to improve the quality and value of forests. This type of forest has high coverage, but the productivity is lower due to no management.

The team selected 20 commercial tree species equivalents to 2,534 trees with high-value and good growth-potential (Table 4). These trees were marked as Future Crop Trees (FCT), painted on the trunk at DBH, and recorded their UTM coordinates (Figure 7). The FCTs are distributed in the central part of Bos Thom CF (Figure 8). The vines/climbers were cut off surrounding the FCTs to assist their growth. The field work was finished at the end of April 2019.

Table 4. Summary of Selected Trees in the 25 ha Slightly Degraded Forest

Scientific Name	Local Name	No. of Trees Marked
Anisoptera costata Kort	Phdeak	163
Artocarpus sampor Gagnep	Som Por	2
Artocarpus rigidus Blume	Khnol Prey	64
Carallia brachiata Merr	Tro Meng	118
Dehaasia cuneata Blume	Khtet	4
Dialium cochinchinensis Pierre	Krolanj	188
Diospyros pilosanthera	Tro Yeng	312
Dipterocarpus alatus Roxb	Che Teal	4

Scientific Name	Local Name	No. of Trees Marked
Dipterocarpus intricatus Dyer	Trach	79
Eugenia Spp	Pring	451
Hopea odorata Roxb	Koki	1
Irvingia malayana	Chombok	269
Lagerstroemia calyculata Kurz	Sro Lov	43
Mangifera indica L.	Svay Prey	5
Parinarium annamensis Hance	Thlok	199
Peltophorum dasyrrhachis	Tro Sek	349
Pterocarpus macrocarpus Kurz	Thuong	22
Shorea cochinchinensis Pierre	Popel	44
Sindora cochinchinensis H.Baill	Kor Kos	85
Vatica odorata Griff	Chromas	132
Total		2,534

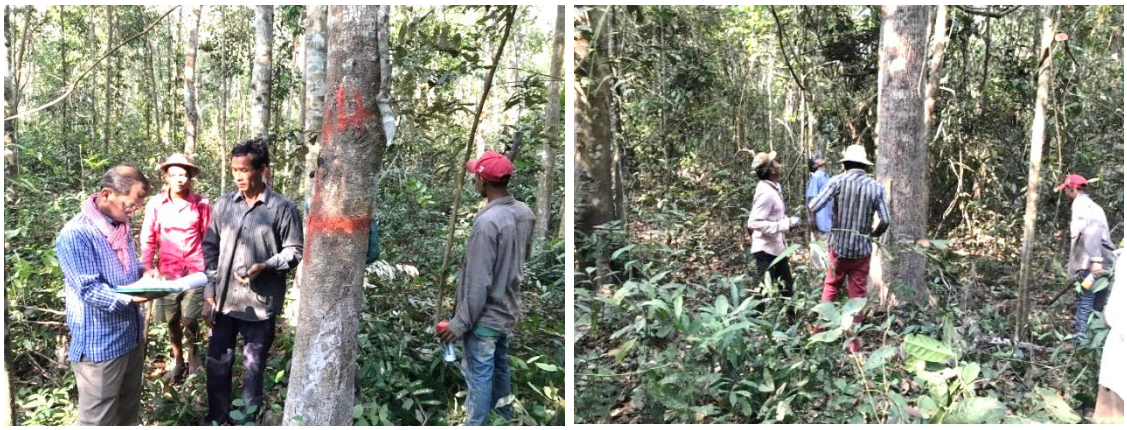


Figure 7. Tree selection and marking future crop trees

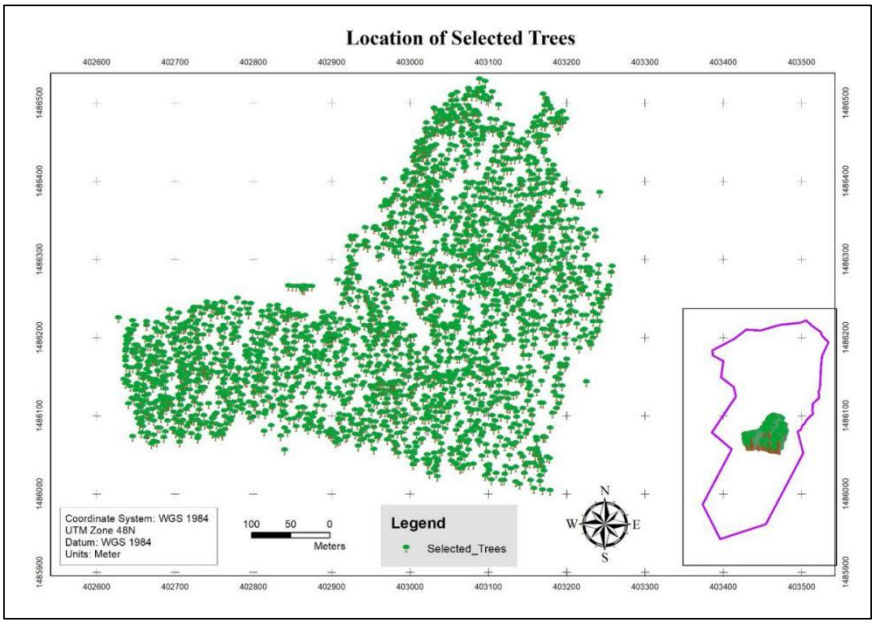


Figure 8. Location of selected trees within Bos Thom CF

The team conducted 3-time thinning in the 25 ha of slightly degraded forests (Figure 9). All non-valuable plants including shrubs, vines, poor sprouts of the marked/selected future crop trees (less than 5 cm in diameter) were all removed to help growth of the future crop trees. The poles collected from thinning site were given to the villagers for firewood in households, tools of crop cultivation, or the chicken, cow and pig cages.

Figure 9. Conduct silvicultural practices to enhance growth of future crop trees.

Activity 1.3 Forest ecological and economic assessment

In order to evaluate forest economic and ecological benefits, we monitored 9 sample plots with three forest degradation types throughout the project. Survey indicators included soil physical and chemical properties, forest structure, forest growth, biodiversity, and forest carbon storage.

After 3.5 years of project implementation, forest community structure was further optimized, and carbon storage of the forest ecosystem increased significantly. Both stand volume and economic value increased obviously because we inter-planted a large number of nitrogen-fixed precious tree

species, and took some measures to improve the crop trees' growth that grew faster than the other trees. Additionally, soil organic matter were all increased significantly in three types of forests. However, some other growth and soil physio-chemical indicators did not change significantly due to the short implementation period of the project.

Output 2: Non-forestry livelihood activities are developed to improve the local's livelihood.

Activity 2.1 Construction of home garden and planting fast-growing fruits and/or crops of high economic value

Activity Summary

The village has 108 households who live on cultivating rice, collecting non-timber forest products, and production of other crops. A baseline survey to Bos Thom village was conducted by the team in May 2019. The information of current income, family population, preferred fruit trees and crops, available land for home garden, etc. were interviewed and recorded. The project originally planned to build a 10-hectare home garden. Because home garden is very popular in Cambodia, twenty eight (28) and twenty three (23) households were selected to establish a total of 19.94 hectares home garden in early July 2019 (9.94 ha) and 2020 (10 ha), respectively.

The ECTF team designed two models i.e. Fruit Tree Model and Mixed Fruit Tree & Crop Model, for the establishment of home garden (Figure 10). The IRD team made a specific design for each household in planting fruit trees and crops. The selected households were provided with high economic-value fruit tree seedlings i.e. lemon, orange, mango, and short-term crop seeds i.e. long bean, eggplant, etc. (Table 5 and Figure 11).

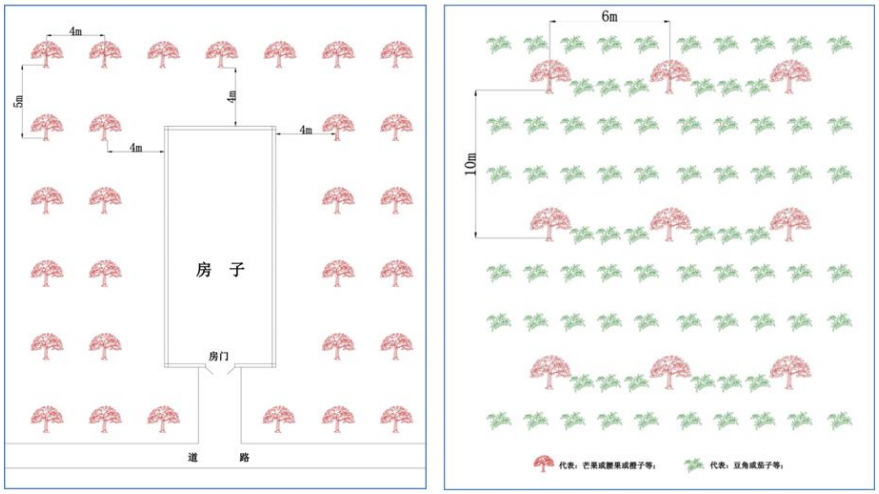


Figure 10. Fruit Tree Model and Fruit Tree & Crop Mixed Model, for home garden establishment

Table 5. List of Fruit trees and Vegetable given to farmers

No.	Description Species	Unit	Quantity
	Vegetable (seeds)		
1	cucumber	can	42
2	long bean	can	82
3	egg-plant	can	122
4	Chili	can	82
5	bitter melon	pack	43
6	Cabbage	can	40
7	Growing net	pack	170 (1pack =60m)
	Fruit Tree (3204 seedlings)		
1	Orange	Seedling	600
2	Lemon	Seedling	360
3	Sapodilla	Seedling	655
4	Sweet mango	Seedling	460
5	Mango	Seedling	668
6	Longan	Seedling	291
7	Guava	Seedling	170

Figure 11. Distribute fruit tree seedlings and vegetable seeds to farmers

Implementation Details

- Fruit Trees Model. This model was to establish home garden by planting fruit trees surrounding folk houses. Popular fruit tree species with high-economic value such as mango, lemon and orange are selected for establishing home garden. The planting density is 500 trees/ha, with a space of 4 × 5 m.
- Fruit Tree-Crops Model. This model was to plant fruit trees among the existing crop land (i.e. eggplant, long bean, etc.). The planting density of fruit trees was 166 trees/ha, with a space of 6 × 10 m. The space of crops varied from different crops.
- Key Technologies.
  Seedlings: Grafted seedlings with nutrition bags would be used. The seedlings should be 40-50 cm in height and healthy, no damage, no diseases and insect pests.
  Site preparation: The size of planting pit should be 80 × 80 × 50 cm. The surface soil and the inner soil should be separated while digging the pit.

About 2.5-3 kg of manure or compost was applied into each pit. When pushing back the soil, mix the compost and surface soil, and push the mixture in the bottom of the pit while the inner soil should be on the top.

Planting season: should be planted in rainy season while the pit was totally wet.

Planting: First, a small hole was dug with the planting hoe in the center of the pit. The hole was slightly bigger and deeper than container size. Second, unfold the plastic bag of the seedlings, and squeeze the soil of the root to avoid soil loss, and place in the hole. Keep the seedlings upright and fill back the soil. Stamp the soil around the seedlings tightly, and then backfill 2-3 cm of loose soil to keep the moisture in the soil. Finally, put a stake to support the seedlings and prevent from falling.

Management: The planted seedlings were watered enough to soak the root zone after planting. Weeding should be conducted in time when the weeds grows rapidly competing the growth of seedlings. Another fertilization (i.e. manure or compost or urea) should be applied 30 days after planting to promote the growth of the young trees.

The project team followed up the activities of livelihood improvement. The team regularly visited the individual household to visit the home garden (Figure 12). The selected farm for this activities continued cultivating crops and maintaining the fruit trees in their own garden.

Figure 12. Visiting the fruit trees and vegetables in home garden

Activity 2.2 Developing community alternative energy sources and conserving forest resources

The village was located in rural area that was not connected to the electrical grid. The project team consulted with the heads of the village and community to select the right households for supporting solar systems. The project originally planned to install 16 sets of solar system in 2019 and 2020. Because many households did not have electricity, we added another 4 sets of solar system equipment in 2022, with a total of 20 sets. Eight (8), eight (8), and four (4) households in the village were supported with a set of solar system each in 2019, 2020 and 2022, respectively (Figure 13). The set of solar panels were working and generating electricity for daily use of the households. The households qualified under the following selection criteria:

1. Family participate in the community activities
2. Family has enough land for home garden
3. Family doesn't have electricity connection

Figure 13. Solar systems provided to farmers

Activity 2.3 Revolving funds and marketing of village products

The livelihood condition in the community was still low and lack of money conducting livelihood activities. The project team established a group loan in the village for poor farmers who needed money to expand or create livelihood activities (Figure 14). This project provided a loan to 39 members with 4 groups. The loan was managed by a committee consisting of 5 members (3 women). Regulation and loan contract were developed, and managed by committee and project coordinator. The committee set up benefit sharing of the interests under the following scheme:

a. 65% of interest put into the loan or use for forest development
b. 25% of interest will be shared to the committee
c. 5% of interest for administration cost
d. 5% of interest for contribution to commune

Figure 14. Establishment of Loaning Group

The team followed up the revolving fund provided to the community (Figure 15). It was reported that the process of fund management were going well. Up to now, the total amount has been increasing up to $ 6,238 compared to the original fund $ 5,000. In 2022, we added another $2,840 to our revolving fund to improve villagers' livelihood activities.

Figure 15. Check the running of revolving fund

Activity 2.4 Assessing the livelihood improvement

The livelihood assessment was conducted annually since 2019 in order to monitor the changes of the livelihood improvement of the community during the project period. The project team selected 37 households who received direct benefits from the project, such as home garden, solar panel and loan for interview (Figure 16). The specific objectives of the livelihood survey were as follows:

1. To understand the situation, living standard, social economic of the selected households in the target area with respect to livelihood

activities, annual income and expand, and the support of the project;

2. To assist the project and stakeholders in determining whether verifiable indicators and related targets, stated at the beginning of the project and encapsulated in Outcomes 2 is achieved over time; and
3. Examine the current situation of the project beneficiaries in terms of their economic and social aspects and the issues affecting their lives.

Figure 16. Interview Assessing livelihood improvement

According to the livelihood survey report, about 81.08% of respondents were males, and males were likely the head of households who knew more about family status and project information. Majority of them was below 45 year old, which was a productive age. About 51.35% were illiterate since they were born during the civil war, and in rural area where education was not widely distributed at that time. About 81% were pure farmers (working on rice and crop production), and a few had extra jobs, such as house constructor, vendor, village chief, and high school teachers. About 86% of the respondents had a residential land (eg. home-garden) less than one hectare. Majority had an agricultural land ranging from one to five hectares, which would generate incomes depending on the size of their lands.

The largest income was from labor, followed by rice production and vegetable cultivation. The rest income were from livestock, NTFP (charcoal, wild fruits, mushroom) and others. The largest expenditure was food, followed by farming activities and education. Each household had higher income than expenditure from 2019 to 2021. They could save around 925 $, 1438 $, and 1357 $ as an asset in 2019, 2020 and 2021, respectively.

Activity 2.5 Field monitoring

Staff from IRD travelled from Phnom Penh to Bos Thom village once a month to monitor the field activities, such as establishment of demonstration forests and home gardens, etc. to ensure the implementation of the activities.

The management team of forestry administration (FA) and IRD who were the project leaders in Cambodia visited the site for nine times, and followed up the progress of the project via monthly report and meetings (Figure 17).

Figure 17. Project team meeting and on-site visit

Output 3: To share information and knowledge of best practices on degraded forest restoration and rehabilitation in Cambodia.

Activity 3.1 Awareness raising and training courses/study tours for local and nearby staff and farmers

Training course

A training course was organized by the ECTF to train local people surrounding the project sites in December 2018. The training course included indoor lectures in the nearby primary school and outdoor practical training (Figure 18). Experts from the ECTF gave two indoor lectures: forest restoration technology and home garden establishment. Basic silvicultural techniques were trained in outdoor practice, i.e. site preparation, planting techniques, maintenance and tending. Fourty (40) local people were trained, including forestry managers/technical personnel as well as community farmers.

Figure 18. Indoor and outdoor technical trainings

Inception workshop

The project inception workshop was held in Siem Reap 20-21th December, 2018. About 50 Participants from the FA, ECTF, local authorities, local communities, NGO and other stakeholders attended the inception workshop (Figure 19). Mr. Sea Ra, the Deputy Director General of FA, Mr. Zhang Zhong Tian, the AED of APFNet, and Mr. Tea Kimsoth, the Director of Provincial Department of Agriculture, Forestry and Fisheries gave remarks in the opening ceremony. With the witness of Mr. Sea Ra and Mr. Tea Kimsoth, the project agreement was signed by Dr. Zhang Zhong Tian, the AED of APFNet, Dr. Sokh Heng, the director of IRD and Prof. Cai Daoxiong, the director of ECTF.

In the academic exchange section, oral presentations were given by experts from FA, ECTF and RECOFTC, including forest management and supportive policy in Cambodia, an overview and best practices on sustainable management and restoration of degraded forests in ECTF, supporting community forestry on sustainable forest management and forest restoration. The project director Prof. Cai Daoxiong introduced the overview of the project. Participants discussed and comments actively about project activities.

The day after the inception workshop, the participants visited the Bos Thom community forest in Siem Reap, and had a face-to-face discussion with participating communities on their perceptions of and expectations from this project.

Figure 19. Inception workshop

Activity 3.2 Holding seminars and technological discussion and experience exchange between China and Cambodia

Activity 3.2.1 Holding international seminars on Restoration and Reconstruction of Tropical Forest

On 8th June 2022, we hold an online international seminar on Restoration and Reconstruction of Tropical Forest to share the experience and outputs of the project (Figure 20). About 46 experts and young scholars participated in the seminar, including Asia-Pacific Forest Restoration and Sustainable Management Organization (APFNet), Institute of Forest and Wildlife Research and Development of Forestry Administration of Cambodia (IRD) , Research Institute of Tropical Forestry of Chinese Academy of Forestry (RITF), Henan University, Guangxi Academy of Science, and the ECTF. Taking into account the uncertainties of the Covid-19 epidemic, we changed the on-site international seminar to an online meeting.

Figure 20. China-Cambodia International seminar on Tropical Forest Restoration and Reconstruction

Four well-known experts and scholars were invited to give presentations in the seminar. The topics focused on the transformation and sustainable management of degraded forests, afforestation and forest restoration, tropical

forest protection and restoration, and multi-functional multi-functional activities led by the cultivation of precious tree species and large-diameter timber. Also, the participants discussed the effective ways to restore tropical degraded forests and the advantages and potential of sustainable forest management in coping with climate change, which would better promote ASEAN forestry cooperation and regional economic development.

Activity 3.2.2 To provide technical guidance and implement project activities

The ECTF team flied to Cambodia for two times to conduct project activities (Figure 21). The first trip was in December 2018, a group of 6 people flied to Cambodia to attend the inception workshop, conducted forest inventory survey and organized a training course. The second trip was in July 2019, a group of 3 people flied to Cambodia to check the performance of the new planted seedlings, provided technical support on tending and maintenance, as well as home garden establishment.

Figure 21. ECTF team fly to Cambodia to provide technical guidance

However, due to the Covid-19 epidemic and international travel restrictions, the ECTF team could not fly to Cambodia to provide technical guidance and implement project activities in both 2020 and 2021. Instead, the ECTF team provided technical guidance through online communications.

Activity 3.3 Technical manual compiling

Under the guidance of the expert committee, the project team developed a technical manual in three versions (Chinese, English, and Cambodian languages) for internal and external use under the supervision of the project team. The technical manual in English and Chinese version will be published in China Forestry Publishing House, and a total of 300 copies will be issued (Figure 12).

The outline of the technical manual mainly includes four chapters, of which Chapter one (1) Overview of forest degradation; Chapter two (2) Overview of degraded forest restoration; Chapter three (3) Application case of tropical degraded forest restoration and sustainable management in Siem Reap, Cambodia; Chapter four (4) Experiences sharing on restoration of tropical degraded forests.

Figure 22. Publish a technical manual

Activity 3.4 Project dissemination

2.2 Project resources and costs

The budget of this project is $503,000, of which $378,000 is funded by APFNet and $125,000 is contributed in kind by IRD.

By 15th July 2022, APFNet has funded $321,889, of which $166,783 was allocated in February 2019; $78,624 was allocated in April 2020; $76,482 was allocated in June 2021. The actual expenditure was $317,291.45, the balance of funds was $4,597.55.

The EA and IA have established a project account and nominated some special financial personnel to ensure the reasonable use of project funding. The approved budget and actual expenditure during the reporting period budget (both by activity and

by category) are shown in Annex B.

2.3 Procurement and consultant recruitment

We purchased some equipment based on the approved work plans. These equipment are directly and only used by the Project and contributed to the achievement of project goals and objectives. A detailed list of purchased assets is shown in Table 6.

Table 6 A List of purchased equipment

No.	Equipment name	Anticipated (USD)	Unit price (USD)	Number	Actual cost (USD)
1	Solar System	3,600	450	8	3,600
2	Solar System	3,600	455	8	3,640
3	Solar System	1,840	460	4	1,840
4	Projector	1,200	1,130	1	1,130
5	Vehicle	30,000	30,000	1	30,000
6	Camera	1,000	985	1	985
7	Video recorder	1,000	996	1	996
8	Computer	1,200	1,200	1	1,200
9	Printer	600	750	1	750
10	Silviculture equipment (including shipping to Cambodia)	2,360	3.19	100	319
11	GPS	2,400	530	4	2,120
12	VERTEX	5,600	2,377.5	2	4,755
13	Safe box		219	1	219
Total		54,400			51,554

local and international consultants were hired to fulfill specific tasks and functions for the project, especially in terms of project design, monitoring and evaluation and output editing, auditing, legal consultation. A list of work done by consultants and actual outputs are shown in Table 7.

Table 7 A List of work done by consultants

No.	Expert name	Activity	Unit price (USD)	Number	Actual cost (USD)
1	Doung Saraun	2.1	150	4	600
2	Som Chomrong	2.2	150	5	750
3	Vath Vouth	2.3	150	2	300
4	Tong Chantheang	2.3	150	2	300

5	Or Thy	2.4	150	8	1,200
6	Kong Srornos	2.4	150	8	1,200
7	Chi Lo	1.2.1	259.25	1	259.25
8	Kong Boravuth	1.1.2	150	1	150
9	KANG YOURIKO	3.2		2	1,340.59
10	Liu Shirong	3.2		2	1,562.30
11	Lu Yuanchang	3.2	429.68	1	429.68
12	Du Xiaojuan	3.2.1	1,770.28	1	1,770.28
13	Zeng Jie	3.2.2	340.73	1	340.73
14	Lu Junkun	3.2.2	340.73	1	340.73
15	Lei Xiangdong	3.2.2	340.72	1	340.72
Total					10884.28

2.4 Monitoring & evaluation and reporting

Project team from IRD travelled from Phnom Penh to Bos Thom village regularly to monitor the field activities including establishing the demonstration forest, establishing home gardens, checking the survival rate of the seedlings by using the annual plans as a reference. Mid-term evaluation to assess project progress against objectives was also conducted. Some key findings of the this evaluation are as follows:

Output 1. To explore and demonstrate effective approaches on degraded community forest, optimize the forest structure, and improve forest ecosystem services

Four suitable tree species were screen out by the project team for planting: *Dalbergia cochinchinensis* and *Pterocarpus macarocarpus* were prior tree species, while *Afzelia xylocarpa* and *Cassia siamea* were alternative tree species. The project had transformed the 50 hectares of the degraded forest with rare species and demonstration forest through thinning in the project site. According to the field observation and interviewing with project team and various stakeholders, project had performed highly satisfied to this output as it met the target of expected indicator and the quality of each activities were high with supporting reports.

Output 2: Non-forestry livelihood activities are developed to improve the local's livelihood

Under this output, the project had established 19.94 hectares of home garden in the target area with plenty of crops and trees were provided to villagers. On the other hand, 20 families were supported with a full set of solar equipment and all of it work quite well nowadays. The project had created 4 groups of Group Loan with the total 39 people. The project also provided 7,840 $ to the groups in order to make a loan for creating livelihood activities with 1.5% annual interests. To make sure that the project is effectively reduce the pressure on the forest dependent, the project team had done the household baseline survey in the target area and then, the end-line assessment survey will be done in the end of the project. All activities under this output were implemented smoothly and reflect to the objective of the project.

Output 3: To share information and knowledge of best practices on degraded forest restoration and rehabilitation in Cambodia

The project had organized a two-day training course to train local people surrounding the project sites in December 2018. The training course included indoor lectures in the nearby primary school and outdoor practical training and 40 local people were trained including forestry managers/technical personnel as well as community farmers. After interviewing some trainees, it was indicated that the knowledge of best practices on degraded forest restoration and rehabilitation had been spread and practiced by farmers in the target area. In this case, this output seemed to be satisfied with the objective of the project. However, some part of this output will be achieved in the final year of the project.

2.5 Dissemination and knowledge sharing

Dissemination and knowledge sharing is very important for this project. A news report on international seminar “China-Cambodia International seminar on Tropical Forest Restoration and Reconstruction” was reported on the website of the Chinese Academy of Forestry on June 13, 2022.

The project team installed 6 billboards in two project sites: at the restoration plot in severely degraded forest and in the village (Figure 23).

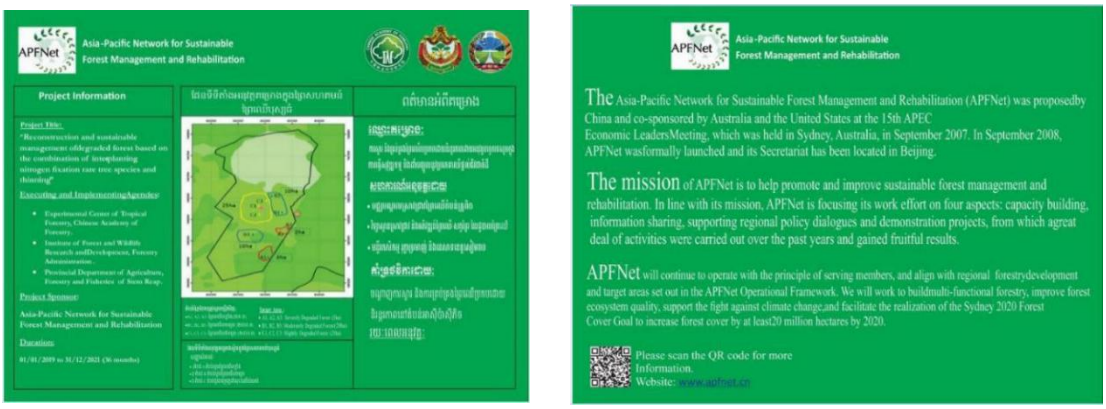


Figure 23. Project billboard

For project video clip production, the project team contracted with a local media firm to make a short video with or without English subtitle including all activities carried out by the project.

Figure 24. Make a 12-min project video

- Distributed 100 copies of leaflets to the participants in a launching workshop "Sit Restoration and Sustainable Management of Community Forestry Using Multiple Tree Species and Agroforestry" on 15th June 2022 in Phnom Penh.
- Distributed 300 copies to local authorities in Bos Thom village and commune.
- Distributed 100 copies to the Provincial department of agriculture, forestry and fisheries of Siem Reap.
- Distributed 200 copies to Forestry Administration's library
- Distributed 160 copies to all departments attached to the Forestry Administration.
- Stored 140 copies in the IRD's library.

3. PROJECT PARTNERES' PERFORMANCE

3.1 Performance of Supervisory Agency (if any)

N/A

3.2 Performance of Executing Agency (EA)

According to the project agreement, EA has taken the following responsibilities: 1) established a Project Management Team to be headed by the Project Director; 2) made an overall project design and planning, prepared Detailed Implementation Plan, regularly checked the progress and completion of the project, and made every effort to ensure that the project tasks are completed within the budget; 3) taken primary responsibility for the reports required by APFNet (i.e. Annual Work Plan, Annual Progress Report, Audit Report, Project Completion Report, etc.). Overall, the EA has fulfilled the above responsibilities and tasks well.

3.3 Performance of Implementing Agency (IA), consultants (technical assistants), contractors, and suppliers

According to the project agreement, IA has taken the following responsibilities: 1) set up Project Offices to supervise the launching of local project activities and make sure of smooth project operation; 2) implemented certain activities of the Project in accordance with the Project Document; 3) assisted in providing any supporting documents, financial statements, photos, videos, so that the EA could have a better understanding about the status of the project; 4) coordinated and facilitated among relevant agencies of Cambodia government for the transfer and transportation of vehicle and project equipment, the exemption of taxes and duties occurred during these process, as well as other project implementation related issues. The IA has fulfilled these responsibilities and tasks 100%.

A Project Steering Committee was established to supervise project implementation and make decisions on crucial issues. The Committee was composed of representatives from the Executing Agency, Implementing Agency, local forestry administration and other key project stakeholders. The Committee has been responsible to review annual project progress report, work plan for next project year, mid-term progress report and final progress report, etc., and provide guidance to addressing technical and financial issues as well as the policy hurdles. In short, the Project Steering Committee has completed the above tasks very well.

3.4 Performance of APFNet

APFNet has approved and made available of a grant for supporting the implementation of Reconstruction and sustainable management of degraded forest based on the combination of inter-planting nitrogen fixation rare tree species and thinning [2018P4-CAF]. In this project, APFNet mainly undertaken the following responsibilities: 1) timely support and clear guidance for project planning, implementation and management, 2) timely disbursement of project grant, 3) effective communication with project executing agency and partners in proper facilitation in undertaking project activities and project dissemination, 4) external M&Es during the project implementation and shared swift feedback accordingly. Up to now, APFNet has fulfilled the above responsibilities and tasks very well.

4. PROJECT PERFORMANCE

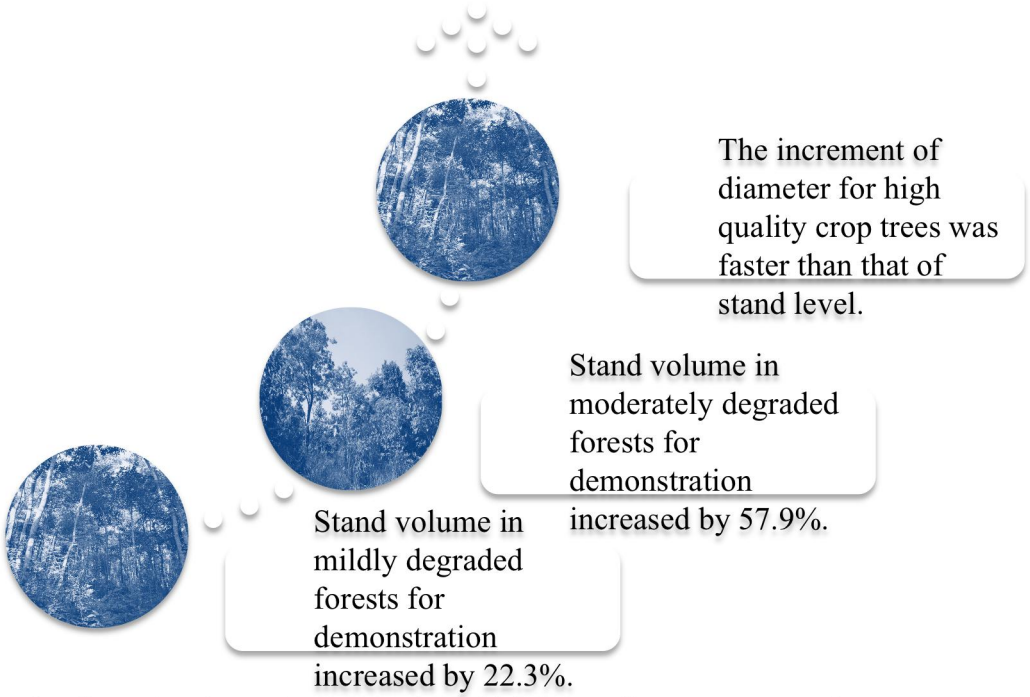
4.1 Project achievements

The project uses tropical degraded forest protection and restoration (severe, moderate and slight) and agroforestry as the main tools for tropical forest restoration and livelihood improvement in Siem Reap province, Cambodia. The project has been implemented for 3.5 years and achieved remarkable achievements: 1) Establish a 50-hectare demonstration forest through thinning and planting nitrogen-fixing tree species, strengthen forest restoration and sustainable forest management, improve forest growth and quality, and enhance various ecological service functions; 2) A 19.94-hectare

home garden with short-term economic benefits of fruit trees or crops with high economic value has been established, which has significantly improved the lives of poor local villagers who rely on forests for their livelihoods; 3) By providing technical training and guidance for local villagers, holding an international seminar, compiling a technical manual and more to share best practices and experiences on restoring degraded forests. The achievements of this project prove that our ecological restoration measures has had a positive impact on the restoration of tropical degraded forest ecosystem services in Cambodia. In the future, it will serve as a good example and reference for the surrounding areas and countries to continue to carry out ecological restoration of degraded forests.

4.2 Project Impacts

4.2.1 Economic impacts



（1）Stand volume increased and high-quality trees grew faster

（2）Stand value was improved by replanting nitrogen-fixing tree species

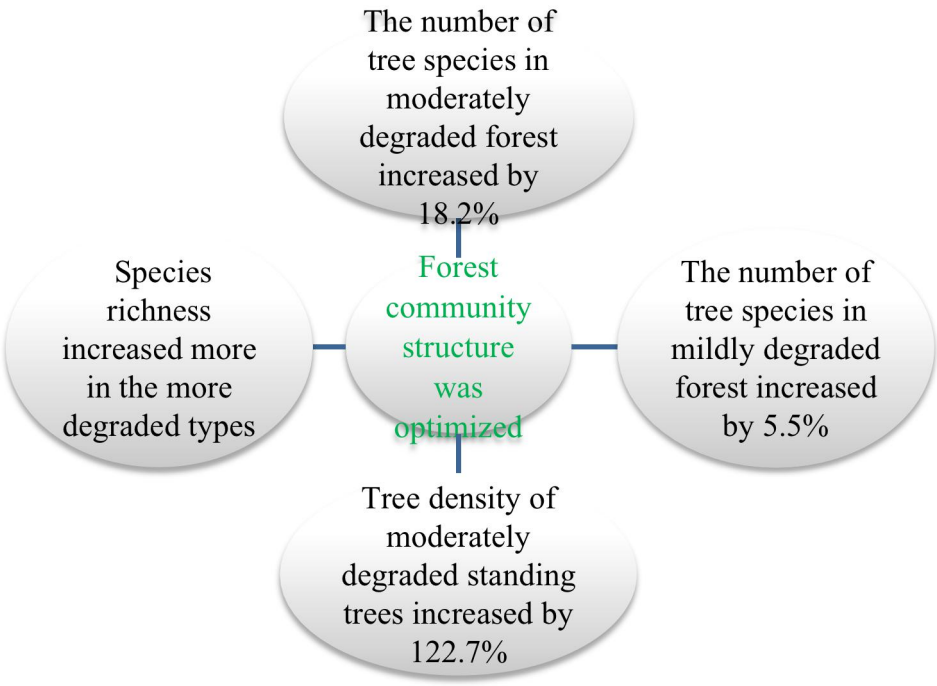
In this project, valuable nitrogen-fixing tree species with high economic value were replanted in moderately and severely degraded forests, the proportion of high-value timber trees was greatly increased. After carefully artificial management and tending, the survival rate of afforestation was higher than 90%, the economic value of the stand was thus greatly improved.

（3）The livelihood of residents in community was improved

People's livelihood has been improved. The employment and the income of residents in community increased by participating in establishing the 50 hectares of demonstration forests of degraded forests restoration and 20 hectares of agroforestry management with high economic value fruit trees and short-term economic crops.

4.2.2 Ecological benefits

（1）Optimization of forest community structure



（2）Soil nutrient contents increased

Soil total carbon and organic matter contents increased in different degraded forest types. The total phosphorus content in 20 cm soil layer of severely degraded forest was significantly higher after restoration compared with before. However, there was no significant difference in other soil layers, the total nitrogen, available phosphorus and pH values also showed no obvious and regular variation before and after restoration.

（3）Carbon storage increased significantly in forest ecosystem

Vegetation carbon storage in moderately and mildly degraded forests increased significantly, and soil carbon storage in moderately degraded forests also increased. It increased by 22.4% after restoration compared with before.

4.2.3 Social impacts

（1）Technical training and guidance for local villagers, organizing international seminars and compiling technical manuals were carried out to share the best practices and experiences on forest restoration, which greatly improved the forest management ability of local foresters.

（2）The establishment of the demonstration forests will lay a good foundation for the further promotion of tropical forest restoration technology in neighboring countries and regions in future.

4.3 Sustainability

Restoration of degraded forests is a long-term process. To enhance the ecological and economic values further after the end of the project, forest management and tending should be strengthened continuously. First, soil improvement, water and nutrition protection as well as fertilizer supplement should be adopted to solve the problems of water and fertilizer stress on forest growth; Second, the management and tending on newly planted trees of the severely and moderately degraded should be enhanced, e.g. cutting lianas and appropriate pruning on time. Third, interfering trees felling and lianas cutting should be carried out every 5 to 8 years in lightly degraded stands. Fourth, accessibility to water resource is a key to home garden construction. If the project can provide water wells for farmers, it will further improve their livelihoods.

5. CONCLUSION, LESSONS LEARNED AND RECOMMENDATIONS

5.1 Conclusion

Since the launching of the project, the project team has conducted project activities in accordance with the tasks and schedule of the Project Documents and Annual Work Plans. Although the project was extended for half a year due to the impact of the Covid-19 epidemic, the overall objective of this project was fully achieved, therefore, the self-assessment of the project progress is satisfactory. First, a total of 50 hectare demonstration forest was established through thinning and replanting of nitrogen-fixing precious tree species, which significantly improved quality and values of degraded forests in local area. Second, the local villagers' livelihood were obviously improved at the end of this project, by establishing a 19.94-hectare home garden, installing twenty (20) solar systems to provide energy sources, providing a resolve fund of USD 7,840 to 39 families. Third, the project team shared information and knowledge of best practices on forest restoration and rehabilitation during the project, such as installing billboards, wiring a news report on international seminar, training more than 40 people, developing a 12-minute project video, and compiling a technical manual in Chinese, English and Cambodian languages.

5.2 Lessons learned and recommendations

Considering the fragmentation and habitat loss of tropical forest ecosystems in Cambodia, tropical forest conservation and management strategies should protect forests and meanwhile encourage artificial and natural restoration actions.

Due to the fact that the degrees of degradation for tropical forests in Cambodia was different in different regions, various strategies and technologies of forest restoration should be adopted in accordance with the principles of close to nature and sustainable forest management. However, close-to-nature sustainable forest management has just carried out in Siem Reap Province of Cambodia for a short time, it means an attempt of new technology. Therefore, it is important to strengthen technical guidance and training for forest practitioners.

Agroforestry is important to improve the livelihood of the community and could coordinately solve livelihood needs and environmental issues. Appropriate incentive measures (such as fruit tree seedlings or vegetable seeds supplying, revolving fund, installation of solar energy for alternative energy) were taken to help local communities participate in forest restoration.

Annexes

A. Implementation status (scheduled versus actual)
B. Annex B (1) Details of project cost by activity
C. Annex B (2) Details of project cost by category

Annex A Implementation status (scheduled versus actual)

Project Objective/Outputs/Activities (in line with PD/AWPs)	Indicators (in line with PD/AWPs)	Baseline of activities	Progress made (%completion of activities and degree of output/objective achievement)	Appraisal time	Actual time
Objective 1					
Output 1: To explore and demonstrate effective approaches on degraded community forest, optimize the forest structure, and improve forest ecosystem services				Dec. 2021	Jun. 2022
Activity 1.1 Forest Status Survey and Species Selection	A summary report of forest inventory will be presented. About 1-2		We set up 9 sample plots and investigated forest structure, productivity and soil fertility for	Jun. 2019	Jan. 2019

	nitrogen fixation species should be selected as prior tree species for artificial enrichment planting, another 1-2 species should be selected as alternate tree species.		each forest type. A summary report of forest inventory was completed. Project team screened out 4 suitable tree species for planting, in which cochinchinensis and P. macarocarpus are considered priority tree species, while A. xylocarpa and C. siamea are alternate tree species.		
Activity 1.2 Establish Model Forest through Thinning, Planting and Tending	About 50 hectares of demonstration forest will be restored by thinning and replanting with nitrogen-fixing tree species.		There were 50 hectares of demonstration forest established, including 5 hectares of severely degraded forest, 20 hectares of moderately degraded forest, and 25 hectares of slightly degraded forest.	Dec. 2021	Jun. 2022
1.3 Assessment of Forest Ecology and	An assessment report will be submitted at the end of the project.		By monitoring the 9 sample plots established in activity 1.1	Dec. 2021	Jun. 2022

Economic Benefits			representing for different degraded forest, we assessed the forest ecological and economic benefits and submitted an assessment report.		
Objective 2					
Output2 Non-forestry livelihood activities are developed to improve the local's livelihood					
Activity 2.1 Building Home Gardens and Planting Fast-Growing Fruits and/or Crops of High Economic Value	A total area of 10 hectares of home garden will be established in this activity.		A total area of 19.94 hectares of home garden was established, which is 9.94 hectares more than expectation.	Jun. 2020	Jun. 2022
Activity 2.2 Developing	A total number of 16 small-scale solar		A total number of 20 small-scale solar systems were installed,	Jun. 2020	Jun. 2022

Alternative Energy Sources for Communities and Protecting Forest Resources	systems will be installed in the village.		which is 4 sets more than expectation.		
Activity 2.3 Revolving Funds and Village Product Marketing	Setting up a revolving fund of $5,000 for the local farmers.		The total amount has been increasing up to $ 6,238 compared to the original fund $ 5,000. In 2022, we added another $2,840 to our revolving fund to improve villagers' livelihoods.	Jun. 2020	Jun. 2022
Activity 2.4 Assessment of Livelihood Improvement	An assessment report will be submitted at the end of the project.		A local consultant group was hired to make a livelihood survey and we submitted an assessment report at the end of the project.	Dec. 2021	Jun. 2022
Activity 2.5 Field Monitoring	Staff from IRD will travel from Phnom Penh to Bos Thom village once a		Staff from IRD travelled from Phnom Penh to Bos Thom village once a month to monitor	Dec. 2021	Jun. 2022

	month to monitor the field activities.		the field activities, such as establishing the demonstration forest and establishing home gardens, etc.		
Objective 3					
Output 3: To share information and knowledge of best practices on degraded forest restoration and rehabilitation in Cambodia					
Activity 3.1 Provide awareness training and training courses/inspections for local and nearby staff and farmers	A training course will be organized to train local people surrounding the project sites. At least 50 local people will be trained including forestry managers, technical		A training course was organized by the ECTF to train local people surrounding the project sites. Fifty (50) local people were trained including forestry managers, technical personnel as well as community farmers.	Dec. 2020	Jan. 2019

	personnel as well as community farmers.				
Activity 3.2 Holding Seminars, Technical Discussions and Experience Exchanges between China and Cambodia	A four-day international seminar on Restoration and Reconstruction of Tropical Forest will be held in China to share the experience and outputs of the project. The team member of the ECTF will fly to Cambodia to provide technical guidance and implement project activities.		Due to the Covid-19 epidemic and international travel limit, the seminar was changed to an online meeting. The ECTF team could not fly to Cambodia, so they provided technical guidance through online communications, and entrust IRD team to implement project activities, such as sample plot repetitive measurement.	Dec. 2021	Jun. 2022
Activity 3.3 Technical manual compiling	Integrating the achievements of project activities to compile a technical manuals for degraded forest		The project team developed a technical manual in three versions (Chinese, English, and Cambodian languages). The technical manual in English and	Dec. 2021	Jun. 2022

	transformation and cultivation in tropical regions, using Chinese, English and Cambodian. 300 copies of the technical manuals are going to be printed out and disseminated.		Chinese language was published in China Forestry Publishing House, and 300 copies were issued.		