Technical Notes on Forest Restoration in Community Forests

Prepared for the Institute of Forest and Wildlife Research and Development (IRD)

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Preface

Most of the community forests are in degraded condition after several decades of overharvesting which affected the biodiversity and the livelihoods of the community. Restoration of the community forest is needed in order to conserve the remaining forest resources and to improve the forests' capability to provide the basic needs of the community. This is also in support of the National Forest Programme of Cambodia. Although this technical notes focus on the restoration of the forests, it considers the most important element of restoration: the people, particularly the vulnerable communities who depend on the forests. APFNet has taken steps in helping the IRD of the Royal Government of Cambodia in addressing the forest degradation but at the same time empowering the communities. The technical notes draw most of the key lessons learned from the implementation of the APFNet project. The work is just an initial contribution to a protracted battle of combating forest degradation. This Technical Notes hopes to help in building the body of knowledge on forest restoration and in equipping the community leaders and Forestry Personnel who are at the forefront in the forest restoration programmes.

Executive summary

The APFNet Project was launched in December 2011 to train local communities in O Soam and Tbeng Lech on forest restoration and restore parts of the community forests. In line with the NFP Programme's approach to forest restoration, the APFNet project takes into consideration the multifunction of the forest in the rehabilitation of the degraded forests. The technical notes is written to capture the lessons learned and experiences of implementing the APFNet-funded project and provides a basis in the restoration of the other degraded forests in the country with similar conditions. Aside from the experience of implementing the APFNet project, the technical notes also integrates literatures that provide some useful principles in the restoration of the degraded forests.

The main section of the technical notes includes introduction (Section 1) which covers the rationale of the community forest restoration and the technical notes, introduction to community forestry (Section 2) which covers the legal aspects and history of the community forests of the study sites, the condition of the forest resources and the use of the forest by the communities; forest restoration (section 3) that covers the selection and species for restoration, the steps of seedling production, technical and social considerations in forest restoration; and the lessons learned and recommendations (Section 4). In Section 2, the different ecological zones of the two CF areas were described including the possible restoration approaches. The result of the Participatory Resource Appraisal (PRA) was also used in describing the importance of the community forests to the local communities. In Section 3, the Technical Notes describes the different principles and approaches in the forest restoration. The section extracts some methodologies from the literature and integrated with the APFNet experience. This section presents the various forest restoration techniques including the research and establishment of demonstration and research plots. Section 4 presents the lessons learned in the implementation of the APFNet project. The recommendations were also submitted on how to further improve the implementation of the forest restoration activities.

List of acronyms

ANR	Assisted Natural Regeneration
APFNet	Asia-Pacific Network for Sustainable Forest Management and Rehabilitation
CF	Community Forestry
CFMC	Community Forestry Management Committee
CFSD	Community Forestry Sub-Decree
CPAR	Community Participatory Action Research
ELC	Economic Land Concession
FA	Forestry Administration
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
HVT	High Value Timber
IRD	Institute of Forest and Wildlife Research and Development
ITTO	International Tropical Timber Organization
KII	Key Information Interview
MAFF	Ministry of Agriculture, Forestry and Fisheries
NCFP	National Community Forestry Programme
NFP	National Forest Programme 2010-2029
NGO	Non-Government Organizations
NRM	Natural Resource Management
NTFPs	Non-Timber Forest Products
PRA	Participatory Resource Assessment
RGC	Royal Government Programme
SWOT	Strength, Weakness, Opportunities and Threats
WWF	World Wildlife Fund

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Section 1: Introduction

1.1 Rationale of community forest restoration

The forests in Cambodia provide social and economic services to local communities. But the forests have been degraded. The Forestry Administration (FA) estimated that the deforestation rate from 2006 to 2010 was estimated at 0.5 % annually (FA, 2011 cited by Kuy, 2013). The forest degradation has reduced the quality of the forests, diminished forest products, increase the loss of native species and diversity that threaten the livelihoods of local communities. Restoration efforts are needed to address the problem (Dudley *et al.*, 2005). About 400,000 ha of forested areas in Cambodia are managed by local communities living in or adjacent to the forests whose livelihoods depend on access to forest resources. However, the majority of community forests are severely degraded and poorly stocked with timber and non-timber forest products. In most CFs, the forests were left alone to recover (APFNet Project Document, Unpublished). The degraded condition of the community forests and its inability to support the need and wellbeing of the community calls for its rehabilitation. The community envisions having a forest composed of mature and adequately stocked community forest but the current conditions of the forests are composed of less-valuable, pioneer species. There are some areas that are sparsely vegetated and needing rehabilitation. While the Non-timber Forest Products (NTFPs) collected from the community forests provide livelihoods to the communities, these are considered very limited. Apparently, there is a gap from the vision of the community on what their forests should be in the future and its present conditions.

1.2 Purpose of the APFNet project

The Asia Pacific Forest Network (APFNet) launched in December 2011 the project "Multi-function Forest Restoration and Management of Degraded Forest Areas in Cambodia" to train local communities on forest restoration and restore portions of community forests (CF) in Tbeng Lech and O Soam CFs located in Siem Reap and Kampong Thom province respectively. The goal was to increase the stocks of timber and NTFPs that could improve livelihoods of the local communities in the future. Several activities were conducted including training, nursery establishment, and establishment of research/demonstration plots and dissemination of project's results to relevant stakeholders (APFNet Project Document, Unpublished). The purpose of this technical notes is to provide guide to the Natural Resource Management (NRM) practitioners on some approach in forest restoration. This technical note consolidates the experience of the APFNet-funded project in O Soam and Tbeng Lech CFs and other literatures on the restoration of the forests.

Section 2: Introduction to community forestry

2.1 Legal aspect and history

In the late 1990s, after the civil war, investors/concessions flocked to Cambodia to exploit the forests and to develop the lands for rubber, cassava and other industrial crops that triggered a land rush and converted many forestlands to agro industries. Not to be outdone, the community also rushed to lay claim over the lands by establishing their farms (chamkars) although some of them ultimately sold their clearings to private individuals. Most of the trees were felled and the forests were converted to farms. According to the Key Informant in the area, the clandestine cutting and land conversion was at its peak in 1989-1990s. The unregulated extraction of the timber and NTFPs (such as rattan and resins) resulted to their decline (PRA Report, 2014). Protection of the few patches of forests started when the Community Forestry was established in 2000 but the forests were left alone to recover from its degraded state. As a consequence only trees that have the capacity to regenerate through coppice or root suckers dominate the second growth forest (Source: APFNet Project Document). The National

Forest Programme in Cambodia recognizes the importance of forest resources to rural livelihoods, and peoples' access to those resources (Source: NFP 2010-2029, Sub-Programme 6). Thus, the Royal Government of Cambodia (RGC) and many NGOs have since then provided supports in the establishment and management of many community forests.

The Community Forestry provides an ideal approach for meeting the livelihood development needs of Cambodia's rural people, conserving the nation's forest resources and biodiversity, ensuring the proper functioning of watersheds and hydrological systems, and poverty reduction. Community Forestry is an important national strategy for the stewardship of state public lands. The National Community Forestry Programme (NCFP) seeks to formally integrate and engage rural Cambodians in the management of state public forest land through implementation of the Community Forestry Sub-Decree (CFSD) and related rules and regulations (FA, 2006).

The project is located in two CFs: Tbeng Lech and O Soam CFs. Tbeng Lech Community Forestry is located in Tbeng Lech village, Tbeng Commune, Banteay Srey District, Siem Reap Province. It is about 50 km to the Northeast of the Siem Reap provincial town, or about 370 km from Phnom Penh. Tbeng Lech covers a total area of 210 ha. The Community Forestry in Tbeng Lech started organizing in 2000 with assistance of FAO and Forestry Administration (FA). It was officially declared thru a "Prakas" by the Ministry of Agriculture, Forestry and Fishery (MAFF) in May 22, 2007 and completed its CF formalization when it signed a CF Agreement with the FA Cantonment in November 19, 2007. O Soam CF is located in Sala Visay Commune, Prasat Balang District, Kampong Thom Province. It is about 200 km from Phnom Penh by national road no. 6. O Soam covers a total area of 307 ha. It started organizing in July 30, 2004 with the assistance of Non-Government Organizations (NGOs) and FA Cantonment. It has not been formally recognized by the Ministry of Agriculture, Forestry and Fisheries (MAFF) yet although the documents were already submitted to the MAFF and the community still has to complete the formalization process.

2.2 Forest conditions: Soil, trees and wildlife

2.2.1 Soil conditions

O Soam is relatively flat with sandy to sandy clay soils. There are two main types of soils in this CF: Plinthite Podzols and Cultural Hydromorphics which are mainly sandy soil and low quality. Tbeng Lech community forest on the other hand, consists of two main soil types, namely: Red-yellow podzols and Cultural hydromorphics (Table 1). Red-yellow podzols as a soil type that has a low natural fertility with acidic soil (Crocker, 1962). The A horizon is usually friable loamy sand or sandy loam while B horizon was sandy loam to clay loam.

Table 1. Soil types of Tbeng Lech and O Soam CFs (estimated by the author)

Soil type	**Area (Has.)**	
	Tbeng Lech CF	**O Soam CF**
Cultural Hydromorphics	156	54
Plinthite Podzols	-	253
Red Yellow Podzols	54	-
Total	**210**	**307**

2.2.2 Vegetation

The forests in O Soam are composed of semi-evergreen and deciduous forests (PRA Report, 2014) that have been disturbed by human activities through over harvesting, shifting cultivation, and forest

fires. It is observed that, there are only few mother trees of some high-value timber species. The two main forest types in O Soam CF are deciduous and semi-evergreen forest. The deciduous forests are further classified into small patches of abandon agricultural land with grass and land area dominated with Tbeng (*Dipterocarpus obtusifolius*). Tbeng Lech CF was formerly a dry evergreen forest dominated by *Anisoptera costata*, *Hopea odorata*, *Dipterocarpus alatus* and *Shorea roxburghii*. The forests started to recover after the establishment of the Community Forestry (CF). Most of the stands are in the early stage of development composed of small diameter sized pioneer species. There are still areas that have not yet fully recovered and needing rehabilitation (Figure 1). In the current state, the forested areas in the two CFs are classified into semi-evergreen forest, deciduous forest, degraded evergreen forest, abandoned agricultural lands and waterlogged areas (Figure 2).

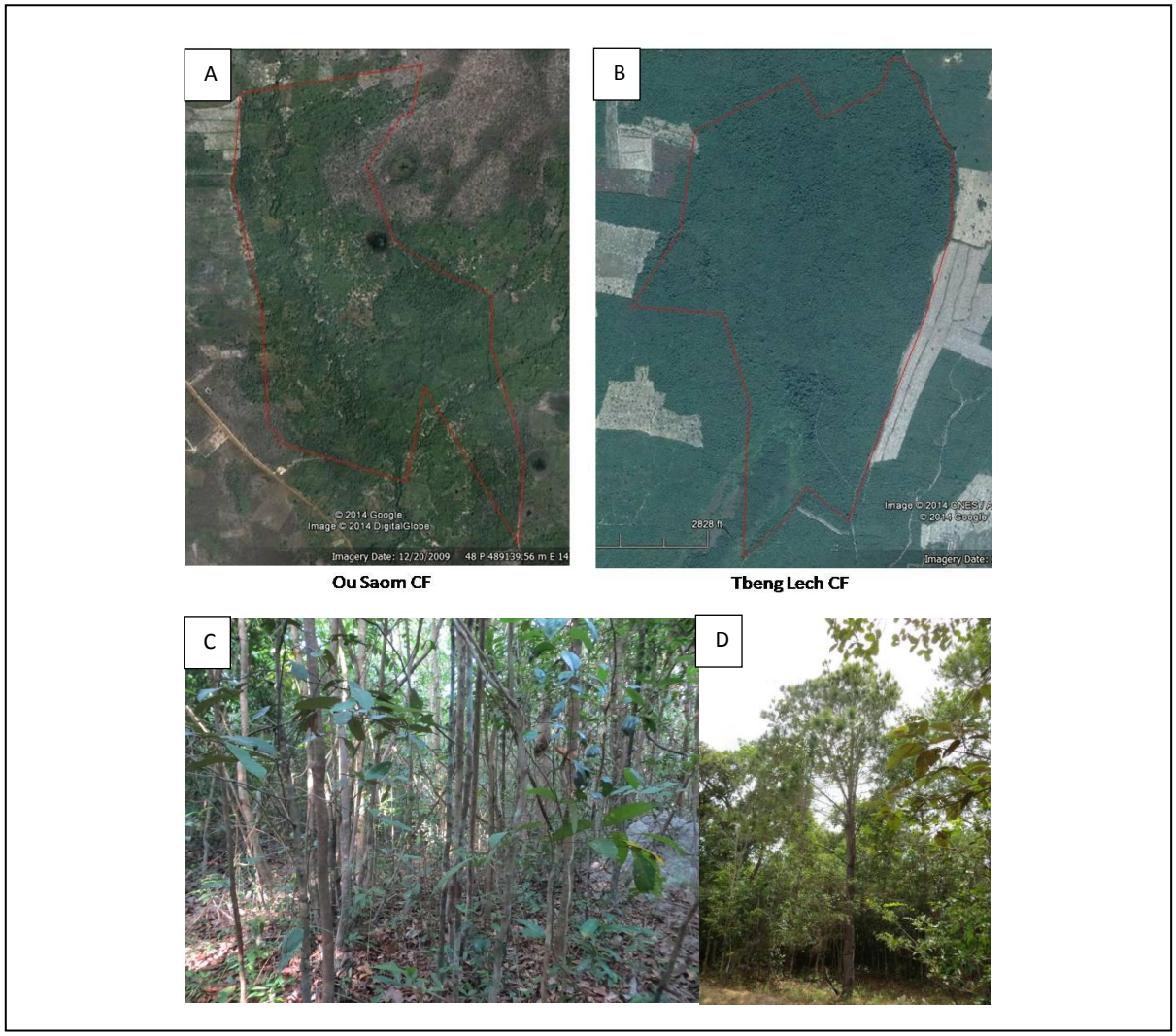

Figure 1. Forest condition of the study sites. Image of O Soam (A) and Tbeng Lech (B) CFs. (C) young stands in Tbeng Lech CF; naturally growing *Pinus merkusii* in O Soam (D).

Semi-evergreen forest: This forest is composed of few mature high-value timber (HVT) species that were spared from illegal cutting. Few big trees of lesser known species such as Khos, Pun Svay and Kreang still remains. The site has high natural regeneration but mostly of commercially less important species such as *Vatica* sp., *Sindora cochinchinensis*, *Hopea* roxburghii and *Syzyzium* sp. (Source: Consultancy Report). Since the forest canopy is largely open, the ground layer are covered with light demanding species such as climbing plants, bamboos and rattans. Enrichment planting by lines with

shade tolerant, high-value timber species is recommended. Shade demanding species, particularly those of the Dipterocarp family (*Dipterocarpus alatus, D. costatus, Anisoptera costata, Hopea odorata*, and *Heritiera javanica*) are suitable for this site. Assisted natural regeneration (ANR) can be applied, in combination with line planting of the above mentioned species, where there are insufficient natural regenerations of commercial species (seedlings or saplings).

Degraded evergreen forest: This forest type is found in O Soam. The area was once dominated with commercially important species such as *Dipterocarpus alatus, Anisoptera costata, Hopea odorata, Sindora cochinchinensis, Dalbergia cochinchinensis* and *Pterocarpus macrocarpus*. The site is devoid of these species and become degraded after massive illegal cutting and farming and is now dominated with lesser known species. Very few mature trees of the above mentioned, commercial species remain in the forests (Source: Consultancy Report). Enrichment planting by lines with shade tolerant, high-value timber species is recommended. Shade demanding species, particularly those of the Dipterocarp family, *Dipterocarpus alatus, D. costatus, Anisoptera costata, Hopea odorata*, and *Heritiera javanica*, are suitable for the current site conditions. ANR can be applied, in combination with line planting of the above mentioned species, where there are natural regeneration of commercial species (seedlings or saplings).

Deciduous forest dominated with Tbeng (*Dipterocarpus obtusifolius)*: *Dipterocarpus obtusifolius* comprise around 60% of tree species in the O Soam area. Kreil (*Melanorrhoea laccifera*) is also abundant especially those with the dbh≥30cm. The site is noted with high regenerations. Most of the seedling species are Plong, Tbeng, Kreal, Kray and other species of low commercial value (Source: Consultancy Report). Few species were found in this stand, such as *Pinus merkusii* and *Anisoptera costata* while most of other species are non-commercial tree species. At this stage of development, mixed forest tree species dominated by Tbeng should be left to natural regeneration; no thinning or pruning are needed as canopy closure is necessary to eliminate grass and keep the soil moisture.

Abandoned agricultural lands inside deciduous forest: This area in O Soam CF is dominated with invasive species, *Imperata cylindrica* (Sbove), that mix with pioneer tree species, such as *Pinus merkusii, Irvingia* sp. and *Peltophorum ferrugineum*. There are limited regeneration of commercially important species, such as *Vatica* sp., *Calophyllum* sp., and some *Sindora cochinchinensis*. Natural regenerate occur from sprouts, however, many seedlings have been damaged due to frequent forest fires in the dry season. (Source: Consultancy Report). Rehabilitation of this site is a challenge since the site conditions, soil fertility and microclimate, are less favorable for replantings. Two methods of forest rehabilitation, mix species plantation of nitrogen-fixing trees in this area; and enrichment planting of legume species are recommended. Legume species recommended for these areas include: *Albizia lebbeck, Albizia lebbeckoides, Dalbergia cochinchinensis, Pterocarpus macrocarpus*, *Sindora cochinchinensis* and *Xylia xylocarpa*. ANR could be applied in connection with the method mentioned above. Protection from forest fires is very necessary.

Abandoned agricultural lands (Veal Trapeang Rumpeak): This area is abandoned rice cultivation in Tbeng Lech. Different trees and other plants are present like *Dipterocarpus alatus*, *Hopea odorata,* Komphneang, and small rattan. The area is flooded every year from September to November. Enrichment planting of mixed species in line or group in the areas that are not flooded is recommended. This include the planting of mix species of legume family, such as *Albizia lebbeck, Albizia lebbeckoides, Dalbergia cochinchinensis, Pterocarpus macrocarpus*, *Sindora cochinchinensis* and *Xylia xylocarpa*, with *Dipterocarpus alatus, D. costatus, Anisoptera costata, Hopea odorata* and *Heritiera javanica*.

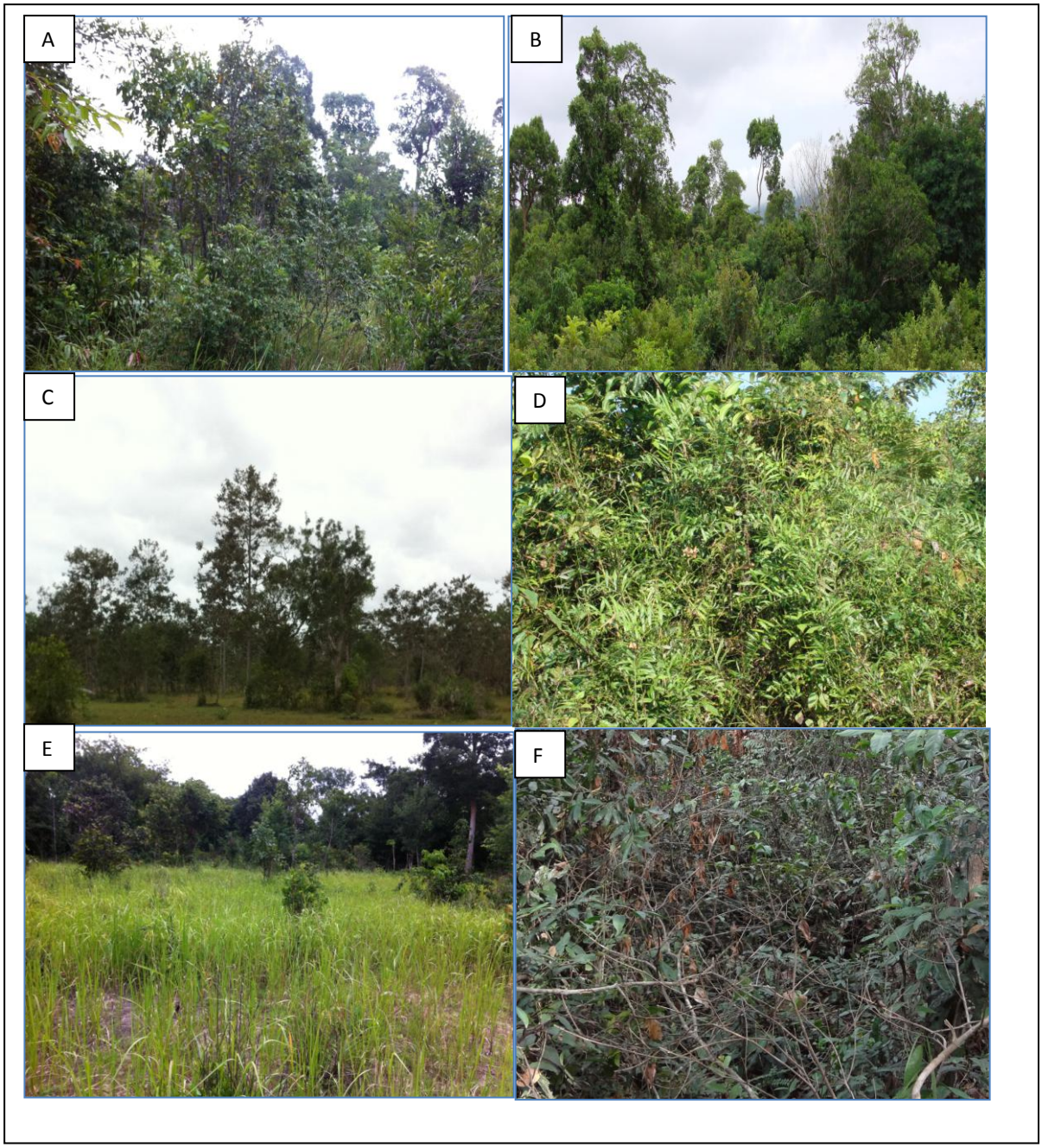

Figure 2. Forest types of the project sites. (A), Semi-evergreen forest (O Soam); (B), evergreen forest (Tbeng Lech); (C), deciduous forest dominated with *Dipterocarpus tuberculatus* (O Soam); (D), abandoned agricultural land in Tbeng Lech dominated with rattan; (E) abandoned agricultural land in O Soam (dominated with *Imperata* grass; and (F), waterlogged/flooded area (Tbeng Lech).

Waterlogged area: This waterlogged zone is located in southwestern part of Tbeng Lech CF. Not so many tree species are present in this area since it is flooded whole year round. The main species in this area are Sroeng and Khloem Andoek. Only Sroeng can be used locally for cottage construction, warehouse and for low cost construction materials (for pigs and cow pens).

2.3 Dependence of local communities on the forests

The number of households collecting the forest products varies. Around 60% of the forests products collected by the CF members are sourced from the community forests, and about 40% were collected from the nearby forests. The forests provide a large number of goods and services, including habitat for wildlife, recreational areas, food, medicines, and environmental services such as soil stabilization (Mansourian, 2005). In Kampong Thom, the forest provides provisioning benefits to the communities, especially among the Kuy communities in Kampong Thom (Source: PRA Report, 2014). The most important products that are collected in the community forests are wild fruits, edible insects, fuel wood, resins, mushrooms, rattans, vegetables, wild potatoes, fish, thatching materials, and honey. The timber products that are used for construction are the only ones being regulated by the Community Forest Management Committee (CFMC). Other products collected include wild fruits and mushrooms. In Tbeng Lech CF, the economically important forest products are rattans, honey, poles, fuel woods, mushrooms and wild fruits. Fuel woods are considered to be the most important forest products that are collected from the community forests. The rattans collected were mainly used for household use. Honey is one of the major forest products that contributed to the household income. Some members of the CF collected wild potatoes from the community forest to support them during periods of stress (Figure 3) (Source: PRA Report, 2014). Except for honey, the other collected forest products are wild fruits, rattans and vegetables that are mainly used for home consumption. There are local buyers of honey in the village. In O Soam, the stream located inside the community forest that are source of fish to the community members.

Figure 3. Forest products collected from the community forest. (A) Wild potatoes collected from the community forest in Tbeng Lech CF; (B) honey collector/trader interviewed in O Soam CF

In Tbeng Lech, the total value of the incomes from the sale of forest products collected from the community forests could reach $7,570 per year. The mushrooms collected are (mostly) for consumption or be sold at the local (village) market for about $1.25 /kg. The edible spiders are also being sold at $0.075 per piece, for small ones, and $0.125 for bigger spiders. The traditional medicines collected from the forests are usually for home consumption. In Tbeng Lech, if the consumed forest products will be valued, the total value of the products collected from the community forest could reach approximately $14,130 per year. The estimated benefits from the community forests is conservative and does not cover the income generated from outdoor recreational visitors frequenting the areas due to its complexity in accounting and inadequacy of information. In O Soam, the income from the sold forest products is estimated at $1,041 per year and may reach to $1,148 if

the quantity consumed will be valued. A Focus Group Discussion (FGD) with the community members indicated that they got temporary employment from the CF, especially when there are development projects.

Section 3: Forest restoration

Forest restoration is the principal management strategy applied to degraded primary forests (ITTO, 2002). Forest restoration is a process of rebuilding the ecosystem to some earlier or more desirable stage (Dudley, 2005). It aims to enhance and accelerate natural processes of forest regeneration in order to re-establish a healthy and resilient forest ecosystem. Forest restoration is perceived in a way that the species composition, stand structure, biodiversity, functions and processes of the restored forest will match, as closely as feasible, those of the site-specific original forest (ITTO, 2002). Because of the persistent physical, chemical, and biological barriers to forest regeneration, these severely degraded areas need human intervention to initiate recovery (Shono *et al.*, 2007). ITTO (2002) and Mansourian (2005) suggested that the sociocultural, economic and ecological aspects of a forest landscape should be considered in the restoration and management of degraded primary forests and its rehabilitation (Figure 4). In addition, ITTO (2002) also outlined the different strategies for rehabilitating the degraded forest for multiple uses (Figure 5) indicating various approaches for different objective functions. This framework provides a useful basis for approaching the rehabilitation of a degraded forest landscape.

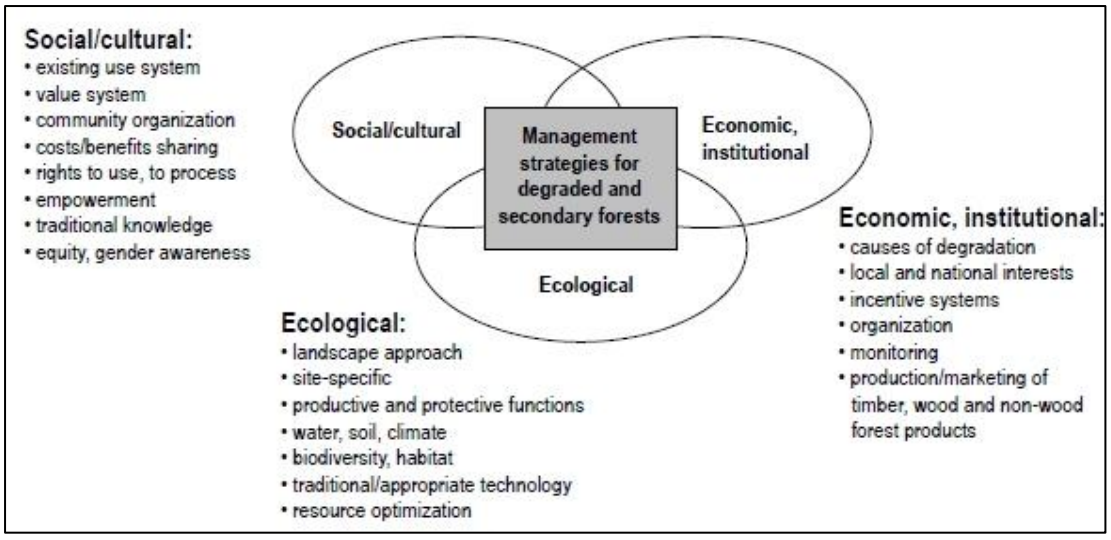

Figure 4. Proposed framework for sustainable development of the forest landscape (Source: ITTO, 2002)

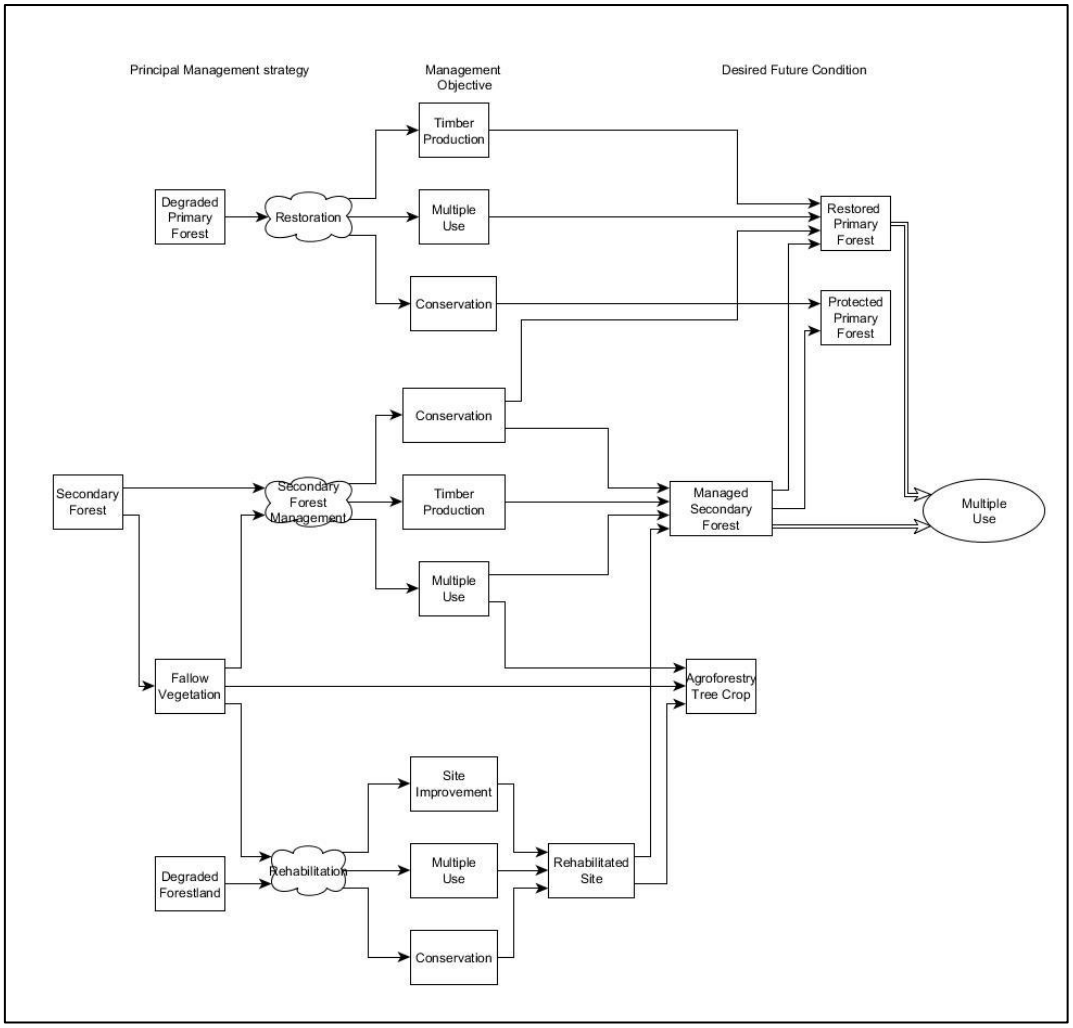

Figure 5. Outline of NRM approach of diffent NRM objectives (Source: ITTO, 2002)

Some degraded ecosystems are able to recover naturally but many do not. Even at sites where natural recovery is taking place, the process may be slow. Human interventions are needed to either initiate the recovery process or to accelerate forest recovery (Lamb and Gilmour, 2003). But restoration should not focus on trees alone but considers accompanying elements that go with healthy forests, such as nutrient cycling, soil stabilization, medicinal and food plants, forest dwelling animal species, etc. (Mansourian, 2005). Re-colonizing strategies typically include the ability to produce abundant and widely dispersed seeds. Often species that are good re-colonizers are also capable of rapid vegetative reproduction (often from roots or rhizomes) once re-established from seeds. Considerations for the establishment phase include:

- **Space.** Suitable substrate and microsites are required.
- **Light.** Excessive light, or insufficient light for photosynthesis, must both be considered.
- **Moisture.** Sufficient moisture near the soil surface is required for plants during establishment. Surface moisture conditions may be limiting even when moisture conditions deeper in the soil profile are adequate.
  Propagule bank. The presence of ruderal species that may compete with desired plant species.

The above principles and framework is helpful guide in designing the restoration of a forest landscape and is also used in the development of this technical notes.

3.1 Priority species for planting in community forests

3.1.1 Species selection based on objectives

Selecting the tree species for rehabilitation or restoring a degraded site will be based on the end product or purpose. These can either be:

- Timber production
- Fruit production
- Food production
- Degraded land rehabilitation
- Watershed rehabilitation

Harum and Forening (Undated) provided a general guide of the species that can be used for restoration (Table 1).

Table 2. Type of species used for forest restoration

Species type	Purpose
• native species	• to enhance biodiversity
• species attractive to frugivores	• to encourage seed dispersal
• species forming mutualistic relationships with animals	• to foster wildlife populations
• poorly dispersed species (e.g. large fruit)	• to facilitate their colonization
• rare or threatened species	• to increase their populations
• fast-growing species	• to increase their populations
• species tolerant of poor soils	• to facilitate rehabilitation
• nitrogen-fixing species	• to improve soil fertility
• economically or socially beneficial plants	• to provide economic "goods"
• fire tolerant trees	• to use in fire-prone landscape, create new forests or form buffers around restored forests

In O Soam and Tbeng Lech CF, high-value legume trees and those classified as endangered or threatened species, such as *Afzelia xylocarpa*, *Dalbergia cochinchinensis*, *Xylia xylocarpa*, *Pterocarpus macrocarpus*, *Sindora cochinchinensis* and those providing NTFPs were used in pilot forest restoration (APFNet Project Document, Unpublished). In a thinning operation before enrichment planting, the community in O Soam identified the less important species to be thinned out, such as: Phlong, Krie, Smach, Khosh, Sma Krabei, Pou Plea, Cheu Pleung, Ongkot Khmao, Seimoan and Kreang and marked those that the community would like to retain in the community forest, such as *Anisoptera costata*, *Shorea r*oxburghii, *Melanorrhoea laccifera*, *Sindora cochinchinensis*, *Dipterocarpus tuberculatus*, *D. intricatus*, *D. alatus*, *Pinus merkusii*, *Hopea*

odorata, *Dalbergia cochinchinensis* and *Fagraea fragrans*. When the community members were asked on one species that are most important yet too difficult to propagate, the community decided to propagate and plant Pine species (*Pinus merkusii*) including rattan (*Daemonorops jenkinsiana*). The pine is used for boards but the community is most interested for the production of resin that has a good market. Rattans are potential product that can be raised in the area. They already started raising the small rattan species "lopeak", a native species that has pencil-sized canes and growing profusely in the area especially in the degraded parts of the CF.

The same activity was conducted in Tbeng Lech, where the communities identified the following species to be removed before enrichment planting: Chr'mas, Pngea, Kroung, Prieng, Kraek, Seymoan, Angkat Khmao, L'ngeang, Kreang, Thlork, Tromoung, Tromoung Saek, Tromeing, Trouyeaung and Troseik. The species that were decided to be retained are similar to those identified by O Soam CF. In this CF, the community members identified *Dipterocarpus alatus*, *Hopea odorata*, *Dalbergia cochinchinensis* and *Pterocarpus macrocarpus* to be propagated and piloted for planting. They also identified rattan as important NTFP to be developed in their CF. The main uses of trees is classified into the following: high-value timber, fruits, fuel wood, pole, resin and timbers.

3.2 Trainings and capability building

The APFNet project helps in building up the skills of the CF members on restoring the community forests with valuable species (Figure 6). The trainings cover collection and storage of seeds, conducting seed germination and viability experiments, seedling production and silvicultural methods (planting and thinning).

Figure 6. One of the training sessions conducted by the APFNet Project

3.3 Nursery Establishment

The forest restoration needs basic facilties for the production of planting materials. The APFNet project established two nurseries (one in each CF site) (Figure 7) that are also used as reseach and training facilities.

Figure 7. Nursery in O Soam CF

The successful operation of a nursery depends on the proper selection of the nursery site, observing basic principles in the design of the nursery and procuring the basic equipment and tools. In Tbeng Lech and O Soam CF, the nurseries were constructed near the community forests. The sites selected were accessible to the communities and strategically located as a demonstration site to any visitors who wish to observe or learn the nursery activities. The basic guidelines in site selection and putting up of a nursery are presented below:

Guideline for nursery selection

- ❑ Located on flat land with good drainage
- ❑ The area should be shaded and protected
- ❑ Close to source of water
- ❑ Good and easy access

Guideline for the design of the nursery

- ❑ Protected and shaded area
- ❑ Sowing beds
- ❑ Nursery beds
- ❑ Media processing
- ❑ Space for filling the poly bag
- ❑ Source of water
- ❑ Storage
- ❑ Fence
- ❑ Shelter
- ❑ Toilet
- ❑ Billboard

Required equipment and materials

- ❑ Spade and pitchfork
- ❑ Sieve (1,5 cm)
- ❑ Ladle for filling in media
- ❑ Watering can
- ❑ Water hose (rubber pipe)
- ❑ Wheelbarrow
- ❑ Scissors cut
- ❑ Poly bags
- ❑ Media
- ❑ Shadings (made from Imperata leaves or shading nets
- ❑ Seeds

3.4 Phenology survey

A seed phenology study was conducted in O Soam and Tbeng Lech CFs to determine the fruiting season and seed collection period for some priority species. A seed calendar was developed that could guide the resource managers in the collection of seeds (Table 3).

3.5 Seed collection and storage

The quality of forest stands depends largely on the quality of the seeds that will be used as planting materials. The selection of mother trees, the scheduling the collection of seeds and the subsequent storage should not be taken for granted. Harum and Forening (Undated) provided the following guidelines in the collection and storage of seeds:

Guideline for seed collection:

- ❑ Get the seeds from nearby tree stands which look healthy: straight stem, good branch and canopy.
- ❑ Collect the seed by climbing or shaking the tree or branch.
- ❑ If seed is collected from the ground, make sure the seeds are not infected by diseases.
- ❑ Never collect seeds from isolated single trees. You should collect seed from minimum of 25 trees.
- ❑ Collect the mature seeds or fruits, which are indicated by color and shape of fruit
- ❑ The viability of seeds can be checked by cutting or opening the fruits.

Guideline for seed storage:

- ❑ Only store orthodox seeds like legume seeds
- ❑ Semi recalcitrant seeds can only be stored for a certain period of time. For example, seeds of mahogany (*Swietenia macrophylla*) can be stored up to 3-6 months.
- ❑ Recalcitrant seeds can only be stored for short period after collection.
- ❑ The seeds should be stored in dry conditions with max 12% moisture content inside the dry and sterile containers in the cool and dry room.
- ❑ The recommended containers are: bottles, cane containers, wooden boxes, and gunny sacks.
- ❑ Plastic containers are not recommended.

Table 3. Seed calendar of selected commercially important species in O Soam and Tbeng Lech CFs

Local Name	Scientific Name		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chres	*Albizia lebbeck*	Flowering								X	X			
		Fruiting										X		
		Fruit Harvesting	X	X									X	X
Chorm Reak	*Albizia lebbeckoides*	Flowering								X	X			
		Fruit Harvesting	X	X									X	X
Chambok	*Irvingia malayana*	Flowering				X								
		Fruiting					X							
		Fruit Harvesting						X	X	X				
Chheuteal	*Dipterocarpus alatus*	Flowering	X										X	X
		Fruiting		X										
		Fruit Harvesting			X	X	X							
Chramas	*Vatica astrotricha*	Flowering					X							
		Fruiting					X							
		Fruit Harvesting						X						
Koki	*Hopea ferrea*	Flowering	X										X	X
		Fruiting		X										
		Fruit Harvesting			X	X	X							
Kor Koh	*Sindora cochinchinensis*	Flowering	X										X	X
		Fruiting		X	X									
		Fruit Harvesting				X	X	X						
Kro Nhoung	*Dalbergia cochinchinensis*	Flowering							X	X				
		Fruiting											X	
		Fruit Harvesting	X	X										X
Phdeark	*Anisoptera costata*	Flowering	X	X										
		Fruiting			X									
		Fruit Harvesting				X	X							
Phlou	*Dilennia ovate*	Flowering				X								
		Fruiting					X							
		Fruit Harvesting						X	X					
Popel	*Shorea cochinchinensis*	Flowering		X										
		Fruiting			X									
		Fruit Harvesting				X								
Popoul	*Vitex* sp. ,	Flowering						X						
		Fruiting							X					
		Fruit Harvesting								X				
Pring	*Eugenia* sp.,	Flowering			X	X								
		Fruiting				X								

Local Name	Scientific Name		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Fruit Harvesting					X	X						
Rom Dul	*Melodorum fruticosum*	Flowering			X	X								
		Fruiting				X								
		Fruit Harvesting					X							
Smar Krobey	*Knema cortocosa*	Flowering			X	X								
		Fruit Harvesting					X	X						
Snul	*Dalbergia nigrescens*	Flowering	X	X										
		Fruiting			X									
		Fruit Harvesting				X								
Sral	*Pinus merkusii*	Flowering							X	X				
		Fruiting									X	X		
		Fruit Harvesting											X	X
Sromor	*Terminalia chebula*	Flowering						X	X					
		Fruit Harvesting								X				
Tbeng	*Dipterocarpus obtusifolius*	Flowering	X											X
		Fruiting		X										
		Fruit Harvesting			X	X								
Thlork	*Parinarium annamensis*	Flowering	X									X		
		Fruiting		X				X	X				X	X
		Fruit Harvesting		X	X	X	X							
Thnong	*Pterocarpus pedatus*	Flowering					X	X						
		Fruiting							X	X	X	X		
		Fruit Harvesting											X	X
Tra meng	*Ceratilia lucida*	Flowering		X	X									
		Fruiting			X									
		Fruit Harvesting				X	X							
Trach	*Dipterocarpus intricatus*	Flowering		X	X									
		Fruiting			X									
		Fruit Harvesting				X	X							
Traptuom	*Crypteronia paniculata*	Flowering				X	X							
		Fruiting					X							
		Fruit Harvesting						X	X					
Trar Yeang	*Diospyros helferi*	Flowering				X								
		Fruiting					X							
		Fruit Harvesting						X	X					

The APFNet project guided the community members in the selection of mother trees. A survey was conducted on the flowering, fruiting and the fruit maturity to support the seed collection activities. The community members undergo training on collecting seeds from the plus trees (mother trees exhibiting superior phenotypic characteristics), assessment of the quality of collected seeds (Figure 8), and the proper storage. During the seed collection, the reproductive stage (flowering, fruiting and fruit maturity) of the identified mother trees were recorded (please see the seed calendar).

Figure 8. The FA Subnational Staff teaching the local community on assessing the collected seeds.

3.6 Seed pretreatment

Some of the seeds need to be treated to hasten their germination or break their dormancy. Several seed pretreatment may be employed to different types of seeds (Harum and Forening, Undated):

- For fleshy fruits: remove fleshy part in order to avoid attack from fungi. The seeds should be sown directly in poly bags or in sowing beds. The legume seeds are normally released easily when mature. The seed pretreatment can be done by soaking in cold or hot water for 24 hours.
- For seeds with hard seed coat. The seed pretreatment can be done through soaking – drying – soaking over 2-3 days.

A seed treatment experiment was conducted to test the appropriate seed treatments to the selected species. There were eight species that were tested using different seed treatment methods (Figure 9 and Table 4). The experiment was conducted by the community memebrs. The seed treatment used and the species that responded to these treatments are:

1. Pricking (Germination Method A): a small part of the seed coat was removed and soaked in a tap water for 5 to 6 hours. The seeds were then sown in the wet sand and kept the moist condition by spraying with water daily. The species that are suitable for this treatment are:
   - Chorm Reak (*Albizia lebbeckoides*) (92% germination)
   - Chres (*Albizia lebbeck*) (100% germination)
   - Kor Koh (*Sindora cochinchinensis*) (91% germination)

2. Soaking with tap water (Germination Method C): The seeds were soaked in tap water and kept in the shaded place for one day. The seeds were then sown in a sand germination media. The moisture was maintained by watering daily. The following species respond positively to this treatment:

- ❑ Kor Ki (*Hopea odorata*) (48% germination)
- ❑ Kror Nhoung (*Dalbergia cochinchinensis*) (72% germination)
- ❑ Thnung (*Pterocarpus macrocarpus*) (64% germination)

3. No Treatment (Germination Method D): Seeds were directly sown in the sand germination media and watered daily. The species that germinates well without treatment are:
   - ❑ Chher Teal (*Dipterocarpus alatus*) (72% germination)
   - ❑ Traptuom (*Crypteronia paniculata*) (76% germination)

Table 4. Results of the seed treatment study

Local Name (Scientific Name)	Germination by treatment (%)				Recommended treatment
	TA	TB	TC	TD	
1. Chher Teal (*Dipterocarpus alatus*)	0	0	50	72	Treatment D
2. Chorm Reak (*Albizia lebbeckoides*)	92	82	78	81	Treatment A
3. Chres (*Albizia lebbeck*)	100	26	0		Treatment A
4. Kor Ki (*Hopea odorata*)	0	22	47.5	35.5	Treatment C
5. Kor Koh (*Sindora cochinchinensis*)	91	53	72	84	Treatment A
6. Kor Nhoung (*Dalbergia cochinchinensis*)	20	9	44	14	Treatment C
7. Thnung (*Pterocarpus macrocarpus*)	52	1	64	60	Treatment C
8. Traptuom (*Crypteronia paniculata*)	0	56	56	76	Treatment D

Note of the treatments:

Treatment A (TA): Pricking: a small part of the seed cover was removed and soaked in a tap water for 5 to 6 hours. The seeds were then sown in the wet sand and kept the moist condition by spraying with water daily.
Treatment B (TB): Hot Water Treatment: The seeds were immersed in the hot water (approximately 60^{o}C. The treated seeds were then sown in the sand germination media. The moisture was maintained by spraying daily.
Treatment C (TC): Soaking seeds with Tap Water: The seeds were soaked in tap water and kept in the shaded place for one day. The seeds were then sown in a sand germination media. The moisture was maintained by spraying daily.
Treatment D (TD): No Treatment: Seeds were directly sown in the sand germination media and watered daily.

Figure 9. Community Forestry members conducting simple seed pretreatment experiments.

3.7 Preparation of potting mixes

Potting media was prepared in advance for the transplanting of the germinated seeds (Figure 10). The function of potting media is to promote the growth of seedlings. Potting media should be prepared to support a healthy root system with enough oxygen, nutrient and water (Harum and Forening, Undated). There are several types of potting media that can be used, depending on the availability. It is very important to maintain the porosity of the potting mixture to allow the development of roots.

An experiment was conducted together with the community members to determine the suitable potting mixes for a specific species. The experiment was carried out in the two Community Forestry sites. The species tested were:

- *Afzelia xylocarpa*
- *Albizia lebbeck*
- *Albizia lebbeckoides*
- *Dalbergia cochinchinensis*
- *Dipterocarpus alatus*
- *Hopea odorata*
- *Pinus merkusii*
- *Pterocarpus macrocarpus*
- *Sindora cochinchinensis*

Figure 10. Members of the community learning to prepare the potting media.

Six potting mixtures were tested. The performance was based on the height and diameter growths of the species. From the experiments, four potting mixtures were recommended for the species tested (Table 5).

3.8 Seedling production

The number of seedlings needed in the field is defined by the following factors (Harum and Forening, Undated):

- Size of land (planting area)
- Tree spacing and planting design
- Percentage of seedlings survival during transportation to the field
- Percentage of seedlings survival in the field

The basic computation to determine the required seedlings are shown below:

- If the spacing is 5 m x 5 m, then the number of seedlings needed per ha is: 10,000/(5x5) = 400 seedlings
- If the spacing is 5 m x 2 m and the size of land is 5 ha, then the number of seedlings needed is: 5 x 10,000/(5x2) = 5,000 seedlings

Table 5. Result of the experiment with soil potting media

Species	Treatment						Recommended potting mix
	T1	T2	T3	T4	T5	T6	
Afzelia xylocarpa							Potting Mix 1: Termite mount soil (1) + forest soil (1) + cow dung (1) + rice husk charcoal (1)
Diameter	11.17	10.50	9.93				
Rank	3	2	1				
Height	64.47	52.53	49.07				
Rank	3	2	1				
Total Score	6	4	2				
Albizia lebbeck							Potting Mix 4: Forest soil (2) + river sand (1) + cow dung (1)
Diameter				6.50	5.00	3.83	
Rank				3	2	1	
Height				63.60	47.63	24.53	
Rank				3	2	1	
Total Score				6	4	2	
Albizia lebbeckoides							Potting Mix 5: Forest soil (2) + river sand (2) + rice husk charcoal (1)
Diameter				1.80	2.87	1.87	
Rank				2	3	1	
Height				17.37	34.40	18.33	
Rank				1	3	2	
Total Score				3	6	3	
Dalbergia cochinchinensis							Either Potting Mix 4: Forest soil (2) + river sand (1) + cow dung (1) or Potting Mix 5: Forest soil (2) + river sand (1) + cow dung (1)
Diameter	3.47	1.87	1.33	5.88	4.88	4.34	
Rank	3	2	1	6	5	4	
Height	21.47	8.87	4.53	67.08	68.56	49.94	
Rank	3	2	1	5	6	4	
Total Score	6	4	2	11	11	8	
Dipterocarp alatus							Potting Mix 4: Forest soil (2) + river sand (1) + cow dung (1)
Diameter	4.20	3.40	3.70	7.60	6.77	6.23	
Rank	3	1	2	6	5	4	
Height	40.17	34.33	32.33	53.70	41.50	32.67	
Rank	4	3	1	6	5	2	
Total Score	7	4	3	12	10	6	
Hopea odorata							Potting Mix 1:

Species	Treatment						Recommended potting mix
	T1	T2	T3	T4	T5	T6	
Diameter	6.27	5.17	5.70	4.03	4.17	3.43	Termite mount soil (1) + forest soil (1) + cow dung (1) + rice husk charcoal (1)
Rank	6	4	5	2	3	1	
Height	47.80	32.13	36.80	37.97	38.23	26.40	
Rank	6	2	3	4	5	1	
Total Score	12	6	8	6	8	2	
Pinus merkusii							Potting Mix 4: Forest soil (2) + river sand (1) + cow dung (1)
Diameter				4.67	4.53	3.20	
Rank				3	2	1	
Height				9.25	6.35	3.40	
Rank				3	2	1	
Total Score				6	4	2	
Pterocarpus macrocarpus							Potting Mix 2: Termite mount soil (4) + forest soil (2) + cow dung (1) + rice husk charcoal (1)
Diameter	5.43	8.73	0.47	7.83	7.27	6.27	
Rank	2	6	1	5	4	3	
Height	30.300	46.333	4.367	42.33	46.37	26.27	
Rank	3	5	1	4	6	2	
Total Score	5	11	2	9	10	5	
Sindora cochinchinensis							Either Potting Mix 2: Termite mount soil (2) + forest soil (1) + cow dung (0.5) + rice husk charcoal (0.5) or Potting Mix 5: Forest soil (2) + river sand (2) + rice husk charcoal (1)
Diameter	4.52	4.71	2.92	4.97	4.87	4.43	
Rank	3	4	1	6	5	2	
Height	21.0	25.5	17.3	20.20	24.30	19.53	
Rank	4	6	1	3	5	2	
Total Score	7	10	2	9	10	4	

Note:

Treatment 1: Termite mount soil (1) + forest soil (1) + cow dung (1) + rice husk charcoal (1)
Treatment 2: Termite mount soil (4) + forest soil (2) + cow dung (1) + rice husk charcoal (1)
Treatment 3: Termite mount soil (3) + cow dung (1) + NPK (0.1 kg)
Treatment 4: Forest soil (2) + river sand (1) + cow dung (1)
Treatment 5: Forest soil (2) + river sand (2) + rice husk charcoal (1)
Treatment 6: Forest soil (4) + river sand (2) + NPK (0.5 kg).

The guideline for preparing the sowing beds, sowing, and maintenance of seedlings is provided as follows (Harum and Forening, Undated):

Guideline for the preparation of sowing beds:

- The seeds should be sown in sowing beds.
- The sowing beds can be made from unused containers, bamboo, wooden boxes or directly on the ground.
- The sterile media consists of compost and sand (1:1).
- The thickness of the media is 6 – 10 cm.
- Make small holes under the container in order to have good drainage.

Guideline for seed sowing:

- Watering the media (not too wet)
- The seed sowing should be done in the morning or evening
- Sowing the seeds over the media (not over lapping)
- Cover with mixed media (compost and sand) 1 cm
- Watering the sowing bed in the morning or afternoon as necessary (not too wet)
- Place the sowing beds on the shaded and protected area
- The big seeds can be directly sown in poly bags. For example: mahogany or candlenut seed.

Guideline for pest and disease control

- ❑ Common Pest: rats, birds, insects
- ❑ Disease: fungi
- ❑ How to control:
  - Place the beds in safe areas
  - The media, water and seeds should be clean from any pest and disease
  - Spray the media and seeds with insecticides if required
  - Remove the attached seedlings.

Guideline for filling the mixed media in the container

- ❑ Spray the mixed media with water (not too wet)
- ❑ Fill the container with mixed media by using hand or special tools made from wood
- ❑ Make sure the container is full but not too tight

Figure 11. Prepared pots with soil media ready for seeding or transplanting.

Guideline for transplanting the seedlings to polybags

- ❑ The transfer will be done when the seedlings have two fully open leaves. If the transfer is delayed, the rooting structure will be effected
- ❑ Use a piece of wooden stick to remove the seedlings and place the seedlings on wet containers (could be banana leaves or plastic containers)

Nursery maintenance operations:

- ❑ Watering
- ❑ Weeding
- ❑ Fertilizing (if required)
- ❑ Pest and disease control
- ❑ Light control
- ❑ Seedlings grading
- ❑ Seedlings transport
- ❑ Acclimatization

Guideline for the preparation of seedlings for planting

- ❑ Height of seedlings average 30 – 60 cm
- ❑ The seedlings vigor is good
- ❑ The seedlings should be healthy with good root development

Figure 12. Seedlings maintained in the nursery.

3.9 Methods of forest restoration

The NFP (2010-2029) prescribes the development of multipurpose tree plantations which have a potential to supply domestic timber needs, increase incomes of local communities, and improve the environment through watershed protection and erosion control (Source: NFP 2010-2029, Sub-Programme 6). It is important that restoration should consider various species for multi-purpose planting for long-term and short-term rotation in line with needs or possible future demands (Source: NFP 2010-2029, Sub-Programme 6). In the restoration of the site, the project combined several methods: (1) agroforestry; (2) enrichment planting; (3) cluster planting; (4) direct seeding; (5) liberation cutting or improvement thinning. The choice of each method considers the economics of restoration, multifunctionality of the species and to promote the rapid establishment of the desired commercial species.

Agroforestry. In O Soam, agroforestry is tested in a demonstration plot that is thinned. Pineapples were planted under the thinned natural stands. Pineapples were chosen by the community members for planting in the area. Although the area is rich in organic matter, the success of pineapples under a partially shaded condition still needs to be observed. This approach is applied in the pilot site to meet

the short term needs of the community members (e.g. food and cash income). In Tbeng Lech, agroforestry system was applied in home gardens belonging to two members of the CF. Agroforestry is a form of agriculture that combines complex mixtures of trees and other crops grown in the same area of land. Some involve mixtures of multipurpose trees and food crops; others combine scattered trees and pastures. In most cases a variety of species are used in the farm or "home garden" that differ in canopy and root architecture, phenology and longevity (Gouyon and Levang, 1993). This technique enables the land to provide food and agricultural products to communities in a way that is relatively sustainable. It also creates spatial and structural complexity across landscapes and offers the prospect of agricultural sustainability.

Cluster planting (Rodwell and Patterson, 1994). Cluster planting was conducted in some parts of O Soam CF dominated with *Imperata* grass. The purpose is to create a microclimate and in each spot and shade the *Imperata* from the close canopy cover created thru close spacing. Cluster planting is also called low-density tree plantings. Clusters are uniformly distributed "nests" (nest planting) or "groups" (group planting) (5m x 6m) that consist of several seedlings planted in an aggregated manner. The technique is aimed at lowering the establishment costs while offering the opportunity to produce high quality timber. Cluster plantings also provide vacant space (typically more than 60% of the area) for natural regeneration between clusters (Saha *et al*., 2013; Nepstad, *et al*., 1991). Only two or three tree species are advised rather than more intimate mixtures because of the difficulties of matching complementary species. The spacing between clumps can also be varied to create gaps. The understory and tree species used depend on the sites and soil types (Rodwell and Patterson, 1994). The trees initially planted might be one or more species with seed not dispersed by animals (e.g. species with large fruit or seed or wind-dispersed species (Nepstad *et al*., 1991).

Direct seeding. Direct seeding was tested for rattan in the research plots. Initial results of the direct seeding trial indicate a limited germination. There is no conclusive result yet since the rattan seeds did not exhibit a one-time flush germination. For rattan, direct seeding is not recommended. Direct seeding is aimed at reducing the cost of restoration (by eliminating the nursery operation cost and reducing the cost of seedling transport). Seeds will be sown on bare soil so that it can establish quickly in weed-free conditions. Using the technique can cover wider area of the landscape for restoration, including sites that might be difficult to reach when carrying boxes of seedlings (Mergen *et al.*, 1981).

Liberation cutting or improvement thinning combined with encouragement of understory development/assisted natural regeneration and enrichment plantings (Ashton *et al.*, 1997; and Finegan, 1992). The project combined three techniques in the demonstration plot: liberation cutting or thinning, encouragement of understory development and enrichment planting. In many plantation forests, especially those near areas of intact forest, an understory of native tree and shrub species will develop over time. A large number of species may colonize, leading to a substantial change in the appearance and structure of the plantation over time (Lamb and Gilmour. 2003). Removing or thinning competing trees aims to foster the growth of certain tree or other plant species within the forest that are commercially attractive. The relative abundance of these favored species increases over time. The method maintains much of the residual biodiversity still present and prevents the forest from being cleared for other uses such as agriculture or plantations (Adjers *et al.*, 1995).

In the demonstration plots, gaps or strips are opened up in the canopy and seedlings of the desired species are planted into them. The less commercially important species were removed (about 50%) to allow the growth of the seedlings and saplings of commercially important species. The demonstration plots are located in the evergreen forests composed of young trees with dense canopy. Seedling recruitment is encouraged by creating canopy openings (thru thinning) that allows the seeds dispersed from the parent trees to fall to the ground. Initial result showed a high survival of the planted

commercially important species although the establishment of new seedlings of commercially important species is not yet readily observable. Monitoring is still being conducted.

3.9.1 Resource assessment and zoning

A rapid site assessment in Tbeng Lech and O Some community forestry were conducted to: (1) to determine the condition of resources (vegetative cover, species diversity and soil characteristics); (2) to determine the provisioning services of the community forest (livelihoods); (3) to determine the community needs and expectations from the community forests and what the community's vision of their community forests to improve their living conditions; and (4) to serve as a basis in zoning the area for restoration. The community members have been consulted in order to better understand about some constraint on forest restoration as well as local knowledge on forest restoration. The PRA used a combination of several tools, such as Focus Group Discussion and Participatory Mapping. The resource assessment also validates with the communities the areas needing rehabilitation and the forest products that are collected. The result of the resource assessment and ocular visit indicate that there are four zones that can be found in the project site. (A), Semi-evergreen forest; (B), evergreen forest; (C), deciduous forest dominated with *Dipterocarpus tuberculatus*; (D), abandoned agricultural land in Tbeng Lech; (E) Abandoned agricultural land in O Soam; and (f) waterlogged/flooded area (Figure 13) (please see Section 2.2.2) (Source: Consultancy Report).

3.9.2 Research and demonstration area

The demonstration site, research plot and pilot restoration area was established to field test the different restoration techniques. This demonstrates to the communities the different techniques of restoring the degraded sites

3.9.2.1 Demonstration plots

Demonstration plots were established to showcase to the communities the technical aspects of restoring and maintenance of the plantations (Figure 14). The two main methods recommended for forest restoration are: (1) enrichment planting in line or group combined with thinning; and (2) assisted natural regeneration (ANR). Enrichment planting is recommended for the area where the required species are insufficient to colonize the area while ANR is applicable for the area where the required species are adequate. The species in used in rehabilitation are those that are commercially important to the communities. There were four plots established in each CFs where combination of thinning and enrichment planting with the different species was considered. Some of the less valuable species were marked for cutting (approximately 50% of the growing stocks). The species that were marked to be left or to be cut were identified by the communities. After removing the trees, a number of high-value timber/multipurpose species (*Dalbergia cochinchinensis, Dipterocarpus alatus, Hopea odorata, Pterocarpus macrocarpus, Pinus merkusii, Albizia lebbeck, Albizia lebbeckoides* and *Sindora cochinchinensis*) were planted in the gaps.

In O Soam and Tbeng Lech CF, the rehabilitation method consists of a combination of different techniques (enrichment planting, assisted natural regeneration, and thinning). The specific treatments recommended for each type of site condition is summarized in Table 6.

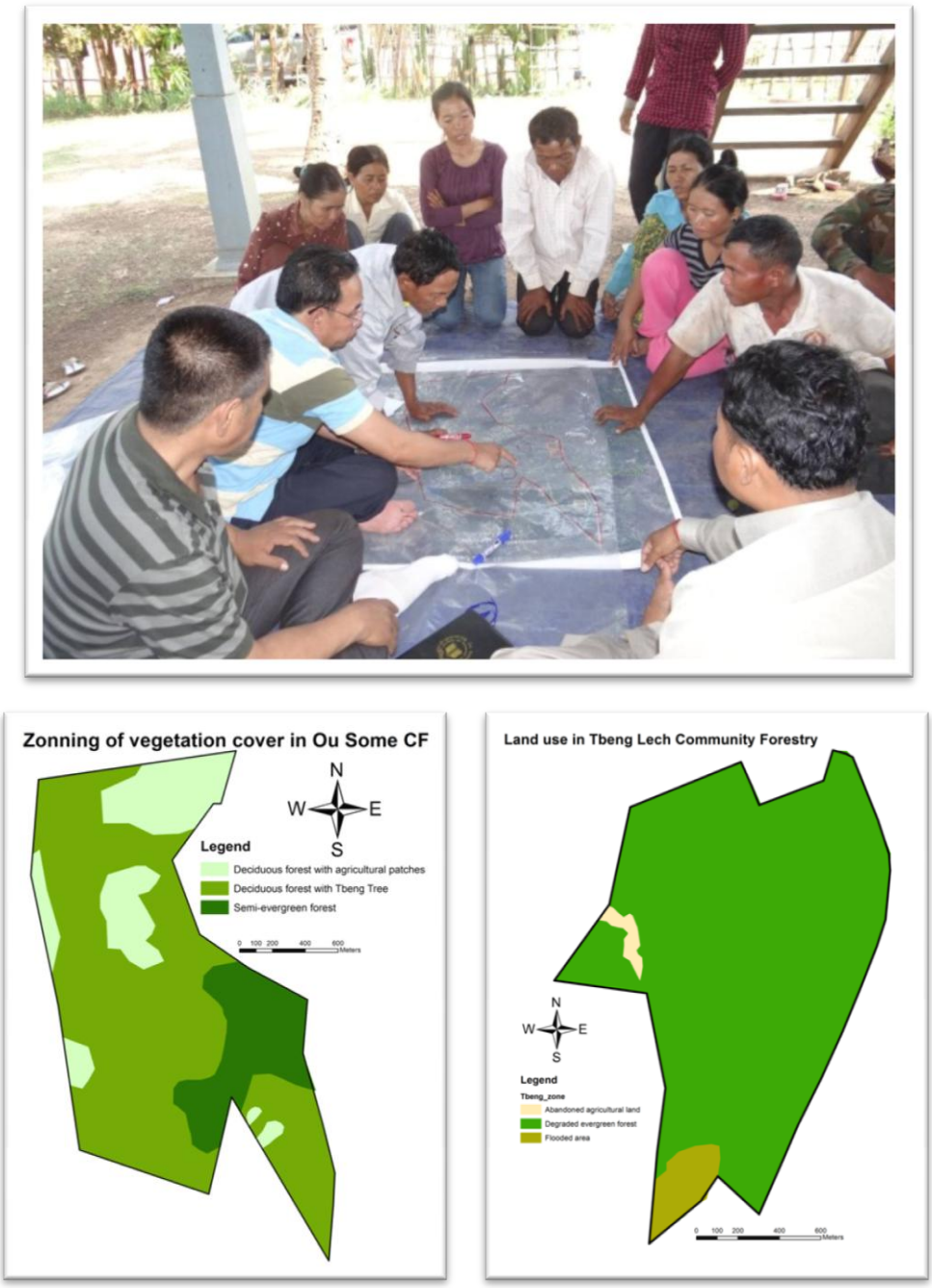

Figure 13. PRA Mapping conducted with the CF members.

Table 6. Recommended methods for rehabilitating the degraded sites

Type of vegetation	O Soam Community Forestry	Tbeng Lech Community Forestry
Deciduous forest dominated by Tbeng	▪ Assisted natural regeneration, combined with fire prevention	
Degraded semi-evergreen forest	▪ Enrichment planting (line or group/gap) planting of commercial species ▪ Assisted natural regeneration	
Abandoned agricultural land inside deciduous forest	▪ Mixed species planation in line or group of nitrogen-fixing trees ▪ Assisted natural regeneration, combined with fire prevention	
Degraded evergreen forest		▪ Enrichment planting (line or group/gap) of commercial species in combination with assisted natural regeneration where adequate seedlings is observed
Waterlogged/flooded areas		
Abandoned agricultural land		▪ Enrichment planting of mixed species in line or group in the area that is free from flooding

Figure 14. Community members getting guidance on the establishment of the treatment plots and selection of trees to be retained and to be cut.

3.9.2.2 Research

A research entitled "Community Participatory Action Research (CPAR) Approach of Enrichment Planting with *Daemonorops jenkinsiana*, *Pinus merkusii* and *Dalbergia cochinchinensis* in CF Sites" was conducted in the two CF sites. Four plots (1 hectare each) were established (2 in O Soam and 2 in Tbeng Lech CF). In O Soam, the first plot was planted with *Pinus merkusii* and the second plot was planted with *Daemonorops jenkensiana*. In Tbeng Lech CF, the first plot was planted with *Dalbergia cochinchinensis* and the second plot was planted with *D. jenkinsiana* (Figure 15). The plot planted with *D. jenkinsiana* was subdivided into 2 (0.5 hectare each). One half was planted with nursery grown rattan seedlings and the other half was planted using direct seeding.

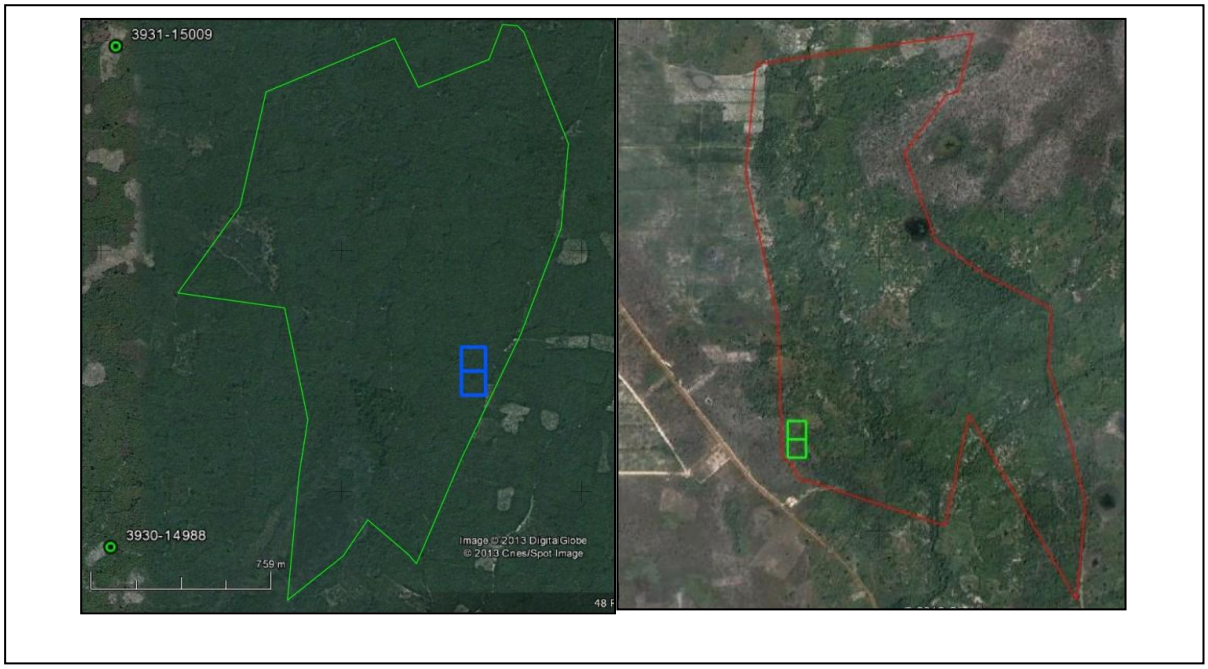

Figure 15. Location of the research plots in Tbeng Lech and O Soam Community Forestry.

The aim of the research is to determine what conditions will influence the growth and survival of the planted seedlings (dominant upperstorey species, stocking/basal area etc.). Knowing the influence of the upperstory plants can guide the community in forest restoration works. The research was conducted with the participation of the community. Aside from the technical aspects of forest research, the research seeks greater involvement of the community. The idea is to build a body of knowledge with what the local people have and their natural resources. It seeks a bottoms up approach in conducting the research (Richards, 1995). This is also in recognition the traditional knowledge of methods of natural resource management of the communities (Altieri, undated) and ensuring that the technological generation and research priorities are founded on the socio-economic and environmental needs of the community (Blauert and Zadek, 1998). CPAR is an effective approach in working with the communities who will be the ultimate beneficiary of the project and trained on how to conduct researches. The research approach was consulted with the Research Staff and the community on the specific focus of the research. The field work was conducted together with the key research staff of community members. In conducting the participatory action research, the conceptual model was used in (Figure 16).

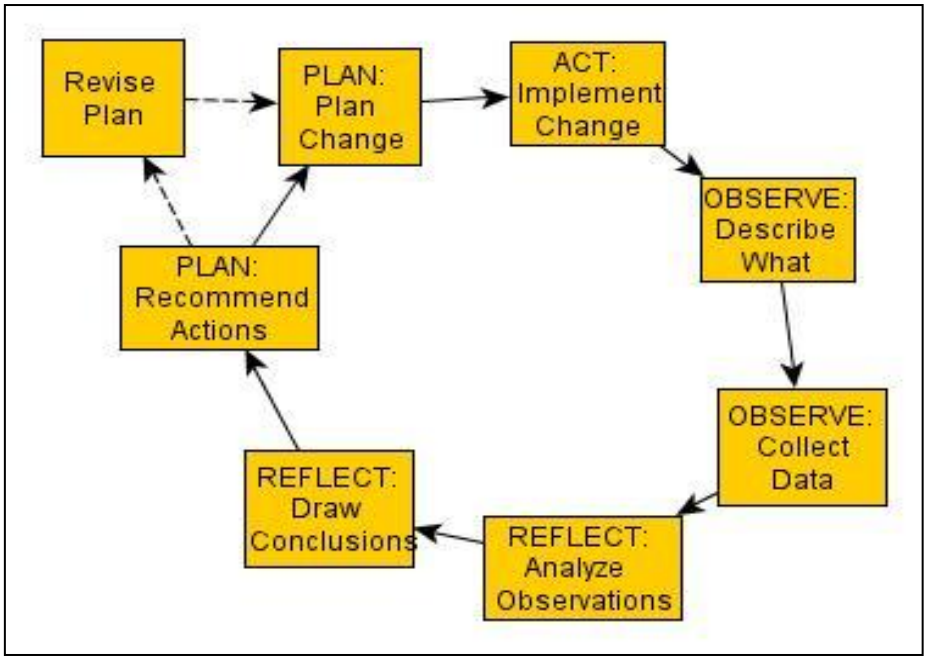

Figure 16. The Community Participatory Action Research (CPAR) Approach of conducting the study.

As part of the participatory approach, the community was consulted on which among the species that they think are most important to them and difficult to propagate. From the consultations, the community identified *Pinus merkusii* and *Daemonorops jenkinsiana* (rattan) in O Soam CF and *Dalbergia cochinchinensis* and *D. jenkinsiana* in Tbeng Lech CF. The seedlings were planted at a spacing of 15 x 15 m. The nearest upperstorey plants (7 trees following the K-Tree method) were identified and measured. The small diameter trees were removed (those measuring < 5 cms. diameter) (Figure 17).

Initial findings indicate that the survival of *Pinus merkusii* is influenced by partial shading. The type of species of overstory plants does not differ so much on the survival of the Pines. Their performance in the field also depends on the maturity of outplanted seedlings. The outplanted Dalbergia seedlings also perform well in the field. This species seems could tolerate on a partially shaded condition regardless of the density of the upperstory plants. The outplanted rattan (*Daemonorops jenkinsiana*) thrives well in the partially shaded condition. Greater mortality of rattan seedlings was observed in the deciduous forest where there are wider canopy openings. Initial survival of rattans are also higher in the evergreen forests (in Tbeng Lech CF. However, the direct seeding did not show promising result. It was also observed that the germination in the field were not simultaneous. The result shows the importance of nurse trees and partial shading for the establishment of Pines, Dalbergia and Rattan seedlings. For rattan seedlings, it is advisable to use the potted seedlings as planting materials.

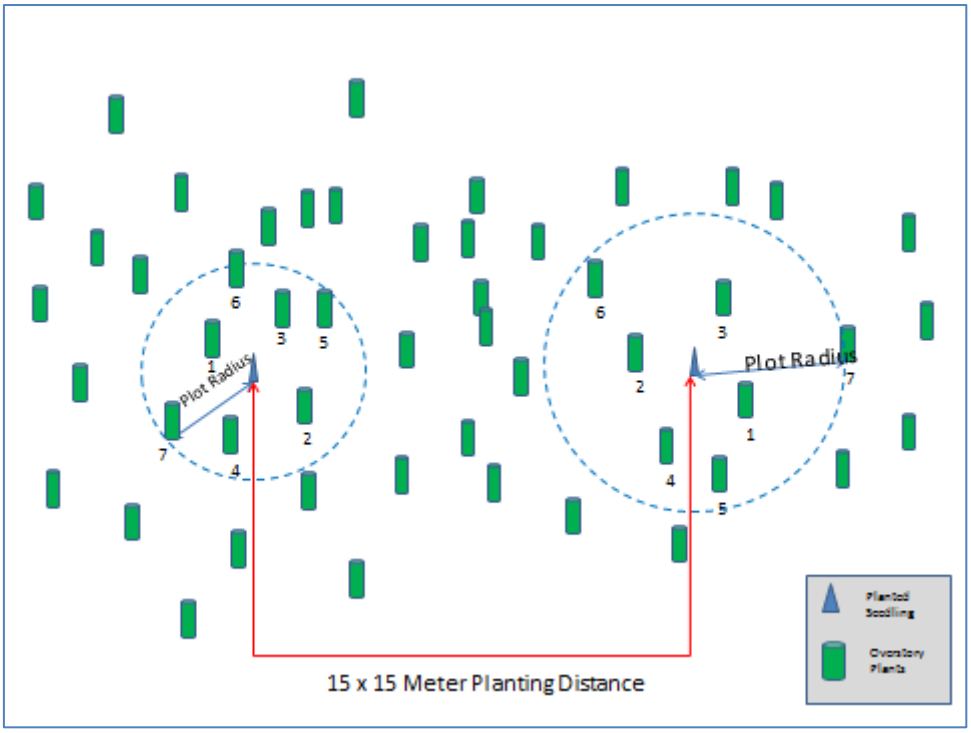

Figure 17. Layout of the planting spots. The 7 upperstory plants that will be measured in each planting spot

3.9.2.3 Pilot restoration

Pilot restoration was conducted in the areas with very degraded forests. Line planting was applied in both community forests. The spacing between two adjacent lines varies between 10 and 15 m, based on site condition and between seedlings in the same line is about 5 m. Cluster planting was applied in the *Imperata* grassland (O Soam CF), with a total area of about 3 – 4 ha (Figure 18). The clusters of 9 plants (planted at 1 m x 1 m) at 5m x 6 m between cluster was used in this area. The plants (mix species) within the cluster are expected to rapidly colonize the planting spot and create a microclimate that shades out the weeds within the cluster. This will then ensure the survival of planted seedlings in each cluster, or establish cluster of plants which may expand and colonize nearby areas. The space between the cluster in the same row and that between rows of clusters can be used for planting of the agricultural crops (in the form of agroforestry system).

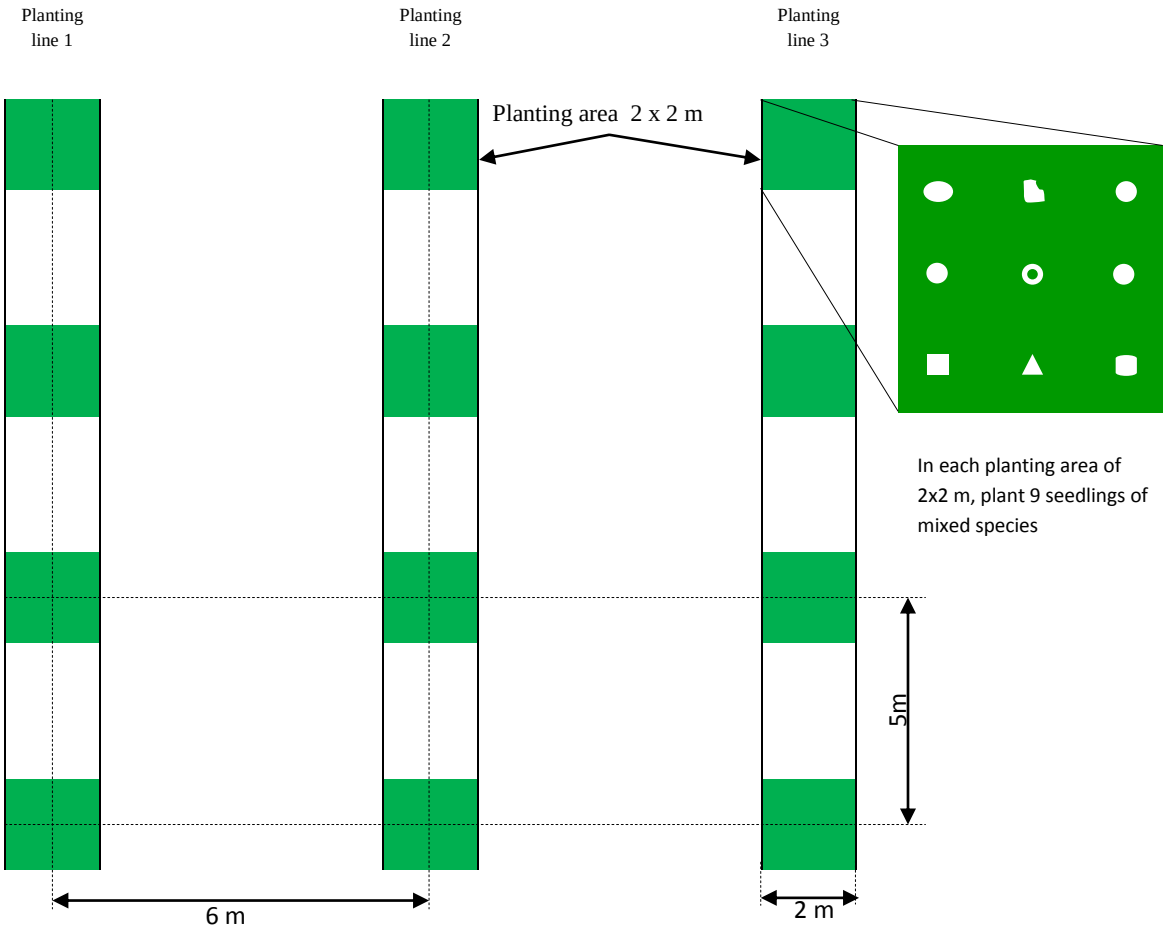

Figure 18. Layout of the planting of the Restoration Plot in the *Imperata* grassland in O Soam CF in 2014.

3.9.3 Engagement of local communities and relevant stakeholders

The project sought the involvement of the communities in Tbeng Lech and O Soam CFs in the implementation of the project (Figure 19). The communities participated in the establishment of the nursery and in conducting local experiments, planning or deciding of species to be planted, as well as the actual planting or restoration of the sites (please see Sections 3). The generation and diffusion of "farmer friendly" technologies suggest that full participation of farmers is essential to the development and dissemination of sustainable agriculture methods and technologies (Altieri, Undated). The involvement of the community especially in the planning and decision making of forest restoration will result to a sustainable implementation of the project (Mansourian, 2005; Mansourian *et al.*, 2005). People who have a stake in the forest landscape are more likely to engage positively in its restoration (Mansourian *et al.*, 2005*).* Altieri (Undated) emphasized the need to bring local knowledge and skills on the research process and involving farmers directly in the formulation of the research agenda.

Figure 19. Consultation with the village members in O Soam CF in Kampong Thom and in Tbeng Lech CF in Siem Reap.

The restoration of the community forests in O Soam and Tbeng Lech CFs is in support of the communities' visions:

> *Vision of O Soam CF: "A forest composed of big trees that could support the housing construction needs of our children, with abundant NTFPs and creek has fishes that could support the livelihoods of the community"*
>
> *Vision of Tbeng Lech CF: "The community forest will recover and the biodiversity is restored that can provide forest products for home consumption and support the ecotourism industry of the community."*

Gaps exist between the community vision and the current status or condition of the community forests. Thus, to achieve the vision, the capacity of the community on forest restoration needs to be enhanced. The community expects that at the end of the project, the forests will continue to recover and the population of the important or valuable species will increase.

Section 4: Lesson learned and recommendations

4.1 Lessons learned

Since the restoration work has just started in 2013, it is still too early to notice significant results. Restoration may take time to exhibit positive impacts. However, the project has motivated the community to conserve their community forests and utilized the forests on a sustainable manner.

A significant outcome of the APFNet project is the improvement of the capacity of local communities and staff from local Forestry Administration on forest restoration.The project was able to strengthen the technical capability of the Subnational FA staff and local CF communities on forest restoration. The result of the PRA shows the contribution of the APFNet project to the knowledge, attitudes and practices of the community members. The knowledge and skills were imparted to the community members thru practical trainings from nursery and seedling production to plantation establishment.

The training and extension activities have motivated the community members to protect the community forests. The communities actively participated in the production of seedlings and in the planting of some parts of the community forests. This resulted to the gradual recovery of the community forests including the NTFPs.

Although the forests only provided modest income to households, they provided subsistence forest products, such as wild potatoes, honey, edible insects, and wild vegetables including shoots of rattan and wild fruits that support the households' food requirement during periods of stress. Several members of the CFs collected forest products either for subsistence or for selling. The non-timber forest products provide income to the households. The community forest also provides fuel wood as cheap source of household energy needs.

4.2 Challenges in restoration of community forests

Along the community's vision, the community aims to develop their forest-based enterprises. This includes processing and trading of honey and other NTFPs, such as rattans. There are some members of the community that processed the rattan products (Figure 20). Achieving the vision of the community is constrained by the limited funds of the community to finance the development activities (e.g. production of seedlings, enrichment planting, and value adding of NTFPs, protection, and marketing of the products). Low cost restoration technologies as well as efficient utilization of the forest products are also a challenge. To achieve the vision, different strategies are need either to take advantages of the current strengths and opportunities or minimizing the impacts of the current weaknesses and threats of the CF (Table 7).

Figure 20. Consultation with the community members on the products to produce.

Table 7. SWOT analysis for Tbeng Lech and O Soam Community Forestry

OPPORTUNITIES: ❒ There are growing interest from the development agencies on the Community Forests in O Soam and Tbeng Lech. ❒ Existence of Development Agencies that can provide assistance to the communities. ❒ There is a growing demand for ecotourism, carbon market and potential payments for environmental services. STRATEGIES: ❒ The community should complete their CF Management Plan and develop the enterprises. ❒ The community should be trained on how to develop their CF Management Plan. ❒ The restoration works should further be enhanced in order to improve the forest resources.	THREATS: ❒ Some outsiders occasionally enter the CF area illegally and poach some forest products. ❒ The population is growing and demand for more lands for agriculture. ❒ In Tbeng Lech, the community forest is near the military camp. Occasionally, some military personnel do some illegal cutting. ❒ The Commune councils give low priority to the livelihood development of CFs. STRATEGIES: ❒ Support the development of firebreaks and patrol activities of the CFs. ❒ Support for the extension activities of the forestry laws to outsiders. ❒ Seek support from other development NGOs for the livelihoods of the CFs.
STRENGTHS: ❒ Awareness of the community members on the relevant laws on forestry. ❒ The two CF areas are located near the tourism areas, particularly Tbeng Lech. ❒ The CF members acquired skills and learned the technical aspects of nursery soil treatments and seed treatment technologies. ❒ The two CFs are well-known and trusted by various development agencies. ❒ The CFs have nurseries and experience in producing timber species seedlings. ❒ The boundary of the CF is demarcated delineated. ❒ Existence of the CF regulations. ❒ The CFs has demonstration plots of forest restoration that can serve as learning sites for other communities and visitors. ❒ The communities are aware on the benefits of the forests. ❒ The women are actively involved in all CF development activities. STRATEGIES: ❒ Secure support from the local authorities and the FA on CF development activities. ❒ Link the community forestry activities to the programs of the other NGOS. ❒ Develop the local community enterprises.	WEAKNESSES: ❒ The CF has limited resources to conduct patrolling activities. ❒ Some CF members have limited knowledge on Forestry. ❒ The CF in O Soam is not yet officially recognized from the national level. ❒ The CF has no CF management plan (O Soam) to be able to do commercial utilization of the forest products. ❒ Limited skills in the formulation of the CF Management Plans and in running the CF STRATEGIES: ❒ Build the capacity of the community by tapping the programs of other NGOs an donors ❒ Complete the CF formalization process ❒ Complete the CF Management Plan in O Soam that integrates the Business Management Plan of the identified products/enterprise of the community.

The community requested for support in the development of their livelihoods and enterprises as well as in patrolling works (e.g. logistical support) either from the local authority or development partners. Aside from logistical support, the community also need support in terms of developing their skills on the management of habitats of honeybees, the processing (value adding and packaging) and marketing of their products(rattan and honey), sustainable collection of the honey, and development of

ecotourism. The communities are also looking for support in the enhancement of the growing stocks of their community forests including enrichment planting with rattans and other valuable timber species.

4.3 Immediate and long-term impacts of forest restoration on livelihoods of local communities and general public

The implementation of the project has resulted to the conservation of the remaining forests, sustaining the livelihoods of the communities, improving the knowledge and skills on forest restoration, and increasing the communities' commitment to manage the community forest on a sustainable manner.

- **Conservation of the forest resources**. The implementation of the project has contributed to the conservation of the community forest. The on-going activities in the nurseries have sustained the community activities and prevented any outsiders from entering the community forest.

- **Sustaining community livelihoods**. The sustained protection and conservation of the community forests has preserved the forests that provide material products to the communities. Some of the livelihoods of the community were sustained by the continued availability of forest products (e.g. honey, wild vegetables, fuelwood, wild fruits and other NTFPs).

- **Knowledge and skills**. The practical and hands-on trainings were conducted by the Project Staff to the CF members (source: FGD with community members) resulted to the development of practical knowledge on the technical aspects of Forestry. Most of the CFMC members who received trainings applied their knowledge and shared to the members in restoring the community forest. The community now has a nursery and office where they could meet, especially when there are visitors who would like to learn from their experience. The basic techniques of raising seedlings enabled the community members to explore new ways of raising other species. The communities were able to raise the valuable timber species such *Dalbergia* and other luxury timber species, pines and rattans using wildlings.

- **Commitment of the Community**. The positive outcome of the project has led to motivation and increased commitment of the community members to get involved in the conservation of the community forests which is very critical in sustaining the project.

1.3 Recommendations

Sustain the forest restoration works. The current restoration work is just in the initial phase. The outcome of the restoration on the forest resources is long term and may take years before the community visions can be realized. To achieve the goal of the community, the restoration and protection of the community forest needs to be supported. The project should continuously enjoin the CF members to participate in the development activities. The market of wild honey should be expanded.

Support the community livelihoods. The communities need to be assisted in the production of seedlings that can be used for future restoration works. The community already have a nursery that can be used as facility for the production of seedlings. The community can include the production of seedlings such as rubber and fruit trees that may be sold to private developers. But to achieve this, they need to be supported in terms of marketing of seedlings and capitalization. The community may be linked to funding grants or low interest loans to start the production of the seedlings. The FA and Economic Land Concessions (ELCs) can even purchase seedlings from the communities for its restoration programmes and land developments. To sustain the forest based livelihoods, the

community needs to complete their CF Management Plans. The development of potential forest-based products needs to be supported (for example, honey in O Soam). The value of the product can further be improved if the processing and packaging will be improved. Linking these products to the market will also increase the viability of the enterprise. In supporting the intermediate and long term needs of the community, the restoration programmes should consider the multifunction of the forests. Restoration should endeavour the conservation of diversity of the forests by restoring the forests using the existing forest species and NTFPs.

Completion of the CF formalization and formulation of the CF management plan. O Soam CF has not yet completed its CF formalization process. This situation makes the community forests very vulnerable to land encroachment that may undermine the success of forest restoration. The two CFs have no CF Management Plan yet that can provide the direction and strategies of managing the community forests. Legally, the community cannot go into commercial utilization of the community forests without a CF Management Plan. Both the completion of the CF formalization and development of CF Management Plan are highly technical, thus, the Community Forestry needs assistance in their formulation of the CF Management Plans.

Use of the O Soam and Tbeng Lech CFs as learning sites. The nurseries should be used as a learning site for trainings to FA staff and university students on forest restoration. This will extend the usefulness of the nursery facilities and the community forests. But aside from the outsiders, the skills of the community members should also be continuously developed by exposing them to successful CFs in Cambodia or in neighboring countries.

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