Asia-Pacific Network for Sustainable
Forest Management and Rehabilitation

Experiences
From Restoration, Silvicultural Management and Installation of Forest Watcher System

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I Introduction

1.1 Background

Conserving the forests upstream is very critical since the rivers and surface runoffs drains towards Phnom Penh. At the southeastern part of Prek Thnot watershed locates some rice producing areas that depends on the water coming from the tributaries of Prek Thnot. The drying up of the headwaters due to deforestation and land conversion will expectedly affect rice productivity and increase flooding, pollution, and loss of life and property downstream (Thapa, 2005) due to the sediments. Most of its forests are severely degraded and needing rehabilitation. The loss of forest cover can greatly diminish the protective role of the watershed and increase the vulnerability of the downstream communities and increasingly subjects the downstream communities like Phnom Penh to flooding. It is expected that the community forest will also be able to increase its provisioning services to the community.

The demonstration project in the CF will complement the land use planning exercise that is currently being implemented by IRD and funded by APFNet. Implementing the project in the CF also contribute to the sustainability of the National Forestry Programme of the FA. Furthermore, establishment of Forest Watcher System in state-owned forests in Khun Ream and Ta Khmao will provide monitoring on forest fire, and supervision on forest resources and wild lives, which meets one of APFNet's priorities of reducing forest loss and degradation, and enhancing biodiversity conservation.

The demonstration sites will expectedly contribute to the overall framework of development of the Lancang - Mekong watershed management through the lessons learned from implementing the project. The project sites will also showcase the approach of restorations in Cambodia and will serve as a model for visitors on ecosystem management.

The goal of this project is to rehabilitate the ecological services and product provisioning services of forests in Cambodia through improvement of forest management and introduction of advanced forest monitoring system, so as to contribute to sustainable forest management in Greater Mekong Sub-region.

To achieve the goal, the project aims to achieve the following objectives:

1. To develop a model for community forest management by strengthening CF management and testing appropriate restoration and silviculture technology;
2. To mitigate the dependence of community to forests by improving household farming systems;
3. To enhance forest protection through adopting advanced forest monitoring system (Forest Watcher); and
4. To extend achievements and related techniques in Cambodia and GMS by demonstration and experiences sharing.

1.2 Purpose of the Report

This report aims to summarize relevant technologies based on activities carried out and experience of the project. The technologies implemented by the project include restoration of degraded community forest, establishment of agroforestry and home garden farming systems, as well as the documenting the experiences of installing and operating the forest watcher system.

II Methodology and Limitations

All document produced by the project have been collected and reviewed. In case of

missing some information, these were collected through project staff interview. The main objective of the interview was to describe the experience from project implementation such as Strengths, Weaknesses, Opportunities and Threats (SWOT), challenges, and lesson learnt from each activity and outcome.

III Activities of the Project and Assessment of Technologies Used

3.1 Forest Restoration

3.1.1 Forest Restoration Design and Species Selection

This output aims to establish restoration models in the community forest. This activity is also aligned with the current CF management plan of Damrey Chakthlork CF. The restoration site was divided into three categories, namely, i) Deforested Area, ii) Severely Degraded Forest and iii) Moderately Degraded Forest as shown in Figure 1 and 2 below. Each categories consists of 4 ha of land area.

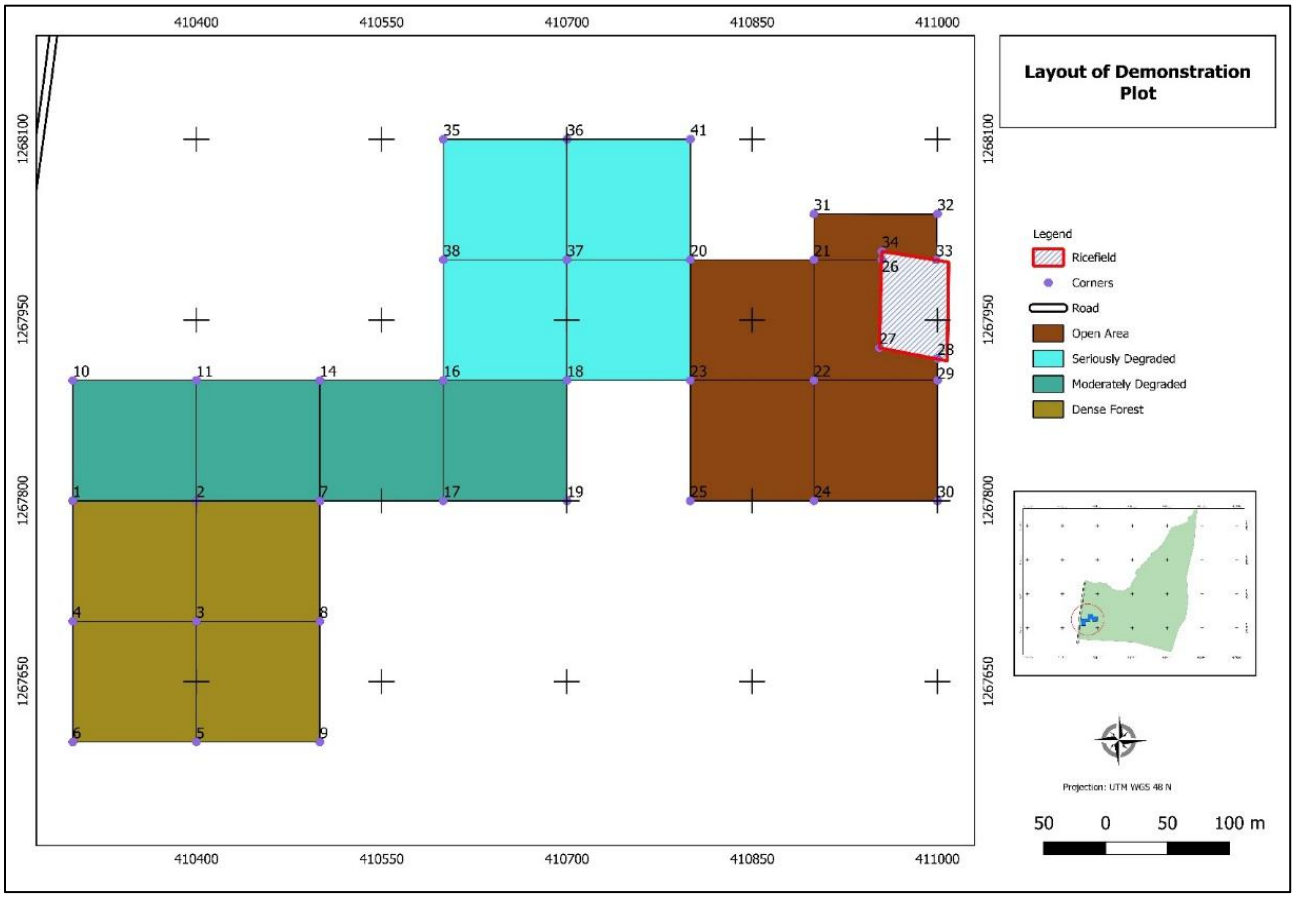

Figure 1. Design of demonstration plot for forest restoration

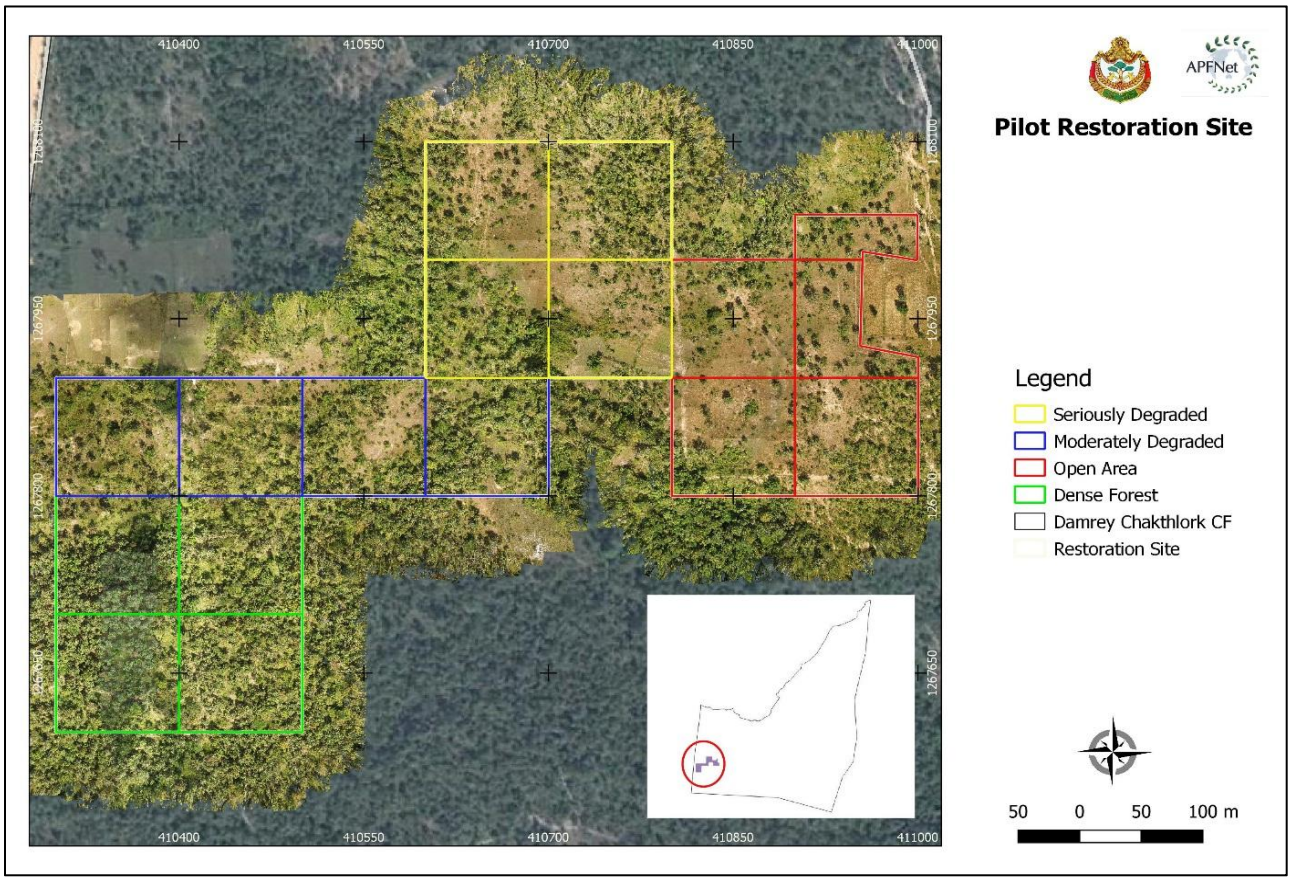

Figure 2. Arial image of forest restoration plot

The design of forest restoration area, planting and maintenance of saplings are crucial in the success of restoration activity. These activities involved planting of young trees in the designated plots. The young trees (at least 1-year old) were prepared and jointly planted by villagers, monks and CF members.

Only Cassia siamea was selected for planting in severely degraded forest while two species, namely Pterocarpus macroparpus and Dalbergia cochinchinensis, were selected for planting in the moderately degraded forest area. The deforested area was planted with four main species including Pterocarpus macroparpus, Dalbergia cochinchinensis, Dalbergia oliveri, and Tectona grandis.

3.1.2 Outcome

The project restoration activity is implemented in Damrey Chakthlork Community Forestry (CF) located in Kampong Speu province. The project has completed planting the 16 hectares of the target restoration areas. High mortality (approximately 22-82%) was experienced by the project due to the harsh condition of the site. During rainy season, water do not easily go out due to poor drainage system while the during dry season, the site is easily dry up due to the poor water holding capacity of the soils.

Due to poor soil condition, which poorly retain water during dry season, the seedlings were regularly watered and maintained regularly in dry season (December to May). The project also installed the water tank to irrigate the seedlings. The project constructed ponds and drainage canal to drain excess water during rainy season. Furthermore, the planted seedlings were protected by establishing a fireline around the restoration area.

Aside from planting using the conventional method, Cluster planting and Miyawaki method of planting was tested to restore the site. The planting used a mix of fast growing

and commercial tree species. The initial monitoring indicates that the survival rate under the Miyawaki method is estimated at 98% which is much higher than conventional restoration planting method. However, this survival rate will be updated in year 4.

To monitor and evaluate the forest restoration activities, K-Tree sampling method was employed to determine the survival rate and growth characteristic of planted trees. This method is one of the distance sampling methods based on point-to-tree distance measurements. It is also known as the fixed count or plotless method. This method is a practical field method for forest inventories and ecological surveys.

Seed recruitment: There are different seedlings used in reforestation activities in deforested area, severely degraded forest, and moderately degraded forest area. In deforested area, premium timber tree species, Pterocarpus macrocarpus, Dalbergia cochinchinensis, Dalbergia oliveri, and Tectona grandis were introduced while in severely degraded area were planted with Cassia siamea for firewood production. Seedlings of premium tree species were produced from identified seed sources that established by IRD.

SWOT Analysis of the Restoration Technology: The technologies introduced in this project site has the followings:

- Strengths: Most of premium tree species selected for restoration activities are commonly find in the area. Therefore, ecological requirement of the species is the same with site characteristics. This would promote best growth of the species.
- Weaknesses: Cambodia is also one of the countries who is affected by climate change. This emerging issue would cause seedling to dry out and cause high mortality rate after planting. In addition, seeking participation from the community members on restoration is difficult due to limited income of the villagers.
- Opportunities: Since the development of new technology, such as construction of drainage canal and watering system, and new planting technique such as Miyawaki method has shown increase survival rate of tree planted out.
- Threats: Since this restoration are located in community forestry, therefore, the well-being of community member would be strongly affect to the participation of maintenance and monitoring of the activities.

Due to the low survival in some areas of the restoration sites, a new method called Miyawaki method was tested. The project tried Miyawaki tree planting technique as an approach of restoring open area by using 7 species and a total of 1,350 seedlings). The Miyawaki method require dense planting using a mix of several species (climax, pioneer and some fruit bearing trees) over an area at close spacing. The area proposed for the Miyawaki technique is within severely degraded areas with a size of 30 m X 100 m. The luxury species (hard wood) like Dipterocarpus, Pterocarpus macrocarpus and Dalbergia were mixed with the fast growing species such as acacia and Acacia siamensis using seedling and direct seeds planted at 1 m x 1 m apart. This method was tried after encountering some low survival using conventional planting method. The result indicates a survival of 98%.

3.2 Agroforestry and Home Garden

3.2.1 Technical Design

Agroforestry. The project established an agroforestry model by intercropping of high value cash tree species such as macadamia trees with vegetables. The model tries to generate cash incomes for the farmer soon since the first year by planting vegetables and

in late stage the farmer can get long-term benefit from cash trees. The land for agroforestry was 100 x 100m which divided into to 3 zones as follows:

Zone 1— erosion control strip. In this zone, 3 strips, measuring 5-meter-wide were established and the distance between strip is approximately 30 meters. The first strip is intended for soil and water erosion control. The soil and water erosion control strip kept the original vegetation composed of secondary shrubs.

Zone 2—border control line. Zone 2 separates the agroforestry system from community forest. Sweet bamboo, Dendrocalamus brandisii, a kind of sympodial bamboo were planted in this zone. The distance of each cluster of sweet bamboo is 5 m and total 20 clusters of bamboo were planted in the area. Bamboo planting is expected to bring not only economic benefits to the farmers, but will help in conserving the soil and water, protection from strong winds, prevent the top soil from being eroded, and enhance the esthetic view of the landscape. A ditch with the depth of 1 m and the width of 0.5 m were dug between second and third zones to prevent invasion of bamboo root system into fruit tree plantation.

Zone3—fruit tree plantation. It is the main part of the farm and is divided into 6 areas (each area measures 30 m x 50 m) separated by erosion control strips. The fruit trees planted were macadamia, pomelo and cashew. The grafted seedlings of macadamia and pomelo were imported from China.

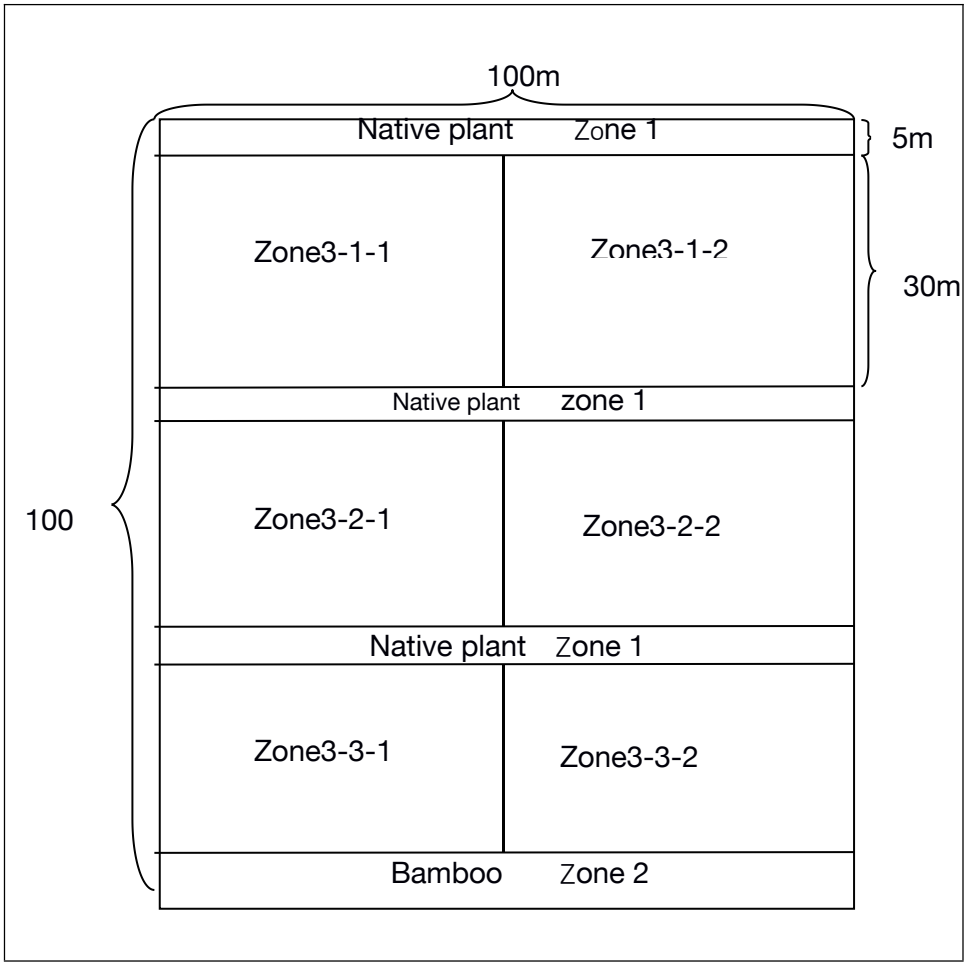

Figure 3. Lay out of agroforestry design plot

Home Garden. The project helped the farmers to developed a farm plan for their home gardens. The home garden of the farmer was subdivided into compartments with the

rows of bananas. The rows are spaced at 10 meters apart along the east-west direction. The bananas occupied the upper story canopy were planted at 3-meter x 10 meter distance. The vegetables were planted In between rows of the bananas.

The subdivision of farms by blocks allows the rotation of crops. The rotation planting of crops is intended to disrupt the life cycle of soil borne-pathogen and to present the depletion of soil nutrients. The farmers were advised to alternately plant the compartments with leguminous and a non-leguminous plants to avoid exhausting the soil nutrients. The continuous planting of single crop over the same piece of land will have the tendency to deplete a specific nutrient of the soil. The rotation of different plants will replenish some nutrients to the soil through the litters that the plants will deposit to the soil.

The planting design was developed in such a way that the space of farm lot is optimized both spatially and vertically. The vertical space is optimally utilized by arranging the upper story and the understory plants with minimal obstruction of sunlight reaching the understory plants. The wide space between rows of bananas is oriented along the east-west direction where the cash crops were planted in between.

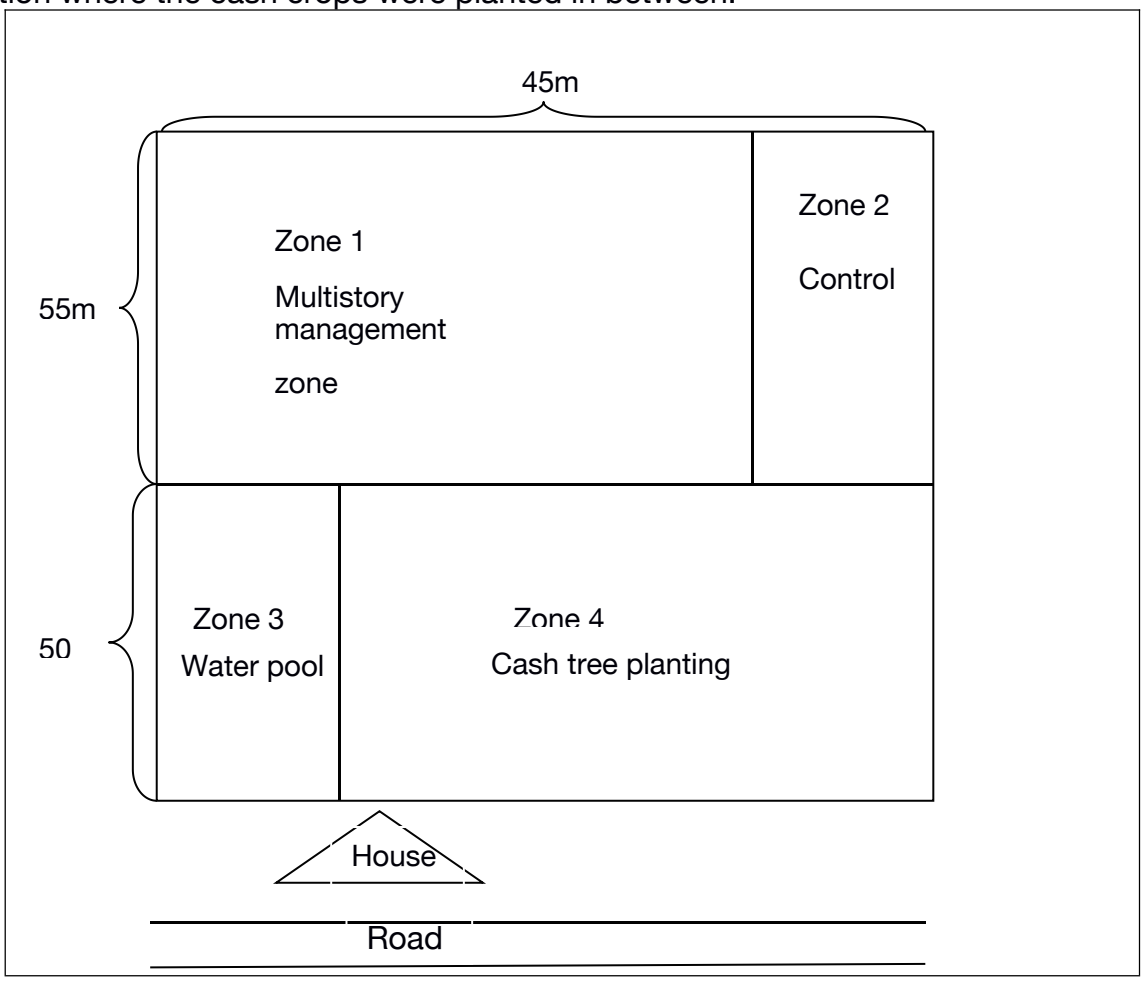

Figure 4. Planting design of home garden

3.2.2 Outcome

Agroforestry. After one year planting of macadamia, pomelo and cashew in agroforestry area, only cashew have shown good growth while macadamia and pomelo showed poor growth performance and low survival rate. The project team has decided to plant other fruit trees such as mango to replace macadamia.

Figure 5. Agroforestry plot

Home Garden. The home garden technology maximizes the utilization of the vertical canopy and prevents the depletion of soils through crop rotation. Previously, the farmers harvested about 150 – 200 kg per month of vegetables which are sold at around $0.3-$0.75 per kg. This makes the farmers earn approximately $50 - $100 per month. Since the farmers applied the technique recommended by the project, their vegetable yield has increased. The farmers now harvest vegetables about 450-700 kg per month and earn an income of $300--$500 per month. There are no wastes for the vegetables produced since those that were not sold were used by the farmers as feeds for chicken and pigs.

Figure 6. Harvesting morning glory in home garden

Technologies introduced in agroforestry and home garden site in this project site has the following SWOT:

- Strengths: both technologies provide not only short term benefit but also the long term benefit in term of cash income which is important for the poor farmer in the project sites. Beside direct cash income, both technologies provide other non-cash income benefit such as soil erosion control and contribute to local environmental benefit for local community.
- Weaknesses: identification of Market demand as well market trend for products produced by the model is very important for the success of model. Furthermore, competition and quantity of product produced by the model is still low, thus, high cost in transportation which is difficult to compete with outside producers.
- Opportunities: Since the development of road network, this product can be easily transported to different market even in local community. In addition, local knowledge seems to be aware of the benefit of consuming chemical-free vegetable and farm products. This would help the model farmers to succeed in selling the

products. Furthermore, farm planning for the land use and seasonal cultivation improves the productivity of the small lot and, thus, increase the production and market price.

- Threats: Site characteristics such as soil and water supply would be emerging threat to the model, especially vegetable which can be produced only seasonally and not year-round production.

3.3 Woodlot Development

Woodlot was implemented on area of 7,433 sq.m. subdivided into two blocks. The first block is to maintain existing trees while the second block was applied with silvicultural treatments (thinning) and understory planting of shade-tolerant crops. The strips measuring 3 m wide were established where the undesirable tree species were removed, keeping the commercially important trees. In between the spaces, galangal and turmeric were planted. Pepper was planted in the initial design. However, the planted pepper did not grow well. The project decided to modify the design by planting turmeric and galangal in the thinned strips in the second block. In the second block, water system was also established for watering. The objective of this model is to demonstrate the possibility of interplanting shade tolerant cash crops in the second growth forests to generate intermediate income. Between galangal and turmeric, it is galangal that grows well. The intercropped galangal is maintained by providing mulch and removing the competing weeds. Fertilizers were also applied to the intercropped plants to increase its growth.

Figure 7. Galangal intercropped in a clear strip under canopy in the woodlot

Figure 8. the growth performance of galangal planted in the woodlot

The selection of right shade-tolerance crop for intercropping under forest canopy such as galangal and turmeric would promote success of the project.

Technologies introduced in agroforestry and home garden site in this project site has the following SWOT:

- Strengths: This technology provides not only forest product from maintaining the forest but also short-term benefit from cash crop which is important for community member involve in the project. The technologies also provide other non-cash income benefits such as soil erosion control and contribute to local environmental benefit for local community.
- Weaknesses: Community members cannot depend mainly on income from this technology. Therefore, they have to involve with other job for their main income which lead to weak commitment of some community members.
- Opportunities: Carbon market would be one opportunity for community member to use the woodlot technology. Furthermore, people are now interested in forest as tourist destination site. So in the future, generating income from eco-tourism services would be one opportunity for community member to maintain forest while generating extra income for their livelihood improvement.
- Threats: the area was affected by El Niño and the planted peppers have experienced high mortality. There are now very few black peppers left. So the project team decided to shift to galangal and turmeric species.

3.4 Forest Protection and Monitoring

3.4.1 Patrol Operation

Boundary demarcation and patrolling is one main output among the 4 output that was set in the first objective of the project. The community forestry member conducted patrolling to prevent illegal logging in the community forest. The patrolling has been conducted every month, especially during dry season because of illegal logging rarely happen in rainy season. Moreover, during rainy season, community members come to forest to collect NTFPs, therefore, they can report it to CF leaders in case they have encountered illegal activities in the forest. Patrolling is also conducted frequently during dry season in order to respond immediately in case forest fire happen. The community forestry leader organized 20-30 members to carry out patrol work.

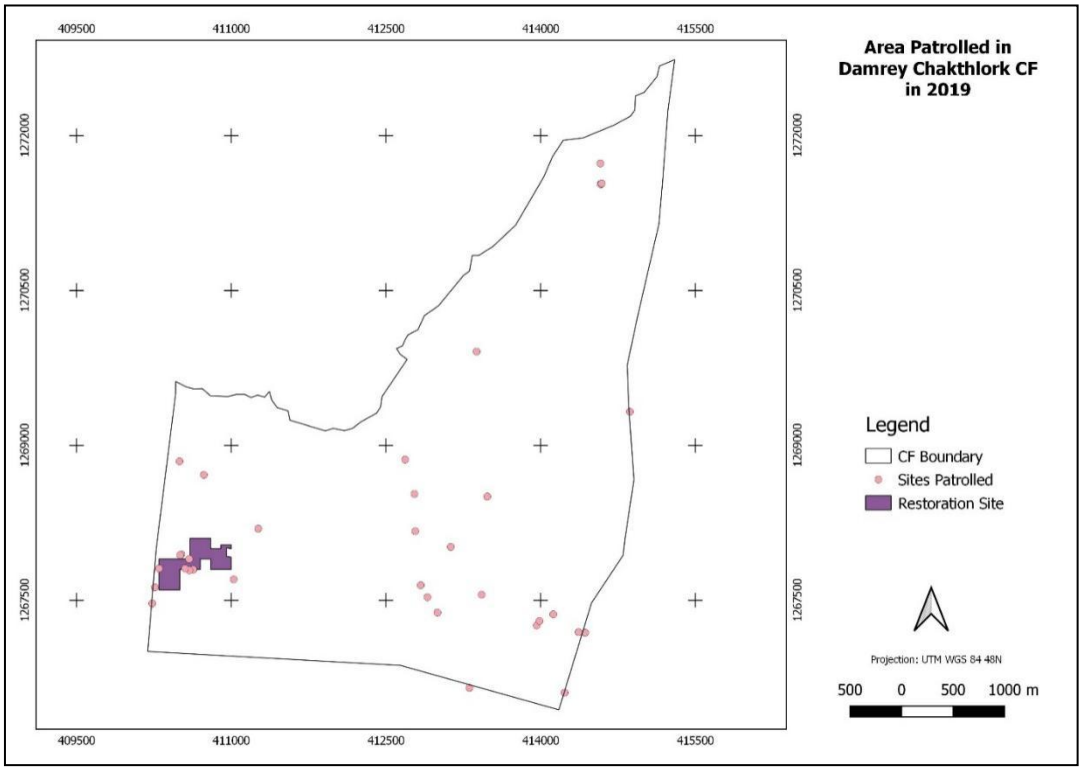

Figure 9. Map of location site visited by patrol group

3.4.2 Fuel Management (Controlled Burning)

Fires frequently happened in the adjoining areas which pose serious threat to the established plantations. In order to cope with this challenge, the project has constructed fireline or firebreak around the area with the average width of 5 meters. This fireline have been maintained every year. Besides the fireline constructed to prevent forest fire, controlled burning method was also employed. This method is used to reduce forest litters and grass from forest floor so as to eliminate or reduce fire risk. The burning is scheduled for the time when fire will not pose a threat to the public or to fire managers. Controlled burning is used when forest condition in the area should call for controlled burning and whether condition should be right to allow burning but not enable a fire to spread out of control. The fuels burned in this method include dead grass, fallen tree branches, dead trees, and thick undergrowth.

There are three main steps for controlled burning or prescribed burning method which can be described as follow:

1. Plowing: this step is to plow the area, especially between planting row. Plowing was conducted in January or February the wide of this plowing is about 10 m in order to control the spread of fire into the forest or forest restoration area.
2. Preparation of firefighter truck: it is to make sure that water is available in firefighter truck so that they can operate immediately if needed.
3. Identify wind direction: the project team identify wind direction so that they start burning on the sport.
4. Burning: After the 3 main steps above are done, the burning will be started. After burning the officer have to keep an eye on the burning site because after burning the wind direction may change and, the fire might spread to other area where is not necessary. In case of escaped fires, the officer can immediately put out the fire from the beginning and not wait until it is big and difficult to control.

Technologies introduced in this project site has the followings SWOT:

- Strengths: Low cost method compared with other methods. However, it needs experience staff to carry out the techniques, otherwise, it will spread to other areas.
- Weaknesses: can only carry out when weather is not windy so that the fires will not spread to surrounding area.
- Opportunities: Participation from local community member as well drainage canal, firebreak/fireline, and pond were constructed. Therefore, in case of escaped fires, the water from these canal and pond can be used to put out the fire.
- Threats: Fires mostly occurred in dry season. The early dry season is always windy causing controlled fire more difficult to implement.

Figure 10. Controlled burning

3.4.3 Installation and Operation of the Forest Watcher System

The project has installed a forest watcher system to help in monitoring the status of the vegetation in the surrounding areas, like fires and the condition of the vegetation. There are three main stage of installing the forest watcher system. First, is the survey stage. This stage tries to conduct site survey in order to select the proper site for forest watcher system. The suitable site should be safe and not flooded. The second stage was the construction stage. The construction was made by Chinese contractor who constructed and installed forest watcher system, and provided training and coaching to the FA personnel. The trainers came from the Project Staff, staff from Tamao Zoo, from the local FA, and even community members who were able to observe the capability of the forest watcher to collect real time data. The third stage was the operation of the system to collect data of its surroundings.

However, since this is a novel technology introduced to Cambodia, especially the project team, the project officer relies mainly on the experts from China. Since the COVID outbreak, the communication and support from Chinese experts was limited. Furthermore, Khun Ream station is not yet connected to electricity and the monitoring was intermittent.

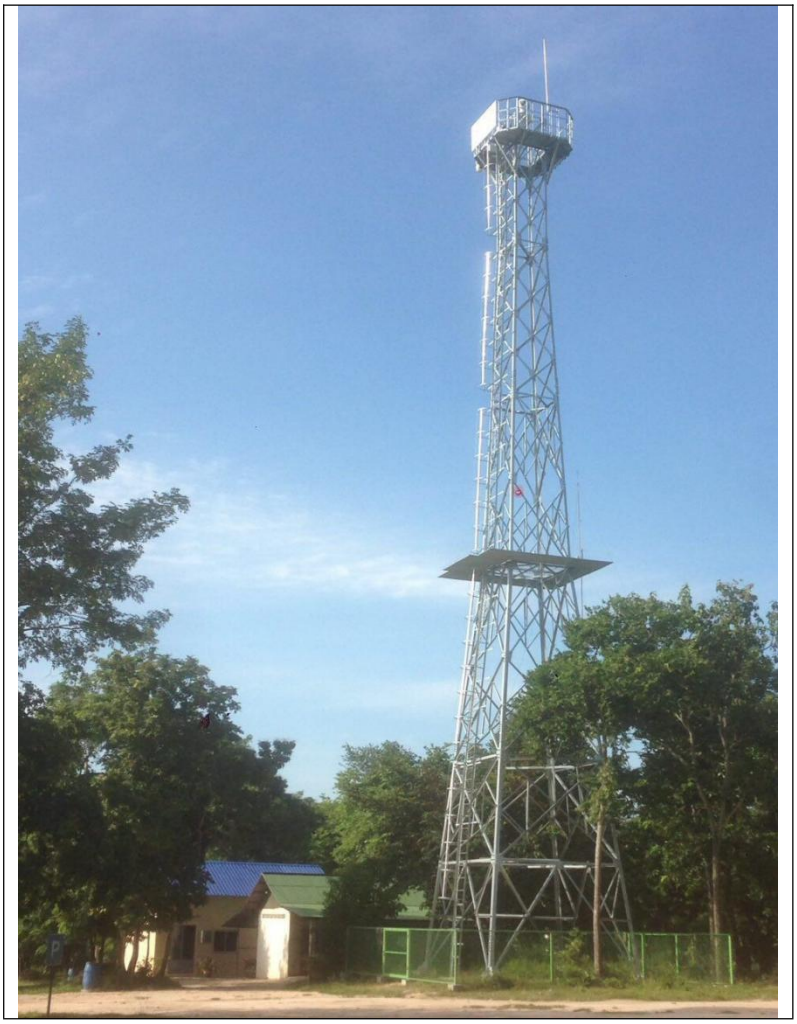

Figure 11. Forest watcher system

Figure 12. The Chinese experts and project staff coaching on operating forest watcher

system

Figure 12. Images collected from forest watcher system

Technologies introduced in this project site has the following SWOT:

- Strengths: Technical support from Chinese experts which can back up the project staff in operating the system. Furthermore, this technology can be used to monitor a huge forest area during day and night time so that action can be taken immediately if needed.
- Weaknesses: A new technology which need not only one time training but also back up and refresher training to project staff so that the operation of the system can be carried out properly.
- Opportunities: Young newly recruited staff who can capture and be transferred new knowledge and technology for further development.
- Threats: The spread of corona virus has threatened transferring this technology to project team through delays and postponed visits of the expert to the project site. Furthermore, electricity is not continuous to run the system.

3.4.5 Use of Geotagged Photos in Monitoring

This technology has great application for forest monitoring real ground development of reforestation and other activities or events happening in the forest.

Based on this technology, the project team has set up the following steps for forest monitoring:

1. Form up patrolling team led by local community member
2. The patrol team were issued digital camera to take geotagged photos. The patrol team took photos if they encounter unusual activities during their patrolling such as forest fires, illegal logging, etc.
3. After taking photos, the project team checked coordinates of the photos and uploaded the photos in the computer.
4. By using Map Utility, the photos were exported to Google Earth to generate KMZ file. These files can then be opened in google earth where we can see

the activities such as illegal logging or forest fire happened so that the project team can have a better plan for coping with those activities.

Besides monitoring the illegal activities, the technology also captured the physical growth of vegetation such as the growth of reforestation area from the first year of project implementation. Around 24 patrol operation had been conducted and photos were captured in the CF area covering 1,000 hectares. The photos can be displayed in google earth which all project team can access to see the activities such as illegal logging and forest fire in community forestry.

The technologies introduced in this project site has the followings SWOT:

- Strengths: project team can monitor the area over time with clear understanding about the activities happening in the forest. The technology is easy to use and low cost appropriate for monitoring the field. The technology can monitor not just only the illegal activities but also physical growth characteristic of the forest.
- Weaknesses: need some training to community members since they need to know how to set up GPS in the camera, otherwise, they can only take ordinary photos instead of geotagged photos.
- Opportunities: Current development of smart phone which also consist of GPS function which can be used for this geotagged photos. Furthermore, with free google earth access, this technology can be uploaded and view in google earth without costs.
- Threats: Most of devise utilize English language while most of community member can read or write only Khmer language. This would provide higher chance for community members to confuse if the devise is set to different mode.

IV Challenges

Even if the project is going on and running smoothly, the project team encountered the following challenges:

- In forest restoration activities, the harsh climate caused high mortality rate of planted seedlings. The site has a poor drainage which contributed to the high mortality.
- Although the agroforestry and home garden provides an opportunity for the farmers to improve their production. However, the income of farmers remains low due to the low buying prices of their products. The community members who implemented this technology need to have other sources of income to supplement their income from farming despite adopting the agroforestry and home garden technologies.
- Like agroforestry and home gardens, woodlot development also faced similar challenges. Community members are generally poor who mostly depend on immediate return of their efforts. Otherwise, they will be less interested in implementing the activities. There is also limited information on the condition of the soil, making it difficult to determine the exact fertilizer requirement of the vegetables. Galangal, which has a potential to be interplanted in the woodlot, faces uncertain market prices.
- The installation of forest watcher system provides an opportunity for the FA to monitor its area. However, maintaining and operating the system is quite challenging. The first challenge was the technology is very new to the project team and the staff depends mainly on Chinese experts to transfer knowledge to the project team. However, since the spread of COVID 19 pandemic, the visit of experts from China was stalled. Thus, the project team could not run the system. The availability of electricity also poses another challenge. The forest watcher system depends on availability of electricity. But Khun Ream is not yet connected

to the grid. Thus the operation of the system is intermittent.

- Deciduous forest has been encountered in project. This forest type shed off their leaves during dry season which is the main cause of forest fire in project site. Even many activities such as fire line and prescribed burning had been carried out to reduce the fuel, the experience of project staff is limited on how to properly apply controlled burning. The project staff need to have the knowledge on fire ecology and local climate of the area such wind direction, wind speed, and seasonal variation.
- Geotagged photos is a new technology to the project team, especially community members. The experience from the project showed that working with community members encountered some challenges in collecting geotagged photos. This is because local community member can take photo easily but have difficulty in setting the GPS in camera. Therefore, some photos have been taken without coordinates which cannot be used in mapping.

V. Lessons Learned

Based on the project implementation many good lessons can be learnt from the experience:

- Selecting the right species, by mixing fast growing and slow growth species with right planting technique would promote survival rate and, thus, contribute to the success of forest restoration program.
- The main objective of agroforestry and home garden development is to provide cash income to improve local livelihood. It is, therefore, important if the products which are produced by the model can be continuously sold in the market. Hence, linking market with farmer would be an option to promote the product.
- Woodlot development involves planting of crops/plants in the forest canopy. Selecting the right shade tolerant species will increase the success of interplanting in the woodlot. As we can see clearly in this project, after selecting galangal and turmeric which are the shade tolerant species, the activities was going on smoothly. Furthermore, good market price for turmeric and galangal would be also important considerations in woodlot development.
- Forest watcher system is promising technology for managing and monitoring forest. The activities introduced in this project can be used to monitor the forest not only in day time but also during night time. However, this technology depends solely on availability of electricity. Therefore, the introduction of solar energy in the system would be an advantage since Cambodia is in the tropical zone where sunlight for establishing solar energy can be available almost everywhere.
- Forest fire is a destructive factor affecting the success of forest restoration program. Therefore, fuel management would be important for fire management. Prescribed burning is one method for fuel management. Plowing around 10m width before prescribe burning would provide the success of prescribe burning since plowing can reduce fuel on the ground and also reduce the speed of fire spread.
- Geotagged photos is important for forest monitoring. Training community member to involve and take the geotagged photo would lower the cost. However, training and field practice to community members is crucial for the right collection of geotagged photos.

VI Conclusion and Recommendations

In conclusion, the project has been designed not only for forest restoration but also livelihood improvement that benefits the environment such as preventing soil erosion. However, after the implementation, livelihood improvement have slowed down due to

poor market prices of agricultural products. The limitation of income generation lowered the enthusiasm of the community members to engage in farming.

For the next phase of project, livelihood improvement has to be taken seriously so that local community members can fully participate with strong commitment for forest restoration activities in their community. This livelihood improvement can be achieved through following:

- Bring wholesaler and traders to communicate with local community members to discuss what are in demand in the market and what products that community members should produce. This means matching product market requirement and local community products.
- Expanding the farm production needs bigger capital. Bringing the products to the market also needs to have economies of scale to reduce the transportation cost. The product that community member produce was still limited and could not offset the cost of bringing the products to the market. Under the current level of production, the farmers cannot compete with other producers.
- Product quality is one main factor that need to be taken into account for scaling up. Because product that will be sold in the market does not only concern bringing down the cost but also maintaining the quality and physical appearance of the products.
- Aside from livelihood improvements of local community members, capacity building of project team on forest watcher system is also needed. The capacity building is not just only on theoretical aspect, but also requires on the job training. Building the capacity of the project staff will reduce the dependence of external experts, particularly the Forest Watcher system.