Document No.:

Receiving Date:

Asia-Pacific Network for Sustainable Forest Management and Rehabilitation

Completion Report

Demonstration of Sustainable Upland Agroforestry Systems in Chinese Taipei

September 2011 to August 2013

Taiwan Forestry Research Institute, Chinese Taipei

December 31, 2013

Basic Project Information

Project Title(ID)	Demonstration of Sustainable Upland Agroforestry Systems in Chinese Taipei	
	Approved	Actual
Date of commence	September 1, 2011	September 1, 2011
Date of completion	August 31, 2013	August 31, 2013
Extension period	N/A	N/A
Project Budget (in USD)		
APFNet's Grant (in USD)	400,000	ca. 400,000
Counterpart Contribution (in USD)	137,000	ca. 137,000
Supervisory Agency	N/A	
Project Executing Agency	Taiwan Forestry Research Institute, Chinese Taipei	
Project Director	Cheng-Kuen Ho	

Project description:

This project aims to demonstrate the ability of agroforestry systems in preventing the destructive landslides and surface erosions on cultivated uplands, develop the criteria and indicators for evaluating the sustainability of such agroforestry management systems and encourage the communities of mountain villages to participate in the development of new agroforestry systems and take part in the dissemination of new technologies.

Prepared and Submitted by	**Reviewed and Endorsed by**
Cheng-Kuen Ho	Yue-hsing Huang
Cheng-Kuen Ho Project Director signature Date 2013.11.01	Yue-hsing Huang Project Steering Committee Chair signature Date 2013.11.01

FOR APFNET USE

Reviewed and comments by	**Reviewed and comments by**
ED signature Date	PO signature Date

Executive Summary

There are about 58.5% of forest lands in Chinese Taipei [1]. Upland area is very vulnerable and unstable due to its rugged topography. However, the upland villages reply heavily on agricultural practices for livelihood. On the other hand, the Chinese Taipei administration is seeking for sustainable management and increasing carbon sink solutions on these forest lands. This project was carried out mainly by the Taiwan Forestry Research Institute (TFRI), cooperated with the Taiwan Forestry Bureau (TFB) and the Chinese Forestry Association (CFA) to demonstrate sustainable agroforestry systems in upland areas. APFNet has provided financial support and clear guidance/feedback for project implementation and management.

When the project was completed, all activities were finished on schedule. Actual accomplishments were generally consistent with project Annual Work Plans. About 99.4% ($463,502 USD) of the fund (from both APFNet grant and counterpart funding) was spent at the end of the seventh quarter.

As the main goal of this project was to develop and demonstrate the sustainable agroforestry systems adaptable in upland areas of Chinese Taipei, the project's objectives were achieved when five study sites, including three demonstration sites, were successfully established. The three demonstration sites were Pinglin (northern Taiwan, Tea-*Cinnamomum kanehirae* system), Yuchi (central Taiwan, Betel nut-*Cinnamomum kanehirae* system), and Kalala (eastern Taiwan, Betel nut-coffee-*Cinnamomum osmophloeum* system). All the agroforestry systems can be easily copied to adjacent areas or similar regions. Based on runoff and soil erosion monitoring data at Kalala agroforestry study site, surface runoff amounts of all treatments were little. More than 30 indicators/criteria in environment, economy and society themes for evaluating the sustainability of agroforestry management systems were provided.

The project research results would help the Chinese Taipei administration to make appropriate and practical forestry policy. Based on the data collected from this research project so far, recommendations in conducting sustainable agroforestry have been provided to TFB for making relative forestry policy. The criteria cover aspects of both soil and water conservation and silviculture, including soil conservation method, plant spacing and arrangement, species selection, and environmental friendly tending requirements. Agroforestry workshops were held in several upland village communities to promote the concept of agroforestry and/or train farmers. Visiting the project study sites is one of the best ways to demonstrate and show people how agroforestry may be put into practice and benefit.

To make sound policy and regulations, further discussions among different parties of agroforestry in Chinese Taipei is necessary to sustain the project results, which will certainly play an important role during the process.

[1] Chinese Taipei, which makes up islands of Taiwan as well as Penghu, Kinmen, Matsu, and other minor islands. The “Taiwan” in the report represent “Taiwan island of Chinese Taipei”.

TABLE OF CONTENTS

1. INTRODUCTION

Taiwan is a mountainous island with lush and diverse forests which occupy 58.5% of the area. Upland area is vulnerable and unstable, especially to huge landslides and debris flow disasters that occur in upland areas frequently in recent decades. However, agricultural practices in upland areas are continuously carried out for local communities' livelihood. In Chinese Taipei, one of the present research priorities to forester policy making has been carbon sink effect through afforestation and reforestation. In this regard, upland agroforestry could be a solution to address both needs.

In other cases, agroforestry can make it easier for farmers to transit from one type of crop planting to another as market demands for their products change. While many landowners in upland areas are getting old yet most of their descendants are working in urban areas, they would like to change their intensive-managed cultivation lands into a low input and labor-saved system, such as forestation. In this case, agroforestry systems are good choices during the transition period.

In spite of the advantages of introducing agroforestry systems in upland areas, land management under agroforestry system legally is still rare in Chinese Taipei. During 1951 to 1975 in several stages, part of publicly owned forestland (which accounts for 3/4 of forestland in Chinese Taipei) was leased to individuals, aboriginal people and/or organizations to help the government with planting and managing trees especially in upland areas. No agricultural crops planting and harvesting on forestland were allowed according to their lease policy. However, to gain more income in a shorter period of time, many leaseholders had low intention of reforestation but planted high revenue agricultural crops instead. Their behaviors not only violate the forest regulation, but also may result in soil and water conservation problem. Nevertheless, the government, in practice, was incapable to either evict all illegal cultivated leased land or correct every violating leaseholder. As a result, sustainable agroforestry system in some suitable area of publicly owned forestland might solve the problem.

Since agroforestry was not prioritized and encouraged in the past in Chinese Taipei, agroforestry related researches are not sufficient and out of date. More update of technologies in silviculture and plantation management, soil and water conservation, and system evaluation approaches are urgent. Proper and practical forestry policies can only be made based upon adequate research and results.

Through developing sustainable agroforestry demonstration sites in upland areas, this project provides more knowledge and techniques in this field. Furthermore, agroforestry management systems that encourage the farmers to interplant trees on their cultivated lands can be a solution to harmonize the land use types in these upland areas.

As one of APFNet's objectives is to strengthen sustainable forest management

and improve forest quality in the Asia-Pacific region, this project helps achieve this objective, such as developing upland area sustainable agroforestry systems and increasing carbon sequestration.

This 2-year project, approved by APFNet in July, 2011, was started on September 1, 2011. The total budget is $537,000 USD, including 74% ($400,000 USD) from APFNet and 26% ($137,000 USD) as counterpart contribution from project executing agency.

2. PROJECT GOAL, OBJECTIVES AND FORMULATION

2.1 Project Goal

The goal of this project is to develop and demonstrate the sustainable agroforestry systems adaptable in upland areas of Chinese Taipei.

2.2 Project Objectives

1. To develop at least two different agroforestry management systems to cope with different demands of crop cultivation and tree planting.

2. To demonstrate the ability of these systems in preventing the destructive landslides and massive surface erosions on cultivated uplands.

3. To develop the criteria and indicators for evaluating the sustainability of such agroforestry management systems.

4. To encourage the communities of mountain villages to participate in the development of new agroforestry systems and take part in the dissemination of new technologies. Two technical teams from upland villages will be fostered.

2.3 Project Designing

The study sites are selected in the aboriginal reserves or on private upland farms in Chinese Taipei, as agroforestry is not allowed in publicly owned forests yet. The majority of aboriginal reserves are located in upland area. When aboriginal people work on their reserve areas, there are special regulations which are usually more flexible to fit the tribe's traditions. Study sites are selected in northern, eastern and central Taiwan, respectively. They vary in elevation and crop species. Although most population of the Island is living in the downstream plain areas, the upland areas are closely related to the environmental conditions of downstream cities. However, the major activity for livelihood in upland villages (including aboriginal areas) is agricultural productions, such as betel nut, tea, fruit and vegetables. Surface erosion problems may be serious on these cultivated uplands. Therefore, appropriate agroforestry management system(s) in these areas are expected to balance different interests among different stakeholders.

Taiwan Forestry Research Institute (TFRI), the executing agency (EA), cooperated with two agencies, Taiwan Forestry Bureau (TFB) and Chinese Forestry Association (CFA) to carry out this project. In the process of selecting upland villages and fostering technical teams, TFB and CFA also participated in the activities.

Farmlands of betel nut and tea are the main target of this study. Firstly, betel nut and tea farms occupy majority of upland agricultural areas. In 2009, betel nut and tea farm areas were 49,093 ha and 14,855 ha, respectively. Secondly, the prices of both betel nut and tea are dropping gradually every year since cheap products are imported from abroad. As a result, some farmers are considering changing their crops of betel nut or tea to other crop(s) or even planting trees.

Interplanted tree species were selected carefully. First of all, the environmental conditions have to be suitable for the species growth. The species recommended to be interplanted in this project, *Cinnamomum kanehirae*, *Calocedrus formosana*, and *Cinnamomum osmophloeum*, are profitable when they are ready to harvest in the future. The most important is the farmer is willing to plant these species.

Farmers who provide their farms as experimental plots, farmers' communities, and industries interested in forest products also played an important role in this project. To clarify the responsibility and obligation of each party, an agreement between TFRI and the landowner during the project implementation was signed.

The risky extreme weather events such as typhoon impacts which might ruin the experimental plots and postpone the completion of the project did not occur.

3. PROJECT EXECUTION

3.1 Start-up

Before applying for this project, TFRI had just initiated a study on the effect of agroforestry management in mountainous areas on carbon sequestration. Under the supervision of TFRI Director General, Yue-Hsing Huang, the study team was then starting the preparation of this project. Moreover, TFRI has been focusing researches on the sustainable management and multi-purpose utilization of forests recently. Thus the interdisciplinary project team including various experts of silviculture, forest management, forest hydrology and forestry economics etc. was already available. As soon as receiving the project approval letter from APFNet, TFRI began to develop the first annual work plan and necessary paper work. After reporting to Council of Agriculture, the supervisory authority for TFRI, the project director and key project team were determined.

Before the inception workshop, a Project Steering Committee (PSC) was established as suggested by APFNet. The PSC consists of one representative from the EA (TFRI Director General, Dr. Huang), one government authority (TFB director general, Tao-Sheng Lee), and five university professors in the relevant fields (Annex

A). TFRI Director General, Dr. Huang, is the chair of this PSC.

APFNet and TFRI have different procedures and regulations in either procurement or reporting management systems. In order to meet the requirements from both parties, the project team spent some time to adjust or communicate during the implementation of project.

3.2 Implementation schedule

At the end of the project implementation (August 31, 2013), all activities originally planned were completed on schedule. Actual accomplishments are consistent with approved Annual Work Plans. There is only one sub-activity whose completion time was somewhat different from the anticipated schedule without negative effects. Two seminars (Activity 3.1) organized in year 1 were held earlier than originally scheduled. The planned and actual implementation schedules of all project activities are presented in Annex B.

3.3 Procurement and consultant services

As TFRI is a governmental agency, all purchase of equipment and materials abided local laws and regulations, such as Government Procurement Act of Chinese Taipei. Procurement personnel, procurement supervision personnel, and accounting personnel of TFRI ensure the project team follows all financial rules. A list of purchase, including equipment and software, over $335 USD ($10,000 NTD) is attached in Annex C.

Instead of signing subcontract with each individual/party of this project, all services/labors (such as site preparation, interplanting and weeding labors) were purchased or hired through an inter-entity supply contract between TFRI and a single supplier each calendar year.

There is no contractor or consultant additionally hired in this project.

3.4 Monitoring, evaluation and reporting

Except the visits of APFNet delegation in project inception, mid-term evaluation and at completion stages, there are several internal methods to ensure the project is properly implemented and on schedule.

Meeting mechanism: To monitoring the progress of project, the project director, Dr. Ho held meetings with the project team quarterly. Each researcher gave a brief report of their current progress, problems they were facing, and future planning.

Monitoring and evaluation: TFRI has a complete research management system for all research projects, including tracking and assessment system. The Project Steering Committee met once a year (i.e. in the inception workshop and the mid-term evaluation) to review the project progress and the Annual Work Plan for the next year, as well as visiting the study sites.

Progress reporting: Quarterly Progress Reports, covering actual

accomplishments and status of finance during the period, were submitted to APFNet by the end of each project quarter. At the end of the first project year, a mid-term report was provided for mid-term evaluation. This completion report is submitted to APFNet for terminal evaluation.

3.5 Efficiency and effectiveness

As the goal of this project is to develop and demonstrate the sustainable agroforestry systems adaptable in upland areas of Chinese Taipei, the project's objectives were achieved when five study sites, including three demonstration sites, were established. It is important to demonstrate various agroforestry management systems due to the significant nature variations in Chinese Taipei. To ensure the success of a demonstration site, the project team carefully evaluated both the natural conditions and farmer/community organization before establishing each study site. Careful and comprehensive evaluation in advance has significantly reduced the chance of abandonment of a study site.

In addition, the cooperation among the project team, farmers, and industries who are interested in forestry products has extended the benefit of agroforestry and is proved an effective way on developing forestry industry. The project team provides relevant concepts, techniques and tools. The farmers provide sites and labors for active participation. The industries facilitate the collaboration among stakeholders and producing forestry products in the future. One company, who has land develop department, helped the project team to find possible suitable private land for study. The company has signed contract with the landowners of Pinglin and Yuchi study sites of purchase *Cinnamomum micranthum* timber after 10 years. It is also a very economical and efficient approach for the research team to tend trees and maintain study sites.

Before making finally decisions of each study site, the project team members had to interview and discuss with farmers/village, as well as visit potential study sites for several times. Many potential sites were rejected due to unsuitable landowner or site conditions. To ensure the sustainability and success of a study site, there are some criteria to choose suitable participating farmers. First of all, the farmer should be enthusiastic on agroforestry practices on his/her land. The participating farmer/village is potentially able to well disseminate the project concept in the future, such as the village head or a well-organized community association leads. The site has to be large enough (> 0.3 ha) and with relatively even slope. The farmer is capable to manage the crop and trees.

The achievements of this project benefit both the upland villages and the governmental administration. After joining the workshops and visiting demonstration sites, many farmers express the desire of knowing more knowledge in practice of sustainable agroforestry. The updated research results were also provided to TFB, which is responsible for managing publicly owned forests and regulating private forests. With these more updated and relative research results in agroforestry, the

forestry administrative authority of Chinese Taipei will then be able to make more appropriate and practical forest policy.

Carbon sink effect by planting trees in agroforestry system is significant. For example, it is estimated that *Cinnamomum micranthum* at the density of 2,000 individual/ha (as planted at Yuchi study site) under the condition of 6% mortality yearly, 147 ton CO_2/ha will be sequestrated at the end of 15th year after planting.

3.6 Project Costs and Sources

About 99.4% ($463,502 USD) of the fund (from both APFNet grant and counterpart funding) was spent at the end of the seventh quarter. The details of project cost by category during 1st-7th quarter (September 1, 2011 to May 31, 2013) are listed in Annex D. The actual expenses under most categories were under 10% in variance rate when comparing to anticipated cost.

Regarding the APFNet grant, two categories, “publication & Dissemination cost” and “Monitoring, evaluation and audit cost“, have lower actual expenses then the original budget. However, there are only a few hundred dollars in difference ($693 USD and $881 USD, respectively). For training tour and related cost, some variance rates in sub-category were over 10% due to much lower or higher airfare and living expenses then original plan. From the counterpart fund, a little more travel expenses on data collection were spent at the beginning ($861 USD), while less meeting and training cost spent then original plan ($1,595 USD).

Two and four contract fulltime assistants were hired to assist the project implementation in project year 1 and 2, respectively. Their main tasks were list in Annex E. A total of $109,200 was spent to their salary and insurance.

3.7 Dissemination

Eight seminars and workshops were organized not only at TFRI but also at some upland villages, providing good opportunities to disseminate the concept and practice of sustainable agroforestry and to understand the needs of farmers (Annex G).

An international symposium on agroforestry was successfully held in July, 2013. Invited local and international experts shared their observation and research experiences in agroforestry during the symposium. The preliminary results of this project, as well as “Feasibility Study on Agroforestry System in the National Taiwan University (NTU) Experimental Forest” were presented by researchers from TFRI and the Experimental Forest, NTU, respectively. The symposium has provided participants with the opportunity to hear inspirational speakers, promote the exchange and communication among researchers in agroforestry. Papers from Chinese Taipei, USA, Japan and China were collected in the symposium proceedings.

Through visiting demonstration sites and experience exchanging among the technical farmer teams trained by the project, which are much more convincing than

other promoting materials, e.g. booklets and photos, more upland farmer villages are willing to convert their cultivated lands into sustainable agroforestry systems.

APFNet annual Focal Point meeting is also a good occasion to disseminate the idea of this project, i.e. 3rd annual meeting in Beijing in 2012 and 4th annual meeting in Kunming in 2013. Many focal points and observers from various economies and regional organizations expressed their interests in promoting agroforestry after the project status was introduced.

4. PROJECT STAKEHOLDERS' PERFORMANCE

4.1 Supervisory Agency

Council of Agriculture (COA) is the supervisory agency of TFRI. The application and approval of this project was reported to COA. The government authority representative of PSC was appointed by COA. COA is also the supervisory agency of forestry policy in Chinese Taipei. The recommendations and results generated from this project were asked to provide to COA.

4.2 Executing Agency (project team and project director)

The project was carried out mainly by the TFRI. TFRI is currently focusing researches on the sustainable management and multi-purpose utilization of forests, and therefore has various experts of silviculture, forest management, forest hydrology and forestry economics etc. to form the executing team. TFRI took all responsibilities in implementing and procurement activities for and managing this project. The EA well prepared and provided APFNet with the Project Proposal, Overall Work Plan, Annual Work Plans, reports (Quarterly Progress Reports, Midterm Report, and Completion Report) and other promotional materials as requested by APFNet in a timely manner. The EA also ensure the project implemented on schedule, within the agreed budget, and on the right track toward project objectives.

No project revision or extension was ever requested. No major obstacle or uncontrollable events occurred during the project implementation. Small mistakes were fixed and did not affect the overall

There were three main missions during the implementation of the project:

1. Human Resource Management: The Project Director, Dr. Cheng-Kuen Ho, as well as the Project Management Team were appointed by the EA. The Project Director acted as the overall coordinator of the project implementation and assumed the primary responsibility for project monitoring and evaluation. The tasks and responsibilities of each member of the team were stated and appointed clearly when launching the project (Annex E). Each member then took the responsibilities and finished his/her tasks. For example, Dr. Fen-Hui Chen was responsible for experimental site establishment and monitoring, team member job assignment, and project reporting. Dr. Juang-Pey Lin analyzed soil erosion and surface runoff.

Silviculture Division, the core member of the Project Management Team, incorporated with Watershed Management and Forestry Economics Division on agroforestry research. Administrative Units, including Secretarial Office, Accounting and Statistics Office, and Personnel Office, were in charge of general affairs, purchases, personnel management, etc.

2. Demonstration Site Selection and Establishment: Dr. Cheng-Kuen Ho and Dr. Fen-Hui Chen searched interested farmers/communities, as well as facilitated the cooperation between farmers and Yiengu Environment Engineering Company, who has "*Cinnamomum kanehirae* tissue culture" technology transfer of TFRI. After sites were selected, the final agricultural interplanted system was discussed. The cooperating farmers were paid to help establish each site.
3. Demonstration Site Monitoring and Cooperation among Stakeholders: Team members conducted survey and monitoring at each study site periodically. Cooperating farmers/communities invited neighbors to join activities and in turn disseminated the concept of agroforestry.

4.3 Other project partners

The EA cooperated with two project partners: the Taiwan Forestry Bureau (TFB) and the Chinese Forestry Association (CFA, Chinese Taipei).

TFB helped in study site, upland village and technical term selection, and in organizing discussion seminars. Director General of TFB has attended all project progress workshops (i.e. inception, mid-term, and terminal workshops) and made suggestions on project implementation. TFB provided necessary information on relatively regulations and laws. TFB also arranged the research team to visit more than eight leased publicly owned forestland with temporally agroforestry system. The research team was able to discuss with TFB in the field about the problems, feasibility and implementary approach of agroforestry on leased publicly owned forestland.

CFA, an association connecting academy and industry in forestry, was in charge of some invitation and general affairs of the international symposium. The assistance of CFA has contributed to the success of the international symposium. In the "New Direction of Agroforestry and Forestry Management Conference", held in 2011 by the President of CFA, preliminary research results on evaluation for the implement of agroforestry in the Experimental Forestry, National Taiwan University (NTU) was presented. The field visit during the conference showed the current agroforestry status in NTU Experimental Forestry, and in turn benefited the research team on planning agroforestry demonstration in this project.

The cooperation from famers and upland village communities is significant and valued. In line with local needs mentioned in the background, the project attracted voluntary and active participation of farmers, whose support also ensure the

sustainability of the project. Farmers who provide their cultivated lands as study sites usually assisted the project team on field observation, tending, data collection, and reporting any problems. The upland village communities help the EA with organizing activities of fostering technical teams. Feedback from famers and communities has helped the project on the right track in terms of meeting the needs of all parties.

4.4 APFNet

APFNet has provided support and clear guidance/feedback for project implementation and management. The disbursement of APFNet's grant was guaranteed. The communication between APFNet and the executing agency was frequent and smooth.

The assistance from APFNet on arranging two training tours to Yunnan and Sichuan Provinces of China facilitating the project team to visit the appropriate areas and persons is highly appreciated.

One minor problem the executing team encountered a few times was temporary short of funds during the period between the end of one quarter and the reception of next quarter's fund. During this period of time, all grants from the previous quarters were spent; however, installment for the next period was pending until the approval of the Quarterly Progress Report. If the period is too long, normal research activities might be affected.

5. RESULTS

5.1 Achievements

Objective 1: To develop at least two different agroforestry management systems

Five study sites, including three demonstration sites (more easily accessed to for demonstration purpose) and two research sites, were established. The study sites located in northern, eastern and central of Taiwan Island, respectively. Except the position, crop species and elevation are varied among the study sites. The three demonstration sites are Pinglin (northern Taiwan, Tea-*Cinnamomum kanehirae* system), Yuchi (central Taiwan, Betel nut-*Cinnamomum kanehirae* system), and Kalala (eastern Taiwan, Betel nut-coffee-*Cinnamomum osmophloeum* system).

Objective 2: To demonstrate the ability of upland agroforestry systems in preventing the destructive landslides and massive surface erosions

Runoff and soil losses monitoring instrument was also installed at Kalala study site. With proper forestry management techniques, agroforestry may raise agricultural productivity, increase the afforestation area on cultivated lands, and enhance soil and water conservation in the long-term perspective. The project offers management approaches on upland slope lands conservation, such as soil erosion control techniques in betel palm plantation on slopeland. In Chinese Taipei, Soil and water conservation data and information obtained from experiments since 1952

have been contributed to the compilation of “Soil conservation handbook”. All these practices were proved helpful and effective for control of soil erosion and improvement of slopeland development, detailed information please see Project Technical Report.

Objective 3: To develop the criteria and indicators for evaluating the sustainability of upland agroforestry systems

More than 30 indicators/criteria for evaluating the sustainability of agroforestry management systems of the 5 project sites were developed. The indicators/criteria are categorized into three main themes according to the conceptual framework in “Agenda 21” of Chinese Taipei, namely, environment, economy and society, respectively. Detailed information please see Project Technical Report.

Objective 4: Dissemination of agroforestry systems

Two farmers’ technical teams (in Yuchi and Kalala) were trained and fostered. The technical teams served as assistants of the researchers to disseminate the concept of agroforestry. The general secretary of both communities helped organizing the workshops, including suggesting training topics and inviting interested farmers. Each community has its own interests and demands. According to the topics the communities concerned, the project team would arrange proper experts and training sessions in the workshop.

Agroforestry workshops were held in two upland village communities to promote the concept of agroforestry and/or train farmers (Annex G).Feedback to the Satisfaction questionnaires after the workshops shows that almost all participants were satisfied or very satisfied with the workshops. Visiting the project study sites is one of the best ways to demonstrate and show people how agroforestry may be put into practice. Increasing afforestation on marginal agricultural land in upland area may raise agricultural productivity, carbon sequestration, wood production, and soil erosion control. The project also helps the communities increasing the accessibility to forest resources and enhancing farmers’ capabilities in SFM, and in turn contributing to local economic development and poverty alleviation.

Other achievements:

The research results of TFRI help the forestry administration of Chinese Taipei to make appropriate and practical forestry policies. Taiwan Forestry Bureau (TFB) is the governmental agency who takes responsibility for managing public forests, the business of conservation and private forestry administration in Chinese Taipei. According to the data collected from this research project so far, recommendations in conducting sustainable agroforestry has been provided to TFB for their reference when modifying relative forestry policy. The criteria cover aspects of both soil and water conservation and silviculture, including soil conservation method, plant spacing and arrangement, species selection, and environmental friendly tending requirements.

A number of enterprises are interested in developing some particular forest product industry. For example, *Cinnamomum kanehirae,* which is a unique culture medium for growing a famous medicinal fungus, is one of the species that the industry is interested in. They have helped find suitable upland villages (i.e. Yuchi and Pinglin) to participate, as well as facilitating the cooperation between project teams and farmers. With the participation of enterprises, more farmers will have motivation to join agroforestry practices.

More farmers, authorities, and professors recognized APFNet through attending workshops, seminars, the international symposium or listening to introductions when being interviewed during this project. During the two training tours in Yunnan and Sichuan Provinces, China, academic and technology exchange and cooperation between TFRI and other institutes were initiated.

5.2 Good stories, best practices, intelligence products to be shared in the region

As stated above, visiting of demonstration sites in person is usually much more convincing than other promoting materials. One good example is at Kalala village, an aboriginal community in eastern Taiwan. Kalala is pleased to start applying agroforestry as it is likely a recall of their traditional practices. Based on runoff and soil erosion monitoring data at Kalala agroforestry study site, surface runoff amounts of all treatments were little. Soil erosion amounts were less than Taiwan average erosion rate (5.2 mm per year). These hydrological characteristics are related to factors such as tree crown cover, soil organic content and soil porosity in betel palm plantations. The crown characteristics of betel palm are rather different from those of fruit trees. The forest crown interception will consume water which evaporates back to atmosphere. Basically, adding tree planting area in agroforestry will increase the consumption of evaporation and can contribute to reduce runoff and surface erosion. In order to control soil erosion, we have provided a recommendation on “Soil and Water Conservation Treatment on Slopeland Agroforestry Systems” as listed in the Project Technical Report.

After joining this project, Kalala trained agroforestry technical team proudly presented their agroforestry sites to others and encouraged other upland village communities to modify their agriculture land into agroforestry management system. Sharing experiences from participating farmer is very effective when promoting agroforestry. An active and healthy farmer’s village cooperative will increase the success of a project.

5.3 Lessons learned and outstanding issues

Both meeting the demand of each stakeholder and keeping good communication are critical to the success of a new project. For example, before deciding a study site, visiting the sites is a must to evaluate the environmental conditions, and most importantly, to discuss with the landowner/community for several times. Only when the natural conditions of site met the minimum standard and a consensus reached on how the experiment practiced, a pilot study would be

started at that site. Once a study site is set, continuing communication and necessary adjustment is still essential.

Most study sites have sound experimental purposes and design. However, due to the natural topography and high density of Chinese Taipei, most study sites are small in size. Small sites may lead to inadequate repeat of experiments. For runoff and soil erosion monitoring in betel palm plantation, all subplot designs followed the specifications of Universal Soil Loss Equation (USLE) (22.3 x 10 m). With the same designs, research results of the project can be compared to others easily. The subplots were fenced with steel plates that directly inserted into soil depth of 15 cm and above soil surface of 15 cm.

Since TFRI is a governmental agency, it has a complete system and requirements on project management including implementation progress, reporting, financial supervision, procurement procedure, and personnel management. The project team follows all TFRI rules as other projects.

The originally targeted study sites were in the publicly-own forest area, the aboriginal reserves, and private upland farms in Chinese Taipei. However, because agroforestry practice is still prohibited in publicly-owned forest areas, no study site was set in there in this project. Nevertheless, results and suggestions collected from this research project are good references for the administration when making relative forest policy.

5.4 Impacts

Although agroforestry is not a new concept in Chinese Taipei, it is not allowed in all publicly owned forest areas. In other words, agroforestry is not institutionalized in TFB's concepts, strategies, and programs for decades. After the implementation of this project, there are more and more discussions and concerns on this issue. Most upland village farmers are expecting incentive policy that promotes agroforestry in the future. As a result, TFB has initiated considerations on agroforestry related policy. Recommended agroforestry systems on existing illegal cultivated leased publicly owned forests are also discussed in the Project Technical Report (Annex G)

Betel palm, one of project target crops, when planted on slopeland may cause soil erosion. The public and conservation groups frequently express great concern over the potential negative hydrological impacts of betel palm plantations on steep slopes. Agroforestry management system can be a solution of balancing agriculture for livelihood with ecosystem sustainability in upland villages of Chinese Taipei. Under an agroforestry system, loss and degradation of agricultural land will be reduced, and resource use efficiency both above and below ground will be increased. Moreover, by planting trees carbon dioxide reduction can be addressed. Depending on the tree species interplanted, other advantages of agroforestry systems can be obtained such as erosion control, soil improvement, windbreak, groundwater management, wildlife habitat improvement, etc.

Despite of the advantages of agroforestry, some environmentalists may have concern about deforestation due to agroforestry practice. They worry that some natural forests might be converted to agroforestry systems once agroforestry is allowed in publicly owned forest area. To make sound agroforestry policy and regulations in Chinese Taipei, more discussions among different parties in the future is necessary. The results of the project will certainly play an important role during the process.

6. SUSTAINABILITY

As the agroforestry system is a dynamic system, it may take several years for a land to be stable in the newly developed agroforestry sites. Moreover, the actual performance of agroforestry systems also depends on the effectiveness of management practices by the landowners/farmers. After the expiration of this project, the project team of TFRI will conduct new projects to 1) monitor continuously the study sites and 2) offer continuously technical supports to participating farmers.

With the success of several demonstration agroforestry systems, TFB may use these results to modify the current forestry policy which does not allow agroforestry management on publicly owned forest areas. Furthermore, TFB may then apply these research results to encourage other upland villages to start their own agroforestry systems.

Project results will also encourage some enterprises who are interested in developing forest products to participate in agroforestry. In the long-term program, the cooperation between industries and farmers can help the farmers to gain more stable income and, in turn, lead them managing the land in a more sustainable way. The farmers currently have some incomes from crops (i.e. tea and betel nut). In a few years when the planted trees grow up, more income may come from harvesting the leave of *Cinnamomum osmophloeum* or timber of *Cinnamomum kanehirae*. The planted trees are belonged to the farmers. If they take good care of trees, they can expect more reward from the forestry product.

To make sure the sustainability of this project, TFRI has planned to conduct newly 4-year projects after the completion of this project. The research team will keep providing technical support to the farmers and villages. All the agroforestry systems can be easily copied to adjacent areas or similar regions.

7. RECOMMENDATIONS

Agreement among stakeholders is very important. Communication with farmers and other involving parties frequently will ensure that everyone reaches the consensus. It can also assist to achieve the objectives and correct problems early enough to reduce potential harm during the process. Adjustments at each step may be necessary.

For projects involving tree growing, a 2-year period is usually too short to see the results of planting trees. We would suggest at least a 4-year period to observe the effect of planted trees. Otherwise, the EA should be able to conduct follow-up project to continuously monitor study sites, as well as offer technical supports to farmers. Especially for demonstration sites, constant maintenance is usually required to keep the function of demonstration.

Interplanting tree species should be selected carefully. First of all, the environmental conditions have to be suitable for the species growth. The forest product should be potentially profitable when it is ready to harvest in the future. It would be in vain if the farmers realize they can not sell the forest products after years. Cooperating with interested industrial may help solving this problem, when the planting area is large. For smaller planting areas, planting diverse species for demand in local community or adjacent areas is another possibility. Developing new and unique potential plant resources, especially learning from aboriginal culture, is always favorable. Be careful the arrangement of the interplanted trees will not hinder the harvest of other crops.

Training tours to other economies does help the project team in the particular study field. The project team may get new knowledge/ideas and avoid mistakes. Discusses with local experts indoor and especial in the field is the best way to learn their experiences. From the visit, technology and academic exchange will benefit both sides. Furthermore, connections for future cooperation with the visited economy would be facilitated certainly. The summery report of each training tour is attached in Annex I.

Annexes:

Annex A Members of Project Steering Committee

Name	School/Agency	Department
Yue-hsing Huang	TFRI	Director General
Tao-Sheng Lee	Taiwan Forestry Bureau	Director General
Ming-Jen Lee	National Chiayi University	President (emeritus)
Ya-Nan Wang	National Taiwan University	School of Forestry and Resource Conservation
Hurng-Jyuhn Wang	National Dong Hwa University	Graduate Institute of Environmental Policy
Chyi-Rong Chiou	National Taiwan University	Department of Forestry and Resources Conservation
Shu-Tzong Lin	National Ilan University	Department of Forestry and Natural Resources

Annex B Implementation schedule (scheduled versus actual)

Outputs & activities	Completion time		Key points of the results achieved (qualitative or quantitative)	
Output1	Anticipated	Actual	Anticipated	Actual
Activity 1.1	August 2013	August 2013	Establishing 3 study sites	Established 5 study sites
Activity 1.2	August 2013	August 2013	Data collection and analyses	Data collected and analyzed
Activity 1.3	August 2013	August 2013	Model simulation	Model simulation
Activity 1.4	June 2013	July 2013	3 training tours	3 training tours
Output2				
Activity 2.1	August 2012	August 2012	Income analyses and land productivity evaluation	Income analyses and land productivity evaluation
Activity 2.2	August 2013	August 2013	3 soil and water conservation demonstration areas	3 soil and water conservation demonstration areas
Output3				
Activity 3.1	June 2012	March 2012	Holding 1-2 seminars	Held 2 seminars
Activity 3.2	August 2013	August 2013	Organizing 2-3 technical teams	Organized 2 technical teams
Activity 3.3	August 2013	August 2013	Setting up 2 demonstration sites	Set up 3 demonstration sites

Annex C A list of purchase over $335 USD ($10,000 NTD)

Item	Brand	Amount
Equipment		
Color Printer	Fuji Xerox	1
Compass	Neofang	1
Computer	ASUS	1
Data logger	HOBO	11
Digital camera	Nikon	1
	SONY	1
Digital recording binoculars	SONY	1
Flashlight	Nikon	1
GPS	GARMIN	2
Hard disk 512G	Smartdrive	2
Height gauge (12m)	SK	1
Homo disperser mixer	NIHONSEIKI	1
Horizontal Laminar Flow	Minzheh	1
Label Printer	Brother	1
Laptop	Toshiba	2
Laser ranger	Nikon	1
Loop cinerator	CMP	2
Micro lens (105mm)	NIKON	1
Mobile projector	Vivitek	1
Storage solid state drive	Synology	2
Turbimeter and water level monitoring system	HOBO	1
Software		
SigmaPlot		1
Acrobat 10		2
Adobe CS6 Design standard		1
Adobe Photoshop CS6		2
EndNote X6		3
Microsoft Office -professional		1
Microsoft Office -standard		1

Annex D Details of project cost by category

(September 1, 2011 to May 31, 2013)

Expenses (USD)	APFNet Grant				Counterpart Fund			
	Anticipated A_1	Actual B_1	Variance $C_1(A_1-B_1)$	Variance rate D_1 $(C_1/A_1*100\%)$	Anticipated A_2	Actual B_2	Variance $C_2(A_2-B_2)$	Variance rate D2 (C2/A2*100%)
Project staff cost								
1. Developing different agroforestry management systems	67,800	63,512	4,288	6.3	35,100	35,000	100	0.3
2. Establishing criteria and indicators for evaluating sustainability	30,600	30,333	267	0.9	24,050	24,000	50	0.2
3. Technology dissemination	10,800	10,859	- 59	-0.5	19,700	19,550	150	0.8
Subtotal	**109,200**	**104,704**	**4,496**	**4.1**	**78,850**	**78,550**	**300**	**0.4**
Travel and related cost								
1. Study sites survey and establishment	300	148	152	50.7	7,800	7,800	-	0
2. Inception workshop field trip	1,500	1,223	277	18.5				
3. Growth and environmental factor data collection	6,750	7,305	-555	-8.2	-	861	-861	-
4. Survey of soil and water conservation demonstration sites	5,600	6,189	-589	-10.5				
5. Training & workshops	2,638	2,882	-244	-9.2				
6. Interviewing farmers	2,350	2,181	169	7.2				
7. China training tour-Sichuan	9,450	9,457	-7	-0.1				
8. US training tour	31,500	25,633	5,867	18.6				
9. China training tour-Yunnan	10,850	12,588	- 1,738	-16.0				
Subtotal	**180,138**	**172,311**	**7,827**	**4.3**	**7,800**	**8,661**	**-861**	**-11.0**

Meeting and training cost								
1. Inception workshop fare	7,500	6,381	1,119	14.9	220	85	135	61.4
2. Farmers' training and workshop	3,393	3,518	-125	-3.7	1,590	1,635	- 45	-2.8
3. Income analyses workshop	1,000	512	488	48.8	1,500	1,148	352	23.5
4. Technological discussion and experience exchange meeting	4,500	4,854	-354	-7.9	1,280	127	1,153	90.1
Subtotal	**16,393**	**15,265**	**1,128**	**6.9**	**4,590**	**2,995**	**1,595**	**34.7**
Field activities cost								
1. Site survey labors					7,200	7,200	-	0
2. Site preparation	12,750	11,855	895	7.0				
3. Seedling nursing	11,500	12,443	-943	-8.2				
4. Forestation & tending	19,890	20,572	-682	-3.4	12,000	12,000	-	0
Subtotal	**44,140**	**44,869**	**-729**	**-1.7**	**19,200**	**19,200**	**-**	**0**
Publication & Dissemination cost	2,500	1,807	693	27.7				
Office Operation cost	31,445	32,680	- 1,235	-3.9	2,520	2,739	-219	-8.7
Procurement								
1. Materials	24,525	25,409	-884	-3.6				
2. Monitoring equipment and survey tool	35,910	40,609	- 4,699	-13.1	3,000	5,191	- 2,191	-73.0
3. Computer	1,850	2,046	-196	-10.6	***6,000***	***4,555***	***1,445***	***24.1***
4. Equipment maintenance	5,000	4,971	29	0.6				
Subtotal	**101,230**	**107,522**	**- 6,292**	**-6.2**	**11,520**	**12,485**	**-965**	**-8.4**
Monitoring, evaluation and audit cost	2,525	1,644	881	34.9				
Other (Balance of the 1st quarter)			1,107				352	
TOTAL	**344,426**	**341,611**	**3,922**	**1.1**	**121,960**	**121,891**	**421**	**0.3**

Annex E A list of contract fulltime assistants and their main tasks

Name	Project year	Tasks and responsibilities
Shou-Yan Chang	1	Study plot management
Kun-Chin Chao	1, 2	Income analysis and model simulation
Jin-Soon Chang	2	Field data collection and analysis
Yi-Hsin Hou	2	Establishing criteria and indicators for evaluating sustainability
Mei-Fang Chu	2	Farmers training and technology dissemination

Annex F Tasks and responsibilities of key members of project team

Name	TFRI Division	Position	Tasks and responsibilities
Yue-hsing Huang	Director General	Chair of PSC	Project supervision
Cheng-Kuen Ho	Silviculture	Project director	Project progress monitoring, tree breeding, site selection
Fen-Hui Chen	Silviculture	Project senior staff	Agroforestry management systems and experimental site establishment
Ching-Te Chien	Silviculture	Project senior staff	Plant propagation and planting design
Chu-Mei Huang	Silviculture	Project senior staff	Soil properties analysis
Hui-Sheng Lu	Watershed Management	Project senior staff	Soil and water conservation evaluation
Juang-Pey Lin	Watershed Management	Project senior staff	Soil erosion and surface runoff analysis
Chin-Shien Wu	Forestry Economics	Project senior staff	Upland village cooperation, economics analysis
Jiunn-Cheng Lin	Forestry Economics	Project senior staff	Establishing criteria and indicators for evaluating sustainability, carbon sequestration
12 Technicians	Silviculture/ Watershed Management	Project Technicians	Field and laboratory work, general affairs, administrative management

Annex G A list of agroforestry workshops/meeting/symposium held

Date	Location	Topic	Participator	Amount of participator
2011.9.26	TFRI	Inception workshop	Researcher, farmer, industry, APFNet delegation	75
2012.3.13	TFRI	Agroforestry and suitable fruit trees research meeting	Researcher, farmer, governmental department	50
2012.10.25	TFRI	Mid-term workshop	Researcher, farmer, Industry, APFNet delegation	70
2012.12.30	Kalala	Agroforestry technology dissemination workshop	Farmer	25
2013.1.19-20	Kalala	Agroforestry technology dissemination workshop	Farmer, student	55
2013.1.23	Yuchi	Agroforestry technology dissemination workshop	Farmer	20
2013.5.30	Yuchi	Agroforestry technology dissemination workshop	Farmer	20
2013.7.16	Nantou	International symposium on agroforestry	Researcher, farmer, student	90

Annex H Recommended agroforestry systems on existing illegal cultivated leased publicly owned forests

For those existing illegal cultivated leased publicly owned forests in Chinese Taipei, some areas (based on the land slope and effective soil depth conditions) may practice agroforestry when considering both environmental conservation and farmers' livelihood. If areas should only be forestland for a long run for conservation reasons, an agroforestry system may be a good choice during the transition period. Suggestions and conditions are discussed as following.

1. Interplanting Density and Soil and Water Conservation Treatment

- Betel nut plantations

Betel nut plantations should interplant tress at least 600 trees/ha in density. No clearcutting of existing betel palm is suggested before forestation planting. The clearcutting practice may lead to soil losses; meanwhile, betel palm may play as nurse tree to protect planted seedlings. When interplanted trees grow high enough and betel palms are too tall for harvest, betel palms can be removed or injected to die.

- For perennial orchards and tea gardens with bench terraces

Trees should be interplanted at least 600 trees/ha under contour strip system on slopes between bench terraces. If 600 trees can't be planted on the slope per ha, the remaining trees can be planted along the bottom edge of the orchard/garden to establish a forest buffer strip. Over 70% coverage of grass mulching on the bench (flat part) is recommended.

- For perennial orchards and tea garden without bench terraces

Trees should be interplanted 600 trees/ha in appropriate section (e.g steep slope or serious soil erosion area) in patches or alone contour strip. Distance between contour planting strips should be less than 10 m. If 600 trees can't be planted on the strips or patches per ha, the remaining trees can be planted along the bottom edge of the orchard/garden to establish a forest buffer strip. Over 70% coverage of grass mulching on the bench is recommended.

2. Interplanted Tree Species and Practices

Interplanting tree species should be selected carefully. First of all, the environmental conditions have to be suitable for the species growth. To encourage leasers joining forestation, interplanting tree species which is potentially profitable when it is ready to harvest in the future is recommended, such as *Cinnamomum kanehirae*, *Calocedrus formosana*, and *Cinnamomum osmophloeum*.

Environmental friendly and sustainable practices are essential. For example, chemical herbicide should be banned. Applying sustainable weed management systems

may reduce both herbicide dependency and the burden of manual weeding. If fertilization is necessary, unfermented animal feces should be avoided as which may contaminate water.

Annex I Summary reports of training tours

1. Training tour to Sichuan Provence, China: July16-20, 2012

Five members of TFRI researcher team joined this 5-day field trip. Several successful “tea interplanted with expensive trees” agroforestry systems were visited. The most popular interplanted tree species is *Osmanthus fragrans*, which is a valuable ornamental tree. Others tree species include Ginkgo and *Phoebe zhennan*. A density of 6x6 m tree plantation in tea orchard is suggested according to local experts’ experience.

The Conversion of Degraded Farm Land into Forest Project has been conducted in China for over 10 years. The project is somewhat related to the idea of agroforestry. We visited varied reforestation systems in Pengzhou, Sichuan (Fig. 1), such as orchard, Ginkgo, and Eucalyptus plantation. Under this project, there are many successful cases which improved the live of local people and creating environmental- friendly agriculture systems at the same time. By understanding the implement details and visiting the results, we can learn the advantages from each case.

Fig. 1 TFRI researcher team was talking to experts at an agroforestry demonstration site in Sichuan, China.

2. Training tour to the US: September 30-October 11, 2012.

Six members of TFRI researcher team joined this 12-day field trip. We visited several successful agroforestry systems in Oregon and Washington states, as well as had a meeting with the experts from the Colleague of Forestry of Oregon State University. Although the nature environment, law, and background in the US are very different from those in Chinese Taipei, we still learned a lot from their experiences.

Agroforestry system is getting more and more attentions in the US. In 2010, the Forest Service (FS) and Natural Resources Conservation Service (NRCS) initiated to develop a National Strategic Framework for Agroforestry. It not only combines agriculture and forestry, but also takes ecology and human into consideration. There are five main types of agroforestry practice in the US, including Silvopasture, Alley Cropping, Riparian Forest Buffers, Windbreaks and Forest Farming.

We first visited Kenagy Family Farms (Albany, Oregon), which has both Riparian Forest BuffersWindbreaks and Forest Farming types of agroforestry practice (Fig. 2). The other farm we visited is Wild Thyme Farm at Oakville, Washington (Fig. 3). They have diverse agroforestry activities in their property, including food agroforestry, bamboo agroforestry, and riparian agroforestry.

Fig. 2 In Kenagy Family Farms, Columbia brome (*Bromus vulgaris*), a native woodland grass that requires shade, is planted underneath hybrid poplar. They sell Columbia brome seeds for local restoration project uses.

Fig. 3 John Henrikson from Wild Thyme Farm was explaining his design and plans to TFRI researcher team.

3. Training tour to Yunnan Provence, China: June 24-July1, 2013

Five members of TFRI researcher team joined this 8-day field trip. Yunnan and Chinese Taipei are similar in the mountainous landscape and subtropical weather. Moreover, Yunnan has accumulated abundant experience in agroforestry management since agroforestry has been practiced for many years. Diverse topography and aboriginal culture also contribute to the diverse of their agroforestry systems.

TFRI researcher team first visited the Yunnan office of International Centre for Research in Agroforestry in Kunming (Fig. 4). The Principle scientist and the Director, Dr. Jianchu, Xu shared his experience and provided valued suggestions to TFRI researchers. For example, he mentioned that agriculture and forest should not be treated separately. Establishing demonstration sites is one of the useful approaches on disseminating new concept and affecting future policy.

Tea is one of the main target crops of this demonstration project. Pu'er, known as the Tea City in China, is the center of native tea tree habitat. Tea gardens occupy large areas in the hillside of Pu'er region. To develop green industry in Pu'er, farmers are advised to interplanted trees in all hillside tea gardens (Fig. 5). It is suggested to interplant at least six tree species in the density of 150 trees/ha with 30% cover. Coffee agroforestry system is also getting more popular there.

Dr. Jianwei Tang from Xishuangbanna Tropical Botanical Garden has been devoted to agroforestry study for years. He suggests a few species to be interplanted under rubber monoculture plantations, such as *Flemingia macrophylla* (Willd.) Prain (medicinal herb and soil improvement) and *Rauvolfia verticillata* (Lour.) (medical use).

Fig. 4 TFRI researcher team visited the Yunnan office of International Centre for Research in Agroforestry, located at Kunming Botanical Garden.

Fig. 5 All hillside tea gardens in Pu'er city, Yunnan Province are advised to interplanted trees.