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Agroforestry for Livelihoods of Smallholder Farmers in Northwest Vietnam

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Contents

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2 Executive summary

The “Agroforestry for Livelihoods of Smallholder Farmers in Northwest Vietnam” (AFLi) is a five-year project (2011-2016). The World Agroforestry Centre (ICRAF) is the commissioned organization in-charged of overall project implementation. The project was implemented with six main partners namely, Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI), Forestry Science Centre of the Northwest (FSCN), Tay Bac University (TBU), DARD Son La, DARD Yen Bai, and DARD Dien Bien. The project’s aim was to improve the performance of smallholder farming systems in northwest Vietnam through agroforestry. It sought to increase the productivity of associated crop and livestock systems, leading to more diverse and sustainable production systems and better income from tree products. The project introduced trees in mono-cropped landscapes through agroforestry to reduce dependence on annual crops, as well as to increase and diversify incomes from tree products.

Ten established agroforestry trials were monitored and evaluated, of which, 8 were for scientific analyses and 2 for demonstration purposes. The trials were distributed across six districts in Son La, Yen Bai and Dien Bien provinces, involving 58 farmer co-operators. The trials were established in representative areas of three main agro-ecological zones: lower zone (below 800 m) where the Thai, Kinh and Muong are the main ethnic groups; middle zone (600–800 m) and upper zone (above 800 m) where the H‘mong, Dao and Thai people dominate. Seven agroforestry systems can be considered best-bet options for smallholder farmers based on productivity, profitability and long-term benefit as shown in the 3-4 year AF trials. These are (i) Son tra-forage grass; (ii) Acacia-mango-maize-forage grass; (iii) Longan-maize-forage grass; (iv) Shan tea-forage grass; (v) Acacia-longan-coffee-soybeans-forage grass; (vi) Teak-plum-coffee-soybeans-forage grass; and (vii) Macadamia-coffee-soybean systems. Forage grasses, leguminous species and annual crops e.g., maize provide short-term income and help farmers maintain their cash flow while incomes from coffee and Son tra commence on the 3rd year, with fruit and timber trees contributing to system profitability from the 5th to the 12th year. Multi-strata systems were found superior in terms of controlling soil erosion, indicating a net savings of about 250 USD/ha from procurement of fertilizer to replenish soil nutrient loss. Returns to investment can be observed earlier, with higher economic benefits accruing overtime, albeit the break-even point of trialled systems appears to be only on the 4th year; hence, smallholder farmers need technical support and financial incentives, as the establishment cost and delayed returns to investment may hinder spontaneous adoption.

Seven group nurseries have been established with approximately 30,000 seedlings produced for 15 different fruit and timber tree species. These seedlings were planted in 49-ha Farmer Demonstration Trials (FDT), involving 71 co-operators trained on laying out contour lines, establishing nurseries, preparing seedlings and designing agroforestry farms. In addition, 7 extension materials on production techniques of different seedlings have been published and distributed to intended users.

Furthermore, two agroforestry exemplar landscapes (ELs) have been established through a co-investment scheme by the project, farmers and the Department of Agriculture and Rural Development (DARDs) of Son La province and Department of Science and Technology (DoST) in Yen Bai province. A total of 22,000 trees of five different fruit and timber species have been planted by farmers in the agroforestry exemplar landscape of Son La province while more than 20,000 grafted Son tra seedlings and *altingiacea sp.* are to be planted in Yen Bai. In total, 105 farmers are involved in Son La and Yen Bai’s exemplar landscapes. The expected tree cover increase in the landscape, arising from tree planting efforts in the FDT and exemplar landscapes provides significant agri-biodiversity and carbon sequestration benefits.

A series of Son tra studies (*Docynia indica*) have been conducted, including selection of superior clones, grafting techniques, tree management, market value chain, nutritional

analysis and product development. At least, 30 superior Son tra clones were identified, of which, 20 are considered 'plus' trees suitable for processing while 10 are for fresh fruit consumption. These mother trees are now considered source of quality planting materials for Son tra. Tree management techniques such as top-working, pruning, and pest management were also conducted, resulting in better tree performance compared to un-managed/treated Son tra trees. In July 2015, the project witnessed the signing of the Technology Transfer Agreement for Son tra processing techniques between ICRAF and Tay Bac Tea and Special Food Company Limited (TAFOOD). TAFOOD uses our research results to produce different processed products from Son tra fruits, creating income opportunities for Son tra producers and markets for local traditional products. This type of public-private sector partnership is much needed where local governments could not single-handedly address the livelihood needs of local people. To increase the diversity of species and income generation options in agroforestry systems, suitable fast growing timber species were also evaluated in the northwest, such as acacia hybrid (*Acacia mangium x A. auriculiformis*), hybrid *Eucalyptus urophylla* and *E. pellita, Pinus caribaea,* and *Grevillea robusta.* Based on timber demand and supply analyses, these species have potential to supply the wood industry in the region.

The project published 4 international and 4 Vietnamese journal articles, 4 working papers, 20 technical reports, 14 extension materials, 24 blog stories and videos. It was also featured in both national and provincial TV programs. As part of the project's goal to develop local capacity, the project facilitated cross-farm visits and trainings on various aspects of agroforestry, benefiting more than 1,200 individuals, including the DARD's provincial, district and commune staff, village leaders, farmers, and research partners, as well as, supported 6 MSc students and 7 BSc interns. Our project site has been also visited by various donor-funded projects in Vietnam and neighbouring Laos. The capacity built amongst stakeholders can be directly associated with project activities as shown in our evaluation survey—73% of trained farmers are now technically equipped to implement agroforestry on their own, which meant that agroforestry skills can be acquired through trainings, and with adequate extension services and government support, farmers can, and would be more able to shift to agroforestry.

Moreover, Yen Bai and Son La provincial governments adopted local policies to provide incentives for farmers to establish Son tra-based agroforestry systems, establish contoured grasses to control erosion in sloping maize fields, and expand existing Son tra plantations. As a result of our policy analyses and national-level policy dialogues, the Ministry of Agriculture and Rural Development (MARD) created the first national agroforestry Technical Working Group to (i) develop a major Agroforestry proposal to be endorsed by MARD as an ODA priority (Overseas Development Assistance); and (ii) extensively conduct an agroforestry policy analysis.

The project contributed to alleviating the paucity of agroforestry research, and to the scarcity of scientific literature of *Docynia indica* (Son tra) in the northwest, and Vietnam in general. The mapped agroforestry expansion domain provides a basis for investment planning by decision-makers and other stakeholders, leading to more targeted socio-economic and environmental benefits. The economic potential of converting 360,000ha of sloping croplands into agroforestry in the region is enormous, with approximately 10^{-4x} VND in anticipated revenue after four years.

The project has accomplished a number of unplanned outputs in addition to project targets, as a direct result of the team's adaptive management, and the social capital created with local governments, farmers and the private sector. Local needs change rapidly, requiring the project's ability to deploy innovative recourse measures. The project contributed to the theory of change of agroforestry development in the region, by helping national and provincial-level governments, researchers and farmers create their aspirations for agroforestry, and enhancing local capacity to innovate and implement new agricultural systems. Finally, the project recommends that agroforestry be integrated in rural development, green growth and climate change-related programs.

3 Background

About 3.4 million people (4% of Vietnam's population) live in the five north-western provinces, in culturally diverse communities made up of 30 ethnic groups. The landscape can be divided into three agro-ecological zones, being a lower zone (below 600m), a middle zone (600-800m) and an upper zone (above 800m). Forests occupy more than half of the area and agriculture is characterised by shifting cultivation. Recent improvements in infrastructure, which facilitate market access, have increased livelihood opportunities, but the rapid expansion of agriculture and ongoing widespread shifting cultivation have resulted in degradation of agro-ecosystems and forest destruction and fragmentation, which threatens environmental sustainability and food security.

Current land use in the area is plagued by several problems that are mutually reinforcing: environmental degradation, deforestation and poverty. To ensure household food security, natural fallows are becoming shorter (1–2 years), leaving insufficient time for soil recovery. The majority of agriculture takes place on steep slopes, which causes soil degradation and declining crop yields. Shifting cultivation of upland rice, maize, soybean and cassava, mainly carried out by upland poor households for home use, is one of the main causes of deforestation in the northwest upland region. Another cause of loss of natural forests is expansion of agricultural land for commercial purposes. In Son La province, 65 000 ha of natural forest has been lost for maize cultivation between 2002 and 2009.

Agroforestry offers an integrated approach that can secure the livelihoods of rural households while curbing land degradation and deforestation. However, there are significant limitations in terms of (i) the capability within research and management agencies to identify appropriate agroforestry technologies and systems for the agro-ecological and socio-economic conditions of the uplands; (ii) experience of farmers and agencies to manage integrated systems; (iii) responsive extension approaches that are sensitive to less educated and non-Vietnamese-speaking sections of the farming communities; (iv) agroforestry systems and species that are attractive financially to smallholders; and (v) incentives to support agroforestry development. In response to efforts both from government and ACIAR to support the region, ICRAF Vietnam joined forces with national partners to implement a comprehensive program of agroforestry research in three provinces of Northwest Vietnam.

4 Objectives

The overall aim of the project was to improve the performance of smallholder farming systems in Northwest Vietnam through agroforestry. The project sought to increase the productivity of associated crop and livestock systems, leading to more diverse and sustainable production systems and better income from tree products. The specific objectives and activities were to:

- develop best-practice agroforestry systems for three agro-ecological zones;
- improve the availability of high-quality germplasm to enable the expansion of agroforestry systems;
- enhance market access for, and opportunities for adding value to, agroforestry products; and
- improve extension methods and policy dialogues for successful dissemination of agroforestry systems.

The project built on ICRAF's work in Vietnam, Indonesia, the Philippines and Cameroon and related research by other institutions in Northwest Vietnam on holistic, systematic and participatory agroforestry research. The project involved most of the agencies involved in ACIAR-funded activities in the Northwest, which then, created space for inter-project collaboration and sharing of experiences, technologies and pathways for extension.

5 Methodology

The 5-year project addressed six key research questions:

- Which agroforestry systems and technologies are best able to deliver livelihoods and environmental improvements in the target region?
- How to design innovative agroforestry systems to best match different local agro-ecological zones, socio-economic settings and infrastructure opportunities?
- What are the most appropriate propagation and establishment techniques for desired agroforestry species and how to improve farmers' access to high-quality seeds and seedlings of these species?
- Where in the value chain of priority agroforestry products can farmers get better income and how can farmers' entrepreneurship for agroforestry products be improved?
- What are the policy opportunities and constraints for expanding promising agroforestry systems in the region?
- What are the best methods for promoting adoption of beneficial agroforestry systems and technologies?

Objective 1: To develop best practice agroforestry systems for three agro-ecological zones

1.1. Together with 58 farmer co-operators, 10 agroforestry systems, including multi-strata systems were established across six districts in three provinces in the northwest, to test innovative agroforestry systems and species at the project sites using the following principles. Figure 1 shows the type and distribution of 10 agroforestry trials across three provinces.

- Choosing and applying appropriate, replicated experimental designs to enable statistical analysis and valid, robust conclusions and inferences to be drawn from experimental outcomes.
- Make best use of existing on-farm plots with focus species (Son tra, fruit trees, timber trees, etc.) for establishing experiments and trials by including new, associated crops, forage grasses, and/or new management techniques (pruning, thinning, fertilizing, mulching etc.).
- The experimental sites and trials should be easily accessible in order to be used as sites for demonstration and training.

1.2. The established trials were designed with stakeholders, to ensure their needs and interests are address, and to evaluate the effect on livelihoods and the environment.

1.3. Participatory management and monitoring was employed to collect data on livelihood and environmental indicators in on-farm trials.

- Participatory research management (Type 2): Researchers, in consultation with farmers, design standard experimental treatments, and management schemes, but farmers are managing all farming activities, including improved techniques such as planting, fertilizing, watering and harvesting.
- Participatory assessment: Researchers are leading soil-plant sampling and analysis but farmers are doing the measurements and recording of indicators such as crop and tree growth and yields.

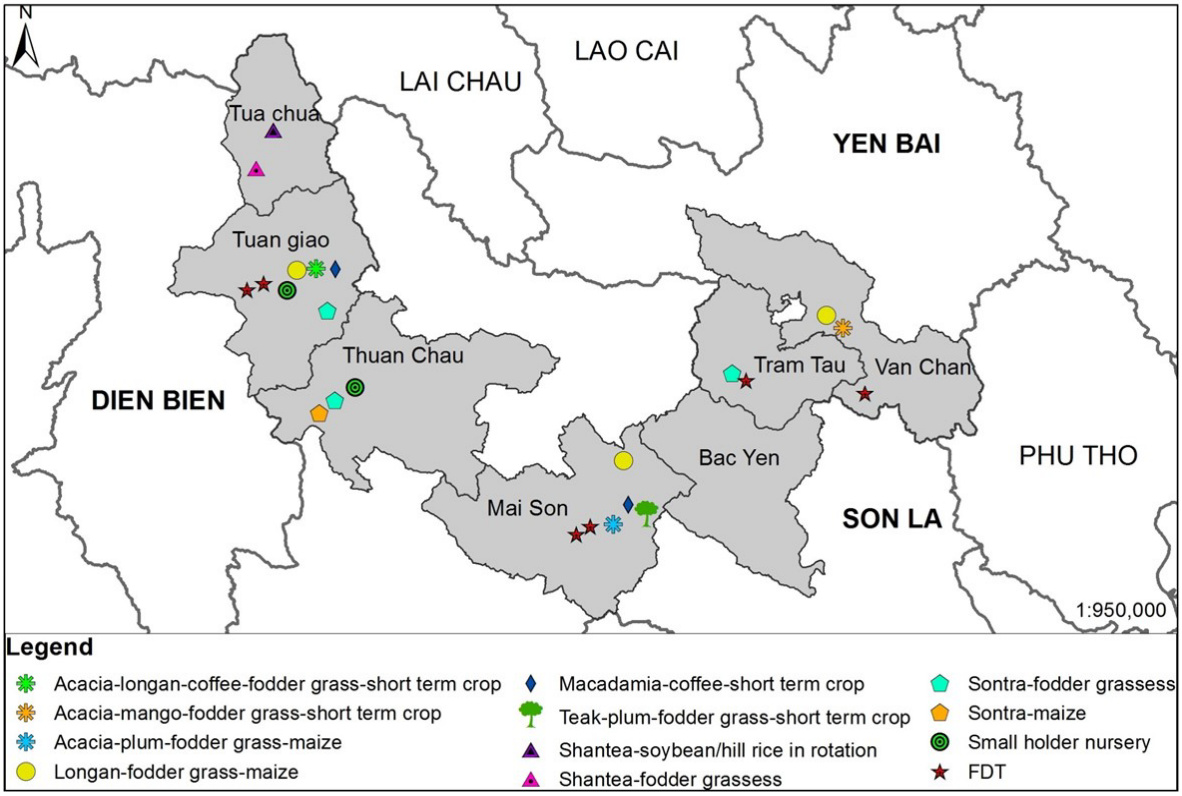

Figure 1: Distribution of agroforestry trials in Northwest Vietnam

1.4. To complement the knowledge gained from agroforestry experiments and to facilitate greater adoption of agroforestry systems, a series of Farmer Demonstrations Trials (FDT) were established in each province where a particular agroforestry system is being trialled. Interested farmers were provided with tree and fodder grass seedlings for testing in combination with existing trees and crops on their farms. Four steps were carried out in FDT development: (i) evaluation of strengths, weaknesses, opportunities in the locality; (ii) understanding the socio-economic conditions of farm households; (iii) (determining distinctive limitations, specific requirements and potential for agroforestry development; and (iv) determining suitable tree species in different agroforestry systems. Researchers work with groups of farmers (not individuals), to develop their capacity to establish agroforestry farms, and develop them further in the future. FDT involved two components (i) establishment of a group nursery to support the seedling requirements of the FDT; and (ii) establishment of agroforestry farms in a step-wise manner. Farmers were trained on nursery establishment and management, preparing seedlings, grafting, marcotting techniques, and designing system with trees and crops. Researchers and extension workers are working closely with farmers, and village leaders. Extension workers were involved, by actively supporting the researcher in training activities and establishing the FDTs, as they have already gained experience in the trial.

Furthermore, two 50-ha agroforestry exemplar landscapes (EL) were established to demonstrate scale of adoption, through a co-investment scheme. The aim was to demonstrate agroforestry at the landscape level, to encourage decision-makers to support agroforestry using local resources. Researchers, provincial extension staff and interested farmers worked closely, and shared resources. The project covered about 48%, provincial government 21%, and farmers 31% of the total cost of establishing the ELs. Farmers were trained on establishing agroforestry farms, and their choice of species was taken account.

1.4. Comparative analysis to generate best practices was carried out by monitoring tree-crop-forage growth parameters, production, input costs, and selling price. Quantitative data on the growth of trees such as height, base diameter and canopy diameter was collected every three months. Forage grass, annual crop and fruit yields were measured at the time of harvest. Using a soil trap, soil loss was measured in a 122.5 m^2 area laid out within the experimental plot. Sediments were collected from the soil trap, and dry weight was recorded and calculated as soil loss per ha. To calculate system profitability, all inputs such as fertilizers, pesticides, labor, seeds/seedlings were recorded and calculated. Total income was computed based on input cost, yield, and market price. NPV analysis was also employed to project long-term profitability of trialed agroforestry system.

Objective 2: To improve availability of high-quality germ plasm to enable expansion agroforestry

2.1. Germplasm sources, smallholder nurseries and tree seedling markets were assessed through in-depth surveys, focal group discussions, observations, field visits and stakeholder workshops. Rapid market appraisals were conducted to evaluate existing and potential seedling markets. Review of previous studies and relevant literature were conducted prior to the inception of the activity.

2.2. A survey was conducted in plantations and natural forest areas in Dien Bien, Son La and Yen Bai provinces. Some 2,400 trees in the selected populations were characterized for growth and fruit yield. Subsequently, the trees that were judged to be superior in fruit yield were then screened for fruit appearance. Fruit samples from trees that were superior in both yield and appearance were collected for 'taste' testing, and were ranked for their suitability either for fresh fruit consumption or production of wine, juice or other products. The final selection (for fresh fruit consumption and for processing) was documented, and scion materials were collected and grafted onto seedling rootstocks for clonal testing. The seven stages of selecting superior Son tra genotypes are:
Step 1. Identification of stands for candidate tree selection
Step 2. Ranking trees in the selected populations for fruit yield
Step 3. Ranking high-yielding trees according to fruit appearance
Step 4. Allocating selected trees to use categories of fresh fruit and processing
Step 5. Selection of candidate plus trees for fruit consumption and processing
Step 6. Registration of selected trees
Step 7. Grafting for clonal field trials

2.3. Monitoring Son tra tree growth and fruit yields commenced in January 2012, and continued for three years in exiting trials established in Ngoc Chien Commune, Muong La District, Son la Province. Three types of planting materials were used: seedlings (planting stock raised from seeds collected from the eight selected trees); cuttings (planting stock raised from rooted cuttings taken from seedlings collected from the eight selected trees); and grafts (planting stock raised by grafting scion material from selected trees, grafted onto seedling rootstocks). Data on Son tra growth parameters such as stem diameter at breast height (DBH), tree height and crown diameter, and fruit production were collected when the fruits are suitably ripe for collection. Either one or two fruit harvests were conducted per tree. Total weight of fruit harvested per tree was recorded. Fruit harvested from each tree was examined and fruit quality was assigned to one of the three following categories: High quality – fruit predominantly uniform-size with diameter >3 cm and yellow in color; Moderate quality – fruit diameter range 2-3 cm and predominantly yellow in color; and low quality – fruit predominantly uneven-size, diameter <3 cm and brown or greyish in color.

2.4. Review of relevant literature and consultation with national experts were conducted to design propagation studies, particularly for Son tra. Germplasm (seed and vegetative material) collection was conducted from Son tra superior

sources. Seed-based and vegetative propagation studies were conducted on-farm to disseminate technical information to partners (researchers and farmers). The experiments were carried out from November 2015 in Hua Xa A village, Toa Tinh commune, Tuan Giao district, Dien Bien province. At the time of applying grafting techniques, the trees were 5-years old and tree base diameter was about 10 cm—the trees had not been producing fruits, yet. From farmers filed, 30 Sontra trees (host trees) were randomly selected for testing different grafting techniques. The top of host trees was cut and the host trees were kept about 1.2 -1.5 m in height. Hence, different diameter of stocks was selected on host trees at 1, 3 and 5 cm to apply different grafting techniques. The scions material (0.5 cm in diameter) for grafting was collected from 12 selected superior Sontra trees in Tuan Giao district, Dien Bien province.

Grafting techniques assessed include cleft, splice and side grafts. In cleft graft, the scion material was grafted on the cleft of the stock with a diameter of 1cm and 3cm; whereas the side graft including the scion material was grafted on one side of the stock diameter of 3cm and 5cm. In the splice graft, the scion material was spliced on a stock diameter of 1cm and 3cm. Data on survival rate and growth of scions were monitored frequently for 30 days, and used to evaluate the difference in survival rate and growth of scions between the three techniques.

2.5. To assist farmers and community groups establish and operate tree nurseries, the 'farmer nursery schools' approach was used. This includes the establishment of nurseries, training of farmers in nursery management and propagation techniques for targeted species. Group nurseries were developed with motivated farmer groups, empowering them to produce quality seedlings of priority species to enhance local agroforestry systems. It is anticipated that the primary objective of most community nurseries will be capacity building and seedling production to meet members' needs. When those objectives are achieved some community nurseries may dissolve or reform with new objectives – fruit or timber production/marketing, for example.

The project has established the following nurseries: 1 on-station nursery to supply seedlings to the agroforestry trials; 3 smallholder tree nurseries and 2 fodder grass nurseries to supply seedlings to interested farmers. Two smallholder nurseries were maintained in Co Ma (Son La) and Toa Tinh (Dien Bien), while 7 group nurseries were added, in the context of FDTs in three provinces.

2.6. Smallholder tree nursery development guidelines suitable for the conditions in northwest Vietnam was developed together with relevant stakeholders. This was be done by compiling and synthesizing results from nurseries established. Based on the result of on-station nursery, smallholder nurseries and group nurseries, the recommendation methods were published as extension materials for different tree species.

2.7. To assess the demand and supply of both indigenous and exotic timber tree species, and their potential growth in the region, a series of surveys was conducted as follows:

-Survey of timber processors: Information on total plantation areas and number of wood processing mills in the three provinces as of 2011 was provided by the provincial forestry departments. In each province, 5-6 mills were selected to survey the tree species and wood volumes used, the trends over time in t wood supply by volume and species, current log and sawn timber prices and their plans for future development.

-Survey of timber and fuelwood demand and supply: In each of the three provinces, 4-5 villages from three main ethnic groups, Mong, Thai and Kinh, and one additional village of Muong ethnicity, were selected for investigation. Villages

were chosen according to elevation (below 400 m, 400-700 m and above 700 m) and ethnic groups represented at each elevation. Within each village, 3-4 households were randomly selected and surveyed to determine demand for wood products, preferred tree species, their views on fast-growing plantation species as alternative to traditionally used species from natural forests, and whether they planted fast-growing tree species. Fuelwood demand was estimated in steres (1 stere = 1 stacked m^3) per month, while demand for sawn timber was estimated in m^3 of sawn boards per year.

-Survey of adaptability and growth of planted trees: In each of the three provinces, 7-12 timber tree plantation blocks in each of 3 altitudinal zones (<400 m, 400 – 700 m, above 700 m) were examined. At each site, information was collected on tree species, year of planting, ownership, source of funding and source of germplasm. Depending on plantation size, 1-3 plots of 1000 m^2 were randomly selected. Diameter at breast height and height of all trees in each plot, pest and disease attack and survival percentage were measured. Individual tree stem volumes over bark were estimated. Plot volumes were calculated by summing individual tree volumes, enabling approximate estimates of volume per hectare and mean annual volume increment to be made.

2.8. A survey of macadamia clones was conducted in macadamia plantations in different locations in the Northwest region, in Son La (Mai Son, Chieng Sinh and Pung Tra), Dien Bien (Muong Lay, Dien Bien city) and Lai Chau (Tan Uyen). The following data were collected: Growth parameters such as diameter ground level, height, crown diameter; Total weight of nuts per tree; and nut yields in the clonal trial in Mai Son were also recorded in 2011. Data collected was analyzed to differentiate the growth performance and nut production of different treatments (clones and control).

2.9. Screening trials for exotic timber species were established in 2 locations in Son La province, Chieng Den (790 masl) and Chieng Bom (1250 masl). Genetic materials used in the study comprised 16 seedlots of 12 species, 28 control pollinated hybrid Eucalyptus progenies and 17 Eucalyptus clones. In summary, they included:

- Materials for species adaptability evaluation: Acacia hybrid (*Acacia mangium x A. auriculiformis*), *A. mangium, A. mearnsii, Alnus nepalensis, Casuarina junghuniana, Eucalyptus grandis* (2 provenances), *E. microcorys* (2 provenances), *E. pellita, E. urophylla* (2 seed sources), clones of *E. urophylla x E. pellita* hybrid and *Schima wallichii*.
- Materials for hybrid progeny testing: Hybrid progenies of *E. urophylla x E. pellita* (16), *E. pellita x E. urophylla* (6) and *E. pellita x E. camaldulensis* (6). The hybrid progenies were polymix crosses produced by control pollination of mother trees with pollen mixes including pollen from 20-30 trees.
- Eucalyptus clones including 7 pure *E. urophylla* clones and 10 *E. urophylla x E. pellita* hybrid clones were also included in the species screening trial in Chieng Bom.

The trials used randomized complete block designs. The following data were collected: Tree height was measured to the nearest 0.1m using height poles. Diameter at breast height (1.3 m) over bark was measured to the nearest mm using diameter tapes. All measured traits, including survival were analyzed using the linear model in order to test the significance of treatment effects and estimate the performance of treatments (Genstat).

Objective 3: To enhance market access for, and opportunities to add value to, agroforestry products

3.1. Research and extension partners were trained on participatory market value chain of agroforestry products to better understand different actors along the

chain, the challenges and opportunities, as well as the value and potential growth of agroforestry product in the chain.

3.2. The exploratory market study for walnut was conducted using secondary data. Analysis on the international market for walnuts relied on data from Comtrade UN. Additional data on walnut production was obtained from FAO. Data from other sources have been used as reference to validate the results of the study. Data about walnut production in Vietnam was collected based on available data from MARD and other resources.

3.3. Value chain assessment for Son tra was carried out to identify market actors, product flows, price margins, marketing costs (with specific emphasis on transport costs) and consumer preferences. Value chain analysis team was formed with a lead consultant and selected members from different partner organizations and agencies in Son La, Dien Bien, and Yen Bai. Training for the team members on basic value chain development was given, followed by surveys in various locations across the three provinces. The team interviewed key informants, surveyed farmers, analyzed the data together and discussed potential interventions.

Ex-ante cost-benefit analyses were also conducted for five agroforestry systems (Son tra-forage grass, Son tra-maize, Shan tea-forage grass, Macadamia-coffee-soybeans and Longan-maize-forage grass) looking at different combinations of the target agroforestry species with associated crops. The objective was to project the system's profitability while being evaluated in on-farm trials. The analyses have shown that agroforestry is superior compared to monoculture maize in terms of overall profitability and income sustainability.

3.4. Linking Son tra producers to other market actors employed group marketing approaches that create economies of scale that benefit all market actors were the focus. Producers were encouraged to organize into groups, and were trained in identifying market opportunities and negotiation skills so that they can develop business relationships with other actors in the value chain. Two producer groups were formed. Meetings between producer groups and institutional buyers were facilitated.

3.5. Simple, low-cost post-harvest techniques to add value to Son tra fruits were selected, and producer groups were trained, and assisted in their application. This includes drying and sorting fruit quality. The groups were monitored to evaluate the feasibility, acceptability and profitability of the techniques, using participatory data collection tools, such as recording of quantities produced, processed, sold, costs incurred and profits made. Further, techniques for producing pre-processed Son tra products (extract and tea bags) were developed in collaboration with the National Institute for Medicinal Materials (NIMM), and transferred to TAFOOD, a private medium-size tea producing company.

3.6. In collaboration with NIMM, nutritional analysis was conducted for Son tra. Knowledge on the nutritional value of Son tra was used in identifying value-adding products. Two samples from two selected superior trees in each province were taken in August 2013 for a comparative study. One additional sample per province was taken in 2014 to validate the results obtained in 2013. Analyzing variations in content composition of fruits grown in different places was conducted for dry and fresh fruits samples.

3.7. Lessons learned from action research were used to develop marketing strategies for Son tra. The marketing strategy was designed to ensure Son tra producers secure their market share by reviewing current market conditions and elaborating on existing marketing options for Son tra producers. Information about product development, price setting, appropriate distribution

channels, market outlets, and promotional activities were considered to recommend flexible and context-specific marketing strategies.

Objective 4: To improve extension methods and policy dialogue for successful dissemination of agroforestry systems

4.1. Policy analysis was conducted to examine policies relating to agroforestry, and to initiate a policy dialogue on agroforestry development at national, provincial and local levels. The desk-review of existing policies relevant to agroforestry focused on identifying policy incentives and disincentives for agroforestry adoption, gaps/weaknesses inherent in the policies or implementation issues/challenges at the national, the northwest region and sub-provincial levels. The review was done through an iterative process, wherein the policies where listed and disseminated at two informal workshops with government officials and policy makers at local and national levels. This was done prior to the stakeholder workshops in order to account for variations in local implementation of the policies and locally formulated policies.

The policy review results were presented and deliberated at ten formal workshops at the district, province and national levels between September and November 2013. The workshops started at the district level to certify that their recommendations were reported to the next government level. An agroforestry policy expert facilitated the groups. A note-taker documented the discussions and a short report was written up after each workshop. The district level workshops lasted one day and consisted of a brief orientation on agroforestry, a brief review of the policies identified in plenary, followed by group work. Participants were divided into two groups. Commune and district government officials from the departments of Agriculture and Rural Development and Natural Resources and Environment, and local agri-businessmen assessed factors constraining and enabling agroforestry development in terms of the policies. Agroforestry farmers and commune extension workers identified examples of local agroforestry systems, and policies that had influenced those systems. The workshops ended with a plenary discussion aiming to extract factors that would enable agroforestry adoption.

The province and national level workshops lasted a half-day and were divided into two sections as above, and sharing recommendations from previous workshops. The participants represented MARD and MONRE, national research institutes and universities, leaders from two districts that were not part of the previous review, development organizations and the private sector. In the provincial and national workshops, participants (about 30 for each workshop) were divided into one group for leaders and one group with officials, practitioners and agri-businessmen. Each group received a handout with the listed policies for further revision. A policy dialogue jointly organized by ICRAF and MARD, and chaired by MARD's Vice Minister for crop production followed the national workshop.

4.2. From the results obtained through on-farm and on-station experiments, FDTs and EL development, a series of extension materials (poster, booklet and video) were produced to meet different needs, including nursery establishment, different techniques to produce high-quality seedlings of various species, agroforestry cultivation and development methods. Extension materials for specific species such as Son tra were produced in the H'Mong language to directly address language barrier and low literacy of the H'Mong ethnic people.

4.3. Capacity building for farmers and extension workers on improved extension approaches was carried out, and supported with communication and extension methods, workshops, cross-visits, field days, stakeholders' workshops, media engagement and, participatory working and knowledge exchange with

scientists. Capacity development for the partners was also supported through participation in international conferences, workshops, special skills training and close co-operation with national and international scientists.

4.4. To determine the potential areas for tree-based options based on biophysical suitability, biophysical requirements for each tree species were extracted from published literatures, technical guidance or provincial extension manuals. Based on available data, we selected six variables including soil type, soil layer thickness, elevation, slope, annual average temperature, and annual average precipitation. At provincial level, we produced agroforestry suitability maps based on biophysical variables. At district level (project sites), stratified random field sampling was carried out. Another set of cropland data was taken from the LSDF (Land Degradation Surveillance Framework) database. These data were used to calibrate and validate the predictive model for cropland mapping in Vietnam. The Random forest classification model was applied for prediction of annual crop presence, using Landsat ETM + image reflectance bands as predictors. The model was based on the training dataset of field data (N= 12,222) and then related to satellite image reflectance. This study used Landsat 8 taken on 18 April 2016 to map the presence of annual crops in the project site using this predictive model of cropland mapping. Radiometric calibration, atmospheric correction, solar radiance and solar zenith correction were applied for the image. After the pre-processing steps, the cropland model was used to produce the probability of cropland prevalence. The spatial distribution of annual crops was mapped for seven districts in the project areas at 80% probability. The same process was applied for suitability evaluation at the district level. However, to provide more practical recommendations to policy makers and land use planners, we focused on areas with high erosion risks.

The target region was identified by overlaying the annual crop map on a slope map to delineate the boundary of cropland on slopes. Then, we examined the biophysical suitability of selected tree species in the target region to define where selected trees can grow on existing annual cropland with high risk of soil erosion. GIS (Geographic Information System) was used to standardize, overlay and query the areas, which meet the requirement of each species. The last step was overlaying the suitability areas of all species together to identify where different trees can be combined.

Cross-cutting component 1: Project management and Coordination

The main activities of this component were (i) project planning of both technical and financial activities in accordance with the contract with ACIAR and in consensus with all partners; (ii) technical and financial coordination and ensuring the implementation of the plan at all project sites, including solving practical problems; and (iii) reporting to ACIAR, ICRAF and others as appropriate. Throughout the project, partners collaborated closely to successfully implement the activities outlined above, including technical design-workshops of project activities that support the overall goal of the project, coordinating the action plan, logistical arrangements in meetings and workshops, yearly project workshops, coordinating fieldwork in accordance with the annual action plan, reporting activities and findings, updating activities when necessary. Three final provincial workshops and culminating project seminar were organized.

Cross-cutting component 2: Overall monitoring and Evaluation

The participatory Monitoring & Evaluation (M&E) framework and guidance for the development of local monitoring indicators was developed with project partners, including farmer co-operators. The main task of ME was to systematically record, analyse and support the teams to synthesise outputs from all project activities in order to provide a holistic assessment of the studied agroforestry systems, their impacts, principles of

agroforestry development and expansion. This also includes planning for publications, in particular manuscripts, synthesising outputs across all project objectives. Regular M&E was carried out throughout the project duration and as part of each project workshop and meetings.

To evaluate project impacts, the overall objectives and outputs were assessed with indicators identified in the Project Document and revised M&E framework. The evaluation process was conducted through a survey with the engagement of a wide range of participants involved in project activities from provinces, districts, communes and villages. The respondents were (a) 50% of baseline households; and (b) farmers not involved in the baseline survey, village-commune-district-provincial officials and research partners.

6 Achievements against activities and outputs/milestones

Objective 1: To develop best practice agroforestry systems for three agro-ecological zones

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Design agroforestry systems to be tested with trial farmers through participatory priority setting in terms of objectives, species, arrangements and allocation of farms for experimentation	Priority and focused research agreed with local stakeholders Baseline data for integrated assessment of agroforestry systems collected, including water, soil, topography, erosion sensitivity, climate and socio-economic data	Yr 1 (I-II)	Accomplished Farming Systems Diagnosis was conducted in Dien Bien, Son La and Yen Bai provinces. The dominant farming system in all three agro-ecological zones in these provinces was mono-cultivation of staple crops on sloping land. The poor diversity of farming system structure and components made smallholders vulnerable to market fluctuation. Furthermore, soil degradation as a result of mono-cultivation, high soil erosion and intensive farming practices, along with water scarcity, made it difficult for farmers to maintain crop productivity. Moreover, the development of animal husbandry is limited. Traditional agroforestry systems have existed in some locations but at very small scale. Farmers and extension workers' knowledge about sustainable farming and agroforestry practices was limited. The limited adoption of agroforestry in the study areas could be partly due to limited activities, or capacity of the local extension system. Farmers were willing to plant more trees but were concerned about species that have high market potential and the large area of land needed. Therefore, support on developing markets and processing techniques are necessary. Publications: AFLI Technical Report No. 2: ***Diagnosis of farming systems in the Agroforestry for Livelihoods of Smallholder farmers in Northwest Viet Nam project***. Hoang Thi Lua, Elisabeth Simelton, Ha Van Tiep, Vu Duc Toan, Nguyen Thi Hoa, Nguyen Van Chung, Phung Quoc Tuan Anh. AFLI Technical Report No. 3: ***Results of baseline survey of sample households in the AFLI project***. Scientific Research Center and Technology Transfer, Tay Bac University & ICRAF.

1.2	Established trials on agroforestry systems and design with stakeholders measurement scheme to evaluate effect on livelihoods and the environment	10 trials of agroforestry systems established	Yr 1-Yr 2	Accomplished 11 agroforestry trials were established across 3 provinces at different times between 2012 and 2014 due to several reasons such as variation in the planting schedule across the provinces, long preparation of grafted seedlings, and difficulty in finding farmer co-operators and suitable area to establish the trials. 50 farmer co-operators were involved in these trials. The trial on 'Amomum under forest canopy' was concluded in 2013 since the objective of the trial did not necessarily align with the overall project goals. By 2014, the project management assessed the status of 10 remaining agroforestry trials, and found that 8 can be subjected for scientific analyses, whereas the 2 trials can be continued as demonstration due to lack of appropriate replications and poor management (see list below). Issues regarding trial design and management, incentives for farmer co-operators, and institutional challenges were also encountered. Draft technical reports of the initial analyses of field data have been prepared. *Trials for scientific analysis* AFS1: Late longan-forage grass-maize AFS 2: Shan tea-forage grass AFS 3: Son tra-maize AFS 4: Son tra-forage grasses AFS 6: Macadamia-coffee-short-term crop AFS 7: Acacia-late longan-coffee-maize-forage grass-short-term crop AFS 8: Teak-plum-coffee-forage grass-short-term grass AFS 9: Acacia-mango-forage grass-short-term crop *For demonstration* AFS 5: Shan tea-soy bean/hill rice in rotation AFS 10: Acacia-plum-maize-forage grass Results of trials are described in AFLI Technical Report No. 19: ***Results from Participatory Agroforestry Trials***. La Nguyen, Do Van Hung, Pham Huu Thuong, Do Tien Luc, Agustin Mercado, Hoang Thi Lua, Lo Thi Kieu, Vu Van Tuan, Nguyen Van Chung, Do Hai Long, Vu Van Toan, Dao Huu Binh, Dinh Truong Su, Dinh Van Thai, Pham Duc Thinh, Pham Hoang Dan.
		Farmers and other stakeholders involved in on-farm trials trained in agroforestry establishment		Accomplished

		Parameter and methods for trial evaluation identified and data collection protocol designed with farmer participation	Yr 1-Yr 2 (II)	Described in: AFLI Technical Report No. 19: ***Results from Participatory Agroforestry Trials.*** La Nguyen, Do Van Hung, Pham Huu Thuong, Do Tien Luc, Agustin Mercado, Hoang Thi Lua, Lo Thi Kieu, Vu Van Tuan, Nguyen Van Chung, Do Hai Long, Vu Van Toan, Dao Huu Binh, Dinh Truong Su, Dinh Van Thai, Pham Duc Thinh, Pham Hoang Dan.
		Participatory ME indicators established	Yr 1-Yr 2 (II)	Described in: AFLI Technical Report No. 19: ***Results from Participatory Agroforestry Trials***. La Nguyen, Do Van Hung, Pham Huu Thuong, Do Tien Luc, Agustin Mercado, Hoang Thi Lua, Lo Thi Kieu, Vu Van Tuan, Nguyen Van Chung, Do Hai Long, Vu Van Toan, Dao Huu Binh, Dinh Truong Su, Dinh Van Thai, Pham Duc Thinh, Pham Hoang Dan.

1.3	Manage and monitor agroforestry system trials	Trial farmers and extension workers trained on trial management and monitoring/data collection Agroforestry system and livelihood input and output indicators monitored Feedback workshops, study visits and open field days to evaluate trials with local stakeholder	Yr 1-Yr 5	Data collection protocol were designed and implemented, and training on data collection and trial management was conducted with/for partners in 2012. Field data was collected continuously until the end of the cropping season in 2016. Extension workers and farmer co-operators were trained and involved in managing the trials. The trials were monitored every 3 months by field technicians; issues were documented and discussed with farmer-co-operators. Management issues were discussed at the quarterly project coordination meetings and annual meetings. 6 researchers and DARD staff participated in the 3rd World Agroforestry Congress' held in India. Organized 1 cross-visit for 16 project partners to gain knowledge on complex agroforestry management in the Philippines. Organized 1 Farmer Field Days for 82 farmers, extension workers and agricultural division staff from Son La, Yen Bai and Dien Bien. Organized 1 field visit for 50 farmers, extension workers and agricultural division staff to visit the established trials in Co Noi, Son La province. This study tour was conducted in relation to the development of exemplar landscape in Na Ban village nearby. Hosted 1 visit of 28 Laos PDR government staff, facilitated by the SUFORD-SU project (Scaling up participatory sustainable forest management). Participants came from 19 Laos PDR provinces to gain knowledge and experience from the AFLi project. Hosted 1 visit of 50 farmers, government staff and officials from Quang Nam and Hue provinces in Vietnam under the USAID-funded Green Annamites project. Hosted 1 visit of 20 IFAD-project staff from Ha Tinh Province. Hosted 1 visit of the Australian Ambassador to Vietnam, DFAT and ACIAR staff.

1.4	Established Farmer Demonstration trials (FDT)	Minimum 3 FDTs established for each appropriate AF system or its component(s), for each of the 3 provinces	Yr 3-Yr 5	A strategy for Farmer Demonstration Trial (FDT) was developed. A nursery dissemination pathway has been also designed, which was later, revised in the context of the FDT. 6 group-FDTs were established in 3 provinces, with one nursery each, involving 71 farmers, and covering 50 hectares (71 farms). A total of 28,994 seedlings of 18 tree species have been produced in FDT nurseries and planted on the 71 farms. As designed, the project conducted trainings for farmers, extension workers, research partner staff, and local government staff on a step-wise basis following different activities, e.g. establishing nurseries; preparing seedlings, grafting, marcotting, designing system with trees and crops, aiming at enhancing capacity to support agroforestry development (linked to Act. 4.3) An exemplar agroforestry landscape model in Huoi Tan, in Mai Son district, Son la province was established in 2015. The cost of investment was shared amongst partners: ICRAF (54%); farmers (35%), and DARD extension center (11%). The model covers an area of 50 hectares, over which 22,000 trees are to be planted. Species include longan, mango, plum, pomelo, and lemon. Forage grasses were planted along contour lines on sloping maize fields to produce animal feed and control soil erosion. In August, 20,000 seedlings of five tree species were planted, followed by a 50,000m long forage grass strips established along contour lines. In Nov 2015, the farmer co-operators and village leader with support from the People Committee developed a grazing rule to protect the exemplar landscape from damage against strayed animals. Consequently, more farmers living in Na Ban village expressed interest in being involved in the exemplar landscape. In Yen Bai province, a 50-hectare Son tra-based exemplar landscape has been established with 20,000 Son tra trees targeted. A Son tra seedling nursery was established by the Dept. of Science and Technology in Yen Bai. The co-investment scheme is as follows: ICRAF (41%); farmers (28%); provincial government (31%).

1.5	Evaluate trials and identify best practice agroforestry systems for delivering livelihood and environmental improvements with respect to agro-ecological zones, socio-economic settings and infrastructure opportunity	Socioeconomic and biophysical impacts (constrains and benefit) of each agroforestry system analysed at household and community level	Yr 5 (II)	Between 10 tested agroforestry systems, the seven agroforestry systems classified as the best on provide earlier income and profit for smallholder farmers in Northwest Vietnam are: 1.Son tra-forage grasses 2.Acacia-mango-maize-forage grass strips 3. Longan-maize-forage grass strips 4. Shan tea-forage grasses 5. Acacia-longan-coffee-soybeans-forage grass strips 6. Teak-plum-coffee-soybeans-forage grass strips 7. Macadamia-coffee-soybeans In terms of erosion control, the established agroforestry systems, which include soil loss measurement show the effectiveness on reduce soil erosion. Longan-maize-forage grass system reduced from 50-56%, teak-plum-coffee-soybeans-forage grass reduced 22-23%, acacia-longan-coffee-forage grass system reduced 60-90% and acacia-mango-maize-forage grass system reduced 22-74% compared to the maize monoculture system. <u>Publication</u> AFLI Technical Report No. 19: ***Results from Participatory Agroforestry Trials***. La Nguyen, Do Van Hung, Pham Huu Thuong, Do Tien Luc, Agustin Mercado, Hoang Thi Lua, Lo Thi Kieu, Vu Van Tuan, Nguyen Van Chung, Do Hai Long, Vu Van Toan, Dao Huu Binh, Dinh Truong Su, Dinh Van Thai, Pham Duc Thinh, Pham Hoang Dan.
		Best practices identified according to biophysical and socioeconomic context and reports prepared in English, Vietnamese and local languages	Yr 5 (III)	<u>Publication:</u> ***Agroforestry Guide for Sloping Lands in Northwest Vietnam***. La Nguyen, Delia Catacutan, James M. Roshetko, Agustin Mercado, Tran ha My, Vu Thi Hanh, Pham Huu Thuong, Do Van Hung, Nguyen Mai Phuong. ISBN 978-604-943-397-9.
		Manuscript submitted to international journal	Yr 5	Catacutan, D.C., Farhat, N., (2015). ***Gender roles, decision-making and challenges to agroforestry adoption in Northwest Vietnam.*** International Forestry Review Vol.17 (S4)

PC = partner country, A = Australia

Objective 2: To improve availability of high-quality germ plasm to enable expansion agroforestry

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Assess germplasm sources and tree nurseries, including seedling's markets and sources of quality genetic material for priority species	Extension materials on importance of using germplasm and sources of germplasm for agroforestry expansion	Yr 5	Accomplished <u>Publications:</u> 1. Booklet: Nursery establishment 2. Booklet: Son tra grafting technique (Vietnamese) 3. Booklet: Son tra grafting technique (H'Mong and Vietnamese) 4. Poster: Son tra grafting technique (in Vietnamese) 5. Poster: Son tra grafting technique (H'Mong and Vietnamese) 6. Poster: Macadamia grafting technique (Vietnamese) 7. Coffee propagation technique (Vietnamese) 8. Lemon marcotting technique (Vietnamese) 9. Plum marcotting technique (Vietnamese) 10. Longan propagation and grafting technique (Vietnamese) 11. Mango propagation and grafting technique (Vietnamese) 12. Manglietia propagation technique (Vietnamese) 13. Canarium propagation technique (Vietnamese) 14. Agroforestry Guide for Sloping Lands in Northwest Vietnam (English and Vietnamese)
2.2	Study on selection of the best clones Son tra for seedling production	Best clones of Son tra are selected, quality seedling for trial purposes and local need available	Yr 1-Yr 4	Son tra (*Docynia indica*) is an indigenous tree species widely distributed at high elevations in northern Vietnam. Its fruit is traditionally used as a fruit and for making wine, providing a source of income for farmers. Selection of superior planting material can enhance its market potential and benefit growers, processors and consumers. Over 2,400 trees were screened in 13 selected locations, of which 30 trees were selected; among them, 20 candidate plus trees were identified with high yield, superior fruit morphology and suitable taste for processing; whilst 10 candidate plus trees with high fruit yield, superior fruit morphology, fruit peeling characteristics and superior taste for fresh fruit consumption. These 30 selected trees were grafted onto seedling and tested to evaluate their performance and adaptability to local conditions. <u>Publication:</u> Working Paper: ***Selection of Son tra Clones in North West Vietnam***. Tiep Ha Van, Tuan Vu Van, Sammy Carsan, Chris Harwood, Bac Viet Dam, Nguyen La, Delia C. Catacutan and Ramni Jamnadass

	Testing growth of different planting materials (seed, cutting, grafting seedling)	Report detailing the growth of Son tra sourced from different planting materials	Yr 1-Yr 5	Together with the superior clone selection, an assessment for three types of planting materials was conducted. This work was based on the experiment established in 2005 by a finished project in Ngoc Chien commune, Muong La District, Son la Province, Northwest Vietnam. Three types of planting materials were raised from these trees: grafts from the selected trees onto unselected seedling rootstocks, seedlings raised from seeds collected from the superior trees, and cuttings raised from seedlings. The research results showed that grafted trees grew fastest, attaining a mean height of 7.0m and crown width of 4.4m, while trees grown from cuttings grew significantly slower (height 5.0m and crown width 3.4m), and seedling-derived trees performed moderately better or intermediate. Mean fruit yield at 8 years was significantly higher for grafts (38.7kg per tree) compared to trees from seedlings (30.7kg per tree) and those from cuttings (28.9kg per tree). Fruits from the grafted trees were of superior quality, being predominantly yellow in colour and of uniform large (> 3cm) size, while fruit from most of the seedling and cutting-derived trees were of moderate quality with inferior size and colour. Considering the excellent survival of grafts and their superior fruit yield and fruit quality, grafting can be recommended as a better way to propagate selected Son tra trees, compared with using seedlings raised from seed collected from the selected trees or cuttings raised from these seedlings. Publication: Working Paper: ***Growth and fruit yield of seedlings, cuttings and grafts from selected Son tra trees in Northwest Vietnam***. Vu Van Thuan, Chris Harwood, Vu Duc Toan, Doan Duc Lan, Nguyen La, Sammy Carsan
	Testing of different grafting method for improving the performance existing Sontra plantation	Report detailing results from testing of grafting methods for improving the performance of existing Sontra plantation	Yr 4-Yr 5	Assessment of Son Tra's Top-working methods such as traditional graft, cleft graft and side graft at the different crown diameter was conducted. The result shows that, the survival rate of scions after grafting was similar in all grafting techniques. The survival rate of scions was mainly depended by the first 3 months after grafting. Therefore, the recommendation is to take good care of Son tra fields after grafting to ensure the survival rate of the scion. The side graft for a 3cm diameter stock, splice grafts for 3 and 1 cm diameter stocks are easy to implement by farmers. These methods are therefore highly recommended for Son tra improvement in the Northwest Vietnam. Described in: AFLi Technical Report No. 21: ***Assessment of Son Tra top-working methods: traditional graft, cleft graft and side graft.*** Pham Huu Thuong, Do Van Hung, Dam Viet Bac, Le Thi Thao, La Nguyen.

2.3	Develop 9 on-station and smallholder nurseries	Smallholder nurseries producing priority agroforestry species to support project activities and establishment of smallholder agroforestry systems in each of project sites	Yr 1-Yr 4	The project has established the following nurseries: 1 on-station nursery to supply seedlings to the agroforestry trials 3 smallholder tree nurseries and 2 fodder grass nurseries established in 2013, to supply seedlings to interested farmers. Each smallholder tree nurseries produced 500-700 seedlings per year 2 smallholder nurseries maintained in Co Ma (Son La) and Toa Tinh (Dien Bien) 7 group nurseries were established in the context of FDTs in 3 provinces. A total, 28,994 seedlings of 18 tree species have been produced and planted in FDTs.
2.4	Identify best-practice recommendations for germplasm propagation and smallholder nursery	Document in relevant languages: 1. Best practices for germplasm improvement and smallholder nursery development and operation in support of smallholder agroforestry systems 2. Commercial tree markets Peer-reviewed articles produced	Yr 3-Yr 5	Documentation of nurseries and germplasm recommendations were carried out in the context of FDT (linked to Act. 1.4). The recommended methods are published as extension materials for different tree species (Act. 2.1). In Vietnam, seed and seedling supply is managed through an insufficient centralized State system, especially at district and commune level. This leads to a situation where fruit-tree seedlings of poor and unknown origin are produced and distributed in many places. Lack of resources, low capacity, and weak law enforcement are major barriers. Fruit-tree germplasm is produced and distributed by formal and informal production and supply systems. The formal, including state-owned institutions and registered private entities, supplies between 10% and 15% of seedlings. The balance, majority of seedlings, is provided through informal smallholder seedling producers and businesses. A large percentage of these smallholder producers are unable to comply with the requirements necessary for a seedling business and measures designed to strengthen the farmer producers are limited. Germplasm policies focus mainly on the development of new plant varieties, while quality control of seed and seedlings is neglected. Improvement of the current regulations and implementation at local level, as well as stricter and decentralized seedling management combined with appropriate measures to strengthen the role of smallholder seedling producers are key to sustainable delivery of quality fruit-tree germplasm. <u>Publications:</u> Hoang Thi Lua, James M. Roshetko, Delia Catacutan, Le Duc Thinh (2016). ***A Review of Policy Constraints and Opportunities for Sustainable Delivery of Quality Fruit Tree Germplasm in Vietnam***. International Journal of Agriculture Innovations and Research, Volume 4, Issue 3, ISSN (Online) 2319-1473. AFLi Technical Report No. 22: ***Tree Seedlings Supply and Demand in Son La Province: Limitations and Recommendations***. La Nguyen, Delia Catacutan, Nguyen Thi Nhan, Leo Manh An, Pham Huu Thuong, Vu Thi Hanh

2.5	Timber growth and demand and supply study	Technical report "Timber supply and demand and growth potential of fast growing species in the Northwest region of Vietnam"	Yr 1-Yr 2	Households and wood processing businesses in the provinces of Son La, Dien Bien and Lai Chau in the Northwest of Vietnam were surveyed to determine patterns of local wood demand and supply, changes in species utilized over time, and whether timber from planted trees might substitute for species previously harvested from local natural forests. There was high and uniform household demand for fuelwood in the surveyed villages, making fuelwood the dominant use, in terms of wood volume. Use of sawn timber for furniture, home repair and construction consumed less wood but required logs of acceptable species. Sawmills surveyed were small, with input capacity ranging from less than 15 to 500 m^3 of logs per year, suggesting a total log requirement of about 30,000 m^3/year for the 192 known wood processing businesses in the three provinces. Most sawmills still used wood from natural forests, sourced locally or imported from Laos. Sawmill operators and farmers reported a trend of switching from prized timber species from natural forests, now effectively unavailable, to alternatives from natural forests. Some planted species grown on short-medium rotations appear able to substitute for local sawn timber requirements. Publication: Nguyen Duc Kien, Chris Harwood (2016). ***Timber Demand and Supply in Northwest Vietnam: the Roles of Natural Forests and Planted Trees***. Journal of Small Scale Forestry (*in press*)
2.6	Evaluate superior macadamia clones in Northwest region	Technical report "Adaptability of different macadamia clones in Northwest Vietnam"		The study evaluated seven macadamia plantations in the Northwest region. Macadamia shows good adaptability and reasonable nut yields in several different locations 300-700 meters above sea level. A clone trial at Mai Son, Son La Province, tested six selected clones and two controls (unimproved seedlings, and cuttings from selected superior seedling trees). Significant differences in annual nut yield were recorded in two successive years over the period 2011-12. The results suggested that clones OC, 246 and 816 should be planted in mixture to maintain sustainable yield, as well as ensure maximum cross-pollination. Recommendations on suitable climatic conditions for planting macadamia are presented, and management issues in macadamia plantations with respect to the Northwest conditions are also discussed. Publication: AFLI Technical Report No. 5: ***Adaptation and yield assessment of macadamia clones in Northwest Vietnam.*** Nguyen Duc Kien, Chris Harwood, Hoang Thi Lua, Delia Catacutan
2.7	Screening trials on exotic timber species for the Northwest region	Study report/Journal manuscript on suitable timber species recommended for the Northwest	Yr 4	The study tested the adaptability and growth potential of candidate tree species at two elevations in Son La province. In order to recommend suitable fast growing tree species and varieties for planting in the northwest. Species screening trials were established at two elevations, Chieng Den (790 masl) and Chieng Bom (1250 masl). The species tested included acacia and eucalypt species and interspecific hybrids, *Alnus nepalensis, Casuarina junghuhniana, Grevillea robusta, Pinus caribaea* and *Schima wallichii*. In addition, a genetic trial testing control pollinated inter-specific eucalypt hybrid progenies was established at Chieng Den. Publication: AFLI Technical Report No. 7: ***Selection of fast growing tree species for planting in Northwest Vietnam.*** Nguyen Duc Kien, Ngo Van Chinh.

PC = partner country, A = Australia

Objective 3: To enhance market access for, and opportunities to add value to, agroforestry products

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Training partner staff on market value chain assessment		Yr 1 (III)	Accomplished Market value chain training was conducted for local partners in 2012
3.2	Exploratory market study for walnut and sources of planting materials	Report on Market potential of walnut in Vietnam	Yr 2 (IV)	Accomplished Marketing walnuts in Vietnam can be facilitated by the widely known value of walnuts and increasing recognition by domestic consumers. However, serious effort may be required to promote Vietnamese walnuts as opposed to the ones being imported from other countries, mainly the US. In spite of strong recommendation for domestic production to meet market demand in Vietnam, detailed production model with associated cost and volume output is needed to confirm its economic value at farm level. Identification of potential processors/ distributors, as well as support for linkages between farmers and processors are important to ensure that walnuts can be brought to the market. Even though the market for walnuts apparently exists, obtaining serious commitment to purchase output or to co-invest in farm production with farmers is challenging. <u>Publication:</u> AFLi Technical Report No. 8: ***Market for Walnuts in Vietnam.*** Hoang Thi Lua, Delia Catacutan, Ann Degrande, Vien Kim Cuong.
		Walnut seedling are available for testing by farmers		Accomplished >400 walnut seedlings were produced in FDT nurseries and distributed to farmers for testing.

3.3	Assess market value chains for Sontra, and conduct ex-ante cost/benefit analysis for agroforestry system	Market actors, product flows, price margins, marketing costs, consumer preferences identified	Yr 1 (III)	Our analyses revealed several issues indirectly related to marketing, but more to production and post-harvest issues such as managing pests and diseases, pruning, fertilizing, sorting fruits, packing etc. The project responded to these issues by training farmers on pest management and pruning, and also setting up an experiment on different treatments. The market potential for Son tra products particularly for wine and beverage is vast. With improved production and harvesting techniques, adequate support for transportation and post-harvest management, market information and organized marketing support, price stabilization and investments in product development, a vibrant Son tra industry can be created with smallholder producers breaking-through and securing a niche in the market. The market value chain analysis concluded with recommendations for immediate actions. Given the above issues, the development of Son tra value chain must be approached in three stages: Stage 1: Improving the production capacity at household level and resource management at provincial/district level; Stage 2: Increasing farmers' marketing capacity, organizing activities to capitalize on improved skills, and supporting the distribution of high quality Son tra through supermarket distribution channels; and Stage 3: developing processing techniques in parallel with marketing activities to facilitate market penetration of higher value-added Son tra products, especially those which can potentially bring more benefits to smallholder farmers.
		Report/working paper on market value chain for Son tra		Publication: AFLI Technical Report No.9: ***Son tra (Docynia indica) value chain and market analysis.*** Hoang Thi Lua, Ann Degrande, Delia Catacutan, Nguyen Thi Hoa, Vien Kim Cuong
		Report on cost/benefit analysis conducted for each agroforestry systems		Ex-ante analyses of some AF systems are described in: AFLI Technical Report No. 14: ***Ex-ante cost benefit analysis of Son tra and fodder grass trial*** AFLI Technical Report No. 15: ***Ex-ante cost benefit analysis of Son tra and maize trial*** AFLI Technical Report No. 16: ***Ex-ante cost benefit analysis of Shan tea and fodder grass trial*** AFLI Technical Report No. 17: ***Ex-ante cost benefit analysis of Macadamia with coffee, and soybean trial*** AFLI Technical Report No. 18: ***Ex-ante cost benefit analysis of Longan and maize trial*** CBA results from AF trials are described in: AFLI Technical Report No. 19: ***Results from Participatory Agroforestry Trials***. La Nguyen, Do Van Hung, Pham Huu Thuong, Do Tien Luc, Agustin Mercado, Hoang Thi Lua, Lo Thi Kieu, Vu Van Tuan, Nguyen Van Chung, Do Hai Long, Vu Van Toan, Dao Huu Binh, Dinh Truong Su, Dinh Van Thai, Pham Duc Thinh, Pham Hoang Dan.

3.4	Facilitate links between producers and other market actors	Producer trained in identifying market opportunities and in negotiation skills At least, 2 producer groups formed and facilitated for collective product marketing, include achievements and lessons from linking producer groups to market	Yr 2-Yr 5 (I)	Formed 2 Son tra producer groups Assisted producer groups in packaging and labelling fresh Son tra fruits, jam and tea bags Facilitated market linkages between producer groups and buyers in Hanoi city Documented the institutional development and effectiveness of Son tra collective producer and marketing groups Publications: AFLI Technical Report No. 10: ***Part 1-Institutional development and effectiveness of Son tra collective producer and marketing groups.*** Hoang Thi Lua AFLI Technical Report No. 11: ***Part 2- Institutional development and effectiveness of Son tra collective producer and marketing groups.*** Hoang Thi Lua.
3.5	Develop techniques to add value to Son tra and other priority fruits	Appropriate processing techniques identified and producer groups trained on those technique	Yr 3 (IV)	Accomplished Linked to Act. 3.6, methods and standardization of preparing semi-finished Son tra products (water extract/gel) as a pre-product for instant tea and solid extracts was tested. The development of high-quality, instant products can contribute to the popularization of the herbal tea. The extraction and purification methods to produce Son tra instant tea have proven to be simple, quick, and efficient. The identified process creates a foundation for further study and up-scaling the extraction method. These research results were transferred to TAFOOD, a Tea Export Processing Company on the 8th of July 2015, to contribute to the promotion of Son tra products and support the livelihoods of H'mong people in northwest Viet Nam. The Company has established a medium-sized processing facility in Bac Yen district, to have access to the widest area of Son tra plantation in the northwest region. The company has developed a relationship with Bac Yen district government to ensure sustainable supply of high quality Son tra fruits. As part of this objective, the AFLi project has conducted training for district extension workers on identifying Son tra mother trees as source of scion for production of grafted seedlings.

3.6	Nutritional analysis of Son tra fruits and its potential health benefits to promote Son tra consumption		Yr 2 (III)	In-depth study of bioactive substances in Son tra fruit and its processed product development was also conducted. Phytochemical screening of son tra fruits showed the presence of substances such as polyphenol, tannin, saponin, organic acid, amino acid, and reducing sugar, which are essential to human nutrition. TLC identification of Son tra fruits confirmed the presence of triterpene acids, polyphenol, and chlorogenic acid, which are active compounds in the famous Hawthorn (North son tra). The Son tra fruit cannot be consumed directly after purchase. The fruit requires specific processing, which makes son tra fruits inconvenient for many consumers. The production of ready-to–use Son tra products would increase the consumption of Son tra, and thus promote Son tra production. <u>Publications:</u> AFLI Technical Report No. 12: ***Nutrient composition of and processed products developed from Son Tra (Docynia indica (Wall.).*** Nguyen Bich Thu, Hoang Thi Lua, La Nguyen. AFLI Technical Report No. 13 ***Bioactive substances in son tra fruit and its processed product development.*** Nguyen Bich Thu, Hoang Thi Lua, La Nguyen.
3.7	Formulate marketing strategies for Son tra		Yr 3 (III)	Along with the development of agroforestry systems with Son tra, market value chain analysis has been carried out to assess the performance of the current value chain and to identify opportunities for the chain's improvement and especially those that could generate more income for Son tra producers. A number of selected interventions within the framework of the project have been carried out during the last four years including Son tra production improvement, market access and processing. Observations and experiences through four years of project implementation in the region show that the price of Son tra has declined due to the increased supply from newly established Son tra plantations. In order to ensure a stable income from Son tra for local producers and sustainable distribution of Son tra in the market, a comprehensive Son tra marketing strategy for Son tra is needed. The study outlined the key elements of a marketing strategy for Son tra, aiming at ensuring sustainable development of market for Son tra and generating more and stable income for Son tra producers. The strategy should be flexible so that it can respond to the changes in customer specifications and demand. AFLI Technical Report No. 23: ***Son tra Marketing Strategy***. Hoang Thi Lua

PC = partner country, A = Australia

Objective 4: To improve extension methods and policy dialogue for successful dissemination of agroforestry systems

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Policy analysis	Adoption factors for agroforestry determined Current agriculture, forestry and extension policies related to agroforestry reviewed Dialogues with policy makers and extension workers on opportunities for integrating agroforestry into agriculture and forestry policies are carried out	Yr 1-Yr 5	In Viet Nam, the practice of agroforestry has been documented since the 1960s under two common systems: 'garden-fish pond-livestock' and 'forest-garden-fish pond-livestock'. However, not until 1990 were innovative agroforestry techniques and systems at the field level introduced in line with government interventions to halt shifting cultivation. Through intensive literature review, we outlined the history of agroforestry research and development activities in Viet Nam, identified the drivers and agents of change and discuss the issues and challenges facing agroforestry in Viet Nam. Our analyses indicated that it is very important to put more effort into researching agroforestry systems that take into account local ecological knowledge and designing practices that enhance the multi-functionality of landscapes. In addition, demonstrating the role of agroforestry in improving livelihoods, enhancing resilience and in climate-change mitigation and adaption should be an important part of a more systematic research and development agenda for agroforestry in Viet Nam. Publication: Working Paper in English and Vietnamese Journal article: Nguyen Thi Hoa and Delia Catacutan (2013). ***History of agroforestry research and development in Vietnam: Analysis of research opportunities and gaps.*** A National Agroforestry Policy Dialogue was organized in August 2015, with MARD. Two key recommendations emerged from the dialogue: (i) conduct of intensive policy review in the forestry, agriculture and rural development sectors to identify gaps and opportunities for agroforestry development; and (ii) development of a major Agroforestry project proposal to be endorsed by MARD as an ODA priority. To carry out these recommendations, MARD created a national Agroforestry Technical Group with support from FAO, ICRAF and MARD's International Cooperation Department (ICD). Publications: Elisabeth S. Simelton, Delia C. Catacutan, Thu C. Dao, Bac V. Dam, Thinh D. Le. (2016). ***Factors constraining and enabling agroforestry adoption in Viet Nam: a multi-level policy analysis.*** Agroforestry Systems. DOI 10.1007/s10457-016-9906-2 Policy Brief: ***Agroforestry-A policy imperative for Vietnam***
4.2	Developing extension materials	Extension materials in various format	Yr 2 (III)-Yr 5	Extension materials (linked to Act. 1.4, 1.5, 2.1) 1. Nursery establishment 2. Booklet: Sontra grafting technique (in Vietnamese) 3. Booklet: Sontra grafting technique (bilingual H'Mong and Vietnamese languages) 4. Poster: Sontra grafting technique (in Vietnamese)
		Existing extension materials translated in H'Mong language	Yr 3 (IV)	

		Extension materials on producing tree seedling for FDTs.	Yr 4 (IV)	5. Poster: Sontra grafting technique (bilingual H'Mong and Vietnamese languages) 6. Poster: Macadamia grafting technique (in Vietnamese) 7. Coffee propagation technique (in Vietnamese) 8. Lemon marcotting technique (in Vietnamese) 9. Plum marcotting technique (in Vietnamese) 10. Longan propagation and grafting technique (in Vietnamese) 11. Mango propagation and grafting technique (in Vietnamese) 12. Manglietia propagation technique (in Vietnamese) 13. Canarium propagation technique (in Vietnamese) 14. Agroforestry Guide for Sloping Lands in Northwest Vietnam (in English and Vietnamese)
4.3	Capacity development of farmer co-operators, extension workers and research partner	Training farmer co-operators on on-farm trial management, agroforestry practices and trial demonstration conducted Training partners and commune extension workers on agroforestry systems and on-farm research, Training extension workers on smallholder nursery operation, extension methods,	Yr 2-Yr 5 Yr 2-Yr 5 Yr 1-Yr 5	Between November 2011 and March 2012, the following trainings have been conducted with partners: • Nursery establishment training • Monitoring & Evaluation training/workshop • Introduction to Agroforestry • Market Value Chain analysis Between April 2012 and March 2013, a total of 297 researchers, extension workers and farmers have participated in field tours, national and international workshops, and policy dialogues and received training on the following: • Experimental design, data collection and analysis, and scientific writing • Introduction to agroforestry, principles and practices, and management techniques • Advance agroforestry research design and implementation • Participatory technology development and dissemination (PTTD), participatory experimental design. • Simulating agroforestry systems using the Water Nutrient Light Capture in Agroforestry Systems (WaNulCAS) model • Vegetative propagation and nursery techniques for Macadamia • Nursery establishment and management • Market value chain analysis and development Between April 2013 and March 2014, a total of 428 male and female farmers, extension workers and researchers participated in research and management trainings, field tours, workshops and international conference. • Data collection and trial management • Smallholder nursery establishment and grafting technique (TOT) • Agroforestry trial management • Policy analysis • Supported 1 project staff for MSc thesis on "Research and upscaling best agroforestry practices in Quai Nua, Tuan Giao, Dien Bien" and 1 BSc intern on "Modelling of Shantea in WaNuLCAS model

4.3	Capacity development of farmer co-operators, extension workers and research partner	Study tours for project farmer co and project partners organized	Yr 1- Yr 5	• Hosted 1 cross visit for 28 government officials, project staff and farmers from Laos PDR (link to Act. 1.3). • Study tour in Tuyen Quang and Bac Kan provinces • 3rd World Congress on Agroforestry, New Delhi India Between April and October 2016, a total of 80 visitors from the provinces of Quang Nam, Ha Tinh and Hue and the Australian Ambassador's delegation were received by the AFLi project.
4.3	Capacity development of farmer co-operators, extension workers and research partner	Farmer and extension workers trained on nursery establishment and producing tree species seedlings in nurseries in the context of the FDT -operators, extension workers	Yr 3-Yr 4	Between April 2014 and March 2015, a total of 272 farmers (224 male and 48 female), extension workers and government personnel participated in various trainings, farmer field day, field visits and study tours: • Training on nursery establishment • Farmer field day to share good agroforestry systems established in the AFLI project, and develop ideas for up-scaling agroforestry • Study tour to Claveria, Philippines Between April 2015 and March 2016, 193 (154 males, 39 females) farmers, extension workers, government staff, and SUFORD-SU project staff from Laos PDR participated in field visits and various trainings organized on • Son tra pruning technique • Son tra grafting, top-working, pruning, harvesting and post-harvest techniques • Nursery establishment, soil preparation, seed germination, marcotting, grafting for different species, agroforestry system design
4.4	Define "expansion domain" and explore possible pathways for expanding the systems	Synthesis report on potential adoption/ expansion areas Map of areas where each of the agroforestry system could be applied Stakeholder Workshops to communicate extrapolation domain	Yr 5 (II-IV) Yr 5 (III) Yr 5 (IV)	Using LANDSAT 8 satellite imagery, GPS ground truth points and crop modelling, biophysical suitability maps were generated to identify the 'environmental opportunity space' for tree-based systems across different elevation zones. Cropland (primarily maize) covers 23% of this area (approximately 130,000 ha – these areas likely to be very prone to erosion). This is a significant increase from official maps produced by the Ministry of Natural Recourses and Environment (MONRE), in which, cropland accounts 14% of sloping land only. <u>Publication:</u> AFLI Technical Report No. 20: ***Mapping of sloping cropland and potential domains for agroforestry development in the Northwest, Vietnam.*** Nguyen Mai Phuong. Tor-G. Vagen, La Nguyen, Delia Catacutan Oral presentation at the SEA Conservation Agriculture Conference, Hanoi, Vietnam 2013 Oral and poster presentations at the 3rd World Agroforestry Congress, New Delhi, India, February 2014 Oral presentation at the Asia-Pacific Farmers' Association Conference, held in Hanoi on 7 August 2016 Oral presentation at the SEANAFE international conference, held in Buon Ma Thuot City on 29 November 2016 Oral presentation at ALISEA conference, held in Hanoi on 5 May 2016 Oral presentation at German Alumni Workshop, held in An Giang on 15-15 November 2016

Cross-cutting components: Project management and Coordination and Monitoring and Evaluation

No.	Activity	Outputs/ milestones	Completion date	Comments
1.3	Three final provincial workshops	Communicated study researches through provincial workshops	Yr 5 (III)	3 provincial level 'end-of project' workshops were conducted in Son La, Yen Bai and Dien Bien provinces 1 national-level culminating seminar was conducted in Hanoi on December 12, 2016.
2.2	Monitoring and impact assessment	Household baseline analysis completed and utilized for adoption analysis Database established for 3 provinces A paper on potential adoption of AF in the NW region Indicator performance and impacts reported as a key section of the final technical report	Yr 2-Yr 3 Yr 4 Yr 3-Yr 5	Based on the household socio-economic baseline survey conducted by the Agroforestry for Livelihoods of Smallholder Farmers (AFLI) project in northwest Vietnam, the study examined women's participation in, and benefits from agroforestry, control and access to productive resources, decision-making, and the factors affecting agroforestry adoption. The study found that the key constraints to agroforestry adoption by both men and women are lack of technical knowledge on agroforestry technologies. However women, predominantly ethnic minorities, have more constraints in adopting agroforestry compared to men. For female-headed households, this is due primarily to lack of land and labor, and collateral assets; for women in general, interlinked factors such as lack of knowledge, low educational level, and poor access to extension constrained adoption. The study recommends that agroforestry interventions should (i) promote practices that cater to labour-scarce female headed households; (ii) provide preferential credit access to female headed households; (iii) channel extension support to women's associations; and (iv) produce extension materials in the local dialect. The lack of attention to gender issues limits agroforestry interventions to deliver benefits for rural households in Northwest Vietnam Publication: Catacutan, D.C., Farhat, N., (2015). ***Gender roles, decision-making and challenges to agroforestry adoption in Northwest Vietnam***. International Forestry Review Vol.17 (S4) The project impact assessment was conducted. The result shown that through the implementation of the AFLI project and the extensive training and mentoring efforts undertaken to develop the skills and knowledge of farmers, extension workers, policy makers and research partners, the capacity of those stakeholders significantly increased as a direct result from the AFLI project. Participants from the survey suggested that the model of existing trials, FDT and Exemplar landscape should be remained and anyhow multiplied to support farmers to adopt agroforestry systems by themselves. Intensive trainings and post graduate education for partners and researchers should be provided to improve their capacity in the support provinces in upscale agroforestry. Publication: AFLi Technical Report No. 24: ***Assessment of Project Impacts.*** Nguyen Mai Phuong, Vu Thi Hanh, Do Van Hung, Pham Huu Thuong, Delia Catacutan, La Nguyen

PC = partner country, A = Australia

7 Key results and discussion

Objective 1: Develop best-practice agroforestry systems for three agro-ecological zones

From an economic perspective, an important indicator that helps identify best-practice agroforestry systems is changes in yield and income compared to current farming systems and practices. With 3-4 years field data, our analyses indicate seven best-practice agroforestry systems based on the following criteria: low investment cost, early returns to investment, profitability and high NPV. These systems are: (i) Son tra-forage grasses; (ii) Acacia-mango-maize-forage grass; (iii) Longan-maize-forage grass; (iv) Shan tea-forage grasses; (v) Acacia-longan-coffee-soybeans-forage grass; (vi) Teak-plum-coffee-soybeans-forage grass; and (vii) Macadamia-coffee-soybeans. Table 1 provides a summary of incomes derived by farmer co-operators from 7 trialled best-practice agroforestry systems from 2012 to 2016.

Table 1: Income of farmer co-operators from agroforestry trials (million VND/ha)

Agroforestry trial	Year of establishment	2012	2013	2014	2015	2016
Son tra-forage grasses	2013		-	93.8	96.5	110
Acacia-mango-maize-forage grass	2014			13.8	23.8	23.8
Longan-maize-forage grass	2012	37.3	26.1	34.6	41.2	47.1
Shan tea-forage grasses	2013		-	19.3	51.2	64.9
Acacia-longan-coffee-soybeans-forage grass	2014			-	23.4	53
Teak-plum-coffee-soybeans-forage grass	2014			4.9	27.2	41.3
Macadamia-coffee-soybeans	2013		1.4	2.9	25.2	25.8

The Son tra-forage grass system provides the highest income in the second year, mainly from the harvested grass biomass. This system produced about 60tons of fresh grass ha^{-1} $year^{-1}$ starting the second year (1kg of fresh grass is priced at 1,500 VND). The system's net profit in the second year was 64million VND. On the third year, additional income was generated from the first harvest of Son tra fruits at 0.2tons. Total system productivity is expected to increase overtime as the trees mature and bear more fruits.

In multi-strata systems such as Acacia-mango-maize-forage grass and Longan-maize-forage grass, initial cash flow depended on income from maize and forage grasses, as the fruit trees start to bear fruits only on the 4^{th} year and timber trees are usually harvested on the 8^{th} or 12^{th} year, depending on farmers' decision. In the second year, the net profits in

were 7.3 and 6.1 million VND ha^{-1} $year^{-1}$ for Acacia-mango-maize-forage grass and Longan-maize-forage grass systems, respectively. Further, the Acacia-longan-coffee-soybeans-forage grass and Teak-plum-coffee-soybeans-forage grass systems provided a net profit of 13.62 and 9.75 million VND $ha^{-1}year^{-1}$ respectively on the second year. With the first harvest of coffee beans on the third year, the total system profit increased to 38.24 and 26.5 million VND ha^{-1} $year^{-1}$, respectively.

Moreover, the Shan tea-forage grass system started to provide positive returns at 2.3million VND $ha^{-1}year^{-1}$ on the second year, and increased to 22.8million VND ha^{-1} $year^{-1}$ on the 3rd year. Incomes were derived mainly from forage grasses since the Shan tea were not due for harvesting yet.

For Macadamia-coffee-soybean system, the net profit on the 3rd year was 8.2million VND ha^{-1} $year^{-1}$, with coffee as the main earner. Harvest from macadamia is expected on the 5th year. Soybeans provide additional income of about 1.4 million VND ha^{-1} $year^{-1}$.

Furthermore, analysis of net present values (NPV) was applied to project the difference between the present value of cash inflows and outflows, and the benefit that the farmers can gain from their long-term investment in these systems. The NPVs were calculated for one hectare, for 30 years to capture the productive life of fruit trees. These are (i) 1,800million VND for Son tra-forage grass; (ii) 730million VND for Acacia-mango-maize-forage grass; (iii) 1100million VND for Longan-maize-forage grass; (iv) 760million VND for Shan tea-forage grass; (v) 860million VND for Acacia-longan-coffee-soybeans-forage grass; (vi) 590million VND for Teak-plum-coffee-soybeans-forage grass; and (vii) 1,700million VND for Macadamia-coffee-soybeans. The systems provided much higher NPVs compared to maize monoculture, which is only about 150 million VND. The detailed analyses of 10 trialled agroforestry systems are described in AFLi Technical Report No. 19.

In agroforestry systems involving forage grasses planted on contour lines, grasses provide early returns to farmers for their investment in shifting from monoculture maize. Planted along contour lines in the Acacia-mango-maize-forage grass, Longan-maize-forage grass, Acacia-longan-coffee-soybeans-forage grass and Teak-plum-coffee-soybeans-forage grass systems, fodder grass yield reached 4-6 ton ha^{-1} during the initial years of the trials, increasing up to 18 tons ha^{1} $year^{1}$ overtime. With these, farmers can provide sufficient feed to 1-2 cows based on a daily requirement of 30kgs of grasses day^{-1} cow^{-1}. Based on current price in the local market (1,500 VND kg^{-1}), the economic value of these grasses is 24million VND (approximately 1,100 USD). Grass yield in the Shan tea and Son-tra forage grass systems was much higher at 40-60 ton ha^{-1}. This is valued at 75million VND ha^{-1}, and is more than sufficient to feed to 3 cattle heads.

Soybeans were intercropped in three agroforestry systems (macadamia-coffee-soybeans, acacia-longan-coffee-soybeans-forage grass and teak-plum-coffee-soybeans-forage grass) to provide early income for farmers while tree canopies are still open. Soybean yield was between 50 and 150kg ha^{-1}, which equates to 1 and 3 million VND ha^{-1} per year. As N-fixing specie, soybeans have potential to improve soil fertility, leading to low-input agriculture in the immediate future.

Coffee is a promising agroforestry component. On the third year of the Teak-plum-coffee-soybeans forage grass trial, the yield of coffee was 2.2 tons/ha; 4.7 tons/ha in the Acacia-longan-coffee-soybeans-forage grass system; and 4.2 and 4.3 tons/ha for macadamia-coffee-soybean in the 3rd and 4th years, respectively. Coffee yield also contributed about 13.2 million VND ha^{-1} $year^{-1}$ in the Teak-plum-coffee-soybeans forage grass system, and twice as much in the acacia-longan-coffee-soybeans-forage grass and macadamia-coffee-soybean systems.

Forage grasses planted on contour lines in agroforestry systems not only provide initial income, but also help reduce soil loss. Grasses laid along contour lines control run-off, leading the water to infiltrate the soil. When compared to maize monoculture system based on data collected from soil traps after three years of the trials, soil erosion in

Longan-maize-forage grass system reduced up to 56%, 23% in Teak-plum-coffee-soybeans-forage grasses, 90% in Acacia-longan-coffee-forage grasses, and 74% in Acacia-mango-maize-forage grass systems.

From an ecological perspective, the trialled agroforestry systems also provided benefits. On average, the volume of soil conserved in multi-strata systems over three years was 20tons ha^{-1} $year^{-1}$, which is equal to about 250 USD ha^{-1} $year^{-1}$ in NPK replacement (nitrogen, potassium and phosphorous).

However, the establishment cost of agroforestry may hinder spontaneous adoption by farmers. While incremental returns to investments can be observed starting the first year, and for some of the trialled systems, total income could be three times higher than that of maize monoculture on the 3rd year, the break-even point for almost all systems appears to be on the 4th year, with more economic benefits accruing overtime (on average, the net profit from maize monoculture system was 12.5 million VND ha^{-1}). Our analyses of constraining factors have shown that financial capital and labour availability are limiting factors, especially for women-headed households whose financial capabilities are often less than male-headed ones (*Catacutan & Naz, 2015*). This points to the need for incentives that encourage farmers to adopt agroforestry, in the form of training, guidance from extension workers, and/or financial support to cover the cost of tree seedlings.

Learning from the trials, 71 farmers became interested in agroforestry, and eventually became involved in the 6 FDT groups organized by the project. Through the FDTs, 7 group nurseries (in 6 FDT) were established, producing nearly 30,000 seedlings of 15 different tree species and 20 tons of forage grasses. A list of these species is presented in Table 2.

Table 2: Fruit and timber tree species planted in FDTs

No.	Tree Species	Local name	Number of planted trees
1	Canarium nignum	Trám đen	421
2	Manglietia conifer	Mỡ	4877
3	Litchi	Vải	88
4	Graft longan	Nhãn	2415
5	Lemon	Chanh	1375
6	Plum	Mận	1320
7	Eucalyptus	Bạch đàn	3200
8	Coffee	Cà phê	6490
9	Mango	Xoài	390
10	Pygeum arboreum	Xoan đào	1740
11	Melia azedarach	Xoan lai	1730
12	Altingiaceae	Tô hạp	1815
13	Schima wallichii	Vối thuốc	700
14	Docynia indica	Sơn tra	2500
15	Walnut	Óc chó	133

A major result from the project has been the establishment of two Examplar Landscapes (EL)in Son La and Yen Bai provinces In collaboration with the Provincial Extension Department of Son La province and 31 households, a 50-ha agroforestry EL has been established in Huoi Tan, Mai Son district, over which 22,000 trees were planted. Species

planted include longan, mango, plum, pomelo, and lemon. In addition, 50,000 meters of forage grass strips have been planted along contour lines to produce animal feed, and control soil erosion. In Yen Bai province, the 50ha exemplar agroforestry landscape is established in Tram Tau commune, involving 75 H'Mong farmers with a target of 20,000-grafted Son tra trees, fodder grass strips, and To Hap (*altingiaceae*) for windbreak. This EL is a result of a co-investment scheme between the project and Yen Bai's Departments of Agriculture and Rural Development (DARD) and Science and Technology (DoST). As of this report, discussions on the design of the EL in Dien Bien have already been initiated. The ELs were established in a 50-ha contiguous farmland, to demonstrate scale, and inspire farmers and local governments. The establishment of EL provided the opportunity to extension workers to display their acquired extension skills on agroforestry. In the Son La EL for example, the extension worker was filmed by a local Television while explaining the mechanics and outputs of the EL.

Based on the AFLI household socio-economic baseline survey conducted in 2012, we examined women's participation in, and benefits from agroforestry, control and access to productive resources, decision-making, and the factors affecting agroforestry adoption. Published in an international journal, the study found that the key constraints to agroforestry adoption by both men and women is lack of technical knowledge on agroforestry technologies; however women, predominantly ethnic minorities, have more constraints in adopting agroforestry compared to men. For female-headed households, this is due primarily to lack of land and labour, and collateral assets; for women in general, interlinked factors such as lack of knowledge, low educational level, and poor access to extension constrained adoption. The study recommends that agroforestry interventions should (i) promote practices that cater to labour-scarce female headed households; (ii) provide preferential credit access to female headed households; (iii) channel extension support to women's associations; and (iv) produce extension materials in the local dialect. The lack of attention to gender issues may thus, limit agroforestry interventions to deliver benefits for rural households in Northwest Vietnam (Catacutan DC & Naz F, 2015).

The anticipated impacts from Objective 1 were increased awareness, changes in knowledge, skills, aspirations, practices and adoption. The survey conducted in early 2016 to assess project impacts revealed that there was spontaneous adoption by farmers from observing the trials. As the literature suggests, on-farm trials have a demonstration effect, enticing farmers to adopt fully or partially depending on their needs and resources. Farmers and village leaders reported that a number of farmers in the village/commune have adopted some of the agroforestry components and practices demonstrated in the trials, such as planting grasses along contour lines to reduce soil erosion. Accordingly, a 71 farmers have spontaneously planted grasses and trees along contour lines, while 92 farmers adopted the trialled agroforestry systems or their components, such as Son tra-maize-grass, tea-maize, plum, mango, orange, longan, and macadamia intercropping with maize or peanut.

Furthermore, nearly all interviewed farmer co-operators (n=47) confirmed that AFLI activities are useful and relevant. 89% of co-operators have applied the knowledge and skills gained from being involved in agroforestry trials such as agroforestry system design and implementation, nursery establishment, seedling production, pruning, laying-out contour lines, and grass and tree planting to prevent soil erosion; while 40% have transferred their knowledge to other farmers, and 34% have used our training materials. Regarding awareness, 96% of farmer co-operators recognized the benefits of agroforestry benefits and 83% are willing to expand agroforestry on their farms. The rest were concern about land and labour availability in establishing agroforestry.

Objective 2: Improve availability of high-quality germplasm to enable expansion of agroforestry systems

Son tra grows in areas with altitudes above 800 meters above sea level (masl). In the past, the tree can only be found in the wild, but quite recently, it is increasingly used as a

reforestation species. Local people collect fruits from existing trees inside natural forests, as well as in government-supported plantations to sell to local collectors and traders. However, fruit quality is uncontrolled and often low; hence, farmers could not command a higher price. The selection of best Son tra clones resulted in the identification of 20 high-yielding trees with superior fruit morphology and suitable for processing, and 10 trees with high fruit yield, superior fruit morphology, fruit peeling characteristics and superior for fresh fruit consumption (Fig 2). In total, these 30 selected mother trees were grafted onto seedlings, and tested in the 'Son tra-forage grass' trials to evaluate their performance and adaptability to local conditions. Grafted trees in the trials were also found beneficial since it bears fruit, three years after planting compared to 5-7 years when planted using seeds. In addition, the selected clones are also used as grafting material for the 50ha agroforestry exemplar landscape in Tram Tau, Yen Bai province.

Figure 2: Son tra trees and fruit types from selected clones

To improve the fruit quality of existing Son tra plantations, the top-working method was employed, using the scion of the selected tree grafts onto an existing Son tra plantation. We found that, the side graft, in which the scion material was grafted on one side of the stock performed better. These techniques were easy to implement for stocks 3cm and 5cm in diameter. This technique is suitable for farmers since it is easy to apply, requiring less labour compared with the other grafting techniques.

The project exceeded its target of 9 established nurseries, by establishing 13 tree and 2 grass nurseries. The 7 FDT nurseries involved 71 farmers who planted nearly 30,000 trees in 2015 and 2016. Seedlings in the four FDT nurseries in Tan Que and Mon village

(Son La), Giang village (Dien Bien), Van Thi village (Yen Bai) have high survival rates ranging from 65 to 85%. The survival rates of seedlings in two nurseries in Tram Tau (Yen Bai) and Noong Giang village (Dien Bien) were however, much lower at 34% and 46% respectively, due to the extremely cold weather with snow in January 2016.

Further, a survey of macadamia plantations in different locations was conducted to gain better understanding about adaptability, growth and yield in the northwest region. The result shows that macadamia has good adaptability and reasonable nut yield at elevation 300–700 masl. Clones did not differ in growth traits, but there were significant differences in nut yield among clones and controls in a clonal trial in Mai Son district, Son La province, with unselected seedling controls yielding poorly. Clones OC, 246 and 816 had the highest and year-wise stable nut yield, and are recommended for planting in flat lands up to 700 masl, with deep and fertile silty loam soils in the Northwest.

We also tested the adaptability and growth potential of candidate timber tree species at two elevations in Son La province, and found that acacia hybrid (*Acacia mangium x A. auriculiformis*), hybrid *Eucalyptus urophylla* and *E. pellita*, *Pinus caribaea* and *Grevillea robusta* are promising species since they had high survival rates, although slower growth compared to acacia and eucalypt hybrids. These species may be grown on farms, to address the wood demand of sawmills in the region, which is estimated at 30,000 m^3/year.

Finally, the timber demand and supply study in the region revealed that use of sawn timber for furniture, home repair and construction consumed less wood but required logs of acceptable species. Sawmills surveyed were small, with log input capacity ranged from 15 to 500 m3 of wood per year, suggesting a total log requirement of about 30,000 m3/year for the 192 known wood processing businesses in the three provinces. Most sawmills still used wood from natural forests, sourced locally or imported from Laos. A trend of switching from prized timber species from natural forests, now effectively unavailable, to alternatives from natural and planted forests was reported by both sawmills and households. Prospects for planted forests and agroforests to supply timber and fuelwood are considered. Some planted species grown on short-medium rotations appear able to substitute for local sawn timber requirements. Sales of small-diameter logs to local processors of veneer and sawn timber may offer the best market prospects for commercial tree-growing.

Objective 3: Enhance market access for, and opportunities to add value to agroforestry products

For market value chain analysis (MVC) and product development, we focused on Son tra for several reasons--- the tree is native to the region; it is an important source of income for the Hmong people; it is a key reforestation species; and its market was reportedly, small and under-developed compared to other tree species in our trials. The primary issue faced by Son tra producers had more to do with product quality than marketing. For farmers, low yields, pests and diseases were the primary concerns. They believed they could sell and command better prices with improved fruit quality, and requested training on proper tree management. Producers indicated that market would rapidly increase with evidence on Son tra nutritional benefits and institutional buyers and consumers were more interested in ready-to-use or processed product than raw or fresh fruits.

The project addressed these issues by training Son tra farmers on tree management, and exploring the nutritional value and markets of Son tra fruits. As a result of applying pruning, pest management and harvesting techniques, farmers' income from Son tra increased substantially. Positive change in income was observed in 25, among 40 data samples (4 treatments with 10 replicates each (N=40) of the pruning and pest management trials. Incomes from Son tra in 2015 increased by 1,000,000 VND/household, and 5,600,000/household VND in 2016, respectively. The change in income was due to fruit classification into type 1 and type 2 after the application of pruning and pest management techniques, and increase in yield. The selling price of Son tra type

1 ranges from 7,000 to 10,000/kg while the type 2 ranges from 6,000 to 8,000/kg. The average yield also increased after one year from 4.5 kg/tree in 2015 to 15 kg/tree in 2016. Through trainings in Son tra fruit selection, harvesting, management and grafting, the knowledge and skills of Son tra producer groups were improved. In the two producer groups, 52% of members know how to harvest the fruits better, 56% know how to prune Son tra trees, and 44% know how to classify Son tra fruits based on size and quality.

Moreover, the phytochemical screening of Son tra fruits showed the presence of substances such as polyphenol, tannin, saponin, organic acid, amino acid, and reducing sugar, which are essential to human nutrition. The project further developed methods and standard procedures for preparing semi-finished Son tra products (water extract/gel) as a pre-product for instant tea and solid extracts. As a result, TAFOOD Company became interested with Son tra, and a technology transfer agreement for Son tra processing techniques was signed amongst ICRAF, ACIAR and TAFOOD. TAFOOD obtained support from Bac Yen district government in Son La province to secure >1,000 ha of Son tra plantation in partnership with farmers/producers, to ensure sustainable supply of quality Son tra fruits to the company. The AFLi project provided training support to district extension workers regarding mother tree selection, as well as grafting and tree management techniques. This type of private-business partnership was deemed necessary to support market expansion of Son tra fresh fruits and local products.

Plate 1: Signing ceremony on 8th of July 2015 between ACIAR-ICRAF-TAFOOD on transferring Son tra processing techniques. The ceremony was witnessed by then, ACIAR CEO Nick Austin, ACIAR Vietnam country staff, local partners and farmers.

For sustainable supply and distribution of Son tra in the Northwest, the project recommends that the marketing strategy should cover four key aspects: (i) Improving product quality and diversity - fresh fruits grading, price differentiation, product quality improvement (planting materials, cultivar, management techniques), brand development, packaging, etc.; (ii) Optimizing Son tra sales through collective marketing; (iii) Identifying strategic markets for Son tra - provincial markets, high-demanding markets, processors; and (iv) Product promotion through relevant channels and PR tools, communication on health benefits, product safety, poster leaflets, and events.

In addition, the market study on walnut found that 300 hectares have been planted to walnut in Dong Van district, Ha Giang province. The province targeted an expansion area of 2,000 hectares in 2015. Consequently, up to 5,000 ha new plantations in other provinces were to be established in the next five years. It is said that the market for walnut exists, but industry development is sluggish. To achieve market growth for walnut, the

project recommends the following: (i) Investment in processing facilities and distribution channels; (ii) Creative packaging to increase market value; (iii) Promoting nut value, thereby attracting domestic consumers; (iv) Identification of potential processors/ distributors, as well as support for linkages between farmers and processors.

Objective 4: Improve extension methods and policy dialogues for successful dissemination of AF systems

The policy analysis for agroforestry development in Viet Nam has identified a number of gaps in current policies and policy implementation for supporting adoption of agroforestry. There were no specific national and few provincial specific policies promoting agroforestry, and instead, policies are more segregated into agriculture and forestry, which promoted monoculture practices and discouraged tree integration in agriculture. Completing the forestland allocation process was considered essential for long-term investment on land and providing collateral for loans. More holistic policies are needed, such as a provincial strategy for agroforestry development that would enable flexible integration of agriculture, forestry and livestock, which benefit both the poor and non-poor farmers. Specific cross-cutting budget allocation would be necessary for capacity building, up-scaling agroforestry models, procurement of high-quality inputs, and establishing post-harvest processing and marketing investments. The diversity of farmers in terms of wealth status, educational attainment and ethnicity in Viet Nam calls for a holistic and flexible agroforestry policy that caters to different needs. The inadequacy of extension support for agroforestry development is a systemic issue that requires national level policy response. Interviewed policy-makers recommended that agroforestry projects should provide evidence on the economic effectiveness of agroforestry practices, to encourage them to support farmers at landscape scale through appropriate policies, supported with funding and sanctions to ensure successful implementation.

As a direct influence of agroforestry trials and close engagement with local policy-makers in setting up the FDT and ELs, the provincial government of Yen Bai promulgated policy support for agroforestry. First was Decision 15/2015/NQ-HDND, providing financial support (1 million VND) for planting grasses along contour lines on maize sloping fields, to prevent soil erosion, and second was Decision 27/2015/QD-UBND, again providing financial support (6 million VND) for Son tra planting in Tram Tau. Furthermore, the Son La provincial government provided support to the expansion of Son tra plantation, and commissioned our partner research organization, FSCN to assist in producing high quality Son tra seedlings.

Plate 2: Representative of Co Ma farmers discusses commune-district level policies relating to agroforestry

At the national level, agroforestry was for the first time, included in the Action Plan of the Agriculture & Rural Development sector to cope with climate change (2016-2020) with a vision towards 2050. Our policy dialogue also resulted in the creation of a technical working group comprising MARD, FAO, ICRAF, the Vietnamese Academies of Forestry and Agriculture Sciences (VAFS and VAAS) to (i) conduct intensive policy review to identify gaps and opportunities for agroforestry; and (ii) develop a major agroforestry proposal to be endorsed by MARD as a priority for overseas development assistance (ODA). These efforts would lead to a more secure investment in, and wider adoption of agroforestry throughout the country.

From Farmer Participatory Trials (FPT) of agroforestry systems (objective 1), we employed the FDT and EL, defining our notion of 'participatory technology development and dissemination' (PTDD) as a two-pronged approach to demonstrate evidence-based and innovative extension and scaling up approaches (Figure 3 below).

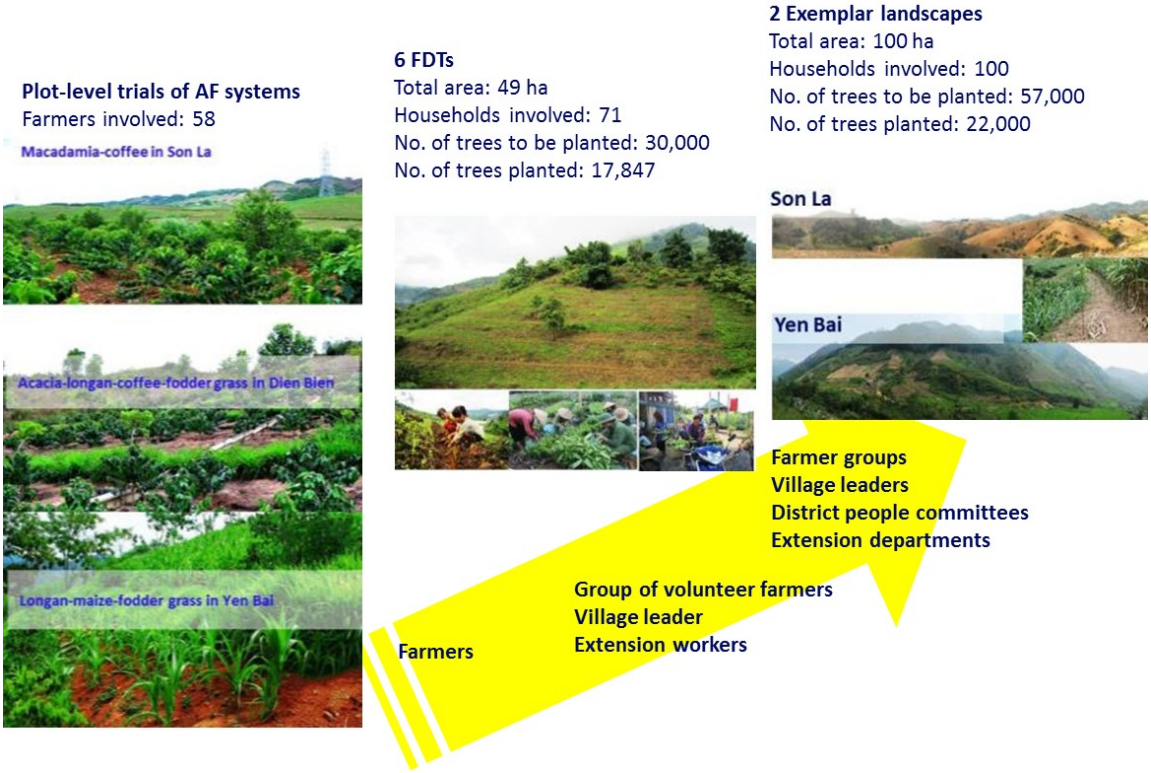

Figure 3: Linkages between FPT, FDT and ELs in the AFLi project

In the FPT, farmers were directly involved in the activities of the trials such as field management and data collection. The data collection and analysis were conducted to provide comprehensive assessment of tested trials to define the suitable systems. The trials served as initial learning ground for interested farmers. Once interest was generated, farmers who were willing to adapt certain agroforestry components and practices were organized and facilitated with trainings to establish their own 'adaptation' of the trialled systems. Their choice of species were considered and nurseries were established to produce the required seedlings, which served as the focus of group-work, leading to improved social capital amongst members. In FDTs, interested farmers were involved as volunteers in designing and developing the FDTs. The FDTs facilitate early adoption of agroforestry based on specific requirements of farmers outside the on-going trials. Five key steps were carried out in facilitating FDTs: (i) Evaluating the strengths, weaknesses, opportunities and threats involved; (ii) Identifying the socio-economic status of farmers/households; (iii) Determining the distinctive limitations, specific requirements and potential for agroforestry development; (iv) Tree species selection based on principles and criteria for agroforestry development; and (v) Conducting technical skills training such as nursery establishment, farm designs, etc. Throughout this process, researchers work

with groups of farmers (not individuals) to develop local capacity, build rapport and create social capital.

Eventually, a group of farmers in a village with contiguous farm units were organized and facilitated to establish the ELs, with great support from the extension department, and the project. Researchers, provincial extension staff, and interested farmers and commune/village leaders work together to establish and manage agroforestry ELs. The ELs aim to demonstrate wider-scale adoption of agroforestry, and attract attention and support from local governments and other agencies. The establishment and maintenance of ELs was cost-shared by the project, the provincial government (seedlings, staff salary), and the farmers who contributed their land, time and labour. A series of meetings, workshops and planning events were held to ensure that the needs and interests of all parties, particularly farmers were addressed. As mentioned above (Objective 1), the EL is a 50-ha contiguous area located in a village with similar socio-economic and biophysical conditions, and with 30-75 farmers involved, depending on the farm size that each farmer commit to it. In total, 105 farmers are involved in two exemplar landscapes in Son La and Yen Bai. A key requirement is the establishment of contoured grass strips as an initial approach to controlling soil erosion, which could also provide fodder for animals, and to some extent, cash income. The tree species were selected in a participatory manner, and planted by farmers on top of the grass strips. Local arrangements or rules with respect to running the exemplar landscape are discussed and agreed upon by farmers together with commune/village leaders, extension workers and project staff. For example, to protect the trees against strayed animals, the commune government enacted a local policy that prohibits free grazing in the locality.

Plate 3: 50 ha exemplar landscape with trees and forage grass planted following contour lines in slopping land in Na Ban village, Hat Lot district, Son La province.

Alongside this two-pronged extension method, the project facilitated field visits for farmer co-operators, farmers and extension workers from other villages, communes and districts to the trial sites, as well as hosted a number of visits by donor-funded projects in Vietnam and neighbouring Laos. The project also conducted numerous trainings on different aspects of agroforestry to more than 2,000 participants, including extension workers, project staff, research partners and local government officials. Topics include, agroforestry design and management, nursery establishment, seedling production through different techniques such as grafting and marcotting, tree pruning, pest and disease management, among others. The project supported capacity building also by developing learning and

extension materials. These include 14 extension materials, 24 blog stories and videos. Some extension materials related to Son tra were published in bilingual languages (H'Mong-Vietnamese) to address language barrier and low literacy level of the H'Mong people. In addition, 7 international BSc student-interns were hosted by the project and 6 MSc students, of which one is a Vietnamese project staff who completed her graduate thesis within the project framework.

Moreover, to support the provinces in identifying potential areas for agroforestry expansion and the appropriate tree species to be planted, we conducted biophysical suitability analysis of selected agroforestry tree species, which revealed that the tree suitability areas cover approximately 85% of the total cropland areas with slopes above 15^{o} across an altitudinal gradient, 100–3,000masl, presenting significant potential for tree integration and expansion of agroforestry systems in the region. As shown in Figure 4, at lower altitude (<800masl), acacia and teak have the largest suitability area, while Shan tea, plum, coffee, macadamia and Son tra are more suitable in altitudes above 800masl. Details of mapping expansion domains of agroforestry in the region are reported in AFLi Technical Report No. 20.

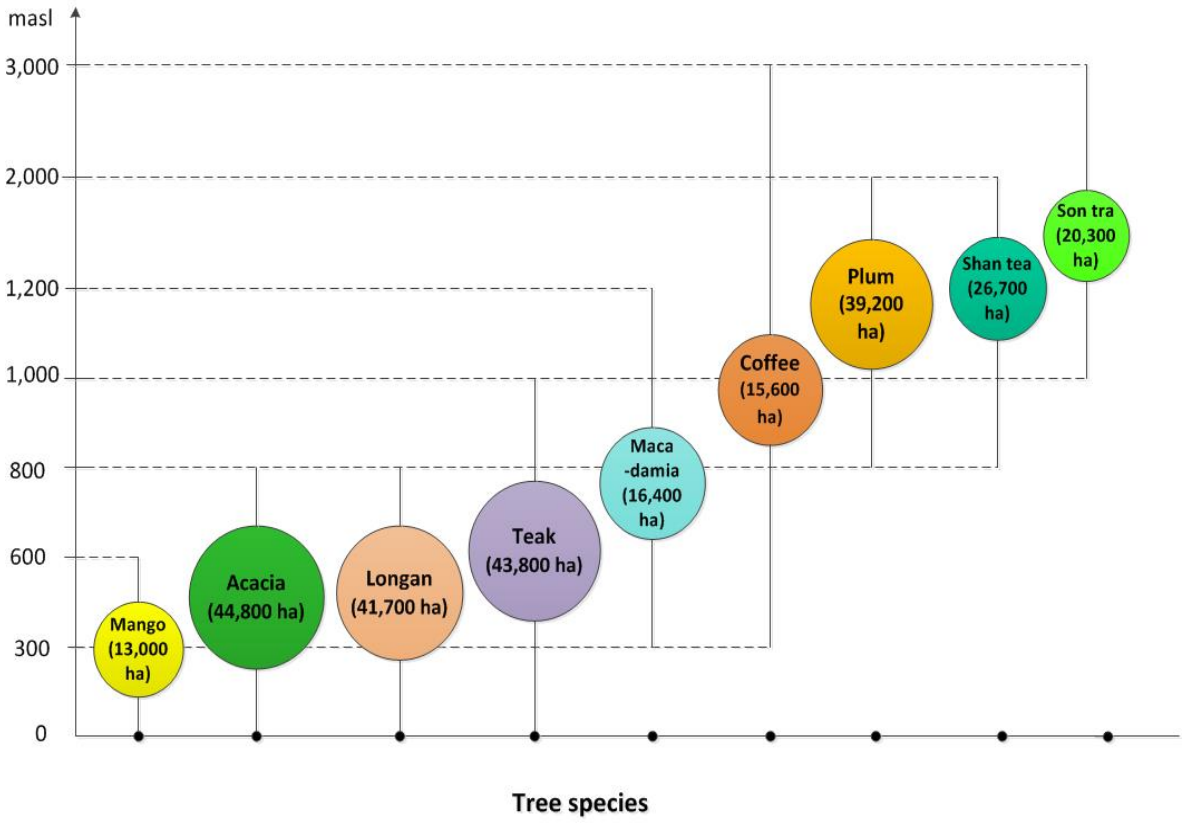

Figure 4: Total suitable areas of different species in sloping croplands

8 Impacts

8.1 Scientific impacts

The project recommends seven best-bet agroforestry options for smallholder farmers based on a 3-4 year trial, which will benefit more from continuous monitoring in the next two years, to enable collection and analyses of more robust data. Previously in Vietnam, research and documentation of agroforestry systems and practices have been limited despite being claimed as a traditional practice by Vietnamese farmers. Our study results therefore, contribute to the literature of agroforestry in the Vietnamese context.

Our Son tra study also addressed the paucity of research and scarcity of scientific literature of this important species. The selected 30 superior Son tra clones could serve as source of good genetic material across the northwest region; in fact, the Son tra exemplar landscape in Yen Bai is expected to evolve as field gene bank, to support the provincial government's 5-year Son tra development strategy (2016-2020). The study on Son tra's nutrient composition was a pioneering study in Vietnam, and provided the foundation for further studies on nutritional properties of indigenous agroforestry products. Results show that Son tra fruits contain nutrients essential to human body, which are comparable to other valuable fruits, and are especially high in polyphenol content. Polyphenol has long been known to have antioxidant properties, which are certainly connected to the potential health benefits of Son tra. The method and standardization of preparing semi-finished Son tra products (water extract/gel) as a pre-product for instant tea and solid extracts was also a pioneering work toward commercial product development. The development of high-quality, instant products can contribute to the popularization of Son tra herbal tea. The extraction and purification methods to produce Son tra instant tea have proven to be simple, quick, and efficient. The identified process creates a foundation for further studies, and up-scaling of the Son tra fruit extraction method.

The project also contributed to the growing body of literature on agroforestry adoption, dissemination, and scaling up. As can be found in the literature, scaling up agricultural innovations remains central over many decades of international investments in agricultural research and natural resources management. The project emulated the role and relevance of science in advancing agricultural policies.

Finally, our tree-suitability analyses and mapping of agroforestry expansion domains not only contribute to the limited knowledge on agroforestry in the region, but are also useful for investment and planning purposes by local stakeholders in northwest Vietnam.

8.2 Capacity impacts

Participatory on-farm research was quite new to partners in the Northwest, creating difficulties, particularly in the initial years. As the project progressed, our partners on one hand, gradually demonstrated improved skills and confidence, developed through the trainings provided, closer interaction with ICRAF scientists, and regular monitoring. On the other hand, our farmer co-operators have incrementally understood and realized the benefits of their participation in the trials.

A key indicator measured against four project objectives is improving farmers' awareness, knowledge and skills, on agroforestry, seedling/germplasm production and marketing, and farmer adoption. More than 2,000 participants or an equivalent 1,200 individual farmers, extension workers and staff, DARD officials and research partners (some of them attend

in different training courses) have been trained on different aspects including agroforestry design, seedling production, MVC analysis, and laying out contour lines, among others[1].

A significant achievement linked with Objective 2 was the improvement in skills of farmers participating in nursery activities. The project conducted trainings for 71 farmers in the FDTs such establishing nurseries, preparing seedlings, grafting, marcotting, designing system with trees and crops. Among 53 interviewed nursery members, 53% have the ability to produce seedlings, 63% are able to graft seedlings, and half of them already transferred grafting techniques to other farmers. The ability to access market is quite low with only 40% of surveyed farmers. It was important to note that 70% of FDT farmers wanted to maintain their nurseries.

A comparison of the results from capacity assessment of two groups was conducted (Fig 5). Group 1 consist of households/farmers (n=143) included in the baseline survey in 2012, and group 2 consist of farmers directly involved in project activities (n=141), including farmer co-operators, FDT farmers, Exemplar landscape members, and Son tra producer groups. There were only 6 farmers involved in both baseline survey and AFLI activities. The result shows that while the rates of farmers who were aware about the environmental and economic benefits of agroforestry are similar between two groups, only 30% of the baseline farmers (Group 1) know how to implement agroforestry by themselves while it is 73% for Group 2. Regarding soil erosion control, only 3% of Group 1 is applying soil erosion control measures while it is 59% for Group 2. Around 60 – 70% of farmers in both groups however, expressed interest in applying or expanding agroforestry on their farms. These figures indicate positive influence on farmers directly involved in AFLi activities than those who were not involved. These further indicate the effectiveness of different AFLi activities in improving farmers' skills.

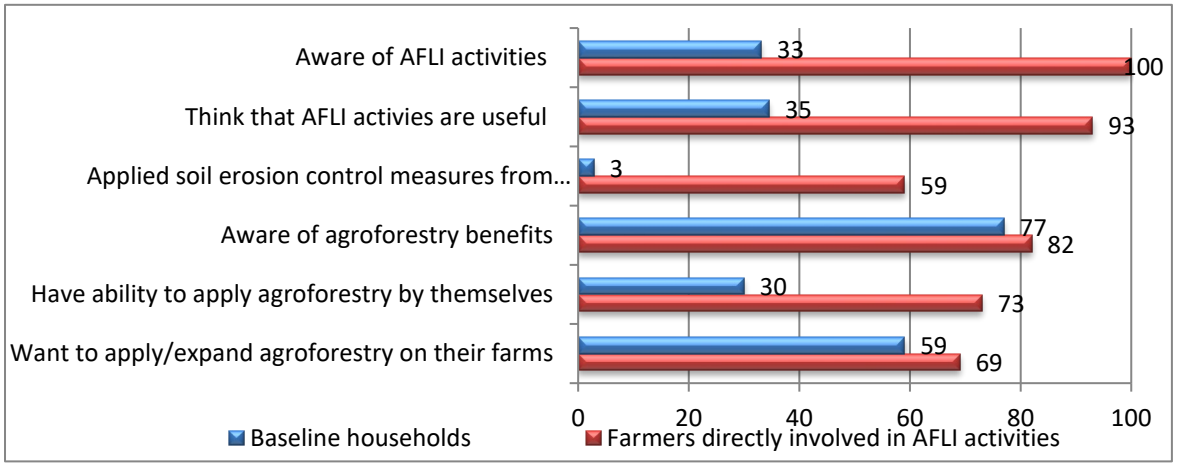

Figure 5: Changes in awareness, knowledge & skills of baseline households in comparison to farmers directly involved in AFLI activities

Another comparison was made between Group 2, wherein farmers were directly involved in various AFLI activities and Group 3, where farmers only participated in AFLI trainings (n=60) (Fig 6). There is significant difference in awareness of agroforestry benefits between the two groups with 31% in Group 3 and 82% in Group 2. However, 55% of Group 3 farmers can also apply agroforestry by themselves, indicating a success in the trainings conducted. The knowledge and techniques from AFLI trainings were applied and transferred at a similar rate by farmers in both groups. Based on the survey, the AFLI project is known to 33% of the baseline households, and 35% of them think that AFLi project activities are useful.

[1] *Some farmers, extension workers etc. participated in more than 2 different trainings.*

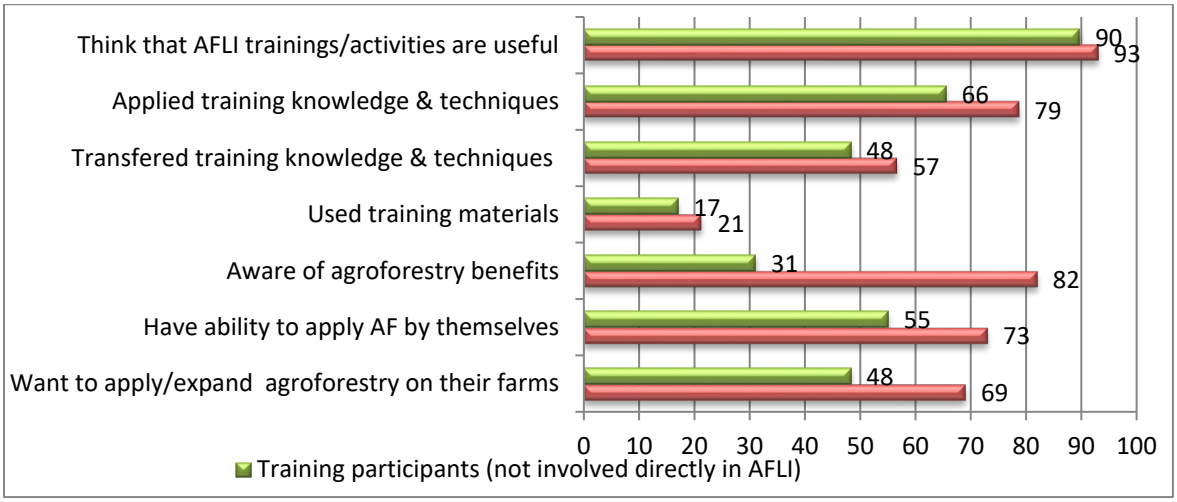

Figure 6: Changes in skills & techniques of training participants in comparison to farmers who were directly involved in AFLI activities, and farmers who were not directly involved in AFLI trials, FDT or exemplar landscape.

The project has trained a significant number of stakeholders, which provide a critical mass to widely promote agroforestry practices across the region.

In terms of agroforestry adoption, a key limitation in our impact analysis was the lack of historical data or information on the rate and extent of agroforestry production in the project site prior to AFLi. Hence, it was difficult to compare AFLI's performance in terms of agroforestry adoption with previous projects and/or extension approaches employed in the northwest. However, as revealed in our M&E survey, a number of farmers was observed to have spontaneously adopted some components and practices in our agroforestry trials, and if based on our M&E survey, the 73% trained farmers who have acquired agroforestry skills are provided with adequate technical support from extension workers and financial/policy support from provincial and district governments, these farmers could potentially lead the way to wider adoption of agroforestry in the region. At a cursory level of aggregation, it can be posited that the northwest region gained approximately 400 new farmer-adopters of agroforestry (including research co-operators, FDT and EL farmers, and spontaneous adopters) as a direct influence of the project. The main message running through our simple analyses is that, agroforestry skills can be adopted more quickly with the right support from extension workers and the local government.

Furthermore, our research and DARD partners reported a significant increase in their capacity to design and implement agroforestry—they all found the in-house trainings helpful, and further demanded relevant trainings in the 2nd phase of the project. In terms of formal short-term trainings, the project hosted and trained 7 international BSc student-interns and 6 MSc students. Details of M&E results are described in AFLi Technical Report No. 24.

8.3 Community impacts

8.3.1 Economic impacts

The seven recommended agroforestry systems trialled for 3-4 years indicated higher productivity compared to maize monoculture over a longer period. The decline in income, usually in the first two years is attributed to the establishment cost and crop area loss[2]. For example, in the longan-maize-forage intercropping, forage grass was the main income

[2] *The area planted to trees instead of annual crops.*

source[3] in the first year, while income from maize started to pick up in the second year, and longan trees start to bear fruits on the third year. As our data have shown, the total incomes gained from seven different agroforestry systems on the 3rd year range from 16 to 38million VND per ha/year compared to the average 12.5million VND/ha in maize monoculture. In sum, income from agroforestry could triple that of maize monoculture on the 3rd year. In addition, the reduction in soil loss from agroforestry systems was equivalent to 250USD/ha of NPK on the 3rd year. Considering this value as the cost of fertilizer saved by farmers is tantamount to higher net economic benefits. However, although the returns to investment can be observed incrementally from the first year, the break-even point for most of the trialled systems appears to be on the 4th year; farmers thus, need support from the government, e.g., seedling subsidy, to better adapt to an agroforestry transformation. The potential areas suitable for agroforestry expansion in sloping croplands are 360,000ha in Son La, Yen Bai and Dien Bien provinces, and based on data from the 3-4 year trial, the potential economic value of agroforestry in this vast area, could reach approximately 10^{-4x} VND (quadrillion) after four years[4].

The FDT nurseries have produced nearly 30,000 seedlings of 15 tree species, which farmers planted on their farms. With this volume of seedlings, the equivalent income from the nurseries was about 430 million VND in total at 15,000 VND per seedling.

Through trainings in Son tra fruit selection, fruit harvesting, and management and grafting, and marketing, farmers have greatly improved their skills, which would create opportunities to change their income in the future. First, 52% of Son tra group members now know how to harvest the fruits better. Second, 56% of Son tra group members know how to prune the trees, and 44% know how to classify son tra fruits based on size and quality. Furthermore, farmers' income from Son tra, particularly in Bac Yen Son La is expected to increase once a tripartite marketing agreement between farmers, Bac Yen district government and TAFOOD company is in place. The three key stakeholders (Bac yen, TAFOOD and farmers) are already working in this direction.

8.3.2 Social impacts

The project facilitated social capital building amongst farmers, between farmers and extension workers and researchers, and between project staff and the provincial government through the co-investment scheme adapted to support the establishment of agroforestry ELs. Social capital is an important capital used by people to achieve their goals. It is manifested by reciprocity, trust, collaboration, and interdependency between and amongst the three main actors.

The project also facilitated partnership-building and enhanced social capital with the private sector, which created economic opportunities for local people as TAFOOD Company collaborates with the District government of Bac Yen and the AFLi project, to secure sustainable supply of quality son tra fruits, and ensure sustainable business into the future.

Within FDTs and ELs, farmer interactions and relations have also shown signs of progress, even in their incipient stage. The FDT nursery activities for example, offered social benefits to farmers in different ways. First, farmers learn from each other, exchange knowledge, and solve problems together when working in a group, something they've never done before. Farmers also worked voluntarily and collaboratively amongst them. Group leaders also had the opportunity display and enhance their leadership and management skills given higher responsibility to take care of the nurseries and their group

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[3] Farmers use the grasses to feed their animals than sell. However, the economic value of fodder grass is 1,500,000 VND/kg.

[4] We used 27,000,000 VND, as the average of annual incomes gained from 7 AF systems, to calculate the potential economic value if the 360,000ha sloping cropland are converted to agroforestry.

activities. Further in the Son tra production group, farmers have increased their network besides learning new skills such as problem solving, pest management, tree pruning and grafting. The project has thus, facilitated social bonding and bridging, which are essential elements of success, as the groups are weaned from project support.

The co-investment scheme that was adopted to support the establishment of the ELs indicates the presence of social capital, manifested by reciprocity, trust, collaboration, and interdependency between and amongst the three main actors---- the local government, the project team, and farmers.

According to research partners (FSCN, NOMAFSI and TBU), there are a number of social benefits gained from being involvement in the AFLI project, some of which are highlighted below:

- After working with AFLI trials on grafted Son tra, a proposal on scaling up grafted Son tra in the Northwest and continuing research on grafting techniques was developed, and approved by MARD. Other ideas under development are agroforestry systems with indigenous species, timber trees, and FDT nursery establishment.
- Working with AFLI helped create opportunities to work with international organizations and donors such as ICRAF, CIFOR, ACIAR and national institutions such as SFRI, Forestry University, Hanoi Agriculture University.
- Group discussion efficiency has been improved by working together on annual plans, trial management, and problems with trial management. Frequency of discussion and contact with other research partners via emails has been improved since the beginning of the project.
- There has been significant change from general management to individual task allocation. The staff also learns from other partners on how to prepare financial report and how to manage agroforestry trials. We also observed change in working attitude with ethnic people from top-down to participatory method.
- When problems of trial management or soil erosion data collection arose, the team received technical support from ICRAF and other research partners, resulting in enhanced capacity and confidence in problem solving. Some problems related to cattle damage were addressed with support from village leaders.
- Decision-making has become more efficient due to clearer task allocation and responsibilities of team members.

On the policy side, the project has successfully influenced some local and national policy decisions, which can be expected to facilitate wide-scale agroforestry adoption:

1. Yen Bai provincial Resolution15/2015/NQ-HDND—Financial support at 6 million VND/ha for individual household or group of households, to establish Son tra-based agroforestry system in Tram Tau and Mu Cang Chai districts
2. Yen Bai provincial Decision 27/2015/QD-UBND—One time financial support at 1 million VND/ha for individual household applying sustainable maize cultivation in sloping lands by planting grasses along contour lines to reduce erosion
3. Yen Bai provincial Decision 2412/QD-UBND—Support for “Son tra development in Tram Tau and Mu Cang Chai districts for the period, 2016-2020”. This involves Increasing the total area of Son tra plantation to 10,000ha, improving the existing 3,820ha Son tra plantation, and Son tra planting in 6,200ha of degraded forestland.
4. MARD Decision 2477/QD-BNN-HTQT, which created the national Agroforestry Working Group (TWG) to:
    - Advise MARD on agroforestry development in Vietnam
    - Review, improve, and propose agroforestry-related policies

- Cooperate with local provinces, national and international organizations to research and developing agroforestry model for Adaptation and Mitigation of Climate Change
- Capacity building for national and local staff, mobilizing funding for sustainable agroforestry development

5. MARD's inclusion of agroforestry in the National Action Plan Framework for Adaptation and Mitigation of Climate Change of the Agriculture and Rural Development Sector (2008-2020).

With the government's numerous strategies towards rural development, green growth, and climate change adaptation and mitigation, the enactment of above policies can stimulate wide-scale adoption of agroforestry in the region and beyond.

8.3.3 Environmental impacts

The agroforestry trials have shown significant reduction in soil erosion compared to maize monoculture practices (see AFLI fact sheet and Technical Report No. 19). If adopted widely in sloping lands, valuable soil and water resources can be saved, soil fertility maintained, and downstream sedimentation can be significantly reduced. Compared to maize monoculture system, for example, the longan-maize-forage grass system on the 3rd year, suggest a reduction in soil loss by up to 56%; 23% in teak-plum-coffee-soybeans-forage grass; up to 90% in acacia-longan-coffee-forage grass system; and up to 74% in acacia-mango-maize-forage grass system. Once the trees reached maturity stage and the grass strips have become stable, erosion can be expected to be 90% less to zero.

The more than 70,000 trees of 16 different fruit and timber species planted by farmers in ELs and FDTs contribute to increased tree cover in the landscape with carbon sequestration and agri-biodiversity benefits. Moreover, the potential area for agroforestry in cultivated sloping croplands in the 3 provinces is 360,000ha, suggesting significant environmental benefits in agri-biodiversity, soil and water conservation and carbon sequestration, if these areas are converted to agroforestry in the future.

8.4 Communication and dissemination activities

Communication and dissemination through various means (TV shows, videos, fact sheets, conference presentations, photo exhibits, blog stories, policy dialogues trainings, etc.) have undoubtedly increased the project's visibility. The project produced 7 videos, of which, two were nationally broadcasted, garnering nearly 1,000 on-line views after airing. It also produced 17 blog stories, 8 international and Vietnamese journal articles, 4 working papers, 20 technical reports, 14 extension materials, 1 fact sheet, 1 policy brief, and 2 information brochures. At least, 13 of our extension and promotional materials collectively garnered nearly 800 on-line views over a short period. The project team was also invited for oral presentations in major conferences such as: (1) Conservation Agriculture in Southeast Asia; (2) World Agroforestry Congress; (3) Asia-pacific Farmer's Association; (4) Southeast Asian Network for Agroforestry Education; (5) and ALiSEA (6). The major field visits organized for other projects are a direct result of the project's growing popularity, such as those of the SUFORD-SU PROJECT in Laos PDR, the IFAD-Ha Tinh project on Sustainable Rural Development, and the USAID-funded Green Annamites project.

9 Conclusions and recommendations

9.1 Conclusions and recommendations

Agroforestry has been reportedly adopted in the past, but recent improvements in rural infrastructure and new market openings for agricultural products have shifted traditional agroforestry practices toward monoculture practices, particularly for maize. The surge in commercial maize production for domestic and foreign markets in neighbouring China triggered conversion of shifting cultivation and fragile sloping lands, with negative consequences to the environment. Income from maize production attracted farmers; nevertheless, the northwest region remains one of the poorest in the country. The AFLi project was implemented out of a demand to reverse this situation.

The project presented a range of agroforestry options to maize monoculture, identified suitable agroforestry-tree species and mapped their potential geographic coverage, as well as created a domestication strategy for Son tra. After 3-4 years of on-farm trials, 7 out of 10 trialled agroforestry systems can be promoted as best-bet agroforestry options for smallholder farmers. Son tra-forage grass system is superior compared to monoculture Son tra plantation in areas above 800masl, while Longan-maize-forage grass system is best in 600masl and below. Forage grasses, legumes, maize and other annual crops are a good source of short-term income, helping farmers maintain their cash flow, while awaiting incomes from coffee and grafted Son tra trees on the third year. Income from other fruit trees such as plum and mango adds up on the 4th year, and finally, macadamia, acacia mangium and teak trees on the 5th to the 12th year.

Our two-pronged approach to agroforestry dissemination, exemplified in the FDT and EL has proven effective in obtaining buy-in from farmers and local governments. Local officials were more interested in the exemplar landscapes due to its bigger scope and potential to impact a large number of people, while farmers are more interested in certain species, practices or agroforestry components that meet their needs and suit their own conditions. Partnership with the private sector also paved the way for the future stability of markets for Son tra fruits, bringing in economic and social benefits, especially to the H'mong people.

Our participatory approach to agroforestry research and development has been quite novel, as government and non-government projects are often implemented in a dole-out mode. From setting up field experiments, to the establishment of farmer demonstration trials and exemplar landscapes, the project team harnessed volunteerism, co-operation and co-investment amongst its partners, albeit it was not without challenges—the project faced initial reluctance and operational difficulties, necessitating apt and timely recourse measures. The project contributed to the theory of change of agroforestry development in the region by helping provincial governments, researchers and farmers build local aspirations, and building local capacity to innovate and implement new agricultural systems. We learned that scaling up agroforestry requires dual efforts of demonstrating evidence while simultaneously engaging local actors such as government officials, n deriving joint ventures for scaling-up. Further, we learned that adaptive research management is key to success, defined by flexibility, adaptiveness and capacity to detect and address emerging challenges.

Our impact assessment is neither complete nor comprehensive, but the capacity of project participants and stakeholders, has significantly increased as a direct result of the AFLi project. Despite the short project duration of AFLi, our agroforestry trials indicated longer-term benefits to smallholder farmers and the environment, albeit the initial direct cost and delay in returns to investment can hinder farmer adoption. Governments and outside support are thus, needed to fill-in this gap, and encourage farmers to explore a range of agroforestry options trialled under AFLi. To scale up wider adoption, agroforestry needs to

be aligned with local government programs of poverty reduction, environmental protection and rural development.

Finally, the project recommends that future agroforestry programs in the northwest consider the following:

1. Further exploration of policy incentives for farmers to invest on agroforestry. This is already initiated in Yen Bai province through Decisions supporting sustainable sloping land cultivation and Son tra production, but much more needs to be done, especially in Dien Bien and Son La provinces where commercial maize monoculture is predominantly practiced;
2. Develop and scale up locally appropriate, market-based agroforestry options that enable farmers to diversify their farming systems and achieve higher incomes than they can from maize;
3. Provide in-kind and/or financial support through loans or small subsidies to stimulate agroforestry adoption;
4. Continuously support the FDT and Exemplar landscape models to achieve long-term impacts—such support is important to ensure continued and increased adoption of agroforestry;
5. Support intensive trainings and post-graduate education for partners and researchers to improve current capacity;
6. Target regular trainings for ethnic minority groups in both Vietnamese and local languages;
7. Improve extension materials in big sizes with more photographs or graphics and less textual, to make them more useful to less-educated ethnic minority people; and finally
8. Address gender-specific needs and constraints to agroforestry adoption.

10 References

10.1 References cited in report

Catacutan, D.C., Farhat, N. (2015). Gender roles, decision-making and challenges to agroforestry adoption in Northwest Vietnam. *International Forestry Review Vol.**17** (S4)*

10.2 List of publications produced by project

In summary, the project has produced a total of 8 international and Vietnamese journal articles, 4 working papers, 20 technical reports, 1 fact sheet, 1 policy brief, 14 extension materials and 17 blog stories and 7 videos.

Publication/Communication type	**Title**
International journal articles (4)	1. Catacutan, D.C., Farhat, N., (2015). *Gender roles, decision-making and challenges to agroforestry adoption in Northwest Vietnam*. International Forestry Review Vol.17 (S4) 2. Elisabeth S. Simelton, Delia C. Catacutan, Thu C. Dao, Bac V. Dam, Thinh D. Le. (2016). *Factors constraining and enabling agroforestry adoption in Viet Nam: a multi-level policy analysis*. Agroforest Syst. DOI 10.1007/s10457-016-9906-2 3. Hoang Thi Lua, James M. Roshetko, Delia Catacutan, Le Duc Thinh (2016). *A Review of Policy Constraints and Opportunities for Sustainable Delivery of Quality Fruit Tree Germplasm in Vietnam* (2016). International Journal of Agriculture Innovations and Research, Volume 4, Issue 3, ISSN (Online) 2319-1473. 4. Nguyen Duc Kien and Chris Harwood (2016). *Timber Demand and Supply in Northwest Vietnam: the Roles of Natural Forests and Planted Trees.* Journal Small Scale Forestry (*in press*)
Vietnamese Journal articles (4)	1. Nguyen Thi Hoa, Delia Catacutan (2013). *History of agroforestry research and development in Vietnam: Analysis of research opportunities and gaps (in Vietnamese)*. Tạp chí Nông nghiệp và Phát triển nông thôn. Kỳ 1+2, 2/2013. 2. Nguyễn Đức Kiên, Chris Harwood, Hoàng Thị Lụa, Delia Catacutan, Mai Trung Kiên (2013). *Adaptability and nut yield of Macadamia clones in North West Vietnam (in Vietnamese)*. Tạp chí KHLN 3/2013 (2988 - 2999) 3. Hoàng Thị Lụa, Delia Catacutan, Ann Degrande, Viên Kim Cương, Chris Harwood (2014). *Market study and development potential of Walnut in Northwest Vietnam. (in Vietnamese)*. Tạp chí KHLN 2/2014 (3355 - 3370) 4. Vũ Văn Thuận, Đoàn Đức Lân, Nguyễn Thị Hòa, Dumas-Johansen, Marc Kristof, Hoàng Minh Hà, Roshetko James M (2014). *Challenges and opportunities for the system of small-scale nurseries in Sơn La province and Vietnam's Northern mountain region (in Vietnamese)*. Tạp chí KHLN 1/2014 (3163 - 3172)

Working papers (4)	1. Tiep Ha Van, Tuan Vu Van, Sammy Carsan, Chris Harwood, Bac Viet Dam, Nguyen La, Delia C. Catacutan and Ramni Jamnadass. *Selection of son tra clones in North West Vietnam* 2. Vu Van Thuan, Chris Harwood, Vu Duc Toan, Doan Duc Lan, Nguyen La, Sammy Carsan . *Growth and fruit yield of seedlings, cuttings and grafts from selected son tra trees in Northwest Vietnam* 3. Hoang Thi Lua, Elisabeth Simelton, Ha Van Tiep, Vu Duc Toan, Nguyen Thi Hoa, Nguyen Van Chung, Phung Quoc Tuan Anh. *Diagnosis of farming systems in the Agroforestry for Livelihoods of Smallholder farmers in Northwestern Viet Nam project* 4. Nguyen Thi Hoa, Delia Catacutan. *History of agroforestry research and development in Viet Nam. Analysis of research opportunities and gaps*
Technical reports (20)	No. 3: Baseline study report. Project “Agro-forestry for livelihoods of smallholder farmers in Northwest of Vietnam (AFLI)” No. 5: Adaptability and nut yield ò macadamia in Northwest Vietnam and recommendation ò suitable clones for commercial planting No. 7: Selection of fast growing tree species for planting in Northwest Vietnam No. 8: Walnuts market study No. 9: Son tra (Docynia indica) value chain and market analysis No. 10: Institutional development and effectiveness of Son tra collective producer and marketing groups No. 11: Institutional development and effectiveness of Son tra collective producer and marketing groups (following up) No. 12: Study on nutrient composition of Son tra fruits (Docynia indica (Wall.) No. 13: Study on nutrient composition of and processed products developed from Son tra (Docynia indica (Wall.). Second part. In-depth study of bioactive substances in Son tra fruit and its processed product development No. 14: Ex-ante cost benefit analysis of Son tra and fodder grass trial plots No. 15: Ex-ante cost benefit analysis of Son tra and fodder grass trial plots No. 16: Ex-ante cost benefit analysis of Shan tea and fodder grass trial plots No. 17: Ex-ante cost benefit analysis of Macadamia with coffee, and soybean trial plots No. 18: Ex-ante cost benefit analysis of Longan and maize trial plots No. 19: Results from Farmer Participatory Trials No. 20: Mapping of sloping cropland and potential domains for agroforestry development in the Northwest, Vietnam No. 21: Assessment of Son Tra’s Top-working methods: traditional graft, cleft graft and side graft No 22: Tree Seedlings Supply and Demand in Son La Province: Limitations and Recommendations No 23: Son tra marketing strategy No 24: Project monitoring and evaluation report
AFLI Fact Sheet (1)	AFLI Project Fact Sheet
Policy brief (1)	Agroforestry-A policy imperative for Viet Nam

Extension materials (14)	1. Booklet: Nursery establishment 2. Booklet: Son tra grafting technique (in Vietnamese) 3. Booklet: Son tra grafting technique (bilingual H'Mong and Vietnamese languages) 4. Poster: Son tra grafting technique (in Vietnamese) 5. Poster: Son tra grafting technique (bilingual H'Mong and Vietnamese languages) 6. Poster: Macadamia grafting technique (in Vietnamese) 7. Coffee propagation technique (in Vietnamese) 8. Lemon marcotting technique (in Vietnamese) 9. Plum marcotting technique (in Vietnamese) 10. Longan propagation and grafting technique (in Vietnamese) 11. Mango propagation and grafting technique (in Vietnamese) 12. Manglietia propagation technique (in Vietnamese) 13. Canarium propagation technique (in Vietnamese) 14. Agroforestry Guide for Sloping Lands in Northwest Vietnam(in English and Vietnamese)
Blogs and videos (24)	1. AFLI Project Website (hosted by ICRAF website). Link: http://old.icraf.org/regions/southeast_asia/vietnam/projects/afli/labs 2. "Seeds of growth" begin to germinate on Vietnam uplands. Link: http://www.worldagroforestry.org/news/%E2%80%9Cseeds-growth%E2%80%9D-begin-germinate-vietnam-uplands 3. Creating complex agroforestry systems in Northwest Viet Nam. Link: http://blog.worldagroforestry.org/index.php/2013/03/26/creating-complex-agroforestry-systems-in-northwest-viet-nam/ 4. Which agroforestry will improve an H'mong farmer's life?. Link: http://blog.worldagroforestry.org/index.php/2013/03/14/1738/ 5. Scientists, donors talk farmers improvement AFLI project. Link: http://www.worldagroforestry.org/news/scientists-donors-talk-farmers-improvement-afli-project 6. NW Vietnam: new fruit species brings ripe opportunity for poverty reduction. Link: http://www.worldagroforestry.org/news/nw-vietnam-new-fruit-species-brings-ripe-opportunity-poverty-reduction 7. High potential for agroforestry in Northwestern Vietnam. Link: http://www.worldagroforestry.org/news/high-potential-agroforestry-northwestern-viet-nam 8. A national agroforestry policy is an imperative for Viet Nam. Link: http://blog.worldagroforestry.org/index.php/2015/04/16/a-national-agroforestry-policy-is-an-imperative-for-viet-nam/ 9. Participatory, on-farm research in Viet Nam is a challenge!. Link: http://blog.worldagroforestry.org/index.php/2015/05/08/participatory-on-farm-research-in-viet-nam-is-a-challenge/ 10. What happens when famers are involved in research. Link: http://blog.worldagroforestry.org/index.php/2015/04/04/what-happens-when-farmers-are-involved-in-research/ 11. Farmers in Viet Nam committed to developing agroforestry systems. Link: http://blog.worldagroforestry.org/index.php/2015/04/15/farmers-in-viet-nam-committed-to-developing-agroforestry-systems/ 12. Agroforestry set to replace monocrops in Northwest Viet Nam. Link: http://www.worldagroforestry.org/news/agroforests-set-replace-monocrops-northwest-viet-nam 13. Son tra, the H'mong Apple. Link: http://blog.worldagroforestry.org/index.php/2015/07/01/son-tra-the-hmong-apple/ 14. Australian support for agroforestry development in Viet Nam. Link: http://blog.worldagroforestry.org/index.php/2015/04/17/australian-support-for-agroforestry-development-in-viet-nam/ 15. Researchers from Viet Nam and Lao PDR learn how to use the Agroecological Knowledge Toolkit. Link:

	http://blog.worldagroforestry.org/index.php/2015/07/03/researchers-from-viet-nam-and-lao-pdr-learn-how-to-use-the-agroecological-knowledge-toolkit/ 16. Technology transfer in Son Tra processing in Viet Nam. Link: http://baocongthuong.com.vn/chuyen-giao-cong-nghe-che-bien-qua-son-tra.html 17. Agroforests expanding across landscapes in Northwest Viet Nam. Link: http://blog.worldagroforestry.org/index.php/2016/05/11/agroforests-expanding-across-landscapes-in-northwest-viet-nam/ 18. AFLI project 5 years journey. Link: https://www.youtube.com/watch?v=h_nVj-7ljog&feature=share 19. Agroforestry for better livelihoods of upland farmers in Northwest Vietnam. Link: https://www.youtube.com/watch?v=kbVux3XjBV4&feature=player_embedded 20. Developing 'son tra' cultivation in the Northwestern region of Vietnam. Link: https://www.youtube.com/watch?v=usRw7ih2R5g&feature=youtu.be 21. Agroforestry for Livelihoods of Smallholder Farmers in Northwest Vietnam. Link: https://www.youtube.com/watch?v=oQ23MY62gUM 22. Developing livelihoods for Northwest farmers in Viet Nam (VTC10). Link: https://www.youtube.com/watch?v=sQ3gSdayl_k 23. Developing Son Tra cultivation in the Northwestern region of Vietnam (VTC10) on Sharing Vietnam. Link: https://www.youtube.com/watch?v=usRw7ih2R5g 24. Introduction to the agroforestry systems of AFLI on VTV2 (National Television). Link: https://www.youtube.com/watch?v=87fw-J4df9c&list=PLostPb_3Bdzk8IF2s5bPK00v0edjTPVBR&index=6

11 Appendixes

11.1 Appendix 1:

Original copies of all publications, technical reports, extension materials and videos. Link: https://www.dropbox.com/sh/9m82nhbel8k31a3/AAAPHVHRYRXrn66CUUtyRll8a?dl=0