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2 Executive summary

The “Developing and promoting market-based agroforestry and forest rehabilitation options for northwest Vietnam” is four-and-half-year project (2017-2021). The World Agroforestry Centre (ICRAF) was the commissioned agent in charge of overall project implementation. The project was implemented with eight main partners namely: Vietnamese Academy of Forest Sciences (VAFS), the Soils and Fertilizers Research Institute (SFRI), the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI), Southern Cross University (SCU), Tay Bac University (TBU) at Son La, and the Department of Agriculture and Rural Development (DARD) of Son La, Dien Bien, and Yen Bai provinces.

The project’s aim was to develop and promote market-based agroforestry options to improve livelihoods and enhance forest and landscape management in northwest Viet Nam. The project introduced agroforestry in the mono-cropped landscapes through agroforestry and developed forest rehabilitation methods in degraded forests, as well as the links to market to increase and diversify incomes for local communities.

Seven agroforestry options established in the first phase of the project, and three new options were established in project design. These compared with crop/tree monocultures on steep eroding in northwest Vietnam. The research clearly showed that, while agroforestry options had significant start-up costs, they could outperform monocultures over the long term as measured by profitability and market potential. In addition, agroforestry options could control soil erosion and improve soil fertility. The FDT and EL approaches were developed and gradually approved with the aim of expanding agroforestry to landscapes, with a supported cooperative economy forming. Smallholder farmers were trained to better manage of agroforestry farms, be proactive in producing high-quality seedlings in order to reduce the cost of establishing agroforestry, in minimum or no use of weeding chemicals and no free grazing of cattle are most significant impacts. More than 400 FDTs and six ELs (50 ha each) were established, and more ELs continued to be set up by the local DARDs with clear monitoring and evaluation, and these provided good evidence for local authorities and the Vietnamese Government to consider in new development strategies and policies.

Son tra has been seen as a multipurpose tree suitable for the high-elevation areas in Northwest. The project has set up nearly 100 trials of Son tra collection in Dien Bien, Son La and Yen Bai province. This plays a very important role in the selection of the most appropriate varieties for specific geographical, social and climatic conditions of local areas and also toward market-oriented production. Future research and local districts and DARDs can utilize outputs of these trials for making better production strategies towards more market-based production by farmers. Moreover, project was contributed on added value for Son tra through supported on developed functional food from extracted Son tra. It created a new opportunity to consume this product.

Ten designed agroforestry options and two climate-change scenarios were used to produce suitable maps for three provinces. Here, climate (including projected climate change), soils, market linkages and the cultural and ethnic characteristics of farmers were all taken into consideration, to evaluate potential agroforestry options and how these can be up scaled to a wider variety of landscapes. However, the northwest is very diverse in terms of geography, culture and connectedness to market. Mapping to show the spatial distribution of existing agroforestry and potential expansion areas are therefore, more applicable to the commune level.

The project started by working with small farmers, now three cooperatives have been formed to trade with six companies, supermarkets, and retail stores. However, linking farmers to market actors (middlemen, traders and small companies) to sell agroforestry products is still limited because of low productivity in the initial years of the project. Farmers have had challenges in getting production tracing certificates for high-end or niche markets such as Production Unit code, VietGAP as required by market. The continuous support to

farmers by making safe products or organic-oriented agroforestry systems should now happen. On the other hand, while the agroforestry model is a good option for sloping land, more attention should be paid to access to markets. Building market capacity for farmers and establishing farmers' organizations, developing agroforestry products brandings and product traceability is also crucial for connecting farmers to markets.

The participatory process was applied for the selection and assessment of degraded natural forests. Na Bai and Leo (Son La) and Na Noi (Dien Bien) villagers recognized that the forests around them were degraded (soil loss, biodiversity loss, fertility loss). However, the degraded forests still provide them with resources (firewood and NTFP's). The following forest restoration methods have been implemented: (i) scattered trees planting; (ii) enrichment planting; (iii) NTFPs planting; and (iv) assisted natural regeneration. In total, 20,000 seedlings planted involved more than 100 households on scattered tree planting activities; Enrichment planting was carried out in 16 ha; Planting NTFPs were involved 27 households in four ha; and assisted natural regeneration carried out in 60 ha. Adaptive measures for forest rehabilitation options by specific locations have been made. The plan of community forest management includes identification the forest target area for management; plan for tending, protection and monitoring; and evaluations of the forest rehabilitation models were carried out. Community engagement was shown to be important for forest protection, and women played an important role. Women in Na Bai, Na Noi and Leo villages make a great contribution to forest restoration activities. In general, there is no gender discrimination in the above villages, the jobs are equally divided among both men and women. The woman typically participated with a high sense of responsibility, and in a hard-working, and industrious manner, which has resulted in the forest rehabilitation models developing well. On the other hand, with the participation of women in forest protection groups, it also contributes to encourage, motivating and propagating for women's associations in the village to raise their responsibility for protecting forest resources.

Driver of land-use change, with the objective of achieving cross-sector planning approaches, were reviewed to understand and cataloguing the different aspects of land uses in several diverse regions. A monitoring framework for integrated tree-based landscape management with monitoring, reporting and verification system was proposed. It was acknowledged that the integration across the country is lacking and requires cooperation with policy makers and more than this, the need for policies to be translated to effective governance. More attention should be given to the market in the integrated tree-based landscape planning process. This should be well considered by geographical locations with different connectedness to market and varying scenarios. Understanding drivers of land-use change and developing cross-sector planning approaches for landscapes, integrating forests and agroforestry land uses needs to have active engagement of private actors (input suppliers, processors, traders) and policy makers. Well identified market scenarios and risk assumptions in cross-sector planning can help farmers better deal with market risks and decide better production and business strategies at small holder and community level.

The extensive effort was invested in providing training to farmers. More than 600 farmers directly involved in the project were benefited in various training sessions when practiced in the nursery with a period of about 18 months each. Farmers learned soil preparation techniques, seed preparation, grafting, design of agroforestry systems, planning and pruning techniques and nursery management. Nursery farmers are happy as they can now produce enough quality seedlings for their agroforestry systems and they can also start-up seedling businesses. Eight group nurseries have been established in Thuong Bang La, Tram Tau, Na Noi, Na Bai, Mon, Huoi Tan, Hoa Quynh and Tuan Giao, produced nearly 200,000 seedlings and distributed to FDT project's farmers. Four existing nursery gardens now became involved in seedling production and trading. The co-operator farmers and other people such as farmers from other provinces, DARD's staffs, district and commune staffs and various donor-funded projects in Vietnam and Laos PDR were benefited through training in the form of field days, workshops and with extension materials provided (fact sheets, print and audio-visual presentations).

During the period 2017-2021, seven students involved in the project have graduated. Include two PhD students, five MSc student. Currently, four PhD students and two Master students are working on on-going research. The capacity-building activities for lecturers and students of TBU through support from SCU established partnerships for R4D and delivered impacts on building capacity for both teachers and students.

The project published six international journal articles, four working papers, 24 technical reports, 14 extension materials in the form of book (1), fact sheet (7) and video (6), one policy brief, two info brief and six video and blog stories.

The project exchanged knowledge with other ACIAR projects (AGB/2012/059, SMCN/2014/049, AGB/2012/060, AGB/2014/035, and LPS/2015/037) and DFAT project and project contributed to a range of strategies and targets set out by the local provinces. On July 20, 2020, the Prime Minister of Vietnam issued Decision No. 1055 / QĐ-TTg on "National plan to adapt to climate changes during the period of 2021-2030, with a vision to 2050." In which defined "Support the application of agroforestry solutions for the development of fruit trees, in order to improve livelihoods and adapt to the climate change for the people in the Northwestern region of Vietnam." The project outputs, therefore, can strongly contribute to the achievement of Vietnamese Government target.

3 Background

Smallholders in northwest Viet Nam face considerable biophysical, socio-economic and technical development challenges. Rural poverty is a major problem, with a prevalence estimated in 2015 ranging from 32% to 48% of households across provinces against a national average of <10%. The region is home to the H'mong and Thai ethnic minorities, whilst the Kinh (Vietnamese) remains the majority group. The predominant agricultural system in this region is maize mono-cropping driven by lucrative markets for livestock feed. The steep terrain and fragile land in this region result in severe soil erosion, occurring in much of the area used for monoculture maize, which only allows farmers to crop once a year. Annual crop area in the region has increased through conversion of shifting cultivation areas and natural forests. In 2013, the total agricultural area was reported as over 573,000 ha, resulting in half of the remnant forest being in a degraded state. Improvements in infrastructure and markets have expanded livelihood opportunities, but annual crop area expansion is limited by terrain and weather. Crop production will therefore, likely remain on smaller farms, in less fertile and steep-sloping lands, and may expand further into the forest frontier. According to the Ministry of Agriculture and Rural Development (MARD—Decision 3135, 2014), although the total forest area of the northwest is 1.7M ha, of which 1.5M ha were natural forests, >800,000 ha were degraded. The forests of northwest Vietnam are also poorly known, as are the methods to restore them; in fact, the majority of restoration literature for Vietnam focuses on mangrove forests.

The project will address these issues by developing and scaling up locally appropriate, market-based agroforestry options that enable farmers to diversify their farming systems and achieve higher incomes than they can from maize, and demonstrating practical mechanisms that enable degraded remnant forests to be rehabilitated. It will also demonstrate landscape-level benefits from combining forest rehabilitation and agroforestry interventions through an integrated landscape management approach that has the potential to improve and secure the livelihoods of 400,000 farm and forest households, and rehabilitate >455,000 ha of degraded natural forest, while curbing land degradation and deforestation.

Studies on agroforestry and forests from across the world, have shown that trees on farms and forests have the potential to provide a suite of services, not only in watershed regulation, nutrient cycling and climate change mitigation, but also producing a range of agriculture, timber and non-timber forest products (NTFPs), which can contribute to improving the livelihoods of local people. The impetus for such work is great, considering the potential benefits to local people in terms of income, as well as the greater population of Vietnam through watershed regulation and climate change mitigation.

4 Objectives

The overall aim of the project was to develop and promote market-based agroforestry options to improve livelihoods and enhance forest and landscape management. The specific objectives and activities were to:

1. quantify and evaluate performance of generic agroforestry options and tree species to underpin investment in promoting agroforestry
2. understand suitability of different agroforestry options in relation to different contexts and develop markets and policy to scale up adoption
3. understand the ecological and economic values of degraded forests and co-develop appropriate forest rehabilitation methods with local communities to enhance them
4. understand drivers of land use change and develop cross-sector planning approaches for landscapes, integrating forests and agroforestry land uses
5. develop local capacity for agroforestry, forest rehabilitation and integrated landscape management.

The project builds upon outputs from FST/2010/034 (Agroforestry for Livelihoods of Smallholder Farmers in Northwest Vietnam - AFLi) in trialling and promoting a range of market-based agroforestry systems. The project addressed these issues by developing and scaling up locally appropriate, market-based agroforestry options that enable farmers to diversify their farming systems and achieve higher incomes than they can from maize, and demonstrating practical mechanisms that enable degraded remnant forests to be rehabilitated. It also demonstrates landscape-level benefits from combining forest rehabilitation and agroforestry interventions through an integrated landscape management. The project interacted with various ACIAR-funded project in the Northwest as AGB/2012/059, SMCN/2014/049, AGB/2012/060, AGB/2014/035, and LPS/2015/037, which then, created space for inter-project collaboration and sharing experiences, technologies and pathway for extension.

5 Methodology

The 4-and-half-years projects addressed six key research questions:

- What are the long-term economic and ecological benefits of agroforestry options, and what timber tree species can be used to diversify tree species grown at different elevations?
- What agroforestry and forest rehabilitation options are suitable across different contexts, how can their management be adapted to suit local conditions, and what market and policy conditions are required to ensure that adoption can be widely scaled up?
- What are the current ecological and economic values of degraded forest and what rehabilitation options are most suitable for enhancing these in different contexts?
- What economic and ecological benefits can be derived from combining agroforestry and forest rehabilitation approaches at the landscape level?
- What are the capacity development requirements needed to generate and sustain impacts from agroforestry and forest rehabilitation at farm and landscape scales?
- How can women, particularly marginalised ethnic groups with low literacy, be more effectively trained in agroforestry and forest rehabilitation, and how can women's participation in various project activities empower them and increase their benefits?

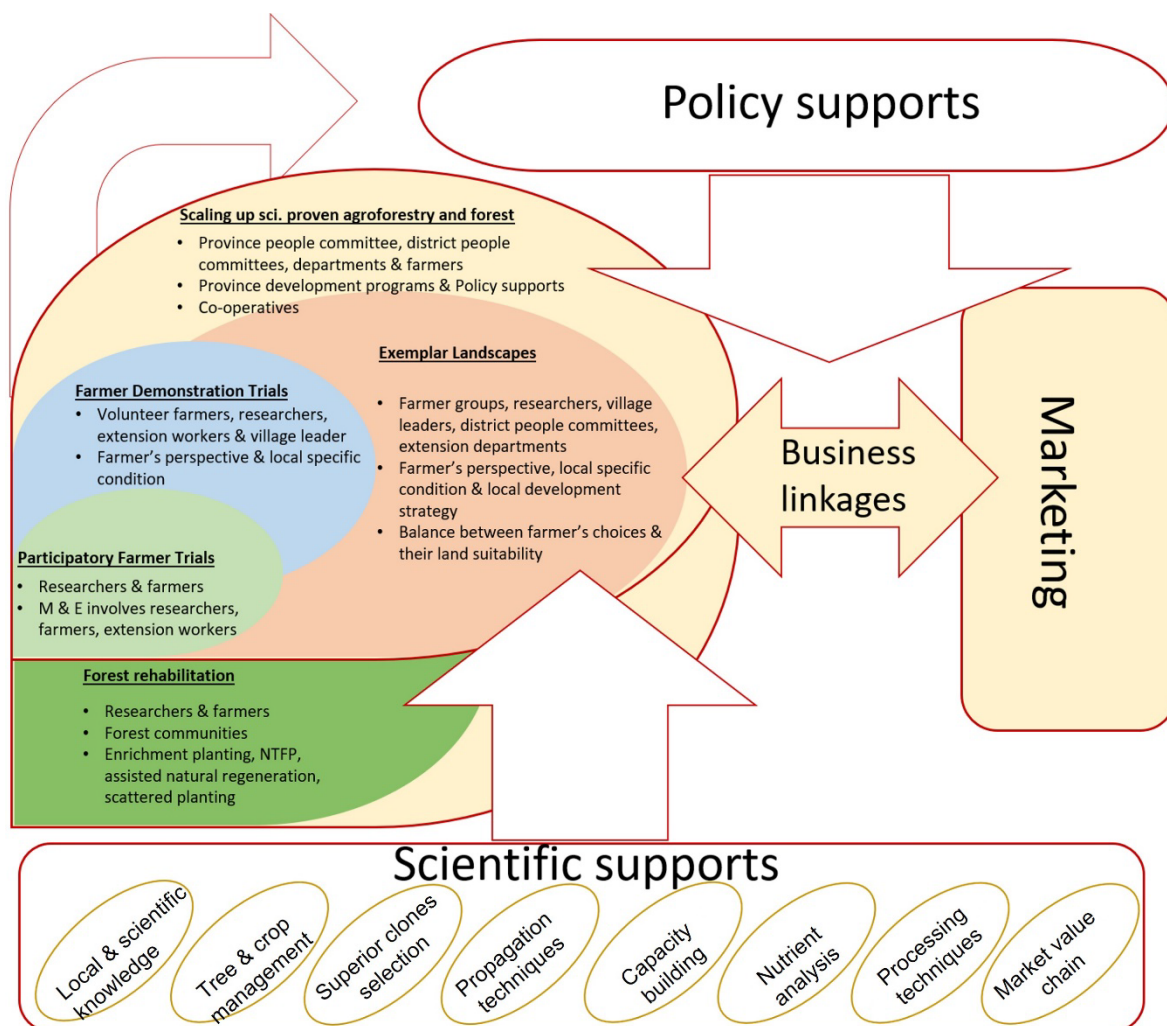


Figure 1: FST/2016/152 research framework

FST/2016/152 develop a range of market-based agroforestry and forest rehabilitation options. The scaling-out process is done by expanding to diversify farming systems in larger scale, which is supported by specialized research and connections to market access and

product development. It supported the scaling-up process through capacity building, which created a strong expert team capable of intervening to develop new agricultural policies. The development policies issued by local government will be beneficial to wider.

Objective 1: To quantify and evaluate performance of generic agroforestry options and tree species to underpin investment in promoting agroforestry

1.1. Seven agroforestry systems established in earlier phase of the project plus three new scientific agroforestry trials of multi-strata agroforestry systems established in this phase were monitored for ecological and economic performance. The results from this assessment were used to advise farmers on appropriate management techniques to optimize resource utilization in agroforestry systems and predicting benefits from these areas systems. In addition to the cost-benefit analysis, it will evaluate the farm business feasibility of tested agroforestry systems when deployed on a large-scale and their contribution to the household economy.

1.2. Project identified both native and exotic timber tree species and established elevation trials at two altitudes, 600 masl and > 1000 masl in Tuan Giao (Dien Bien). Indigenous and exotic tree species included in the trial were based on the species of interest to farmers and in consultation with DARD Dien Bien. This study enables further diversification of trees in adapted agroforestry systems, small woodlots, and forest rehabilitation areas. Data was collected and analyzed for tree growth performance and associated factors such as tolerance to pest and diseases, etc.

1.3. Grafted seedlings and top-working from 36 Son tra superior clones in Son La, Dien Bien and Yen Bai provinces were tested in experiments and in the farmer farms in Tuan Giao (Dien Bien), Bac Yen (Son La) and Tram Tau (Yen Bai). The survival rate, growth yield, pests, fruit yield and the ranking the appearance and quality of their fruits were monitored.

1.4. In the third year of the species-elevation trial, local male and female farmers were invited to select species of their choice for testing on their farms. Seedlings of selected native and exotic woody species that have been produced in the project group nurseries and distributed to test in farmer's farms and in scattered areas depending on the condition of the family and monitor survival and early growth performance under farm conditions.

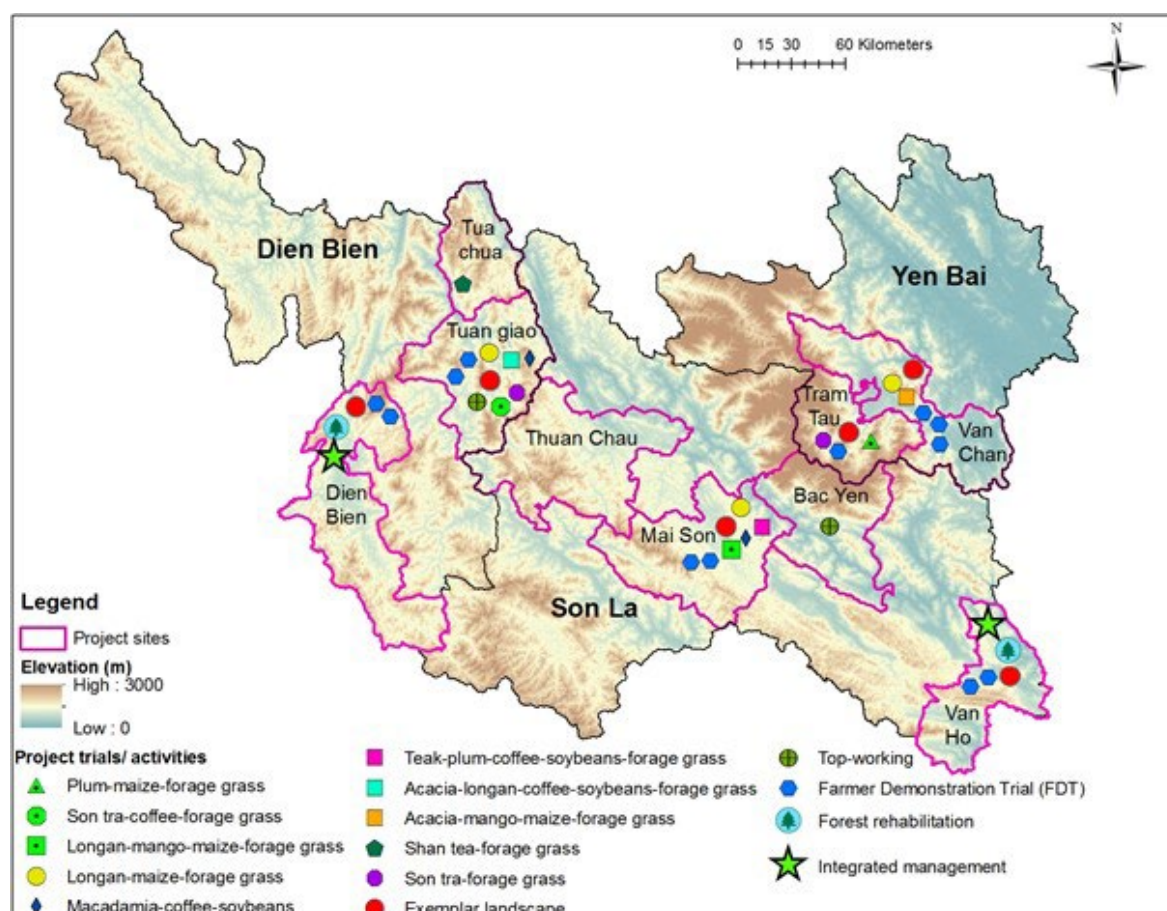


Figure 2: Distribution of agroforestry and forest rehabilitation trials in Northwest Vietnam

Objective 2: To understand suitability of different agroforestry options in relation to different contexts and develop markets and policy to scale up adoption

2.1. Spatial analysis was conducted using recent land use maps from DARD, Ministry of Environment and Natural Resources (MoNRE), statistical data and remote sensing. Two climate scenarios for the period 2046-2065 of MoNRE, RCP 4.5 and RCP 8.5, were used to forecast possible impacts on the expansion of agroforestry. Expected changes in precipitation and temperature under each scenario (lower and higher precipitation and higher temperatures) are used to assess the suitability of tree species in the face of climate change. Mapping the potential for future growth was done by keeping soil growth requirements and topographical factors unchanged, while changing precipitation and temperature parameters. Based on the growth requirement maps, determined the suitability of the overall climate and biophysical scenarios of the selected agroforestry systems. Relevant factors such as market, infrastructure, financial support and policy were discussed in focus group discussions. These results were combined with those from biophysiological suitability analyses determining the overall fitness of the identified tree species for all of these factors. The produced map shows the spatial distribution of areas with potential for agroforestry expansion, such as shifting cultivation and sloping lands, provide future geographic coverage information as well as identify typical landscapes of potential agroforestry development in the target provinces.

2.2. FDT (Farmer Demonstration Trial) and EL (Exemplar Landscape) approaches have been developed in the first phase of project and were improved in this phase. The basic principles that our FDT and EL approach follow, are volunteerism and co-investment. The basic objective is to promote cooperation, participation and sharing of resources. This is especially important because government and/or external resources are often scarce. As a result of this activity, a manual on establishing and facilitating were developed for extension staff of DARDs and R&D organizations to use. FDT explores how farmers adapt

agroforestry to their circumstances. Meanwhile, EL exploits through co-investment programs between the project, local authorities and farmers. The FDTs and ELs implemented in the project were used as learning points for other farmers in the surrounding areas, attracting local government officials and extension officers to scaling up the models through the local government development programs and other incentives outside the project.

2.3. In collaboration with farmers, farmer groups, current projects and development programs in the project provinces, we explored the partnerships to improve market-linkage capacity, learn and act to develop product marketing business models, selling agroforestry products, develop new products with private sectors. Focusing on improving the capacity of market value chain analysis and training farmers to develop the collective economy, produce goods according to market demand, and improve product quality.

2.4. Women's participation in relevant activities was strongly encouraged and supported across objectives to increase access to project benefits. The focus is on "women's empowerment", on "enhancing capacity and participation" in FDT, EL, marketing, forest restoration and landscape planning. Women get input on decision-making as well as apply it on their farms and direct benefits derived from these activities.

2.5. Collected spatial and statistical data will be added to ICRAF-Vietnam's interactive agroforestry online database (<http://scafs.worldagroforestry.org>). By integrating spatial and statistical data to a web interface, interested stakeholders will be able to easily access and query information in which they are interested online.

Objective 3: To understand the ecological and economic values of degraded forests and co-develop appropriate forest rehabilitation methods with local communities to enhance them

3.1. The project established two sites in two provinces for testing forest rehabilitation options, which selected with guidance from the provincial governments, to ensure that project efforts on this aspect align with provincial priorities. The sites selected in locations where there is an integrated approach to agroforestry development and forest rehabilitation one site in Dien Bien and one site in Son La, followed by a participatory inventory of the selected forest sites to assess its structure, biodiversity and environmental parameters, and available NTFPs. Subsequently, the socio-ecological conceptual framework for rehabilitating this degraded forest and identify species appropriate to these sites with potential for economic utilization are developed. Utilization and business potential of different NTFPs appropriate to these sites are assessed through interviews with forest communities and relevant market actors.

3.2. Facilitated by underlying poverty and a range of distal factors, forest degradation is usually induced by human activities; hence, forest rehabilitation efforts should be cognizant to the needs, priorities and limitations of forest dependent people. Interviews and focus group discussions were conducted to elicit information on forest-dependent people's constraints, as well as their stakes and aspirations in forest rehabilitation programs, including those under the Payments for Forest Ecosystem Services (PFES) programme of the government.

3.3. Interviews individual households, discussion with community groups and with local officials were conducted to understand the community's priorities for forest rehabilitation, species of interest, forest values for the community, their vision of forest-dependent in the future, and the incentives needed to encourage forest rehabilitation.

3.4. Forest rehabilitation interventions at two sites were planned with local ecological knowledge and needs, policy maker perspectives, and implemented based on scientific literature on forest restoration, biophysical parameters. The assisted natural regeneration, enrichment planting of multipurpose tree species, NTFP planting, and scattered plantation were carried out in two sites. Capacity development activities were carried out while co-

implementing forest rehabilitation options. Practical hands-on trainings were targeted for forest communities and forestry extension workers on various rehabilitation options mentioned above. Gender-specific training needs were addressed to ensure that women, in particular, are able to access training and other technical assistance at their convenience. And a community forest management plan was developed with defined the roles for forest managers, monitoring regime and guidelines for sustainable harvest of forest products.

3.5. The monitoring regime was established at each site to track the survival and growth of planted individuals, as well as environmental outcomes (i.e., changes in soil fertility and structure, and potentially changes to erosion and stream flow variation) and livelihood outcomes (i.e., measurements of harvest of NTFPs and associated income, and interviews to assess contribution of forest products to farmer incomes). Monitoring also be developed to enable evaluation of the economic and ecological benefits from combining agroforestry and forest rehabilitation activities at the landscape level.

3.6. Policy dialogues were organized at provincial and national levels to elicit feedback, especially on barriers and incentives for forest rehabilitation, and to jointly identify entry points for improving baseline conditions. Recommendations for appropriate incentives for enhancing forest rehabilitation programs for natural forests are expected to be identified through these dialogues.

Objective 4: To understand drivers of land use change and develop cross-sector planning approaches for landscapes, integrating forests and agroforestry land uses

In Vietnam, landscapes are distinctively zoned for forest conservation and agricultural development. Forests are preserved in less accessible or protected areas, while agriculture is allowed in the lowlands or near water sources and paved roads. This strategy has little success in Northwest Vietnam as forests are still continuously converted to maize, while agricultural intensification has created economic and environmental problems such as declining yields and increasing soil erosion.

Our assumption is that, promoting tree-based options in rural landscapes with policies that are adaptable to local conditions and more favourable to landscape management (than sectoral management) will be key to achieving both forest conservation and sustainable agriculture in Northwest Vietnam. We therefore aim to understand the roles and contributions of tree-based farming systems aka 'agroforestry' and forest rehabilitation at the landscape level, through integrated landscape management.

4.1. Two sites in two provinces which carried out both project activities on forest rehabilitation and market-based agroforestry interventions were selected (Na Bai and Na Noi) to demonstrate landscape scale impacts. Digital mapping of landscape boundaries and biophysical features was conducted.

4.2. Sectoral planning has been identified as a barrier to agroforestry, especially at the landscape level where agroforestry is not just simply a technical solution to land degradation but also entails political and economic considerations. The review existing sector plans and their planning processes at two selected sites were carried out, to identify challenges and opportunities for aligning forest rehabilitation and agroforestry in relevant sector plans. Document reviews, informant interviews and focus group discussions were employed to identify these opportunities.

4.3. To understand the pattern of tree cover change in the demonstration landscapes, and the implications for tree-based systems. The time-series land use maps were used to assess the historical changes of tree-based land uses and their drivers. And followed by stakeholder/actor analysis to understand their interests and preferences over tree-based land use options in the landscape. Also the surveys and focus group discussion were conducted to ascertain the socio-cultural and economic factors influencing removal and planting of trees in the landscape.

4.4. To integrate forest rehabilitation and market-based agroforestry options in the demonstration landscape, a series of consultation and planning workshops were conducted to develop different tree-based land use scenarios/options with the view of achieving optimal livelihoods and ecological benefits at landscape scale.

4.5. The works were conducted include combining the legal framework for land-use planning and green-growth development, institutional arrangements for land and forest management, understanding the limitations and challenges in planning for land use and green growth development. Based on that's, the institutional and monitoring framework for integrated landscape management was proposed.

4.6. One national workshop was organized with the following objectives: Share the results achieved under the project with lessons learned; Consult with participants on a policy framework to support integrated agroforestry development and forest rehabilitation in the context of Northwest landscape restoration; Consultation with participants on institutional framework, monitoring and evaluation in integrated landscape management based on trees and ecosystem services, and; Identify some further research and development directions based on the results achieved and discuss with participants at the workshop. The project was enlisting the first 'demonstration landscape' within the Global Landscape Academy initiated by CGIAR scientists and FAO, as one of its global learning landscapes. This could lead to the demonstration landscape being used for training purposes by the Global Landscape Academy. The project will continue to engage in national-level processes and mechanisms such as the Agroforestry Technical Working Group created by MARD and FAO, the Climate Change Action Plan, the Green Growth Strategy, and REDD+, to share our project outputs and influence major policy decisions in the agriculture, forestry and rural development sectors.

Objective 5: To develop local capacity for agroforestry, forest rehabilitation and integrated landscape management

Agroforestry, forest rehabilitation and landscape-level initiatives are knowledge-intensive, requiring intensive capacity development support. Capacity development activities will be implemented with different types of stakeholders as outlined below. A tentative schedule of training targets is presented in Section 4.3.2.

5.1. Farmers participating in the project are the primary target of capacity-building activities. They are the ones directly involved from the design, implementation and evaluation of the models. Extensive exchange and experience sharing were conducted through cross-site visits, farmer seminars and training courses in necessary skills. A range of training topics are identified and carried out with basic skills include nursery establishment, propagation techniques, pest management, crop management, model design and alternatives implementation of particular interest. Experienced farmers in the pilot trials became trainers to support the project staff develop the new FDTs and EIs and support training project's visitors.

5.2. Agricultural extension officers of the DARDs directly participate in the implementation of project's activities. They receive basic training like farmers participating in trials and continue training as the FDTs and EIs expand. Unlike farmers, they will be trained in the entire development process of the project from testing to FDTs and EIs. The target for this person is to become a lecturer working in the DARDs, Extension Committee and Vietnam Farmers Union. They will take on two main functions: training farmers through local projects and programs and participating in consulting for local leaders on policy's development, including in agriculture, forestry, and natural resource management at district and provincial levels. The ToT program was implemented in collaboration with the National Agricultural Extension Center through the publication of official extension materials in the form of book and videos.

5.3. Research partners were gained knowledge through working together in project's activities, learned from their peers and received continuous training. In order to significantly improve the local capacity, the partner's staffs are supported to carry out training at bachelor, master and doctoral levels.

5.4. TBU is the regional university operating in the Northwest with a faculty of agriculture and forestry. Teaching and research capacity on agroforestry was performed by SCU lectures. The necessary research skills are trained such as topics related to agroforestry, forest restoration, competitive analysis, statistical analysis and scientific publication. Their

5.5. The project is closely linked with related ACIAR projects being implemented simultaneously in the Northwest region. Jointly organize seminars and visits to enhance knowledge and experience sharing and strengthen connections between ACIAR projects. The project also shares research sites and links with other projects to combine research, training, and funding. This merger has the goal of developing and expanding the influence of the project.

6 Achievements against activities and outputs/milestones

Objective 1: To quantify and evaluate performance of generic agroforestry options and tree species to underpin investment in promoting agroforestry

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Management and evaluation of agroforestry systems			
	1.1.1 Managing and monitoring 7 scientifically-established AF systems in terms of changes in yield and income, effectiveness in controlling soil erosion, and improving soil fertility.	Draft manuscript	Y2 M9	Seven agroforestry systems have been evaluated and results have been published in the form of fact sheets, scientific papers and manuscripts (link to 1.1.2). The results indicate that farmers likely prefer annual monocultures due to the relatively early income and short time-lag on returns. However, the results also show that annual profits from monocrops can be expected to decrease over time, due mainly to unsustainable soil use. Agroforestry systems, on the other hand, return substantial profits in the long term, but they also incur high establishment and maintenance costs and can generate net losses in the first few years. Initial financial incentives to compensate for these losses may help in promoting agroforestry adoption in the region.
		Final journal manuscript highlighting the economic and environmental benefits of agroforestry options from old trials	Y2 M12	Hung D.V. et al., 2020. <i>Fruit Tree-Based Agroforestry Systems for Smallholder Farmers in Northwest Vietnam—A Quantitative and Qualitative Assessment</i> . Land 2020, 9(11), 451; https://doi.org/10.3390/land9110451 Hoa Do et al. (2020). <i>Decision analysis of agroforestry options reveals adoption risks for resource-poor farmers</i> . Agronomy for Sustainable Development (2020) 40: 20. https://doi.org/10.1007/s13593-020-00624-5 Hoa Do, 2019. MSc thesis: <i>Helping farmers choose — Probabilistic modelling of agroforestry options in Northern Vietnam</i> . RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT BONN. Faculty of Agriculture. Technical report No. 22: <i>Complementarity of trees and crops/forages in agroforestry systems and their economic and ecological benefit compared to other land uses in Northwest Vietnam</i>

1.1.2 Analysis of tree-crop interactions between trees and associated components of 7 agroforestry systems.	Fact sheets for each agroforestry option based on final results analysis	Y2 M12	Completed Fact sheet of seven agroforestry systems produced: 1. Son tra+forage grasses 2. Acacia+mango+maize+forage grass 3. Longan+maize+forage grass 4. Shan tea+forage grasses 5. Acacia+longan+coffee+soybeans- +forage grass 6. Teak+plum+coffee+soybeans+forage grass 7. Macadamia+coffee+soybeans
	Technical guide on above ground resource management in agroforestry systems	Y3 M6	Completed The technical guide on aboveground management (designing, land preparation, fertilizing, pruning, plant protection, harvesting...) have been combined with seven published fact sheets.
	Technical report highlighting complementarity of trees and crops/forages in agroforestry systems	Y3 M12	Completed The comparison between seven agroforestry options and four monoculture systems (maize, longan, Son tra and Shantea) and two inter-crop options (macadamia-soybeans, coffee-soybeans) have been conducted based on tree specie's growth, fruit and crops/forages yield, profit and return on investment from land-use options. The results indicate that the competition between trees and crops in agroforestry options resulted slower growth, lower yields of single trees, and crop yields reduced due to decreases the land-area compared to mono-cultivation. Agroforestry incurred high establishment and maintenance costs and can generate net losses in the first few years. The crops/forages in agroforestry options have an important role in providing the incentive of early incomes and supporting via a shorter time-lag on returns. In the long term, agroforestry options have the possibility of providing substantial profits (link to 1.1.1) <i>Technical report No. 22: Complementarity of trees and crops/forages in agroforestry systems and their economic and ecological benefit compared to other land uses in Northwest Vietnam</i>
1.1.3 Establishment and management of 3 new agroforestry trials embedded in the ELs.	Trial establishment completed	Y2 M6	Completed Three scientific AF trials established, on-going management and monitoring: 1. Longan+mango+maize+forage grass (Son La) 2. Son tra+coffee+forage grass (Dien Bien). 3. Plum+maize+forage grass (Yen Bai)

		Technical report highlighting economic benefits of additional agroforestry options	Y4 M12	<p>The three evaluated agroforestry systems have shown their function in reducing soil erosion in compared with monoculture systems, such as maize and coffee, maintaining the soil, and in building terraces using trees and grass strips within the systems. These agroforestry systems also showed the higher total productivity, more diversified products and higher total income for farmers in compared with monoculture systems.</p> <p>Technical report No. 20: <i>The economic benefit and potential of soil conservation through agroforestry options on sloping cultivation in Northwest Vietnam</i></p>
1.2	Testing native and exotic timber tree species across an elevation gradient Establishing and monitoring elevation trials of selected timber species across an elevation gradient (300-800 and >800 m asl)	Report on priority species	Yr1 M12	<p>A diversity of timber species has been planted including <i>Pinus massoniana</i> (thông) Lamb., <i>Hevea brasiliensis</i> (cao su), <i>Dendrocalamus membranaceus</i> Munro (lúồng), <i>Cunninghamia lanceolata</i> Lamb. (sa mộc), <i>Schima wallichii</i> Choisy (vối thuốc), <i>Tectona grandis</i> (tếch), <i>Eucalyptus</i> ssp. (bạch đàn), <i>Acacia</i> ssp. (keo), <i>Manglietia glauca</i> (mỡ).</p> <p>Agreement with farmers has been reached with regard to test three timber species, which should be well-adapted and relatively fast-growing in the lower-elevation site (about 600 masl.): <i>Acacia mangium</i> (Keo tai tượng), <i>Melia azedarach</i> (Xoan) and <i>Manglietia glauca</i> (Mỡ), and to test four timber species which are suitable for higher-elevation (elevation higher than 1000 masl.): <i>Chuckrasia tabularis</i> (Lát hoa), <i>Schima wallachii</i> (Vối thuốc), <i>Manglietia glauca</i> (Mỡ) and <i>Paramichelia baillonii</i> (Giổi xanh).</p> <p>Technical report No. 1: "The timber tree species in forest plantation in Northwest Vietnam - Native and exotic species proposed for testing in different elevations in Dien Bien province".</p>
		Species-elevation trials established	Yr2 M6	<p>Completed</p> <p>Two trials established in Tuan Giao (Dien Bien) in Jun 2018:</p>
		Tree domestication guide for selected native and exotic timber tree species	Yr3 M12	<p>Trial 1 (600 masl.): <i>Acacia mangium</i>, <i>Melia azedarach</i> and <i>Manglietia glauca</i></p> <p>Trial 2 (1000 masl.): <i>Chuckrasia tabularis</i>, <i>Schima wallachii</i>, <i>Manglietia glauca</i> and <i>Paramichelia baillonii</i>.</p> <p>The two-year monitoring data show that <i>Acacia mangium</i> and <i>Melia azedarach</i> is fast growing species in 600 masl. trial compared to <i>Manglietia glauca</i>. <i>Manglietia glauca</i> grow well in 1000 masl. compared to in lower elevation (600 masl.). <i>Chuckrasia tabularis</i> and <i>Schima wallachii</i> show the significant different in height and stem diameter which higher compared to <i>Paramichelia baillonii</i>. The initial assessment that <i>Manglietia glauca</i> should recommend for higher elevation. We will continue monitoring the trials and farmer's fields until the end 2020 to provide the recommendation of adapted native and exotic timber tree species (link to Act. 1.4).</p>
		Report on tree species performance by elevation	Yr4 M6	
1.3	Son tra management and genetic study	Establishment of 100 new son tra trials on farms	Yr2 M9	<p>57 Son tra trials on farms were established in Sep. 2017 in Tram Tau (Yen Bai) (Link to Act. 2.2.1)</p> <p>In co-operation with FSCN, 32 Son tra farms with 36 superior grafted seedlings were established in August 2017 in Toa Tinh (Dien Bien) and Bac Yen (Son La)</p> <p>Top-working conducted in six farms in Bac Yen (15 ha) (Link to Act. 2.3.1)</p>

		Report on suitability (growth, yield, fruit quality) and genetic sources for the province to upscale Son tra area under specific conditions	Yr4 M12	Completed The assessment of fruit quality of 36 selected superior Son tra was conducted in Sep 2020 (Son tra's harvest season). Technical report No. 21: <i>"Docynia indica clonal trial, fruit quality assessment of 36 superior clones, and improving activities for sontra orchards"</i>
1.4	On-farm adaptation of selected native and timber tree species	Report detailing performance of adapted native and exotic timber tree species on farmers' fields	Yr4 M9	More than 5000 timber tree seedlings (<i>Chuckrasia tabularis</i> , <i>Schima wallachii</i> , <i>Manglietia glauca</i> and <i>Paramichelia baillonii</i> and <i>Melia azedarach</i>) were produced in group nurseries and distributed to farmers. The on-farm adaptations are on-going monitoring until the end 2020 (link to Act. 1.2).

PC = partner country, A = Australia

Objective 2: To understand suitability of different agroforestry options in relation to different contexts and develop markets and policy to scale up adoption

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Agroforestry suitability mapping	Review of variation in and location of ethnic groups and the extent of migration (where people have recently relocated) across the three target provinces	Yr1 M9	Completed Review of migration conducted. The main historical immigration events in Northwest Vietnam are: Immigration of Kinh from 1960s and 70s; Spontaneous migration of H'Mong within province, to Tay Nguyen and to Laos and China; Migration due to construction of Hoa Binh, Son La and Lai Chau hydroelectric power plants. Technical report No. 2: <i>"Review variation in and location of ethnic groups and extent of migration in the Northwest of Vietnam"</i>

		Initial maps showing the spatial distribution of existing agroforestry and potential expansion areas for the three target provinces based on species suitability	Yr1 M12	10 agroforestry options and two climate change scenarios (RCP 4.5 and RCP 8.5) have been used for assessment, the Suitable maps have been produced for Dien Bien, Son La and Yen Bai provinces. Technical report No. 3: " <i>Potential for agroforestry development assessment in Dien Bien, Son La and Yen Bai provinces</i> "
		Suitability maps for agroforestry options across the three target provinces, incorporating social, cultural and market considerations overlain on ecological suitability	Yr 2 M6	10 agroforestry options and two climate change scenarios (RCP 4.5 and RCP 8.5) were used for assessment, the Suitable maps were produced for Dien Bien, Son La and Yen Bai provinces. The agroforestry options include: 1. Son tra+forage grasses 2. Acacia+mango+maize+forage grass 3. Longan+maize+forage grass 4. Shan tea+forage grasses 5. Acacia+longan+coffee+soybeans+forage grass 6. Teak+plum+coffee+soybeans+forage grass 7. Macadamia+coffee+soybeans 8. Longan+mango+maize+forage grass 9. Son tra+coffee+forage grass 10. Plum+maize+forage grass Technical report No. 3: " <i>Potential for agroforestry development assessment in Dien Bien, Son La and Yen Bai provinces</i> "
2.2	Scaling agroforestry FDTs and Els up via			

	<p>2.2.1 Establishing 4 additional ELs (2 in Dien Bien, and 1 each for Son La and Yen Bai) and 300 FDTs across three provinces.</p>	<p>Ethnographic profile summarising what is known about preferences, constraints and opportunities for agroforestry adoption by different ethnic groups across the three target regions</p>	<p>Y1 M6</p>	<p>The study has been conducted and the results provided details of tree species preferences. The respondents from three ethnic groups mainly preferred fruit tree species suitable for their own local natural conditions and with high market values. The study also identified challenges for adopting agroforestry which vary among those three ethnic groups due to their location of origin, accessibility to market, and different cultivation tradition. It is suggested that farmers' specific social circumstances linking with their culture influence their aspiration and constraints for agroforestry intervention.</p> <p>Technical report No. 4: <i>"Ethnographic profile summarizing preferences, constraints and opportunities for agroforestry adoption by different ethnic groups across three provinces in Northwest Vietnam"</i></p> <p>Farmers in northwest Vietnam confirmed that intense corn cultivation on steep slopes provided the majority of income for most households. However, interviews also revealed that farmers were dissatisfied with growing corn because of low income and high input costs. Farmers' replies indicated that they thought they had no alternative to growing corn. However, farmers were aware of alternative crops, and were particularly interested in growing grass, fruit trees and timber trees, although few farmers were keen to be first to adopt these alternative species extensively. Further research is required on development of production-to-commercialization chains for alternative crops, and more generally, to find ways to increase farmer financial security during transition to sustainable land management.</p> <p>Heidi C. Zimmer, Hanh Le Thi, Duc Lo, Jack Baynes, J. Doland Nichols, 2018. <i>Why do farmers still grow corn on steep slopes in northwest Vietnam?</i> Agroforest System. 2018, Volume 92, Issue 6, pp 1721–1735.</p> <p>Nguyen Mai Phuong, 2020. <i>Analysis of Options by Context for Scaling Agroforestry in Northwest Vietnam</i>. PhD thesis. Bangor University UK.</p> <p>The four chapters presented in this PhD thesis develop an integrated framework to scale up agroforestry options in Northwest Vietnam. The framework was developed by mapping the extent and prevalence of soil degradation across the agricultural landscape and associating that with biophysical suitability mapping for different agroforestry options. Next the impact of social factors, including ethnicity and gender, were evaluated in terms of how they influence adoption of different agroforestry options. Finally the impact of social factors including ethnicity and gender affect adoption of different agroforestry options were assessed.</p> <p>The study found that farmers' preferences for agroforestry adoption were highly influenced by social norms associated with different ethnic minorities who make up the majority of the farming population in this area (this study focused on the Kinh, Thai and H'mong groups). A case study looking at gender in H'mong communities found that H'mong men and women had very differentiated roles within the current agricultural systems and were subject to different constraints and interests in relation to agroforestry adoption opportunities. These social norms currently limit H'mong women's full participation in agroforestry expansion.</p> <p>In terms of design, tree selection for agroforestry was significantly influenced by the economic value to the tree (either as timber or fruit) and accessibility to market.</p>
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<p>2.2.2 Tree-biophysical, socio-economic, policy and market suitability analyses in new FDTs and ELs to identify other species in addition to the 18 adapted species.</p>	<p>Report on local knowledge relating to tree establishment and management and culturally specific aspects of adopting market based agroforestry including differential preferences according to gender and age</p>	<p>Yr1 M9</p>	<p>Local knowledge studies have been conducted in six villages of Kinh, Thai and H'mong groups to understand local aspirations and preferences for agroforestry options. The results show the local knowledge of different ethnic group on tree establishment and tree management in different agroforestry systems. Although having deep knowledge of agroforestry techniques, local people hold different perceptions on benefits of agroforestry adoption which have a strong influence in their adoption of agroforestry techniques. Agroforestry options and preferred tree/crop species are mostly driven by culture and market price. Therefore, selecting suitable options for each ethnic group and market support play an important role in scaling up agroforestry in the Northwest.</p> <p>Technical report No. 5: <i>"Local knowledge relating to tree establishment and management and culturally specific aspects of adopting market-based agroforestry including differential preferences according to gender and age"</i></p> <p>The main constraints to agroforestry adoption were identified as the preference and cultural norm towards monoculture, the lack of resource endowments, the lack of agroforestry knowledge and techniques, the lack of extension services and the lack of policies promoting agroforestry adoption. In addressing the latter three constraints, seen to hold more potential opportunities, the study recommends the establishment of community-based, farmer-led extension to meet the local needs of smallholder farmers and the provision of an enabling environment through national and provincial policies, ensuring specific commitment and continuity to agroforestry adoption.</p> <p>Marika Vichitra Samuelsson, 2017. <i>The Perceptions of Smallholder Farmers on Agroforestry Adoption: A Case Study from Northwestern Vietnam</i>. MSc thesis. Imperial College London. Faculty of Natural Sciences.</p> <p>Nguyen Mai Phuong, 2020. <i>Analysis of Options by Context for Scaling Agroforestry in Northwest Vietnam</i>. PhD thesis. Bangor University UK.</p>
<p>2.2.3 Facilitating activities within the network of 370 FDT and 6 EL.</p>	<p>Report of structured stakeholder engagement workshops in the three provinces (informed by ethnic profiling and local knowledge) to develop inclusive agroforestry options suitable for the range of socio-ecological contexts</p>	<p>Yr1 M12</p>	<p>Completed Link to 2.2.1 and 2.2.2.</p> <p>The preferred agroforestry options are fruit trees/crops. Such preference has been mostly driven by culture and market price. The stakeholders involved have raised issues concerning agroforestry products such as standard (e.g. VIETGAP) and the need for building capacity of farmers to manage the quality themselves to separate the agroforestry products from the 'normal' agriculture products. Further studies are needed to identify the advantage of agroforestry and provide evidence to be used to convince the government to develop policies which provide financial support to farmers and private sectors involved in agroforestry development.</p> <p>Technical report No. 6: <i>"Agroforestry - current judgements of stakeholder and vision for development"</i></p>

		Manual for extension workers on establishing and facilitating FDTs and ELs	Y1 M12 (new delivery date Y2 M12)	Extension material: “Sustainable Agroforestry Farming for Northern Midlands and Mountains areas”. Ministry of Agriculture and Rural Development. National Agriculture Extension Centre. Hanoi Agriculture Publishing House, 2020.
		150 FDTs established	Y2 M9	174 FDTs are established in 2018. Trainings on nursery establishment and seedling produce techniques conducted.
		300 FDTs established	Y4 M9	Up to date, 425 FDTs are established. Trainings on nursery establishment and seedling produce techniques conducted.
		Four ELs established	Y2 M6	Four ELs have been established, 50 ha each: <ul style="list-style-type: none"> – In Toa Tinh (Dien Bien), 77 hhs involved – In Na Noi (Dien Bien), 65 hhs involved – In Na Bai (Son La), 119 hhs involved – In Thuong Bang La (Yen Bai), 59 hhs involved In addition, three new ELs are on-going established in Toa Tinh, Dien Bien (50 ha), Quynh Nhai, Son La (50 ha) and Na Ha village, Son La (15 ha) as local provinces and Farmers’ perspective and requested
		Initial report on suitable tree species	Yr1 M9	Link to Act. 2.2.4 Six ELs have been established in three provinces and under monitoring and evaluation.
		Tree species-suitability matrix/guide for two climate scenarios	Yr 2 M9	Link to Act. 2.1 Assessment of all trees and crops (included in 10 agroforestry options) have been conducted for two climate change scenarios (RCP 4.5 and RCP 8.5). Under increasing temperature and rainfall, the Son tra and plum have been two tree species least influenced. Technical report No. 3: “Potential for agroforestry development assessment in Dien Bien, Son La and Yen Bai provinces”

		Print and audio-visual extension materials	Yr 2-4	<p>Link to Act. 2.2.3</p> <p>Extension material: “<i>Sustainable Agroforestry Farming for Northern Midlands and Mountains areas</i>”. Ministry of Agriculture and Rural Development. National Agriculture Extension Centre. Hanoi Agriculture Publishing House, 2020.</p> <p>In cooperation with National Agriculture Extension Centre (NAEC) with additional fund supported by ACIAR, six extension materials in the video form are produced:</p> <p>What is agroforestry (link: https://www.youtube.com/watch?app=desktop&v=-ZJUCIDD7Gg&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi)</p> <p>How to establish contour lines on sloping land (link: https://www.youtube.com/watch?v=cjsPIbeOYOc&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=2)</p> <p>Designing an agroforestry system with trees, crops and forage grass (link: https://www.youtube.com/watch?v=ZBakN4wThzU&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=3)</p> <p>Designing an agroforestry system with timber trees, fruit trees, coffee, crops and forage grass (link: https://www.youtube.com/watch?v=DUJt8CB6rxU&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=4)</p> <p>Designing an agroforestry system with trees, forage grass, fishponds and livestock (link: https://www.youtube.com/watch?v=uEwBoIIRIE0&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=5)</p> <p>Propagation techniques of fruit trees by grafting (link: https://www.youtube.com/watch?v=_UXI5P1WdeE&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=6)</p>
2.2.4	Monitoring and evaluating the ecological and economic benefits of adapted agroforestry systems in FDTs and	Initial report on scaling up through the FDT and EL approach with lessons learnt	Yr2 M12	<p>Completed</p> <p>Agroforestry contributes to improvements of local livelihood both in short- and long-term perspective. By practicing agroforestry, farmers can diversify income and reduce risks. Moreover, any promotion of production must link to consumption. And market access capacity for small-scale producers, group of farmers and cooperatives needs to be improved.</p> <p>Technical report No. 12: <i>Scaling up agroforestry through the FDT and EL approach, ecological and economic benefits, and lessons learnt</i></p>

ELs, as well as farmer	Initial report on benefits, including women's empowerment in FDTs and ELs	Yr3 M12	<p>Completed</p> <p>An evaluation survey was conducted in February and March 2020 with 458 respondents including farmers, extension workers, policy makers, research partners in Son La, Yen Bai and Dien Bien. The survey aims to i) monitor and evaluate project outcomes, ii) document farmers and partners feedbacks and lessons learned on project activities, iii) identify challenges and opportunities to scale up agroforestry and future collaboration, iv) provide recommendations to achieve final project outputs, outcomes and impacts. Together with the evaluation household survey, two in-depth surveys were conducted in two exemplar landscapes in Hat Lot commune, Son La and Toa Tinh commune, Dien Bien to understand deeply the benefits and constraints of farmers participating in the exemplar landscapes. Overall, project activities have provided positive impacts on ethnic women, such as increasing their networks and decision-making and public-speaking skills. However, the rate of female farmers accessing and using project extension material or participating in project nurseries and applying agroforestry techniques was limited. This requires understanding of the real needs and interests grounded in the socio-cultural contexts of the ethnic groups living in the Northern Mountain Region in Viet Nam, who have unique social and cultural norms and values. The case studies show that agricultural activities are highly gendered: men and women play specific roles and have different, particular constraints and interests. Women are highly constrained by gender norms, access to resources, decision-making power and a prevailing positive-feedback loop of time poverty, especially in the Hmong community. A holistic, time-saving approach to addressing women's daily activities could reduce the effects of time poverty and increase project participation. As women were highly willing to share project information, the project's impacts would be more successful with increased participation by women through utilizing informal channels of communication and knowledge dissemination. Extension material designed for ethnic women should have less text and more visuals. Access to information is a critical constraint that perpetuates the norm that men are decision-makers, thereby, enhancing their perceived ownership, whereas women have limited access to information and so leave final decisions to men, especially in Hmong families. Older Hmong women have a Vietnamese (Kinh) language barrier, which further prevents them from accessing the project's material. Further research into an adaptive framework that can be applied in a variety of contexts is recommended. This framework should prioritize time-saving activities for women and include material highlighting key considerations to maintain accountability among the project's support staff.</p> <p>Nguyen MP, North H, Duong MT, Nguyen MC. 2021. "Assessment of women's benefits and constraints in participating in agroforestry exemplar landscapes." Working paper 315. Nairobi, Kenya: World Agroforestry (ICRAF). https://dx.doi.org/10.5716/WP21015.PDF.</p> <p>Nguyen, M.P., North, H., Duong, M.T., Nguyen, M.C. 2021. Info brief "Gender and Ethnicity in Vietnam Agroforestry Landscapes: Lessons for Project Implementation". World Agroforestry (ICRAF).</p>
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		Journal manuscript combining findings from Act 2.2.3 and 2.2.4, with emphasis on the assumption regarding local government engagement to achieve scale of adoption and benefits	Yr4 M12	<p>Completed</p> <p>Nguyen, M.P.; Pagella, T.; Catacutan, D.C.; Nguyen, T.Q.; Sinclair, F., 2021. <i>Adoption of Agroforestry in Northwest Viet Nam: What Roles Do Social and Cultural Norms Play?</i> Forests 2021, 12, 493. https://doi.org/10.3390/f12040493 (link: https://www.mdpi.com/1999-4907/12/4/493)</p> <p>This research applies knowledge-based system methods in order to understand local opportunities, preferences, and constraints influencing the adoption of agroforestry practices, using a purposive, gender-balanced sample of sixty farmers from six villages across three provinces in the northwest region comprising people from Kinh, Thai and H'mong ethnic groups.</p> <p>The results show that although farmers from all groups are aware of the economic and ecological benefits of trees for soil conservation in general, they have different perceptions about the benefits of particular agroforestry practices. Behavioural norms controlling agroforestry adoption vary amongst ethnic groups, and farmers' individual social and cultural preferences influence their aspirations and adoption decisions.</p>
		Journal manuscript on benefits from women empowerment	Y4 M12	
		Consolidated database and report of the ecological and economic performance of FDTs across contexts in northwest Vietnam.	Y4 M12	
2.3	Creating market linkages and exploring product development			
	2.3.1 Cooperating with TAFOOD and local government in securing the source of high quality Son tra fruits	Technical report on capacity building activities and delineated 'expanded' source of good Son tra planting materials	Y2 M12	<p>Completed</p> <p>Ha Van Tiep, Pham Huu Thuong, La Nguyen, Hoang Thi Lua, Vu Van Thuan, Lo Thi Kieu, Sammy Carsan, Ann Degrande, Delia Catacutan & Chris Harwood , 2018. <i>Domestication of Docynia indica in Vietnam</i>. Forests, Trees and Livelihoods. Volume 27, 2018 - Issue 4, Pages 230-242. Published online: 06 Sep 2018</p> <p>Link to Act. 1.3: 57 Son tra trials on farms were established in Sep. 2017 in Tram Tau (Yen Bai) (Link to Act. 2.2.1) In co-operation with FSCN, 32 Son tra farms with 36 superior grafted seedlings were established in August 2017 in Toa Tinh (Dien Bien) and Bac Yen (Son La) Six farmers have been trained on Top-working technique. They have established 15 ha of improved Son tra using top-working technique in their fields.</p>

		10 ha of improved son tra established	Y3 M12	15 ha of improved Son tra using top-working technique are established
	2.3.2 Identifying and developing partnerships with the private sector to create marketing arrangements for some agroforestry products, and thus, demonstrate a business model	Report on marketing strategies developed for each key agroforestry product	Y2 M9	<p>The business model canvas has proved to be an appropriate tool to visualize the current farm business set-up and further develop a strategy for the future. Ample opportunities for farmers to improve market linkages exist. Advocate farmer-initiated change by embracing collective action to solidify bargaining strength and voice in the value chain, inclusive agricultural development for fruit farmers can potentially further be spurred by diversifying the customer base, accessing niche markets and value-addition such as certification, fruit processing, branding and contract farming, further, it is important to take a deeper look at the long-term sustainability and impact of farmer marketing groups or cooperatives and their business model transitions are recommended. The results highlight the importance of other stakeholders along the value-chain adopting inclusive and smallholder friendly buyer-driven business models. The study is regarded as baseline research on producer-driven business model development for smallholder farmers engaging in fruit production.</p> <p>Technical report No. 7: "<i>Developing a farm business model for livelihood enhancement of smallholder farmers in Northwest Vietnam</i>".</p> <p>A survey on market demand of seasonal fruits and agricultural products conducted with a number of fruit chain stores and companies in Hanoi is on-going. Some applicable strategies are advised:</p> <ul style="list-style-type: none"> - Continue to maintain and improve traditional markets for existing products (local wholesale markets and in other provinces and cities). Thus, it is necessary to strengthen and maintain long-term relationships with traders buying products at the farm-gate level. - Discovery of new markets and, step by step, adapt to the requirements of that market. The product can be developed to display and enter into fruit stores in big cities through properly improving trading services (such as establishing cooperative led by a trusted, enthusiastic and talented leader, perfecting the mechanism of packing, preserving and transporting, strictly implementing terms of contracts with buyers). - It is necessary to provide product introduction to a number of companies and fruit stores, to understand their quality requirements, demand and support promotes business linkage.
		At least 2 marketing arrangements developed with the private sector	Y3 M12	<p>Setting up the business between private sectors and farmers:</p> <ul style="list-style-type: none"> – HOANDUONG TRADING & MANUFACTURING JOINT STOCK COMPANY – VIETNAM BIGGREEN CLEAN FOOD COMPANY LIMITED – BHM INTERNATIONAL., JSC – VSAPAT TAY BAC., JSC – DUC THANH SUPERMARKET CHAIN – GREENLIFE CLEAN FOOD – CT FARM

	2.3.3 Analysing demand and supply dynamics of key agroforestry products, to predict future risks and opportunities	Report on market supply and demand sensitivity analysis of key agroforestry products	Y4 M6	<p>Family income of smallholder farmers in North West Vietnam mainly depends on the agricultural products sold locally through small traders. Household economy can be improved by accessing bigger markets and meeting requirements for quantity and quality of products. Research on market linkage for smallholders is conducted with the aim of: (1) Identifying factors that effect to market linkage ability of farmers to private sectors (company, enterprise and supermarket...); and (2) Providing support for farmer cooperative to connect with appropriate markets.</p> <p>Individual smallholders are limited in their ability to meet the demands of the market such as large quantity, uniform quality, trust from businesses and private companies... To overcome this problem, it is crucial that smallholders should form a group or cooperative, in which, they can work together to generate a stable and uniform production system in terms of product quality and quantity to meet a certain standard. With this operation, 30 farmers in Huoi Tan village and 34 households in Mon village (Son La province) has grouped and trading with six companies, supermarkets and retail stores. These groups have directly exchanged information on prices, quantity requests from private businesses then, step by step, they have developed to meet the requirements from markets. In the future, we continue to carry out capacity training on production organization, management, business skills and creating a reliable relationship to partners for the farmer group to maintain and expand the production system.</p> <p>Technical report No. 13: <i>Creating market linkage to support livelihoods of smallholder farmers in Northwest Viet Nam</i></p>
2.4	Gender	Linked to Act. 2.2.3--Audio-visual extension materials and field report on utilization by women	Y3 M12	Link to Act. 2.2.3

		Report on gender-specific preferences for tree species	Y2 M6	<p>Completed</p> <p>A gender survey was conducted in December 2017 in cooperation with FST/2016/152 and AGR/2017/008. The findings have shown that agricultural activities are highly gender-specific. The ways men and women access information are different. Men have both formal and informal learning channels, while women trust informal information from their female peers, indicating that current agricultural extension services are not reaching women, constituting half of the population. A wide range of agricultural challenges were raised among farmers. Some technological issues such as fertilisers, pests and diseases are common for both men and women, while others are gender-specific. Women have time constraints and they are interested in labour-saving technologies. Men, on the other hand, bear heavy decision-making responsibilities as household heads and therefore they need information on investment and market strategies. Based on those findings, gender-responsive agricultural extension services and interventions are suggested.</p> <p>The second survey was conducted in Hat Lot commune, Son La province using similar methodology with the first survey in Toa Tinh, Dien Bien. This aimed to understand the gender norms, power and freedom in the family, access to resources 24-hour time allocations, gender divisions of labour and decision-making as well as farmers' issues and constraints in adopting agroforestry within the Thai community. This second survey enabled the comparative research on gender and ethnicity and resulted in a working paper on "Assessment of women's benefits and constraints in participating in agroforestry exemplar landscapes". The fieldwork and publication production were supported by Gender FTA and Gender Platform.</p> <p>Technical report No. 8: <i>"Exploring opportunities and challenges in agricultural development through the gender lens - A case study in a H'mong community, Dien Bien province in Vietnam"</i></p> <p>Nguyen MP, North H, Duong MT, Nguyen MC. 2021. "Assessment of women's benefits and constraints in participating in agroforestry exemplar landscapes." Working paper 315. Nairobi, Kenya: World Agroforestry (ICRAF). https://dx.doi.org/10.5716/WP21015.PDF.</p> <p>Nguyen Mai Phuong, 2020. <i>Analysis of Options by Context for Scaling Agroforestry in Northwest Vietnam</i>. PhD thesis. Bangor University UK.</p> <p>A video: <i>"Understanding gendered opportunities and challenges in upland Northwest Vietnam"</i> is available (Link: https://www.youtube.com/watch?v=LJBucc0RTJk).</p>
		Report and manuscript linked to Act 2.2.3 & 2.2.4 (see above)	Y3 M12	<p>Link to Act. 1.1.1, 2.2.1</p> <p>Link to Act. 2.2.3, 2.2.4</p>
	2.5	Data management	Y2-4	On-going

PC = partner country, A = Australia

Objective 3: To understand the ecological and economic values of degraded forests and co-develop appropriate forest rehabilitation methods with local communities to enhance them

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Selection and assessment of degraded natural forests	Two sites/provinces identified for testing forest rehabilitation options	Yr1 M6	Completed The two sites are: (1) Na Nhan commune, Dien Bien district, Dien Bien province (Na Noi village) and (2) Chieng Yen commune, Van Ho district, Son La province (Na Bai and Leo villages)
		Report on results of participatory forest inventory and economic species	Y1 M12	Link to Act. 3.2 The forest inventory and economic species study have been conducted in Na Bai and Na Noi. In general, both villages have relatively large areas of forest. However, the forest is degraded, with many high-value species absent (or very depleted) and large trees gone. The communities, for the most part, recognize that these changes have occurred. Nevertheless, the remaining forest provides essential functions in erosion prevention and providing a diverse range resources to the community. The predominant economic (or 'direct') use of the forest by people in Na Bai and Na Noi has been to collect firewood (in terms of numbers of households) from a variety of species. There is also a range of NTFP species used by local households, most common ones are chestnuts, bamboo shoots, mushrooms and honey and medicinal plants. Some species are used such as: <i>Castanopsis chinensis</i> (dẻ gai); <i>Baccaurea ramiflora</i> (Dầu da đất); <i>Melientha suavis</i> (sắn), <i>Canarium tramdenum</i> (trám đen); <i>Ficus auriculata</i> (vả) and <i>Schefflera heptaphylla</i> (chân chim). Technical report No. 9: " <i>Understanding forest degradation and rehabilitation in northwestern Vietnam</i> ".
3.2	Understanding socio-economic and institutional barriers and incentives to forest rehabilitation by forest communities	Report detailing barriers to and incentives for local people to be involved in forest rehabilitation, and the potential for PFES	Yr1 M12	Completed Unsustainable land management practices in Northwest Vietnam have resulted in myriad environmental problems, particularly widespread and severe soil erosion and biodiversity loss. A solution to these problems is to increase the cover of trees (and shrubs), especially on steep lands. This report describes year one results of the forest restoration component of the project. The results showed that the forests associated with both villages were degraded, with the current status of timber stocks, their rankings as poor and medium quality forests. The forests also had a variety of NTFP species, mainly used for food and medicine. However, the main way that people used the forests was to gather firewood. While people recognized that the forests were degraded, having fewer large trees and less species diversity than in the past, barriers to forest restoration were resource limitations (seedlings, funding), capacity limitations (technical skills) and fear of failure. Nevertheless, people had many ideas of species that they would like to see increase in their local forests – both NTFPs and timber species, and understood how improving the forest could improve their livelihood, both by improving the environment and creating more sources of income. These findings provide a strong foundation for us to move forward with the next steps: beginning forest restoration activities on the ground, with the support and participation of the local communities, and monitoring their progress. Technical report No. 9: " <i>Understanding forest degradation and rehabilitation in northwestern Vietnam</i> "

3.3	Determining community priorities for forest rehabilitation and understanding how communities value natural forests.	Report detailing community priorities and aspirations for forest rehabilitation	Yr1 M12	Link to Act. 3.2 Technical report No. 9: " <i>Understanding forest degradation and rehabilitation in northwestern Vietnam</i> "
3.4	Testing forest rehabilitation options and development of sustainable forest management plan.	Two trial sites established	Y2 M6	Completed Enrichment planting: 16 ha In Na Noi (Dien Bien): Village community involved, planting <i>Erythrophleum fordii</i> (lim xanh) and <i>Michelia mediocris</i> (giổi xanh) In Na Bai and Leo (Son La): Village communities involved, planting <i>Michelia mediocris</i> (giổi xanh), <i>Dracontomelon duperreanum</i> (sầu) and <i>Chukrasiatubularis</i> (lát hoa) Planting non-timber forest products: 27 households (HH) in Na Noi, Na Bai and Leo involved and planted 4ha <i>Amomum longiligulare</i> (sa nhân). Assisted natural regeneration in 60 ha belong to Na Noi and Leo community forests Scattered planting: 20,000 seedlings planted In Na Noi: 54 households involved in planting <i>Schima wallichii</i> (vối thuốc), <i>Michelia mediocris</i> (giổi xanh), <i>Canarium tramdenum</i> (trám đen), <i>Manglietia conifer</i> (mỡ), <i>Altingia siamensis</i> (tô hạp Điện Biên), <i>Acacia mangium</i> (keo tai tượng) In Na Bai: 43 households involved in planting <i>Cunninghamia lanceolata</i> (sa mộc), <i>Manglietia mediocris</i> (giổi xanh), <i>Canarium tramdenum</i> (trám đen), <i>Manglietia conifer</i> (mỡ) In Leo village: 9 households involved in planting <i>Cunninghamia lanceolata</i> (sa mộc), <i>Michelia mediocris</i> (giổi xanh), <i>Canarium tramdenum</i> (trám đen) and, <i>Manglietia conifera</i> (mỡ) Expanded scattered planting model in Leo village, including 300 <i>Tectona grandis</i> (Tếch), 200 <i>Chukrasiatubularis</i> (lát hoa) and 300 <i>Michelia mediocris</i> (giổi xanh),
		Two Community forest management plans	Yr3 M9	Based on the results of meeting between the villages and project technical staff, a plan for community forest management was developed. The plan of community forest management includes identification the forest target area for management; plan for tending, protection and monitoring; and evaluation of the forest rehabilitation models in three villages within the project area. Technical report No. 14: <i>Community forest management plan for Na Bai, Na Noi and Leo villages</i>

		Report describing the forest rehabilitation sites and the techniques trialed	Yr2 M9	<p>Completed</p> <p>Forest rehabilitation activities have been carried out in Na Bai village, Leo village (Chieng Yen commune, Van Ho district, Son La province) and Na Noi village (Na Nhan commune, Dien Bien district, Dien Bien province). All households are participating in joint activities in the community forest areas such as enrichment planting, NTFPs planting and assisted for natural regeneration. In addition, some households in the village have registered to grow trees on their family's forest area. There are 43 households in Na Bai, nine households in Leo and 54 households in Na Noi involved in scattered and NTFP plantings. Techniques for planting scattered trees, for enrichment planting, for planting non-timber forest products and for assisted natural regeneration are described in detail in Technical report No. 10: <i>Monitoring mechanism for forest rehabilitation in Na Bai and Na Noi village</i></p>
		Report on the establishment (or strengthening) of local community forest management group	Yr 4 M9	<p>Forest protection teams were established consisting of members of the youth union, women's union, veteran's union and elected by the village people. The task of the forest protection team is to detect and receive information on violations as deforestation, exploitation, encroachment, and forest fire. If the violations are not too serious, the forest protection team will respond by reminding the violator and asking them to make commitment (to not repeat the violation), then report to the commune authority. In case of serious violations, the forest protection team will evaluate the damage, report to the commune forest management and people's committee to handle according to law. The forest protection group plans the patrol schedule (normally once a month), and in addition, they are responsible for daily monitoring and detecting abnormal activities during their daily fieldwork. The forest protection team directly participates in project activities. The operational funding comes mainly from the payment for forest environmental services received by village and partly come from project support.</p> <p>Technical report No. 15: <i>Strengthen the community forest management group in Na Bai, Na Noi and Leo villages</i></p>
		Report on women's participation	Yr4 M9	<p>Completed</p> <p>Women in Na Bai, Na Noi and Leo villages make a great contribution to forest restoration activities. In general, there is no gender discrimination in the above villages, the jobs are equally divided among both men and women. The woman typically participated with a high sense of responsibility, and in a hard-working, and industrious manner, which has resulted in the forest rehabilitation models developing well. On the other hand, with the participation of women in forest protection groups, it also contributes to encourage, motivating and propagating for women's associations in the village to raise their responsibility for protecting forest resources.</p> <p>Technical report No. 16: <i>Women's participation in forest rehabilitation activities in Na Bai, Na Noi and Leo villages</i></p>

3.5	Establishment of forest monitoring regime	Report detailing the monitoring regime for each site	Yr2 M9	<p>Completed Link to Act. 3.4 We mapped the planting areas for all scattered tree plantings, enrichment and NTFP plantings using handheld GPS (Garmin eTrex).</p> <p>A subset of plots was selected for detailed monitoring of survival and/or height growth. For scattered plantings, we selected 20 plots (households) in each village, across a range of plots encapsulating poor, medium or good soil. We characterised slope, distance from forest, planting technique, standard of tending and whether there had been any problems with grazing. The planting technique and tending were each rated as ‘good, moderate or poor’. Planting technique was rated based on the position of the base of the seedling relative to ground level, completeness, of infilling of soil around the seedling and fertiliser application (amount and placement relative to plant). Tending was rated based on the presence of encroaching weeds. Detailed monitoring of scattered plantings was undertaken in April 2019 (i.e., 23 months after planting and 11 months after replanting). Individual trees were not followed through the study, instead numbers of live plants of each species, within each plot, were recorded. It was not possible to differentiate between trees planted in 2017 and 2018; hence indicative survival is given as a combined measure (i.e., 11 or 23 months for Na Bai, and 11 or 25 months for Na Noi).</p> <p>For enrichment plantings, a sample incorporating 200 plants (Table 1) was selected in each village (across three areas in each village; six areas in total) for detailed monitoring of growth in height. Monitoring of height was completed in August 2019, 27 months after planting. It was intended that detailed monitoring sites be representative of the range of light conditions.</p> <p>The light environment for each plant was characterised using hemispherical photographs. A camera (Canon 60D camera with a Sigma 4.5 mm hemispherical lens) was mounted on a tripod, levelled and placed so that the top of the photo was facing magnetic north. Three photos were taken for each gap using automatic exposure bracketing (F 14 and ISO 100). Hemispherical photos were analysed first using the automatic thresholding algorithm in Sidelook (reference). Gap Light Analyser software (GLA; reference) was then used to calculate proportion of canopy and sky and light variables. All analyses were done using the blue channel.</p> <p>For NTFP plantings a sample of 14 plots (seven at Na Bai, two at Leo and five at Na Noi), representative of the range of planting conditions, was selected for detailed monitoring of height and number of stems. In addition, we recorded whether the land was shaded or light, sloping or flat, whether there was competition from weeds. Monitoring was carried out in August 2019, 15 months after planting.</p> <p>For assisted natural regeneration, GPS was used to map areas where weeding had occurred. Detailed monitoring was conducted in five 25 m² quadrats at each of the two villages (125 m² monitored at each village or 250 m² in total).</p> <p>Technical report No. 10: <i>Monitoring mechanism for forest rehabilitation in Na Bai and Na Noi village</i></p>
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		Report summarising economic and environmental benefits derived from integrated forest rehabilitation	Yr4 M6	<p>Completed Link to Act. 3.4</p> <p>In Na Bai, Na Noi and Leo villages, the following forest restoration methods have been implemented: (i) scattered trees planting; (ii) enrichment planting; (iii) NTFPs planting; and (iv) assisted natural regeneration.</p> <p>After two years, initial results showed that in Na Noi, <i>Altingia siamensis</i> (tô hạp Điện Biên) and <i>Michelia mediocris</i> (giổi xanh) have the highest survival rates, with 81.3% and 76.2%, respectively, the height ranges from 1.5 to 3.6 m; <i>Mangletia conifera</i> (mỡ) has the fastest growth with the height ranging from 2.5 - 4.5 m.</p> <p>In Na Bai, <i>Cunninghamia lanceolata</i> (sa mộc) and <i>Mangletia conifera</i> (mỡ) had the highest survival rate (>80%) and good growth (height ranges from 2.5 to 4.6 m.) In the Leo village, most species also grew well. <i>Cunninghamia lanceolata</i> (sa mộc), <i>Mangletia conifera</i> (mỡ), <i>Chukrasia tabularis</i> (lát hoa) and <i>Canarium tramdenum</i> (trám đen) had survival rates of >80%, with height ranging from 1.5m to 4.3 m.</p> <p>In Na Noi and Leo, after 2 years <i>Amomum longiligulare</i> (sa nhân) not bearing fruit yet, the number of stems ranges from 6 to 12 branches per clump, the height ranges from 0.5 to 2.2 m. Planting location has a great influence on survival rate and development, which may be influenced by the variation in tending (e.g., weeding). applied by different households.</p> <p>Since forest trees take a long time to harvest, the project has focused on variation among species in survival rate and growth. We discuss the economic and environmental benefits according to insights from previous studies and expert estimation.</p> <p>Depending on the species, harvest time can be after 7-10 years (start provide fruit) and 20-50 years for timber trees. It is estimated that after 20 years, <i>Canarium tramdenum</i> (trám đen) and <i>Michelia mediocris</i> (giổi) will have a stable fruit harvest, if 50% of the remaining crops are harvested, people in the project area can get about 30 tons of <i>Michelia mediocris</i> (giổi) seeds each year (estimated 5 kg tree⁻¹); 21 tons of <i>Canarium tramdenum</i> (trám đen) fruit (estimated 20 kg tree⁻¹) and about 60 tons of <i>Dracontomelon duperreanum</i> (sấu) fruit (estimated 70 kg tree⁻¹). In particular, after seven years, <i>Amomum longiligulare</i> (sa nhân) possible provide 200 kg year⁻¹ (estimated 60 kg ha⁻¹).</p> <p>For timber, it is estimated that the total wood production (across all species) can reach over 16,000 m³ after 20-50 years with a survival rate at the time of harvest of 50%.</p> <p>In terms of environmental value, the project has contributed to the protection and improvement of 76 ha of natural forests (60 ha for regeneration promotion zone and 16 ha for afforestation and enrichment zone); 20,000 scattered trees equivalent to over 20 ha of concentrated planted forest and 4 ha of NTFPs planting. The estimated total carbon at the time harvest is over 1,300 tons. Thus, the forest area of the project will contribute to the local community such as providing food, materials, and the environment benefit.</p> <p>Collaborations between scientists and communities lead to better forest rehabilitation outcomes: with the support of local communities, we were able to conduct these forest rehabilitation activities over a large area as a result of communities donating land and labour, and select locally appropriate and preferred species. Undertaking forest rehabilitation within the context of a research project we were not only able to build capacity in terms of forest rehabilitation methods, but also</p>
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				<p>gather important data on species survival and growth in real-world conditions. One important outcome of this study, which will be the subject of future research, is utilizing Vietnam's diverse native flora, especially trees, to rehabilitate degraded natural forest and marginal agricultural land to become economically valuable and biodiverse forest.</p> <p>Heidi Zimmer, Tran Lam Dong, Dang Trieu, Thanh Lo Quang, Hanh Le Thi, J. Doland Nichols. <i>Techniques for forest rehabilitation in mountainous northern Vietnam</i></p>
		Technical report / journal manuscript describing the different approaches to forest rehabilitation used in the project, and their relative merits	Yr4 M9	<p>Link to Act. 3.4</p> <p>Heidi Zimmer, Tran Lam Dong, Dang Trieu, Thanh Lo Quang, Hanh Le Thi, J. Doland Nichols. <i>Techniques for forest rehabilitation in mountainous northern Vietnam</i></p>
3.6	Policy Dialogues and potential for scaling up	Policy dialogues at National and Provincial level	Yr 3 M12	Completed
		A policy brief highlighting recommendation for addressing barriers to forest rehabilitation	Yr4 M6	<p>Completed</p> <p>Link to Act. 3.6</p> <p>The Northwest provinces have been actively implementing policies on forest protection and development, achieving certain results, but not avoiding difficulties and limitations in the implementation process. With the recommendations and proposals of provinces made in the process of applying the above forest development policies, in the next 2021-2030 period, the state, ministries, and branches will continue to innovate mechanisms and policies for forest protection and development.</p> <p>This could include:</p> <ol style="list-style-type: none"> (1) Increasing investment from State budgets every year and mobilizing a combination of resources for infrastructure development in mountainous and highland areas. (2) Coordinating and integrating socio-economic development programs and projects with ethnic minorities and in mountainous areas, including attracting and calling for capital sources with investment projects to develop protective forests and special-use forests from places such as ODA and FDI. (3) Encouraging enterprises of all economic sectors to enter joint ventures, link with people to develop forests using dynamic and flexible arrangements such as leasing land, receiving the capital contributions with land use rights of people to plant material forests for industrial production, forest product processing, seed supply, technology transfertogether with people working in forestry. This would ensuring the livelihoods as well as the benefits for local people when participating in forest protection and development activities. <p>Technical report No. 17: <i>Status of application of policies on forest rehabilitation in Northwest Vietnam</i></p>

PC = partner country, A = Australia

Objective 4: To understand drivers of land use change and develop cross-sector planning approaches for landscapes, integrating forests and agroforestry land uses

No.	Activity		Outputs/ milestones	Completion date	Comments
4.1	Delineating the demonstration landscapes		GIS-generated map of the first demonstration landscape	Yr1 M12	Completed Link to Act. 4.3 Working paper 279: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Na Nhan commune, Dien Bien province, Vietnam</i> "
			GIS-generated map of the second demonstration landscape	Yr3 M6	Completed Link to Act. 4.3 Working paper 317: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Chieng Yen commune, Son La province, Vietnam</i> "
4.2	Review of land use, agriculture and forestry sector planning processes		A policy brief highlighting the differences and similarities of sector planning processes, and the entry points for integrating forest rehabilitation and agro-forestation	Yr1 M12	Completed Policy brief for policy markers: " <i>Improving Land Use Planning: An integrated Tree Based Planning Approach</i> "
			Second site specific brief produced for second landscape	Yr3 M6	Completed Link to Act. 4.3 Working paper 317: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Chieng Yen commune, Son La province, Vietnam</i> "

4.3	Assessment of historical tree-based land use changes, and characterization of actors, biophysical and socio-economic factors		A report describing tree cover transition in the first landscape, their drivers and stakeholder perspectives	Yr2 M6	<p>Completed</p> <p>A study has been conducted to explore the land use practices in Na Nhan commune, Dien Bien province, and changes in land and carbon use in the period 2005-2015, linked to economic and social conditions of the local community.</p> <p>Technical report No. 11: <i>Historical land use and carbon stock change: A case study in Na Nhan commune, Dien Bien province</i></p> <p>A study to characterize the landscape in Na Noi to generate knowledge and understanding of local conditions, and to propose a workable governance mechanism to sustainably manage the landscape has been carried out through rapid assessments in the landscape, including land use mapping, land uses characterization, household survey, and participatory landscape assessment using the ecosystem services framework. The results showed that that the landscape and peoples' livelihoods are at risk from the continuous degradation of forest and agricultural lands, declining productivity and ecosystems conditions as well as the ecosystem services. Half of households live below the poverty line with insufficient subsistence agricultural production. Unsustainable agricultural practices and other livelihood activities are causing more damage to the forest. Meanwhile, existing forest and landscape governance mechanisms are generally not inclusive of local community engagement. Initial recommendations are provided, including further assessment to address current knowledge gaps.</p> <p>Working paper 279: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Na Nhan commune, Dien Bien province, Vietnam</i>"</p>
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			A report describing tree cover transition in the second landscape, their drivers and stakeholder perspectives	Yr3 M12	<p>Completed</p> <p>The research assesses different aspects of land uses in Chieng Yen commune, including socio-economic conditions, land uses and land uses change, change in carbon bon stock and land-use scenarios towards 2040 based on local people's perception on improving environmental services. Integrated land-use plan scenario towards to 2040 was collectively developed by villages, local management agencies and socio-civil organizations. The development of land-use plan has considered the targets for improving income and maintaining local environmental services provision functions, especially the protection of head water sources and identification of potential tourism areas. The proposed future land uses focus on protecting and improving natural forests and development of NTFPs, implementing reforestation on non-forestland (bare land) to expand forest areas using native tree species, improving paddy rice productivity, developing fruit trees and applying agro-forestry practices. The projected land use plan towards 2040 can reduce 3% of emissions and increase 8% of sequestration compared to bossiness as usual scenario. Policy and technical support are needed to achieve integrated landscape management at local (commune) level to meet the objective of national green growth strategy. The supports include the technical capacity building for community-based management, investment in forest enhancement and reforestation, development of NTFPs and expansion of tree-based land uses for improved resilience to environmental related issues and securing livelihood for local people.</p> <p>Working paper 317: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Chieng Yen commune, Son La province, Vietnam</i>"</p>
4.4	Integrated tree-based landscape planning		Multi-sectoral planning platform formed and workshops organized for first landscape	Yr2 M3	<p>Completed</p> <p>Link to Act. 4.3</p> <p>Working paper 279: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Na Nhan commune, Dien Bien province, Vietnam</i>"</p>
			Multi-sectoral planning platform formed and workshops organized for second landscape	Yr4 M3	<p>Completed</p> <p>Link to Act. 4.3</p> <p>Working paper 317: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Chieng Yen commune, Son La province, Vietnam</i>"</p>
			Land use scenarios developed and agreed by the Multi-sectoral planning team for first site	Yr2 M9	<p>Completed</p> <p>Link to Act. 4.3</p> <p>Working paper 279: " <i>Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Na Nhan commune, Dien Bien province, Vietnam</i>"</p>

			Land use scenarios developed and agreed by the Multi-sectoral planning team for second site	Yr4 M6	Completed Link to Act. 4.3 <i>Working paper 317: " Understanding tree cover transition, drivers and stakeholder perspectives for effective landscape governance - A case study in Chieng Yen commune, Son La province, Vietnam"</i>
			Journal manuscript on projected ecological and economic benefits of integrated tree-based landscape management	Yr2 M12	Completed Trong Hoan Do, Tan Phuong Vu, Delia Catacutan, Van Truong Nguyen., 2020. <i>Governing Landscapes for Ecosystem Services: A Participatory Land Use Scenario Development in the Northwest Montane Region of Vietnam</i> . Environmental Management. DOI 10.1007/s00267-020-01378-2
			Comparative report on application of integrated planning across two contrasting sites, lessons learnt and recommendations for wide implementation	Yr4 M9	Completed The research assesses different aspects of land uses in two communes that are Na Nhan in Dien Bien province and Chieng Yen in Son La province. The analysis includes socio-economic conditions, land uses and land uses change, change in carbon bon stock and future land-use scenarios with focus on improving ecosystem services to achieve green growth development. Land Use Planning for Multiple Ecosystem Services (LUMENS) and a participatory planning framework are the key concept used in this research. Participatory approach was applied to develop future land use plan with consideration of improving economic incomes and environmental protection, especially improvement of ecosystem services. This paper summarizes the key findings in Na Nhan and Chieng Yen to provide similarities and differences of those issues in the study communes. <i>Technical report No 18: Cross-sites Analysis - Tree cover transition, drivers, and stakeholder perspectives for effective landscape governance</i>
4.5	Development of institutional and monitoring framework for integrated landscape management		A report on institutional framework for integrated tree-based landscape management with monitoring, reporting and verification system	Yr3 M9	Completed This report provides guidance on monitoring integrated tree-based landscape management at commune level which is based on current legal framework related to natural resource management (land and forests) and requirements of national green growth development and assessment of land uses in two project communes in Dien Bien and Son La. Since the concept of integrated tree-based landscape management in Vietnam is still new, therefore this should be further developed for wider application cross levels. <i>Working paper 318: "Commune-level institutional arrangements and monitoring framework for integrated tree-based landscape management"</i>

4.6	National-level policy engagement and global knowledge sharing		Information brief of the first demonstration landscape submitted to the Global Landscape Academy	Yr3 M6	Completed InfoBrief - <i>Land uses, ecosystem services, and governance mechanisms for integrated landscape management in Na Nhan commune, Dien Bien Province, Northwest Viet Nam.</i>
			One national workshop organized and workshop proceedings published	Yr4 M6	Completed Workshop report – Consultation workshop – Agroforestry and forest rehabilitation: Connecting smallholder farmers and providing ecosystem services towards green and sustainable growth in the Northwest Vietnam.

PC = partner country, A = Australia

Objective 5: To develop local capacity for agroforestry, forest rehabilitation and integrated landscape management

No.	Activity	Outputs/ milestones	Completion date	Comments
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5.1	Farmer and extension staff capacity development	Various trainings conducted (Farmer field days, cross-visits, meetings and farmer workshops). Designing and implementing a number of skills trainings identified by farmers and extension workers. and a ToT manual for farmers developed	Yr3 M3	<p>Training for co-operators:</p> <ul style="list-style-type: none"> - 120 farmers and extension workers from Na Noi (Dien Bien), Na Bai (Son La) and Thuong Bang La (Yen Bai) villages participated in the farmer's field days in Na Ban (Son La) to gain knowledge on setting up agroforestry landscape (Link to Activity 2.2.3) - 174 farmers involved in FDT development have been participated in six training on development skill on seedling production and agroforestry implementation, including: establishing group nursery, soil preparation, seed preparation, grafting, design agroforestry systems, planning and pruning techniques - 130 farmers and extension workers participated in three training on development skill on co-operative economic activities, which co-sponsored by project and DGRV (German Cooperative and Raiffeisen Confederation) and Son La Cooperative Alliance. - 86 farmers participating in the project expansion area at Toa Tinh and Quynh Nhai and Mai Son have been participated in training to establish agroforestry landscape. <p>Farmers participate in conferences and workshops:</p> <ul style="list-style-type: none"> - 10 farmers representative for project farmers participated in the Regional Gender Workshop organized by ACIAR in November 2018 - Two farmers - directors of Tan Thao and Thanh Cuong cooperatives representative for project farmers participated in the CEF 2020 co-operative economic forum, December 10-11, 2020. <p>Outside the project:</p> <ul style="list-style-type: none"> - Conducted visiting and training on how to set up agroforestry systems for 43 farmers, extension staffs and provincial staffs from different districts in Son La province - Accommodated the visiting and experience sharing for 20 Hua Phan (Laos PDR) government officials to gain knowledge about agroforestry and understand more about the project.
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2	Researcher capacity development	Peer mentoring of Vietnamese researchers, in-house and short term trainings (4.3.2). Deployment of Vietnamese resident MSc and PhD students to research some aspects of the project (e.g. social, economic, marketing, biophysical, policy). 7 MSc thesis and 2 PhD dissertation completed	Yr3-4	<p>The students involved the study on the project activities have graduated:</p> <p>Two PhD students graduated:</p> <ul style="list-style-type: none"> - Vu Duc Toan, TBU – TBU, Vietnam - Nguyen Mai Phuong, Bangor University, UK <p>Five MSc students graduated:</p> <ul style="list-style-type: none"> - Marika Vichitra Samuelsson - Imperial College London, UK - Do Hoa – Bonn university, Germany - Birgitta Sjödel - Swedish University of Agricultural Sciences (SLU), Sweden - Hanna Thelberg - SLU, Sweden - Pham Huu Thuong – Hanoi University of Agriculture. <p>Four PhD studentson-going research training:</p> <ul style="list-style-type: none"> - Nguyen Thanh Hai, NOMAFSI – University of Queensland, Australia - Do Van Hung, ICRAF – SLU, Sweden - Phạm Hữu Thương, ICRAF – SLU, Sweden - Do Hoa, SLU – Bonn university, Germany <p>Two MSc studentson-going research training:</p> <ul style="list-style-type: none"> - Nguyen Duy Khanh, FSCN, VAFS – TBU, Vietnam - Le Anh Thanh, FSCN, VAFS – TBU, Vietnam.
5.3	Training of Trainer (ToT)	Implementing ToT on Agroforestry establishment for extension workers with DARD extension departments and VNFU. Training conducted, and ToT manual accepted by VNFU	Yr3 M9	<p>Capacity building for partners through joint coordination and project implementation in the project sites. These techniques are summarized in print and audio-visual extension materials, resulting from collaboration with research institutes, local partners and the National Agricultural Extension Centre (details in section 2.2. 3)</p> <p>Project partners attended the conferences and workshops:</p> <ul style="list-style-type: none"> - Agricultural research and development in the Northwest region, Hanoi, 11/2017 - 4th World Congress on Agroforestry in Montpellier, France, 20-22 May 2019 - Tropical Agriculture Conference in Brisbane, Australia, 11-13 November 2019 - DevRes2021, Advancing Sustainable Agriculture, digital conference, 14-16 June 2021. <p>Project partners, DARD of Dien Bien, Son La and Yen Bai carry out capacity building for their local staffs through the implementation of provincial projects and development programs.</p>

5.4	Agroforestry lecturer capacity development	Practical hands-on and formal training activities for TBU researchers, and direct participation in research activities, leading to improvement in the University's Forestry and/or Agroforestry curricula. Teaching and/or lecture notes developed	Yr3 M6	SCU supports TBU in capacity building activities for lecturers and students through training in experimental design, scientific working and writing, data collection, statistical analysis (using R software), soil classification, international scientific community outreach and finalize student handbook of agroforestry. SCU, TBU and ICRAF cooperate to establish and monitoring the agroforestry trial in Bo Muoi (Son La). This trial has been used as a practical location for TBU and SCU students. 19 students from SCU have been visited the study sites in Son La province under SCU and VAFS staff's supervision.
5.5	Exchange knowledge with other ACIAR project	Workshops and join-field visits with relevant ACIAR projects in the northwest. At least, 1 workshop and 2 joint field visits organized with relevant ACIAR funded projects in the NW	Yr1 & 4	Joint studies with ACIAR-AGR/2017/008 in December 2017 and May 2018 on understanding gender opportunities and challenges on the project site ACIAR Regional Gender workshop November 2018 Joint workshop and field visit with ACIAR-LPS/2015/037 Joint workshop and field visit with ACIAR-SMCN/2014/049 Joint CEF 2020 co-operative economic forum, co-funded by ACIAR.

PC = partner country, A = Australia

7 Key results and discussion

Objective 1: To quantify and evaluate performance of generic agroforestry options and tree species to underpin investment in promoting agroforestry

From an economic perspective, an important indicator that helps and quantifies and evaluates performance of agroforestry systems is changed in yield and income compared to current farming systems and practices. The comparisons of the seven agroforestry systems with corresponding monoculture systems were conducted (Table 1). Seven evaluated agroforestry options are Longan-maize-forage grass, Shan tea-forage grasses, Son tra-forage grasses, Macadamia-coffee -soybeans, Teak-plum-coffee-soybeans-forage grass, Acacia-longan-coffee-soybeans-forage grass and, Acacia-mango-maize-forage grass. Monoculture systems with single crop/tree are maize, coffee, longan, Son tra. Results indicated that agroforestry systems provided early and more diverse products. These systems gave higher total productivity for farmers than those one in the monoculture systems from the 2nd year. In the first 1-3 years, the total productivity was mainly from forage grasses and annual crops. In addition, the total productivity of agroforestry systems increased more when the fruit trees bearing fruits in the 3rd - 4th years.

Table 1: Net profit of different agroforestry and monoculture systems (VND ha⁻¹)

Systems	Monitoring years							Mean (±SE)
	2012	2013	2014	2015	2016	2017	2018	
Maize monoculture	22.8	12.0	8.3	5.2	5.3	4.3	4.4	8.9 (± 2.5)
Longan monoculture	-51.3	-7.6	-5.0	0.9	-1.0	2.5	22.1	-5.6 (±8.4)
Longan-maize-ghine	-13.1	19.0	33.2	29.6	30.1	33.1	27.2	22.7 (±6.2)
Shan tea monoculture	na	-31.6	-7.4	-7.4	-7.2	-7.3	-7.3	-10.8 (±4.0)
Shantea-ghine	na	-34.9	4.1	17.6	33.0	5.6	-0.2	5.3 (±9.2)
Shantea-mulato	na	-34.9	-0.4	28.0	40.3	2.6	3.3	7.7 (±10.6)
Son tra monoculture	na	-30.0	-6.2	0.9	48.1	12.2	75.6	16.8 (±15.7)
Son tra-ghine	na	-37.4	70.5	64.3	69.6	54.1	83.3	50.7 (±18.0)
Son tra-mulato	na	-37.4	56.9	68.0	92.2	71.5	111.4	60.4 (±21.1)
Coffee-soybeans	na	-32.6	-11.3	9.7	17.2	57.9	18.8	9.9 (±12.5)
Macadamia-soybeans	na	-17.7	-3.5	-7.6	-7.2	-4.7	28.8	-2.0 (±6.5)
Macadamia-coffee-soybeans	na	-35.5	-12.7	6.3	9.3	34.8	57.3	9.9 (±13.5)
Teak-plum-coffee-soybeans-forage grass	na	na	-39.5	-13.6	26.5	30.4	36.2	13.4 (±13.7)
Acacia-longan-coffee-soybeans-forage grass	na	na	-52.3	9.8	38.0	28.0	25.0	9.7 (±16.2)
acacia-mango-maize-forage grass	na	na	-10.2	-2.9	4.2	19.0	23.3	5.0 (±4.1)

na: not applicable since the experiment was not established in these years

The seven evaluated agroforestry systems also had a higher profitability in compared with corresponding monoculture crop/tree systems from the 2nd to 3rd year. The net profits for farmers from agroforestry systems increased each year. Meanwhile, the net profits from the monoculture systems were only from trees or crops. The trend of decreasing net profit of monoculture maize across years was partially due to the decreasing selling price of maize over time and lower maize yield in the subsequent years. In the monoculture fruit tree systems, farmers had to wait until the 3rd- 4th year, before these systems could bring net profits. The break-even point of Longan-maize-forage grass, Son tra-forage grasses and

Acacia-mango-maize-forage grass was from the 2nd year; Teak-plum-coffee-soybeans-forage grass and Shan tea-forage grasses was from the 3rd year; Acacia-longan-coffee-soybeans was from the 4th year; and Macadamia-coffee-soybeans was from the 5th year.

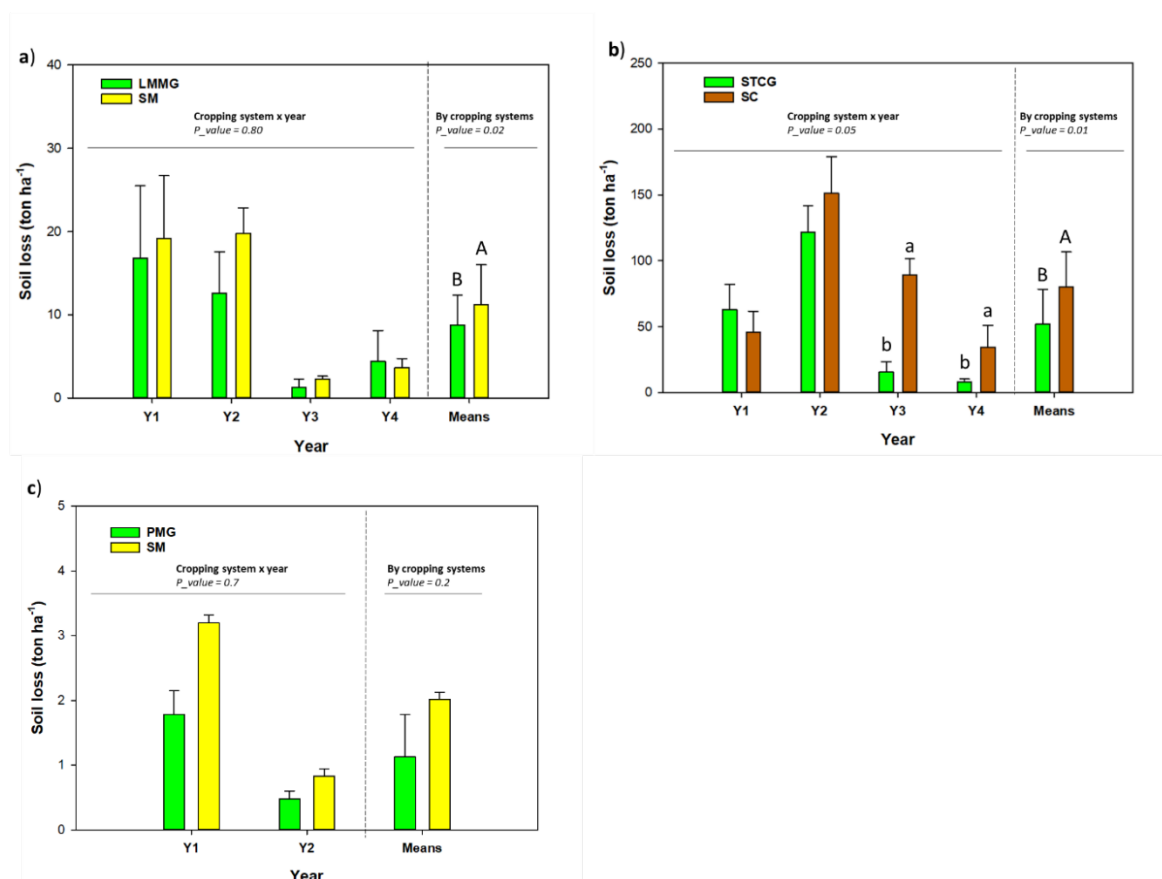
The initial investment cost for seven agroforestry systems ranging from 25 to 55 million VND ha⁻¹ mainly came from tree seedlings invested. It was high in compared with crop monoculture systems as the maize monoculture (14 million VND ha⁻¹). Farmers in the region have a lack of financial backup to shift into new practices, and trees require some years before provide income. Therefore, in some case, it limited the change from crop monoculture to agroforestry. To overcome these problems, reduce input cost from seedlings was applied in the project through training farmers produce high-quality seedlings for chipper price to serve themselves in group nurseries (FDT development in objective 2).

The forage grasses associated on agroforestry systems contributed significantly to early income for farmers with high fresh biomasses. The forage grasses can be used for feeding livestock and fish or selling. Guinea and mulato grass are drought-tolerant grass and performed well in the steep slope and dry conditions of Northwest region. The introduction of forage grass strips in the agroforestry systems may enhance the acceptance from farmers because it can reduce risks associated with dry weather conditions. In addition, ecological benefits or ecosystem services of grass strips indicated by reducing soil erosion and maintaining soil moisture and fertility, but also in forming terraces on the steep slopes. The establishment the grass strips along contour lines on the steep slope are relatively easy to do for farmers without any special techniques nor high cost.

Table 2. The yield of tree, crop and grass from the agroforestry systems and the corresponding monoculture crop

System		2017	2018	2019	2020	2021
Maize monoculture	Maize (dry grain)	4.4	5.4	5.6	3.8	3.5
Longan-mango-maize-forage grass	Maize (dry grain)	3.8	3.4	4.4	3.2	3.0
	Longan (fresh fruit)	<i>na</i>	<i>na</i>		0.35	0.35
	Mango (fresh fruit)	<i>na</i>	<i>na</i>	0.05	1.1	1.15
	Guinea (fresh biomass)	6.4	10.9	10.2	19.8	20.2
Coffee monoculture	Coffee (fresh fruit)	<i>na</i>	<i>na</i>	8.1	6.5	6.7
Sontra-coffee-forage grass	Coffee (fresh fruit)	<i>na</i>	<i>na</i>	7.6	5.3	6.3
	Son tra (fresh fruit)	<i>na</i>	<i>na</i>	0.07	2.27	2.3
	Guinea (fresh biomass)	2.6	11.1	12.8	6.6	12.2
Maize monoculture	Maize (dry grain)	<i>na</i>	<i>na</i>	5.5	6.3	5.2
Plum-maize-forage grass	Maize (dry grain)	<i>na</i>	<i>na</i>	4.9	5.1	5.0
	Plum (fresh fruit)	<i>na</i>	<i>na</i>	<i>na</i>	<i>na</i>	0.25
	Guinea (fresh biomass)	<i>na</i>	<i>na</i>	5.4	9.6	10.2

na: not applicable since the experiment was not established or fruit tree not bearing fruit yet



(a) Longan-mango-maize-forage grass (LMMG), sole-crop maize (SM); (b) Son tra-coffee-forage grass (STCG), sole-crop coffee (SC); Plum-maize-forage grass (PMG), sole-crop maize (SM). Values are means and standard errors. Bars with different letters indicate significant differences ($p < 0.05$).

Figure 3. Soil loss mitigation of agroforestry systems and corresponding monoculture systems

The three scientific agroforestry systems established in 2017-2018 have shown their function in reducing soil erosion in compared with monoculture systems, such as maize and coffee, reducing soil erosion resulted by using trees and grass strips within the systems. The systems are Longan-mango-maize-forage grass and Sontra-coffee-forage grass were established in 2017 in Mai Son (Son La) and Toa Tinh (Dien Bien), respectively, and Plum-maize-forage grass established later in 2018 in Tram Tau (Yen Bai). Table 2 presented the yield of tree, crop and forage grass yield compared to maize and coffee monocropping systems.

After 4 years of establishment, the average soil loss in the Longan-mango-maize-forage grass system was reduced around 22% compared with the maize monoculture system. The Sontra-coffee-forage grass system reduced around 35% compared with the coffee monoculture system. The younger system established in Yen Bai showed Plum-maize-forage grass tends to reduce soil erosion. However, it's not significant different since the systems still young and only two-year data available.

Objective 2: To understand suitability of different agroforestry options in relation to different contexts and develop markets and policy to scale up adoption

The maps of potential areas for agroforestry of three provinces were identified by using the available spatial data (i.e. land-use map, forest inventory map) with supplementary databases such as remote-sensing images, land-cover map, etc. and field survey. These maps were used for physical suitability evaluation (soil, soil depth, soil texture, slope, elevation, rainfall, temperature) for 10 different agroforestry systems. The two climate-

change scenarios representing for the most likely possibility (RCP 4.5) and less likely to happen, but if it happens, it will have the greatest negative impact (RCP 8.5) to evaluate the suitability in the future.

The results showed that in Dien Bien, Son La and Yen Bai provinces, the potential area for agroforestry development was 374,883.64 ha (39.29% of the province's total area), 634,418.28 ha (44.92% of the province's total area) and 389,802.64 ha (56.59% the province's total area), respectively. About 79.62% of the potential area of agroforestry was located on two land use types, including the upland for other annual crops (543,264.94 ha) and production forest (570,732.62 ha). Therefore, potential for agroforestry development is high. The results of evaluating physical suitability for 10 tested agroforestry systems indicated that the suitable area for agroforestry development in Son La province was 405,597.96 ha; in Dien Bien province was 267.74.01 ha and in Yen Bai province was 297,995.55 ha. Changes in temperature and precipitation with two climate-change scenarios did not affect significantly the suitability of agroforestry systems. The potential maps for agroforestry development in three provinces were built, created a comprehensive data set on natural conditions, topography, soil, climate, and growth requirements of crops, compiled suitability maps of agroforestry systems with physical conditions and assessed the impact of climate-change with two factors, temperature and precipitation. The produced maps can be considered as a useful resource for planning the in the future. The detailed analysis is presented in Technical report No. 3.

The FDT and EL approaches were developed and gradually approved with aim to expanding agroforestry to larger scale. The methodologies were summed up as follows:

During project implementation, project's outcome could be presented in various means such as scientific reports, conferences, local meetings, field visiting. By organizing farmer field days, visitors can witness established agroforestry systems and exchange knowledge and experiences with local farmers. Researchers and local farmers will introduce and present how to do, the reasons to do it, initial results and answer all visitor's questions. Visitors have opportunities to learn and evaluate according to their own experiences and preferences. Commonly, perceptions of visitors were on early outputs, growth of trees and crops or soil protection. We found that visiting farmers will not apply all the things they have seen but with their own ways based on their demands. This is the aim of farmer demonstration development. Literally, the farmer demonstration development is a process of inheriting and developing outputs of research with farmers participatory in large scale.

The FDT method is developed in four steps as following: Dissemination of research outputs to arouse interest on agroforestry practice (step 1); Discussion, agreement on plan and conducting method (step 2); Capacity building and establishing farmer demonstration trials (step 3) and; Experiences and knowledge sharing (step 4).

In order to empower a huge number of people to apply, it is not enough to just rely on technical staff and self-reliant farmers. Support through policies that directly or indirectly promote this process should be influential for a larger social and economic development purpose. Although there is no direct role in policy making but if introduce the demonstration in landscape, the visually will be stronger and more convincing to policy makers. The EL approach, partly, served that purpose. The EL developed with five following steps: Introduce research results to local authorities (step 1); Select the location to implement the agroforestry landscape (step 2); Agreement on the plan and method of implementation (step 3); Capacity building and implement agroforestry landscape (step 4) and; Experience sharing and knowledge dissemination (step 5).

During project lifetime, 425 FDTs and 6 ELs (50ha) each were established and more ELs are considered to set up by the local DARDs beyond the project conclusion. The detailed methods are presented in Technical report No. 12.

Eight group nurseries were established in Thuong Bang La, Tram Tau, Na Noi, Na Bai, Mon, Huoi Tan, Hoa Quynh and Tuan Giao during project's lifetime. Nearly 200,000

seedlings were produced with high-quality. It noted that, seedlings produced from project nurseries have a much lower cost than in the market (Table 3).

Table 3: Price of seedling produced in Farmer group nursery

Specie		Price (thousand VND)		% reduced
		Market	Farmer group nursery	
Longan	Grafted seedling ⁻¹	98	14	86
Mango	Grafted seedling ⁻¹	30	14	54
Pomelo	Grafted seedling ⁻¹	30	11	62
Plum	Grafted seedling ⁻¹	21	11	44
Son tra	Grafted seedling ⁻¹	30	18	38
Lemon	Grafted seedling ⁻¹	21	11	44
Melia	Seedling ⁻¹	2	1	60
Grass cutting	kg ⁻¹	2	0.5	80

Smallholder farmers are limited in their ability to meet the demands of the market. FDTs and ELs supported on solving this problem when individual farmers formed to group or/and cooperative. In this project, three cooperatives were formed to trade with six companies, supermarkets, and retail stores. Currently, those cooperatives worked with following strategies:

- Continue to maintain and improve traditional markets for existing products (local wholesale markets and in other provinces and cities). Thus, strengthen and maintain long-term relationships with traders buying products at the farm-gate level.
- Discovery of new markets and, step by step, adapt to the requirements of that market. The product can be developed to display and enter fruit stores in big cities through properly improving trading services (such as establishing cooperative led by a trusted, enthusiastic and talented leader, perfecting the mechanism of packing, preserving and transporting, strictly implementing terms of contracts with buyers).
- Continue introducing to a number of companies and fruit stores, to understand their quality requirements, demand and support promotes business linkage.

Moreover, develop the new products is pursued during the project lifetime. In the first phase of the project, the photochemical 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. Based on this finding, the Son tra extraction in the form of functional food was successful produced by pharmaceutical joint-stock company MEDZAVI in 2021, which promotes Son tra consumption. It created the basis for the other product development (from agroforestry, forest and NTFPs).



Figure 4: Functional food label contains Son tra extraction product

30 mother trees selected in the first phase of project and six trees selected in this phase with high fruit yield, superior fruit morphology and fruit peeling characteristic were grafted onto seedling. Those seedlings were planted on the 89 Son tra trials on farms in Tram Tau (Yen Bai), in Toa Tinh (Dien Bien) and Bac Yen (Son La). The top-working using selected superior clones also conducted in six farms (15 ha in total) in Bac Yen. This work plays very important roles in the selection of the most appropriate varieties for specific geographical, social and climate conditions of local areas and towards market-oriented production.

Objective 3: To understand the ecological and economic values of degraded forests and co-develop appropriate forest rehabilitation methods with local communities to enhance them

Forest rehabilitation activities were carried out in Na Bai village and Leo village (Chieng Yen commune, Van Ho district, Son La province) and Na Noi village (Na Nhan commune, Dien Bien district, Dien Bien province). Both villages have relatively large forest areas (Na Bai 161 ha; Na Noi 230 ha). Most villagers recognized the forest around them were degraded with many high-value species absent (or very depleted) and large trees gone. Nevertheless, the remaining forest provides essential functions in erosion prevention and providing a diverse range resource to the community along with improving livelihoods and timber supplies. Based on the results of meeting between the villages and project technical staff, a plan for community forest management was developed. The plan of community forest management includes identification the forest target area for management; plan for tending, protection and monitoring; and evaluation of the forest rehabilitation models in three villages within the project area.

All villagers participated in joint activities in the community forest areas such as enrichment planting, NTFPs planting and assisted for natural regeneration. In addition, some households in the village have registered to grow trees on their family's forest area. There are 43 households in Na Bai, nine households in Leo and 54 households in Na Noi involved in scattered and NTFP plantings. In Na Noi (Dien Bien): Village community involved, planting *Erythrophleum fordii* (lim xanh) and *Michelia mediocris* (giỏi xanh). In Na Bai and Leo (Son La): Village communities involved, planting *Michelia mediocris* (giỏi xanh), *Dracontomelon duperreanum* (sầu) and *Chukrasia tabularis* (lát hoa). In total, 16 ha enrichment planting were developed. For planting non-timber forest products, 27 households in Na Noi, Na Bai and Leo involved and planted 4ha *Amomum longiligulare* (sa nhân). Assisted natural regeneration developed in 60 ha in Na Noi and Leo community forests. For scattered planting, 54 households involved in planting *Schima wallichii* (vôi thuốc), *Michelia mediocris* (giỏi xanh), *Canarium tramdenum* (trám đen), *Manglietia conifer* (mỡ), *Altingia siamensis* (tô hạp Điện Biên), *Acacia mangium* (keo tai tượng) in Na Noi

village. 43 households involved in planting *Cunninghamia lanceolata* (sa mộc), *Manglietia mediocris* (giỗi xanh), *Canarium tramdenum* (trám đen), *Manglietia conifer* (mỡ) in Na Bai village. 9 households involved in planting *Cunninghamia lanceolata* (sa mộc), *Michelia mediocris* (giỗi xanh), *Canarium tramdenum* (trám đen) and, *Manglietia conifera* (mỡ) in Leo village. In total 20,000 seedling were planted. In addition, expanded scattered planting model in Leo village, including 300 *Tectona grandis* (Tếch), 200 *Chukrasia tabularis* (lát hoa) and 300 *Michelia mediocris* (giỗi xanh).

In Na Bai, Na Noi and Leo villages, the following forest restoration methods have been implemented: (i) scattered trees planting; (ii) enrichment planting; (iii) NTFPs planting; and (iv) assisted natural regeneration. We mapped the planting areas for all scattered tree plantings, enrichment and NTFP plantings using handheld GPS (Garmin eTrex). A subset of plots was selected for detailed monitoring of survival and/or height growth. For scattered plantings, we selected 20 plots (households) in each village, across a range of plots encapsulating poor, medium or good soil. We characterised slope, distance from forest, planting technique, standard of tending and whether there had been any problems with grazing. The planting technique and tending were each rated as 'good, moderate or poor'. Planting technique was rated based on the position of the base of the seedling relative to ground level, completeness, of infilling of soil around the seedling and fertiliser application (amount and placement relative to plant). Tending was rated based on the presence of encroaching weeds. Detailed monitoring of scattered plantings was undertaken in April 2019 (i.e., 23 months after planting and 11 months after replanting). Individual trees were not followed through the study, instead numbers of live plants of each species, within each plot, were recorded. It was not possible to differentiate between trees planted in 2017 and 2018; hence indicative survival is given as a combined measure (i.e., 11 or 23 months for Na Bai, and 11 or 25 months for Na Noi).

For enrichment plantings, a sample incorporating 200 plants (Table 1) was selected in each village (across three areas in each village; six areas in total) for detailed monitoring of growth in height. Monitoring of height was completed in August 2019, 27 months after planting. It was intended that detailed monitoring sites be representative of the range of light conditions.

The light environment for each plant was characterized using hemispherical photographs. A camera (Canon 60D camera with a Sigma 4.5 mm hemispherical lens) was mounted on a tripod, levelled and placed so that the top of the photo was facing magnetic north. Three photos were taken for each gap using automatic exposure bracketing (F 14 and ISO 100). Hemispherical photos were analysed first using the automatic thresholding algorithm in Sidelook (reference). Gap Light Analyser software (GLA; reference) was then used to calculate proportion of canopy and sky and light variables. All analyses were done using the blue channel.

For NTFP plantings a sample of 14 plots (seven at Na Bai, two at Leo and five at Na Noi), representative of the range of planting conditions, was selected for detailed monitoring of height and number of stems. In addition, we recorded whether the land was shaded or light, sloping or flat, whether there was competition from weeds. Monitoring was carried out in August 2019, 15 months after planting.

For assisted natural regeneration, GPS was used to map areas where weeding had occurred. Detailed monitoring was conducted in five 25 m² quadrats at each of the two villages (125 m² monitored at each village or 250 m² in total).

After two years, initial results showed that in Na Noi, *Alightingia siamensis* (tô hạp Điện Biên) and *Michelia mediocris* (giỗi xanh) have the highest survival rates, with 81.3% and 76.2%, respectively, the height ranges from 1.5 to 3.6 m; *Mangleitia conifera* (mỡ) has the fastest growth with the height ranging from 2.5 - 4.5 m.

In Na Bai, *Cunninghamia lanceolata* (sa mộc) and *Mangleitia conifera* (mỡ) had the highest survival rate (>80%) and good growth (height ranges from 2.5 to 4.6 m.) In the Leo village, most species also grew well. *Cunninghamia lanceolata* (sa mộc), *Manglietia conifer* (mỡ),

Chukrasia tabularis (lát hoa) and *Canarium tramdenum* (trám đen) had the survival rates of >80%, with height ranging from 1.5m to 4.3 m.

In Na Noi and Leo, after 2 years *Amomum longiligulare* (sa nhân) not bearing fruit yet, the number of stems ranges from 6 to 12 branches per clump, the height ranges from 0.5 to 2.2 m. Planting location has a great influence on survival rate and development, which may be influenced by the variation in tending (e.g., weeding). applied by different households.

Since forest trees take a long time to harvest, the project has focused on variation among species in survival rate and growth. We discuss the economic and environmental benefits according to insights from previous studies and expert estimation.

Depending on the species, harvest time can be after 7-10 years (start provide fruit) and 20-50 years for timber trees. It is estimated that after 20 years, *Canarium tramdenum* (trám đen) and *Michelia mediocris* (giổi) will have a stable fruit harvest, if 50% of the remaining crops are harvested, people in the project area can get about 30 ton of *Michelia mediocris* (giổi) seeds each year (estimated 5 kg tree⁻¹); 21 ton of *Canarium tramdenum* (trám đen) fruit (estimated 20 kg tree⁻¹) and about 60 ton of *Dracontomelon duperreanum* (sầu) fruit (estimated 70 kg tree⁻¹). In particular, after seven years, *Amomum longiligulare* (sa nhân) possible provide 200 kg year⁻¹ (estimated 60 kg ha⁻¹).

For timber, it is estimated that the total wood production (across all species) can reach over 16,000 m³ after 20-50 years with a survival rate at the time of harvest of 50%.

In terms of environmental value, the project has contributed to the protection and improvement of 76 ha of natural forests (60 ha for regeneration promotion zone and 16 ha for afforestation and enrichment zone); 20,000 scattered trees equivalent to over 20 ha of concentrated planted forest and 4 ha of NTFPs planting. The estimated total carbon at the time harvest is over 1,300 tons. Thus, the forest area of the project will contribute to the local community such as providing food, materials, and the environment benefit.

Objective 4: To understand drivers of land use change and develop cross-sector planning approaches for landscapes, integrating forests and agroforestry land uses

The studies carried out in Na Bai (Chieng Yen commune, Van Ho district, Son La province) Na Noi village (Na Nhan commune, Dien Bien district, Dien Bien province) to generate knowledge and understanding of local conditions. The results showed that the landscape and peoples' livelihoods are at risk from the continuous degradation of forest and agricultural lands, declining productivity and ecosystems conditions as well as the ecosystem services. To meet the objective of national green growth strategy, the development of the land-use plan should focus on protecting and improving natural forests and development of NTFPs, implementing reforestation on non-forest land (bare land) to expand forest areas using native tree species, improving paddy rice productivity, developing fruit trees and applying agroforestry practices with the target of improving economic incomes and environmental protection, especially improvement of head water sources and identification of potential tourism areas. For this purpose, policy and technical support are needed to achieve integrated landscape management at the local (commune) level. The supports include the technical capacity building for community-based management, investment in forest enhancement and reforestation, improved resilience to environmental related issues and securing the livelihood for local people.

The monitoring framework for integrated tree-based landscape management with monitoring, reporting and verification system was developed. The approach for monitoring includes the following key steps.

- Formulating questions to ensure accurate assessment of the planned performance results and impacts.
- Developing indicators for monitoring that help reflect the questions asked.

- Developing a baseline that will be used as the benchmark to assess whether or not the planned outputs have been met.
- Gathering data and information thorough monitoring implementation.
- Overall assessment of outputs and impacts against the baseline for improvement and policy recommendations.

The monitoring institutional arrangements for implementation of integrated tree-based landscape planning focusses on several key aspects with regards to green-growth development, including availability of guiding documents for implementation of tree-based landscape planning (1), Capacity building for stakeholders (2), and implementation and decision-making process (3).

The availability of guiding documents focuses on assessing the readiness of the legal framework for implementation of integrated tree-based landscape planning. Capacity building for stakeholders focuses on how capacity building is provided to the responsible management agencies and other stakeholders. Implementation and decision-making process provides understanding of actual implementation and the decision-making process regarding the preparation and approval of integrated tree-based landscape plans and management.

The monitoring outcomes and impact of integrated tree-based landscape management was developed with indicators: State of physical natural capital (1); Changes in ecosystem services (2); and Impact on land-based socioeconomics (3). The indicators should reflect outcomes and impact, measurable through quantitative and qualitative assessments and cost-effective. The state of physical natural capital aims to quantify how the physical capital (forests and land uses) change over time associated with landscape management plans compared to the baseline. Changes in ecosystem services used to quantitatively and qualitatively assess the quality of ecosystems influenced by the change in forest and land-management practices. Impact on land-based socio-economics used to assess socio-economic impact associated with forest and land-based management practices.

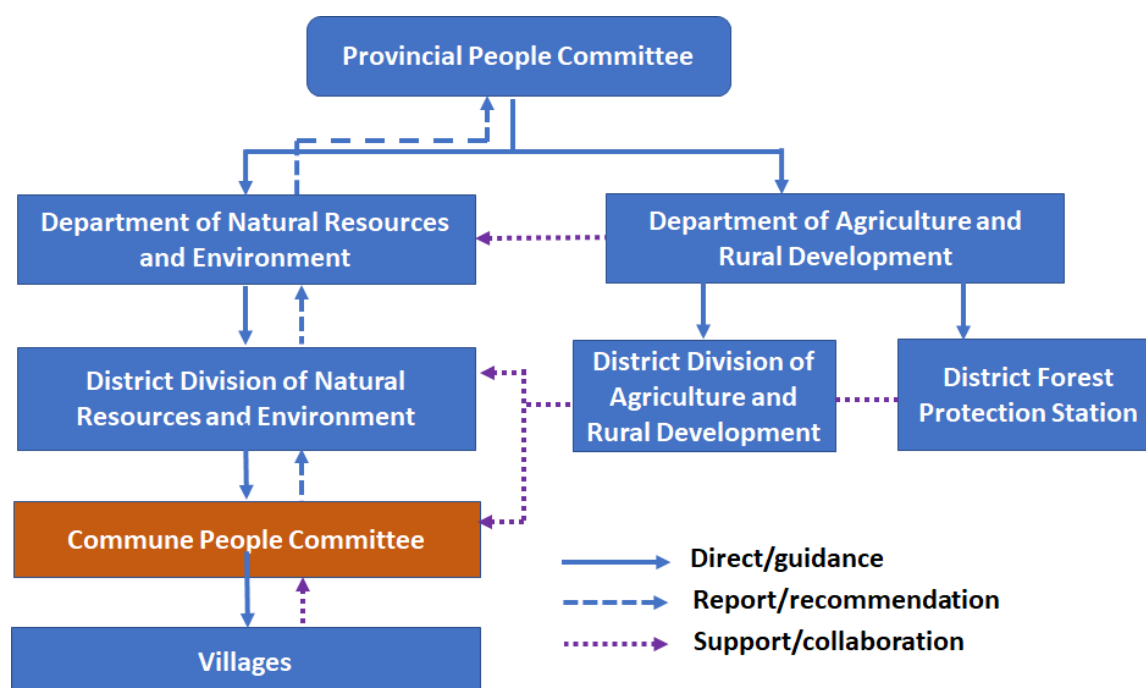


Figure 5. Institutional arrangements for monitoring of tree-based landscape management

The proposed framework for integrated tree-based landscape management are suggested in Figure 5.

At provincial level, DONRE is the lead organization for monitoring implementation. DARD is a key partner. The direct agencies of DARD at the provincial level are the Forest Protection Department and Agriculture Extension Centre. At district level, key actors that should be engaged in monitoring are DiNRE, DARD, Forest Protection Stations.

The concept of the integrated trees based landscape management in Viet Nam is still new and could be further developed for wider application across levels.

Objective 5: To develop local capacity for agroforestry, forest rehabilitation and integrated landscape management

The project has started with different trials in three provinces. Those trials were used as the instrument tool for training on field visits. Together with extension materials in the form of printed materials and video clips, the trials supported to develop various types of FDT and EL models. The new trials, FDTs and ELs, then again, were used as the visit sites to support broader extent during the project lifetime. They not only support project development target but also received the attention from government officials. Project has organized this type of training for more than 600 farmers co-operators. Moreover, conducted visiting and training farmers, extension staffs and provincial staffs from different districts and government officials from neighboring Lao PDR, to gain knowledge about agroforestry and understand more about the project.

Evaluation surveys were conducted in 2020 with 537 respondents, including farmers, extension workers, policy makers, research partners in Son La, Yen Bai and Dien Bien. The results show that, the technical support and extension materials published by project through trainings on agroforestry system establishment, management as well as grafting technique and nursery management are very useful for applying training techniques on farms. However, the use of technical materials was different between new farmers and old farmers who involve to project at different times. Rates of agroforestry adoption/expansion were high among all groups (greater than 50%) but adoptions of soil conservation techniques still low (less than 20%). Farmer adoption in soil erosion control techniques (including tree planting, grass planting on contour lines, terraced farming) faced a number of challenges. The main issue is limited knowledge on the techniques and needs more supportation.

All farmer groups expressed their social benefits by working in groups for the project at the rate of 95% of farmer involved in developed trials, 100% of farmers joined in FDT development in earlier time, 72% of new FDT and nursery farmers, 73% of EL farmers and 48% of forest rehabilitation farmers. It shows the higher rate from farmer groups participating in the project for longer time have social benefits. Those benefits are improved teamwork, connection with other farmers, ability to talk in public, decision making and their confidence to implement agroforestry, improved techniques in tree planting, grafting and management as well as improved community forest management.

Regarding gender, significant numbers of female farmers have been sharing knowledge and skills from project trainings/activities/extension materials. Women's participation in project trainings and access to extension materials can influence the impact of the project by spreading the information widely. Women were empowered through participating in Exemplar landscape.

Project staff member with different background and different specialties, directly implementing, monitoring and evaluating project activities. The knowledge and skills were gained during project implementation and created a working group capable of advising the province leaders in the process of making decisions on local agricultural development. During the period from 2017 to 2021, the project's local partners, include staff of DARDs were contributed on advising the province on issue 20 different Resolutions, Decisions and Implementation Plans, which strongly influenced rural economic development in the provinces (Table 4)

During the period 2017-2021, seven students involved in project have graduated. Include two PhD students, five MSc student. Currently four PhD students and two Master students are on-going research.

SCU –TBU collaborates on capacity building activities through training and collaboration to establish and monitor agroforestry trials and finalize agroforestry student handbooks. Series of training were organized to support TBU in capacity building activities for lecturers and students through training in experimental design, scientific working and writing, data collection, statistical analysis (using R software), soil classification, international scientific community outreach. 19 exchange students from SCU were have chance to visit and practices in Son La province under project's staff supervision.

Table 4: The distributed policies related to project activities in Dien Bien, Son La and Yen Bai province during 2017-2021

In Dien Bien province		
1	Decision No. 14/2018/QĐ-UBND issue date 26/3/2018	Decision promulgated to regulate the management and use of funds to implement a number of contents according to Circular No. 43/2017/TT-BTC dated May 12, 2017 of the Ministry of Finance on regulating the management and use of funds to implementation the National Target Program on building new rural areas in the period of 2017-2020 in Dien Bien province.
2	Decision No. 45/2018/QĐ-UBND issue date 24/12/2018	Policy promulgated to support the development of agriculture and forestry production and restructuring the agricultural sector in Dien Bien province
In Son La province		
3	Resolution No. 76/2018/NQ-HĐND issue date 4/4/2018	Policy promulgated to support the development of production, processing and consumption of safe agricultural products and food in the province for the period 2018-2021
4	Resolution No. 80/NQ-HĐND issue date 4/4/2018	Approving the project: Fruit trees development until 2020 in the province
5	Decision No. 675/QĐ-UBND issue date 30/3/2018	Regulations on density of new planting <i>Docynia indica</i> for fruit production in Son La province
6	Decision No. 1346/QĐ-UBND issue date 12/6/2018	Plan promulgated to support households that are members of agricultural cooperatives and agricultural cooperative unions which defined on Resolution No. 76/2018/NQ-HĐND dated 4/4/2018, implemented in 2018.
7	Decision No. 61/KH-UBND issue date 30/3/2018	Plan to promote trade in consumption of agricultural, forestry and fishery products and safe food in Son La province
8	Decision No. 94/KH-UBND issue date 15/5/2018	Implementation plan of fruit tree development project in the province until 2020
9	Decision No. 110/KH-UBND issue date 2/5/2018	Plan to implement the Resolution 76/2018/NQ-HĐND dated April 4, 2018 of the Provincial People's Council on policies to support the development of production, processing and consumption of safe agricultural products and food in the province. period 2018-2021
10	Implementation plan No. 114/KH-UBND issue date 19/6/2018	Plan to develop 15,000 cooperatives and cooperative unions which effectively operate until 2020 in Son La province project
11	Implementation plan No. 118/KH-UBND issue date 29/6/2018	Plan to organize promotional activities, promote consumption and promote export of Son La longan products in 2018
In Yen Bai province		
12	Resolution No. 11/NQ-HĐND issue date 2/8/2018	Restructuring the agricultural sector in association with the new rural areas contraction in Yen Bai province until 2020. In which, the developing <i>Docynia indica</i> became one of the key products targeted. The area reaches 10,000 ha, the output reaches 7,500 ton year ⁻¹ are targeted
13	Resolution No. 14/2018/NQ-HĐND issue date 2/8/2018	Regulation promulgated to implement the national target program on building new rural areas in Yen Bai province by 2020
14	Resolution No. 40/2018/NQ-HĐND issue date 08/12/2018	Amending and supplementing the item No. 1 in Resolution No. 15/2015/NQ-HĐND dated December 15, 2015 of the Provincial People Committee to support the development of agricultural, forestry and fishery production associated with industry restructuring in Yen Bai province in the period of 2016 - 2020

15	Resolution No. 69/2020/NQ-HĐND issue date 16/12/2020	Policies prescribed to support the development of agricultural, forestry and fishery production in Yen Bai province, period 2021 - 2025
16	Decision No. 183/QĐ-UBND issue date 24/1/2017	Approving funding to support the development of agricultural, forestry and fishery production in association with the project of restructuring the agricultural sector in Yen Bai province in 2017
17	Decision No. 101/QĐ-UBND issue date 29/1/2018	Approving funding to support the development of agricultural, forestry and fishery production in association with the project of restructuring the agricultural sector in Yen Bai province in 2018
18	Decision No. 415/QĐ-UBND issue date 4/3/2020	Approving funding to support the development of agricultural, forestry and fishery production in association with the project of restructuring the agricultural sector in Yen Bai province in 2017
19	Decision No. 727/QĐ-UBND issue date 28/4/2021	Approving funding to support the development of agricultural, forestry and fishery production (phase 1) in 2021
20	Decision No. 1605/QĐ-UBND issue date 30/7/2021	Approving funding to support the development of agricultural, forestry and fishery production (phase 2) in 2021

8 Impacts

8.1 Scientific impacts – now and in 5 years

Research (from this project and others) has shown that agroforestry planting on contour lines is economically effective and contribute to reducing erosion on sloping land. This effect is being recognized by local people and provincial staff, and is reflected in the farmer's perspective on scaling up, especially the support of the local government when expanding the landscape model in Quynh Nhai. In the long term, this will be a demonstration landscape model that contributes to reducing sediment input into the hydro-electric reservoirs within Son La province. The economic benefits of agroforestry are further increased when future reductions in the resourcing required for dredging reservoirs is considered.

Forest rehabilitation has been recognized as an important tool for restoring degraded forest lands, contributing to biodiversity enhancement and carbon accumulation. In addition to identifying which tree species have the highest survival and growth rates, our research has identified the key barriers to forest restoration action, and potential ways to overcome these barriers. Our methods and findings are broadly applicable, and may be applied within forest restoration projects worldwide.

8.2 Capacity impacts – now and in 5 years

Local expertise teams are formed and trained: Normally, the research findings will be given in the form of recommendations for the locality to implement after the research has been completed. However, the effectiveness of this approach can be limited, as local support is often limited after project completion. In AFLi2, capacity-building, including local officials, extension workers and farmers is carried out continuously during the project lifetime. The results of this a local team of experts. These experts have been directly advising local departments, agencies and sectors in mainstreaming research finding in agricultural development policies of the province. The series of policies issued during the project implementation period (2017-2021) are an example (summarized in section 7- Policy impacts). The National policy is also based on local consultation with advice from local governments. As a result of this, the agroforestry development targeted for Northwest described in government's decision No. 1055/QD-TTg is a reflection, in part, of this project's contribution.

Raising awareness of farmers about the benefits and skills: Through the assessment of different groups participating in the project at different times and activities, such as the group participating in trials, in the landscape model and farmer demonstration trial and the group not involved in the project (control), we found that perceived benefits of agroforestry depended on the length of time farmers were involved and the size of the model in different activities. Long-term participants in landscape activities had a better understanding compared to other groups. The control group (not participating in the project) shared the same understanding of agroforestry of reducing soil erosion and increasing income. However, they still doubted the benefits of agroforestry and have not really grasped the benefit of diverse farming techniques in reducing risks and willingness to pay. We concluded that, farmers benefited from learning and applying agroforestry skills gained through project activities. In addition, the group of farmers who participated in the project for the longest time (as collaborators on the trials) demonstrated a higher rate of applying techniques and knowledge from the training than the other groups (81%) compared to the other groups.

The group participating in forest restoration activities has the shortest project implementation time (the maximum time of the survey is two years), so the rate of technical application of this group was the lowest (43%). The training courses that farmers could recall during their participation in the project, including planting trees, tilling the soil, producing seedlings, nursery operations and nursery management, showed that farmers

remembered those activities which were relevant for their needs. They also expressed their wishes for a higher-level of knowledge, such as training in fruit tree management, especially for mango, son tra, fruit tree grafting techniques, pest control, etc. These are techniques which were carried out with a group of households that had a longer time in the project. This shows that the training activities of the project in each period of time have the effect of meeting the scientific and technical needs of the farmers.

Strengthening capacity to identify and decide on appropriate behaviors to increase resilience to disasters in the context of climate change: More than half of farmers from all groups (especially 65% of farmers involved in EL) suffered from extreme weather conditions, such as heavy rain, flash floods causing erosion in rainy season, frost in winter, drought in dry season, and scarcity of water to irrigate trees and crops. These farmers believe that the contour farming technique, as designed by the project, has a good positive effect on their resilience to climate disturbances, and can increase resource use efficiency. In particular, also through application of other auxiliary water conservation techniques (mainly constructing water tanks in farm). Through this project such farmers were empowered to understand and apply techniques.

Capacity building for forest restoration and community forest management: Evaluation results at two sites, in Na Nhan commune (Dien Bien) and Chieng Yen commune (Son La), showed that foresters and local people were highly appreciative of the collaboration with project researchers, particularly in improving the practice skills of forest regeneration, forest enrichment through multi-use tree planting and community forest management. 80% of farmers in the two sites confirmed that their community forest cover was increased by conducted forest enrichment activity. 66% of farmers confirm the improvement of forest quality. 85% of interviewed farmers said that their community forest is well protected by regular activities of the community forest protection team. The activities from the project strengthened the connection as farmers worked as a team to establish a monitoring regime at each site to monitor the survival and growth of trees and protect their community forests.

Benefits of other stakeholders: According to extension workers, policy makers and research partners (FSCN, NOMAFSI and TBU), there are a number of social benefits they have gained from working with AFLi2 project:

- Creation of new initiatives: Policy makers shared that they have developed new ideas from their experiences with AFLi2 project, for example, a policy on developing fruit trees and value chain in Dien Bien province.
- Applying knowledge and skills from project activities to other sites/projects: Project partners (DARD, institution, university) have applied knowledge and skills by implementing project activities in their other projects with the emphasis of farmer participation. Through project, research partners have gained valuable experiences to improve the quality of their teaching. The techniques learnt from project was applied in another site in Thuan Chau with plum-coffee-grass.
- Improved soft skills: Similar to farmers, stakeholders who have been working with projects improved their skills in decision making, public speaking, confidence in designing and managing agroforestry systems, organizing trainings, improving monitoring process, enhancing their connection with other project partners as well as other institutions, organizations.
- Improve knowledge sharing and learning within a group and among different groups: There has been significant change from general management to individual task allocation. Staff also learn 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.
- Increased agroforestry research and teaching capacity by TBU lecturers, consequently helping to build the capacity of future agroforesters in the region.

8.3 Community impacts – now and in 5 years

The project has received special attention from the local governments. This support is demonstrated by their support and facilitation for all project activities, their support and contribution in the expansion of the project. Project staffs are respected, and there is a clear willingness to help from local authorities and people. Moreover, the project also received cooperation and support from the scientific community and other organizations, such as GIZ, AusAID and DGRV. Their supports have also directly benefited the project cooperation farmers.

After a period of time participating in the project, the farmer cooperators have grouped in the form of cooperatives to develop the agricultural economy together, such as two cooperatives in Mai Son (Thanh Cuong in Mon village and Tan Thao in Tan Que village) and one in Tuan Giao (Toa Tinh in Hua Xa A village). Their capacity has improved through joint projects and there is board aspiration to do business under cooperative's management. This is consistent with the goal of developing the collective economic sector of the state.

8.3.1 Economic impacts

Agroforestry has contributed to the improvement of local livelihood both the short- and long-term. It has generated long term stable income from tree products, while supporting other livelihood activities (i.e., animal feed) and provide environmental benefit (i.e., soil erosion). Although it incurred large initial investment and required long-time of wait for compensation, agroforestry have been adapted well to local resources.

Forest rehabilitation models in project used multi-purpose species to help local people benefit by selling products. Most forest tree species have a long rotation, so it takes more time to get products, but people participating in the project have had certain changes in perception about the economic role of forest tree species forestry. This was through a simple comparison of economic benefits between planting forest trees and agricultural crops, with trees having benefits such as being low maintenance, intercropping with other species, suitable for planting on sloping land areas and , degraded areas. Households have raised awareness about planting, maintaining and developing forest tree areas with the long-term goal of improving the living environment and serving the needs of future generations. At present, many households in Son La and Dien Bien have registered to expand the model of scattered trees and NTFPs.

8.3.2 Social impacts

Overall, project stakeholders such as farmers, extension workers, research partners and policy makers are happy with project activities and progress. The objectives of the project are in-line with commune/district and provincial development strategies and are now supported by government in the development of plans for the Northwest.

Technical support has been provided to farmers through trainings, and developed extension materials on agroforestry system establishment, management, as well as grafting technique and nursery management.

The project has started with smallholder farmers, now they are benefitting from their experience with agroforestry and community forest activities. Those benefits are improved teamwork, connection with other farmers, ability to talk in public, decision making and their confidence to implement agroforestry, improved techniques in tree planting, grafting and management as well as improved community forest management.

An assessment targeted on the benefits of women participating in the project shows that: Nearly 70% of female farmers participated in training activities. 20% of them participated in nursery and plant breeding activities. Women rated the training content as useful, specifically improving tree-planting techniques, grafting, nursery management, improving community forest management, and wanted to continue training, especially in fruit tree

management and pest-control topics, and also wish to receive more training on production and marketing of fruit products.

Women participating in the project assessed the positive impacts of the project on ethnic minority women as social benefits they received from the project as developed soft skills such as public speaking, decision-making skills, confidence and, teamwork. Nearly 80% of women are willing to share their knowledge with family members, neighbors and friends. Thai women in Hat Lot and H'mong in Toa Tinh are more active than men in sharing knowledge from the project. In addition, they also develop skills to gather more information from a variety of sources, formal and informal, such as asking the village head or discussing it with their neighbors.

Capacity building was carried out continuously during project implementation. This was done through the joint working group containing staff with different backgrounds and, different specialties, directly implementing, monitoring and evaluating project activities. This work supported the creation of a strong team capable of advising the province leaders in the process of making decisions on local agricultural development. During the period from 2017 to 2021, the project's local partners, include staff of DARDs were contributed on advising the province on issue 20 different Resolutions, Decisions and Implementation Plans, which strongly influenced rural economic development in provinces.

8.3.3 Environmental impacts

The agroforestry systems have shown their function in reducing soil erosion in compared with monoculture systems as maize and coffee, and in maintaining the soil through building terraces using trees and grass strips within the systems. Based on the project results, a simple computer model is being developed to help estimate crop yields and carbon sequestration in agroforestry options.

Forest rehabilitation activities have been gradually contributing to raise the awareness of local people about protecting natural resources, specifically: people pay more attention to planting forestry species and, restrict the use of pesticides and chemical fertilizers in farming. These is raised awareness of livestock management, separate grazing areas have been established, and there is regular tending and protect the project's models and the community forest area of the village. Local people are also converting the use of building materials derived from wood to build houses to using other materials such as cement, iron, and steel.

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 six international journal articles, four working papers, 24 technical reports, one policy brief, two info brief and six video and blog stories and 14 extension materials in the form of book (1), fact sheet (7) and video (6). The extension materials are produced in cooperation with National Agriculture Extension Centre (NAEC) are officially used in the country. The project team was also invited for oral presentations in major conferences such as: (1) Agricultural research and development in the Northwest region; (2) 4th World Congress on Agroforestry; (3) Tropical Agriculture Conference; (4) and Advancing Sustainable Agriculture. The project cooperated activities with other funded projects such as GIZ, AusAID and DGRV are a direct result of the project's growing popularity.

9 Conclusions and recommendations

9.1 Conclusions

Agroforestry was acknowledged as one of the best options for responsible agriculture investment in sloping lands. Sustainable farming techniques designed by the project for sloping lands such as contour farming techniques, replacing monoculture with agroforestry options, especially grass strips prevented soil erosion, improved soil fertility has had a positive effect on the farmers' capacity to adapt to climate disturbances and to use resources more efficiently. Livestock grazing changed from free grazing to control grazing and utilizing grass production under agroforestry systems improved and intensified cattle farming systems. The project conclusively demonstrated that agroforestry options could improve livelihoods and sustainably improve profitability. The costs of production (weeding, labor for corn production, labor for taking cattle) could be reduced. Sources of income from farms could be diversified (fruit, short-term crops, long-term crops/tree, grass production and cattle raising). There would be potential economic gains from soil erosion prevention and degradation reduction. This resulted in higher income for farmers but also environmental protection. There was an improved awareness by farmers of sustainable agroforestry systems, cooperatives to optimize profitability and market access were priorities.

Forest rehabilitation has been considered as an important tool for restoring degraded forest lands, contributing to biodiversity enhancement and carbon accumulation. Potentially there would be economic gains from forestry trees, environmental services, and ecological landscape tourism in line with local provinces' development strategies. Capacity building for forest restoration and community forest management has been enhanced by project as farmers' capacity in improving the practice skills of forest regeneration, forest enrichment through multi-use tree planting and community forest management. The sense of community and the development of cooperative and/or cooperating group was a strong feature of the project. There was community agreement for joint actions towards socio-economic development and environmental protection.

Local governments, scientific communities and private organizations cooperated with farmers in research projects. The research partners have increased their capacity through training activities and carry out project activities. The capacity of local leaders of provincial DARDs in three provinces, and the leaders and staff of extension systems from provincial to communal levels have been much enhanced. They have engaged in policy-making processes at their respective management levels leading to positive changes in range of issues on the development of agriculture and forestry production, restructuring the agricultural sector, promoting trade in consumption of agricultural and forestry products and safe food.

However, there are still a lot of challenges to have these impacts translated across the landscape. Despite this, the project has contributed in changing consciousness and providing methodologies to support this process. It is a useful literature supported the "National plan to adapt to climate changes during the period of 2021-2030, with a vision to 2050" on "Supporting the application of agroforestry solutions for the development of fruit trees, in order to improve livelihoods and adapt to the climate change for the people in the Northwestern region of Vietnam" (Decision No. 1055 / QĐ-TTg).

9.2 Recommendations

The project recommends that future agroforestry and forest rehabilitation programs in the Northwest considers the following:

1. Agroforestry research should be continued with more options and continued to development towards landscape scale implementation. Value can be added by associating with tourism and service activities
2. The current fruit tree-based agroforestry is developed, and this fits with local general development direction on promoting fruit tree development. The next research activities should focus on improving the quality of fruit product.
3. Agroforestry was considered on Nationally Determined Contributions (NDC) and recognized as a solution to GHG emissions reductions in Vietnam period 2021-2030. Research should focus on quantifying the contribution of agroforestry to soil and water protection, carbon storage, On this basis, recommendation for policies of payment for environmental services for agroforestry could be made.
4. Local government policies are encouraging the establishment of farming cooperatives, supported to achieve the necessary certificates required by markets. However, in reality, farmers are not really interested, partly aware of their limited capacity in coordinating and various skills. To encourage farmers to form cooperatives and the cooperative's possible working as enterprise and doing business associated with the market, they need further training. In addition, it is necessary to take into account what policies are needed to support each stage of the development of these cooperatives.
5. Continuing research on non-timber forest products, focusing on locally available and potential species, species which are currently in decline due to economic inefficiency.
6. The development of research on forest rehabilitation needs to be expanded at the catchment level, with the aim of reducing erosion throughout the basin. Which kinds of species to plant? Where exactly they should be planted? And in what order should they be planted? Furthermore, honing techniques for measurement of the environmental impacts of these actions
7. Agroforestry suitability mapping was implemented in three provinces. The next direction could be more detailed mapping at the district level, which would greater practical application. In addition, it is necessary to link with the proposed impact forecast of soil erosion. This is the basis for building erosion maps at the district and provincial scale and applying the soil erosion calculation models. Moreover, to support local governments, scientists, farmers and others to manage and use the information, activities such as building spatial databases (via mobile applications, webGIS) with integrated regional potential maps, appropriate areas, agroforestry options, crop's management, farming guidelines, etc. should be implemented.
8. Agroforestry and forest rehabilitation researchers, anyhow, should be expanded by linking with education in universities and schools
9. The above studies should be consolidated and brought to the dialogue around for achieving policies to support agroforestry and forest rehabilitation options adapting local conditions from the government, and with involvement from private sectors to solving the difficult problems at the provincial level.
10. Improving farmers' knowledge and techniques on soil erosion control remained a critical issue together with improving access to project extension materials, especially for ethnic minority women.
11. Market development for fruits should be strengthened with supporting standard (VietGAP, organic, sourcing area codes) for fruits like mango, plum, longan.
12. Consider the time constraints of women and propose project interventions that are sensitive to this and include support services such as childcare. Implement agricultural training that targets women from a wider community project base and addresses women's time-poverty and empowerment needs.
13. Continue to support marketing for agricultural products and invite stakeholders to invest in processing project agricultural products. For example: *Docynia indica* area in Yen Bai province has increased over 9,000 ha, currently reached about ten tons of fruit, in the coming years, there will be over 100,000 tons of fruit year⁻¹. From local

government side, Yen Bai province already has a policy to support enterprises in production, consumption and processing of products.

10References

10.1 References cited in report

National plan to adapt to climate changes during the period of 2021-2030, with a vision to 2050. Decision No. 1055 / QĐ-TTg. Thủ viện pháp luật. <https://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyết-dinh-1055-QĐ-TTg-2020-Ke-hoach-quoc-gia-thích-ung-voi-bien-doi-khi-hau-2021-2030-447740.aspx>

10.2 List of publications produced by project

In summary, the project has produced a total 6 international journal articles, 4 working papers, 1 policy brief, 2 info briefs, 24 technical reports, 1 extension material in the form of book, 7 extension materials in the form of fact sheet, 6 extension materials in the form of video and 6 video clips and blogs.

Publication/Communication type	Title
International journal article (6)	<ol style="list-style-type: none"> 1. Ha Van Tiep, Pham Huu Thuong, La Nguyen, Hoang Thi Lua, Vu Van Thuan, Lo Thi Kieu, Sammy Carsan, Ann Degrande, Delia Catacutan & Chris Harwood, 2018. Domestication of <i>Docynia indica</i> in Vietnam. <i>Forests, Trees and Livelihoods</i>. Volume 27, 2018 - Issue 4, Pages 230-242. Published online: 06 Sep 2018 2. Heidi C. Zimmer, Hanh Le Thi, Duc Lo, Jack Baynes, J. Doland Nichols, 2018. Why do farmers still grow corn on steep slopes in northwest Vietnam? <i>Agroforest System</i>. 2018, Volume 92, Issue 6, pp 1721–1735. 3. Van Hung Do, Nguyen La, Rachmat Mulia, Göran Bergkvist, A. Sigrun Dahlin, Van Thach Nguyen, Huu Thuong Pham, Ingrid Öborn, 2020. Fruit Tree-Based Agroforestry Systems for Smallholder Farmers in Northwest Vietnam—A Quantitative and Qualitative Assessment. <i>Land</i> 2020, 9(11), 451; https://doi.org/10.3390/land9110451 4. Hoa Do, Eike Luedeling, Cory Whitney, 2020. Decision analysis of agroforestry options reveals adoption risks for resource-poor farmers. <i>Agronomy for Sustainable Development</i> (2020) 40: 20. https://doi.org/10.1007/s13593-020-00624-5 5. Trong Hoan Do, Tan Phuong Vu, Delia Catacutan, Van Truong Nguyen., 2020. Governing Landscapes for Ecosystem Services: A Participatory Land Use Scenario Development in the Northwest Montane Region of Vietnam. <i>Environmental Management</i>. DOI 10.1007/s00267-020-01378-2 6. Nguyen, M.P.; Pagella, T.; Catacutan, D.C.; Nguyen, T.Q.; Sinclair, F., 2021. Adoption of Agroforestry in Northwest Viet Nam: What Roles Do Social and Cultural Norms Play? <i>Forests</i> 2021, 12, 493. https://doi.org/10.3390/f12040493

Working paper (4)	<ol style="list-style-type: none"> 1. WP21015.PDF.Do TH, Nguyen VT and Vu TP. 2018. Landscape tree cover transition, drivers and stakeholder perspectives – A case study in Na Nhan commune, Dien Bien province, Vietnam. Working Paper 279. Hanoi, Viet Nam: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. DOI: http://dx.doi.org/10.5716/WP18006.PDF 2. Vu TP, Nguyen VT, Do TH, Hoang NVH, Nguyen DK.. 2020. Understanding tree-cover transitions, drivers and stakeholders' perspectives for effective landscape governance: a case study of Chieng Yen Commune, Son La Province, Viet Nam. Working Paper Working Paper No. 317. Hanoi, Viet Nam: World Agroforestry (ICRAF). DOI: https://dx.doi.org/10.5716/WP21023.PDF 3. Nguyen MP, North H, Duong MT, Nguyen MC. 2021. Assessment of women's benefits and constraints in participating in agroforestry exemplar landscapes. Working paper 315. Nairobi, Kenya: World Agroforestry (ICRAF). https://dx.doi.org/10.5716/ 4. Vu TP, Nguyen VT, Do TH. 2021. Commune-level institutional arrangements and monitoring framework for integrated treebased landscape management. Working Paper No.318. Ha Noi, Viet Nam: World Agroforestry (ICRAF). DOI: https://dx.doi.org/10.5716/WP21024.PDF
Policy brief (1)	<ol style="list-style-type: none"> 1. Improving Land Use Planning: An integrated Tree Based Planning Approach
Infor brief (2)	<ol style="list-style-type: none"> 1. Gender and Ethnicity in Vietnam Agroforestry Landscapes: Lessons for Project Implementation 2. Land uses, ecosystem services, and governance mechanisms for integrated landscape management in Na Nhan commune, Dien Bien Province, Northwest Viet Nam.
Technical report (24)	<ol style="list-style-type: none"> 1. No. 1: The timber tree species in forest plantation in Northwest Vietnam - Native and exotic species proposed for testing in different elevations in Dien Bien province 2. No. 2: Review variation in and location of ethnic groups and extent of migration in the Northwest of Vietnam 3. No. 3: Potential for agroforestry development assessment in Dien Bien, Son La and Yen Bai provinces 4. No. 4: Ethnographic profile summarizing preferences, constraints and opportunities for agroforestry adoption by different ethnic groups across three provinces in Northwest Vietnam" is available 5. No. 5: Local knowledge relating to tree establishment and management and culturally specific aspects of adopting market-based agroforestry including differential preferences according to gender and age 6. No. 6: Agroforestry - current judgements of stakeholder and vision for development 7. No. 7: Developing a farm business model for livelihood enhancement of smallholder farmers in Northwest Vietnam 8. No. 8: Exploring opportunities and challenges in agricultural development through the gender lens - A case

	study in a H'mong community, Dien Bien province in Vietnam
	9. No. 9: Understanding forest degradation and rehabilitation in northwestern Vietnam
	10. No. 10: Monitoring mechanism for forest rehabilitation in Na Bai and Na Noi village
	11. No. 11: Historical land use and carbon stock change: A case study in Na Nhan commune, Dien Bien province
	12. No. 12: Scaling up agroforestry through the FDT and EL approach, ecological and economic benefits, and lessons learnt
	13. No. 13: Creating market linkage to support livelihoods of smallholder farmers in Northwest Viet Nam
	14. No. 14: Community forest management plan for Na Bai, Na Noi and Leo villages
	15. No. 15: Strengthen the community forest management group in Na Bai, Na Noi and Leo villages
	16. No. 16: Women's participation in forest rehabilitation activities in Na Bai, Na Noi and Leo villages
	17. No. 17: Status of application of policies on forest rehabilitation in Northwest Vietnam
	18. No. 18: Cross-sites Analysis - Tree cover transition, drivers, and stakeholder perspectives for effective landscape governance
	19. No. 19: Commune level institutional arrangement and monitoring framework for integrated tree-based landscape management
	20. No. 20: The economic benefit and potential of soil conservation through agroforestry options on sloping cultivation in Northwest Vietnam
	21. No. 21: <i>Docynia indica</i> clonal trial, fruit quality assessment of 36 superior clones, and improving activities for sontra orchards
	22. No. 22: Complementarity of trees and crops/forages in agroforestry systems and their economic and ecological benefit compared to other land uses in Northwest Vietnam
	23. No. 23: Testing native and exotic timber tree species across an elevation gradient in Northwest Vietnam - Tree domestication guide for selected native and exotic timber tree species
	24. No. 24: Project monitoring and evaluation report
Extension material- Book (1)	1. Sustainable Agroforestry Farming for Northern Midlands and Mountains areas. Ministry of Agriculture and Rural Development. National Agriculture Extension Centre. Hanoi Agriculture Publishing House, 2020.
Extension material - Fact sheet (7)	1. Agroforestry technical manual - Option: Son tra-forage grasses 2. Agroforestry technical manual - Option: Acacia-mango-maize-forage grass 3. Agroforestry technical manual - Option: Longan-maize-forage grass 4. Agroforestry technical manual - Option: Shan tea-forage grasses 5. Agroforestry technical manual - Option: Acacia-longan-coffee-soybeans-forage grass

	<ol style="list-style-type: none"> 6. Agroforestry technical manual - Option: Teak-plum-coffee-soybeans-forage grass 7. Agroforestry technical manual - Option: Macadamia-coffee-soybeans
Extension material- Video (6)	<ol style="list-style-type: none"> 1. What is agroforestry. Link: https://www.youtube.com/watch?v=-ZJUCIDD7Gg&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi 2. How to establish contour lines on sloping land. Link: https://www.youtube.com/watch?v=cjsPIbeOYOc&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=2 3. Designing an agroforestry system with trees, crops and forage grass. Link: https://www.youtube.com/watch?v=ZBakN4wThzU&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=3 4. Designing an agroforestry system with timber trees, fruit trees, coffee, crops and forage grass. Link: https://www.youtube.com/watch?v=DUJt8CB6rxU&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=4 5. Designing an agroforestry system with trees, forage grass, fishponds and livestock. Link: https://www.youtube.com/watch?v=uEwBoIIRIE0&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=5 6. Propagation techniques of fruit trees by grafting. Link: https://www.youtube.com/watch?v=UXI5P1WdeE&list=PLhnzWXR6gFgqyls_FhgtYIVYxjq0n-LNi&index=6
Video/blog (6)	<ol style="list-style-type: none"> 1. Understanding gendered opportunities and challenges in upland Northwest Vietnam. Link: https://www.youtube.com/watch?v=LJBucc0RTJk 2. Profiting from well-chosen tree species: improving the productivity of farming systems in Northwestern Vietnam. https://www.worldagroforestry.org/blog/2017/04/11/profitin-g-well-chosen-tree-species-improving-productivity-farming-systems-northwestern-vietnam?kid=2857 3. Son tra marketing strategy. https://www.worldagroforestry.org/publication/son-tra-marketing-strategy?kid=609 4. Successful agroforestry options in Viet Nam. https://www.worldagroforestry.org/blog/2019/06/19/successful-agroforestry-options-viet-nam?kid=609 5. Domestication of son tra. https://www.worldagroforestry.org/blog/2020/10/07/domestication-son-tra?kid=609 6. Final workshop and closing ceremony 10 years ACIAR's agroforestry program. Economic Department, HTV, Vietnam. Link: https://www.dropbox.com/s/30lua95mdxqj2eh/ACIAR_10_years_Agroforestry_HTV.mp4?dl=0

11 Appendixes

11.1 Appendix 1:

Original copies of all publications, technical reports, extension materials and videos. Link:

https://www.dropbox.com/sh/zn7ks34jvjc8kv/AAAC5UEV9_WFWp4eE53R_BCva?dl=0