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Final report

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1 Acknowledgements

This report presents the results and outcomes of extensive collaboration and the active involvement of researchers from FAVRI, local Son La government officials, value chain actors, extension staff and farmers in Vietnam.

Special thanks go to Dr Nguyen Quoc Hung for his leadership and Ms Le Thi Ha for highly skilful management of project administration, finance and organisation of major events.

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Finally, thanks go to Ms Jenny Margetts and two research assistants, Dinh Thi Huyen Tram and Vu Thi Phuong Thanh; their commitment, enthusiasm, and energy made this project happen.

2 Executive summary

The completed SRA has capitalised on research from Project AGB-2012- 060, “Improving smallholder incomes in the North-western highlands of Vietnam by increasing access and competitiveness in regional temperate fruit markets” and established facilities and processes for developing the apple fruit industry in Son La province, led by the private sector.

Temperate Fruit Association of Son La province was established and administrative, management and financial capacity were built.

The association's mission is to represent the interest of temperate fruit industry stakeholders (nurseries, producers, traders and processors) and facilitate their cooperation and information exchange to promote the sustainable development of the temperate fruit industry in Son La province.

The objectives for 2020-2025 were formulated as follows:

1. Strengthening collaboration of fruit farmers: especially support resource-poor farmers.
2. Cultivation, post-harvest, and processing improvement: training, study tours, development of the productions and post-harvest protocols.
3. High-value varieties testing and commercialisation
4. Production expanding and improving fruit quality and sustainable volume
5. Evaluate potential market approaches
6. Exchange information: market, experience and authority's regulations
7. Representative of fruit farmers in Sơn La to build the external networks

The Association has a website with up-to-date technical and market information covering plums, pears, peaches, persimmon and avocado. The website also provides an easy-to-use fertiliser calculator helping members and other farmers to optimise fertiliser use. The Association organised several training sessions covering orchard establishment, including intercropping with legumes and other broadacre crops, soil management and IPM. SRA team organised a study tour to Da Lat and several central provinces to learn about modern nursery production and processing.

The Association and Son La provincial nursery developed a commercialisation and royalty collection plan and successfully established registration trials to evaluate three varieties of peaches, UF Sun, UF Beauty and UF One, and one nectarine variety Fla. 98-8CNW under cooler climate conditions in Moc Chau/Van Ho and warm conditions in Mai Son. Initial results are positive for all three peach varieties, with UF One being preferred. However, UF One is a late variety, while the other two are earlier varieties; hence if all three gain registration harvesting period will be more than two months.

The SRA also provided an audit of major temperate fruit processing facilities, evaluated several new products and provided recommendations for improvements, of which improved drying of plums and production of mango puree were implemented. The development of cider production was interrupted by the COVID-19 epidemic.

The project team conducted research on Hmong apple supply chains and potential market developments. Hmong apple producers experienced a dramatic reduction in prices due to overproduction. The main recommendations from that research are:

- Halt further expansion of production areas until supply chains improve and new markets are established
- Form farmers' groups and cooperatives to take advantage of the government's existing support policies to develop fresh and processed Hmong apple supply chains and processing facilities.
- Improve the capacity, productivity, quality, and diversity of products processed from Hmong apples.

- Increase economic efficiency of Hmong apple orchards and supply chains and create market linkages for smallholders

Despite these successes, there is considerable risk that the Association will not be able to complete the commercialisation of varieties without further support since it was established during COVID-19 restrictions and hence could only function in a limited capacity during the last half of 2020 and the first half of 2021, when the SRA finished.

We recommend that ACIAR supports the following activities:

- On-going monitoring and review of the performance of new varieties in the field
- Development of a legal framework for the distribution of licenced varieties between the Association, plant nursery licence holders and farmer licence holders
- Training of Association staff in the management and administration of varietal material
- Creation of content and maintenance of communication through the Association website concerning new varieties and other sector development activities

Another activity that could not be completed due to COVID-19 and that should be supported in the future is developing technologies to produce cider from various fruits, including the Hmong apple.

Finally, funding research for the market development of Hmong apples and the development of functional food products from Hmong apples should be prioritised to address the huge oversupply of this fruit.

3 Background

Project AGB-2012-060 has identified major key constraints for temperate fruit development, most important being 1) lack of coordination between different stakeholders in the private sector (seedling producers, growers, traders and retailers) and between the private sector and local government, and 2) the limited number of varieties available to growers, which often lead to an oversupply of few products in a short time and subsequently drop or collapse in price. This SRA

3.1 The need to improve sector coordination and planning

The lack of coordination between different stakeholders in the private sector (seedling producers, growers, traders and retailers) and between the private sector and local government has been resulting in un-coordinated government-led sector planning with little basis on market information which often leads to overproduction and collapse of price. The strategic plan for the temperate fruit sectors in Son La provinces was developed to address this issue. The plan was developed in consultation with several Government departments, including the Department of Agriculture & Regional Development and its various sub-departments; the Department of Science and Technology; and private industry stakeholders, including nurseries, farmers, cooperatives, traders and retailers. There has been strong support for the plan, which reflects the desire for effective management of the sector that achieves sustainable and profitable growth into the future.

During this process, it became evident that no single agency or organisation could take effective ownership of the plan and facilitate its implementation, as the plan spans numerous government departments and value chain stakeholder groups. The solution was found in the formation of the temperate fruit industry association in Son La province. The idea of the association has been very well received by both provincial and district level governments and the private sector stakeholders.

Formation of the Son La Temperate Fruit Association

At a workshop organised by ACIAR ABG-2012-060 project in May 2018, the major stakeholders in Son La province agreed that they would progress the formation of the Son La Temperate Fruit Association and have subsequently created a nucleus group to progress this initiative through the necessary government registration processes. The main objectives of the Association will be to:

- Seek members including nurseries, farmers, cooperatives, traders and processors
- Facilitate a coordinated approach to industry development
- Facilitate communication of information and data. This would include developing a mobile-friendly website (portal) to provide technical support, policy advice, and economic and market information.
- Encourage members to work collaboratively and to create profitable value chains (note: the Association would not be involved in the commercial trade of nursery trees, flowers or fruit but would support its members in developing their commercial activities)
- Set industry quality standards and promote the adoption of these standards across all stakeholder groups. In addition, advocate for research, training and technical support to achieve this outcome.
- Liaise with the government to ensure appropriate planning and policies are in place for the benefit of the sector stakeholders

- Assist with the coordination of RD&E and marketing on behalf of its members and the broader stakeholder groups (including smallholders, women and ethnic minority groups).
- Develop relationships and cooperate with government organisations, local authorities, other social and professional organisations, international organisations, news agencies and other relevant organisations to develop and improve the competitiveness of the temperate fruit sector. Specifically, the Association can assist in informing projects undertaken by international donors such as ACIAR, CIRAD etc.
- Determine the needs for and facilitate the introduction of new varieties to diversify production and prolong production seasons
- Promote engagement and develop the capacity of women and ethnic minority groups
- Promote safe labour conditions, including the safe use of chemicals.

There is a requirement to provide initial support/resources to ensure the Son La Temperate Fruit Association is successful.

3.2 The need to diversify products

Another factor that hinders the development of temperate fruit production in North-West Vietnam is the limited number of varieties available to growers, which often leads to an oversupply of few products in a short time and subsequently drop or collapse in price. This is due to an under-developed nursery industry that suffers from lack of autonomy from government institutions, over-reliance on projects, a lack of entrepreneurship and international contacts and inability to collect royalties, and thus has limited access to new varieties.

Hence there is a need to introduce new varieties that:

- Are more productive and perform under the local environmental and production conditions
- Extend the harvest period, to reduce the concentration of supply at one time
- Meet customer/consumer needs and provides the opportunity for growers to be competitive in the different market segments that they decide to target (including processing, local markets or higher value city markets).

Access to new varieties which are covered by Plant Breeders Rights (PBR) or licencing fees requires the sector to adopt new governance procedures, so that the management of these varieties is conducted in a manner that is consistent with the regulatory, legal and contractual requirements and allows for royalties or licence fees to be collected. As such, a considered process and business model need to be embedded to ensure the success of any new introduction, and potentially the Association can be the holder of the master license agreements for new varieties. There is also a need to enhance technical capacity of local nurseries to ensure proper management of new varieties and improve quality of seedlings, thus giving farmers' confidence to invest in improved varieties.

Another strategy to diversify production and reduce pressure on price in Son La is processing. From 2014 to 2016, production area of plum – Son La's most important temperate fruit – increased by more than 40%, from 2784ha to 4054ha. Thus, in the next 3 or 4 years a huge increase in plum volume is expected. However, market for fresh plum will not be likely to expand significantly as domestic market and export market (to China) have already reach their limits. Therefore the project will aim to explore different opportunities for processing plum and other fruits as a way to mitigate the effect from the upcoming increase

in production volume. First step will be to analyse the current market situation in terms of the existing supply chains and to understand the capacity of the sector and the technologies being utilised. This understanding will help with identification of areas where improvements could be made, and where future investment may be required.

4 Objectives

Aim:

Strengthen leadership, coordination and economic development of the temperate fruit industry in northern Vietnam through the formation and development of a professional and inclusive multi-stakeholder industry association.

Objective:

1. Develop and analyse group organisational structures, communication mechanisms, information collection and management systems required for an industry association to function efficiently and benefit its stakeholders. At the same time, develop core leadership and governance capacity of association members and ensure the inclusion of women and ethnic minority groups

2. Implement and evaluate options to enhance temperate fruit nursery industry's production and variety management capacity and improve Son La temperate fruit sector's access to improved varieties outside Vietnam.

3. Develop capability of the association to evaluate and capitalise on opportunities for temperate fruit processing

5 Methodology

Objective 1. Develop group organisational structures, communication mechanisms, information collection and management systems required for an industry association to function efficiently and benefit its stakeholders. At the same time, develop core leadership and governance capacity of association members and ensure the inclusion of women and ethnic minority groups

Evaluation of major Australian and Vietnamese association statutes and bylaws; interviews with association officials and key stakeholders; cross visits to Australian and Vietnamese association.

Objective 2. Enhance temperate fruit nursery industry's production and variety management capacity and improve Son La temperate fruit sector's access to improved varieties outside Vietnam.

Working face to face with major nurseries in Son La to develop business plan and develop protocols for introduction of PBR varieties. Organise exchange of information between Australian and Vietnamese nurseries.

Objective 3.Support the association to evaluate and capitalise on opportunities for temperate fruit processing

Conduct a rapid market appraisal of Hanoi market for processed products. Through consultative process with key association stakeholders prioritise market segments.

Conduct participatory assessment of market research results followed by technical support (development of technological protocols)for local initiatives. This process will involve various stakeholders in fruit processing industry, including local processors and retailers at end markets.

6 Achievements against activities and outputs/milestones

Objective 1: Develop group organisational structures, communication mechanisms, information collection and management systems required for an industry association to function efficiently and benefit its stakeholders.

no	Activity	What has been done	Comment
1.1	Engage with the Association's working group (formed under project ACIAR AGB/2012/060) to study different forms of associations from Vietnam and Australia.	The Working group visited Australia, studied Macadamia and Avocado associations, and adopted a broad industry association model that includes individual farmers and farmers' cooperatives, traders and processors. Provincial and district DARDs and PCs are the Association's associates but not members.	The Association established a long-term contractual relationship with ANFIC and developed a relationship with Summer Fruit, the Australian stonefruit association.
1.2	Work with the Association's working group to identify suitable organisational structures, communication mechanisms, and information management and sharing systems required for an industry association to function efficiently and benefit its stakeholders.	The Charter for the Association was written and approved by the Peoples Committee, and the Association was officially established in the First Assembly on the 2nd of June 2020. The Association office was established at the 19th May Cooperatives HQ. Part-time Admin staff employed. The Association working group decided to develop a website as the primary communication platform and to release regular newsletters as an additional communication channel.	
1.3	Develop a website for the Association as a platform for information sharing and communication. Explore different ways with which the website can benefit association members in particular and Son La temperate fruit industry in general. Promote the use of the association website	The project team, Association's temporary board and Ms Jenny Margetts developed the website structure and visual design. Bach Khoa Hitech Co. Ltd was contracted and developed the website design. The project team led by Vu Thi Phuong Thanh and Nguyen Van Hai developed website content focusing on plum, peach, persimmon, pear and avocado.	The Association Website http://quaondoisonla.vn/
1.4	Organise three workshops to facilitate association activities, exchange of information and knowledge about processing technologies, market potentials for the processed products, and introduction and management of PBR varieties.	The association convention was organised on 02/06/20. The Association members agreed on their mission, objectives, and future activities at the Convention. The Association organised training workshop for its members on pruning and pest management of stonefruit on 30/03/2021.	Due to COVID-19 the 3rd workshop on

PC = partner country, A = Australia

Objective 2: Enhance the temperate fruit nursery industry's production and variety management capacity and improve the Son La temperate fruit sector's access to improved varieties outside Vietnam.

no	Activity	What has been done	Comment
2.1	Identify suitable varieties to be introduced to North-West Vietnam to diversify products and extend the harvest period.	ANFIC licenced three low-chill non-melting peach varieties, UF Sun, UF One and UF Beauty, and one nectarine variety Fla.98-8CNW to Son La Variety Centre for evaluation and the Association for commercialisation. All varieties were imported into Son La and are undergoing testing.	
2.2	Work with the association and local nurseries to develop a sustainable business model, and the variety protection and royalty collection mechanism to conform with international standards, and thus get access to modern protected varieties	Son La Temperate Fruit Association signed the exclusive licensee for commercialised varieties in Vietnam with ANFIC. The Association's working group, together with the ACIAR project's research team, has developed a model for the commercialisation of licensed varieties with three main pillars: (1) variety protection based on controlled seedling production, with association nursery members having exclusive right to produce seedlings and responsibility to report all sales (2) royalty collection based on the planting area at A$1,000/ha (3) development of an exclusive supply chain to protect the interest of complying farmers	Current project C002720 "Supporting temperate fruit sector development in Son La province Vietnam" finalising legal documents for the Association to licence nurseries to produce grafted seedlings of new varieties and farmers to establish orchards.
2.3	Facilitation of linkages with, and learnings from other Vietnamese and Australian horticultural associations and nursery businesses to foster the exchange of ideas and information.	Linkages with ANFIC and Summer Fruits were established. Initial relationship with Tasmanian cider brewers was established, but the visit of Australian businesses and farmers to Sol La was cancelled due to COVID-19 travel restrictions. Project organised visit for the Association members to Da Lat and My Tho to study nursery production instead.	

PC = partner country, A = Australia

Objective 3: Support the Association to evaluate and capitalise on opportunities for temperate fruit processing.

no	Activity	What has been done	Comment
3.1	Through the consultative process, identify current processed temperate fruits products and map their distribution channels with key association stakeholders, prioritise market segments for processed fruits and extend the harvest period.	Main processors and processed products were identified.	
3.2	A critical assessment of processing technologies and production management of local processors in Son La and recommendation for improvement	Assessment completed and report submitted.	
3.3	Facilitate business to business learning between Son La and Australian processors Due to COVID-19, this activity was changed to: Facilitate business to business learning between Son La and Vietnamese nurseries and processors	Project facilitated business to business learning between the Vietnamese businesses in Da Lat and the Mekong delta. The study tour was organised for the Association members to Da Lat and My Tho to study nursery production and processing.	The project team organised a trip to Tasmania in March 2020 but had to cancel it due to the COVID-19 outbreak. In cooperation with UTas, the project team also secured additional funding from the Crawford foundation for a visit by Tasmanian brewers to Son La province in May 2020, but that was also cancelled.

PC = partner country, A = Australia

7 Key results and discussion

7.1 The Son La Temperate Fruit Association

7.1.1 Establishment of the Association

The formation of Son La Temperate Fruit Association has been a long process that started in 2018 as a part of the recently completed ACIAR project AGB/2012/060. After a series of consultations between the project team and the provincial government, nurseries, cooperatives, large farmers, traders and processors across Son La province, a stakeholder workshop was organised in June 2018. At the workshop, the need to form an industry association was endorsed and the Association's objectives were formulated: (1) to facilitate collaboration between different stakeholders in the industry, including nurseries, growers, traders, processors and local governments; (2) to liaise with the government and inform the planning and policymaking processes; (3) to develop a strategic plan for the industry; and (4) to promote R&D and quality control, especially in processing and in the introduction of new varieties. After the workshop, the local private stakeholders formed a working group to pursue the registration process.

However, during a subsequent meeting between the project team and DARD Son La, it became apparent that establishing an association is a very politically sensitive issue. There were a complex series of approvals that the working group needed to secure, including the approval from the Vietnamese Communist Party.

To help local stakeholders to develop a convincing case for the Association, the project organised a visit to Australia in October 2018 for one representative from Son La DARD and three core members from the working group (from the private sector) to learn from the examples of Australian industry associations (Macadamia Society and Avocado Association). The Son La delegation also visited the Australian Nurserymen's Fruit Improvement Company Ltd (ANFIC), which resulted in the introduction of new peach and nectarine varieties into Son La. Exposure to the Australian industry associations and the way production and trade of stone fruit are organised in Australia helped Son La stakeholders to solidify their own vision for a Son La Temperate Fruit Association. Subsequently, a proposal was developed to form the Son La Temperate Fruit Association, which was submitted to the Son La People's Committee.

On the 1st of April 2019, the working group secured the province's permission to form a "mobilisation group" to seek membership and form the Association. The group had seven members, four cooperatives/enterprise directors, two large traders, and a nursery director. The group's chairperson, Mr Mai Duc Thinh, is the director of a major cooperative in Son La. In December 2019, the group finally enrolled more than 50 members (including five enterprises) to satisfy the requirement for a minimum number of members so they could apply to the Son La People's Committee to approve the Convention of the Association. On the 6th of February 2020, Son La People's Committee issued a decree allowing the organisation of the Association Convention, which was held on the 2nd of June 2020 in Moc Chau when the Temperate Fruit Association of Son La was officially formed.

7.1.2 Association mission, five-year objectives and operation

At the Foundation Convention, the association members formulated a mission statement and objectives for 2020 to 2025. They also elected the president, two vice presidents, and five commissioners (board members).

The association's mission is to represent the interest of temperate fruit industry stakeholders (nurseries, producers, traders and processors) and facilitate their cooperation and information exchange to promote the sustainable development of the temperate fruit industry in Son La province.

The objectives for 2020-2025 were formulated as follows:

8. Strengthening collaboration of fruit farmers: especially support resource-poor farmers.
9. Cultivation, post-harvest, and processing improvement: training, study tours, development of the productions and post-harvest protocols.
10. High-value varieties testing and commercialisation
11. Production expanding and improving fruit quality and sustainable volume
12. Evaluate potential market approaches
13. Exchange information: market, experience and authority's regulations
14. Representative of fruit farmers in Sơn La to build the external networks

The "mobilisation group" members were confirmed as executives, and some new board members were elected. Mr Mai Duc Thinh, the director of "19 May Cooperative", was elected president, Mr Ha Van Lan, the director of "Son La Breeding Centre", and Nguyen Van Ngoc, former vice-director of Moc Chau DARD and currently a private agricultural consultant were elected vice presidents (See Figure). Ms Nguyen Thi Kim Anh was elected secretary, a part-time paid position, the only Association's paid position.

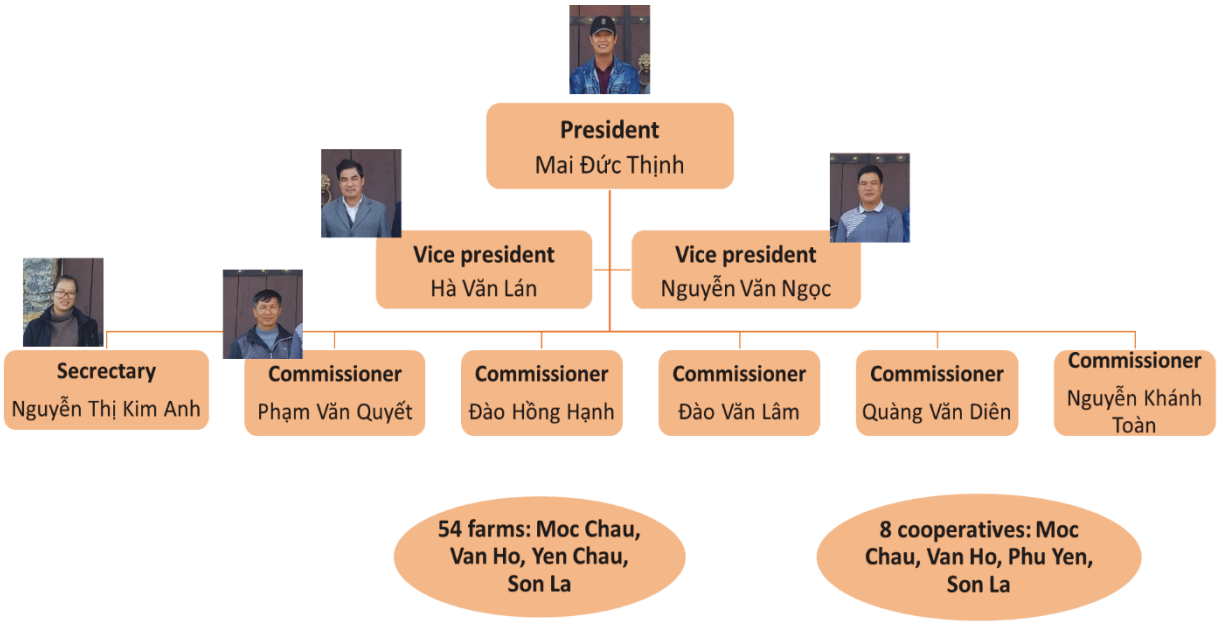


Figure1: The Association's management structure

Picture 1: The Foundation Convention and the Association executives in front of the Associations office in the "19 May Cooperative" building.

Young independent designer Mr Phuc developed the Association logo (Fig 2), officially endorsed at the Convention. A logo has been developed for the Association. It comes in three different versions designed for different usages, including a website, printed materials and stickers for future the Association members produced and meet quality requirements.

Hiệp hội Cây ăn quả Ôn đới tỉnh Sơn La

Son La Temperate Fruit Association

Fig 2: Son La Temperate Fruit Association's logo designed by Phuc

7.1.3 Communication

In parallel with the efforts to establish the Association, the project team worked with the working group to develop communication and information-sharing mechanisms. It was decided that a website would be the most effective tool for the Association to provide technical recommendations and important updates on its activities, government policies and market information, not just to members but also to temperate fruit growers in general. At the end of 2019, the project team led by Ms Dinh Thi Huyen Tram worked with Association's temporary board and Ms Jenny Margetts to develop ideas and the website's structure, and at the beginning of 2020, the project team contracted Bach Khoa Hitech Co. Ltd for website design. Mr Nguyen Nam Hai and Ms Vu Thi Phuong Thanh, with the support of Ms Jenny Margetts and Dr Oleg Nicetic, developed content for the website that became operational in early 2021 (http://quaondoisonla.vn/).

The website features information for five fruits: plum, peach, persimmon, Asian pear and avocado. It has the tool for calculating fertiliser rates, reports from training activities, and educational videos. It also has market information, government policies and decrees, and link for the Zalo group.

The Zalo group is the main platform for fast

The Association

7.1.4 Capacity building

The project team members from FAVRI and PPRI conducted several half-day training activities related to establishing orchards, pruning and integrated pest management. They also developed extension material for farmers, which is available on the website. These activities were performed whenever COVID-19 restrictions were lifted. The main training activity was organised in April 2021, when Vietnam was open for domestic travel.

Study tour to Central Vietnam

A group of five leading members of the Temperate Fruit Association participated in a 6-day study tour and training organised by Dr Chau, former long-time director of SOFRI and one of the most respected Vietnamese experts on fruit and nursery tree production. The study tour included an organic pepper farm and a Global GAP-certified passionfruit farm in Dak Nong, the "King of Avocado" orchard and nursery in Dak Lak, a persimmon drying facility in Da Lat and a meeting with the Cooperative Union of Lam Dong province. Besides learning about fruit and nursery production and management, the Association members had a chance to exchange knowledge with their peers and build networks. After their return to Son La, the study tour participants shared their experiences from the trip with the Association members in the feedback workshop.

Following are some main learnings:

In Dak Lak nursery, the members learned about a technique to graft avocado scions onto two rootstocks to increase the ability of a tree to absorb water from two root systems and increase grafted plants' survival. In addition, the members learned about another new grafting technique, which uses a bud inserted into the rootstock. This technique enhances cambium layers to meet properly.

In Lam Dong, the group was introduced to a valuable cultivation technique that uses the dry season to stress avocado (but can also be used for mango and longan) plants to initiate off-season flowering, thereby producing ripe avocados during the Lunar New Year, when they can get a very high price. The Association members will use this technique in Son La, where the climate is similar to Lam Dong.

The successful case of organic pepper farms in Dak Nong is strong evidence that sustainable farming can be profitable. Mr Quyet, one of the Association members, shared his experience using weeds and green manure to increase soil fertility and protein baits to control fruit flies. Mr Quyet also pointed out that sustainable farming reduces investment costs, and even though the yield was lower, profitability was higher, helping overcome external input supply interruptions during the Covid-19 epidemic.
At the end of the journey, the Cooperative Alliance of Lam Dong province organised a meeting with the Association members to exchange their experiences in fruit production and how to find and engage with profitable markets. The Association members, who pioneered new growing techniques and varieties of plum, peach, and persimmon in Son La province, presented the results of their trials and how to extend the harvesting season for high-quality plum and non-astringent persimmon.

7.2 Introduction of low-chill peach and nectarine varieties

7.2.1 *Variety testing and commercialisation arrangements*

After negotiations between the Son La Plant Breeding Centre (the Centre), the Association and ANFIC, it was agreed that the Centre would conduct the evaluation and registration of varieties since they are authorised by the Ministry of Agriculture and Rural Development (MARD) to conduct the evaluation, and the Association would commercialise successful varieties and manage royalties. The relationship between ANFIC and Vietnamese partners was formalised through two separate contracts signed on 20 January 2021.

The first contract between ANFIC and the Centre licenced the Centre to evaluate varieties according to Vietnamese protocol for registration of new varieties and to establish 100 mother trees per variety. A licence fee of A$1,500 per variety was fully paid to ANFIC by AGB/2018/171 project. The Centre has been evaluating varieties under cooler climate conditions in Moc Chau/Van Ho and warm conditions in Mai Son and has full responsibility to protect planting material from misuse and illegal reproduction.

The second contract licenced the Association to commercialise the varieties, including organising commercial nursery production, organising a register of farmers planting varieties, collecting one-off royalties of A$ 1,000 per hectare, and transferring them to ANFIC once a year (on 15 January each year). Currently, the ACIAR project team, in consultation with the Association, is developing a legal framework for licencing variety production to nurseries and licencing farmers to plant varieties and produce fruit. The Association will be a master licensee in both licence agreements with nurseries and farmers, but nurseries will administer licencing agreements with farmers.

7.2.2 *The initial introduction of varieties from Australia*

The agreement on introducing the varieties between ANFIC and the Centre was reached in early 2019, and an optimum time to collect scion-wood was in June 2019. The Centre had to undertake a lengthy process to secure import permission for the testing of varieties, which was finally granted on 30 July 2019, permission number 022/GPNK-TT-CCN allowing import of 10 branches per variety. Varieties were subsequently imported on 16 August 2019. As Australia and Vietnam are on opposite hemispheres, scion wood was imported in the middle of the Vietnamese summer, during the hot, rainy season unsuitable for grafting. In response to unfavourable conditions Mr Hà Văn Lán, the Centre director, modified standard grafting procedures by providing cover over grafted material to prevent direct rainfall and making canals around areas where the rootstock was planted to prevent waterlogging. Buds were grafted onto young peach rootstocks, which were sprayed with foliar fertilisers a few days before grafting. All vegetative growth of the rootstock was removed before budding.

Imported material was grafted in three locations: FAVRI nursery in Gia Lam near Hanoi, the Centre nursery in Muong Hong, Mai Son district, Son La and Mr Quyet's nursery in Chieng Di, Van Ho district, Son La

In FAVRI, 7 UF Sun, 10 UF One, 9 UF Beauty and 9 Fla98 were grafted on peach rootstock;

In the Centre nursery, 20 UF Sun and 70-80 of UF One, UF Beauty and Fla98 were grafted on peach rootstock.

Picture 1 and 2: Grafting at FAVRI site Gia Lam. Netting provided shading for grafted seedlings

In Mr Quyet's nursery, buds were grafted onto 2-3 years old trees (top working): several buds of UF One were grafted onto 2 trees; UFBeauty and 1 Fla. 98-8CNW, onto one tree each.

Picture 3: Topwork buding in Chieng Di, Van Ho district

Even though efforts were made to increase the survival of grafted material, the survival rate was very low. Fortunately, at least some grafted seedlings of each variety survived. In the FAVRI nursery, which is in the lowlands with a hotter climate, none of the grafted material survived; in the Centre's nursery, 3 UF Sun, 15 UF One, 5 Fla. 98-8CNW and 2 UF Beauty developed well. In Mr Quyet's nursery, UF One and UF Beauty developed branches, but grafting of nectarine Fla. 98-8CNW was unsuccessful (Table 1).

7.2.3 *The propagation of planting material in 2020 and 2021*

After initial propagation from the imported scion wood (original buds) in 2019, the propagation by grafting the first generation buds grown in Vietnam on peach seedlings was conducted in the Centre's nursery in Muong Hong from September to December 2020 (Table 1). A total of 1410 grafted seedlings were produced: 492 Uf Beauty, 544 Fla. 98-8CNW (nectarine), 235 UF One and 139 UF Sun.

Picture 4: Seedlings grafted in 2020 well developed and were ready for transplanting in 2021.

In January 2021, 25 grafted seedlings (6 UF Beauty, 5 Fla. 98-8CNW, 10 UF One and 4 UF Sun) were transplanted in the field in Tan Lap, Moc Chau district and 8 (2 grafted seedlings from each variety) in Chieng Di, Van Ho district. In May 2021, 225 (75 UF Beauty, 66 Fla. 98-8CNW, 550 UF One and 29 UF Sun) seedlings were transplanted in Muong Hong (the Centre's farm). There are still 651 grafted seedlings available for planting in 2022. The Centre requested approximately A$3,000 from the project to support planting of these seedlings to establish approximately 1 ha of experimental orchard.

7.2.4 *Evaluation of fruit*

Only a few fruits were produced in 2021, mainly UF One and UF Beauty, from 2019 top-worked trees. Overall, feedback on UF One was very positive, and the colour of UF Beauty was also praised. The first evaluation of fruits to measure size, hardness and sweetness will be conducted in 2022, but it is unlikely that all varieties will be available.

Pictures 5 and 6: UF One in the orchard and after harvest.

7.3 Processing

The project organised two visits to Son La province by Dr Richard Beyer. During the first visit in June 2019, Dr Beyer and a processing technician from FAVRI visited several major temperate fruit processors in Son La and one traditional fruit processor in Hung Yen province to observe and assess their production practices. The assessment results showed that the temperate fruit processors in Son La mainly work with plum, persimmon and Hmong apple. Their products are limited to dried fruits, jam (from plum), syrup, alcohol (from plum) and wine (from Hmong apple), and the facilities and technologies employed are appropriate. The quality of the products in terms of taste is generally good, and they are mostly sold locally. Some processors expressed interest in expanding their markets to modern retailers in major cities (e.g. Hanoi), but poor hygiene practices remain a serious issue that bars them from entering high-end market segments. There is also room for further product development, and several products were suggested for trials, including fruit ciders and fruit leather.

In September 2019, the project team arranged the second visit for Dr Beyer to Son La to work with one processor in Moc Chau on developing new products from persimmon,

including jam and fruit leather. Production of leather has potential if it can be used as raw material for fruit leather or muesli bars.

7.3.1 Notable temperate fruit processors in Son La

The 19 May Agricultural Service Cooperative

The 19 May Agricultural Service Cooperative is one of the oldest agricultural cooperatives in Son La province. While its business covers a wide range of activities, from fruits and vegetable production to tourism, it is most famous for plum-derived products such as plum brandy and prunes.

The facilities

The cooperative's distillation facilities are in a warehouse which is well maintained. Alcohol is a low-risk product which will not support microbial activity. It is generally regarded as a solvent or food ingredient. The alcohol is bulk stored in the still warehouse.

New premises were under construction.

This is a progressive organisation that commands greater assistance. Assistance may be appropriate in developing ideas for a greater range of products.

The facilities are not vermin-proof and provide easy access for rats, birds, insects and personnel not engaged in immediate processing. It is recommended that these premises are constructed in compliance with the Codex' Hygienic Design of a Food Plant.' www.foodsafetymagazine.com/…/hygienic-design-of-food-processing-facilities.

Products

- Dried fruits (plums, mangoes, banana)
  These air-dried products are of high quality and show no signs of uneven drying. The products are packaged in stand-up multi-component re-sealable pouches and command no further modification. Mr. Thinh expressed a desire to make the slices more uniform – a topic that commands further one-on-one discussion. The colour of dried bananas can be modified by the addition of 0.1% ascorbic acid (vitamin C), which inhibits enzymic browning.
- Jams
  These products are of world-class standard and require no further modification.
- Hmong apple juice
  Product not available, no comment possible
- Maise alcohol
  Maise alcohol is an alcoholic beverage distilled from maize, commonly produced and consumed in Northwest Vietnam. It usually has 20-25% alcohol content. While maize alcohol has almost no flavour in itself, farmers sometimes use it as a base for fruit-infused alcohol products. The cooperative's product is of standard quality.
- (Experimental) freeze-dried fruits (pineapples)
  The cost of freeze drying is very high, so a cost-benefit analysis must be undertaken prior to investment. The product's texture, colour and flavour were very good, but in a price-sensitive market, a full cost-benefit analysis is essential.
- Electrolyte-replacer juice from plum
  The current electrolyte replacer drink, which is a compound of cordial to which salt has been added, is an excellent concept provided that the market has been identified. However, the current product is not suitable for convenient consumption and requires dilution. Most common electrolyte replacer beverages are ready-to-drink. It is suggested that the market is analysed for this product.

It is recommended that a strategy for increasing product width and depth exploiting further extant technologies and raw materials.

Possible further processing may include:

- development of new products such as fruit bars, leathers, fruit paste, ice-cream toppings
- distillation of waste products, for example, using plum/Hmong apple debris (by-products from juice making process) for fermentation through to vinegar.
- further refinement of extant alcohol products to improve such characteristics as clarity and flavour.
- fruit ciders

Quyet Thanh farm (Mr Pham Van Quyet and Ms Luong Thi Thanh's processing facilities)

This is a new processing facility established by one of the largest fruit farmers in Moc Chau district, Son La province. Their production capacity is still small as they mainly focus on processing fruits from their own farms, but the owners expressed interest in increasing investment and expanding production in the future.

The facilities

The business has one food drying machine of moderate capacity, which uses circulating hot air for drying. The drying machine generally serves the business purpose well, albeit with some limitations – most notably the variation in temperature across the drying rackets' surface, which results in unevenly dried fruits.

The preservation techniques used by this processor would be shelf stable if hot filled into a hermetic container such as glass jars. The current technique of supplying in bulk is

susceptible to contamination if the bulk container is not sealable. However, the production conditions are such that there is a significant risk that chemical (e.g. cleaning materials, lubricants etc.), physical (machine parts, clothing, hair and packaging), and biological hazards can gain access to foods. Production is undertaken in a general-purpose facility that appears to have a number of functions other than those related to food production. There is a risk that the items not related to the production of the major commodities may contaminate the finished products. Cloths with unknown histories are hanging and may be used for cleaning food containers. Cleaning fluids are held near the production area. Staff do not wear protective clothing, and street dust and detritus can drop into the product during manufacture. The facilities are not vermin-proof and provide easy access for rats, birds, insects and personnel not engaged in immediate processing.

It is recommended that:

- this organisation is introduced to the basic procedures for safe food handling (https://www.mpofcinci.com/blog/guide-to-sanitary-and-hygienic-design)
- this organisation is introduced to hygienic design of a food plant and the simple steps that can be taken to achieve this end.
- staff are introduced to the basic tenets of food handling

The cost of refurbishment of facilities to reach international standards is frequently a deterrent since the finances ultimately must be derived from sales. Most international markets are sympathetic to this plight and adopt a collaborative approach to upgrading and are tolerant as progress continues

Products

- Dried crystallised plum packaged bulk
- Dried fruits in stand-up composite pouches (persimmon and mango)
- Passionfruit nectar (sugar added) and fruit sauce for use in other products (e.g. yoghurt) - packed in polyethene terephthalate (PET) screw-topped bottles.

While this is by far one of the best-selling products, it is a cause for concern. Since it is impossible to fill the PET bottles with hot nectar or juice (the bottle becomes misshapen under heat), the product must be cooled before filling. Hence there is a risk that bacterial contamination can occur during cooling or from the PET bottle or lid.

It might be necessary to add preservative (200 ppm or 2g in 10 Litres of product) is this product prior to filling. This will prevent bacterial growth that may have entered the product during manufacture and preserve the product after opening.

Alternatively, glass containers which can be sterilised and hot-filled could be used. The risk is for the inclusion of extraneous matter from the field or the processing facility. Bacterial activity is unlikely, but if the jar is not hermetically sealed, the product will absorb moisture from the atmosphere, which will then have a water activity high enough to support mould growth.

•Dried bananas

In the early stages of drying, the polyphenol group of enzymes act on the phenolic components of the banana causing enzymic browning. As the drying proceeds and tissue loose moisture, then heat-induced chemical reactions take place, leading to caramelisation and strecker degradation resulting in the brown colour of products. The colour can be modified by dipping bananas into 200ppm ascorbic acid (2g in 10 Litres of solution) for two minutes. This will inhibit browning. However, the market must determine the degree of browning required, although it seems the preference remains for the dark brown product.

Opportunities:

- Fruit jams: jam should be prepared in a wide open-topped pan to facilitate water evaporation during manufacture. Jam must be boiled down to ensure that the water activity is sufficient low to prevent mould growth. On completion of the boiling, the jars should be filled (hot) to overflowing and the lids applied, the jar inverted and left until cool. This sterilises the inside of the lid, and the jam forms an impermeable seal. It is recommended that a simple demonstration is offered to this organisation for consistent jam manufacture.
- Fruit leather
- Low-pressure frying

Bac Son Ltd Company, Bac Yen district, Son La province

Bac Son Ltd is one of the largest processors for temperate fruits (mainly Hmong apple) in Son La province.

The facilities

The premises are very large, and the main processing facilities are open and contain many tanks originally designed for beer production, thus suitable for fermentation. However, the layout of the facility is not optimal for food processing, and the cost of refurbishing the entire facility would be prohibitive. Still, areas suitable for processing can be identified for blending and packaging for domestic and eventual export release. The equipment is in excellent condition of food grade, but assistance is required in organising facilities that

conform to HACCP standards. Special attention should be paid to ensure that the premises are vermin-proof.

Products

- Fruit-infused alcohols: The major product is alcohol distilled from maise, then infused with fruit – mainly Hmong apple - for flavour. A number of fruit wines were presented, some in bottles and some in boxes.
- Wines from Hmong apples: The wines sampled were cloudy and had a distinct yeast flavour. These are characteristics of wines that had not been fermented to completion. It is suggested that some assistance is offered in the formulations of tinctures and wines.
- Alcohol fruit tinctures (alcoholic base infused with fruit flavourings)
- Dried Hmong apples

Opportunities

It is possible that some novel fermented products may be possible from such raw materials as Hmong apple (*Docynia indica)* and marketed as a 'cider,' analogue.'

Areas for further improvement:

- fermentation refinement
- product development producing bottle-fermented beverages including wine and vinegar
- modifications to existing facilities to conform to international food-handling standards.

This is a progressive organisation that commands greater assistance. Assistance may be appropriate in developing ideas for a greater range of products.

It is recommended that these premises are constructed in compliance with the Codex' Hygienic Design of a Food Plant.' www.foodsafetymagazine.com/.../hygienic-design-of-food-processing-facilities

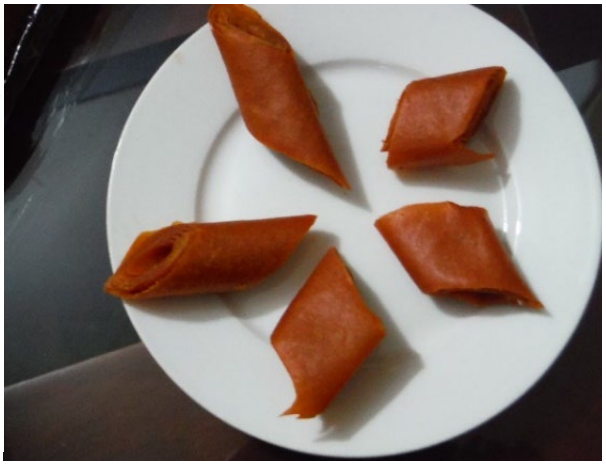
7.3.2 Experiments with new products

During the second trip to Son La, the project team worked with Quyet Thanh company to experiment with different persimmon products other than dried fruits. At FAVRI food processing lab experiment with lactic fermentation of Hmong apples was started but could not be completed due to COVID-19. Only completed trials are presented.

Leather

Leathers are produced by blending fresh fruit and drying to water activity in equilibrium with air of relative humidity of less than 40%. These are shelf stable products and can be rolled into attractive shapes see Figure 4. During drying, the sheets can be impregnated with rolled oats, sesame or other garnishes to produce muesli bars. These can be rolled into convenient, sugar-free confections.

For persimmon leather, a non-astringent variety was used. The final product was of decent quality, and there might be potential for this product.



Sugar preserves

Jam

Jams are institutionalised products appearing in most retail shops including those in Moc Chau.

Jams can be made from the full range of fruits in Vietnam, and each will have the characteristics of the original fruit (astringent vs sweet persimmons) and retain the original fruit flavour characteristics. Spices such as ginger, vanilla or nutmeg can be added for variety.

Persimmon jam was prepared during the experiment using both astringent and sweet varieties, and full procedures were left with Mr Quyet for the production of guava jam. It was concluded that astringent persimmon was not suitable for jam - the cooking process could not remove astringency, so the final product was too astringent.

Figure 4 Early stages of sugar infusion Hmoung apple

Chrystallised (Glacée) fruits

Crystallised fruits are progressively implanted with sugar by diffusion using progressively more concentrated sugar solutions. The treatment is progressive because the addition of high Brix solution is viscous with is inhibits penetration into the cellular fruit tissue. Ultimately the Brix should be 70, which will ensure a shelf-stable product. The experimental product with Hmong apples was promising.

7.4 H'Mong apple (Son Tra)

Full report on Hmong apples supply chains and potential market development is presented in the Appendix 1. Following are main conclusions and recommendations.

Cultivating Hmong apples has brought economic benefits to many farmers in remote areas of Son La province and, at the same time, improved soil management and other environmental benefits provided by forest cover. However, a comprehensive strategy is needed to develop the domestic and export market for fresh and dried Hmong apples, as well as to incentivise the development of capacities to produce high-quality alcoholic and non-alcoholic beverages, functional food, and medicinal products. Existing supply chains are underdeveloped and unable to absorb current production. With the predicted increase of Hmong apple production as a result of a large number of immature trees reaching full production potential in the near future, and continuous expansion of production areas, the price for fresh fruit could soon decrease to the level that will make it uneconomical for farmers to harvest fruit.

To address these issues we recommend the following action:

1. Halt further expansion of production areas until supply chains improve and new markets are established

According to the province's plan, by 2020, 27,800 ha of Hmong apple would be established, and in 2019, only 12,126 ha was established, reaching 43.6% of the plan. At the same time, fruit production reached only 7.6% of the planned (16,000 t instead 213,000 t). The main reason for the delay in planting and lack of investment in production inputs resulting in low yield is a drop in price due to oversupply. In the period 2018 to 2020, due to an increase in production, the average selling price dropped sharply, from 8,000- 25,000 VND in 2018 to 3,000-8,000 VND in 2020. We recommend halting any further expansion of production areas until supply chains improve and new markets are established

2. Form farmers' groups and cooperatives to take advantage of the government's existing support policies to develop fresh and processed Hmong apple supply chains and processing facilities.

Son La Provincial People's Committee provides funding to build pre-processing and processing manufacturing capacities and supports businesses in product promotions, especially through the One Commune One Product (OCOP) certificate (e.g. fresh Hmong apples of Bac Yen). In Bac Yen, the government funded a cooperative to develop 1 ha of mother orchard with several varieties and develop the production of outstanding seedlings in terms of productivity and quality, which are then distributed to farmers.

There are several decisions and resolutions of the Son La government defining support for the development of fruit supply chains in general and Hmong apple in particular:

- Decision No. 1818/QD-UBND on stipulating the content and level of support for investment in facilities for preliminary processing, processing and preservation of longan and other agricultural products in 2021; supplying cold storage, dryers, equipment not more than 300 million VND; 50% of the total investment for an enterprise or cooperative.

- Resolution No. 08-NQ/TU dated January 21st, 2021 of the Party Executive Committee on concentrated, sustainable development of agriculture, forestry and fisheries; high-tech application up to 2025, orientation to the year 2030;

- Resolution No. 128/2020 / NQ-HDND dated February 28th, 2020 of the Provincial People's Council promulgating the policy of investment transfer in agriculture and rural areas in Son La province;

- Official Dispatch No. 723-CV/TU dated July 19th, 2021 of the Provincial Standing Committee on supporting enterprises, cooperatives and households in the production, processing and preservation of Longan products and other agricultural products in 2021;

- Official Dispatch No. 35/TTHDND dated July 27th, 2021 of the Standing People's Council on the consultation with the draft plan to support enterprises, cooperatives and households in preliminary processing, processing and preservation of products;

- According to the Department of Agriculture and Rural Development's request at No. 306/TTr-SNN dated July 23rd, 2021 for improving conditions for infrastructure, especially for regions in Region 3 where the traffic infrastructure conditions are still difficult.

However, to access any government support program funds established as a result of these policies, farmers must set up groups or cooperatives and establish administrative structures to manage and account for the funds they receive. Currently, many available funds remain unused because farmers are not organised to access them.

Besides organising farmers, it is necessary to conduct studies to inform future government stimulative policies about the best way to improve the quality of fresh and processed products, support the development of export markets and promote products in domestic markets and especially encourage and attract businesses to invest in agriculture and rural areas.

3. Improve the capacity, productivity, quality, and diversity of products processed from Hmong apples.

Currently, dried Hmong apples are the main processed product on the market. Dried apples can be used to produce wine, jam, tea and medicinal products and functional foods. Most fresh apples are sliced and dried in the sun by traders using cassava cutters; air dryers are rarely used.

The products dried by an air dryer have the advantage of having a low moisture content so that they can be preserved longer than the ones dried in the sun. However, due to the pre-processors lack of knowledge about how to treat products before drying and the inability of processors to optimise the temperature and drying time, the fruit colour after drying is much darker than that of the products dried in the sun. It's essential to develop standards and criteria to evaluate the quality of dried Hmong apples, such as the moisture content and health beneficial chemicals content, to improve the value of dried Hmong apple products used as a functional food and access to export markets.

With the recent strong increase in Hmong apple production, it is necessary to increase the capacity of the manufacturers as well as enhance processing technologies for final processed products, such as apple cider vinegar, Hmong apple jam, and healthy beverage products such as Hmong apple juice, Hmong apple tea, and medicinal extracts.

Hình 17. Dried Hmong apple products in Bac Yen: air dryer after 32 hours (a); air dryer after 34 hours (b) and dried in the sun (c)

4. Increase economic efficiency of Hmong apple orchards and supply chains and create market linkages for smallholders

There is an opportunity to reduce losses along the supply chains by organising farmers in groups and cooperatives and giving incentives to the private sector to develop facilities to dry apples locally in production areas and then transport dried apples as raw material for further processing. This would reduce transportation costs by nearly ten times because of the reduction of weight and volume of dried fruits; avoid losses of fresh fruits during transportation; and contribute to local income through the value added by drying fruit.

Another advantage of farmers' collective marketing is the aggregation of products and transportation of higher volumes compared to transporting small quantities of fruits on motorbikes. According to Bac Yen Cooperative's director, using trucks can reduce costs by 10-20%. Farmers' cooperatives and groups can easily access the province's support funds to build cool storage facilities to preserve fruits at a time when heavy rain and slippery roads halt transportation for weeks.

The productivity and economic efficiency of orchards can be improved by improving cultivation methods to increase yield (only if there is a market for the additional fruits) and intercropping or feeding animals (pigs and chickens) in Hmong apple plantations.

The current average yield of 4.6 t/ha can be increased to an average yield of 15 t/ha if fertilisers are applied, and trees undergo annual pruning. However, in current market conditions, increasing any investment in production may increase losses.

Research should be conducted to evaluate several options for intercropping within Hmong plantations. There are several potential crops, including cardamom, galangal pumpkin and beans. Candidates with the highest earning potential are the galangal which has a harvest time from January to March and can be processed in Son La province, and cardamom, which has been successfully grown in Sa Pa, but is a new crop in Son La province, so people need

support in harvesting, preservation and market linkage for cardamom to be successfully introduced.

There is also the potential to feed pigs and chickens under the trees canopy, increasing food security and providing additional income.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Scientific impacts were not envisioned in this project as it was mandated to establish the Son La Temperate Fruit Association and develop its ability to support farmers through the production of extension material, which was written.

8.2 Capacity impacts – now and in 5 years

The project developed the capacity of the Association to manage its administration and finances and to cooperate and co-develop activities with the provincial and district government institutions. The Association also developed a strategic and business plan. The Association's capacity to manage the commercialisation of IP-protected varieties was enhanced, but it needs further development.

The project improved the production of dried plums and mango puree in several processing plants. One processor installed better drying equipment in Moc Chau. The project introduced manuals for improving food safety in processing plants and raised awareness of processors about their responsibilities to prevent any contamination of the products, but more training is needed to change current practices.

Several training activities were conducted covering orchard establishment, pruning and IPM. The study tour was organised in Central Vietnam in April 2021 (see Section 7.1.4).

The capacity of the provincial nursery and several private nurseries to handle the introduction, evaluation and commercialisation of IP-protected varieties was significantly improved, and the agreements with the international partner were signed, but further support is needed to ensure that introduced varieties are properly evaluated and commercialised.

8.3 Community impacts – now and in 5 years

The project did not have funds to evaluate impacts, so the claims presented below are based on feedback from DARD officials and the Association's members.

8.3.1 Economic impacts

No short-term development activities were implemented during the project that could have economic benefits other than improvements in a few small-scale processing facilities. However, the establishment of the Association and the introduction of new peach varieties are likely to bring significant economic benefits in the future by addressing the following industry issues:

- Extensive and increasing fruit production areas and volumes of one fruit species/variety causing oversupply and low prices leading to low household incomes from fruit
- Loss of export markets to China due to COVID disruptions and weak compliance to import requirements
- Failure to identify, develop and secure new domestic and export markets
- Lack of established fruit preservation and processing by cooperatives, SMEs and large companies
- Weak or no linkages to markets between individual growers/cooperatives
- Lack of farmer investment in inputs or adoption of good practices, particularly when prices and demand are low

- Low levels of farmer knowledge and skills in fruit production and marketing, particularly the practices needed for higher quality markets
- Limited access to technical support, training and extension services

8.3.2 Social impacts

The SRA succeeded in connecting DARD officials and temperate fruit industry leaders to jointly plan industry development and better target government support, especially to the nursery industry.

The SRA continued to facilitate the relationship between Son La DARD and the Provincial Nursery with the Australian nursery industry, facilitated by ANFIC, to improve the production of their nurseries and undergo restructuring of the operation to handle the introduction of varieties for which royalties have to be paid.

Improvement in fruit processing and the development of strategies for further improvement will have a positive social impact through the increase in employment.

The development of nurseries and processing especially positively impacts women's employment. Women are in many cases proven to be better at caring for younger trees and grafting than men resulting in a high percentage of women working in nurseries. Women also represent the major workforce in the processing industry.

8.3.3 Environmental impacts

SRA had no direct environmental impacts. However, the expansion of fruit orchards on slopes replacing maize production, promoted by the Association, has a positive effect on managing soil erosion and reducing pesticide and herbicide use, particularly by significantly reducing atrazine use.

8.4 Communication and dissemination activities

- The website for the Son La Temperate Fruit Association was established with content regularly updated, comprehensively covering production and marketing topics related to plums, pears, persimmons, peaches and avocados.
- Factsheets on the Association's history, mission and activities (including introducing new varieties) were printed and distributed.
- Information on the establishment of the Association was prepared for the ACIAR Facebook page.
- A video was produced which shows how the Australian industry association model and the Australian stonefruit industry influenced the decision of the Son La provincial government and private sector to form the Son La Province Temperate Fruit Industry Association. The video also showcased the collaboration between the Association and The Australian Nurserymen's Fruit Improvement Company resulting in the introduction of new licenced varieties to Son La province.

9 Conclusions and recommendations

9.1 Conclusions

The completed SRA has capitalised on research from Project AGB-2012- 060, “Improving smallholder incomes in the North-western highlands of Vietnam by increasing access and competitiveness in regional temperate fruit markets” and established facilities and processes for developing the apple fruit industry in Son La province, led by the private sector. With a relatively small investment, the Temperate Fruit Association of Son La province was established and administrative, management and financial capacity were built. The Association has a website with up-to-date technical and market information covering plums, pears, peaches, persimmon and avocado. The website also provides an easy-to-use fertiliser calculator helping members and other farmers to optimise fertiliser use. The Association and Son La provincial nursery successfully established registration trials for licenced varieties introduced from Australia and developed a commercialisation and royalty collection plan. The SRA also provided an audit of major temperate fruit processing facilities, evaluated several new products and provided recommendations for improvements, of which improved drying of plums and production of mango puree were implemented. The development of cider production was interrupted by the COVID-19 epidemic. The project team conducted research on Hmong apple supply chains and potential market developments. The main recommendations from that research are:

- Halt further expansion of production areas until supply chains improve and new markets are established
- Form farmers' groups and cooperatives to take advantage of the government's existing support policies to develop fresh and processed Hmong apple supply chains and processing facilities.
- Improve the capacity, productivity, quality, and diversity of products processed from Hmong apples.
- Increase economic efficiency of Hmong apple orchards and supply chains and create market linkages for smallholders

9.2 Recommendations

Early indications are that several newly introduced stonefruit varieties have been performing very well, and the SRA successfully established a framework for registering and commercialising these varieties. However, there is considerable risk that the Association will not be able to successfully commercialise these varieties without further support since it was established during COVID-19 restrictions and hence could only function in a limited capacity during the last half of 2020 and the first half of 2021 (the project finished in July 2021.

We recommend that ACIAR supports the following activities:

- On-going monitoring and review of the performance of new varieties in the field
- Development of a legal framework for the distribution of licenced varieties between the Association, plant nursery licence holders and farmer licence holders
- Training of Association staff in the management and administration of varietal material
- Creation of content and maintenance of communication through the Association website concerning new varieties and other sector development activities

Another activity that could not be completed due to COVID-19 and that should be supported in the future is developing technologies to produce cider from various fruits, including the Hmong apple.

Finally, funding research for the market development of Hmong apples and the development of functional food products from Hmong apples should be prioritised to address the huge oversupply of this fruit.

10 Appendixes

10.1 Report on Hmong apples supply chains and potential market developments by Lê Như Thịnh, Vũ Thị Phương Thanh and Oleg Nicetic

10.2 OVERVIEW

Hmong apple is one of the recognised fruit trees in Vietnam, grown mainly in 3 Northern mountainous provinces: Son La, Dien Bien and Yen Bai, where the altitude is over 800m above sea level. In the past, the Hmong apple naturally grew in the forest; however, in recent years, it has been recognised not only as an effective forest cover tree but also as a high economic efficiency fruit tree for people in these mountainous areas. In 2015, the total area of Hmong apple in the three provinces was 7,644 hectares, equivalent to an output of 44,416,301 tons, including the areas of trees planted in the form of agro-forest trees and garden trees and natural trees in the forest. Son La province has recognised the Hmong apple as a multi-purpose tree and a priority for development; therefore, the area planted with this fruit tree has increased sharply from 4,009 hectares in 2016 to 11,365 hectares in 2019.

Hmong apple in Vietnam, called Son Tra Nam (*Docynia indica*), is widely distributed in southern Asian countries such as India, Nepal and southern China. Son Tra Bac (*Crataegus pinnatifida*) is a popular cultivar in northern China. Both Son Tra Nam and Son Tra Bac belong to the rose family (Rosaceae) and have been used for a long time because of their medicinal properties.

Picture 1. North's Son Tra fruits in China (Chinese hawberry) (left) and South's Son Tra/ Hmong apple in Vietnam (right)

Since the earlier period, the Hmong apple in Vietnam has been regarded as a healthy product, so it is used to make wine, jam, vinegar, tea, tonic, digestive stimulant, increasing appetite, treating stomach bloating and heartburn. Besides, it can be used in combination with other herbs to treat spleen and gastrointestinal problems. According to the knowledge

of the local people, the Hmong apple has high nutritional value and contains many substances necessary for the human body, so it is also consumed fresh.

The current research results show that the apple is rich in micronutrients and macronutrients. Its nutritional composition includes macronutrients such as carbohydrates, proteins, fats, free sugars - monosaccharides (fructose and glucose), disaccharides (maltose and sucrose), and important micronutrients such as - vitamin C and beta-carotene, fatty acids (palmitic acid, linoleic acid, oleic acid, linolenic acid, stearic acid, arachidic acid, and others), amino acids including essential and nonessential amino acids, and several other essential minerals such as calcium, iron, and phosphorus. The nutritional composition of the apple was determined to be similar to that of some other fruits such as oranges, lemons, other kinds of apples, etc. Despite being rich in nutrients, in Vietnam, up to 80% of the harvested apples, including fresh fruits and dried products, are used to make white wine, vodka, and wine; only 20% of the production volume is for the production of vinegar, tea, jams, juices, and functional foods.

The apple tree is an easy-to-grow, easy-to-care, high vitality and resistant to hoar frost and ice, a common weather phenomenon in the northern mountainous provinces (Picture 2). Therefore, the Hmong apple has been identified as a priority tree to grow on high slopes or on degraded land.

Picture 2. Hmong apple has good resistance to icy in Bac Yen, Son La

In order to improve land degradation, since 2016, Son La has introduced several solutions such as promoting fruit tree planting on sloping land; limiting deforestation for

swidden cultivation, limiting the use of pesticides, developing agroforestry models; promoting zoning, regeneration, and new planting of forests on high-slope areas. As of 2017, Son La still has 777,688 hectares of degraded land in a total of 1,264,068 hectares of land in the province, accounting for 61.52% of the total surveyed area. As of 2019, the cultivated fruit tree area of the province reached 70,327 hectares, of which longan, mango, and plum are the three crops with the largest area, accounting for 60.5% of the total area of all kinds of fruit in the province. Of the total increase in fruit growing area, it is mainly the area converted from inefficient food crops on sloping land such as upland maise, and upland cassava.

Picture 3 . Cultivation on sloping land in Bac Yen, Son La

According to the aggregated data, by the end of 2018, Son La's forest coverage reached about 44%, of which the Hmong apple area was also included. In 2019, Son La still had 369,145 hectares of unused land, of which 85 hectares were flat land and 354,334 ha was sloping land. Therefore, Son La has recently promoted the development of multi-purpose trees such as the Hmong apple on unused hilly land where the slope is not too high and possible to be cultivated. Hmong apple is currently still receiving policy support from the province. Due to realising the high economic efficiency of this easy-to-grow fruit tree and simultaneously with the support of provincial policies, in Thuan Chau, Muong La, and Bac Yen districts, which have mainly high slope land with altitudes from 800 - 1800m and is suitable for Hmong apple cultivation, there has been a rapid growth in this plant area.

Among 12 Son La province districts, the Hmong apple area is concentrated in Thuan Chau, Muong La, and Bac Yen districts, reaching 9,739 ha, accounting for 80.3% of the province's total planted area (Table 1). These districts have an area of sloping and degraded land that need large coverage. Followed are districts with unchanged apple areas: Moc Chau, Phu Yen, Yen Chau, Song Ma, Sop Cop, and Son La city. In the Van Ho district, the

area of Hmong apples decreased in 2019 compared to 2018 due to the switch from growing Hmong apples to other fruit trees such as plums, pomelos, and oranges.

Table 1. Hmong apple area (ha) in Son La's districts in the period 2015 to 2019

No	District\Year	2015	2016	2017	2018	2019
1	Son La city				18	17.6
2	Quynh Nhai					
3	Thuan Chau	1,197	3,732	4,179	4,699	5,167
4	Muong La	661	1,663	1,748	2,069	2,069
5	Bac Yen	1,371	1,973	2,103	2,320	2,503
6	Phu Yen	13		23	86	86
7	Moc Chau	118			194	194
8	Yen Chau	332		332	329	329
9	Mai Son	56	446	133	945	1,035
10	Song Ma	62		93	311	311
11	Sop Cop	196	150	373	378	400
12	Van Ho	3		2	17	14
	Total	**4,009**	**7,964**	**8,986**	**11,365**	**12,126**

(Source: Son La Provincial People's Committee, 2019)

As of the end of 2019, the planted Hmong apple area has tripled compared to 2015, from 4,009 hectares to 12,126 hectares (Figure 1), and output has increased 5 times, from 3,625 tons to 16,151 tons - accounting for the area of apples are being harvested.

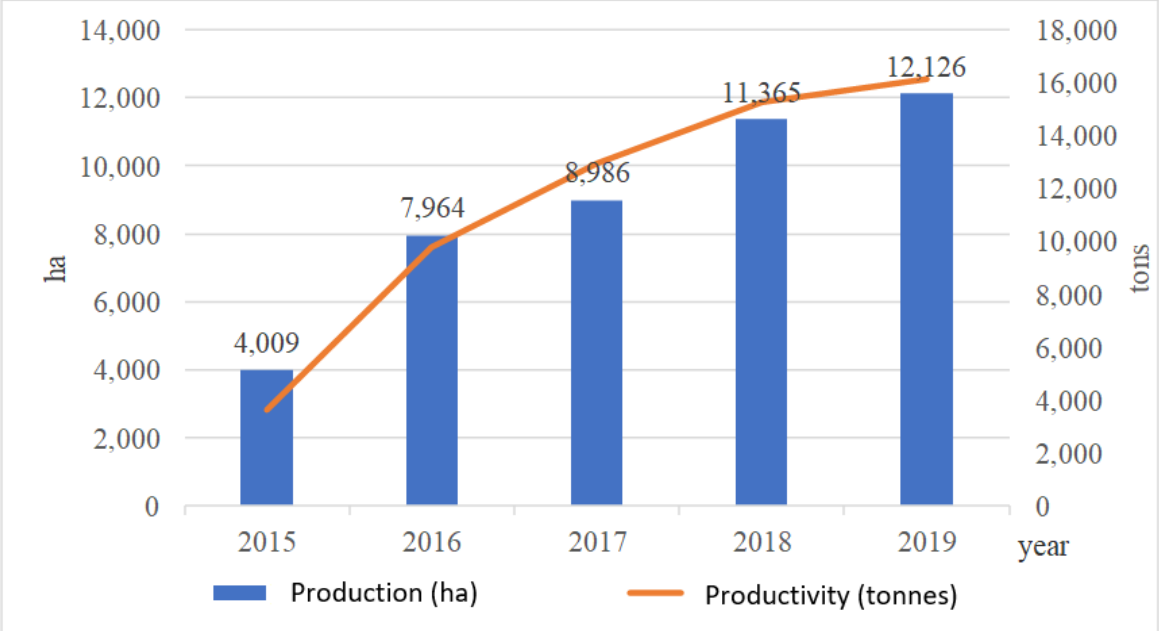


Figure 1. Hmong apple area and output in Son La in the period 2015 to 2019

(Source: Son La Provincial People's Committee, 2019)

According to the province's plan on the area to be covered, the area of Hmong apples in 2019 only reached 43.6% of the plan, and the output reached 7.6% (Table 2). One of the factors affecting the implementation plan is the difficulty of the consumer market for Hmong apple; while the output increased from 2018 to 2020, the average selling price dropped sharply, from 8,000- 25,000VND in previous years to 3,000-8,000VND in 2020. In addition, the apple harvest time is about 3 months only, concentrating from September to November.

Table 2. Son La's plan on the area of planting Hmong apple in 2020

Target	Planted in 2019 (1)	Target in 2020 (2)	Achieving the target (1)/(2) (%)
Total area (ha)	12,126	27,800	43.6 %
Total output (tons)	16,151	213,000	7.6 %

(Source: Son La Provincial People's Committee, 2019)

The difference between the results of achieving the target in terms of planting area with 43.6% and the output target with 7.6% is due to the very low average yield. The average yield of Hmong apples was only 0.8 tons/ha in 2016, 1.5 tons/ha in 2017, and 4.6 tons/ha in 2018. This can be explained by the following reasons:

- Firstly, the grafted Hmong apple could have the first time of harvest after 2-3 years of planting, and begin to fully harvest after 7-8 years. Under good conditions, the grafted plants will yield about 6kg/tree in the 6th year, 15kg/tree in the 7th year, and the 8th year will harvest about 35-40kg/tree (an increase of 5 to 6 times compared to the 6th year).
- The second factor is due to the cultivated conditions reducing the yield. Almost people in the highland grow apple naturally without fertiliser and technical impact on the planting process.

10.3 METHODOLOGY

10.3.1 Objectives

Even Hmong apple has high vitality and is identified as an important source of income for smallholder farmers, there are still gaps in the potential to increase household income by increasing the yield and quality of apple fruit, increasing the selling value of the apple by enhancing postharvest, and access potential markets for millions of tons of the fruit in the coming years.

Currently, the government decided on the area of the Hmong apple mainly based on the economic efficiency of the household before 2017 and its potential to be cultivated on sloping and degraded land coverage in the province, rather than market analysis results on current demand as well as a future potential market. Therefore, the government continues to support the development of the new Hmong apple area, including providing seedlings, initial fertiliser, and possibly financial support. However, there is a lack of support in cultivation techniques to improve production and add value to apples through processing, as well as the transportation of apples from sloping/remote areas and households to consumers. This could lead to the risk of oversupply when the rapidly increasing output in areas that have been expanded in recent years. The evidence of this issue is obvious in recent years; the current output of apple is mainly used to produce alcohol for the domestic market of Vietnam, while a very small number of large purchasers could access and export to China market. Besides, other market segments such as juice, tea, and vinegar have not really been researched and developed. The risk of disparity between the demand for specifications and quality of Hmong apple and potential future markets, such as pharmaceuticals, should also be considered. Different market segments have different fruit quality requirements; for example, fresh fruit in Vietnam (mainly concentrated in Xim

Vang) is different from fresh fruit in China; the fruit for liquor production and wine production seems to have opposite characteristics in taste and fruit size (sweet and sour, large and small). Therefore, developing more distinct varieties to supply to each market segment may be necessary. In addition, if the market for medicinal products from Hmong apple fruit is developed, it would need to identify the chemical constituents of the fruit to be appropriate for the market.

Therefore, the study was carried out with the following objectives:

1. Describe the supply chain of Hmong apples in Son La, identify difficulties and problems in the chain.
2. Assess current and potential markets to identify current market weaknesses and market growth opportunities.
3. Proposing solutions for the comprehensive development of the Hmong apple chain in Son La.

10.3.2 Methodology

The information that needs to be collected from the objectives has been discussed and identified by the research team and district-level local officials in the survey area. Based on that, the initial primary data would be collected and then developed to a semi-structured questionnaire for supply chain sectors. This activity helped participants understand what information they were looking for and why they were looking for it. To match local realities, adjustments to the question structure were also made, as commented by the participants.

The interviews with key informants, especially with sectors involved in the Hmong apple value chain, including seedling producers, traders (small, medium and large), cooperatives/groups of farmers, pre-processors, processors, wholesalers and retailers at survey sites and consumers in Hanoi (table 3). In total, more than 100 consumers in Hanoi, many traders and government employees have been interviewed by both formal and informal meetings as shown in the table below.

Semi-structured interview: 3 questionnaires were given to traders, pre-processors/processors, and retailers to assess supply chain deficiencies, thereby giving recommendations and recommendations to solve these difficulties.

Group meeting: a group meeting in Bac Yen, including officers of DARD, extension, traders and pre-processors, was held to find a coordinated solution between the parties to solve the difficulties, and challenges that the parties are facing, as well as to ensure and improve the economic efficiency for the people who grow apples.

Consumers interview: more than 100 questionnaires were given to consumers in Hanoi; the results obtained were 50 face-to-face interviews and 63 online interviews; of those, 30 direct answer sheets and 60 online answer sheets are valid.

Table 3: List of semi-structured interview objects

Interviewee	Quantity	Location
Department of Agricultural and Rural Development (DARD)	1	Son La
DARD specialist officer	1	Bac Yen
Vice president of Farmers Association	1	Bac Yen
Large traders	3	Bac Yen
Medium traders	2	Bac Yen + Muong La
Small trader	1	Bac Yen
Cooperatives	2	Muong La
Processors	4	3 Bac Yen + 1 Hung Yen
Consumers (64 online forms and 50 self-declarations forms)	114	Hanoi
Total	129	

10.3.3 Scope of the research

Hmong apple is mostly grown in 3 provinces: Dien Bien, Yen Bai and Son La. The plating in Dien Bien is mainly for land cover and afforestation; therefore, the fruit is small, green, has acrid taste, and is not suitable for harvesting fruit for sale. In Yen Bai and Son La, besides the areas of apples that are grown in the wild, in recent years, with support from the government's policies and non-governmental projects in selecting the dominant apple

varieties to be suitable for covering land and able to harvest fruit for sale, the planted areas have increased rapidly. Most people cultivate apples by the natural method and sell them mainly in the form of fresh fruit to traders (small, medium and large) or to cooperatives/groups with government support.

In Son La, the province received support from ACIAR's project in selecting superior varieties and also received approval from the government to expand and develop a multi-purpose Hmong apple. Therefore, Son La province was selected for this research. The research team could also identify the interaction of all sectors in the apple chain. We chose Ta Xua commune, Bac Yen district and Ngoc Chien commune, Muong La district as the survey sites for the study; especially Bac Yen emerges as a leading district in planting and developing grafted plants.

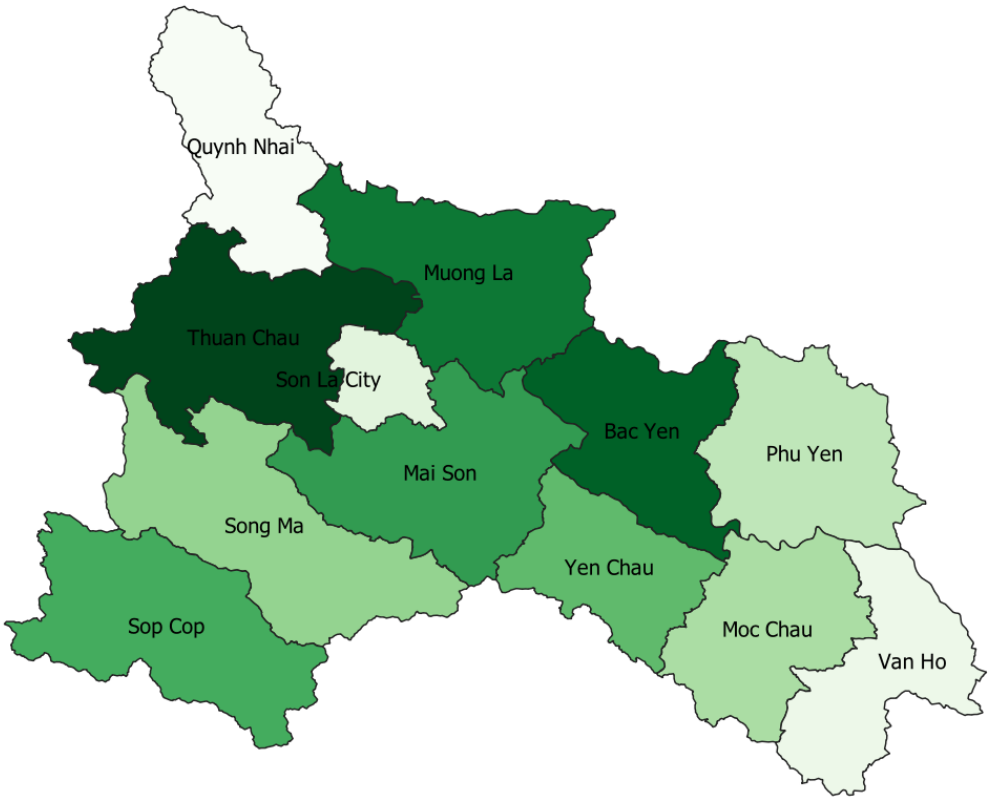


Figure 1: Map of planting area in Son La in 2019

10.4 RESULTS

10.4.1 Hmong apple supply chain in Son La

Actors and relationships among actors in the Hmong apple supply chain

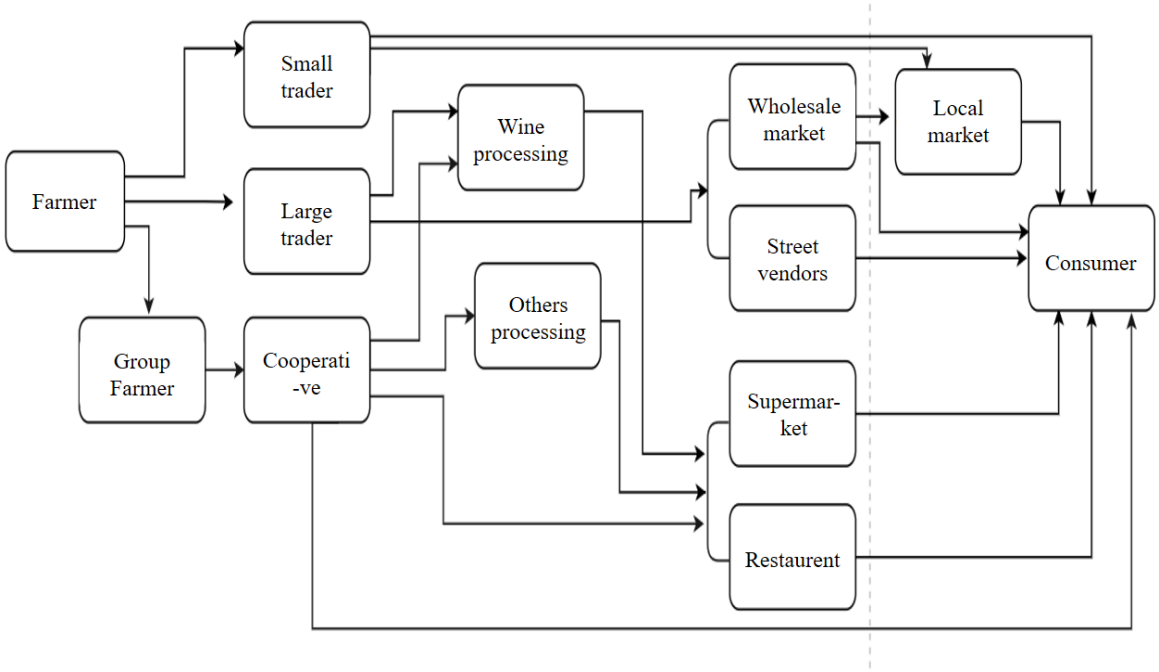


Figure 2. Hmong apple supply chain in Son La

Smallholder farmers in the above supply chain are growing Hmong apples or managing to harvest the fruit from forest areas for sale. On average, the farmers growing Hmong apples in Son La manage an area of 0.3 - 0.5ha with many different varieties such as sweet apples in Xim Vang, small, green-skinned apples, big red-yellow-skinned apples, etc. Currently, Hmong apples are identified as a multi-purpose tree, which is a forest tree covering the land, providing wood, and is the only fruit tree supported by the province in terms of seedlings and initial fertiliser when planted. Most farmers consider the Hmong apple as a kind of forest tree that provides wood to sell, and the Hmong apple is just a by-product of the forest. Therefore, they don't fertilise, spray or prune this kind of tree. Hmong apples are harvested mainly from early September to December. Unlike ripe apples, which are harvested in September at the beginning of the season for high prices, many poor households often sell unripe apples in July. This results in lower quality, lower productivity, and lower price. Men in farming households often carry Hmong apples to the consumption point of traders in the area by motorbike; each vehicle can carry 200kg, with a distance of 5 to 50km. A few people who join the farmer or cooperative group will take the products to the group leader's house or the cooperative headquarters. After that, the products will be transported by cars to big consumption points. As usual, when there

is heavy rain, the farmers can not transport Hmong apples to the collecting point but have to wait for 2-3 days after the rain. Transportation costs are already high, but when the output of Hmong apples increases significantly due to many young trees reaching full productivity and supply exceeding demand, transportation costs will become prohibitive, with the price of this fruit dropping sharply.

Collectors and small traders are mostly apple growers, and some are officers who trade Hmong apples as part-time jobs. Collectors have acquaintance with large traders for whom they buy fruit from farmers in the area and transport them to the collecting points of traders in town, near the highway. Small traders are usually seasonal traders who trade less than 15 t/year, with the apple trade being their side business. They often buy Hmong apples right at the farmers' houses with better quality and higher prices but limited quantity compared to large traders. Then these small-scale traders often sell the products online to customers in other provinces. These customers buy fresh, big, pink-green-skinned Hmong apples to soak in wine (mainly) or make vinegar. They deliver to customers by bus or combined trucks. In the current context of Covid-19 from 2021, the restriction of buses and the closure of the wholesale market are the reason why many Hmong apples cannot be sold.

Large traders buy apples from farmers or small traders (collectors) with a trading volume of over 15t/year. Most of these traders will also trade in other agricultural products such as corn, vegetables and other fruits. Only a few of them trade fresh and dried apples year-round. Large-scale traders trade both fresh and dried products from Hmong apples. Additionally, some mobile traders from other regions come to Son La with a truck to directly buy the products from their acquainted farmers or through large traders. These traders will sell to street vendors or sell directly to consumers in big cities. During the harvest time from September to December, these traders will sell fresh Hmong apples, and at the same time, they will dry them to produce dried Hmong apples to store and sell for the rest of the year. The major customers of large-scale traders are wine producers, small-scale traders from other provinces, and wholesale markets.

Cooperatives are established under the Law on Cooperatives issued in 2012 and have business in apples. They should have at least five members contributing capital and should have a management structure prescribed by the Law, but the current cooperatives involved in the Hmong apple business are mainly run by the director, who invested all the initial capital for the operation of the cooperative and provides ongoing operational capital. The

main benefit for members is access to government support and, to a lesser extent, better access to the market. They rarely have the benefits of better production planning.

Wholesalers at wholesale markets buy Hmong apples mainly from large-scale traders and then sell the product to small business owners at local markets. These wholesalers and small-scale traders in local markets have their main source of income from trading fruit or other agricultural products.

Convenience stores in Hanoi, such as BigGreen and Bac Tom and some supermarkets, sell Hmong apple cider vinegar. Besides this product, these shops introduce fresh and dried Hmong apples as regional specialities. These products are produced in small quantities, handmade and naturally fermented.

Wine processor: the technology and capacity are limited to produce a good quality wine from fresh or dried fruit. The processors first dry most of the fresh Hmong apples (as shown in picture 4). Dried fruit is the major product that can be used to make wine/liquor, vinegar, tea, etc. On average, 5 - 7 kg of fresh fruits should be dried to get 1kg of dried apple. The drying efficiency is related to variety, fruit maturity, and processed method. There are two methods of drying Hmong apples: drying in the sun and a semi-industrial heat dryer (capacity of 5 tons/day). These dryers are provided as a part of the provincial support program. In the province, less than ten processors are using these dryers. The advantage of dryers is lower moisture content that allows longer storage, 1-2 years, but due to limited technology, the temperature adjustment is not suitable, resulting in the colour of the apple being too dark, not as yellow as when naturally dried. The exposure to sunlight produces more beautiful fruit colours, but the humidity is high, allowing only 6 months to 1-year storage. After being harvested, the apples are sliced by machine and then dried.

Picture 4: Dried apples with a semi-industrial machine at Son Tra Cooperative - Bac Yen

Picture 5: Natural dried apples of large traders in Bac Yen

Picture 6: Street vendors selling Hmong apples in Hanoi

Bac Son wine company (located in Bac Yen District) is a relatively large processing facility but was not successful in marketing wine, which was of low quality. The company is developing a range of products such as fruit, wine, juice, and Hmong apple tea.

Picture 7. Other products processed from Hmong apples

Obstacles of the current supply chain

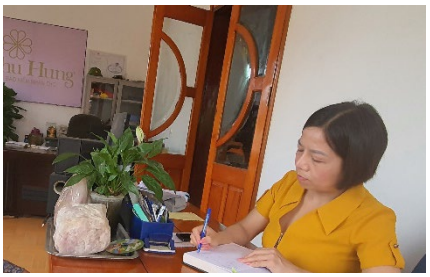
There are three major problems in the current supply chain: (1) oversupply, (2) low value-adding and (3) the weak linkages between actors along the chain and government institutions.

(1) In recent years, the harvested volume of Hmong apples has increased sharply, from 4,000 t in 2015 to 12,000 t in 2019, three times higher in five years. As a result, the selling price has dropped significantly, from 8.000 – 15.000 VND/kg before 2012 to 3,000 VND/kg – 8.000 VND/kg in 2018, and is forecasted to drop to 1.000VND/kg as the production continues to increase due to the growing production area and the yield increase due to maturing of young trees and reaching full productivity. No contract or commitment between farmers and collectors/ traders makes any production planning ineffective, even for cooperative members.

(2) Low value-adding (economic efficiency) for farmers, traders and processors. For farmers, the current average selling price is 3.000VND/kg with average productivity of 4.6 tons/ha, so if farmers can sell the total volume, their income is VND 13.8 million/ha/year (i.e. 3 times less than income from maise or six times less than income from average quality plums). The traders have other businesses, such as trading coffee, maise and other fruits, while trading a low volume of Hmong apples with a low profit, mainly during the 3-month season, is just an additional activity. For processors, the investment cost for an air dryer that only operates for 3 months is not interesting, and they only buy them because of the government subsidy.

(3) The lack of information exchange, weak relationships between actors along the chain, and disconnect with local government institutions in charge of planning lead to oversupply and lost benefits for farmers. Many farmers would be better off if they did not change from maise to Hmong apple or from wild variety to hybrid variety. Hybrid varieties have large fruit sizes, thin skin and beautiful colours, making them good for fresh consumption and the production of wine and liquor, but they are not very suitable for drying. Few buyers supplying fresh markets were prepared to pay a high price (around VND 25,000/kg) for a small volume of high-quality hybrid apples. Based on this high market price, the nurseries produced grafted seedlings which dominate new plantings and farmers grafted existing trees with the hybrid Hmong apple but unfortunately, because of very limited demand for fresh apples, the price collapsed, while the price for traditional smaller apples suitable for drying remains relatively stable.

Picture 8. Ripe Hmong apple and Unripe Hmong apple



Picture 9. The directors of Bac Yen Coop. (left) and Bac Son Wine Company (right)

Picture 10. Dried Hmong apple storage in processing manufacturer

10.4.2 Assessment of the current and potential markets

The grading of fresh fruit is mainly based on fruit size and colour. In terms of size, Hmong apples are graded into 3 categories: big, medium and small. The sorting is done by farmers or by large-scale traders for both fresh and processing markets. In terms of colour, the large-scale traders grade the products into 3 types: green, yellow, and yellow-red, with yellow-red skinned varieties being the most expensive and the green-skinned having the lowest price in fresh markets. Fresh Hmong apples are also distinguished based on taste (sweetness) and juiciness, with a preference for sweet and juicy fruits.

For the dried market, the major market of Hmong apple, large-scale traders and processors prefer the old wild variety, not the hybrid varieties, which are preferred by the fresh market because they have lower moisture content. From 10 kg of wild variety (green-skinned apples), processors get 2 kg of dried fruit, while from 10 kg of hybrid (yellow-skinned apples), they get only 1.5kg of dried fruit using a longer and more expensive drying process. To improve hybrid varieties' drying efficiency, the processors buy immature fruit because they are smaller and have lower moisture content than mature fruits. So if they buy fruits from farmers who planted the hybrid variety, they instruct farmers to harvest unripe Hmong apples in July or August instead of October. However, the traders only buy small and unripe fruit at a very low price of around 1.000VND/kg.

Besides dried Hmong apples that are produced in large volume, there are a limited number of other processed products made from Hmong apples. Medicinal and functional food products are mainly produced in China, and in Vietnam, the production of "wine" is the only product manufactured in a relatively large volume, while jam, cider vinegar, and juices are produced in small quantities.

Wine: there are many different types of wine – white wine, red wine, fruit wine, etc., in which the main product is white wine soaked from fresh Hmong apples by traditional methods, refined wine such as vodka, Bac Son. Red wine and fruit wine made from Hmong apples are still in the process of testing and finding domestic consumption channels.

Hmong apple jam: this product is often consumed at speciality stores and is introduced in tourist attractions such as Sapa and Moc Chau. *Hmong apple cider vinegar and Hmong apple juice*: are well-known for their effects on weight loss and beauty boost for women. These products are often consumed in supermarkets and the chain of food safety stores in big cities. *Instant Hmong apple tea, tea bags, and other functional foods*: currently, these products have been in the stage of product development and testing the responses from the market.

10.5 CONCLUSIONS AND RECOMMENDATIONS

Cultivating Hmong apples has brought economic benefits to many farmers in remote areas of Son La province and, at the same time, improved soil management and other environmental benefits provided by forest cover. However, a comprehensive strategy is needed to develop the domestic and export market for fresh and dried Hmong apples, as well as to incentivise the development of capacities to produce high-quality alcoholic and non-alcoholic beverages, functional food, and medicinal products. Existing supply chains are underdeveloped and unable to absorb current production. With the predicted increase of Hmong apple production as a result of a large number of immature trees reaching full production potential in the near future, and continuous expansion of production areas, the price for fresh fruit could soon decrease to the level that will make it uneconomical for farmers to harvest fruit.

To address these issues we recommend the following action:

1. Halt further expansion of production areas until supply chains improve and new markets are established

According to the province's plan, by 2020, 27,800 ha of Hmong apple would be established, and in 2019, only 12,126 ha was established, reaching 43.6% of the plan. At the same time, fruit production reached only 7.6% of the planned (16,000 t instead 213,000 t). The main reason for the delay in planting and lack of investment in production inputs resulting in low yield is a drop in price due to oversupply. In the period 2018 to 2020, due to an increase in production, the average selling price dropped sharply, from 8,000- 25,000 VND in 2018 to 3,000-8,000 VND in 2020. We recommend halting any further expansion of production areas until supply chains improve and new markets are established

2. Form farmers' groups and cooperatives to take advantage of the government's existing support policies to develop fresh and processed Hmong apple supply chains and processing facilities.

Son La Provincial People's Committee provides funding to build pre-processing and processing manufacturing capacities and supports businesses in product promotions, especially through the One Commune One Product (OCOP) certificate (e.g. fresh Hmong apples of Bac Yen). In Bac Yen, the government funded a cooperative to develop 1 ha of

mother orchard with several varieties and develop the production of outstanding seedlings in terms of productivity and quality, which are then distributed to farmers.

There are several decisions and resolutions of the Son La government defining support for the development of fruit supply chains in general and Hmong apple in particular:

- Decision No. 1818/QD-UBND on stipulating the content and level of support for investment in facilities for preliminary processing, processing and preservation of longan and other agricultural products in 2021; supplying cold storage, dryers, equipment not more than 300 million VND; 50% of the total investment for an enterprise or cooperative.
- Resolution No. 08-NQ/TU dated January 21st, 2021 of the Party Executive Committee on concentrated, sustainable development of agriculture, forestry and fisheries; high-tech application up to 2025, orientation to the year 2030;
- Resolution No. 128/2020 / NQ-HDND dated February 28th, 2020 of the Provincial People's Council promulgating the policy of investment transfer in agriculture and rural areas in Son La province;
- Official Dispatch No. 723-CV/TU dated July 19th, 2021 of the Provincial Standing Committee on supporting enterprises, cooperatives and households in the production, processing and preservation of Longan products and other agricultural products in 2021;
- Official Dispatch No. 35/TTHDND dated July 27th, 2021 of the Standing People's Council on the consultation with the draft plan to support enterprises, cooperatives and households in preliminary processing, processing and preservation of products;
- According to the Department of Agriculture and Rural Development's request at No. 306/TTr-SNN dated July 23rd, 2021 for improving conditions for infrastructure, especially for regions in Region 3 where the traffic infrastructure conditions are still difficult.

However, to access any government support program funds established as a result of these policies, farmers must set up groups or cooperatives and establish administrative structures to manage and account for the funds they receive. Currently, many available funds remain unused because farmers are not organised to access them.

Besides organising farmers, it is necessary to conduct studies to inform future government stimulative policies about the best way to improve the quality of fresh and

processed products, support the development of export markets and promote products in domestic markets and especially encourage and attract businesses to invest in agriculture and rural areas.

3. Improve the capacity, productivity, quality, and diversity of products processed from Hmong apples.

Currently, dried Hmong apples are the main processed product on the market. Dried apples can be used to produce wine, jam, tea and medicinal products and functional foods. Most fresh apples are sliced and dried in the sun by traders using cassava cutters; air dryers are rarely used.

The products dried by an air dryer have the advantage of having a low moisture content so that they can be preserved longer than the ones dried in the sun. However, due to the pre-processors lack of knowledge about how to treat products before drying and the inability of processors to optimise the temperature and drying time, the fruit colour after drying is much darker than that of the products dried in the sun. It's essential to develop standards and criteria to evaluate the quality of dried Hmong apples, such as the moisture content and health beneficial chemicals content, to improve the value of dried Hmong apple products used as a functional food and access to export markets.

With the recent strong increase in Hmong apple production, it is necessary to increase the capacity of the manufacturers as well as enhance processing technologies for final processed products, such as apple cider vinegar, Hmong apple jam, and healthy beverage products such as Hmong apple juice, Hmong apple tea, and medicinal extracts.

Hình 17. Dried Hmong apple products in Bac Yen: air dryer after 32 hours (a); air dryer after 34 hours (b) and dried in the sun (c)

4. Increase economic efficiency of Hmong apple orchards and supply chains and create market linkages for smallholders

There is an opportunity to reduce losses along the supply chains by organising farmers in groups and cooperatives and giving incentives to the private sector to develop facilities to dry apples locally in production areas and then transport dried apples as raw material for further processing. This would reduce transportation costs by nearly ten times because of the reduction of weight and volume of dried fruits; avoid losses of fresh fruits during transportation; and contribute to local income through the value added by drying fruit.

Another advantage of farmers' collective marketing is the aggregation of products and transportation of higher volumes compared to transporting small quantities of fruits on motorbikes. According to Bac Yen Cooperative's director, using trucks can reduce costs by 10-20%. Farmers' cooperatives and groups can easily access the province's support funds to build cool storage facilities to preserve fruits at a time when heavy rain and slippery roads halt transportation for weeks.

The productivity and economic efficiency of orchards can be improved by improving cultivation methods to increase yield (only if there is a market for the additional fruits) and intercropping or feeding animals (pigs and chickens) in Hmong apple plantations.

The current average yield of 4.6 t/ha can be increased to an average yield of 15 t/ha if fertilisers are applied, and trees undergo annual pruning. However, in current market conditions, increasing any investment in production may increase losses.

Research should be conducted to evaluate several options for intercropping within Hmong plantations. There are several potential crops, including cardamom, galangal pumpkin and beans. Candidates with the highest earning potential are the galangal which has a harvest time from January to March and can be processed in Son La province, and cardamom, which has been successfully grown in Sa Pa, but is a new crop in Son La province, so people need support in harvesting, preservation and market linkage for cardamom to be successfully introduced.

There is also the potential to feed pigs and chickens under the trees canopy, increasing food security and providing additional income.

Picture 11. Intercropping with cardamom and galangal under the Hmong apple in Bac Yen province

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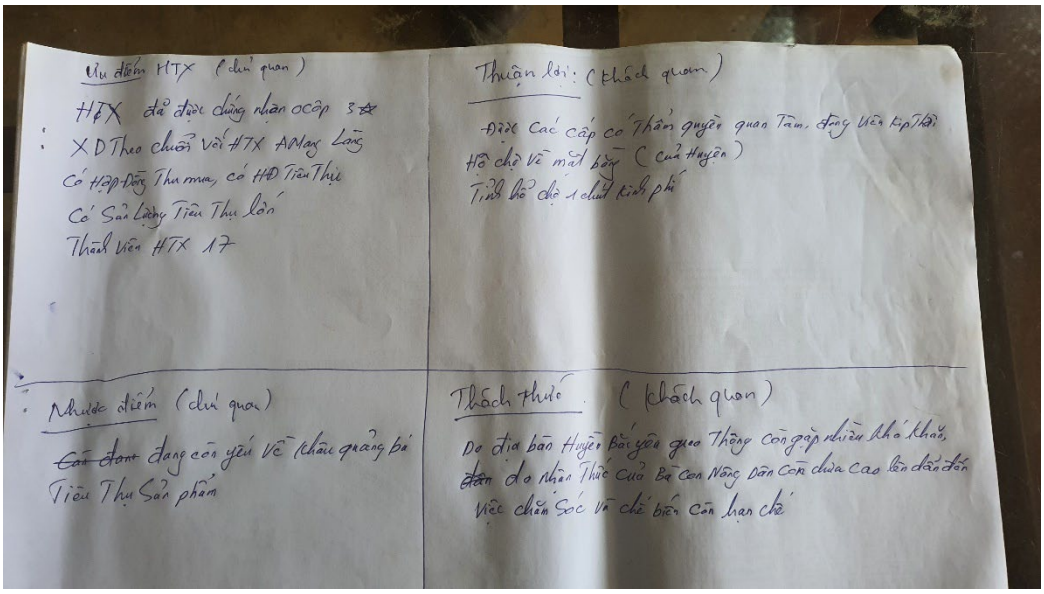
Picture 12. Hmong apple nursery of Son Tra Coop.

Picture 13. Hmong apples drying machine (5 tons/ time)Picture 14. Dried Hmong apple processing manufacturer of Son Tra Agricultural Cooperative and general service

Picture 15. SWOT assessment of Hmong apple cooperative - Bac Yen



11 V. CONCLUSIONS

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