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Final Report

Project

Towards more profitable and sustainable vegetable farming systems in north-western Vietnam

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Contents

Abbreviations

ABC	Australian Broadcasting Corporation
ACIAR	Australian Centre for International Agricultural Research
AEC	Agriculture Extension Centre
ASPAC	Australasian Soil and Plant Analysis Council
CAP	Centre for Agricultural Policy
CIAT	International Centre for Tropical Agriculture
CIRAD	Agricultural Research for Development
DARD	Department of Agriculture and Rural Development
FAVRI	Fruit and Vegetable Research Institute
FBS	Farmer Business School
FFS	Farmer Field School
FGD	Focus Group Discussion
GFAR	(The Centre for) Global Food and Resources
GSO	Vietnam General Statistics Office
IPSARD	Institute of Policy and Strategy for Agriculture and Rural Development
ISO	International Organisation for Standardization
IV	Indigenous Vegetables
M&E	Monitoring and Evaluation
MALICA	Markets and Agriculture Linkages for Cities in Asia
MARD	Ministry of Agriculture and Rural Development
NIMM	National Institution of Medicinal Materials
NSW DPI	New South Wales Government Department of Primary Industries
PM&E	Participatory Monitoring and Evaluation
PPsD	Plant Protection sub-Department
RRD	Red River Delta
SFRI	Soil and Fertilizer Research Institute
TOF	Training of Facilitators
UoA	University of Adelaide
UQ	University of Queensland
VAAS	Vietnam Academy of Agricultural Sciences
VC	Value Chain
VND	Vietnamese Dong
VNUA	Vietnam National University of Agriculture
V-R	Vegetable & Rice System
VTC	Vietnam Television Corporation
V-V	Vegetable Only System
VWU	Vietnam Women's Union

1 Acknowledgments

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Interviews and surveys used to collect data from food consumers and producers were approved by the Human Research Ethics Committee at The University of Adelaide (HREC number H-2015-159) and the Human Research Ethics Committee at The University of Canberra (HREC number 14-137).

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2 Executive summary

Project AGB/2015/059 sought to enhance the profitability and sustainability of smallholder vegetable farming households in the Sa Pa and Bac Ha districts of Lao Cai Province in north-west (NW) Vietnam. Lao Cai Province was selected as the study location because of potential opportunities in emerging high value horticulture markets, both domestically and in nearby China. Additionally, the region has climate and soil conditions favourable for growing vegetables. Smallholders were increasingly integrating vegetables into their existing, largely subsistence or semi-subsistence farming systems. Thus, the focus was on improving smallholders' market opportunities and market engagement; and implementing integrated resource and disease management practices into smallholder farming systems.

Despite opportunities, significant development of a viable smallholder inclusive vegetable sector in the region faces several challenges, including: (1) rapidly transforming and highly competitive regional vegetable markets; (2) poor competitiveness with peri-urban and regional producers; (3) poor infrastructure and logistics; (4) nutrient depleted soils; and (5) soil-borne diseases.

To address these issues which affected both supply and demand for vegetables from the region, this project implemented a multi-disciplinary approach. All activities focused on capacity building of partnering institutions in Vietnam as well as Australia. The main project activities were divided into four components, and significant outputs and key findings for each component are highlighted in the following paragraphs: 1) Market analysis; 2) Market development; 3) Farming systems; and 4) Capacity building.

Market Analysis

A survey of 2,000 urban Vietnamese households in Hanoi, Ho Chi Minh, Lao Cai and Son La, was conducted to understand consumer preferences, food expenditures, shopping behaviour and willingness to pay for vegetables differentiated with credence (production and process) attributes. In all urban locations, food safety was the main factor influencing the types of vegetables consumers purchased, as well as the preferred outlet for purchasing vegetables. Traditional markets, both formal and informal, were where most vegetables were purchased. Modern retail outlets accounted for less than 20% of retail sales of vegetables in all northern cities (Hanoi, Lao Cai and Son La).

Consumers were most interested in certifications which they perceived to signal improved safety and or nutrition such as "certified safe", "organic", "VietGAP" or region (e,g, Moc Chau or Bac Ha). The highest premiums (approximately 25%) were for "Certified Safe" tomatoes and water spinach. Results from the consumer study are available as a factsheet series and have been presented to stakeholders and policymakers in Vietnam as well as Australia. The market insights were used for the market development phase of the research project.

In addition to consumer research, the project collected detailed supply and demand data for key vegetable products in retail and wholesale markets. Analysis of price trends in Hanoi's key vegetable markets identified short windows of opportunity during which Lao Cai vegetables can potentially be cost-competitive in Hanoi. However, a survey of Hanoi's vegetable markets demonstrated very strong, intensifying competition from Chinese imports and production from other highland regions. The project identified a more feasible expansion path that focuses more on capturing the off-season vegetable markets in neighbouring NW provinces such as Yen Bai and Dien Bien where local vegetable production is in short-supply during the off-season summer months. Results were used for the market development interventions and have been presented at conferences and workshops attended by researchers, policymakers, and industry stakeholders.

Market development

A set of interventions to support the marketing of Lao Cai's vegetable products was conducted. Interventions included: tasting events, product fairs, networking events, distribution of product description cards, development of production timing calendars, and

targeted support to develop trade relationships for Lao Cai vegetable enterprises. In addition, training sessions were implemented with farmer groups in Lao Cai to increase their knowledge and capacity to sell into new markets.

Consignment tracking and package trials identified areas for improvement in postharvest handling and packaging. Insights were used to develop a postharvest guide that was used in the Farmer Business School (FBS) pilot in Lao Cai. As a result, farmers in Lao Cai have adopted some improved postharvest recommendations. For example, ice bottles are now being used to cool product during transit, and farmers are not pre-peeling cabbages prior to packing, with the intent of better protecting the crop in-transit.

Farming systems

Key farming system issues were identified in participative dialogue with farmer groups, and a series of applied research experiments were designed to develop practical management practices to improve farm performance. Pest and disease surveys were regularly conducted in Sa Pa and Bac Ha districts which identified important pests and diseases in both districts. Club-root was identified at this time as the predominant soil-borne disease affecting Sa Pa.

Control trials successfully identified an effective low-cost control of club-root disease that used a combination of lime and fluazinam. This significantly reduced the incidence of disease which was the major factor preventing expansion of vegetable production in the area. This control method has been extended at wider scale to local farmers through adaptive trials, and a workshop attended by local government, extension agents, and input suppliers was held to disseminate this technique and accelerate diffusion of the control to improve farm household welfare in the region.

A survey followed by trials demonstrated widespread deficiencies of boron and possibly copper in cabbage in Bac Ha and SA Pa districts. Nutrient budgets conducted at the start of the project identified that existing soil and nutrient management strategies were far from optimal. There was widespread over-application of nitrogen, phosphorous, and potassium on farms, and farm profits could significantly increase with optimized strategies for nutrient management. Nutrient trials successfully identified optimum applications of fertilizers which helped identify strategies to improve profitability of vegetable farming systems.

Capacity Building

The project evaluated sustainable strategies for upscaling Farmer Business Schools (FBSs) in NW Vietnam and identified key factors for successful implementation of the capacity building program. Insights were used to develop and test a pilot FBS program, which incorporated training materials developed as part of this project. Of the participants in the FBS, 75% developed new business plans for adopt new technologies or adopted new marketing strategies as a result of the program. VWU, SFRI, NIMM, CIAT, and Lao Cai PPsD are now collaborating to scale FBS and have secured an additional grant funding to support the expansion of FBS in Lao Cai.

Project Recommendations

Maximising the profitability of Lao Cai's smallholder vegetable farming systems, whilst sustainably managing soil, water and nutrient resources will continue to be challenging, particularly given the need to intensify production to maximise returns to smallholder farmers operating on very small parcels of land. However, key insights gained from the research conducted in this project results in the following seven recommendations:

1. Further market growth of Lao Cai vegetables into Hanoi is limited due to strong competition from imports and supply from other highland areas in Vietnam. Further investment in project market development activities is required to facilitate smallholder market linkages and strengthen trade relationships for Lao Cai's vegetable products.
2. Both public and private sector investment in whole-of-chain interventions, including postharvest interventions, traceability and certification programs, is required to provide customers with quality assurance, and to ensure the integrity required to build a "brand"

for Lao Cai vegetables. Further development of certification programs is one strategy for further developing markets for smallholder vegetable products from this region. However, for certifications schemes to provide value, they must be trusted by the market and they cannot be overly burdensome for smallholders.

3. A more viable strategy for Lao Cai smallholder vegetable farmers may be to expand counter-season supply of select vegetables to neighbouring NW provinces where Lao Cai has a competitive advantage. Farmers' adoption of counter-seasonal vegetable production has been limited due to concerns related to production risk and market risk. More focused extension efforts and demonstrations of summer-season production and marketing systems would support adoption.
4. Since completion of the highway connecting Lao Cai to Hanoi, there has been a dramatic rise in tourism in the region. Increased tourism has created new market opportunities for Lao Cai vegetable producers. Yet, very little is known regarding tourist demand for vegetables. Understanding the size of this segment and the particular products being demanded would provide valuable information as vegetable value-chains develop strategies to service this rapidly growing group. A focused consumer study targeting NW tourists would inform NW enterprises and ACIAR projects in the region.
5. Future research for development projects would benefit from greater participatory involvement of the private sector to support the adoption of innovations and on-farm behaviour changes. For example, engagement of prospective buyers in training events, market visits, or postharvest trials would help build trust between the community and the buyers that can be leveraged to access new markets.
6. There is an ongoing need in the region to build the capacity of both ethnic communities and women working in vegetable value chains. The FBS approach can be further adapted to address gender and ethnicity aspects that are particularly important in NW Vietnam. A more in-depth treatment of facilitation skills that focuses on the gender and ethnicity constructs of target communities could improve the effectiveness of the capacity building program.
7. Capacity development at SFRI's soil analysis lab should continue to be supported as SFRI provides chemical analysis support to a growing network of research projects throughout the region. In addition, plant analysis is a strong complement to soil analysis, whether running nutrient trials, estimating nutrient budgets, or diagnosing nutrient problems on-farm. Consequently, it is strongly recommended that ACIAR consider investment in the development of plant analysis, and of quantitative quality control for both soil and plant analysis. Such investment would build on success in this project and provide high quality laboratory services to multiple projects in Vietnam and the region.

3 Background

The north-west (NW) of Vietnam hosts some of the poorest provinces in the country. For example, in 2014 more than 25% of the population of Lao Cai Province was classified as living in poverty (Vietnam General Statistics Office (GSO) 2015). This was substantially higher than the estimated national poverty rate of 8.4% (GSO 2015). In addition to poverty, these communities also struggle with chronic malnutrition. For example, in Lao Cai Province 40% of children under 5 years of age suffer from stunting, with a further 26% classed as underweight (Vietnam National Institute of Nutrition [NIN] & United Nations Children's Fund [UNICEF] 2011). The NW of Vietnam is also home to a number of ethnic minority communities; in particular there are significant populations of H'mong, Tay, Nung, Dao and Thai ethnic groups in the NW highland regions (Roche & Michaud 2000; Tran 2003). Engaging with these communities to reduce the incidence of poverty and improve livelihoods is a key focus area of the Vietnam Government and partner organisations such as the Vietnam Women's Union (VWU; VWU 2012).

Subsistence agriculture is critical to the livelihoods of most rural households in NW Vietnam, especially ethnic minority households. Adjustments to farm enterprises to increase farm-household incomes (including from off-farm income) or, reduce income vulnerability have long been advocated as options to alleviate poverty. One adjustment option is to move resources from low value agriculture (or subsistence agriculture) to high value agriculture, such as horticulture (Joshi et al. 2003; Weinberger & Lumpkin 2007). Horticulture can offer opportunities to reduce poverty rates by providing households with higher cash incomes (Weinberger & Lumpkin 2007) relative to a subsistence agricultural system that is often focussed on the production of staple crops such as rice and maize. However, it is important to note here that this is only effective in increasing cash incomes and alleviating poverty if farmers can secure market access (e.g. Barrett 2007). As well as alleviating poverty, diversifying farm systems to include vegetables can also contribute to improved agrobiodiversity and diet diversity (Sibhatu et al. 2015). The introduction (or upscaling) of vegetables in production systems can contribute to improved nutrition outcomes by increasing the dietary intake of important vitamins and minerals, if the vegetables are consumed by the household (Sibhatu & Qaim 2017). In addition, farm households must buy some foods from the market, for which cash income is needed (Sibhatu & Qaim 2017) and the production of vegetables for the market could be the provider of this necessary cash income.

The NW of Vietnam exhibits favourable climate and soil conditions for vegetable production (Wijk & Everaarts 2007) and, consequently, there could be opportunities to integrate vegetable production in the existing, largely subsistence or semi-subsistence farming systems in the region. However, development of the vegetable sector by increasing the involvement of smallholder, semi-subsistence farmers in the industry and engagement with markets faces a number of challenges. These challenges include: (1) rapidly transforming markets including the types of markets and the demands of consumers; (2) poor competitiveness with peri-urban and regional producers; (3) poor infrastructure and logistics; and (4) nutrient depleted soils and erosion. Maximising the profitability of vegetable farming systems, whilst sustainably managing soil, water and nutrient resources is a challenge, particularly given the need to intensify production to maximise returns to smallholder farmers from very small parcels of land. Market access is an additional challenge and increasingly contingent on meeting consumer demands for safe, high quality and nutritious vegetables (Wertheim-Heck et al. 2014; Wertheim-Heck et al. 2015). Furthermore, the quantity and quality (consistency) standards imposed by the growing modern retail sector, e.g. supermarkets and specialty stores are strict (Cadilhon et al. 2006).

Advances in smallholder vegetable farming systems in the NW of Vietnam requires multidisciplinary research to explore options to overcome challenges or barriers to adopting different farm management practices and market engagement. Following the

challenges outlined in the previous paragraph, there is a need for market research and the identification of pro-poor marketing models appropriate for farmers shifting from subsistence agriculture to market-oriented vegetable farming systems. In addition, there is a need for biophysical farming systems research to create an evidence base for management recommendations for vegetable systems, in particular pest and disease management and fertility management. Consideration of historical land uses (traditional farming systems) and farmers' knowledge and constraints is necessary to deliver appropriate market development models and crop management recommendations. The project was designed to address these knowledge gaps and work with farmers using participatory action research to design production and marketing research specific to their major constraints. The specific objectives of the project are detailed in Section 4.

3.1 Project origin and contribution

This project was initiated following the recommendations of the final review of a previous ACIAR-funded project, Project Number AGB/2006/112 "Increasing the safe production, promotion and utilisation of indigenous vegetables by women in Vietnam and Australia" which provided a strong case for a new phase of research. This previous project looked to develop and test models to improve the profitability of farmers (in particular, women) supplying indigenous vegetables into transforming markets (Newman et al. 2013). Key research questions remaining at the conclusion of the previous project, included (Newman et al. 2013):

- What are the key drivers of consumer demand for vegetables? Do consumers perceive these vegetables as safe? What attributes enhance consumers perceptions of food safety?
- Do NW vegetable producers have a regional comparative advantage to supply the market with vegetables with consumers' desired attributes?
- What marketing models can enable smallholders (including ethnic minorities) to successfully engage with local, regional and urban markets?
- What low-cost strategies can effectively manage nutrients, pests and diseases in vegetable farming systems?
- What contribution to income and household nutrition do vegetables play in the different farming systems in the NW of Vietnam?
- What factors determine differences in diet quality of households between urban and rural areas in Lao Cai Province? How does diet quality compare between vegetable producing households and non-vegetable producing households (i.e. households following traditional rice-maize cultivation practices)?
- What opportunities exist to up-scale the FBS as a means to increase farmers' business management and marketing skills?

This project was designed to answer some of these questions and continue to develop strategies to support women and ethnic minorities engaged in agriculture. The Vietnam Country Gender Report (World Bank 2011) highlighted the important role of women and women's labour in the agricultural sector in Vietnam, for example women earn the majority of the family's income from agricultural activities. This project, like the preceding project, was designed to address the productivity of women's labour with the purpose of increasing incomes and other livelihood indicators (e.g. nutrition outcomes) of rural households (Newman et al. 2013). With this, women farmers, particularly those in ethnic minority groups of the NW highlands of Vietnam, were the key beneficiaries of this project.

As well as smallholder farmers, consumers in both rural and urban Vietnam were at the centre of efforts to design this project. Improvements to farming systems and farmers' access to markets is expected to have positive impacts on consumers' access to food. However, other research also guided the development of this project. For example, there is a growing body of literature documenting the growth in supermarkets and modern food retail outlets in Vietnam (e.g. Reardon et al. 2012; Maruyama & Trung 2007; McDonald et

al. 2000) highlighting the need to understand the shopping and food consumption behaviours of consumers to understand impacts of changing food shopping and consumption patterns on smallholder producers.

Farmers and extension providers also set to benefit from continued piloting of the FBS model. The FBS builds on the participatory Farmer Field School (FFS) model, first used in Indonesia in 1989, to upskill farmers to manage a farming system, e.g. manage a crop from seed to harvest, and overcome constraints such as pests and diseases (Braun & Duveskog 2008). The fundamental difference between FFS and FBS is that FBS focuses on farmers' marketing knowledge and skills, i.e. the scope extends beyond the field where the crop is growing and beyond the lifespan of the crop. The on-farm focus of FFS is beneficial, but a focus on this aspect of farming alone neglects issues related to market access that, like on-farm constraints, also influence livelihood outcomes (Newman et al. 2013). As such, the strategy for this project, like the preceding project (AGB/2006/112) was to integrate aspects of the FFS and FBS by incorporating activities that relate to better on-farm management and market engagement with a focus on minimising constraints that limit the flow of products and information between actors in the supply chain. Previous projects have reported positive impacts for farmers involved in FFS and FBS-like programs, so the logical next step is to explore opportunities to make FBS available to more farmers beyond the involvement of donor agencies or development projects, i.e. how do we make the FBS mainstream and accessible? Answering this question was central to the design of this project and the major contribution of the FBS aspect of this project, relative to the previous project (AGB/2006/112).

4 Objectives

The overall aim of the project was to enhance the profitability and sustainability of smallholder vegetable farms in NW Vietnam through improved market engagement and integrated resource and disease management practices. The project particularly focused on women and ethnic minorities engaged in horticultural value chains in Sa Pa and Bac Ha districts in Lao Cai Province.

Objective 1: Identify market opportunities and consumer preferences for indigenous and conventional vegetables in local, provincial and urban markets

1.1 Undertake a comprehensive market analysis (in local, provincial and urban markets) for conventional and indigenous vegetables.

- Focus: local and provincial markets in the NW highlands, urban markets in Hanoi
- The analysis will include: current and future potential market size and value; current production volumes; seasonality (supply and demand); spatial product flows and market channels; current and potential market segments; intrinsic and extrinsic quality attributes demanded and the value of these attributes and time series data (where available) on volume, price, quality and origin.

1.2 Conduct a consumer survey with a representative sample of households in key markets (e.g. Hanoi and NW Vietnam) to understand vegetable consumption patterns, purchase locations, preferences for vegetable attributes (e.g. varieties, origin, quality attributes) and perceptions.

Objective 2: Develop and promote competitive and efficient marketing models that deliver high quality safe vegetables to market, meet consumer demands and benefit smallholders (particularly women and ethnic minorities).

2.1 Select case studies that demonstrate different production and marketing models (e.g. collective input procurement, collective marketing and collector-led).

- Document case studies detailing baseline production and marketing operations of farmer groups, group governance, aspirations for development and business profitability
- Select 3–5 cases to enact group-driven interventions that improve farmer profitability (particularly for women and ethnic minorities)
- Monitor and evaluate intervention impacts (e.g. detailing market opportunity realised, technical or market constraints overcome, economic performance and application of lessons learnt to other similar enterprises).

2.2 Develop whole-chain marketing strategies (including brand development) that enable the development of a competitive position for smallholders.

2.3 Map vegetable supply chains from Sa Pa/Bac Ha to Hanoi and Lao Cai City to identify where losses are occurring and determine appropriate interventions.

- Undertake a participatory risk analysis to identify, characterise and evaluate food safety risks in vegetable supply chains.

2.4 Develop and test improved postharvest management strategies with commercial partners to enhance quality out-turn and minimise the risk of foodborne illnesses.

Objective 3: Develop and demonstrate whole-farm management practices that improve sustainability, productivity and household livelihoods in (i) rice-vegetable and (ii) vegetable-only systems.

3a: Develop productive and sustainable soil, crop nutrition and soil-borne disease management strategies.

3a.1 Identify natural resource constraints (soil, water, nutrition) through focus groups and interviews with farmers and strategic sampling and analysis of soil and plant nutrient status in both rice-vegetable and vegetable-only systems.

3a.2 Compare the fertility, productivity and sustainability for each system and identify opportunities for improved management using nutrient-balance modelling.

3a.3 Conduct on-farm field trials (replicated and adaptive) to evaluate and refine promising soil and crop nutrition management practices for key vegetable crops, systems and markets.

3a.4 Compare the effects of farming systems on soil-borne disease and develop optimal (economic and cultural) strategies for cropping cycles and management to ameliorate the effects of soil-borne diseases.

3a.5 Develop technical recommendations for sustainable and profitable soil, nutrient and soil-borne pathogen management in vegetable production systems.

3b: Improve smallholder household livelihoods

3b.1 Collect socio-economic data at the farming system and household level (pre-and post-research intervention) to support project benchmarking and farming systems and livelihood modelling.

3.b.2 Undertake diet quality and consumption surveys in 500 households to determine differences in diets between vegetable producing households and non-vegetable producing households and identify the factors that explain more diverse household diets, i.e. socioeconomic status, ethnicity, gender, farm scale and access to market.

3b.3 Develop or adapt a systems framework (“model”) and analyse the socio-economic inter-linkages and performance of each of these farming systems and related farming practices (e.g. liming and nutrient application).

3b.4 Develop recommendations to improve livelihoods for smallholder households’ reliant on vegetable systems.

Objective 4: Develop sustainable models for up-scaling the Farmer Business School (particularly targeting women smallholders) and building capacity in research, development and extension.

4.1 Develop, implement and evaluate sustainable options for upscaling the FBS.

4.2 Identify and develop additional FBS modules on food safety (following changes to Vietnamese legislation) and soil and nutrient management.

4.3 Build research capacity through targeted short-term training initiatives, mentoring schemes, study tours and cross-linking with other project initiatives.

5 Methodology

5.1 Case study region

The project case study regions were Sa Pa and Bac Ha districts within Lao Cai Province (Figure 1). Both districts have a temperate climate with two distinct seasons. The summer season, from May to October, is characterised by high rainfall and mild temperatures, and the winter season, from November to April, has relatively cold temperatures and minimal rainfall. Both districts are mountainous with areas as much as 1600 metres above sea level, which contributes to the cool temperatures experienced and the variability in climate within districts. In Sa Pa, and the highland areas of Bac Ha, the weather is cold and dry in winter and cool in summer. The annual average temperature is 18 - 20°C. For the rest of Bac Ha, the average temperature is higher, i.e 25 - 28°C. The annual rainfall in Sa Pa is relatively high, about 2700 mm; concentrated from May to August. In Bac Ha, rainfall is lower, with total rainfall at about 2000 mm, also concentrated in May to August (Figure 2).

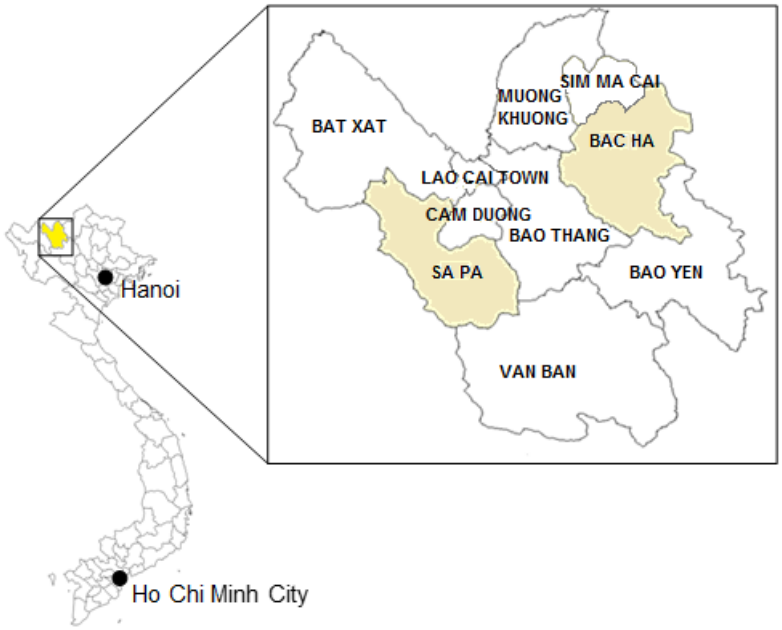


Figure 1. Location of project case study regions, Sa Pa and Bac Ha districts in Lao Cai Province, northwest Vietnam.

Both districts are approximately 680 km^2 with a population density of 86 people per km^2 (People's Committee of Lao Cai Province 2015a; 2015b). The H'mong are the most populous ethnic minority in both districts: 52% of the population of Sa Pa and 46% of the population of Bac Ha are H'mong (GSO 2010). This contrasts to the population share of H'mong people at the province level (20%) and nationally (1%). Following the H'mong people, the Dao and the Tay ethnic minorities are the next most populous in Bac Ha and Sa Pa.

There is a relationship between the ethnicity of the population and topography in these districts (Roche & Michaud 2000). The ethnic minority groups such as the H'mong, Tay and Dao are largely located in the highlands with towns and lowland areas dominated by the majority ethnic group, the Kinh people (Roche & Michaud 2000).

Bac Ha and Sa Pa are the third and fourth poorest districts in Lao Cai Province with 28% and 25% of households in each district respectively classified as living in poverty in 2014, and an additional 12% and 10% classed as marginal (UNICEF & People's Committee of Lao Cai Province 2016). Poverty rates are also correlated with rates of childhood stunting rates; Bac Ha and Sa Pa have the third and fourth highest district-level stunting rates for

Lao Cai Province with 35% of children stunted, behind Muong Khuong (47%) and Si Ma Cai district (36%; UNICEF & People's Committee of Lao Cai Province 2016).

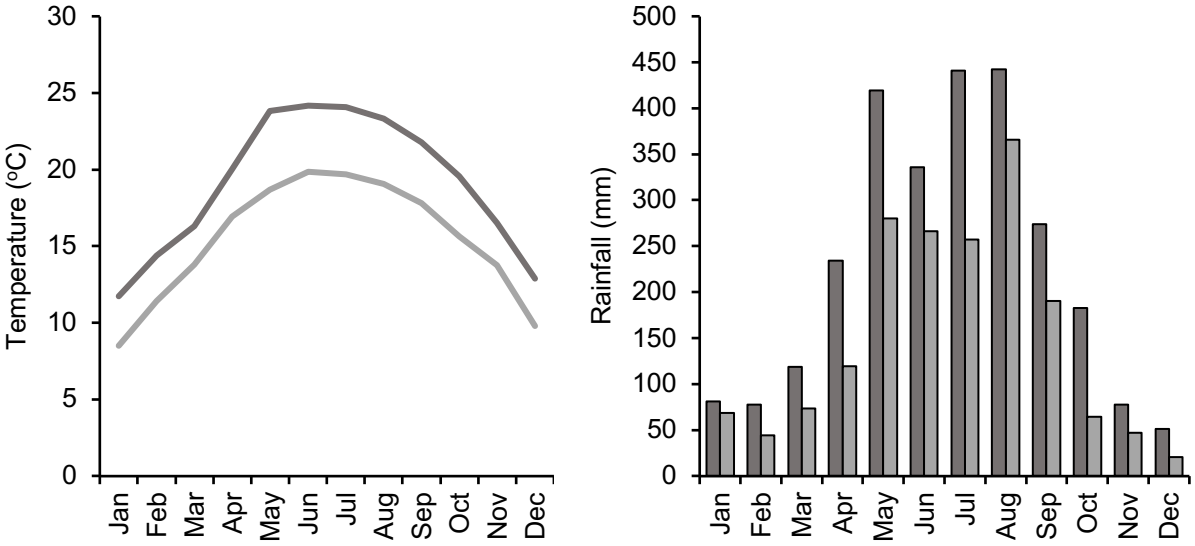


Figure 2. Mean air temperature (left) and average monthly rainfall for 2001–2009 (right) for Bac Ha (light grey) and Sa Pa (dark grey).

The same case study regions were the focus of the previous project, AGB/2006/112, and continuing with these districts allows us to build on partnerships in the region and changes or skills accumulated in the previous project.

5.2 Project Structure

Work on the project was divided into four components. Each component corresponded to a project objective as illustrated in Table 1.

Table 1. Project objectives and corresponding work components.

Objective			Component	
Obj. 1	To identify market opportunities and consumer preferences for indigenous and conventional vegetables in local, provincial, urban and export markets	↔	**C1**	Market Analysis
Obj. 2	To develop and promote competitive and efficient marketing models that deliver high quality safe vegetables, meet consumer demand and benefit smallholders	↔	**C2**	Market Development
Obj. 3	To develop and demonstrate whole-farm management practices that improve sustainability, productivity and household livelihoods in (i) rice-vegetable and (ii) vegetable-only systems	↔	**C3**	Farming Systems
Obj. 4	To develop sustainable models for upscaling the Farmer Business School and building capacity in research, development and extension	↔	**C4**	Capacity Building

The project built on the approach taken and research partnerships developed in the preceding project, AGB/2006/112. It used a multi-disciplinary approach with all research activities also focused on capacity building of key institutions.

The four components were separated based on the project objectives and the different research disciplines and geographic scopes required to address each objective. Though operating independently on some activities, the components were interlinked. For example, the research findings in different components of the project fed into the design and trials of the research activities in other components (Figure 3).

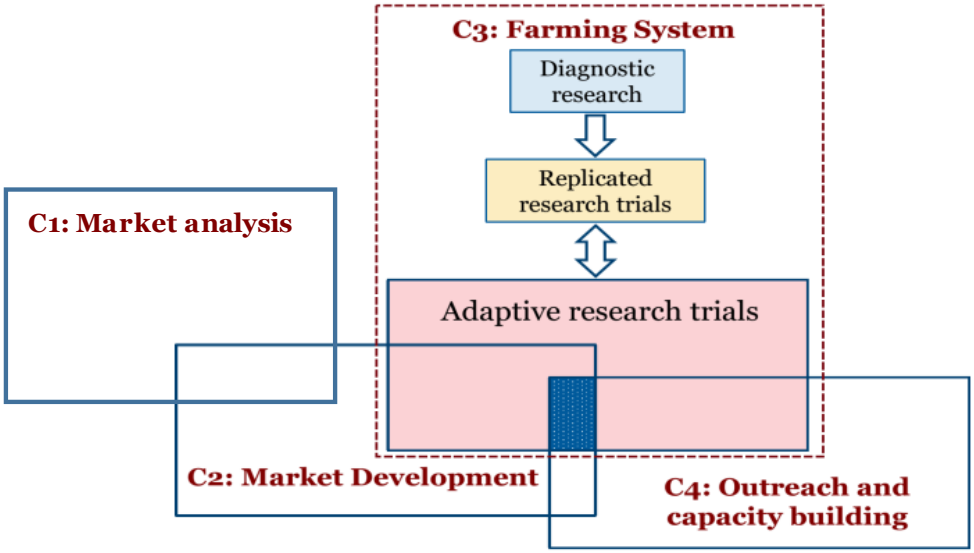


Figure 3. Inter-relationships between components and sub-components of the project.

5.3 Project Management

The project formally employed expertise from three partner institutions in Australia and eight partner institutions in Vietnam:

1. The University of Adelaide (UoA; commissioned organisation)
2. New South Wales Department of Primary Industries (NSW DPI)
3. The University of Queensland (UQ)
4. Vietnam Women's Union (VWU; lead institution in Vietnam)
5. Plant Protection sub-Department, Lao Cai (PPsD Lao Cai)
6. Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD)
7. Fruit and Vegetable Research Institute (FAVRI)
8. Vietnam National University of Agriculture (VNUA)
9. National Institute of Medicinal Materials (NIMM)
10. Soils and Fertilisers Research Institute (SFRI)
11. International Center for Tropical Agriculture, Asia, Vietnam (CIAT)

In addition, the project also engaged individuals with relevant expertise, each of these people were contracted through The University of Adelaide and are affiliated with institutions including Western Sydney University, The Queensland Government Department of Agriculture and Fisheries and the University of the Sunshine Coast.

Given the project's complexity, a management structure was necessary to facilitate effective communication and coordination of activities across Australia and Vietnam, across 11 institutions and four work components (Table 1). The overall management structure used is detailed in Figure 4.

Overall project operation was managed by the project leaders:

- Wendy Umberger (UoA; 2018 to project completion in 2019)
- Dale Yi (UoA; 2017)
- Suzie Newman (UoA; 2014 to 2017)

- Nguyen Thi Mai Hoa (VWU; 2014 to 2016)
- Truong Thi Thu Thuy (VWU; 2017 to 2018)

and project coordinators:

- Phan Thuy Hien (NIMM)
- Nguyen Hien (VWU; 2014 to 2016)
- Ha Thi Tra My (VWU; 2017 to 2018).

Project coordinators facilitated cross-organisation and cross-component communication and coordination.

Each work component was managed in partnership between a Vietnamese and Australian team leader. These component leaders were a central point for contact and management in Australia and Vietnam to plan and coordinate activities and make strategic and tactical decisions regarding methods and use of resources. The leadership team (Australian and Vietnamese project leaders, component leaders and project coordinators) met regularly to review and plan project activities.

PPsD Lao Cai were engaged with each of the components and facilitated communication and coordination between components in the field and with provincial stakeholders. The project also employed two village researchers (one in Sa Pa and one in Bac Ha), managed by SFRI and NIMM, who assisted in the day-to-day management of project trials, activities in field sites and interactions with farmers.

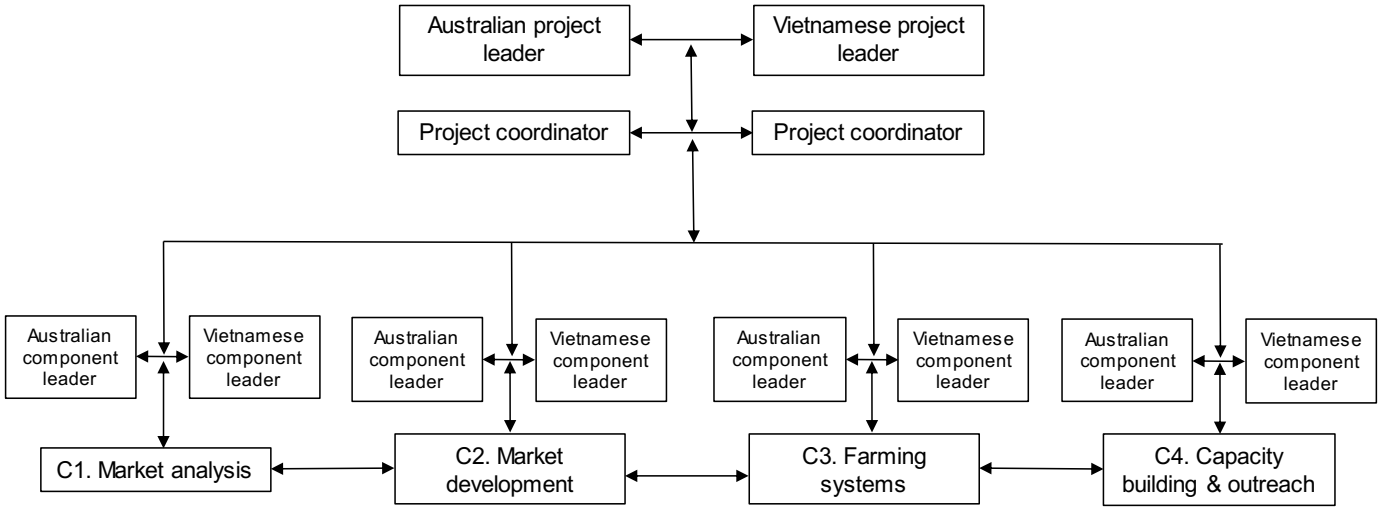


Figure 4. Project management structure.

5.4 Component 1 — Market analysis

To understand the market dynamics and identify opportunities for NW vegetable producers in local, provincial and urban markets, the market analysis component was divided into three subcomponents. These subcomponents included: (a) an analysis of vegetable trade to understand existing trade flows of vegetables in NW Vietnam; (b) an analysis of time-series vegetable prices to identify when prices peak, price differences between vegetables from different origins and at different markets and (c) an analysis of urban consumers demand and preferences for vegetables.

5.4.1 C1a: Vegetable trade patterns

This subcomponent aimed to identify opportunities to expand trade of indigenous and conventional vegetables in local, provincial and urban markets in Vietnam. To do this we

conducted an analysis of the supply chain structures and spatial trade flows of key NW vegetable commodities to identify seasonality in the trade of vegetables within Lao Cai Province, with neighbouring NW provinces, and with Hanoi.

Study sites were located in the main retail and wholesale markets of the following provinces: (1) Lao Cai; (2) Son La; (3) Yen Bai; (4) Dien Bien and (5) Hanoi. In each of the provinces, the study was carried out in three phases as follows.

Phase 1: Reconnaissance

'Meta-informants' were interviewed to characterise the basic structure of vegetable trade. Meta-informants are actors who have an overarching view of the vegetable value-chains (VC) and markets. These informants provided broad meso-level information on vegetable trade in the case study regions and mapped out all of the different types of VC actors involved in vegetable marketing.

Phase 2: Case studies

Case studies were conducted on each type of actor of the vegetable VC using structured interview guides. Multiple informants from each actor type were chosen for interviews to understand the function and position of the actor type in the chain.

Phase 3: Synthesis

The information collected was analysed to identify patterns and trends that were common across interviews and findings were synthesised to articulate a cohesive story of vegetable trade. Interview data was supplemented with secondary data to draw overall conclusions regarding the trade patterns, constraints, and growth opportunities.

5.4.2 C1b: Price analysis

Given the strong seasonality of vegetable production and a complex network of suppliers into markets in Hanoi, there was a need to understand when prices were peaking and when products from different origins were entering the market. This information can be used to understand any comparative advantage for vegetables grown in Sa Pa and Bac Ha relative to other source locations for Hanoi markets. In addition, prior to this project, the efficiency of vegetable trade in Vietnam had not been studied. This vegetable price analysis also served as a way to measure the extent to which prices in one market affect prices in another market.

Data collection

Price data were collected on the following commodities: (1) H'mong mustard; (2) chayote leaves; (3) chayote fruit; (4) tomato; (5) cabbage and (6) broccoli. Data were collected on the main variety, quality grades, and geographic origins of each vegetable commodity during a peak trading period (e.g. between 12am and 1am in the wholesale markets) every day from 1 February 2016 to 31 January 2017. Daily prices were collected in three regions: eastern, southern and western Hanoi. In each region of Hanoi, data were collected in the main wholesale market, the main wet-market (traditional retail market) and supermarket, as well as a three specialty shops (Table 2).

Table 2. Markets in Hanoi where daily price information was collected.

No	Name	Type of outlet	Address
1	Minh Khai	Wholesale market	Minh Khai ward, Bac Tu Liem district
2	Long Bien	Wholesale market	Phuc Xa ward, Ba Dinh district
3	Den Lu	Wholesale market	Hoang Van Thu ward, Hoang Mai district
4	Big C	Supermarket	222 Tran Duy Hung, Trung Hoa ward, Cau Giay district
5	Metro	Supermarket	126 Tam Trinh, Yen So ward, Hoang Mai district
6	Lang Thuong	Retail market	Lang Thuong ward, Dong Da district
7	Ngoc Lam	Retail market	Ngoc Lam ward, Long Bien district
8	Tan Mai	Retail market	Hoang Van Thu ward, Hoang Mai district
9	Biggreen	Specialty shop	113 Hoang Van Thai, Thanh Xuan district
10	BacTom	Specialty shop	06 Nguyen Cong Tru, Hai Ba Trung district
11	Ecomart	Specialty shop	Hoang Quoc Viet, Cau Giay district

Daily price data was collected using a protocol developed by VNUA before being entered into a central database. The form used by vegetable traders (or retailers) to record the price data is presented in Table 3.

Table 3. Example of a price collection instrument used by traders to record data.

Type of vegetable	Source of supply	Ungraded (*'000 VND/kg*)	If vegetable is graded, please indicate the graded prices		
			Grade 1 (*'000 VND/kg*)	Grade 2 (*'000 VND/kg*)	Grade 3 (*'000 VND/kg*)
H'mong mustard	Son La/Lao Cai (NW)				
	Red River delta				
	Nghe An				
	China				
	Other: _____				

Time series analysis

Time-series regression was used as a diagnostic tool to identify if market and trade institutions were functioning efficiently and competitively. Market co-integration tests were used to identify whether prices in different markets were moving together, i.e. to test whether changes in the price of vegetables in one market were also occurring in other markets. If this was found to be the case then it could be concluded that there is no profit to be gained by buying vegetables in one market and selling them in another or, in other words, no advantage to selling your vegetables in one market instead of another and that the market is operating efficiently and competitively. In addition, Granger causality tests were used to identify the direction of relationships between prices in different markets. For example, the test was used to determine whether price shocks in one market are transmitted to a related (co-integrated) market.

5.4.3 C1c: Urban consumer study

To provide insights into vegetable expenditure and consumption behaviours, and preferences of consumers for vegetable attributes, we implemented The Vietnam Urban Food Consumption and Expenditure Study during December 2016 to March 2017. The

study was conducted in four urban locations: Hanoi (n = 700), Ho Chi Minh City (n = 1000), Lao Cai City (n = 150) and Son La City (n = 150). The survey was implemented in partnership with another ACIAR-funded project, AGB/2015/029 "A strategic approach to pro-poor consumer research in the Mekong region — extended analyses". Given the broader scope of the co-implementing project, the survey and sampling design was designed to collect data on more than just vegetable expenditure and consumption behaviour.

Survey instrument design

The survey was designed to collect information at the household and individual level and included questions to capture: (1) socio-demographic characteristics of each household member; (2) health information, including diet-related health issues; (3) expenditure and consumption for 92 food products; (4) food shopping behaviour and (5) access to food outlets.

The survey was initially modelled on that used by Umberger et al. (2015) and Minot et al. (2015) in Indonesia and updated for the objectives of the present study and context of our study areas in Vietnam using available literature and focus groups. Ten types of food retail outlets were accounted for, each defined as follows (adapted from Dyck et al. 2012; Minot et al. 2015):

- *Hypermarkets and Supermarkets* (examples include Metro, Big C, Fivi Mart, AEON, Lotte Mart)
- *Minimart* (examples include 7-Eleven, Vinmart, Shop & Go, Circle K)
- *Specialty shops*: small sized shops with clear external billboards signalling the offer of certified safe, clean or organic vegetables (examples include Soi Bien, Bac Tom, Big Green and Klever Fruit)
- *Formal wet market*: a market formally established by the authorities
- *Traditional family shop*: a traditional family shop is a small food shop run by a household that commonly sells processed foods and beverages
- *Semi-permanent stand*: a retailer selling from a table, stand, cart, or stall that can be moved, but generally stays in one place during the day
- *Peddlers/mobile street vendors*: a retailer operating on foot, on a bicycle, or from a pick-up and sells both food and non-food items
- *Informal street markets*: retailers sell to the public without having a permanent structure for the market
- *Phone order*: customers order food over the phone and have their order delivered or prepared for collection
- *Online*: customers order food online and have their order delivered or prepared for collection.

We classified the 92 food groups included in our survey into 12 general groupings. Descriptions of each group are provided in Table 4.

Once the survey was designed it was programmed into CommCare, a tablet-based application available on the Android platform that enabled digital data collection and direct entry of data into a format suitable for analysis.

Sample design

Surveyed households were randomly selected using a proportional random sampling method. Each city was divided into wards, then, wards were weighted by population, and a population weighted random sample of wards was drawn. From each randomly drawn ward, a fixed number of households were sampled using a random walk algorithm. This sample design ensured that there was sufficient variation in household income, access to food retail outlets, and other characteristics that influence decisions on household consumption.

Table 4. Foods in different food groups used in analyses.

Food category	Types of foods included in category
Rice	Rice
Food consumed away from home	Food and beverages consumed away from home
Vegetables	All fresh, frozen, dried and canned vegetables
Meat and eggs	Fresh pork, fresh fish and seafood, fresh chicken, fresh beef, fresh duck, fresh lamb, fresh mutton, fresh veal, processed meat, dried meat, eggs
Pulses, nuts and beans	Beans (e.g. kidney, soya beans), pulses, nuts, tofu
Fruit	All fresh, frozen, dried and canned fruit
Processed cereals	Maize products, other grains and flour, pasta, noodles, bread, breakfast cereals
Sugar, spices and sauces	Sugar and sweeteners, salt, soya sauce, monosodium glutamate, chilli sauce, other sauces, spices and seasonings (e.g. pepper, coriander, etc.)
Beverages	Bottled water, tea, coffee, fruit juice, soft drinks, alcoholic beverages, herbal drinks, infant formula, nutrition drinks, vitamin drinks
Oils and fats	Coconut oil, palm oil, lard oil, other cooking oils, coconut milk, fats, butter, margarine
Processed food	Instant noodles, cakes, biscuits, pastries, chocolate bars, ready-to-eat meals, quick prepare meals, potato crisps and other snack food
Milk and milk products	Fresh, powdered, UHT and canned milk, other dairy products (e.g. cheese, cream and yoghurt,)

Enumerator training and data collection

Enumerators were employed to conduct the survey with households. Each enumerator used a tablet with the CommCare application and survey installed to conduct the survey. Prior to commencing data collection, the enumerators participated in an intensive 10-day training program to build capacity in their ability to use the survey instrument, operate the CommCare application and follow data collection protocols. Following this training, enumerators conducted trial interviews with respondents that were supervised by training staff.

Data collection commenced in December 2016 and was completed in March 2017. This period spanned the Tet Holiday in Vietnam, 26 January to 1 February 2017. To avoid potential atypical food expenditure and consumption patterns associated with Tet, the data collection effort was paused for 1 month over this period.

Data were collected from approximately 2000 households:

- Ho Chi Minh City (1000 households)
- Hanoi (700 households)
- Lao Cai City (150 households)
- Son La City (150 households)

Data analysis

Data were downloaded from the CommCare server directly into Excel. Following this, data from each module was cleaned and used for a number of analyses, depending on the research question.

5.5 Component 2 — Market development

The objective of this component was to develop and promote competitive and efficient marketing models that deliver high quality safe vegetables, meet consumer demand and benefit smallholders. The component included case studies on common marketing models in Lao Cai Province, interventions to improve market access, and postharvest work to reduce losses along the supply chain.

5.5.1 C2a: Case studies

A case study approach was used to: (1) understand the general context and structure of the production and trading system in NW Vietnam (led by key actor groups including cooperatives, farmer groups, and private traders); (2) identify constraints and opportunities to these key actor groups for the development of vegetable value chains with smallholders in these regions; and (3) identify the development orientation and plans for the production and trading systems of vegetable smallholders in NW Vietnam.

Farmer groups, cooperatives, collectors and private enterprises were engaged in the case study activity and served as the primary source of information used to describe typical marketing models (Table 5). Documentary research methods were used in combination with focus group discussions (FGD) and in-depth interviews. FGDs and in-depth interviews were structured around production, marketing and group governance issues. Primary data were supplemented by a review of existing literature, data collected in the pursuit of other objectives under this project (e.g. market analysis), and official vegetable production and marketing data for Lao Cai Province.

Table 5. Case study groups that were interviewed and or participated in focus group discussions to characterise marketing models used in Lao Cai Province.

Types of participants	Participating groups
Co-operatives	Thanh Cong (Sa Pa) Di Thang (Bac Ha) Na Lang
Farmers' vegetable production groups	Ma Tra farmers' group (Sa Pa) Na Kheo farmers' group (Bac Ha)
Private enterprises	Anh Nguyen company (Bac Ha) Vegetable collectors in Lao Cai City

Following data collection, results were cross-validated and developed into a collection of individual case studies. Broader conclusions on marketing models were also developed.

5.5.2 C2b: Market development

This subcomponent aimed to implement whole-chain marketing strategies (including brand development) that enabled the development of a competitive market access position for smallholders.

Marketing strategies and interventions were developed in consultation with stakeholders, farmers and local authorities using the Collaborative Problem Solving Methodology (CPSM) which was also used in the preceding project, AGB/2006/112 (Figure 5).

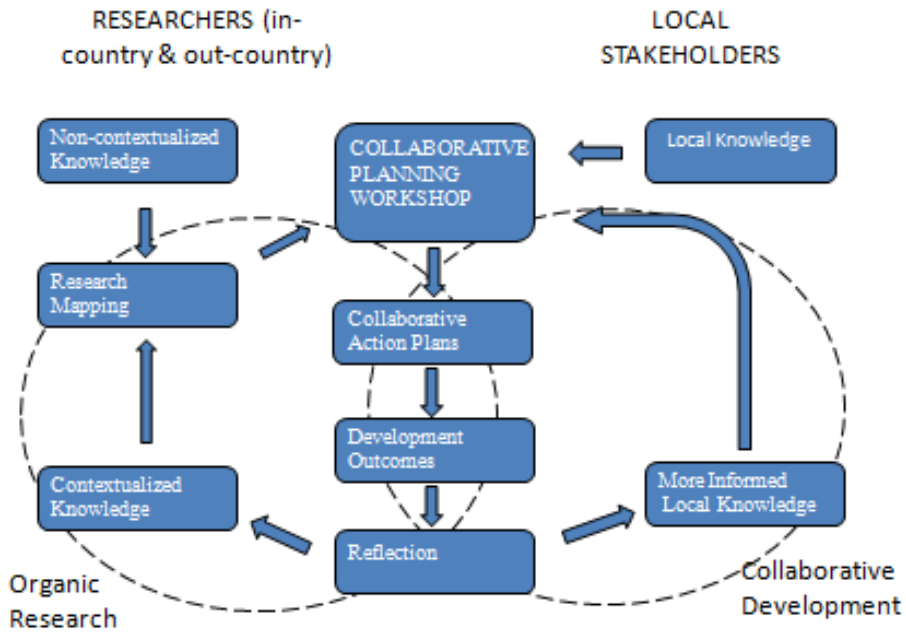


Figure 5. Collaborative Problem Solving Methodology (Spriggs & Chambers 2011).

A series of stakeholder workshops and steering committee meetings were used to consult stakeholders on priorities and strategies:

- Stakeholder workshop for local government (October 2014)
- Stakeholder workshop for supply chain partners (October 2014)
- Steering committee set priorities and then implementation plans (March 2015).

Input provided by the steering committee and stakeholders was used to design market interventions. These interventions were then implemented by the FAVRI market development team. Intervention activities included product fairs, production timing calendars, farmer group consultation and facilitation of market links.

Outcomes were assessed and used as input in the next iteration of interventions, going back to Step 1:

- Stakeholder workshop for input into next phase of interventions (March 2016)
- Stakeholder meeting upscaling and out-scaling project (May 2016).

Preliminary findings from market analysis studies (see Section 5.4) also used in the design of market interventions.

5.5.3 C2c: Postharvest

This subcomponent was tasked with identifying where postharvest losses were occurring, determining interventions and analysing food safety risk.

Consignment tracking

Ten commercial vegetable consignments were tracked from farms in Lao Cai Province to market in Hanoi. The methods employed were like those of Tomlins et al. (2000). Including:

- Evaluating the physical environment (temperature, humidity and impact) that the vegetables are exposed to from farm to market. Temperature/humidity/shock data loggers were enclosed in bags/boxes/crates of vegetables
- Assessing quality losses (weight loss, mechanical damage, colour change and postharvest disease using a scoring system e.g. Figure 6) at transfer points in the

supply chain (i.e. at harvest, following sorting and grading, following unloading at urban markets)

- Identifying bottlenecks and critical control points and causes of postharvest losses. This determined which technologies and/or supply chain modifications to trial to improve quality out-turn.

Turgid	*Slight wilting (<10%)*	*Some wilting (11- 25%)*	*Moderate wilting (26-50%)*	*Severe wilting (>50%)*
Score: 0	**Score: 1**	**Score: 2**	**Score: 3**	***Score: 4***

Figure 6. Example of quality measurement for leafy vegetables (wilting score 0–4 indicates increasing severity).

Testing interventions

The consignment tracking activities focused on identifying factors that contributed to postharvest losses to inform potential interventions to reduce losses. These interventions designed and tested were alternative packaging options. Specifically, five different packaging types were assessed:

1. foam boxes
2. medium-sized cardboard boxes,
3. plastic crates
4. foam boxes with ice
5. medium-size cardboard boxes with ice

The effectiveness of interventions was assessed on the significance of differences in weight loss or the incidence of bruising in vegetable consignments receiving different treatments.

Participatory food safety risk analysis

A rapid analysis of food safety risk was undertaken for ten smallholder farmers in Bac Ha and ten smallholder farmers in Sa Pa. Food safety risk was determined based on a semi-structured interviews that sought to identify on-farm food safety hazards and their likely risk. Interviews were undertaken by staff from FAVRI in September 2018 and supported with further farm visits in October 2018.

5.6 Component 3 — Farming systems

An integrated soil management, farming systems and socio-economic approach was used to analyse and improve the performance of farming systems in Bac Ha and Sa Pa districts of Lao Cai Province. This component used a participatory approach to identify production constraints faced by farm households, and then trialled technologies and practices to address those problems and adapt them for use by farm households. The approach taken required basic research followed by adaptive research as per the Innovation for

Sustainable Development Framework (Figure 7). The component was divided into five subcomponents: (1) baseline analysis; (2) soil and nutrient management; (3) plant pathology; (4) adaptive trials and (5) socio-economic and consumption analysis.

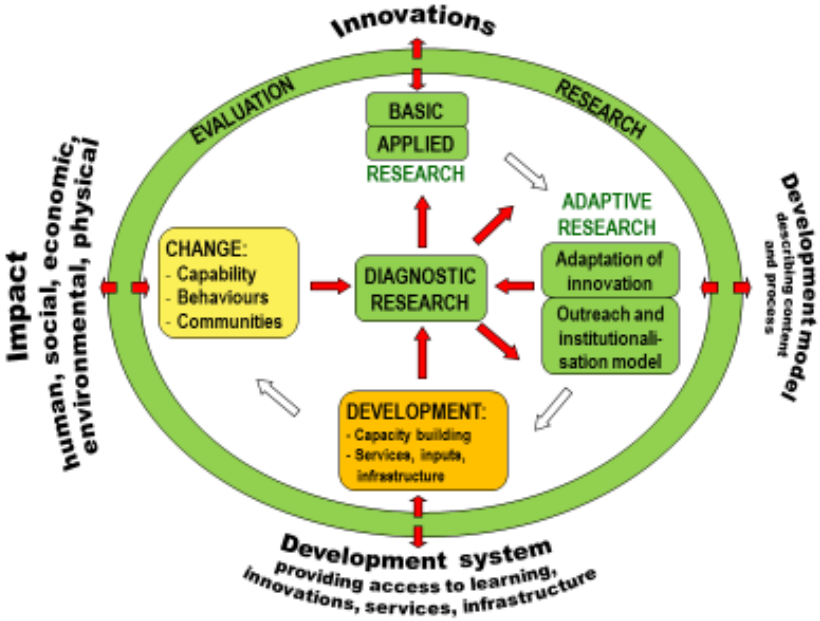


Figure 7. Innovation for Sustainable Development framework (van de Fliert .and Nicetic, AGB/2008/001)

5.6.1 C3a: Baselining

Baseline data were collected for the priority farming systems (rice-vegetable and vegetable-only farming systems) to understand the socioeconomic context of farming in the case study regions and to identify production problems (nutrient management, pest and disease constraints, and water quality). Baseline information was collected using a combination of FGDs, direct sampling of the cropping system and a survey of farm households. Detailed information was collected on:

- Household characteristics
- Crop schedules (using a crop calendar)
- Cultivation techniques
- Nutrient management
- Soil characteristics (using soil samples)
- Irrigation water quality
- Pest and disease constraints.

Baseline information was used to inform the design of the farming systems research component. Information on soils and nutrient management practices, pest and disease constraints and controls, and direct input from farmer groups were used to prioritise research areas to be addressed with additional work.

5.6.2 C3b: Soil and nutrient management

Following the conclusion of the preceding project, AGB/2006/112, sustainable nutrient management was identified as requiring further research (Newman et al. 2013). In both the preceding project and the baseline surveys of the farming systems, farmers' knowledge of nutrient management was found to be limited with empirical evidence

suggesting that smallholder farmers were mismanaging fertilisers. This subcomponent identified problems in soil and nutrient management and conducted a series of trials to inform optimum soil and nutrient management practices.

Nutrient budgets

Nutrient budgets, a record of nutrient inputs and outputs, are an important tool used to identify nutrient surpluses and deficits to ensure that nutrient management practices are efficient and sustainable.

To evaluate the general nutrient status of vegetable crops, a survey was conducted using cabbage as the reference crop (and the youngest wrapper leaf selected) across 30 farms in Sa Pa and Bac Ha districts. In addition, a series of on-farm partial nutrient budgets was conducted in Sa Pa and Bac Ha for key vegetable crops including: H'mong mustard, cabbage, kohlrabi and unfolded cabbage (cai bap xoe). This information was used to identify major nutrient deficiencies and surpluses. Results from nutrient budgeting were used to determine the focus of nutrient trials.

Nutrient Trials

Nutrient budgeting results indicated over application of nitrogen, phosphorus and potassium whilst deficiencies of some critical micronutrients were identified. This warranted further investigation with trials (Figure 8) to identify optimum fertiliser applications for:

Nitrogen

Nitrogen (N) response trials were conducted in Bac Ha in two crop seasons (October 2015 to January 2016 and November 2016 to January 2017). These trials were initiated to identify optimal N application rates in cabbage, broccoli, H'mong mustard, Chinese flowering cabbage (choy sum) and cai bap xoe. For cabbage and broccoli, five N application rates (30, 90, 150, 210, 270 and 40, 100, 160, 220, 280 kg N ha^{-1}, respectively) were imposed. For Chinese flowering cabbage, nine N application rates (0, 15, 30, 45, 60, 75, 90, 120 and 150 kg N ha^{-1}) were imposed. For H'mong mustard and unfolded cabbage, eight N applications rates (0, 40, 80, 120, 160, 200, 240 and 280 kg N ha^{-1}) were imposed.

Phosphorus

Phosphorus (P) response trials were conducted in two crop seasons in Sa Pa (off season, from April 2017 to July 2017, for cabbage; and main season, from October 2017 to February 2018, for kohlrabi), and main season with cabbage in Bac Ha. The trials included six P application rates (0, 30, 60, 90, 120, and 150 kg P_2O_5 ha^{-1}).

Lime

Field and laboratory lime trials were conducted to identify suitable lime application rates. The laboratory incubation studies evaluated equivalency lime rates of 0, 0.5, 1.0, 2.0, 3.0, 5.0 and 6.0 t ha^{-1} on soil pH for 5 soil types, three soils from Bac Ha and two soils from Sa Pa. Field lime trials were conducted for cabbage with six lime rates (0, 0.25, 0.5, 1, 2 and 4 t ha^{-1}) in two crop seasons in Sa Pa and Bac Ha.

Micronutrients

Field trials were conducted to assess cabbage response to micronutrient application in Sa Pa and Bac Ha. Six treatments were imposed including application of zinc (Zn), boron (B), molybdenum (Mo), and copper (Cu) individually, an 'all' treatment and a nil treatment (no applied micronutrient). Treatments were applied as three foliar applications.

a) Field survey to select experiment site

b) Soil preparation

c) Vegetable planting

d) Field trial after fertiliser application

Figure 8. Photos of steps to implement nutrition trials.

5.6.3 C3c: Plant pathology

Soil-borne pathogens are one of the most important challenges to vegetable production in Lao Cai Province. Many soil-borne pathogens have the propensity to survive for several years outside their preferred hosts and may colonise and multiply in alterative hosts, thus reducing the effectiveness of fallowing or crop rotations as a control. This subcomponent conducted pest and disease surveys to identify critical soil-borne diseases and conducted field trials to identify effective control strategies to support smallholder vegetable farming systems affected by disease. Team members were trained in disease diagnostics.

Pest and disease survey

Field surveys were conducted in February, May and October 2014, in conjunction with soil and nutrition baseline surveys, to identify diseases and pests associated with the crops planted in the three farming systems (characterised by crop rotations): vegetable-only, vegetable-temperate fruit and vegetable-rice. Four additional surveys focusing on vegetable diseases were conducted in in Sa Pa and Bac Ha in May and October each year for two years (2015 and 2016) to monitor any new disease occurrence and major disease threats to vegetable farms in Sa Pa and Bac Ha. Disease symptoms and the incidence of each disease were recorded. Symptomatic plant samples were collected for laboratory identification.

Every vegetable field that was visited by the project team was examined for the occurrence of disease symptoms. Disease symptoms were recorded and samples were collected for laboratory identification. For every disease sample, isolations were made and the cause of the disease was identified and recorded. The incidence of each disease was classified into four different levels based on the incidence:

- Low (< 10% of plants infested);
- Moderate (11-25% of plants infested);
- Medium (26-50% of plants infested);
- High (> 50% of plants infested).

The incidence of each disease was classified into four different:

- Uncommon (<5% of incidence)
- Low (6-20% of incidence)
- Medium (21 to 40% of incidence)
- High (41-60% of incidence)
- Very high (> 60% of incidence)

Two important soil-borne pathogens, *Plasmodiophora brassicae* causing clubroot and *Rhizoctonia solani* causing collar rot on brassica vegetables, were chosen for further research to develop effective control measures.

Laboratory diagnostics

Disease samples collected in field surveys were examined and diagnosed based on the following procedures.

Diseased samples were rinsed in running water and small sections (10x10mm) were cut aseptically from the margin between healthy and diseased tissue. Sections were surface sterilised in 70% ethyl alcohol for 15 – 20 seconds, rinsed in sterile water and patted dry on sterile paper tissue. Small pieces (5x5mm) were cut and plated into low-nutrient or selective medium (eg: water agar with antibiotics [WA]), selective isolation medium for Phytophthora ass (PSM), quarter-strength potato dextrose again with antibiotics (1/4 PDA). Plates were checked daily and colonies subcultured to obtain pure colonies. Pathogens were morphologically identified using a microscope.

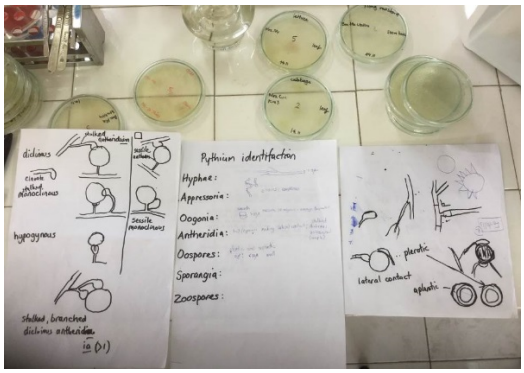
Additional diseased samples were rinsed in running water to remove soil and other debris and then humidified on moist sterilised paper in a 9cm petri dish. Samples were examined under a dissecting microscope after 1 – 2 days to identify spores or spore-forming structures such as pycnidia, acervuli or sporodochia.

This process formed part of the capacity building in disease surveys and plant health diagnostics providing scientists with a greater understanding of what to look for in the field, how to collect field samples and how to isolate and identify potential pathogens from diseased plant material (Figure 9).

a) Field survey

b) Isolating fungal pathogens

c) Examining fungal culture at NIMM lab



d) Morphological taxonomy — *Pythium* spp.

Figure 9. Photos of plant pathogen survey, isolation and identification activities.

Clubroot control trials

Trial design

In 2015 and 2016 trials were established on two vegetable farms in Sa Pa to evaluate the efficacy of selected treatments against clubroot. The farms were naturally infested with *Plasmodiophora brassicae* and had previously been affected by cabbage clubroot in two successive crops. Beds of 12 plants each were prepared in a Latin square design for each trial plot with 5 replicates. Two additional trials were conducted in 2017.

Experimental treatments were as follows:

Experiment 1 (2015)

1. Untreated control
2. Agricultural lime (powdered calcium carbonate) at 5 tonnes/ha incorporated into 20 cm in crops 1 and 2
3. Fluazinam drenching of seedlings at transplanting at 1.15kg a.i./ha (0.33g ai/plant)
4. Chopped spring onions at 5 kg/ha
5. Lime + fluazinam (rates as per 2 and3)

Experiment 2 (2016)

1. Untreated control
2. Agricultural lime (powdered calcium carbonate) at 5 tonnes/ha incorporated into 20 cm in crops 1 and 2
3. Fluazinam drenching of seedlings at transplanting at 1.15kg a.i./ha (0.33g ai/plant)
4. Flusulfamide drenching at transplant at 10.6 kg/ha (0.3g ai/plant)
5. Lime + fluazinam (rates as per 2 and 3)

Experiment 3 & 4 (2017)

1. Untreated control
2. Agricultural lime (powdered calcium carbonate) at 5 tonnes/ha incorporated into 20 cm in crops 1 and 2
3. Fluazinam drenching of seedlings at transplanting and spraying 1 month after planting at 1.15kg a.i./ha (0.33g ai/plant)
4. flusulfamide drenching at transplant at 10.6 kg/ha (0.3g ai/plant)
5. Lime + fluazinam (rates as per 2 and 3)

At harvest, plant roots were rated for disease severity (0–5 rating, from no disease to dead). Heads were weighed to obtain marketable fresh weights. Economic analysis (partial gross margin) was conducted for each treatment based on the input costs and crop revenue per sao (360m^2).

Collar-rot (Rhizoctonia) trials

Trial design

Trials were established using H'mong mustard for 2 successive crops on a vegetable farm in Bac Ha that was naturally infested with *Rhizoctonia solani* and had previously been affected by collar rot. The trials ran from October 2017 to February 2018 and again in August-September 2018.

Eight replicates of four treatments were arranged in two 4 x 4 Latin Square designs. The 2 squares were named 'Plot 1' and 'Plot 2' and the columns within each square were named 'Bed 1,2,3,4'. There were 32 experimental units from which plant weights from 4 subsamples ('frames') were recorded.

Five grams of H'mong mustard seeds were added to each plot at the time of treatment application.

The following treatments were applied:

1	Untreated control
2	*Trichoderma* sp. incorporated into soil to a depth of 20 cm at planting at a rate of ½/1 m^2
3	Cruiser Plus (Thiamethoxam + Difenoconazole + Fludioxonil) treated seed before sowing: 4 µl/ 5 g seed
4	Cruiser Plus (Thiamethoxam + Difenoconazole + Fludioxonil) treated seed before sowing: 4 µl/ 5g seed? + Amistar Top 312.5 FS (Azoxystrobin + Difenoconazole (50µl/ m^2) spray twice (once before sowing, and again after germination, about 15 days)

The total number of germinated seedlings and the number of plants affected by *Rhizoctonia* was recorded and the mean disease index recorded after 7 days after germination.

The mean disease index was recorded based on the following scale:

Score	Description
1	<5% plants died
2	5-20% plants died
3	20-50% plants died
4	>50% plants died

Statistical analysis

Club root trials

A mean of the 12 plants in each bed was calculated for analysis. Total plot yield, average head weight and proportion of plants producing a cabbage head were analysed. The four experiments were analysed separately and together. The disease assessment data was not analysed because of anomalies between the value allocated from the scale and the weights recorded for the cabbage heads.

Rhizoctonia collar rot trials

For each experimental unit, the plant weights in each of the 4 frames were summed. The mean and standard error were calculated.

Disease surveys in Australia

Surveys of Australian tomato, chilli and capsicum farms were conducted from 2014 to 2017 to identify and monitor pathogens[1].

5.6.4 C3d: Adaptive trials

This subcomponent conducted on-farm adaptive trials of improved farming practices in collaboration with farm households in Bac Ha and Sa Pa. Promising farm management practices identified in literature and applied research trials(disease control, nutrient management, seedling production) and novel commodities and varieties identified by farmers and in lesser extend by market research were tested and demonstrated under a broader set of biophysical and socioeconomic conditions in adaptive on-farm trials.

Participatory monitoring and evaluation was employed as part of the adaptive research process and continuous feedback was used to further develop farming practices and prioritise applied research. The approach for conducting adaptive on-farm field trials included the following monitoring and evaluation steps:

- Step 1: An initial participatory meeting to identify issues and constraints in the main vegetable farming systems in Sa Pa and Bac Ha districts, Lao Cai Province
- Step 2: Participatory planning to (i) agree on the trial design with suitable treatments and (ii) make a detailed plan to work together
- Step 3: Mid-trial review meeting with farmers to review progress
- Step 4: Final evaluation of the field trials by collecting samples, calculating yield and economic efficiency for each treatment.

Crop management practices were tested and demonstrated under a broad set of biophysical and socioeconomic conditions in adaptive trials. Each trial was conducted on at least 3 farms (farm≡replicate). Participatory monitoring and evaluation as part of adaptive research process was conducted 2–3 times per crop cycle. Indicators assessed were determined in consultation with farmers using participatory processes and consequent participatory economic analysis included land productivity (net income per hectare) and labour productivity (net income per day of labour).

5.6.5 C3e: Socio-economic analysis

A diet quality and consumption survey of rural household was conducted to identify linkages between farming systems, market access, consumption patterns and dietary outcomes. An economic analysis of farming systems was also conducted to identify behavioural constraints to development.

Rural consumption study

To understand the relationships between smallholder vegetable production and dietary outcomes, a survey was used to capture information about households' vegetable production and market access and the households' access to foods and consumption behaviours. It was hypothesised that households growing vegetables would have better dietary outcomes than households growing only rice and maize. The improved dietary

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[1] In Australia, vegetable research relies on a grower levy. Despite its size, the tomato industry does not have a compulsory levy, and research often relies on funding through sources such as this project.

outcomes could stem from either eating more home-grown vegetables or having higher cash incomes from vegetable sales which could be used to buy healthy food products.

The survey instrument contained questions to collect detailed information on household and individual-level socio-demographic characteristics and individual food consumption patterns, farm production and crop disposals, market access and economic shocks. The diversity of food consumed and the origin of the foods (home grown versus purchased) were collected using a 24-hour food recall diary. Households completed the diary by filling in information about what foods were eaten, where the ingredients were from (e.g. market or home garden) and how much each household member ate of each meal. The diary was completed for 2 non-consecutive days, typically a weekday (usually a non-market day) and a weekend day (usually a market day). This allowed the capture of differences in food consumption between market days and non-market days.

Data were initially collected from 510 smallholder farming households in July/August 2016. Smallholder farming households were selected using a stratified multistage sampling strategy across 51 villages in 13 communes across four districts in Lao Cai Province: Bac Ha, Sa Pa, Muong Khuong and Si Ma Cai (Figure 1). The same households were visited again in November 2016 to conduct a second 24-hour food recall diary. The follow-up visit in November was necessary to capture seasonal differences in food consumption patterns.

Multiple-regression analyses were conducted on this dataset to identify relationships between farming systems and the quality of rural household diets as measured by the dietary diversity score (DDS) and healthy food diet indicator (HFDI). In addition, anthropometric data were used to determine the prevalence of stunting among the children in the sample and the probability of stunting was then looked at alongside other household characteristics such as market access, farming system characteristics and intra-household decision making.

The analyses found indirect associations between smallholder vegetable production and the household dietary quality as well as children's nutritional outcomes. Specifically, children from vegetable-producing households, which are able to engage more in markets, through both improved market access and market participation, have more diverse diets. This is particularly true for schoolchildren and adolescents. The results imply that additional income from selling vegetables allows households to purchase diverse food, which is likely to have a positive impact on the dietary quality and nutritional outcomes of these children. Understanding these associations and parental food choice motivation can help the Government develop dietary change interventions that, by using a targeted approach, are resource-efficient.

Socio-economic system analysis

This study was designed to characterise why traditional farming systems persisted despite the much higher returns to more advanced systems, and provide insights on what can facilitate a transition to the more advanced production and marketing systems.

Information from in-depth interviews and data from the socio-economic baseline survey were combined. Based on this information, farm households were categorised into three stylised types: (1) Traditional — farms that are more subsistence oriented and farming intricately integrated farming systems; (2) Advanced — farms that are purely commercial and specialised in vegetable production and sales, and (3) Developing farms — former traditional farms that are moving away from subsistence oriented production to more market oriented production systems.

Each of the farm types was characterised and compared on three main themes: (1) crop rotations; (2) production technology and costs; and (3) marketing behaviour. Comparisons across groups were used to identify constraining factors that trap smallholder farms in less-productive systems, and domains of improvement to facilitate development of smallholder farming systems.

5.7 Component 4 — Outreach and capacity building

5.7.1 Farmer Business School

A literature review was conducted to review the implementation process of Farmer Business School (FBS) programs and, in particular identify success factors of FBS in five projects in Southeast Asia (Indonesia, the Philippines, Cambodia, and Vietnam). Success factors or recommendations from past experiences identified in the literature review were taken on-board in the development of an enhanced curriculum to pilot with the farmer groups participating in this project. Alongside building a comprehensive and relevant curriculum, the project also sought to engage with institutional partners to innovate, enhance and implement effective up-scaling strategies for FBS in Vietnam. The underlying goal was for the project to contribute to FBS scaling by strengthening capacities and mobilizing resources among government extension agencies and community-based groups.

Existing materials from past FBS programs in Vietnam and other projects in SE Asia were adapted and further developed to fit the context of production systems in Lao Cai Province. This meant careful selection of practical exercises to be conducted with farmers, development of case studies for reference within training modules, and incorporation of new modules in response to the needs of Lao Cai and ethnic minority farm households.

The FBS training manual (business skills) developed (see Section 10.2) was organised in three parts:

- Identifying market opportunities and innovations
- Business planning
- Implementation and evaluation

The FBS core learning focus is on reorienting farmers' perspectives toward market-driven technological and institutional innovations that enable them to strengthen business relationships based on trust, collaboration and equitable benefit with value chain actors. Indeed, this was an important motivating factor to build the FBS into the design of this project. In addition, a series of guides on production techniques were developed, including seeding production, pest and disease control, crop nutrition management, post-harvest.

Following curriculum design and identification of partners a series of training workshops were conducted to provide a core group of professional trainers/co-trainers with FBS facilitation skills (Figure 10). A total of 18 FBS facilitators were trained. The facilitators were either local extension staff with at least 4-5 years of work experience (10 of the 18 facilitators were district or commune level staff and three were provincial level staff) and/or farmer leaders (five of the 18 facilitators) willing to take on FBS facilitation roles. After training, the facilitators planned and implemented their respective FBS pilot activities, together with colleagues, to further hone their capacities in FBS facilitation.

The trained facilitators were tasked with the implementation of FBS in their assigned areas. In general, each FBS program consisted of a total of 6-14 training days, depending on the demands/current knowledge of the farmers, spread throughout the whole cycle of production to marketing (i.e. one day per week, 3-4 months).

The FBS program was implemented in 2017-18 (Figure 10) in three districts of Lao Cai Province, Bac Ha, Sa Pa, and Bao Thang. The FBSs provided training to around 160 farmers in these three districts through combined project and external financial sources. The 160 participants were trained as eight groups. The project had resources to pilot FBS implementation with four groups and this was increased to eight after the implementing team were successful in obtaining additional funding the Australian Alumni Program Small Grant Fund (Round 1, 2017).

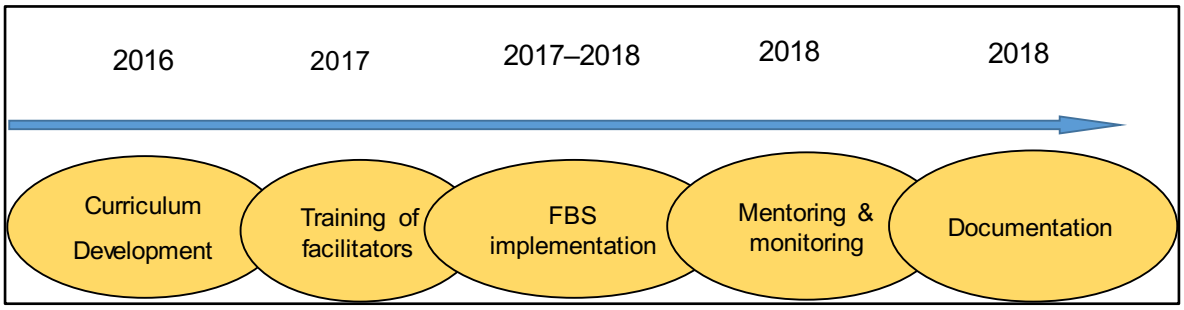


Figure 10. Key activities undertaken in the development and piloting of the Farmer Business School (FBS).

During FBS implementation, monitoring workshops were held to review and assess the training curriculum, to ensure its continuing relevance to the local community, and to ensure that facilitators had adequate capacity to successfully implement the FBS program. Project team members and other external resource persons organized retraining/refresher workshops for facilitators. These workshops provided an opportunity to share experiences and identify where they needed further help, as well as to discuss difficulties and potential solutions including modifying the FBS curriculum. After the retraining workshops, further backstopping on-site was provided by the partner institutions and the project team.

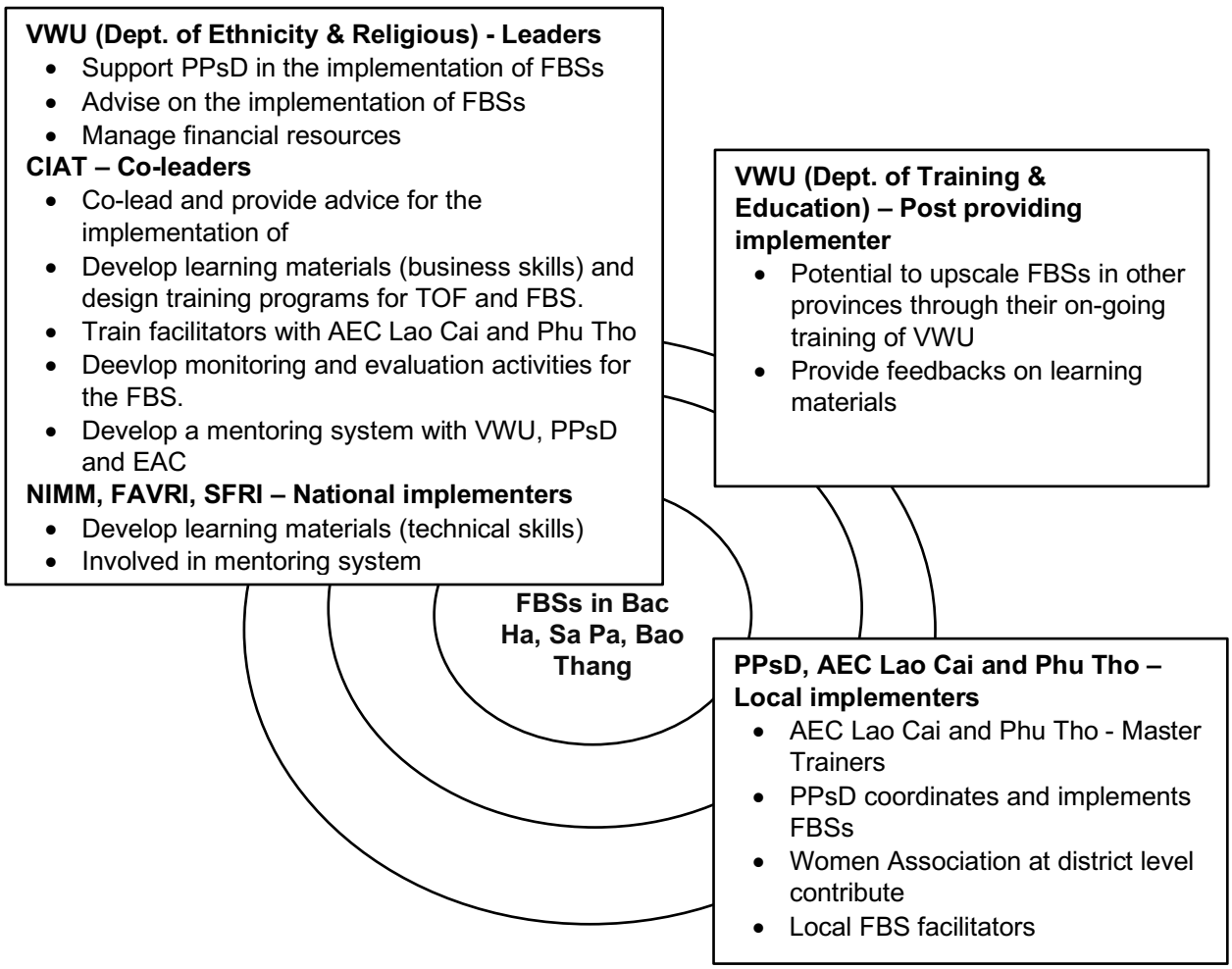


Figure 11. Roles of different organisations in the implementation of Farmer Business School (FBS) programs in Lao Cai Province.

The key implementing partners in Lao Cai Province were the Crop Production and Plant Protection sub-Department (CPPPsD) and the Agricultural Extension Center (AEC). The project strategy was to empower, and guide local extension providers (at commune, district and province level) in FBS implementation and delivery at scale as a step towards developing a sustainable strategy for FBS up-scaling. The role of each partner organisation is detailed in Figure 11.

Monitoring and evaluation of FBS

FBS monitoring and evaluation was developed to track and assess implementation, as well as to potentially evaluate the effectiveness of both the TOF and FBSs.

A mixed methods approach was used to conduct the FBS evaluation. Data was collected using a standardized questionnaire for participants, as well as focus group discussions with each group to identify benefits and areas for improvement. Moreover, semi-structured interviews were conducted with five facilitators to understand how well the training was received and provide an opportunity for them to make recommendations for future FBSs.

The evaluation was conducted in three parts.

1. Evaluation of FBS implementation (reaction and learning outcomes)

Survey questions were used to assess farmer's experiences with respect to the effectiveness of the training program in delivering on its objectives (and delivering co-benefits). Specifically, the survey was designed to elicit a level of agreement/disagreement with statements such as:

- Training program increased business knowledge and skills
- Training program increased opportunities to have a network of farmers to learn and share information with
- Training program improved social interaction

Farmers were also provided the opportunity to provide more broad feedback, related to, for example:

- Adequacy of training program
- The need for more advanced training for future programs.

2. Evaluation of application of what was learned from FBS (behaviour outcomes)

The evaluation of FBS application was based on what changes, if any, farmers made after participating in the training program. The survey was designed to elicit the number of farmers conducting the following activities following FBS participation:

- Farmers collect price information
- Farmers increase or expand their interaction with market actors
- Farmers consider market opportunities before deciding on production
- Creation and maintenance of the trading relationship with actors along the chain
- Creation of a business plan.

3. Evaluation of results and sustainability

This evaluation activity was focused on measuring the sustainability of learning models used in the FBS. For example, this activity was designed to understand whether farmers continued with self-learning or felt they gained sufficient learning/confidence in the FBS. The outcomes from this activity are critical to guide the process of evaluating whether the FBS model is likely to be sustainable in the long-term. The survey was designed to elicit the level of change in:

- Farmer to farmer knowledge and information sharing;
- Farmers' and other actors' knowledge and information sharing;
- Development and testing of new market/value chain innovation(s);

- Profit;
- Confidence in business skills;
- Confidence in technical skills.

5.7.2 Capacity building

Specific training and capacity building activities detailed under Component 4 of the project are reported on in later sections of this document, for example in Section 7 “Key results and discussion” and Section 8 “Impacts”.

6 Achievements against activities and outputs/milestones

Objective 1: Identify market opportunities and consumer preferences for indigenous and conventional vegetables in local, provincial and urban markets.

No.	Activity	Outputs/ milestones	Complete	Comments
1.1a	Conduct key informant interviews with relevant government, non-government organisations (NGO) and private sector agencies and conduct desk studies to determine the availability of supply and demand data needs identified during January 2013 scoping study.	Report from activity, including summary of data quantity and quality available	2014	A review of existing literature and data and 54 key informant interviews were conducted. Information collected was used to plan field activities for primary data collection and field interviews of traders in NW Vietnam. In addition to the specified activity, key information interviews and data reviews were incorporated in all related research activities. Findings/considerations have been reported on in all relevant project outputs.
1.1b	Design interview instruments and conduct semi-structured interviews (approximately 50) with conventional and specialty vegetable retail stores in Hanoi. At this point we will identify the main supplier of their vegetables, supply issues (e.g. quantity, quality, availability) and aspects of customer/consumer demand.	Development of interview instrument, interview guidelines and field manuals. Report from activity with quantitative data summary to identify key opportunities and issues for conventional and indigenous vegetable producers from NW Vietnam.	2015	A scoping trip was used to understand the state of knowledge and plan and develop a methodology for the interviews. Following the trip and analysis of information collected on the scoping trip the retailer questionnaire was developed (included as appendix in relevant reports). The questionnaire was used to conduct: • 20 interviews with traditional retailers; • 26 interviews with specialty shops; • 6 interviews with supermarkets. The questionnaire was also used for Activity 1.1e. Data collection was completed in March 2015. This activity was conducted in conjunction with Activity 1.1c (see more information below). The following outputs (Section 10.2) correspond to this activity: • N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2016) Vegetable markets and trading systems in Hanoi, Vietnam (unpublished project report), Hanoi, Vietnam.

No.	Activity	Outputs/ milestones	Complete	Comments
1.1c	Design semi-structured questionnaire /survey instrument, pre-test and conduct survey with representative sample of *wholesalers* in key wholesale markets around Hanoi (approximately 75 interviews).	Development of survey instrument, Data collection, Summary and report of data to further identify key market opportunities and issues for vegetable producers from NW Vietnam.	2014	The questionnaire was designed as per Activity 1.1b and then used for 80 wholesaler interviews Data collection was completed in March 2015. The following outputs (Section 10.2) correspond to this activity (and 1.1b): • N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2017) Vegetable markets and trading systems in Hanoi, Vietnam (unpublished project report), Hanoi, Vietnam. • N. Tran, T. Truong, D.Yi (2017) Interprovincial trade opportunities for indigenous and conventional vegetables Lao Cai, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

No.	Activity	Outputs/ milestones	Complete	Comments
1.1d	Collection of information on varieties, prices, quality and origin of relevant vegetables in a selection of *retail and wholesale* markets where interviews are conducted in and around Hanoi. This will require the development of an instrument to be used to collect the data, including the vegetables, prices, quality and origin (if it can be determined).	Data are collected, summarised and reported.	2017	Price data (reflecting variety, grade, and origin) were collected daily from 3 wholesale markets, 3 traditional retail markets, 2 supermarkets and 2 specialty stores in Hanoi from 1 Feb 2016 to 31 Jan 2017. A questionnaire was developed so that traders could easily fill in prices for different vegetables (in the same format) at the same time (peak trading time) each day. Price information was collected for 6 case study vegetables. Data analysis was completed in 2017. The method used is being adapted by researchers in Indonesia and in Vietnam for use in ACIAR funded fruit projects (AGB/2009/060 and AGB/2012/060). The following outputs (Section 10.2) correspond to this activity: • A.D. Nguyen (2016) Price differences and market integration: A study of vegetable markets in Hanoi (Unpublished master's thesis). The University of Adelaide, Adelaide, Australia. • A.D. Nguyen, D. Yi (2016). Price differences and spatial market integration: A study of vegetable markets in Hanoi. *AgriFood Research Network Conference*, Adelaide, Australia, 7-10 December 2016. • —. (2018) Price differences and market integration: A study of vegetable markets in Hanoi, Vietnam, Australasian Agricultural and Resource Economics Society 62nd Annual Conference, Adelaide, Australia, 6-9 February 2018. • A.D. Nguyen, D. Yi, H.V. Pham, N.D.T. Nguyen, T.X. Ninh, & L.V. Tran (2018) Price differences and market integration: A study of vegetable markets in Hanoi (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam.

No.	Activity	Outputs/ milestones	Complete	Comments
1.1e	Using instrument from 1.1b, 1.1c conduct structured interviews with vegetable retailers, wholesalers and collectors in 5 key provincial and local markets in the Northwest and markets in bordering Chinese provinces (320 interviews).	Data collection, summary and report of data to further identify key market opportunities and issues for vegetable producers from NW Vietnam Report from activity with quantitative data summary	2017	The questionnaire was designed as per Activity 1.1b and then used for interviews in four NW Vietnam Provinces. Interviews were completed in July 2016. The reporting approach was changed to best address the commodity specific information collected as part of this activity as well as the skills of the researchers working on this activity. The following outputs (Section 10.2) correspond to this activity: • N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2017) Interprovincial trade opportunities for vegetables in NW Vietnam (unpublished project report), Hanoi, Vietnam. • N. Tran, T. Truong, D.Yi (2017) Interprovincial trade opportunities for indigenous and conventional vegetables Lao Cai, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.
1.1f	A report summarising wholesale price data collected in local and provincial markets in Lao Cai Province as well as describing any data collection issues.	Data are collected, summarised and reported.	2018	The priority for this activity was to collect data on a weekly basis to support activities conducted under Objective 2. For example, the data collected supports identification of the most suitable time and weight to harvest cabbage to sell at high prices (at a profit). The following outputs (Section 10.2) correspond to this activity: • N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2017) Interprovincial trade opportunities for vegetables in NW Vietnam (unpublished project report), Hanoi, Vietnam.

No.	Activity	Outputs/ milestones	Complete	Comments
1.2a	Develop a consumer survey instrument and sampling methods in order to assess vegetable consumption patterns and purchase locations, and assess preferences for vegetable attributes and perceptions of different types of vegetables and attributes. This step includes sample design, focus groups, pretesting of survey instrument and revisions of instrument.	Survey designed, pretested and contact information of potential respondents is collected.	2016	Preliminary survey design was developed using input and learnings from other surveys used to collect consumer information in developing countries (e.g. Indonesia) experiencing transformation in the retail and food retail sector. The surveys that formed the base of our survey design are those used by, for example, Umberger et al. (2015). The survey was adapted to meet our objectives and the context of this research and then further tested and adapted using focus groups in Hanoi and Lao Cai. The survey was designed in collaboration with other ACIAR projects, namely AGB/2015/029 as well as AGB/2012/060. Meat and Livestock Australia (MLA) also contributed questions for inclusion in the survey. The survey design was completed for final input from in-country partners and pre-testing in August 2016. ACIAR undertook a Mobile Acquired Data Evaluation in 2015 and 2016. Following outcomes of this evaluation, CommCare was selected for use for this survey. Consequently, this project was one of the first ACIAR projects to use CommCare for digital data capture. Ag Impact provided support to the project in developing the application in CommCare. A professional enumerator company was selected (IndoChina Research Ltd) to implement the survey. Two PhD students (Jesmin Rupa and Anh Duc Nguyen) were involved in designing and implementing the survey (more information in Section 8.2).

No.	Activity	Outputs/ milestones	Complete	Comments
1.2b	Conduct a consumer survey with a representative sample of households in key consumer markets Hanoi (n=600) and NW Vietnam (n = 400), Enumerators will need to be trained on interview techniques.	Survey conducted, data entered and cleaned.	2017	The survey was implemented and data were collected from December 2016 to March 2017 (with a 4-week break over Tet to avoid any atypical food expenditure and consumption behaviour). A second round of data were also collected in July 2017 to obtain food diary information for a second time and pick up any seasonal differences in consumer behaviour. Data were collected from approx. 700 households in Hanoi, 150 households in Lao Cai City and 150 households in Son La City. The survey was also implemented in Ho Chi Minh City (as per objectives of ACIAR project AGB/2015/029, with which this survey was co-implemented). All enumerators were provided with a tablet to collect data through the CommCare app. All enumerators were trained in using CommCare and the survey in advance of implementation. Each enumerator also conducted two 'practise' surveys as training and pre-testing. The use of CommCare significantly improved transparency in the data collection process, the quality of data collected, and eliminates errors in data entry. Households were selected using a proportional random sampling method. This means we divided each city into wards and wards were then selected based on their population as a share of the total population of the city. In the case of Lao Cai City and Son La City where the population is smaller, all wards were selected. From the selected wards a constant number of households was selected. The survey sample is representative of different income groups (e.g. our results match those from the Nielson database). Natural variations in access to modern retail outlets including supermarkets and minimarts have also been captured in the survey sample.

1.2c	Analyse the results of the survey including an econometric analysis to determine how consumer preferences vary with income, education, location, and occupational profile of the household members.	Data analysis is complete, report on market segments and identification of segments with most potential for Obj. 2 activities completed.	2018	A number of preliminary and more advanced analyses have been completed or are being conducted at present. Two PhD students (Jesmin Rupa and Anh Duc Nguyen) are using these data in their theses. The following outputs (Section 10.2) correspond to this activity: • D. Zeng, W.J. Umberger, J. Rupa (2017) Implications of Supermarket Revolution on Weight Outcomes of Vietnamese Urban Consumers, *Agricultural & Applied Economics Association Meeting*, Chicago, United States, 31 July–1 August 2017. • W.J. Umberger, N.P. Dumbrell, A.D. Nguyen, D. Zeng (2017) Consumer preferences and consumption patterns for fruit & vegetables in urban Vietnam, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • A.D. Nguyen, W.J. Umberger, D. Zeng, N.P. Dumbrell (2017) Concerns and valuation of food quality and food safety in urban Vietnam, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • N.P. Dumbrell, W.J. Umberger, D. Zeng, A.D. Nguyen, L. Pagliuca (2017) The role of market research in agricultural development for northwest Vietnam: The case of fruit and vegetables, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • A.D. Nguyen, W. J. Umberger, D. Zeng (2018) Concerns and valuation of food quality and food safety in urban Vietnam, *Australasian Agricultural and Resource Economics Society 62nd Annual Conference*, Adelaide, SA, Australia, 6-9 February 2018. • L. Pagliuca, N. P. Dumbrell, W. J. Umberger, D. Zeng (2018) Drivers of changing meat expenditure and consumption patterns in urban Vietnam, *Australasian Agricultural and Resource Economics Society 62nd Annual Conference, Adelaide, SA, Australia, 6-9 February 2018.* • J. Rupa, W. J. Umberger, D. Zeng (2018) Food market modernization, dietary diversity and diet quality: Evidence from urban Vietnam, *Australasian Agricultural and Resource Economics Society 62nd Annual Conference*, Adelaide, SA, Australia, 6-9 February 2018. • N.P. Dumbrell, W.J. Umberger, L. Pagliuca, A.D. Nguyen, D. Zeng (2018) The Vietnam Urban Food Consumption & Expenditure Study Factsheet Series. The Centre for Global Food and Resources, The University of Adelaide, Adelaide, Australia. Available online at:

No.	Activity	Outputs/ milestones	Complete	Comments
				https://www.adelaide.edu.au/global-food/research/international-development/vietnam-consumer-survey/
1.2d	Write full report summarising activities 1.1 and 1.2a-1.2c outlining key findings and identifying market opportunities form smallholder vegetable farmers in NW highlands.	Report will provide market assessment for conventional and indigenous vegetables identifying market segments.	2018	Results are provided in Factsheet 14 https://www.adelaide.edu.au/global-food/research/international-development/vietnam-consumer-survey/

Objective 2: Develop and promote competitive and efficient marketing models that deliver high quality safe vegetables to market, meet consumer demand and benefit smallholders (particularly women and ethnic minorities).

No.	Activity	Outputs/ milestones	Complete	Comments
2.1	Select case studies that demonstrate different production and marketing models (e.g. collective input procurement, collective marketing, collector-led etc.). a) Identify and document case studies from each model. Determine data to be collected and analysed. Report on each of the case studies. b) Conduct annual stakeholder workshops to report findings from Obj.1&2, facilitate networking between stakeholders, determine action plan including marketing interventions to be tested c) Select 3-5 cases to enact group-driven interventions that improve farmer profitability (particularly for women and ethnic minorities). d) M&E intervention impacts (e.g. detailing market opportunity realised, technical or market constraints overcome, economic performance and application of lessons learnt to other similar enterprises)	Action plan for C2 component detailing marketing strategies/ interventions to be tested Report(s) on stakeholder workshops 9 case studies documented Report on application of findings	2.1a 2017 2.1b 2014-2016 2.1c 2017 2.1d 2018	The following outputs (Section 10.2) correspond to Activity 2.1a,c: • D. Yi, H.N. Nguyen, T.T.H. Nguyen (2017) Smallholder participation in vegetable value-chains in Lao Cai Province, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • N.H. Nguyen, H.T.Y Nguyen & D. Yi (2018) Marketing and farmer group case studies in northwest Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam. • Nguyen, H. N., Nguyen, T. T. H., Nguyen, T. D. N., Pham, V. H., Pham Kieu, M., Ninh, X. T., & Dale, Y. (2018). Improving vegetable farming systems and marketing for small-scale producers in Bac Ha district, Lao Cai province. *Vietnam Journal of Agricultural Science, 16*, 11. Stakeholder workshops were conducted for Activity 2.1b as follows: • Stakeholder workshop for local government (October 2014) • Stakeholder workshop for supply chain partners (October 2014) • Steering committee to set priorities and implementation plans (March 2015) • Stakeholder Workshop for input into next phase of interventions (March 2016) • Stakeholder Meeting upscaling and out-scaling project (May 2016) Stakeholder workshops and steering committee meetings were used to set priorities to drive the design of market interventions, which were carried out by the subcomponent team as Activity 2.2. Group-driven interventions were implemented with three groups (H'mong farmer group in Sa Pa, a cooperative and a private company in Bac Ha). This activity was run in conjunction with Activity 2.2 (see details below).

No.	Activity	Outputs/ milestones	Complete	Comments
2.2	Develop whole-chain marketing strategies/interventions (including brand development) that enable the development of a competitive position	Marketing strategies for selected mainstream and indigenous vegetables	2017	Early in the project, the project team met with stakeholders to identify challenges and opportunities, and establish priorities. A steering committee (with stakeholders, e.g. traders, distributors, wholesalers and retailers) was established to guide activities. Building relationships with key value chain actors was considered a priority as well as increasing farmer knowledge of alternative market options. Marketing calendars (for farmers) that visually communicate price fluctuations (following seasonality) in key output markets were created and shared with farmers. Copies of calendars included in Section 10.2. Farmers were taken on guided market visits in 2017. Visits to a major supermarket chain were used to develop and strengthen trading relationships. Further, two farmer groups participated in a market day in Hanoi in early 2017to sell produce and increase awareness of NW-produced vegetables. Lao Cai PPsD in collaboration with FAVRI developed a label for farmer groups to use to signal the origin and other credence attributes of their products. The team are also exploring other packaging options to develop a regional brand. The logo and branding graphics can been seen on the Lao Cao PPsD website.

No.	Activity	Outputs/ milestones	Complete	Comments
2.3	Map vegetable supply chains from Sa Pa/Bac Ha to Hanoi to identify where losses are occurring and determine appropriate interventions. 2.3a Select commercial partners 2.3b Track 10 consignments from farm to market. 2.3c Identify bottle necks and critical control points that lead to postharvest losses. 2.3d Undertake a participatory risk analysis to identify, characterise and evaluate food safety risks in vegetable supply chains. 2.3e Present findings to stakeholder workshop and private sector partners to determine interventions to be trialled.	Report, presentation to stakeholder workshop and conference paper detailing consignment trials and food safety risk analysis	2.3a 2015 2.3b 2017 2.3c 2016 2.3d 2018 2.3e 2018	10 commercial supply chains were identified and mapped (August 2015 to October 2018) to quantify the level of postharvest loss and identify key contributing factors. Mean postharvest loss (all chains and all crops) was 25-30%. Current vendor packaging and transport practice was identified as the primary cause of postharvest loss. A food safety risk analysis was completed in 20 farms (10 farms in Sa Pa & 10 farms in Bac Ha) in September 2018. The survey identified a series of food safety hazards, due to inappropriate chemical storage, poor on-farm hygiene, potential irrigation water contamination, and the use of partially composted animal manures. Due to limited awareness of food safety hazards and risk by smallholder farmers and vendor, adoption of improved food safety practice will require extensive future participatory-based training, and should be considered a priority for future ACIAR investment in the industry. Postharvest training resource material was prepared and provided to local stakeholders and extension staff. Two stakeholder postharvest workshops were completed. • A postharvest handling and food safety awareness workshop (10/10/2018) @ the Di Thang Cooperative • A train-the-trainer workshop for Ministry of Agriculture extension staff in Lao Cai City (12/10/2018).

No.	Activity	Outputs/ milestones	Complete	Comments
2.4	Develop and test improved postharvest management strategies in conjunction with commercial partners that enhance quality out-turn and minimise the risk of foodborne illnesses. 2.4.1 Select at least 3 postharvest and food safety interventions for testing. 2.4.2 Undertake trials in conjunction with commercial partners, including refinements. 2.4.3 Report on findings.	Determination of postharvest and food safety interventions to be tested Report and conference paper	2018	Partners for postharvest intervention were selected and interventions identified. The first set of interventions were implemented for the harvest of the winter production cycle (Nov to Dec 2017). Two commercial outturn trials undertaken with Hanoi market vendors in August 2018. Two postharvest trials were undertaken to evaluate options to improve packaging practices. Trials were based on four different interventions: reduce packaging size, inclusion of ice-packs, alternative packaging (foam box), use of foam layering. Vendors in Bac Ha have commercially adopted the recommended use of cool packs to aid in-transit temperature management. Postharvest and food safety research finding have been documented. The following output (Section 10.2) correspond to Activity 2.3 and 2.4: • V.H. Nguyen, S. Underhill (2018) Towards more profitable and sustainable vegetable farming systems in north-western Vietnam: Postharvest report (unpublished project report). Fruit and Vegetable Research Institute, Hanoi, Vietnam.

Objective 3: Develop and demonstrate whole-farm management practices that improve sustainability, productivity and household livelihoods in (i) rice-vegetable, (ii) vegetable-only systems

3a: Develop productive and sustainable soil, crop nutrition and soil-borne disease management strategies

3b: Improve smallholder household livelihoods

No.	Activity	Outputs/ milestones	Complete	Comments
3.1	Appoint a soil scientist to manage the soil research component (3a). Appoint a farming systems economist to determine the approach to be used in objective 3b.	Review of potential approaches and selection of appropriate methodology.	2014	Dr Stephen Harper acted as a soils/agronomy consultant to the project from November 2014 to 2018 to develop research priorities, experimental approaches and protocols together with the team. Christian Genova worked as the farming systems economist to the project from commencement until July 2014 when he took up a PhD scholarship opportunity with The University of Adelaide (see Activity 3.4 & 3.10). Following Christian's departure from this role, other project staff as well as Christian (in his PhD) absorbed this task as part of existing roles, e.g. VNUA staff and University of Adelaide staff.

3.2	Review of soil analytical methods and procedures. Implement laboratory quality assurance. (3a) Capacity building with Vietnamese chemical analysts. (3a)	Updated methods and procedures. Lab quality assurance procedures and protocols.	2018	Dr Paul Milham worked closely with the team at the SFRI over the course of the project. Together they have: 1. Prepared reference materials 2. Implemented quality control procedures using reference materials. Quality control methods were improved to include tests on reference samples for each analysis batch 3. Developed new laboratory protocols. Since the commencement of this project and following improvements in laboratory capacity, methods and equipment, the Soils and Fertilizers Research Institute lab is now certified by the Australasian Soil and Plant Analysis Council (ASPAC) and has ISO certification for a range of chemical tests. As well as building capacity in laboratory analyses, this activity has also led to opportunities to build capacity in writing and publishing work in academic journals. The following outputs (Section 10.2) correspond to this activity: • L.B. Bui, H.M.T. Le, .H.A. Bui, P.J. Milham (2016) Preparation of a soil reference sample and initial results on laboratory quality improvement, *Journal of Vietnam Agricultural Science and Technology*, 1(2), 130-134. • L.B. Bui, P. Do, R.D. Pham, M.T. Pham, H.M.T. Le, H.A. Bui, H.T. Mai, H.M.T. Phung, T.M. Tran, H.T. Phan, P. Milham (2017) Nutrient sufficiency and management: Benefits of high quality laboratory analysis, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • L.B. Bui, H.T.M. Phung, R.D. Pham, M.T. Pham, T.T. Do, S. Harper, P.

No.	Activity	Outputs/ milestones	Complete	Comments
				Holford, P. Milham (2019). Trace metal contamination during grinding of plant samples. *Communications in Soil Science and Plant Analysis*, 50, 102-107. • —.Trace metal contamination during grinding of plant samples. *Conference of Soil Science Australia and the Australasian Soil and Plant Analysis Council, Canberra, Australia, 18–23 November 2018.* • Le, Do, Bich, et al. (2018) Laboratory capacity building, Soils and Fertilizers Research Institute, Hanoi (unpublished project report), Hanoi, Vietnam.
3.3	Develop criteria for project site selection. Select 4 sites for each of the 3 farming systems in both Bac Ha and Sa Pa (total 24 sites) (3a and 3b)	Report outlining criteria for selection and brief description of selected locations with justification for their selection.	2014	Selection criteria were developed in 2014. Sites were evaluated over several visits before the final sites were selected. Example selection criteria: • sites likely to respond to nutrient applications • sites exhibiting plant pathology issues • willingness of farm owner to collaborate with the project.

3.4	Collect baseline data for three farming systems[a] in Bac Ha and Sa Pa district using a combination of quantitative and qualitative methods: • Household socioeconomic — data (240 households) (3b) • Household consumption/nutrition data (500 households) (3b) • Crop production characterisation (includes agronomy and plant protection) (3a) • Physical and chemical characterisation of soils (includes soil analysis at 24 sites) (3a) • Water analysis (availability and quality) (3a)	Baseline data analysed and presented. Report on study. Recommendations for appropriate sampling design, data frequency, and key indicators to use developed. Project report and journal article(s)	2014 2015 and 2017	Baseline studies for both socio-economic and biophysical characteristics of study region were completed in September and November 2014 respectively. The following outputs (Section 10.2) correspond to this activity: SFRI & NIMM (2014) Baseline report: Farming systems in north-western Vietnam (unpublished project report), Soils and Fertilizer Research Institute and National Institute of Medicinal Materials, Hanoi, Vietnam. VNUA (2014) Baseline report: Socio-economic characteristics and vegetable production systems of farm households in Sa Pa and Bac Ha districts, Lao Cai Province, Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam. Key farming system constraints identified in the baselining activity fed into the design of the farming system adaptive trials in Activity 3.8. Participant observation study conducted in Bac Ha and Sa Pa in July-August 2015 to: (a) document the consumption and shopping behaviour of six households in selected areas in Bac Ha and Sa Pa districts, and Lao Cai City. Observations of interest food preparation times and methods, where and how food is sourced, who purchases ingredients and/or prepares food, portion sizes, main decision-maker in food preparation/selection. (b) Determine how market days affect consumption patterns as compared to other ordinary days (variability in consumption). Household consumption and nutrition data were collected from 510 households (through interviews) from two project districts (Bac Ha and Sa Pa), and two non-project districts

				(Muong Khuong and Si Ma Cai) in 2016. Household consumption and individual nutrition data collection was carried out by Christian Genova (PhD student at The University of Adelaide) as part of his PhD project. See Activity 3.10.

No.	Activity	Outputs/ milestones	Complete	Comments
3.5	Analyse baseline data to identify constraints and opportunities related to: • Resources — capital, labour, knowledge and skills, availability of inputs (3b) • Biophysical — climate, soil characteristics, pest and diseases, water quality and availability (3a) • Agronomic practices (3a) Partial nutrient budgets developed for each of the 3 farming systems[a].(3a)	Report documents progress towards constraint and opportunity identification and the development of nutrient budgets	2014	Baseline data were collected, analysed and written up as per Activity 3.4. Using results from analyses two additional reports were also produced (see Section 10.2): • M.T. Chu, H.T. Phan, L.T.D. Hoang, H.T. Dang, L. Tesoriero (2014) Farming system baseline report: Pests and diseases (unpublished project report) National Institute of Medicinal Materials, Hanoi, Vietnam. • Nguyen Thi Binh, Tran Thi Minh Thu, Bui Hai An, Tran Minh Tien, Stephen Harper (2017). Nutrient budgeting survey in Sa Pa and Bac Ha district, Lao Cai province (unpublished project report). *Soils and Fertilizers Research Institute & National Institute of Medicinal Materials*, Hanoi, Vietnam. Key nutrient management and soil-borne diseases affecting vegetable production were identified. This informed the design of replicated trials and eventually adaptive farming system trials conducted as part of Activity 3.6, 3.7 and 3.8. Results from nutrient budgeting and pest and disease surveys were presented at stakeholder workshops and the ACIAR North-West Research Symposium (see details in following Activities).

3.6	Identify and characterise soil-borne plant pathogens with potential to persist in rotations and cropping systems. Develop disease survey strategies and compile a list of significant diseases. Characterise soil-borne plant pathogens, particularly species of Pythium, Sclerotinia and Fusarium in Vietnam and in certain vegetable crop rotations in Australia. Assist with skills development of Vietnamese plant pathologists and within diagnostic laboratories. (3a)	Reports and a scientific paper on soil-borne plant pathogens with potential to persist in rotations and cropping systems. New host and pathogen records. Technical resources and procedures for accurate disease recognition and diagnosis of plant. Report containing practical farm-level recommendation for cost-effective and safe pest and disease management in vegetable based farming systems.	2014 – project end 2018	Pest and disease surveys identified a number of serious soil-borne diseases in Lao Cai Province, including clubroot disease and Rhizoctonia rot. Diseases were more prevalent in Cruciferous vegetables crops and trials were conducted to identify effective low-cost control methods. The project trialled potential methods to control clubroot disease and Rhizoctonia rot. The most promising controls identified were then trialled on farms in the adaptive farming systems trials (Activity 3.8). Dr Len Tesoriero (later Dr Rosalie Daniel) worked closely with the team at NIMM to build capacity in pest and disease diagnostics over the course of the project. A whole process of field and laboratory diagnostic procedures was implemented by Len and the team during his visits to Vietnam, which included: (1) Field survey and sampling; (2) Isolation of pathogens; (3) Identification of pathogens. Clubroot control results were presented at stakeholder workshops (Activity 3.9). The following outputs (Section 10.2) correspond to this activity: • M. Chu, L. Tesoriero, H.T. Phan, H. Dang, L. Hoang (2017) Managing clubroot disease of cabbage in Sa Pa, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • M.T. Chu, H.T. Phan, L.T.D. Hoang, H.T. Dang, L. Tesoriero (2014) Farming system baseline report: Pests and diseases (unpublished project report) National Institute of Medicinal Materials, Hanoi, Vietnam. • H.T. Phan, R. Daniel, M.T. Chu, L.T.D. Hoang, H.T. Dang, L.Tesoriero (2018) Towards more profitable and sustainable vegetable farming systems in north-

No.	Activity	Outputs/ milestones	Complete	Comments
				western Vietnam: Plant pathology research report (unpublished project report), National Institute of Medicinal Materials, Hanoi, Vietnam. • Pest and diseases of brassicas manual (unpublished).
3.7	Design and conduct appropriate field trials and/or other experiments to: a) Optimise N, P & K response for cabbage and H'mong mustard. b) Evaluate trace element impacts on productivity. c) Evaluate liming response. d) Determine impact of organic amendments and compost-tea on vegetable productivity. e) Optimise management practices to retain soil structure and improve nutrient availability in the transition from rice to vegetables.	Brief report on each trial detailing design, results and recommendations. 2 conference and/or refereed journal papers.	2018	Replicated trials were completed for soil and nutrient management. Nutrient budgeting results generally showed that farms were over-applying N, P, and K fertilisers while being deficient in critical micronutrients. Nutrient trials were conducted to identify optimum nutrient applications, and adjust soil pH to optimum for vegetable production. The following outputs (Section 10.2) correspond to this activity: • Do,T.T., T.M.T. Tran, H.A. Bui, T.T. Nguyen, T.M. Tran, D.V. Luong, B.T. Nguyen, S. Harper (2017) Vegetable responses to fertilizer in Lao Cai Province, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • Nguyen, B.T., T.M.T. Tran, H.A. Bui, T.M. Tran, H.M.T. Phung, D.V. Luong, S. Harper (2017) Nutrient status of vegetable crops in Lao Cai Province, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • Bui Hai An, Tran Minh Tien, Do Trong Thang, Tran thi Minh Thu, Phan Thuy Hien, Nguyen Thi Binh, Stephen Harper (2018). Effectiveness of the nitrogen fertilizer on cabbage and H'mong mustard in Bac Ha district, Lao Cai province. *Journal of Vietnam Agricultural Science and Technology, 12 (97), 38-43*.

No.	Activity	Outputs/ milestones	Complete	Comments
3.8	Design and conduct at least 6 adaptive participative farming system trials per year that include cycles of participatory monitoring and evaluation (PM&E) aiming to test initial farming system models. PM&E will include socio-economic, human, environmental and agronomic aspects of the systems. Design of adaptive trials will be based on outputs from applied trials. Results of PM&E will be complemented with economic analysis (3a and 3b)	Reports and scientific (2-3) papers Farming system framework developed.	2018	PM&E training completed with 30 project staff and staff of partner organisations trained in the technique by late 2015. An interdisciplinary team implemented adaptive farming systems trials. These trials took results from replicated trials (Activity 3.6, 3.7) and implemented them in farmer-led trials conducted for nutrient management, disease control practices, composting, seedling production, and various other improved farming practices in project sites. Twenty-three trials were conducted in Sa Pa town and commune, and experimental results were used to formulate a 'best practices' trials implemented in 2017. Best practice combined nutrient management strategies, pest and disease management strategies, new types and varieties of vegetable with the aim of addressing challenges relevant to local farms. The report on farming system sub-component is presented in Section 10.2.

No.	Activity	Outputs/ milestones	Complete	Comments
3.9	Conduct regular consultative meetings and workshops that include Ministry of Agriculture & Development (MARD), Department of Agriculture and Rural Development (DARD), government and non-government extension services and variety of stakeholders involved in vegetable supply chains. (3a and 3b)	Briefs and recommendations to MARD and DARD on how to improve and optimise existing farming systems.	2015 & 2018	Stakeholder workshops were regularly held with farmers (minimum three per crop cycle) and other local stakeholders in Lao Cai Province. Larger, higher level stakeholder workshops focused specifically on sharing information with different levels of government. Year / Location / With 2014 Hanoi MARD 2014 Lao Cai DARD 2015 Lao Cai DARD 2016 Lao Cai DARD 2017 Lao Cai DARD 2018 Lao Cai DARD 2018 Hanoi MARD The North-West Research Symposium (Nov 2017) was an additional important communication and dissemination activity for the project.

3.10	Develop or adapt a systems framework ("model") and analyse the socio-economic inter-linkages and performance of each of these farming systems. Explore interactions between ethnic groups and their livelihoods, vegetable production, market engagement and vegetable consumption. Likewise, identify and compare key indicators (including net household income, market engagement, household nutrition) for three[2] systems. (3b)	Report. Enable impact of the different farming systems on livelihoods to be evaluated. Report (Assessing the economic access, dietary composition and drivers of fruit and vegetable consumption in Vietnam) and policy recommendation	2017	The rural household market links and consumption analyses formed the basis of Christian Genova's PhD thesis. The following outputs (Section 10.2) correspond to this activity: • VNUA (2017) Farming system transition in Lao Cai Province, Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam. • Phan, C.C. (2017) Off-season vegetable production development in Sa Pa commune, Sa Pa district, Lao Cai Province (Unpublished undergraduate thesis). Vietnam National University of Agriculture, Hanoi, Vietnam. • Genova, C., W.J. Umberger, S. Newman, A. Peralta (2016) Understanding the relationship between a household's food choices, the Household Food Insecurity Access Scale (HFIAS), and the body mass index (BMI) in rural Vietnam, *AgriFood Research Network Conference*, Adelaide, Australia, December 2016. • Genova, C., W.J. Umberger, S. Newman, A. Peralta (2017) Linking smallholder vegetable production to household diet quality: Evidence from rural Vietnam, *Australian Agriculture and Resource Economics Society 61st Annual Conference*, Brisbane, Australia, 7-10 February 2017. • Genova, C., W.J. Umberger, S. Newman, A. Peralta (2017) To Market, to Market: Does smallholder vegetable production lead to increased children's dietary diversity and improved diet quality? Empirical evidence from Northwest Vietnam. *Agricultural & Applied Economics Association Meeting*, Chicago, United States, 31 July – 1 July 2017. • Genova, C., W.J. Umberger, S. Newman, A. Peralta (2017) To market, to market: does smallholder vegetable production lead to increased children dietary diversity? Empirical evidence from north west Vietnam, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • Genova, C., W.J. Umberger, S. Newman, A. Peralta, D. Zeng (2017) Do farmers reap what they sow? Impact of smallholder vegetable production on child nutrition in rural Vietnam, *North-West Research Symposium*, Hanoi, Vietnam, 22-24 November 2017. • Genova, C., W.J. Umberger, S. Newman, A. Peralta (2018) The impact of smallholder vegetable production on child nutrition in rural Vietnam, *Australasian Agricultural and Resource Economics Society 62nd Annual Conference*, Adelaide, SA, Australia, 6-9 February 2018. • Peralta, A., W.J. Umberger, C. Genova (2018). Spousal Agreement and women participation in decision making in rural Vietnam. *Agricultural & Applied Economics Association Meeting*, Washington D.C., United States, 5-7 August 2018.

No.	Activity	Outputs/ milestones	Complete	Comments
3.11	Develop technical recommendations for sustainable and profitable soil, nutrient and soil-borne pathogen management in vegetable production systems. (3a) Develop recommendations to improve smallholder household livelihoods in vegetable systems. (3a)	Report and briefs with recommendations to MARD and DARD on how to improve and optimise existing farming systems.	2017	Recommendations were included in documentation and presentations for stakeholder workshops (Activity 3.9). Recommendations also included in each relevant output from Objective 3 (see documents listed in Section 10.2). Results from early trials (e.g. plant pathology and soil nutrient management) were used to design further trials and adaptive farming systems trials (Activity 3.8) which were then used to formulate management recommendations for farmers.

Objective 4: Develop sustainable models for up-scaling the Farmer Business School (particularly targeting women smallholders) and building capacity in research, development and extension.

No.	Activity	Outputs/ milestones	Complete	Comments
4.1	Appoint a 0.5 FBS facilitator to be primarily responsible for undertaking the up-scaling component.	Appointment of personnel	2015	CIAT was sub-contracted to complete this work in 2015 and the 0.5 FBS facilitator was drawn from existing CIAT staff (Pham Thi Mai Huong). This activity was completed later than the original due date given that time needed to research potential providers. Delays with contracting negations between organisations involved in the project, were beyond the control of the project team. The delay had no major impact on the project.

[2] Following the Mid-Term Review in May 2016, the temperate-fruit vegetable farming system sites were removed.

4.2	Develop, implement & evaluate a sustainable strategy up-scaling the FBS (refer to the methodology for a detailed implementation plan).	Reports documenting 1. Review regional FBS activities 2. Review IV Indigenous Vegetable FBS 3. Develop sustainable strategy for up-scaling 4. Develop partnerships and models 5. Provide training/mentoring support to external providers 6. Piloting of FBS by external partners 7. Determine and implement M&E approach 8. Compare FBS models and produce final report	1-2: 2016 3-4: 2017 6-8: 2018	Literature review of FBS implementation in SE Asia, with specific reference to experience with indigenous vegetable farmers in Vietnam completed in 2016. Review document (output 1 & 2) informed the design of the pilot FBS curriculum and strategies for upscaling to broad scale implementation (output 3). The strategy for FBS pilot implementation was documented and presented to stakeholders in May 2016 (output 4). Output 5: A network of 18 local staff (from 3 districts) were trained as FBS facilitators. Facilitators included 3 provincial staff, 5 lead farmers, and 10 district and commune staff. A mentoring network was developed to support the long-term sustainability of the training program. Output 6: Positive post-test assessment of initial pilot • 1 FBS program implemented with Gia Phu cooperative, largely Kinh ethnicity farmers, from July–October 2017. • 1 FBS program implemented with Ma Tra group, largely H'mong ethnicity farmers from 2017 to early 2018 and repeated with more farmers in March–May 2018. • 2 FBS programs implemented with Na Kheo farmer group and Sin Chai AB group, largely Tay ethnicity farmers from December 2017 to early March 2018. The FBS pilot was up-scaled using resources provided by an external grant awarded to VWU, SFRI, NIMM and PPsD in collaboration with CIAT staff. This grant was used to increase farmer groups involved from 4 to 8. Lao Cai PPsD and AEC partnered to implement the FBS pilots, with support from district level Women's Associations used to extend the networks. M&E surveys were conducted with participants using the CommCare app on tablets to ensure fast turnaround of data collection.

				A video featuring selected FBS impact stories was created to convey outcomes. The following outputs (Section 10.2) correspond to this activity: • H.M.T. Pham (2016) Farmer business school in Southeast Asia and its modification and adaptation to Vietnam (unpublished project report), CIAT–Asia, Hanoi, Vietnam. • H.M.T. Pham (2018) Sustaining and scaling Farmer Business School (FBS) (unpublished project report), CIAT–Asia, Hanoi, Vietnam. • A FBS manual (available in English and Vietnamese).
4.3	Identify and develop additional FBS resources in Food Safety and Crop Nutrition and Soil Management	Publication of new training modules – Food Safety, Crop nutrition and Soil Management Evaluation of NSW DPI/HAL application '*Undercover Grower"* as a business training tool in FBS.	2017	See FBS manual (as listed under Activity 4.2) and outputs listed in Activity 3.11. The NSW DPI *'Undercover Grower'* application was discontinued preventing this evaluation.
4.4	Build research capacity through targeted short term training initiatives, mentoring schemes, study tours and cross linking with other projects	Mini-project designed and delivered as part of Crawford Fund Agribusiness Master Class Develop cross-project marketing team with AGB/2012/060 Explore and develop linkages with MALICA – at	Nov 2014 February 2014 June 2014	The Agribusiness Master Class was successfully delivered in 2014. As part of this class participants undertook a mini-project for this project. Seven project staff were involved in Masterclass: Three project staff that participated in the Agribusiness Master Class went on to graduate study in agribusiness and social science. For more information about the Agribusiness Masterclass see the video. A cross-project marketing team was successfully developed during the scoping studies for AGB/2012/059 and AGB/2012/060. This resulted in shared personnel at VNUA and FAVRI undertaking work for both projects. In addition, this project worked with the AGB/2012/060 project team on elements of the urban consumer survey (Activity 1.2).

		least one joint event held per annum		The Agribusiness Master Class was a shared event with MALICA, however, MALICA linkages did not extended beyond the Agribusiness Master Class due to retirement of key staff.
		Increase soil laboratory quality assurance capacity	2018	The SFRI lab is now certified by ASPAC and has ISO certification for a range of chemical tests. See Activity 3.2.
		Increase plant pathology diagnostic capability	2018	Throughout the project there was extensive mentorship and in-field training provided by Stephen Harper and Len Tesoriero (and then Rosalie Daniel) to soil science and plant pathology teams at SFRI and NIMM, respectively.

7 Key results and discussion

7.1 Component 1 — Market Analysis Results

7.1.1 C1a Trade Analysis

Lao Cai Market

Overall, Lao Cai's municipal markets trade about 16,000–20,000 tonnes of vegetables each year. This constitutes around 20% of Lao Cai province's total vegetable production, therefore, there is definitely room to increase the commercialisation of vegetables from the province.

Lao Cai's vegetable value chain structure appears to be changing in response to growing opportunities to sell into nearby urban markets and competition from China. While the majority of Lao Cai produced vegetables are still marketed through very rudimentary value chains where farmers market directly to consumers or via retailers; collectors and wholesalers are stepping-in and providing valuable services to reduce transaction costs in trade. However, the presence of these actors is still limited to a small radius surrounding the municipal markets. Expanding the role of collectors and transporting wholesalers in the vegetable value chains will be critical to the growth of the vegetable sector as a whole.

Meanwhile, Chinese imports coming across the border or coming through Vinh Phuc markets present a major threat in the Lao Cai markets. Imports from China constitute nearly half of the total vegetable products sold in these markets already, and locally produced vegetables are not very competitive with imports except during the off-season.

Improving the efficiency of the trading system for locally produced vegetables and finding new profitable markets to absorb excess will be critical for Lao Cai's vegetable sector. Furthermore, developing value-chains for Lao Cai's indigenous vegetable products will be very challenging unless farmers participate in markets and take a more commercial orientation. Development of vegetable value-chains in Lao Cai will depend on:

(1) Farmers increasing their marketed quantity and selling in larger shipments to reduce transportation and transaction costs on the producers' side;
(2) Collectors or rural trading hubs must expand. These intermediate points of aggregation for farmers are crucial to reducing the transportation and transaction costs per shipment from the traders' side;
(3) Meanwhile, vertically integrated cooperatives can fill the missing markets for trade services by acting as collector, wholesaler and broker. Helping cooperatives improve upon their existing functions may be the most immediate way forward.

Developing long-distance trade and counter-seasonal trade is also important as Lao Cai positions itself to supply off-season vegetables to distant urban markets. To develop this function, there needs to be a cost-effective way to access timely market information from a distance and reduce settlement risk in sending shipments. This may require:

(1) Expanding cooperative activities to include the collection of market information on buyers and prevailing prices in the markets of interest, and coordinating production to fall in line with seasonal price spikes;
(2) The rise of a population of brokers that specialise in market information for long-distance vegetable trade, and help to reduce settlement risk in the transaction by handling the cash-flow.

Hanoi's Markets

Hanoi is an important destination market for vegetables produced in NW Vietnam, especially during the summer off-season period when peri-urban producers near Hanoi are unable to supply Hanoi markets.

The study found the following:

(1) NW vegetables are sold (almost exclusively) through traditional channels. Supermarkets and specialty shops account for only 3–4% (a generous figure) of vegetables sold in Hanoi. Despite the recent proliferation of modern food retail outlets, consumers are still purchasing almost all of their vegetables from wet-markets located in every neighbourhood in the city.
(2) Interestingly, the share of NW vegetables in select specialty shops averaged to almost 50% for certain commodities. This channel shows promise as an outlet for NW vegetables as they are able to capture a price premium for origin and indigenous vegetables. However, the expansion is constrained by the specialty shops unique and very specific sourcing strategies that are difficult to replicate and expand to accommodate new untested suppliers.
(3) Supermarkets sold a small share of NW vegetables, and captured a premium for origin information. However, increasing trade with supermarkets requires large investments of time and resources to facilitate a link with new farmer groups in the NW.
(4) NW vegetables have a very small share in the wet-markets (<5% for key commodities), with almost no product from Lao Cai. Here, NW vegetables must compete on price as they do not fetch a premium for origin. NW vegetables are only cost-competitive during the off-season period. Until trade institutions can credibly signal origin and quality, NW vegetables will face difficulty competing with products from other highland regions and from China during the main season.

The strong competition from Red River Delta (RRD), imports and production from other NW provinces makes it very difficult for product from Lao Cai to compete in the Hanoi market. This is mainly because currently, there is a lack of reliable market signals for origin and quality, therefore, Lao Cai vegetables must compete on price. As a result, vegetables from Lao Cai are only competitive during the off-season, but expansion from Son La and surrounding highland production regions is quickly filling in this market.

The most feasible market appears to be increased sales into specialty vegetable shops that offer premiums for origin, but these shops demand high quality and the use of safe production protocols, which will require further value chain interventions (post-harvest and traceability systems).

Interprovincial Trade

Improving the trading system for vegetable products in NW Vietnam is paramount to connecting small farms with local and regional markets. The ability of the trade system to efficiently integrate markets across space and coordinate timely supply of counter-seasonal products is crucial. The overall aim of this sub-component was to understand regional trade flows and to identify potential destination markets for Lao Cai's vegetables.

Results from key-informant interviews were used in analysis of the vegetable trade system in four key markets of the region: Lao Cai, Son La, Yen Bai and Dien Bien. The main results are as follows:

- Son La is the dominant producer of the NW provinces. Son La has a strong supply link to Hanoi's urban markets and consistently supplies a large proportion of vegetables to Hanoi market throughout the year. For example, 60–70% of marketed chayote, 25–35% of marketed cabbage, 30–35% of marketed H'mong mustard is destined for Hanoi's markets, and these percentages are stable across

growing seasons. Despite Son La's dominant position in NW Vietnam, very little vegetable production is traded from Son La to other NW provinces.

- Yen Bai and Dien Bien are small 'importing' markets that do not produce enough vegetables to supply internal provincial demand. As a result, they rely on products from neighbouring provinces and imports from China to supply consumers. There appears to be significant room for Lao Cai to further expand vegetable trade into these provinces.
- Surprisingly, Lao Cai is serving as the spot-market supplier of vegetables to 'importing' markets like Yen Bai and Dien Bien. This is most obviously the case during the summer off-season period when Lao Cai's produce comprises 100% of the chayote and H'Mong mustard in the markets in Dien Bien and Yen Bai.

While Lao Cai vegetables cannot always compete in Hanoi's markets, there appears to be an opportunity to be the regional NW supplier of vegetables to smaller 'importing' provinces that neighbour Lao Cai. Interprovincial trade of large volumes requires coordination and timely access to market information. As a result, only a select group of elite traders in Lao Cai who have strong relationships with traders in destination markets are able to take advantage of interprovincial trade opportunities for vegetables.

Price Variation and Market Integration

In general, vegetable prices peak during a short period leading up to Tet holiday (lunar New Year) and during the summer off-season period from June – August. Across vegetables this pattern is consistent with the exception of cabbages and tomatoes. During the summer off-season, cabbage from China and tomato from Dalat enter Hanoi markets and offset the RRD supply shortage. This stabilises prices throughout the year for cabbage and tomatoes.

The wholesale market prices exhibit high variability especially for perishable goods such as leafy vegetables (e.g. H'mong mustard, chayote leaves). Supermarket prices are much more stable over time relative to traditional markets and relatively independent of prices in other markets. This is due to storage systems and advertising strategies, which could allow a single supermarket to better control supply quantities to maintain a more stable price. Lastly, the wholesale market prices appear to move together very closely, which suggests a competitive market in the trade of vegetables.

Regression results show that:

(1) In the long-run, the vegetable markets in Hanoi are integrated and competitive. Wholesale prices and retail prices throughout the city are moving together and traders are competing away any profits from spatial arbitrage, even with more distant markets.

(2) Interestingly, we see that traditional markets are the price setters in vegetable markets. Supermarkets are responding to price signals observed in traditional markets and adjusting prices to be more competitive. This speaks further to the dominant position of traditional markets despite the recent proliferation of modern retail formats in Hanoi.

(3) Specialty shops have set prices for vegetables that see almost no variation throughout the year. They appear to be operating completely independently with little interaction with local markets or supply chains that service those markets.

7.1.2 C1b — Urban consumer research

With Vietnam's population now exceeding 90 million and the economy becoming increasingly open and disposable incomes increasing, the patterns of food purchase and consumption are also changing. For example, the introduction of modern retail outlets such as supermarkets in urban Vietnam has influenced both food expenditure and consumption behaviour. However, the extent to which changing markets are affecting

vegetable consumption patterns, preferences and purchasing behaviour was previously unknown.

To address the gap in consumer market information with respect to vegetables, we conducted a household survey, The Vietnam Urban Food Consumption and Expenditure Study, in four urban areas and 2000 households across Vietnam: Ho Chi Minh City, Hanoi, Lao Cai City and Son La City during December 2016 to March 2017.

As the survey was implemented in partnership with another ACIAR-funded project (AGB/2015/029) it was designed to obtain detailed information about overall household food consumption patterns, expenditure on foods, the relative importance and value of fruit and vegetable varieties, attributes and credence information (e.g. provenance or safety certification), and characteristics of market segments, which may offer profitable and sustainable opportunities for smallholders producing food products for sale in local and regional markets.

The data gathered from the survey modules relevant to this project provided previously unavailable information on urban Vietnamese households' vegetable purchase behaviour, expenditures on vegetables, and consumption drivers and value of different vegetable attributes, including certification schemes.

Analysis of the household data found that urban Vietnamese consumers spend 9–13% of their monthly food budget on vegetables. Considering households' vegetable expenditure shares, cabbage is the most popular vegetable in Hanoi and Son La City and H'mong mustard accounts for the highest share of household vegetable expenditures in Lao Cai City.

The majority of vegetable expenditures are made at traditional outlets such as wet markets and informal street markets. These expenditure patterns indicate that smallholder farmers who produce vegetables, and other items commonly purchased at traditional outlets, will likely not be negatively affected by the growth of modern outlets in the short to medium term.

In all urban locations, food safety was the main factor influencing the types of vegetables consumers purchased, as well as where (i.e. the type of retail outlet) they purchased vegetables. For 43% of the respondents, safety was the most important factor influencing their decision to buy tomatoes and water spinach. Safety was also the most important factor for 33% and 34% of the respondents in buying susu leaves and cai meo, respectively. Traditional markets, both formal and informal, were where most vegetables were purchased, and modern retail outlets accounted for less than 20% of retail sales of vegetables in all northern cities (Hanoi, Lao Cai and Son La).

The survey also explored preferences, understanding and willingness to pay for certifications of credence attributes (safety, origin, production method) for a sub-group of vegetables (tomato, water spinach, susu leaves, cai meo). The vegetables considered were of particular interest to the project and were perceived by consumers to have food safety and/or quality issues. When asked about their interest in 10 different certifications, they were on average most interested in certifications which they perceived to signal improved safety and or nutrition such as "certified safe", "organic", "VietGAP" or region (e,g, Moc Chau or Bac Ha).

When asked about their experience in buying "Certified Safe" vegetables, which is an existing government certification scheme, around one-half of the respondents indicated that they had previously purchased "Certified Safe" vegetables

Consumers were asked about their perceptions of "Certified Safe" and "Certified Bac Ha" vegetables. Nearly 70% of the respondents agreed that "Certified Safe" vegetables are healthier to eat, while 65% agreed that they are safer to eat. For "Certified Bac Ha" vegetables, 59% agreed that they are healthier and 56% agreed that they are safer to eat.

Finally, consumers were asked to indicate their willingness to purchase and their willingness to pay for two certification labels ("Certified Safe" and "Certified Bac Ha") for the four vegetables. For all four vegetables, the majority of the respondents (65%–68%) were willing to pay a premium of 25% more for "Certified Safe" vegetables compared to conventional vegetables. Most of the respondents (61%–64%) were also willing to pay 25% more for "Certified Bac Ha" vegetables. Consumers' willingness to pay premiums for certifications were significantly related to food safety and nutrition concerns, positive perceptions towards certified vegetables, and food expenditure at modern retail outlets. Interestingly, the value of the premium for the certification was found to decrease with household income.

This consumer research has identified potential opportunities and threats for farmers supplying food to rapidly changing markets in Vietnam. Importantly, this information can give farmers (directly or indirectly) the capacity to be proactive rather than reactive to change in the agricultural industry and wider Vietnam economy.

Further development of certification programs that are trusted by the market and that are not overly burdensome for smallholders is one strategy for further developing markets for smallholder vegetable products from this region.

For more results please read the Factsheet series published on the project website. In addition to the Factsheets, results have been presented to stakeholders and policymakers in Vietnam as well as Australia. The market insight was also used for the market development activities in Component 2.

7.2 Component 2 — Market Development

7.2.1 Case Studies

Case studies were used to understand and explore different marketing models and farmer group structures in Bac Ha and Sa Pa districts of Lao Cai Province. Interviews of stakeholders and FGDs with farmer organisations provided information on the production and marketing strategies used by smallholder farmers. Smallholder inclusive chains were classified into three broad types based primarily on the method of coordination and access to markets. The three types identified were:

Traditional wet-market coordinated chains

The survey found that this is the dominant chain used by smallholder vegetable producers in Lao Cai. Products are produced and transported by farmers to wet-markets where they are sold using spot-market arrangements. Prices are not known until arrival at the market, and farmers simply accept the prevailing price of the day. These growers do not plan production according to market signals, and their supply behaviour results in over-supply during peak production season and under-supply during the off-season.

Advanced collector-coordinated chain

In this chain, a marketing intermediary (typically a collector) coordinates transactions between a small network of 20–30 producers and high-end buyers in Lao Cai. The collector develops preferred supplier relationships with restaurants, retailers and institutions (schools and hospitals) that establishes price premiums for quality and a production schedule to work around. Although the producers in the chain produce high quality and safe produce, this chain cannot supply to 'premium markets' in Hanoi because they are not individually certified. Farmers in this chain are dispersed across multiple districts making formal certification at the group-level impossible, and certification of an individual farm is too costly.

Cooperatives

Cooperatives are similar to 'advanced collector coordinated chains' in that they can coordinate with producers to provide price premiums for quality. Cooperatives takes it one step further by facilitating group-level certification for 'safe' vegetables. This allows them access to premium markets in distant high-end markets in Hanoi to earn higher prices. However, cooperatives are captive to the diverse and often divergent interests of member farmers. As a result, governance of the cooperative becomes increasingly difficult as cooperatives develop and expand.

Overall

The study finds that the dominant system of marketing through local wet-markets is inefficient. It is unable to reward safe vegetable production or differentiate quality because of a lack of standards and grades. In addition, there is a larger problem of a dysfunctional market. The price mechanism does not appear to be effective in coordinating farm supply behaviour because farms are not fully commercial and lack the capacity to use the market mechanism effectively. This is demonstrated in clear over-supply behaviour during the winter and under-supply during summer. Low commercialisation and lack of farmer business skills are the main factors inhibiting development of the vegetable sector.

Expansion and development in the sector is driven by a small set of forward-thinking actors. These actors have the ability to coordinate with farmers to ensure they produce the most profitable commodities and harvest when prices are peaking. Cooperatives and collector-coordinated chains are examples of successful value-chain development in Lao Cai. They have found a way to service higher-end markets by securing price premiums for quality and coordinating production of high quality products. However, development hinges on strong coordination and cooperation of growers.

7.2.2 Market Interventions

This subcomponent implemented a series of whole-chain marketing interventions to encourage the development of a competitive position for smallholder vegetable producers in Lao Cai Province. Marketing strategies and interventions were developed in consultation with stakeholders, farmers and local authorities, in a series of stakeholder workshops and steering committee meetings:

- Stakeholder workshop for local government (October 2014)
- Stakeholder workshop for supply chain partners (October 2014)
- Steering committee set priorities and implementation plans (March 2015)
- Stakeholder workshop for input into next phase of interventions (March 2016)
- Stakeholder meeting upscaling and outscaling project (May 2016)

A number of interventions were prioritised:

Technical support

- Production techniques for safe vegetables
- Techniques for counter-seasonal vegetables
- Guidance in trialling new vegetable commodities
- Quality certification assistance

Technical recommendations were passed onto the farming systems research component of the project, which trialled counter-seasonal vegetable production and helped farmers trial new commodities (see 7.3).

Market information

- Tasting events (Figure 12)
- Product fairs
- Networking events

- Seasonality of supply and prices in markets (Figure 13)

The market development team worked to execute a series of networking events and product promotion events for Lao Cai vegetables.

Figure 12. Recipe cards describing indigenous vegetables and offering serving suggestions were distributed to sales outlets to raise awareness and demand for indigenous vegetables (from Lao Cai Province) in Hanoi.

In addition, production calendars were produced with close feedback from farmer groups to inform smallholder farmers on optimum timing to supply Hanoi's markets (when prices peak, and competition from other locations is low; Figure 133).

Figure 13. Excerpt from production calendar indicating seasonal production capacity for a range of vegetables in Bac Ha and price patterns (in Hanoi markets) to aid farmers to target production when competition is low and prices are high.

Logos and branding materials (Figure 14) were developed for farmer groups in Bac Ha district. They were developed by PPsD and FAVRI in close collaboration with the Di Thang farmers' group. These materials are planned to differentiate product from Bac Ha, and improve consumer awareness.

Figure 14. Logo and packaging options indicating production origin designed for Bac Ha.

7.2.3 Postharvest

The current supply chain in Sa Pa operates on limited loss (estimated <5%) due to the very small volumes being traded, short transport distances from farms to the local market and high consumer-demand leading to limited in-market storage. As such there appeared to be little incentive for the Sa Pa smallholder farmers to improve their postharvest handling systems. Following this, efforts were concentrated on understanding postharvest losses in the packing and transport of vegetables from Bac Ha to Hanoi markets. Ten vegetable consignments were tracked to evaluate postharvest handling practices and to document resultant postharvest quality changes and losses at key points on the supply chain between harvest in Lao Cai Province and arrival at wholesale markets or specialty vegetable shops in Hanoi (Table 6).

Table 6. Vegetable consignments tracked to assess postharvest losses.

Consignment number	Date	Origin	Transport means	End destination
1	Aug 2015	Sa Pa	Truck	Hanoi
2	Sept 2015	Bac Ha	Public bus	Hanoi
3	Dec 2015	Bac Ha	Public bus	Hanoi
4	Mar 2016	Bac Ha	Public bus	Hanoi
5	May 2016	Bac Ha	Public bus	Hanoi
6	July 2016	Bac Ha	Public bus	Hanoi
7	Oct 2016	Bac Ha	Public bus	Hanoi
8	Nov 2017	Bac Ha	Public bus	Hanoi
9	Jun 2018	Bac Ha	Public bus	Hanoi
10	Sept 2018	Bac Ha	Public bus	Hanoi

The type of packaging used by farmers (i.e. large 12 kg nylon bags or 50-60kg cardboard boxes) was one of the key contributors to reduced postharvest quality and loss. The level of postharvest loss varied between chains and product type being transported. Mean postharvest loss for all crops and all chains monitored (see Table 7) was 25-30%, which is considered relatively high, when additional pre-transport loss of 10-15% is also considered. Postharvest loss was highly variable between similar commodity chains. For example, H'mong mustard (Chain 3, Dec 2015) experienced 30% loss, compared to H'mong mustard (Chain 5, May 2016) where losses were only 7.5%. While the possible influence of seasonality cannot be excluded, such disparity in the level of postharvest loss for the same product and the same transport route, warrants further investigation.

The type of injuries observed during packaging, transport and marketing typically included, physical cuts and bruising, with little evidence of postharvest disease. The incidence of physical damage was greater at the market-end of the chain. For example, physical damage in a chayote consignment increased from less than 1% to 9%, once product arrived at the market.

In several of the chains, we observed the product being roughly packed, with an emphasis on maximising the amount packed. Handling practice needs to be improved through ongoing farmer and packer training. Consignments were commonly transported to Hanoi using public buses. This also creates potential food safety risks where product is co-transported with non-food material or high-risk contaminants such as raw meat products.

While there was evidence of poor packing and an assumption of poor unloading, when handling practice was assessed quantitatively using impact loggers we found that product was subjected to more severe impact shock whilst in-transit. Unfortunately, GPS and speed-trackers were not included in this trial, so the possible contributory effect of driver behaviour or consignment loading, or the road conditions is unclear.

Whilst we observed significant risk factors likely to lead to elevated postharvest diseases, the incidence of postharvest disease in all chains assessed tended to be low. In chain 5,

the incidence of postharvest disease in the commodities assessed was 0.9% (Ngong cai xoe) to 1.73% (cabbage). We did note a slight seasonality difference in the incidence of postharvest disease (data not shown), with elevated incidence during the summer months. As a result, postharvest disease is not considered a major contributor to current postharvest loss in the chains assessed.

To improve product quality and reduce postharvest loss the following critical intervention points were identified:

- The practice of harvesting in the late afternoon when temperatures are frequently 27-29°C results in the product having retained field-heat at the point of packing which reduces shelf-life. Farmers need to consider alternative practices to reduce field-heat, such as harvesting in the early morning, delayed packing or hydro-cooling.
- The practice of immediately packing warm-product and then sealing the carton with tape, retains field-heat during transit. We found that humidity within the carton increased rapidly and was maintained at 90 - 98% relative humidity, increasing the risk of postharvest diseases. Internal carton temperature also remained above 30°C during transport, also reducing potential product shelf-life.
- The use of 50-60kg locally-made cardboard cartons to transport vegetables (often co-packed with other items such as meat, eggs, alcohol) is contributing to in-transit product damage (Figure 15). Large-volume packaging cartons are more likely to be poorly handled and dropped during transport, they offer reduced in-transit protection to products and noting the practice of packing warm product, would retain field heat longer. To reduce losses, farmers need to adopt smaller packaging ideally no more than 20kg units.

Figure 15. Example of overloading of cartons (left) and co-packing of vegetables with other products (chayote, sweet potato, pumpkins, raw meat, and distilled alcohol; left) leading to product in-transit damage.

The farmers seem to be aware that the current packaging types are causing damage. Some of the vendors are actively communicating issues back to the collectors. While vendors mentioned that farmers improved their on-farm practices when issues were raised (i.e. elevated loss due to pest damage); however, the same does not seem to occur for packaging-related issues. One vendor indicated that farmers tended to see postharvest losses during transport (associated with poor packaging) as simply bad luck.

Based on the results of the consignment tracking and the identification of prominent causes of postharvest losses, trials were designed to improve packaging and reduce loss. The different treatments applied are described in Section 5.5.3. While more protective

packaging (foam boxes and ice) reduced weight loss for H'mong mustard and chayote (Figure 16), the benefit in terms of reduced bruising was much less than anticipated (data not shown). To generate conclusive results on which to base recommendations, this trial needs to be repeated to replicate results, include a wider range of packaging options, and incorporate different packing practices and consignment loading.

Farmers have adopted some postharvest recommendations following the alternative packing trials. For example, ice bottles are now being used to assist with cooling the product during transit (though the 300 mL bottles being used are too small). Also, farmers are not pre-peeling cabbages prior to packing, with the intent of better protecting the crop in-transit.

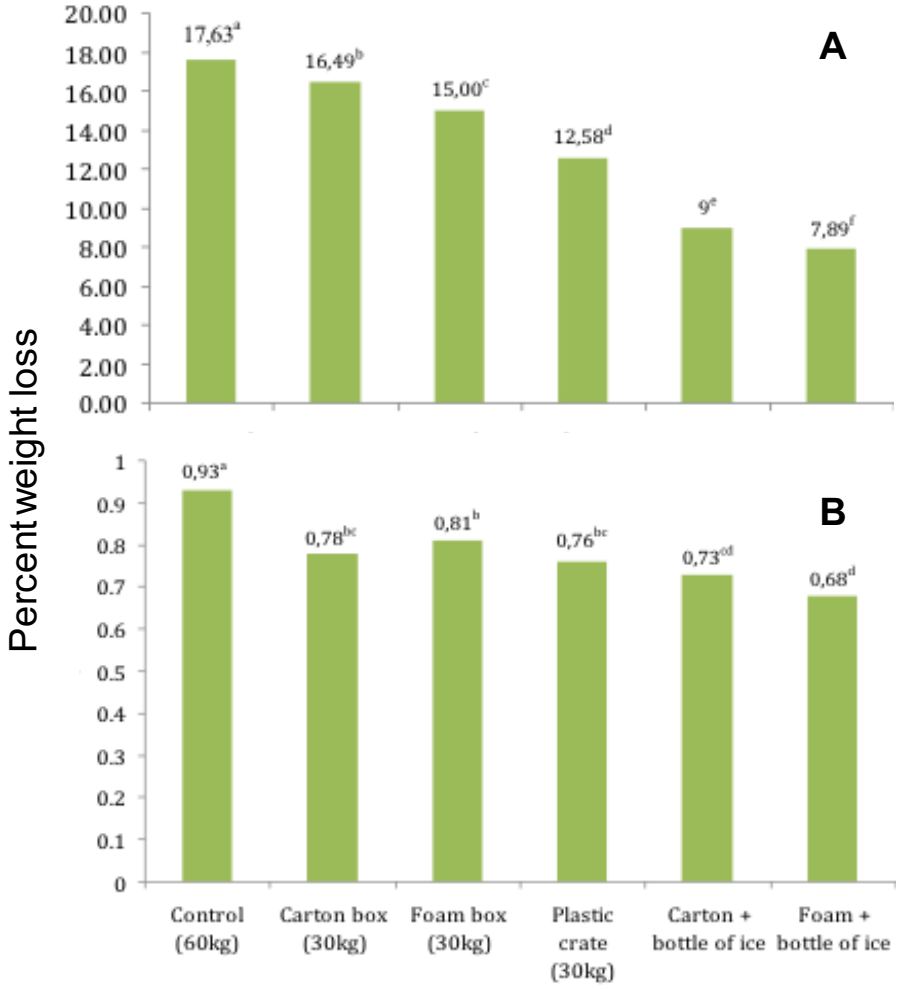


Figure 16. Percent weight loss in various packing options (Bac Ha to Hanoi) [A] Percent product weight loss of H'mong mustard transported in various packing options from Bac Ha to Hanoi. [B] Percent product weight loss of chayote transported in various packing options from Bac Ha to Hanoi.

One of the impediments to improving smallholder farmer postharvest practice is that most of the damage due to poor harvesting and handling is only seen when the product arrives at the market-end of the chain. As such, farmers are often unaware of the consequence of their current handling and packaging practices. While postharvest training has been provided, this might explain inconsistent farmer adoption. In addition, the traders (rather than the farmers) are the key cohort responsible for product at points in the supply chain

where the postharvest capacity activities need to be focussed and improved. Their decisions and practices appear to have the greatest influence on potential loss.

The bus company transporting consignments of vegetables from Bac Ha to Hanoi and transporters in Hanoi appear to prefer single packaging units because it is more efficient to load and unload. If the product was alternatively transported in a series of smaller crates, some vendors thought this might increase the likelihood of boxes being misplaced during unloading or being damaged in-transit (i.e. having one large and very heavy box was thought to be more likely to remain where it was originally placed in the bus, and as a result more easily and quickly identified during unloading). One of the vendors (in Hanoi) trading with Bac Ha farmers mentioned that she has previously requested product to be supplied in plastic crates, but was unable to continue the practice due to problems raised by the bus company. Therefore, as long as Bac Ha farmers continue to use commercial buses to transport product and/or the product volume being supplied remains relatively low, it is unlikely that they will transition to multiple smaller boxes. To reduce transport losses, the initial aim should be to focus on alternative packaging options that are of a compatible size and contain a single vendor's consignment. The small volume of product and irregular supply undermines transitioning to more commercial modes of transport, where alternative packaging might be easily adopted.

7.2.4 Food safety risk analysis

Chemical use

Households use chemicals during vegetable cultivation. Commonly used chemicals are widely available in the market and have clear instructions for use on the label. Despite this, control of dosage and the duration of use is a problem. The recommended period between the last pesticides spray and harvest is often not followed. Farmers often use both organic and inorganic fertilisers. Nearly 100% of vegetable-growing households integrate vegetables with raising buffalo, pigs and chickens. As such, the households have access to manure as a source of fertiliser. Of the interviewed farmers in Sa Pa, 60% were using composted manure and the remaining 40% used fresh manure (not composted) to fertilise their plants. Meanwhile, in Bac Ha, these numbers were 70% (composted manure) and 30% (fresh manure) respectively. The use of fresh manure directly on plants can increase the risk of E.coli infection and other diseases. The contamination risk is particularly important for leafy vegetables as the edible parts are in direct contact with soil and manure. This is an important consideration for crops such as lettuce and cucumbers, which can be eaten without cooking.

Harvesting

None of the interviewed households had specialized harvesting tools such as knives and scissors. These tools are often used in daily life with many purposes: collecting vegetables, peeling fruits, cutting meat, digging soil, etc. Harvesting equipment and tools are also often stored in different places. The hygiene conditions of containers such as plastic and bamboo baskets is also variable. Such containers are also used for many purposes. Sacks used for harvesting vegetables may have previously been used to store and transport fertilisers.

More than 80% of farmers leave their vegetables directly on the soil in the field after harvesting before putting them into baskets and sacks to bring back, wash, classify, pack and transport to collection agents or sell to local markets.

Transport

Farmers often bring their vegetables to the local market for sale in baskets, backpacks or boxes. Alternatively, they may pack the vegetables into 7 kg, 10 kg or 15 kg nylon bags and put them aside for collectors who will often on sell the vegetables in larger consignments. As described in the preceding section, vegetables destined to Hanoi

markets tend to be packed in 50 - 60 kg cardboard boxes. Each box may contain many kinds of vegetables as well as raw meat, alcohol, and eggs. These boxes are then commonly placed in the storage compartment of public buses and transported to Hanoi. Only names of senders and recipients are written on parcels. The farmer's name or farmer code is not recorded on the crate, box or sack. This practice limits product traceability as well as feedback regarding practices and the condition of vegetables on arrival at Hanoi that could potentially help farmers to change practices to limit food safety risks.

Awareness of good food safety practice

The farmers in Sa Pa and Bac Ha have received food safety extension material (i.e. farmer guides or hand-outs on good food safety practice). However, prior to this project they had not attended any training in food safety awareness. To partially cater for this missing experience, this project supported farmers to transition from the use of fresh manure to using composted manure and communicated the importance of adhering to chemical withholding periods and providing high quality 'safe' vegetables in order to build long-term, trusted, trading relationships. In addition, the project hosted postharvest and food safety risk workshops for farmers in Bac Ha and for extension organisations and local government in Lao Cai City.

In addition, improved packaging of vegetables for transit, i.e. packing vegetables in smaller consignments and without other items (e.g. raw meat) in the same boxes, as described in the preceding section, if adopted, is likely to produce co-benefits in the form of reduced food safety risks.

7.3 Component 3 – Farming Systems Research

7.3.1 Baseline

Baseline surveys were conducted to understand the context of production systems in Sa Pa and Bac Ha districts, the main problems faced by growers, and identify priority areas for the farming systems research component to address.

Findings included:

- Majority of farmers are from ethnic minority communities e.g. H'mong, Tay, and Nung people
- The farms are relatively small in scale. Total operated area is 0.44 ha in Bac Ha, with a very small proportion of that allocated to vegetable production
- There are constraints in adopting off-season vegetable production
- Households market output directly at local retail markets
- Soils are poor and have low pH which constrains productivity
- N, P, K, fertiliser applications appear to be excessive
- There are indications of micro-nutrient deficiency e.g. Ca, B, Cu, Mn, Zn
- Pest and disease problems cause significant crop loss

In focus group discussions farmers stated that the main problems they face include:

- Bac Ha
  - Unstable markets and price volatility
  - Vegetable diseases
  - Poor quality seed / planting materials
- Sa Pa
  - Vegetable diseases
  - Capital constraints
  - Low prices

Baseline information was used to design research programs to address the major problems identified by scientists and by farmers. These primarily focused on:

- Plant protection
    - Development of effective controls for the major diseases encountered in Bac Ha and Sa Pa
- Soil and nutrients
    - Investigate lime applications to optimise soil pH for vegetable production
    - Field trials to identify optimum applications for macro and micro nutrients.

7.3.2 Plant Pathology

Pest and disease survey

Soil borne diseases were identified as major impediments to production in brassica vegetables in the Bac Ha and Sa Pa. Fewer diseases were observed in the mixed cropping systems. Pest incidence was similar regardless of the cropping system. Cabbage crops were affected by four diseases at high incidence: black rot (*Xanthomonas campestris* pv. *campestris*), clubroot (*Plasmodiophora brassicae;* Figure 17), wet rot (*Pectobacterium carotovorum*) and Sclerotinia head rot (*Sclerotinia sclerotiorum)* (Table 8). The current practice of cultivating brassicas continuously, without rotation, has most likely contributed to the high level of pathogen inoculum in soil. The vegetable diseases observed were similar in Sa Pa and Bac Ha, with the exception of clubroot which was detected only in Sa Pa. Wet rot of cabbage was much more severe in Bac Ha. Clubroot first appeared around 3 years ago in Sa Pa but has spread quickly. Every farm growing brassicas in Sa Pa is now affected by clubroot. The disease also spread to other farms in Sa Pa and Ta Phin commune. Nurseries may be a potential source of inoculum and this needs to be investigated in the future. *Rhizoctonia solani* caused collar rot of seedlings and young plants in most of the vegetables surveyed, especially brassicas (Figure 18). The disease was more severe in wet conditions.

Efficacy of treatments for control of clubroot in cabbage

The application of fluazinam, with and without lime, and flusulfamide at planting successfully controlled clubroot disease compared with the control treatment increasing the average plant weight per plot, the proportion of plants that produce a head and the total marketable yield per plot when compared with the untreated control (Figure 18 and 19). Fluazinam in combination with lime application was recommended for vegetable farmer's adaptive trials with a large field scale in Sa Pa, resulting in their successful cabbage harvest in 2016. Economic analysis showed that cabbage growers would get most income from application of fluazinam + lime, followed by fluazinam then flusulfamide with approximately VND 18.3 million, VND 11.6 and 10.8 million respectively, excluding the input cost for lime and fungicides (Table 10).

The proportion of plants treated with lime or spring onion amendments that formed a cabbage head was not significantly different to the proportion of plants in the control treatment that produced a marketable head (Figure 18). The average plant weight per plot following application of lime to soil was greater than that observed following spring onion amendments, and significantly less that the Flusulfamide and fluazinam treatments, but not significantly different to the control (Figure 19). The average total yield in each plot treated with lime was also not significantly greater that in untreated control plots. The recommendation for clubroot control is to modify soil pH to 8. The soil pH in these trials did not reach 8 and that is likely to be a contributing factor to the results observed. The spring onion trial was only conducted only once and may benefit from being repeated.

Figure 17. [A] Symptoms of clubroot disease on cabbages. [B] Symptoms of *Rhizoctonia* disease on cabbage (left), H'mong mustard (centre) and Chinese flowering cabbage (right).

Table 7. Pathogens isolated from diseased vegetable samples collected during field surveys in Sa Pa from 2014–2017.

Crop	Disease	Causal agent	Incidence (frequency)		Part affected
			Summer	Winter	
Cabbage	Clubroot	*Plasmodiophora brassicae*	High	Moderate	Root
	Downy mildew	*Haloperonospora parasitica*	Moderate	High	Leaf
	Leaf spot	*Aternaria brassicae*	Moderate		Leaf
	Head rot	*Sclerotinia sclerotiorum*	Medium	Medium	Head form
	Wet rot	*Erwinia carotovora*	Medium	Medium	
	Black rot	*Xanthomonas campestris* pv. *campestris*	Medium	High	Leaf
Choy sum	Clubroot	*Plasmodiophora brassicae*	Moderate		Root
	Downy mildew	*Haloperonospora parasitica*		Medium	Leaf
French bean	Leaf spot	*Cercospora* sp.	Low	Low	Leaf
Gold bean	Leaf spot	*Cercospora* sp.	Low		Leaf
	Fruit spot	*Colletochicum trancatum*	Moderate		Fruit
H'mong mustard	Clubroot	*Plasmodiophora brassicae*	Medium		Root, leaf
Kohlrabi	Collar rot	*Rhizoctonia solani*		Medium	Stem base
Coriander		*Fusarium oxysporum*		Medium	Stem

Note: Incidence: Low is < 10% of plants infested); Moderate is 11-25% of plants infested; Medium is 26-50% of plants infested; High is > 50% of plants infested.

Table 8. Pathogens isolated from diseased vegetable samples collected during field surveys in Bac Ha from 2014–2017.

Crop	Disease	Causal agent	Incidence (frequency)		Part affected
			Summer	Winter	
Cabbage	Wet rot	*Erwinia carotovora*	Moderate	Low	Head
	Collar rot	*Rhizoctonia solani*		Medium	Collar
	Downy mildew	*Haloperonospora parasitica*		Moderate	Leaf
	Sclerotinia head rot	*Sclerotina sclerotiorum*	Low	Moderate	Leaf
	Leaf spot	*Alternaria brassicola*		Moderate	Leaf
		Alternaria brassicae	Low	Moderate	Leaf
	Black rot	*Xanthomonas campestris* pv. *campestris*	High	Medium	Leaf
Bean	Sclerotium rot	*Sclerotium rolfsii*	Low	Moderate	
Snow pea	Root rot	*Rhizoctonia solani*	Moderate	High	Leaf, stem
Spring onion	Rust	*Puccunia allia*	Medium	Low	Leaf
	Leaf blight	*Stemphylium* sp.		High	Leaf
	Anthracnose	*Colletotrichum* sp.	Low	High	Leaf
Lettuce	Leaf spot	*Cercospora lactucae*	Moderate	Medium	Leaf
	Root rot	*Rhizoctonia solani*		High	Leaf, stem
H'mong mustard	Root rot	*Rhizoctonia solani*		Medium	Leaf, stem
	Downy mildew	*Haloperonospora parasitica*		Moderate	Leaf
	White rust	*Albugo occidentalis*		Moderate	Leaf
Chilli	Root rot	*Phytophthora* sp.		Moderate	Root
Pumpkin	Downy mildew	*Pseudoperonospora cubense*	Moderate		Leaf
	Powdery mildew	*Erysiphe cichoarcearum*	Moderate		Leaf
Chinese cabbage	Sclerotinia head rot	*Sclerotina sclerotiorum*		Medium	Leaf, head
	Sclerotium rot	*Sclerotium rolfsii*		Moderate	Leaf
	Collar root rot	*Rhizoctonia solani*		Medium	Collar, root
Mint	Root rot	*Rhizoctonia solani*		Medium	Leaf

Note: Incidence: Low is < 10% of plants infested); Moderate is 11-25% of plants infested; Medium is 26-50% of plants infested; High is > 50% of plants infested.

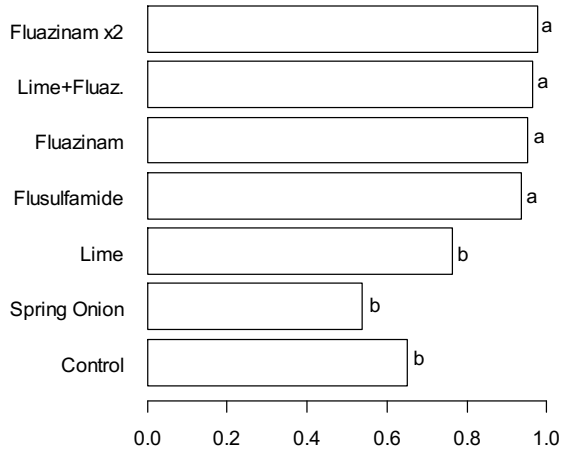


Figure 18. Proportion of plants producing a marketable head of cabbage.

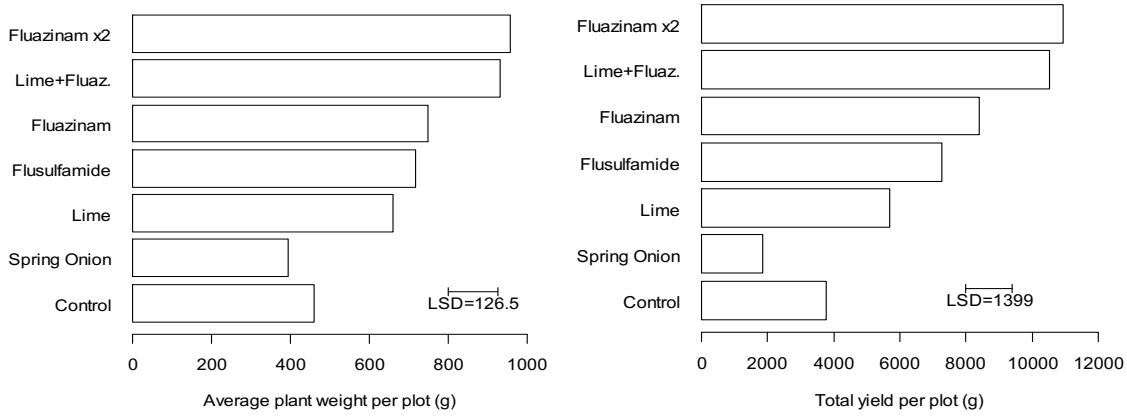


Figure 19. Left: Effect of fungicide treatments, lime application and incorporation of spring onion into the soil on the average plant yield per plot (grams) of cabbages. Right: Effect of fungicide treatments, lime application and incorporation of spring onion into the soil on the total plant yield per plot (grams) of cabbages. Data presented includes that from all four trials.

Table 9. Economic analysis of clubroot control measures.

Treatment	Input for clubroot control per sao			Yield (kg/ sao)	Price ('000 VND/kg)	Income per sao ('000 VND)	Partial gross margin ('000 VND)
	Lime (kg)	Fungicide	Cost ('000 VND)				
Control	0	0	0	278.5	10	2,785	1,558
Lime	180	0	900	843.4	10	8,434	6,307
Fluazinam	0	5 packs	200	1180.6	10	11,806	10,379
Flusulfamide	0	10.8 kg	720	1080.0	10	10,800	8,853
Fluazinam + lime	180	5 packs	1,100	1946.1	10	19,461	17,134

Note: 1 sao is equivalent to 360m^2; VND is Vietnamese Dong; partial gross margin is income/sao minus clubroot input cost (i.e. not all input costs).

Efficacy of treatments for management of Rhizoctonia collar rot

The trials to evaluate treatments to control collar rot were affected by variation in seed germination and plant establishment as a result of very cold temperatures and insect damage. The number of plants affected by Rhizoctonia collar root was reduced when treated with Cruiser and Cruiser + Amistar (as described in Section 5.6.3) when assessed on 26 August 2018 (Figure 20). The application of Trichoderma did not reduce the number of diseased plants (Figure 20). The application of Trichoderma to soil 1-2 weeks prior to sowing may also be more effective as the Trichoderma would have time to establish. Total plant weight was not affected by the treatments and was not significantly different to the control (data not shown). Trials conducted to assess the efficacy of chemical treatments against collar rot were affected by poor germination of seeds and poor plant establishment as a result of very cold (3°C) temperatures and in subsequent trials, by insect attack. The data analysis suggests that fludioxonil may be effective in reducing disease caused by *Rhizoctonia solani* but additional trials would be needed to confirm this.

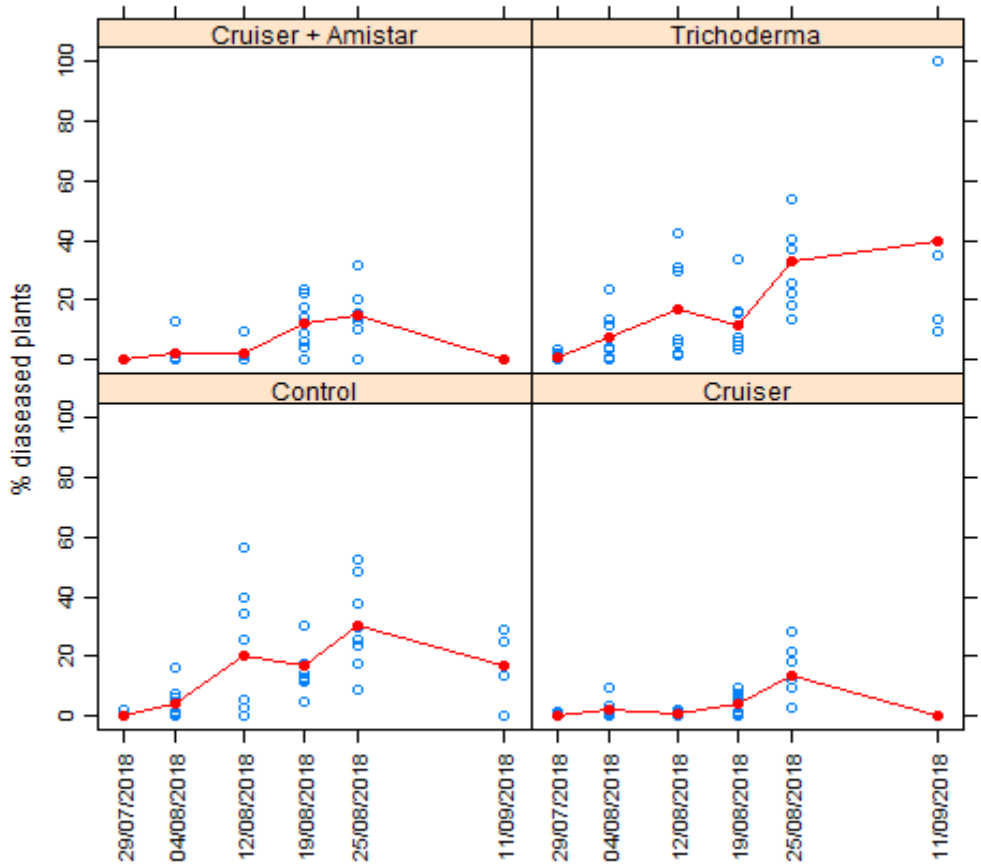


Figure 20. Percentage diseased plants for each treatment and assessment time. Raw data (open blue circles) and means (filled red circles) are shown.

Australian component

The Australian component monitored pathogens of Solanaceous crops (tomato, chilli, capsicum, potato) in Australia[1]. These crops are commonly subject to root rot and damping off and wilt diseases caused by species of *Pythium*, *Fusarium*, *Sclerotinia*. The diseases and associated pathogens sampled during surveillance activities, and the sampling locations are listed in Table A1 (Appendix 1). Similar pathogens were detected on the same and different hosts across the sampling locations, with the exception of *Ralstonia solanacearum*, which was restricted to Queensland with a single detection in NSW. Ralstonia typically occurs in warmer climates, which likely explains this observation. It should be noted that the non-detection of a given species in a state does not mean that

it does not occur there. Other databases need to be consulted to confirm this at the state and federal policy level.

This type of surveillance and a knowledge of the pathogens that are present in crops, is important for developing disease management strategies. For example, when selecting rotation or break crops, choosing a crop that is not a host of the soil borne pathogen can provide a break in the disease cycle of the pathogen, reducing pathogen levels for the subsequent crop. Alternatively, break crops that are toxic to the soil borne pathogen, such as certain brassica crops or buckwheat, for example, can be selected to reduce pathogen levels in the soil. When selecting fungicides, knowing what is causing the disease is important to target pathogens. Knowledge of pathogens that already occur is also important for biosecurity to allow agencies to prepare for potential incursions, establish area-freedom and for market access. No new host-pathogen records were observed during the surveys.

During the surveys, *Fusarium solani* was isolated from greenhouse capsicums showing a stem rot. A range of *Pythium* species were isolated, as well as *Sclerotinia sclerotiorum* and *S. minor* on tomatoes and *Sclerotium rolfsii* on chillies. Greenhouse trials were conducted to characterise Fusarium isolates that were collected from tomato affected by stem and root rot, including *F. oxysporum* f.sp. *radicis-lycopersici*. Molecular analyses suggested that this f.sp. had been detected, but pathogenicity tests failed to produce any disease symptoms and host pathogenicity could not be confirmed.

7.3.3 Soil and Nutrient Management

Baseline Soil Characteristics

In the baseline study, soil quality in Bac Ha and Sa Pa districts was found to be suboptimal. The soils are mostly of low nutrient status and of low pH. Symptoms of nutritional deficiencies were also observed in fields as well, including calcium and micro-nutrients like boron (B), copper (Cu), molybdenum (Mo) and manganese (Mn). This is the result of soil genesis from acidic rocks under humid conditions. Additionally, vegetable farmers generally do not apply lime, which reduces crop growth restrictions associated with acidic soil infertility.

The data for 15 surface soils (0–10 cm) was collected from farms in these districts and all the soils were found to be acidic (pH values in water <7 and pH in 1 M KCl (pHKCl) <6.0). Acidic pH was partially the result of leaching, erosion, nitrogen (N) fertiliser use, and the removal of ‘basic’ cations such as Ca and magnesium (Mg) in harvested crops. Minimising leaching and erosion and regular inputs of liming materials was identified as an area of focus to counter acidification processes and sustain these farming systems. One other important chemical property is cation exchange capacity (CEC), which for the soils in the focal areas is in the medium range; the lowest value being 8.98 cmol kg^{-1} soil and the highest 20.08 cmol kg^{-1} g soil.

Nutrient budgeting

The amount of macronutrient (N, Phosphorus (P) and potassium (K)) applied to vegetable crops varied considerably across farms. For example, for cabbage the removals were about 150 kg N ha^{-1} , 25 kg P ha^{-1} , and about 50 kg K ha^{-1}. However, at all farms, the applications far exceeded the inputs and varied from farm to farm (FigureFigure 21). Similar results were found for trials conducted on H’mong mustard, Kohlrabi and cai bap xoe.

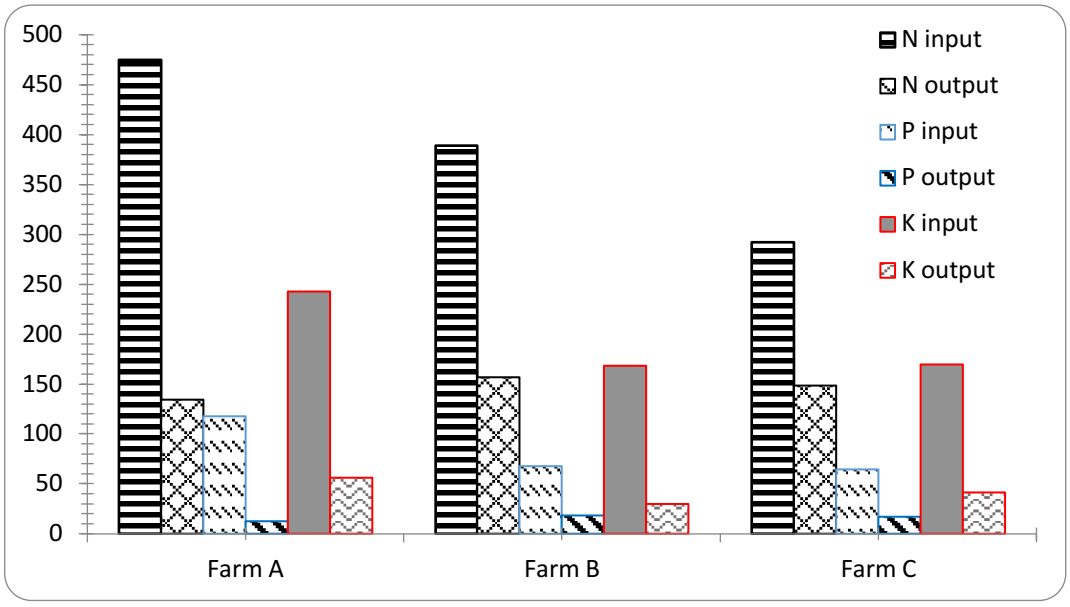


Figure 21. Partial nutrient budget for cabbage.

Furthermore, results from the survey of reference leaves of cabbage crops confirm the nutrient budget data. Of the samples 96% were sufficient to high for N and 100% of samples had sufficient to high concentrations of P and K. For Ca and S, 100% of samples were adequate to high, for Mg about 76% of samples were adequate and about 24% marginal in Mg supply. For the micronutrients, low concentrations of most elements (Mn, Zn, B, Cu and Mo) could be observed, but low B and Cu status were most prevalent with more than 70% of samples being nominally deficient.

The research confirms the need to reduce major nutrient application rates whilst confirming, identifying and addressing limitations in micronutrient nutrition.

Nutrient Trials

Results from nutrient budgets demonstrated over-application of N, P, K, and deficiencies of micronutrients. To support farming systems in Sa Pa and Bac Ha, trials were initiated to help understand the importance of applying optimal nutrient rates through which farms can improve their nutrient management strategy and improve livelihoods.

Key results of some of the nutrient trials included:

Nitrogen Trials

The highest yield for H'mong mustard (about 12 t ha-1) and "Bap cai xoe" (about 20 t ha^{-1}) was obtained at 280 kg N ha^{-1}, however, there was no significant difference in yield at N rates from 200–280 kg N ha^{-1} (Figure 22). This rate is less than half the average N applied by farmers. At 50 days after planting the maximum yield of choy sum (12.5 t ha^{-1}) was achieved at a N rate of only 120 kg ha^{-1}.

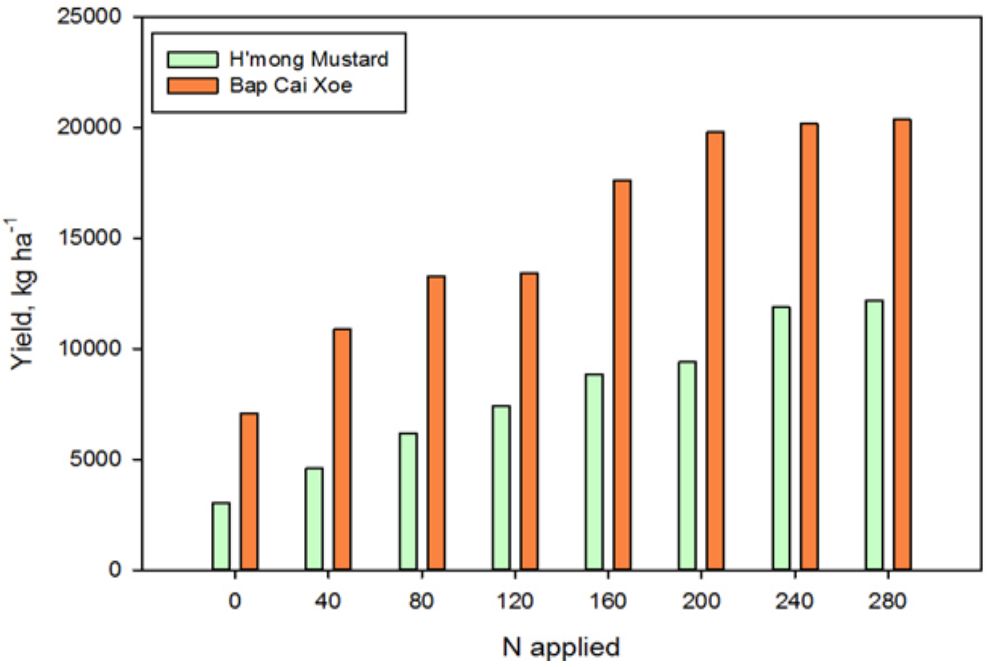


Figure 22. Response of H'mong mustard (cai meo) and bap cai xoe to different nitrogen (N) applications rates.

Micronutrient trials

Application of the micro-nutrients Zn, B and Cu, particularly, increased cabbage growth. In the ALL treatment the total plant biomass increased by 34% compared with the NIL micronutrient control treatment whilst head yield increased by about 60%.

Lime trials

Trials (Figure 23) showed that soil pH reached near neutral at lime application equivalencies of 1–2 t ha^{-1}. This pH is suboptimal for controlling clubroot in cabbage. The field assessment of liming evaluated lime rates of 0, 0.25, 0.5 1.0, 2.0, and 4.0 t ha^{-1}) on yield of cabbage at a site in Sa Pa. Optimal application of lime did not give a yield improvement, but liming was found to be an effective control of disease in the pathology trials [see pg. 73].

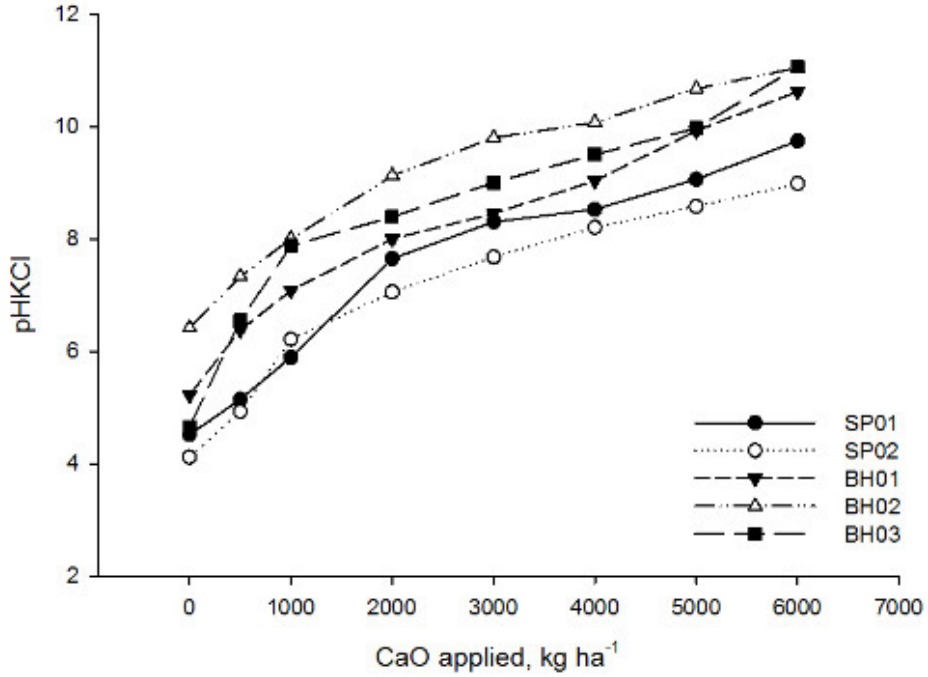


Figure 23. Soil pH response to lime application, measured 15 days after lime application. Data presented for three soils in Bac Ha (BH01, BH02, BH03) and two soils in Sa Pa (SP01, SP02).

The research results confirm the need to optimise nutrient inputs to ensure greatest crop productivity. Relatively low lime applications are required to maintain a pH optimal for crop growth and responses to micronutrient application are evident. Dissemination of crop nutrient management strategies and information is necessary for the vegetable farmers in Sa Pa and Bac Ha to improve nutrient use efficiency (NEU) and improve farmer's income.

To this end, the team developed soil and nutrient management material for dissemination through the technical component of the FBS implementations rolled out in 2017–2018.

7.3.4 Adaptive Trials

Crop management practices were tested and demonstrated under a broader set of biophysical and socioeconomic conditions in adaptive trials. Each trial was conducted on at least three farms (farm=replicate). Farming systems trials are summarised in Table 10. Key results from the adaptive trials are organised by group.

Sa Pa commune (Sa Pa):

All farmers in this group are of the H'mong ethnic minority. Before the project, most farmers produced vegetable for subsistence, some on rice fields after the rice harvest (V-R system) and some in home gardens. Main challenges for vegetable production in this group were: difficulty in marketing output due to low diversity of vegetables; limited experience in vegetable production, especially in using fertilisers, and in producing good seedlings.

The priorities for adaptive participative farming system trials in this group were improving fertiliser management and testing new vegetable products. New practices of fertiliser application for the vegetable only system (V-V) aimed to improve nutrient balance by reducing N and increasing K. However, significant reduction in N affects the colour of cabbage, and reduces its marketability (as experienced by farmers in 2016, when traders refused to buy pale-colour cabbage after farmers reduced N application - as recommended by project team). Adjustments were made in 2017 and the practice showed clear economic effectiveness, reducing the cost of mineral fertilisers by 3 - 5 million VND ha^{-1}. Balanced fertiliser application could also improve vegetable products and soil qualities. In regards to

diversification of products, new varieties or vegetable types, including kohlrabi shoots and broccoli, were introduced, which, together with better agronomical practices, increased farmers' income by 20 - 25%. Economic effectiveness of new vegetable varieties has changed farmers' practices of growing only one kind of vegetable to more diverse products to meet market requirements.

By the end of the adaptive trials, a package of best practices was compiled that includes:

(1) Improved fertiliser management (mean-season and off-season)
(2) Seedling production in trays
(3) Improved pest and disease management
(4) Product differentiation during the main-season — new varieties

Table 10. Adaptive farming system trials.

Location	System	Time	# of farms	Trial practice
Sa Pa commune (Sa Pa)	V-V	Apr-Jul 2015	3	Fertilisers
Sa Pa commune (Sa Pa)	V-V	Jul-Nov 2015	3	Fertilisers
Sa Pa commune (Sa Pa)	V-V	Nov 2015-Apr 2016	4	Fertilisers + New varieties
Sa Pa commune (Sa Pa)	V-R	Apr-Jul 2016	5	Fertilisers
Sa Pa commune (Sa Pa)	V-V	Jul-Nov 2016	9	Fertilisers + Clubroot control
Sa Pa commune (Sa Pa)	V-V	Nov 2016-Mar 2017	7	Fertilisers + New varieties
Sa Pa commune (Sa Pa)	V-V	Apr-Jul 2017	10	Fertilisers + Clubroot control
Sa Pa commune (Sa Pa)	V-V	Aug 2017-Jan 2018	8	Combined best practices
Sa Pa town (Sa Pa)	V-V	Apr-Jul 2015	4	Fertilisers
Sa Pa town (Sa Pa)	V-V	Jul-Nov 2015	2	Clubroot control
Sa Pa town (Sa Pa)	V-V	Nov 2015-Apr 2016	1	Clubroot control
Sa Pa town (Sa Pa)	V-V	Apr-Jul 2016	6	Clubroot control
Sa Pa town (Sa Pa)	V-V	Jul-Nov 2016	3	Clubroot control
Sa Pa town (Sa Pa)	V-V	May-Aug 2017	2	Clubroot control
Na Hoi commune (Bac Ha)	V-V	Mar-Jul 2015	1	Plastic/net house
Na Hoi commune (Bac Ha)	V-V	Jul 2015-Feb 2016	3	Plastic/net house
Na Hoi commune (Bac Ha)	V-V	Feb-Sep 2016	8	Plastic/net house
Na Hoi commune (Bac Ha)	V-V	Oct 2016-Feb 2017	3	New varieties + Seedlings on trays
Na Hoi commune (Bac Ha)	V-V	Apr-Sep 2017	8	New varieties + Seedlings on trays
Ta Chai commune (Bac Ha)	V-R	Oct 2015-Feb 2016	6	Fertilisers + Composting
Ta Chai commune (Bac Ha)	V-R	Oct 2016-Feb 2017	6	Fertilisers + New varieties
Ta Chai commune (Bac Ha)	V-R	Sep 2017-Feb 2018	6	Combined best practices
Ta Chai commune (Bac Ha)	V-TF	May-Dec 2015	5	Fertilisers

Sa Pa town (Sa Pa):

Most farmers in this group are Kinh people and experienced vegetable producers. The challenge in vegetable production with Sa Pa town group was managing diseases and pests, especially club root disease on *brassicas*.

Adaptive participative farming system trials in this group focused on controlling club root diseases, using protocols developed by the project team. Use of lime and Furama (fluazinam + metalaxyl) reduced disease severity by 80 - 90%, and this practice was successfully adopted by farmers. A farmer field school was then organised by the plant pathology and farming system team at the end of off-season production in 2016 for vegetable farmers in Sa Pa town and Sa Pa commune to raise their awareness about the disease and appropriate control measures.

Farmers in Sa Pa town were not interested in experimenting with fertilisers and new varieties since their production was already advanced, and they have their own network to identify market demand. The advanced farmers from this group would be excellent trainers in Farmer Field School program.

Na Hoi commune (Bac Ha):

Farmers involved in the farming system activities in this group are members of Di Thang Cooperative and also experienced vegetable producers. Main challenges with this group were low quality and expensive vegetable seeds, difficulty in crop management and low yield of off-season vegetables due to high rainfall and diseases. Improving production of off-season vegetables by using plastic/net rain shelters and producing vegetable seedlings on trays were the focus of adaptive participative farming system trials.

Efficiency of plastic/net house was dependent on crop type and crop season. Because of high input cost for building the houses, the profit was much lower than conventional practices in the initial season, but it improved in the following seasons, increased by 20-30% depending on crop types and net house structure. It should be noted that farmers' income per unit area in Na Hoi group (80 million VND/ha per cycle while other groups have 7-12 million VND/ha) is much higher than that of farmers in other groups. However, farmers in this group have very small production areas (often 1000 m^2 or less) under rain shelter in the peri-urban environment of Bac Ha town, so production volume is small and the majority is sold through the cooperative directly to Hanoi commanding premium price. In addition, estimation of production volume from very small area tends to exaggerate production per hectare. In any case, results achieved with Di Thang cooperative are difficult to replicate with ethnic minority farmers living in more remote areas.

By the end of the adaptive trials, a package of best practices weas compiled that includes:

(1) Improved fertiliser management
(2) Seedling production in trays
(3) Improving production of off-season vegetables by using plastic/net rain shelters

Ta Chai commune (Bac Ha):

Most farmers in this group are Tay and Nung ethnic minority. They produced vegetables mainly in winter on rice fields as part of a rice-maize-vegetable farming system. Ta Chai is also a peri-urban area and many families have additional income outside farming, so they were not interested in intensifying off-season vegetable production, mainly due to a lack of labour and previous bad experiences. The main challenges for vegetable production in this group were an unstable market and the low price of produce, expensive and low quality vegetable seeds and unsuitable use of manure (using fresh liquid manure).

Adaptive participative farming system trials in this group (Figure 24) focused on producing safe vegetables by appropriate nutrient management such as composting and mineral fertiliser application. Replacing fresh liquid manure by composted manure improved hygiene conditions for farmers and the safety of the vegetables. Net-income of farmers was improved up to 40%, and even though it remains relatively low (7.8 million/ha) it is achieved with minimal inputs and it is additional income outside the maize-rice growing season.

Producing vegetable seedlings on trays was also included in trials. However, farmers in this commune are not interested in producing seedlings by themselves.

By the end of the adaptive trials, a package of best practices was compiled that includes:

(1) Improved fertiliser management and composting methods
(2) Product differentiation – new varieties
(3) Seedling production in trays

a) Farmer group meeting in Na Hoi

b) Preparing manure for composting

c) Addressing clubroot disease

d) H'mong farmer group field trial

Figure 24. Implementing adaptive farming systems trials.

Conclusion

Based on the results of the individual adaptive trials, integrated best practices were developed for different biophysical and socioeconomic conditions. The results were included in the Farmers' Field School curriculum and manuals as well as project recommendations. However, main aim of adaptive research was not to develop general recommendations, but to adapt recommendations from the literature and other project components to very specific conditions and to adapt production to target specific markets appropriate to farmers' capacity. Trans-disciplinary and participatory approaches used in this research component aimed at development of farmers' analytical skills and critical thinking rather than to produce technical recommendations.

The challenges for vegetable production are changing over time. It is important to maintain the participatory approach to identify farmers' priorities for sustainable, safe and efficient vegetable production. The feedback from markets is required for suitable adaptation of production practices to meet the market demands.

7.3.5 Economic Analysis

Rural consumption survey

A typical rural farming household is composed of six members, with an average monthly per capita food expenditure and monthly non-food expenditure of 2.1 million VND and 4.2 million VND, respectively. In terms of its production practices, it has on average 15 years experience in vegetable cultivation, on a 1.1 hectares (ha) of cultivated land. Our sample also shows that women are the main food preparers (65%) from the Mông ethnic minority group (72 %), with an average age of 35 years. Many have not attended school (46 %); and for those who did, the majority attended only primary and/or lower secondary education. There was a nearly balanced number of male and female children (53 % male) aged 6 - 59 months, with an average age of 35 months.

We find strong evidence supporting our hypothesis that shows smallholder vegetable production is significantly associated with the diverse dietary outcomes of children aged 6 - 59 months. This suggests the importance of vegetable production in the diets of children in these remote rural farming areas: for subsistence families who need to produce their own food to meet their dietary requirements due to missing markets; and for farming households who have access to traditional and modern food retail markets to sell their agricultural produce and buy other nutritious and diverse food. Our results also show the delicate balance women in rural farming areas must contend with, wherein active involvement in the agricultural production decision-making negatively affects their child dietary diversity outcomes on the one side, and, a lesser workload on the field to tend to their children at home positively affects their child dietary diversity outcomes. The latter, however, implies working less hours and transferring workload from one productive and experienced individual to other household members or hired labourers that require financial resources, and may not operate in similar efficient capacity as the mother.

Farming system socio-economic analysis

Farming and marketing systems in Lao Cai were assigned to three broad categories in our analysis:

1. *Traditional systems (rice–vegetable rotations)* are intricately integrated farming systems that are primarily geared towards establishing household food security. The production system is characterised by rice in the summer and vegetables in the winter, thus mirroring crop rotations in the Red River Delta against whom these farms are not competitive. These households typically spend large amounts of time marketing output directly at wet-markets and cut-out intermediaries to fetch the highest possible price (i.e. retail price).

2. *Developing systems (partially vegetable–vegetable rotations)* are transitioning out of traditional systems into more advanced commercially oriented systems. They have shifted out of summer rice to the more profitable off-season vegetable production, but still rely mostly on conventional marketing practices to sell output. These households may still produce consumption goods like rice and corn on other plots, but they are implementing year-round vegetable production on selected plots.

3. *Advanced systems (fully vegetable–vegetable rotations)* are fully commercial and specialised in the production and marketing of vegetables. These advanced farmers have better knowledge regarding production practices for a wide range of commodities and have more sophisticated marketing practices, compared to the average farmers in Sa Pa and Bac Ha districts.

Overall, there are large increases in profit as systems move from traditional, through developing, to advanced systems. However, increased profits are also accompanied by significantly higher total costs of production resulting from more intensive application of external inputs. There is also an increased engagement with labour markets as systems advance. More advanced systems employ more hired labour to substitute household labour. Surprisingly, it is female family labour that is being substituted. Commercialisation of farming systems and engagement with labour markets appears to be reducing the household female labour-burden on vegetable farms.

Furthermore, the transition out of traditional autarkic systems means that households must abandon their summer rice crop, which is the foundation of food security for the household. The choice to abandon the tried and true staple crop in favour of a riskier vegetable cash crop is a difficult one. While it may simply appear to be a change in crop rotation, it is a significant change for households that requires the simultaneous adoption of unfamiliar farming practices and reliance on the market mechanism to provide a sufficient income from vegetable sales for household needs.

Given the array of problems in summer vegetable production (pest, disease, damaging rain) and lack of experience, there is a lot of risk and uncertainty associated with producing a summer vegetable crop. A systematic shift to counter-season vegetables will hinge on the development and dissemination of successful controls to address the pest, disease, and weather risks that occur in the summer.

7.4 Component 4 – Capacity Building

7.4.1 Review of FBS implementation in SE Asia

Review of FBS programs and experiences in Southeast Asia found eight projects that were reported to have applied FBS in 2008-2016 (including four in Vietnam). While FBS was originally developed in Indonesia, it has been adapted for various value-chain contexts and farmer-learning needs in other countries, including Vietnam. FBS provides flexibility in terms of curriculum and learning methods, which offer wide opportunities for application. It likewise facilitates an inclusive framework for joint action learning, as demonstrated by significant women's participation in FBS implementation.

FBS has been demonstrated to be an effective learning platform to enhance business and marketing skills for farmers to respond market opportunities. They help farmers to orient to market-driven production and pay more attention on building relationship with other chain actors.

The adaptation of the conventional Farmer Field School (FFS) with FBS played an important role in most of the projects. Typical FBSs have no straight-lecture sessions. Training activities are based on experiential, field-based and joint learning. In FBS, the "field" is not only the farm, but also the market and the value chain.

Identified success factors for FBS from the literature review included: adaptation of learning contents to local situations; use of responsible and suitable facilitators; use of local farmer leaders as facilitators; suitable size (small) groups; involvement of practical interactions between farmers and other actors in the value chain; participation of local partners in the implementation process from the project beginning both for capacity development and as a pre-requisite for higher ownership. In addition, to ensure the sustainability of the training, post-training support is generally considered as an indispensable element to ensure all acquired knowledge and skills from the trainings are applied. Through post-training support, the farmers continue to learn and share knowledge and experiences.

7.4.2 Monitoring and evaluation results

Monitoring and evaluation show learning and livelihood benefits for FBS participants. Many farmers nominated that the training program was adequate/suitable and met their needs to fill knowledge gaps (with average value >3.5 on a 5-point Likert scale). In addition, many farmers reported indirect benefits from the training, for instance, improved social interaction and opportunities to have a network of farmers to learn with and with whom to share knowledge and information.

The adoption of skills and business innovations provided in training program indicated a positive behavioural change. Following participation, farmers tend to consciously consider market opportunities, systematically identify innovations to address them and develop business plans before making production and marketing decisions (Figure 25). Compared with before the FBS training, the level of price information collection by farmers and farmers' interaction with market actors increased. Most of the local farmers indicated that they had strong interactions with market actors, especially Gia Phu Cooperative and the Na Kheo group (e.g. meeting them at least once per week to discuss products and market requirements following factors such as consumers' preference, etc.). This change was emphasised in comments made by a farmer participant in FBS, *"[c]ompared to before the*

training, I use price information and feedback from my buyers to plan my production and business more often".

More than 50% of the participants have worked on business plans (which they did not do before) in Gia Phu Cooperative (80%), Na Kheo group (67%), Ma Tra group (55%) and Sin Chai AB group (52%; Figure 25). The participants were also encouraged to try new production techniques and target new buyers (Figure 25). This was a substantial change compared with before FBS training, when local farmers normally imitated others to make production and business decisions. In addition to survey responses, this change in behaviour was highlighted in comments from participants such as *"we take advantage of market opportunities that we had never done before the FBS training".*

While strengthening trust and collaboration with current buyers, around 70% of farmers in three of the trained groups (Gia Phu Cooperative, Na Kheo and Ma Tra group) felt more confident to enter new markets following FBS training (Figure 25). The majority of farmers in the Sin Chai AB group did not report similar gains in confidence (Figure 25). Sin Chai AB group is likely in need of more training.

The introduction of FBS also positively influenced local partners' extension and farmer-training methods, which previously focused on technical perspectives. For example, a local government employee trained as a facilitator said *"[t]his is the first training program I am in charge as a facilitator that covers the whole crop production-marketing cycle. I see farmers' big interests with the training that included a lot of practical exercises".* Further, the Head of Lao Cai PPsD commented that*, "[i]n addition to contributing to increased capacity for local extension network, the FBSs increase farmers' satisfaction with the extension service quality"*.

Additional results and outcomes stemming from the FBS program are provided in the form of 'impact stories' in Section 8.3.

7.4.3 Sustainability and upscaling

Learning and working together in a group had a positive effect on maintaining and developing the business and technical skills for individual FBS farmers. Several farmers introduced other farmers to the FBS following the benefits they obtained from their training experience. The groups that participated in the FBS maintained group operations by having a meeting every two weeks to share experiences (e.g. the Gia Phu Cooperative and Na Kheo group). Farmers of the Gia Phu Cooperative also used their own money for learning visits as well as for additional training on marketing skills.

During discussions with the farmers and facilitators, it was emphasized that whether the benefits of the FBS were maintained beyond the length of the training was largely dependent on farmers' relationships with actors along the value chain. In order to be successfully sustained, it was considered very important for the groups to connect with traders to maintain stable markets for products. The Gia Phu Cooperative and Na Kheo group appear to be realising and maintaining the benefits of FBS training after strengthening trading relationships throughout the FBS experience.

The evaluation found that local facilitators (including key farmers who delivered training) were an important factor to ensure the sustainability of the FBS as they often worked closely with the farmers and visited them after the training ended. These lead farmers also view this as an important role for them to continue, e.g. a farmer leader stated, *"I see myself with important responsibilities to help other members to study market opportunities before making any decision on production".*

Upscaling the FBS program and making such training available to farmers on a broader scale, without the support of a development project, will rely heavily on buy-in from local government organisations and potentially from NGOs. This project explored opportunities to establish FBS as a fee-for-service training opportunity run by NGOs but, this is unlikely to take hold in the near future as the costs quoted by the NGOs to deliver the training

were beyond the capacity of most farmers, especially resource-poor farmers with much to (potentially) gain from a transition to market oriented agriculture.

Local government partners have integrated FBS training into other economic development programs in their province/district. Further, the VWU, with a national network has started to integrate the learning approach into other programs they host and co-host with government organisations. However, models (particularly financing models) for FBS expansion, to a higher level or mainstream training programs across Vietnam, are yet to really be identified.

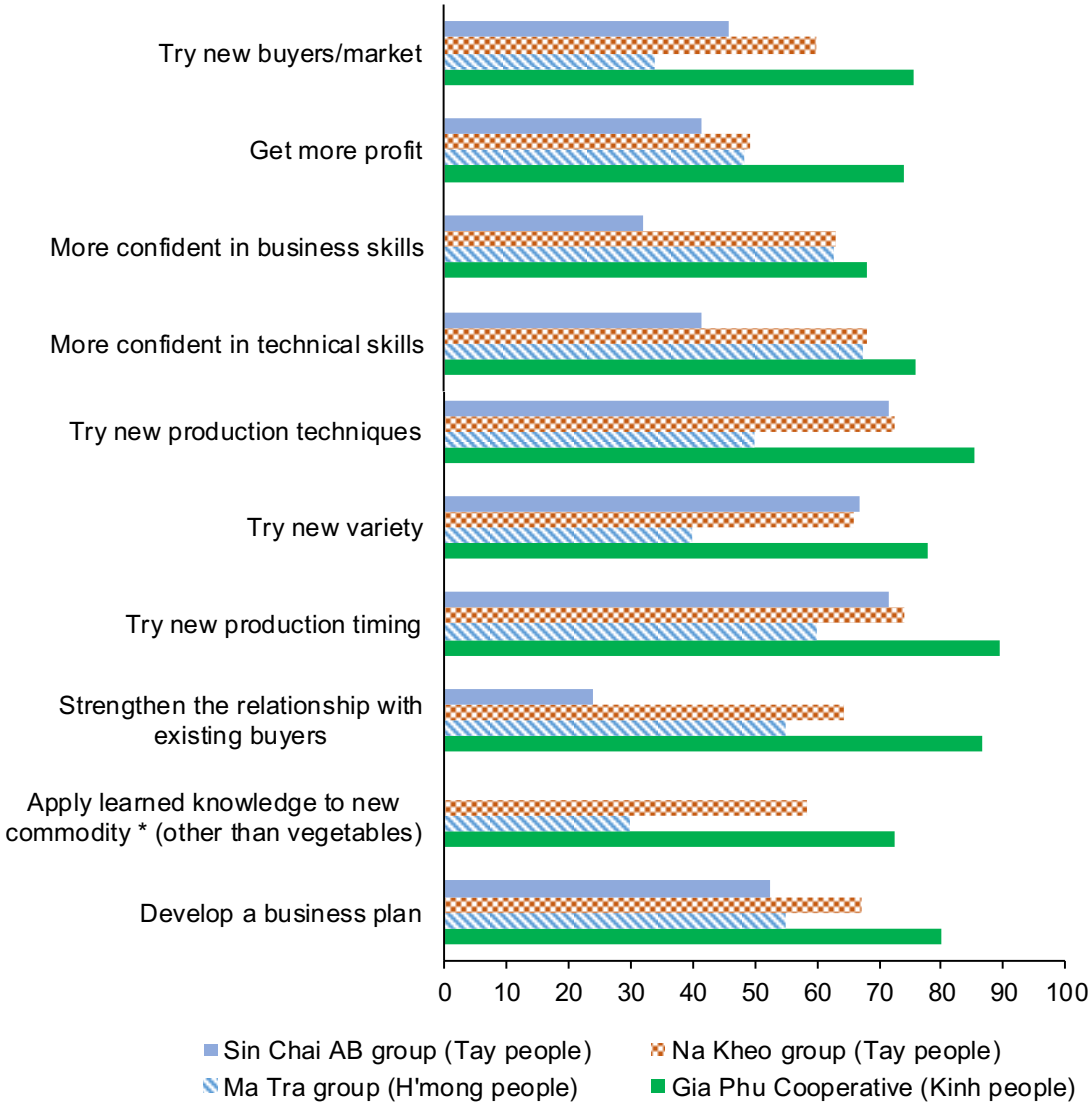


Figure 25. Share (%) of Farmer Business School participants from groups of different ethnicity that reported changing their behaviour or improved business outcomes following participation in Farmer Business School. Specifically this figure presents responses from monitoring and evaluation surveys that ask questions in the format "Compared to before Farmer Business School, did you….?"

7.4.4 SFRI Laboratory Capacity Building

The Soils and Fertilisers Research Institute (SFRI) is charged with providing expert advice on soils and fertilisers to Vietnam. It has laboratories to support that statutory responsibility in Hanoi and Ho Chi Minh City; however, this project interacted only with the laboratories in Hanoi. These laboratories have been established for about 50 years and are equipped with flame AAS and spectrophotometers. Traditionally, staff are graduates of the Faculty of Agriculture at Vietnam National University; more recently, staff have been recruited with more chemistry training. SFRI staff identified quantitative quality assurance and control as the main deficits in their capacity and these have consequently been the focus of capacity building activities with this project. Both quantitative quality assurance and control are major components of quality management.

Assessment of existing quality systems revealed that the quality process was subjective, based on the application of standard methods, and on prior knowledge about similar samples or samples from related sites. Given the considerable history of SFRI, this is an intuitively sound process. Discussion then turned to ISO IEC quality standards and how they might be met.

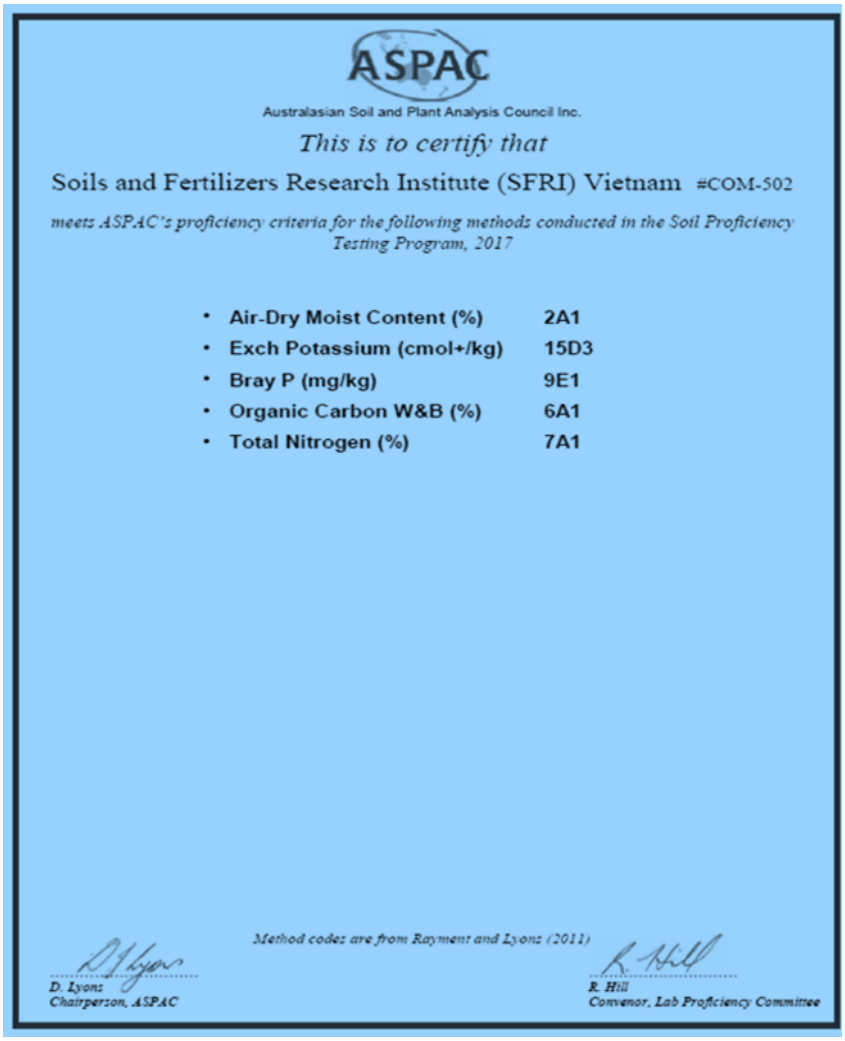
The first focus was to calibrate balances and a set of old masses was found. These were subsequently replaced, and a simple calibration protocol was developed and put into regular use. Fortunately, all the balances were load cells, not more than a decade old, and they were working well enough so as to not constrain the quality of the analysis.

A more rapid semi-micro-Kjeldahl digestion method than the standard practice was validated using the recovery of N from the pure compound TRIS. This was the first validated test method at SFRI. The results from the original and the modified N methods were compared and found not to be different (paried t-test). The N method received attention first because large improvements were possible, and a validated, efficient N method was needed for the following step.

The laboratory had no reference materials and could not afford the ongoing cost of purchasing them for quality control. Therefore, it was agreed that the laboratory team make their own and start by collecting 90 kg of Red River Delta soil (RRD Reference Soil), then drying, crushing and mixing it until they could confidently split it into two representative parts. One part was sent to Australia where it was processed further and circulated among about 30 laboratories in the Australasian Soil and Plant Analysis Council (ASPAC) network as a proficiency sample. This provided a set of median concentrations, with uncertainties, for a large number of tests that would become the quantitative basis of comparison for the in-house reference material. The remaining half was processed at SFRI. This involved very careful mixing, and splitting among containers, homogeneity testing their contents using the validated semi-micro-Kjeldahl method and storage in a freezer to ensure stability. A similar process was used to create a Hanoi Cabbage Reference Sample.

From 2015 to 2017, the RRD Reference Soil was used to validate soil tests for: C (Walkley Black), pH in water and 1 M KCl, EC, and Bray-1 P. During 2017 the laboratory acquired accreditation from the Australasian Soil and Plant Analysis Council (Figure 26) for proficiency in most of those tests.

The only plant test validated was semi-micro-Kjeldahl N. However, the Hanoi Reference Cabbage Sample is available should the laboratory wish to proceed with plant analysis at a later date. Plant analysis for the Project was undertaken in Australia on a fee-for-service basis using a reliable ICP-MS laboratory. This analysis serviced a district nutrient survey using cabbage as the index crop, and field trials for both nutrients and control of the disease, clubroot. Management of this disease required pH adjustment to pH 8 with the risk of inducing micronutrient deficiencies.



ASPAC

Australasian Soil and Plant Analysis Council Inc.

This is to certify that

Soils and Fertilizers Research Institute (SFRI) Vietnam #COM-502

meets ASPAC's proficiency criteria for the following methods conducted in the Soil Proficiency Testing Program, 2017

• Air-Dry Moist Content (%)	2A1
• Exch Potassium (cmol+/kg)	15D3
• Bray P (mg/kg)	9E1
• Organic Carbon W&B (%)	6A1
• Total Nitrogen (%)	7A1

Method codes are from Rayment and Lyons (2011)

D. Lyons
Chairperson, ASPAC

R. Hill
Convenor, Lab Proficiency Committee

Figure 26. Australasian Soil and Plant Analysis Council Inc. (ASPAC) certification for five soil tests for SFRI laboratory obtained in 2017.

8 Impacts

8.1 Scientific impacts — now and in 5 years

8.1.1 Chemical testing supporting scientific research

The improvement in SFRI's laboratory protocols and standardisation of materials and approaches (more details in Section 7.4.4) has enabled the SFRI laboratory to consistently return quality soil test results to support field trial research. Improving the reliability of SFRI's chemical tests improves the quality of its research output and widens the scope of research projects that can be undertaken. As a result of the use of new protocols and standard procedures, the SFRI lab has obtained ASPAC certification for five key chemical tests in soils.

8.1.2 Mobile acquired data

An application, CommCare available on the Android platform was used to develop a digital survey instrument used to collect data in the field for the rural consumption survey (Activity 3.4) and urban food expenditure and consumption survey (Activity 1.2). While this technology has been available for a number of years, adoption of digital data collection tools has been relatively low for large-scale complex survey designs due to uncertainty regarding stability and robustness of digital tools in field conditions.

During ACIAR's mobile acquired data evaluation in 2015, the CommCare application was identified as appropriate for use in agricultural research projects operating in remote rural areas with limited connectivity during ACIAR's mobile acquired data evaluation in 2015 (Higgins et al. 2015). AGB-2012-059 was one of the first ACIAR projects to use CommCare for digital data capture in the field, and the surveys conducted were some of the most complex to be programmed into CommCare to date.

The successful execution of these large surveys served to de-risk the adoption of digital tools for data collection in other similar projects. The key contributions of this technology to this project and to future project that can utilise this (and similar technologies) included significant improvements, relative to paper-based surveys, in: (1) transparency in the data collection process; (2) the quality of data collected; (3) time taken to implement the survey and upload data in a useable format; (4) data entry errors.

8.1.3 Rural and urban consumer survey methods

In the process of developing the sampling frame and survey instrument for the Vietnam Urban Food Consumption and Expenditure Study we conducted training for members of the project team (both Vietnamese and Australian partner institutions) on "best practice" when conducting qualitative and quantitative consumer research and household food consumption and nutrition /diet quality studies. Training was provided on random sampling methods, interviewing and questionnaire design to reduce research bias. These research workshops and practical applications have increased the capacity of project institutions in conducting consumer and household research that is representative of the populations being studied and will be more useful for policymakers.

8.1.4 Time-series price analysis

While the price analysis methods (law of one price) used in this study are not novel in themselves, their application to horticultural commodities is relatively new. The method used in this project (Activity 1.1d) is being applied to time-series price data on fruit in Vietnam (ACIAR project AGB/2012/060), and the method was adopted by Bogor Agriculture University in Indonesia to examine market performance for a range of fruit and vegetables.

8.2 Capacity impacts — now and in 5 years

8.2.1 Agribusiness Master Class developed market analysis skills

Seven project team members — Le Nhu Thinh (FAVRI), Nguyen Thi Tan Loc (FAVRI), Bui Thi Viet Anh (CAP/IPSARD), Pham Thi Thuy (CAP/IPSARD), Ha Tra My (Fresh Studio, now project coordinator VWU), Nguyen Thi Thu Hien (VWU) and Nguyen Thi Thu Huyen (VNUA) – took part in the inaugural *Agribusiness Master Class* held in Vietnam in 2014. The *Agribusiness Master Class* was run by The University of Adelaide with support from ACIAR and The Crawford Fund.

The course was principles-based and practical, participants were able to do hands-on research and apply their new knowledge to issues and problems of importance to Vietnam. At the completion of the course, participants were able to:

- Identify and define real-world issues, opportunities and constraints to pro-poor agribusiness development in agri-food value chains in Asia
- Identify and define relevant and important research questions
- Understand and apply appropriate methods in consumer research, market research and value chain research
- Develop and apply appropriate experimental design and sampling methods
- Develop effective communication, facilitation and data collection skills and methods for use with consumers, traditional and modern retailers, wholesalers, traders/collectors and farmers
- Analyse and present results and conclusions
- Effectively communicate results and findings both orally and in brief written reports.

The impact of the training for project researchers was immediate. Following the first module of the *Agribusiness Master Class* in June 2014, the project team started the design of the value chain and market research components of the project. Project researchers were able to use skills and lessons from the *Agribusiness Master Class* in the design and implementation of the market research elements of this project and will be able to continue to use these in future projects.

Note: Following the success of the Vietnam Agribusiness Master Class, The University of Adelaide and ACIAR continued to invest in developing early to mid-career researchers' knowledge of principles and practical analytical skills needed for market, consumer and value chain research across south east Asia with the project "Developing a sustainable business model for upscaling the Agribusiness Master Class", Project Number, AGB/2015/030.

8.2.2 Participatory monitoring and evaluation

Participatory on-farm research was a relatively new approach for many project partners. At the commencement of the project, project researchers worked with farmers to identify key constraints and obstacles to production and marketing and then prioritise research to develop strategies to overcome them. This participatory action research approach was not new to project researchers, however, the regular monitoring and evaluation workshops with farmer groups was somewhat new. The farming systems research team regularly conducted participative monitoring and evaluation workshops with each of the farmer groups at the start and end of each adaptive trial (Activity 3.8) with more frequent collaborative feedback provided by the researchers who resided in project districts (villages). These workshops were conducted jointly with soil scientists, plant pathologists, economists and local research staff who integrated knowledge to provide a more comprehensive summary of the outcomes of the adaptive farming systems trials (Figure 27). Activities conducted with farmer groups in these workshops included calculations of

input costs, time needed to do certain activities, yield, disease incidence and sale price, enabling the calculation of a gross margin and comparison of gross margins across different management alternatives.

As the project progressed, project partners demonstrated improved skills and confidence in consulting farm households, identifying priorities for adaptive trials, and evaluating results on dimensions important to the farmers.

Figure 27. Participatory monitoring and evaluation workshops were held with farmer groups conducting adaptive farming systems trials to help farmers understand the outcomes of the trials and compare outcomes to alternative approaches used in the trials.

8.2.3 Plant pathology diagnostics

Five researchers from NIMM were comprehensively trained in pest and disease diagnostics at the commencement of the project and throughout the early stages of the project. Their skills in conducting trials, diagnosing disease, and disease management were improved. The NIMM team is able to carry out field trials, take samples and analyse them, diagnose diseases, conduct disease monitoring and document new host/pathogen records.

Eight people working at district and provincial DARD, PPsD and extension workers were also involved in field surveys (for pathogen diagnosis), field trials and analysis. This provided an opportunity for learning and sharing knowledge between researchers based in Hanoi and local counterparts. In addition, 20 researchers from other institutes including Lao Cai PPsD participated in short term training organised by the lead plant pathology researchers on the project.

8.2.4 Laboratory quality assurance

Under the guidance of Dr Paul Milham, a number of researchers at SFRI received special training and mentoring to improve quantitative quality assessment and control (refer to Section 7.4.4).

The project directly trained 15 SFRI staff to implement conduct reproducible analyses of demonstrably high quality. These 15 SFRI staff members in turn trained 120 Vietnamese and 3 international students.

The training resulted in demonstrable improvements in analysis quality that have substantial legacy benefits to SFRI in supporting fertility management and other research. A high functioning SFRI laboratory with improved procedures and consequently improved results will have benefits to many future projects in addition to the positive impact it had in this project.

The capacity building process was slow but effective in several ways. First, many staff understand the principles and practices of method validation and at least the basics of quality control. Second, they also understand how to prepare and use reference materials. These are valuable legacies. In addition, the objective measures of quality for soil analysis have attracted interest from laboratory clients. The value of this interest is difficult to quantify but should be ongoing. e.g. SFRI now has contracts with the International Center for Tropical Agriculture, Asia; the Institute of Research for Development; and the Japan International Cooperation Agency.

Changing the ways of qualified individuals, grounded in long-term practice, and working in a respected organisation, is not easily done. Respect for the people and for the culture of the organisation is needed, combined with patience to implement a learning approach that leads towards the desired goal(s). This is similar to the model used in farming systems research and has proven effective at the SFRI laboratories. The importance of confidence building and patience in implementing this approach should not be underestimated.

8.2.5 Graduate Student Training

Eight PhD and Masters students have conducted (are conducting) research related to the project. Supervisors are largely drawn from the project team, representing a significant investment in capacity building. Below is the list of students, their supervisors, research topic and funding source:

- **Christian Il Genova**
  Program: PhD
  Institution: The University of Adelaide
  Year of commencement: 2014
  Supervisors: Wendy Umberger, Alexandra Peralta, Suzie Newman
  Topic: Does vegetable production lead to improved diet quality? The case of Lao Cai, Vietnam
  Scholarship funding: The University of Adelaide
  Operational funding: AGB/2012/059

- **Pham Thi Hanh Tho**
  Program: PhD
  Institution: University of Canberra
  Year of commencement: 2014
  Supervisors: Katja Mikhailovich, John Spriggs, Suzie Newman
  Topic: Participatory Action Research for vegetable quality guarantee and smallholder income improvement
  Scholarship funding: ACIAR John Allwright Fellowship
  Operational funding: AGB/2012/059

- **Le Thanh Son**
  Program: PhD
  Institution: University of Newcastle
  Year of commencement: 2015
  Supervisors: Sophie Parks, Paul Roach, Suzie Newman, Len Tesoriero
  Topic: Grafting to improve bitter melon productivity and quality in Vietnam and Australia
  Scholarship funding: ACIAR John Allwright Fellowship
  Operational funding: AGB/2012/059

- **Jesmin Rupa**
  Program: PhD
  Institution: The University of Adelaide
  Year of commencement: 2015
  Supervisors: Wendy Umberger, Di Zeng, Nicholas Sim
  Topic: Socioeconomic influences on food security, dietary diversity and diet quality in developing countries: Evidences from rural Bangladesh and urban Vietnam.
  Scholarship funding: The University of Adelaide
  Operational funding: AGB/2015/029 (Project that co-implemented the urban consumer survey, Activity 1.2)

- **Nguyen Anh Duc**
  Program: Masters
  Institution: The University of Adelaide
  Year of commencement: 2015
  Supervisors: Dale Yi
  Topic: Price differences and market integration: a study of vegetable markets in Hanoi
  Scholarship funding: ACIAR John Allwright Fellowship
  Operational funding: AGB/2012/059

  Program: PhD
  Institution: The University of Adelaide
  Year of commencement: 2017
  Supervisor: Wendy Umberger, Daniel Gregg, Di Zeng
  Topic: Understanding factors driving changes of food consumption in urban Vietnam
  Scholarship funding: The University of Adelaide
  Operational funding: AGB/2015/029 (Project that co-implemented the urban consumer survey, Activity 1.2)

- **Nguyen Thi Thu Hien**
  Program: Masters
  Institution: Flinders University
  Year of commencement: 2016
  Supervisors: Yvonne Corcoran-Nantes, Mia Urbano
  Topic: Agricultural program interventions in Sa Pa: Analysis of gender impact towards improving nutrition practices for women and children
  Scholarship funding: ACIAR John Allwright Fellowship
  Operational funding: AGB/2012/059

- **Nguyen Thi Binh**
  Program: PhD
  Institution: The University of Queensland
  Year of commencement: 2017
  Supervisors: Neal Menzies, Stephen Harper
  Topic: Understanding the role of trace minerals in improving vegetable crop productivity, nutrient use efficiency and food quality
  Scholarship funding: ACIAR John Allwright Fellowship
  Operational funding: SMCN/2012/029

- **Tran Thi Minh Thu**
  Program: PhD
  Institution: Vietnam Academy of Agricultural Sciences
  Supervisors: Nguyen Van Bo, Tran Minh Tien
  Topic: Investigating limiting factors of the soil for cabbage production in Lao Cai Province

Operational funding: AGB/2012/059

8.2.6 John Dillon Fellow

Dr Tran Minh Tien, Deputy Director of SFRI and co-leader of Component 3 was awarded a John Dillon Fellowship in 2016.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Counter-season production

The H'mong farmers in the Ma Tra farmer group (Sa Pa district) traditionally planted only one cycle of rice each year. After the rice cycle, the plot would typically be left empty and farmers would go to earn income from non-farm employment in nearby cities. With support from the project, farmers planted vegetables and now all of the farmers in Ma Tra group have replaced their main rice crop with the significantly more profitable off-season vegetable crops. Shifting to off-season vegetable production has increased on-farm incomes for households in Ma Tra group.

For example, a member of Ma Tra group, traditionally grew one rice cycle and harvested about 30 bags (1 tonne) of rice valued at about 10 million VND. His salary from off-farm work was less than 10 million. Since planting vegetables, he has tripled his on-farm income to more than 30 million from his vegetable crop alone.

Clubroot control

Clubroot disease was one of the most significant vegetable production problems in Sa Pa. The only control tested by farmers was to apply Nebijin, a commercial product containing flusulfamide, which was not regularly available in local markets and was expensive. The lack of effective control methods and the risk of disease was one of the main factors preventing expansion of vegetable production in the area.

A farmer in Sa Pa noted,

> *"vegetables got infected in the root and then died slowly. We were all confused, worried and did not know which disease it was. Because that was the first time this disease happened in Sa Pa. We did not know why it happened, what it was, and the disease just kept spreading. […] At first, when there was no solution, I did not dare to plant [cabbage] anymore and switched to other plants […] because after planting it would give no harvest anyway"*

The clubroot control trials successfully identified a low-cost control method using a combination treatment lime + fluazinam. The control method was applied successfully on a larger scale by the local farmers through adaptive trials over two years.

> *"The project gave guidance on how to apply plant protection chemicals, also they created trials to experiment if the treatment worked or not. But after the trial of the project, it was effective immediately, first it saved 70-80% of the crop, the second and third crop, it kept getting better"*

Vegetable producers in Sa Pa are now confident to use the treatment developed by the project team and maintain their good vegetable income, especially for off-season vegetable production. Club-root control has been adopted by many additional farmers in Sa Pa, but further work is needed to extend the control method. A club-root workshop was held in late 2018 specifically to disseminate this control technique to local government, extension, and input supply shops to accelerate the diffusion of the control method. This

extension effort should be continued to ensure that this method is available in newly infected production areas.

Farmer business school (FBS)

Through the FBS approach, the project supported the development of farm entrepreneurship and agricultural marketing-related capacities of women and ethnic minorities in Sa Pa, Bac Ha and Bao Thang districts — particularly to enhance farmers' engagement with high-value markets.

The quantitative information collected in the monitoring and evaluation of the FBS program is largely presented in Section 7.4.3. The 'impact stories' below illustrate some particularly pertinent 'change cases' or experiences.

Gia Phu cooperative, Bao Thang district: The FBS creates initial changes for poor farmers

In July–October 2017, 35 vegetable farmers (over 60% categorised as relatively resource-poor) participated in the FBS. By sensitising them to market opportunities suitable to their asset capacity, the FBS helped farmers build business relationships with actors along market chains. The improvement in business skills also enabled farmers to adopt simple techniques for improving farm productivity (e.g. nylon covering for cabbages, pest and disease management and pruning techniques for tomatoes). Within the group farmers also formed Common Interest Groups to share knowledge and help each other in marketing of their products — with particular focus on off-season vegetable production and testing of new products with consumers. Participants claimed that FBS boosted their confidence in trying out different innovations — technologies, products and market relationships. Although limited in scope, this outcome is a promising benefit of FBS.

Based on positive feedback from farmers that participated in the 2017 FBS, another training class applying the FBS approach was carried out for other cooperative members from May to July 2018. This FBS was implemented using funds from the economic development fund of the district as well as farmers own funds.

Alongside FBS training, a logo for 'safe' certified vegetables from Gia Phu Cooperative was designed and registered with Lao Cai Department of Agro-Forestry-Fisheries Quality Assurance in September 2018. The logo is believe to help consumers to identify safe vegetables grown by Gia Phu farmers and is an opportunity for the local farmers to strengthen trade relationships with value chain actors seeking safe vegetables. During the FBS, a new value chain with big restaurants and safe vegetable shops in Lao Cai City was tested with participating farmers.

Na Kheo farmer group, Bac Ha district: Seizing all market opportunities

The Na Kheo farmers' group (predominantly female with 20 members from the Tay ethnic minority community) started participating in an FBS program in October 2017. These farmers were working together with other aspects of the project before commencing the FBS training. As such, the farmers had a well-established group and co-learning environment before FBS. The largely female membership of the group was a reflection of the ethnic and cultural norms for the community as well as a reflection of the number of male household heads who were engaged in off-farm employment, following the rice harvest and consequently leaving the female household head to manage the farm and related vegetable crops. By attending the FBS and learning from modules such as "identifying and prioritizing market opportunities", some women in the group saw the profit-making opportunity from cabbage due to high market price during the early part of the local growing season. Rather than wait until the following season to plant, they decided to buy cabbages from Sa Pa (where climate conditions enable earlier harvest of cabbage) to sell in Bac Ha market when supply in Bac Ha was low and prices were high. Additionally,

the group specialised in marketing short-day vegetables (e.g. edible Chrysanthemum) to maximise market opportunities during periods of cold weather. These were not their focus in previous seasons. Members of the group also showed much initiative to apply business knowledge obtained from the FBS to other products, e.g. chicken raising.

In addition, the group strengthened their trading relationship with Di Thang Cooperative – a cooperative in Bac Ha supplying vegetables to the Hanoi market. Collectors for the cooperative help Na Kheo farmers to understand the current market demands and which informed production plans for the group. With this stronger trading relationship, the Na Kheo group has a stable customer base and is oriented to produce products in demand.

Ma Tra farmer group, Sa Pa district: Off-season vegetable production is a priority

The Ma Tra farmer group (13 farmers of H'mong ethnic minority with an additional seven members who joined in February 2018) participated in the FBS in late 2017. As with the Na Kheo group, the farmers had been working together with other components of the project before commencing FBS training and as such had a well-established co-learning environment. Membership of the group was largely male: however, throughout the project the male group members were increasingly encouraged to bring their wives or partners along to the trainings as well. The group leader was trained as a co-facilitator. He was an active participant in the training of facilitators and highly regarded by the master trainers. It was considered important to draw a facilitator from the H'mong community as he was sensitive to cultural norms and able to speak Vietnamese as well as local H'mong languages. Through the FBS experience the group received training and support to learn about various topics related to business skills development. Following FBS training and learning via participation in the adaptive farming systems trials (Activity 3.8), the farmers gained more confidence in their business decision to strategically change from rice to off-season vegetable production. Off-season vegetable production as well as specialisation in indigenous vegetables is an attractive option as Sa Pa has a comparative advantage to produce in the off-season (due to high altitude) and a growing tourism industry that is increasing demand for locally grown vegetables. In taking advantage of the huge market opportunity for off-season vegetables (with many kinds of indigenous varieties), the group has increased their range and intensity of business interactions with other chain actors. The group leader has proposed to develop a business plan for the group for next season to keep building on experiences from the FBS. An additional benefit: some group farmers have also been able to apply knowledge gained from the class to orchid growing.

Improved nutrient management

Improvements in nutrient management deliver direct economic benefits to farmers. The over-application of major nutrients (N, P and K) has been identified in the project and optimised application rates identified and validated. This allows farmers to substantially reduce (by about 50%) their fertiliser inputs, which represents one of their major costs. The preliminary studies conducted have identified suboptimal ("hidden hunger") micronutrient status in vegetable crops that reduces crop productivity and causes low fertiliser use efficiency and quality (colour).

8.3.2 Social impacts

Ethnic Minorities

The project assessed the traditional farming systems of H'mong, Tay, and Nung ethnic groups and designed farming system trials and interventions to help farm households transition from autarkic integrated systems to more commercially oriented farming systems. This involved addressing food safety issues in traditional production methods, trialling of more profitable commodities and varieties, improving nutrient management and trialling off-season production methods.

FBS and women's farmer groups

The FBS directly targeted gender outcomes, particularly in terms of women's participation in value chains and markets. Most (>70%) of trainees and business-group members of the FBS pilot program were women from minority ethnic communities. The project demonstrated effectiveness in overcoming previous issues with providing training opportunities for women — by designing the FBS program and implementation to accommodate women's roles, time allocation and resources to participate.

FBS pilots were specifically been implemented with groups led by women (Na Kheo group, Gia Phu cooperative, Sin Chai A&B group). This has encouraged confidence in these women-leaders, as well as other women to aspire to high-level roles in community-based and other collective undertakings.

Refer to Section 8.3.1 for more 'impact stories' from the FBS program.

Reduced seasonal migration

As vegetable farming systems became more profitable, male household heads in Sa Pa's farmer groups reduced their off-farm employment and increased their roles in managing the farm. As a result, the seasonal migration of male household heads to earn income from construction and other temporary employment was reduced. This change enabled families to stay together in their communities.

Reduced food safety risk

In traditional farming systems in Bac Ha, households were applying fresh manure to fertilise vegetable crops. In addition to being an inefficient practice, the use of fresh manure in vegetable production means that consumers of the produce were exposed to high risk of microbial contamination. The marketing system is not able to screen unsafe vegetables produced in this system and was failing to ensure safety to consumers.

The project worked with farmers to change their management of soils and nutrients in a way that complies with basic safety measures. Farmers adopted improved soil and nutrient management strategies on the farm that reduce the risk of microbial contamination of vegetables.

Diet quality improvement

The expansion and development of vegetable production systems has improved dietary outcomes in rural farming households. The rural consumption survey found strong evidence that smallholder vegetable production is significantly associated with the dietary diversity outcomes of children aged 6 to 59 months of age. This stresses the importance of vegetable production for the diets of children in these remote rural farming areas:

- For subsistence families who have to produce their own food to meet their dietary requirements due to missing markets
- For farming households who have access to traditional and modern food retail markets to sell their agricultural produce and buy other nutritious and diverse food.

8.3.3 Environmental impacts

Wider planting of indigenous vegetables as a result of the project will lead to the retention of biodiversity within each of the project regions. In addition, further development of markets for these products is likely to see an expansion in indigenous vegetable plantings.

Project activities and extension has improved soil and crop nutrient management. In turn, improved nutrient management has increased plant biomass production and hence the availability of crop residues to return to the soil thus protecting the soil surface, reducing evaporation and helping to control erosion. Furthermore, the optimisation of vegetable crop nutrient rates has identified farmer application of N and P fertiliser can be reduced

substantially, thereby reducing the negative environmental impacts from excesses of these nutrients.

8.4 Communication and dissemination activities

8.4.1 Major Workshops/Meetings/Events

- **Project Inception Meeting**, 19–20 February 2014, Hanoi, Vietnam.
    - Official launch by the Hon. Julie Bishop, Minister for Foreign Affairs and the President of the Vietnam Women's Union.
- **Stakeholder Workshop** for local government, 15 October 2014.
- **Stakeholder workshop** I for supply chain partners (collaborators on activities for Objective 2), 16 October 2014.
- **Nutrition-sensitive Agriculture Workshop**, 1–2 December 2014, Hanoi, Vietnam.
- Visit by Mr Layton Pike, Deputy Head of Mission, Australian Embassy to project sites in Bac Ha, Vietnam, 11 November 2015.
- **Launch of project video** showcasing the Australian Government's work on women's empowerment in Vietnam at Taste of Australia 'Penfolds Wine Dinner', 20 April 2016, Hanoi, Vietnam
- **Stakeholder Workshop II**, (collaborators on activities for Objective 2) 14 March 2016, Hanoi, Vietnam
    - This workshop was held at Fivimart in Hanoi and brought together farmers, cooperative leaders, wholesalers and retailers to determine marketing interventions to be trialled in the next phase of the project.
- **Stakeholder Workshop** (upscaling and outscaling results), 4 May 2016, Vietnam Women's Union, Hanoi, Vietnam.
- **Mid-Term Review Workshop**, 16–20 May 2016, Hanoi and field site visits in Sa Pa and Bac Ha, Vietnam.
- **Lao Cai Vegetable Product Promotion:** NW Vegetables Tasting Festival, 17 January 2017, Hanoi, Vietnam
- **Lao Cai Vegetable Product Promotion:** CIAT's 50th Anniversary event "Sustainable Agriculture Solutions Fair", 4 April 2017, Hanoi, Vietnam.
- **The Mobile Acquired Data Showcase**, 9 August 2017, Canberra, Australia.
- **Crawford Fund Forum** "World Food Security, opportunities and partnerships", 17 November 2017, Adelaide, Australia.
- **ACIAR North-West Vietnam Research Symposium**, 22–24 November 2017, Hanoi, Vietnam.
- **End of Project Review Workshop**, 4–6 April 2018, Hanoi, Vietnam (plus field trip to Sa Pa and Bac Ha, Vietnam for reviewers, 6–8 April 2018).
- **Lao Cai Vegetable Product Promotion**: 25 year anniversary of ACIAR in Vietnam Market Stall event, 11 April 2018, Hanoi, Vietnam.
- **Stakeholder Workshop** for local government and other stakeholders, Lao Cai Province 3 October 2018
- **Postharvest Workshops** for local government and farmers, 10 & 12 October 2018, Lao Cai Province, Vietnam.
- Visit by delegation from Australian Embassy, led by Ms Rebecca Bryant, Deputy Head of Mission to Di Thang Cooperative, Bac Ha District, Vietnam, October 2018.

8.4.2 Media coverage

- Dr Suzie Newman was interviewed on Sharing Vietnam by VTC 10. Program available here: https://www.youtube.com/watch?v=a0bIAT0vonI

- Dr Suzie Newman was interviewed on the South Australian Country Hour (ABC Rural) on 8 March 2016. Program available here: http://www.abc.net.au/news/rural/programs/sa-country-hour/2016-03-08/sa-country-hour-8-march-2016/7230002)
- "Women leading the way in sustainability in Asia", The Wire, March 2016. Article available here: http://www.thewire.org.au/storyDetail.aspx?ID=13696
- "Counter season vegetables help improve women's lives in north-western Vietnam", ABC Rural, March 2018. Article and audio available here: http://www.abc.net.au/news/rural/2018-03-08/international-womens-day-vietnam-aciar-vegetables/9524998

8.4.3 Videos produced

- Dr Suzie Newman describes the project context and expected outcomes
- Chef Luke Nguyen travelled to Lao Cai, Vietnam to understand the impact of the project for local vegetable growers
- The Agribusiness Masterclass helped to train young researchers in southeast Asia in the latest agriculture business skills
- Project impacts video
- Farmer Business School 'Change Cases' film

8.4.4 ACIAR Partners Magazine articles

- Women Working Wonders, Issue 1, 2014
- Made in Vietnam by Women, Issue 1, 2016
- Luke Nguyen's recipe for prawn mousse wrapped in cabbage leaves, Issue 1, 2017.
- Quality vegetables find their markets, Issue 4, 2017, page 10-13.
- Opportunities in changing markets, Issue 4, 2017, page 11.
- Addressing child under-nutrition in Lao Cai, Issue 4, 2017, page 30

8.4.5 Blogs

- Learning by doing: Consumer research in Agribusiness Master class in Vietnam
  - 27 June 2014
  - Blog from The Centre for Global Food and Resources, The University of Adelaide
- Meeting partners and measuring diet quality in Vietnam
  - 30 March 2015
  - Blog from The Centre for Global Food and Resources, The University of Adelaide
- GFAR students presented at John Allwright Fellows Meeting
  - 30 September 2015
  - Blog from The Centre for Global Food and Resources, The University of Adelaide
- Celebrating the Role of Women in Agriculture
  - 8 March 2016
  - Blog from The Centre for Global Food and Resources, The University of Adelaide
- From Paper to Paperless with CommCare
  - 11 May 2017
  - RAID Network Blog
- GFAR researchers at the North-West Vietnam Research Symposium
  - 29 November 2017
  - Blog from The Centre for Global Food and Resources, The University of Adelaide
- GFAR Vietnam vegetables project in the news for International Women's Day
  - 8 March 2018
  - Blog from The Centre for Global Food and Resources, The University of Adelaide

8.4.6 Papers (contributed & refereed) presented at academic & professional meetings

See Section 10.2.2.

9 Conclusions and recommendations

9.1 Conclusions

AGB/2015/059 sought to enhance the profitability and sustainability of smallholder vegetable farms in NW Vietnam through improved market engagement and integrated resource and disease management practices. The project particularly focused on women and ethnic minorities engaged in horticultural value chains in the Sa Pa and Bac Ha districts of Lao Cai Province. The project built on the approach taken and research partnerships developed in the preceding project, Project Number AGB/2006/112. It used a multi-disciplinary approach with all research activities also focused on capacity building of key institutions.

Key achievements of the project included:

- Understanding vegetable trade, value-chains, and consumer behaviour identified future market strategies for Lao Cai's vegetables. Analysis demonstrated that entry of Lao Cai vegetables into Hanoi is very difficult due to strong competition from imports and supply from other highland areas in Vietnam. A viable strategy for Lao Cai may be to expand off-season supply of select vegetables to neighbouring NW provinces where Lao Cai has a competitive advantage.
- Implementation of marketing interventions to improve consumer awareness and develop market linkages between Lao Cai's vegetable production industry and the consumer base in Hanoi. Product fairs, production calendars, and facilitation of market linkages helped to develop markets and trade relationships for Lao Cai's vegetable products.
- Consignment tracking and package trials were identified areas for improvement in postharvest handling and packaging. Insights were used to develop a postharvest guide that was used in the FBS pilot in Lao Cai. As a result, farmers in Lao Cai have adopted some improved postharvest recommendations. For example, ice bottles are now being used to cool product during transit, and farmers are not pre-peeling cabbages prior to packing, with the intent of better protecting the crop in-transit.
- Pathology component conducted trials that successfully identified effective low-cost control strategies for diseases in Sa Pa and Bac Ha. A major achievement of the project is the development of a control for the clubroot disease which was devastating brassica crops in Sapa. The control method was developed, adapted for use by smallholder farms, and extended to the community. A workshop was held in Lao Cai to accelerate diffusion of the control to a wider community.
- Diagnostic research conducted in the beginning of the project identified mismanagement of soils and nutrients. Many farmers were over-applying nitrogen fertilisers while being deficient in critical micronutrients. This meant farms were incurring unnecessary costs while achieving suboptimal yields. Nutrient trials were conducted to identify optimum applications and insights were used to inform the nutrient management strategies of growers in the area.
- Adaptive trials were conducted in Sapa and Bac Ha. A broad range of farm management technologies and practices were adapted, tested, and demonstrated in a broad set of biophysical and socioeconomic contexts to ensure that recommended technologies are viable for use by smallholder farmers in real-world conditions. Results show that recommended practices improved in nutrient and disease management, which has translated into significant increases in yield and incomes for household farms.
- An FBS program was designed, developed and piloted. FBS was designed to enable farmers to rapidly capitalise on learnings about the production and marketing of

vegetables. The project was able to train 18 FBS facilitators who went on to train 160 farmers in the initial pilot FBS implementation, which was positively evaluated by participants.

- Capacity development in chemical analysis of soils at SFRI lab to enable analytical support for ongoing applied research in soil and nutrient management.

9.2 Recommendations

Based on the experiences and insights gathered over the previous 4 years of operations, this project offers up a number of recommendations to inform the development community working in this domain:

- Options should be explored for extending outcomes of AGB/2012/059 through the new DFAT project and undertaking any complementary research to strengthen collaboration.
- Since completion of the highway connecting Lao Cai to Hanoi, there has been a dramatic rise in tourism. This has created new market opportunities for Lao Cai's vegetable producers, but very little is known regarding tourist demand. Understanding the size of this segment and the particular products being demanded would provide valuable information as vegetable value-chains develop strategies to service this rapidly growing group. A focused consumer study targeting NW tourists would inform NW enterprises, ACIAR projects in the region, and the DFAT project underway.
- In the future, greater participatory involvement with the private sector is recommended to support the adoption of innovations and behaviour changes. For example, engagement of prospective buyers in training events, market visits, or postharvest trials would help build trust between the community and the buyers that can be leveraged to access new markets.
- Assisting ethnic communities and focussing support on women will require on-going intervention. FBS approach can be further adapted to address gender and ethnicity aspects that are particularly important in NW Vietnam. A more in-depth treatment of facilitation skills that focuses on the gender and ethnicity constructs of target communities could improve the effectiveness of the capacity building program.
- Counter-seasonal production is the most profitable market opportunity for vegetable producers in Lao Cai. However, farm households are often reluctant to forego the summer-rice crop in favour of the summer-vegetable crop due to perceived increase in production risk and market risk. More focused extension efforts and demonstrations of summer-season production and marketing systems would help to facilitate adoption.
- Capacity development at SFRI's soil analysis lab should continue to be supported as SFRI provides chemical analysis support to a growing network of research projects throughout the region. In addition, plant analysis is a strong complement to soil analysis, whether running nutrient trials, estimating nutrient budgets, or diagnosing nutrient problems on-farm. Consequently, it is strongly recommended that ACIAR consider investment in the development of plant analysis, and of quantitative quality control for both soil and plant analysis. Such investment would build on success in this project and provide high quality laboratory services to multiple projects in Vietnam and the region.

10 References

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Higgins, S., Hamakawa, T., McGill, D., et al. (2015) Final Report: Assessment of digital data collection apps to support ACIAR's M&E. Final Report Number FR2016-03, Australian Centre for International Agricultural Research, Canberra, Australia.

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10.2 List of publications produced by project

10.2.1 Journal Articles

L.B. Bui, H.M.T. Le, A.H. Bui, P.D. Do, P. Milham. (2016). Preparation of a soil reference sample. *Journal of Vietnam Agricultural Science and Technology*, 1(2)/2016, 130-134.

H.N. Nguyen, T.T.H. Nguyen, T.D.N Nguyen, V.H. Pham, K.M. Pham, X.T. Ninh, D Yi. (2018). Improved vegetable farming systems and marketing for small-scale producers in Bac Ha district, Lao Cai province. *Vietnam Journal of Agricultural Sciences.* 16(9)/2018, 847-858

L.B Bich, H.P Thi My, R.P Dinh, T.P Minh, T.D Trong, S. Harper, R. Wuhrer, Q. Huang, L. George, P. Holford, C.C Zhao, C. Mitchell, P. Milham. Trace Metal Contamination During Grinding of Plant Samples. *Communications in Soil Science and Plant Analysis*, 50:1, 102-107

J. Rupa, W.J. Umberger, D. Zeng. (2019). Does food market modernization lead to improved dietary diversity and diet quality for urban Vietnamese households? *Australian Journal of Agricultural and Resource Economics*, 59, 1-22. Available via open access: https://onlinelibrary.wiley.com/doi/full/10.1111/1467-8489.12308.

J. Rupa, W.J. Umberger, D. Zeng. Understanding food westernization and other contemporary drivers of adult, adolescent and child diet quality in urban Vietnam. *Public Health Nutrition* (under review).

10.2.2 Papers (contributed & refereed) presented at academic & professional meetings

S. Newman (2014) Maximising the market potential of indigenous vegetables. Indigenous Vegetable Symposium*, International Horticultural Congress*, Brisbane, Australia, 17-22 August 2014.

C. Genova., W.J. Umberger, S. Newman, A. Peralta (2016) Understanding the relationship between a household's food choices, the Household Food Insecurity Access Scale (HFIAS), and the body mass index (BMI) in rural Vietnam. *AgriFood Research Network Conference*, Adelaide, Australia, 7-10 December 2016.

A.D. Nguyen, D. Yi (2016). Price differences and spatial market integration: A study of vegetable markets in Hanoi. *AgriFood Research Network Conference*, Adelaide, Australia, 7-10 December 2016.

C. Genova, W.J. Umberger, S. Newman, A. Peralta (2017) Linking smallholder vegetable production to household diet quality: Evidence from rural Vietnam, *Australian Agriculture and Resource Economics Society 61st Annual Conference*, Brisbane, Australia, 7-10 February 2017.

C. Genova, W.J. Umberger, S. Newman, A. Peralta (2017) To Market, to Market: Does smallholder vegetable production lead to increased children's dietary diversity and improved diet quality? Empirical evidence from Northwest Vietnam. *Agricultural & Applied Economics Association Meeting*, Chicago, United States, 31 July – 1 July 2017.

D. Zeng, W.J. Umberger, J.A. Rupa (2017) Implications of Supermarket Revolution on Weight Outcomes of Vietnamese Urban Consumers. *Agricultural & Applied Economics Association Meeting*, Chicago, United States, 31 July–1 August 2017.

C. Genova, W.J. Umberger, S. Newman, A. Peralta (2017) To market, to market: does smallholder vegetable production lead to increased children dietary diversity? Empirical evidence from north west Vietnam. *Australian Centre for International*

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C. Genova, W.J. Umberger, S. Newman, A. Peralta, D. Zeng (2017) Do farmers reap what they sow? Impact of smallholder vegetable production on child nutrition in rural Vietnam. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium, Hanoi, Vietnam*, 22-24 November 2017.

W.J. Umberger, N.P. Dumbrell, A.D. Nguyen, D. Zeng (2017) Consumer preferences and consumption patterns for fruit & vegetables in urban Vietnam. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

N.P. Dumbrell, W.J. Umberger, D. Zeng, A.D. Nguyen, L. Pagliuca (2017) The role of market research in agricultural development for northwest Vietnam: The case of fruit and vegetables. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

A.D. Nguyen, W.J. Umberger, D. Zeng, N.P. Dumbrell (2017 Concerns and valuation of food quality and food safety in urban Vietnam. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

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M. Chu, L. Tesoriero, H.T. Phan, H. Dang, L. Hoang (2017) Managing clubroot disease of cabbage in Sa Pa. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

T.T. Do, T.M.T. Tran, H.A. Bui, T.T. Nguyen, T.M. Tran, D.V. Luong, B.T. Nguyen, S. Harper (2017) Vegetable responses to fertilizer in Lao Cai Province. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium*, Hanoi, Vietnam, 22-24 November 2017.

B.T. Nguyen, T.M.T. Tran, A.H. Bui, T.M. Tran, H.M.T. Phung, D.V. Luong, S. Harper (2017) Nutrient status of vegetable crops in Lao Cai Province. *Australian Centre for International Agricultural Research North-West Vietnam Research Symposium,* Hanoi, Vietnam, 22-24 November 2017.

A.D. Nguyen, D. Yi (2018) Price differences and market integration: A study of vegetable markets in Hanoi, Vietnam, Australasian Agricultural and Resource Economics Society 62nd Annual Conference, Adelaide, Australia, 6-9 February 2018.

L. Pagliuca, N.P. Dumbrell, W.J. Umberger, D. Zeng (2018) Drivers of changing meat expenditure and consumption patterns in urban Vietnam. *Australasian Agricultural and Resource Economics Society 62nd Annual Conference*, Adelaide, Australia, 6-9 February 2018.

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J. Rupa, W.J. Umberger, D. Zeng (2018) Food market modernization, dietary diversity and diet quality: Evidence from urban Vietnam. *Australasian Agricultural and Resource Economics Society 62nd Annual Conference*, Adelaide, Australia, 6-9 February 2018.

J. Rupa, W.J. Umberger, D. Zeng (2018) Does food market modernization lead to improved diet quality for urban Vietnamese households? *30th International Conference of Agricultural Economists*, Vancouver, Canada, 28 July – 2 August 2018.

A. Peralta, W.J. Umberger, C. Genova (2018). Spousal Agreement and women participation in decision making in rural Vietnam. *Agricultural & Applied Economics Association Meeting*, Washington D.C., United States, 5-7 August 2018.

L.B. Bui, H.T.M. Phung, R.D. Pham, M.T. Pham, T.T. Do, S. Harper, P. Holford, P. Milham (2018). Trace metal contamination during grinding of plant samples. *Joint Conference of Soil Science Australia and the Australasian Soil and Plant Analysis Council*, Canberra, Australia, 18–23 November 2018.

L.B. Bui, H.T.M. Phung, R. D. Pham, M.T. Pham, T.T. D, S. Harper, R. Wuhrer, P. Holford, E. Huang, L. George, C.C. Zhao, C. Mitchell, P. Milham (2019). *Trace metal contamination during grinding of plant samples*. Communications in Soil Science and Plant Analysis 50, 102-107.

10.2.3 Theses

A.D. Nguyen (2016) Price differences and market integration: A study of vegetable markets in Hanoi (Unpublished master's thesis). The University of Adelaide, Adelaide, Australia.

C.C. Phan (2017) Off-season vegetable production development in Sa Pa commune, Sa Pa district, Lao Cai Province (Unpublished undergraduate thesis). Vietnam National University of Agriculture, Hanoi, Vietnam.

T.S. Le (2018) Grafting to improve bitter melon (*Momodica charantia* L.) productivity and fruit quality (submitted for examination). The University of Newcastle, Newcastle, Australia.

J. Rupa (2019) Analysing Drivers of Food Security, Dietary Diversity and Diet Quality in Transition Economies: Evidences from Rural Bangladesh and Urban Vietnam (Unpublished PhD thesis). The University of Adelaide, Adelaide, Australia.

C. Genova (2019) The Effect of Smallholder Vegetable Production on Children's Diet Quality and Nutritional Outcomes: Evidence from Vietnam (submitted for examination, May 2019). The University of Adelaide, Adelaide, Australia.

10.2.4 Project Outputs (additional to those listed above)

Component 1 – Market Analysis

N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2017) Interprovincial trade opportunities for vegetables in NW Vietnam (unpublished project report), Hanoi, Vietnam.

N.T.T. Tran, T.T.T. Truong, A.T.T. Nguyen, L.D. Pham, T.C. Nguyen, H.L. Nguyen, T.N. Le, L.V. Tran & D. Yi (2016) Vegetable markets and trading systems in Hanoi, Vietnam (unpublished project report), Hanoi, Vietnam.

A.D. Nguyen, D. Yi, H.V. Pham, N.D.T. Nguyen, T.X. Ninh, & L.V. Tran (2018) Price differences and market integration: A study of vegetable markets in Hanoi (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam.

N.P. Dumbrell, W.J. Umberger, L. Pagliuca, A.D. Nguyen, D. Zeng (2018) The Vietnam Urban Food Consumption & Expenditure Study Factsheet Series. The Centre for Global Food and Resources, The University of Adelaide, Adelaide, Australia. Available online at: https://www.adelaide.edu.au/global-food/research/international-development/vietnam-consumer-survey/

Component 2 – Market Development

N.H. Nguyen, H.T.Y Nguyen & D. Yi (2018) Marketing and farmer group case studies in northwest Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam.

V.H. Nguyen, S. Underhill (2018) Towards more profitable and sustainable vegetable farming systems in north-western Vietnam: Postharvest report (unpublished project report). Fruit and Vegetable Research Institute, Hanoi, Vietnam.

Other outputs produced by project to create awareness of the relationship between seasonality of supply and market prices:

- Production/Price calendar for Bac Ha farmers selling to Hanoi
- Production/Price calendar for Sa Pa farmers selling to Hanoi

Other outputs produced by project to create awareness of (especially indigenous) vegetables grown in northwest Vietnam:

- Product origin logo and branding graphics featured on Lao Cai PPsD website

Component 3 – Farming Systems

SFRI & NIMM (2014) Baseline report: Farming systems in north-western Vietnam (unpublished project report), Soils and Fertilizer Research Institute and National Institute of Medicinal Materials, Hanoi, Vietnam.

VNUA (2014) Baseline report: Socio-economic characteristics and vegetable production systems of farm households in Sa Pa and Bac Ha districts, Lao Cai Province, Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam.

M.T. Chu, H.T. Phan, L.T.D. Hoang, H.T. Dang, L. Tesoriero (2014) Farming system baseline report: Pests and diseases (unpublished project report) National Institute of Medicinal Materials, Hanoi, Vietnam.

H.T. Phan, R. Daniel, M.T. Chu, L.T.D. Hoang, H.T. Dang, L.Tesoriero (2018) Towards more profitable and sustainable vegetable farming systems in north-western Vietnam: Plant pathology research report (unpublished project report), National Institute of Medicinal Materials, Hanoi, Vietnam.

SFRI&NIMM (2018) Report on farming system sub-component

VNUA (2017) Farming system transition in Lao Cai Province, Vietnam (unpublished project report), Vietnam National University of Agriculture, Hanoi, Vietnam.

Component 4 – Outreach and Capacity Building

H.M.T. Pham (2016) Farmer business school in Southeast Asia and its modification and adaptation to Vietnam (unpublished project report), CIAT—Asia, Hanoi, Vietnam.

H.M.T. Pham (2018) Sustaining and scaling Farmer Business School (FBS) (unpublished project report), CIAT—Asia, Hanoi, Vietnam.

H.M.T. Pham and H.T.T. Le (2019) Farmer Business School – Learning manual for business skills – Facilitator's Manual (Vietnamese), ISBN 978-604-56-6567-1. Women's Publishing House. Hanoi, Vietnam. 132 pages.

H.M.T. Pham and H.T.T. Le (2019) Farmer Business School – Learning manual for business skills – Facilitator's Manual (English). online report.

Le, Do, Bich, et al. (2018) Laboratory capacity building, Soils and Fertilizers Research Institute, Hanoi (unpublished project report), Soils and Fertilizers Research Institute, Hanoi, Vietnam.

11 Appendices

11.1 Appendix 1: Results of plant pathology research in Australia

Table A1. Pathogens of Solanaceous crops identified in surveys of Australian tomato, chilli and capsicum farms, conducted between 2014 and 2017. Table continues over page.

Host	Pathogen	Disease	Geographic location
Tomato seedlings (*Solanum lycopersicum*; Nursery)	*Pythium ultimum* (minor pathogen)	Root rot	Tomato nurseries; Victoria
	P. dissotocum (minor)	Root rot	
	P. irregulare (minor)	Seedling root rot	
	P. rostratum (minor)		
	P. spiny (minor)		
	P. vexans (minor)		
	Pythium spp.	Unknown if significant	
	Fusarium oxysporum	Wilt	
	Fusarium spp. (not *F. oxysporum*)	Unknown if significant	
	Rhizoctonia sp.	Damping off, root rot	
	Thielaviopsis sp.	Minor root rot in field tomatoes	
	Plectosphaerella sp.	Wilt (Minor pathogen)	
	Alternaria alternata	Saprophyte in nursery; Fruit rot postharvest	
	Stemphyllium sp.	Leaf spot and blight	
	Cladosporium sp.	Saprophyte in nursery; Fruit rot postharvest	
	Botrytis sp.	Saprophyte in nursery; Fruit rot postharvest	
	Macrophomina phaseolina	Charcoal rot (Minor)	
Tomato	*Stemphyllium* sp.	Grey leaf spot	Leppington, NSW Ourimbah, NSW
	Ralstonia solonacearum	Bacterial wilt	Bundaberg, Queensland
	Aceria anthocoptes	Russet mite	Bundaberg, Queensland
	Fusarium oxysporum	Fusarium wilt	Doyalson, NSW
	Rhizoctonia sp.	Root rot	Lancaster, Victoria
	Phytophthora sp.	Root rot	Shepparton, Victoria
	Pythium sp.	Root rot	Shepparton, Victoria
	Fusarium sp.	Wilt	Shepparton, Victoria
	Thielaviopsis basicola	Black root rot	Victoria

	Sclerotinia sp.	Root rot	Shepparton, Victoria
	Ralstonia solonacearum	Bacterial wilt	Coffs Harbour, NSW
	Pythium rostratum	Root rot	Rochester, Victoria
	Fusarium sp.	Wilt	Rochester, Victoria
	Plectosphaerella sp.	Wilt	Rochester, Victoria
	Thielaviopsis sp.	Black root rot	Rochester, Victoria
	Sclerotium rolfsii	Blight	Clayfield, Queensland
	Fusarium sp.	Wilt	Clayfield, Queensland
	Phytophthora sp.	Root rot	Toolamba, Victoria
	Rhizoctonia sp.	Root rot	Toolamba, Victoria
	Fusarium sp.	Wilt	Toolamba, Victoria
	Phytophthora sp.	Root rot	Murchison, Victoria
	Rhizoctonia sp.	Root rot	Murchison, Victoria
	Fusarium oxysporum	Wilt	Murchison, Victoria
	Pythium sp.	Root rot	Murchison, Victoria
	Phytophthora sp.	Root rot	Tatura, Victoria
	Rhizoctonia sp.	Root rot	Tatura, Victoria
	Fusarium oxysporum	Wilt	Tatura, Victoria
	Pythium sp.	Root rot	Tatura, Victoria
	Ralstonia solanacearum	Bacterial wilt	Queensland
	Tomato Spotted Wilt Virus (TSWV)	Wilt	Tatura, Victoria
	Rhizoctonia sp.	Root rot, wilt	Coffs Harbour, NSW
	Pythium sp.	Root rot	Coffs Harbour, NSW
	Ralstonia solanacearum	Bacterial wilt	Stanthorpe, Queensland)
	Cladosporium sp.	Leaf mould	Bundaberg, Queensland
Tomato	*Pseudomonas syringae* pv. *tomato*	Leaf spot	Boort, Vic
Tomato	*Pseudomonas syringae* pv. *tomato*	Leaf spot	Sydney Basin, NSW
Tomato	*Xanthomonas sp.*	Leaf spot	Bundaberg, Queensland
Tomato	*Tomato yellow leaf curl virus*	Leaf curl	Bundaberg, Queensland
	Aceria anthocoptes	Russet mite	Cooperabung, NSW
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Shepparton, Vic
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Port Augusta, SA
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Stanthorpe, Qld
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Virginia, SA
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Carnarvon, WA
Tomato	*Sclerotinia minor*	Sclerotinia rot	Boort, Vic
Tomato	*Clavibacter michiganesis* ssp. *michiganesnis*	Bacterial canker	Rossmore, NSW
Chilli	TSWV	Wilt	Vaneroo, WA
Chilli	*Fusarium solani*	Wilt	Bundaberg, Qld
Chilli	*Sclerotium rolfsii*	Root rot	Bundaberg, Qld

Chilli	*Pythium aphanidermatum*; *P. spinosum*	Root rot	Bundaberg, Qld
Tomato	TSWV	Wilt	NSW
Tomato	TSWV	Wilt	Virginia, SA
Capsicum	TSWV	Wilt	Virginia, SA
Capsicum	*Fusarium solani*	Stem and fruit rot	Baldivis, WA
Capsicum	*Tomato yellow leaf curl virus (TYLCV)*	Leaf curl	Bowen, Qld
Capsicum	*Rhizoctonia solani*	Root rot, wilt	Bowen, Qld
Capsicum	*Xanthomonas euvesicatoria*	Leaf spot	Bundaberg, Qld
Chilli	*Sclerotium rolfsii*	Root rot	Bundaberg, Qld
Chilli	*Rhizoctonia solani*	Root rot	Bundaberg, Qld
Tomato	*Pythium* sp.	Root rot	Mangrove Mountain, NSW
Tomato	*Phytophthora* sp.	Root rot	Mangrove Mountain, NSW
Tomato	*Rhizoctonia* sp.	Root rot	Mangrove Mountain, NSW
Tomato	*Phomopsis* sp.	Blight	Eumundi, Qld
Tomato	*Fusarium* sp.	Wilt	Eumundi, Qld
Chilli soil	*Pythium* sp.	Wilt	Bundaberg, Qld
Potato	*Phoma* sp.		Virginia, SA
Chilli	*Rhizoctonia* sp.	Root rot	Bundaberg, Qld