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Situational Analysis in Support of the Development of Integrated Agricultural Systems in the Upland Areas of Nan Province, Thailand

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Executive Summary

The overall objective of this study is to help develop integrated agricultural systems in the upland areas of Nan province in Thailand by analyzing the current situation and develop potential solutions to the problems found. The specific objectives are: 1) to use problem analysis to describe the issue of unsustainable land use as well as analyze the direct and indirect causes of this, 2) to use quantitative data collected during the research to describe the current situation in terms of farming systems, soil fertility management, markets and institutions with regard to maize, livestock, vegetables, fruit and mushrooms in the study area, and 3) to use pathway analysis to investigate and describe eleven small-scale agricultural diversification initiatives taking place in Nan province and elsewhere that could serve as a model for sustainable intensification initiatives in the future.

In this report, the causes of unsustainable land use in the study area are investigated based on several sources, such as literature on the topic, interviews with both government and non-government organizations that have recently been working on agricultural and highland development in Nan province, and also interviews with farmers who are growing maize in the study highland area. To assess the current situation, data were collected from existing sources such as national, regional and provincial statistics and different government agencies, from previous research studies carried out in Nan province and also from a review of the existing literature. In-depth and open-ended interviews, and focus group discussions, were held with key informants to fill any data gaps and verify the data obtained from secondary sources. Geographic information technology was used to conduct a spatial analysis of local maps in relation to natural resource management in the area. To help with pathway analysis, information regarding the existing agricultural diversification initiatives taking place in Nan province was collected from the Hak Mueang Nan Foundation, an organization which has been promoting the expansion of sustainable agricultural practices in Nan province over recent years. A list of some of these initiatives was obtained, then a 'snow-ball technique' applied to gather information on other initiatives in the area. From this list 11 cases were selected to help assess diversification among crop and livestock components such as rice, field crops, fruit trees, trees grown for timber, mushrooms and livestock. For each case, in-depth and semi-structured interviews were conducted with relevant group representatives. The information collected was analyzed to formulate the key success pathways and using a combination of outcome mapping and change frameworks theory. The success pathways for the 11 initiatives were generalized to identify the key critical success factors and their supporting elements.

Problem Analysis

The expansion of upland maize cultivation activities is believed to play a role in causing deforestation and environmental problems in the study area, as it can cause water contamination from the chemicals used, air pollution due to the burning of stubble, soil erosion on steep slopes, a loss of soil fertility and drought**,** as well as a reduction in biodiversity levels. The fact that these problems exist shows that unsustainable land use practices take place in Nan province. The results of this study showed that there are three direct causes of unsustainable land use in Nan province: (i) The rapid expansion of upland maize production on steep slopes due to economic pressure on livelihoods, including the indirect promotion activities of the private sector based on credit provision, the use of hybrid seed varieties suitable for rainfed crops in the highlands, and also convenient market offers. In addition, the Thai government runs a price guarantee program which reduces price risk, plus highland farmers have limited market information and access on other alternative crops which can be grown under the rainfed and steep slopes conditions. (ii) The low rate of adoption of conservation practices in the highlands. This low rate of adoption is due to land rights insecurity and also outdated forest regulation practices, which are now inconsistent with highland livelihood patterns. Forest legislation that separates people from their forest livelihood sources has created a negative attitude towards the economic benefits to be derived from the forests. In addition, the cultures of the ethnic groups living in the highlands have also contributed to the low adoption of conservation practices. (iii) The limited natural resources to be found in the highlands of Nan province; for example, a lack of water sources and the presence of steep slopes lead to natural low soil fertility levels and high rates of soil erosion, limiting land use options.

Development Overview

Nan has a population of 478,264, with almost no population growth taking place (0.06%) over the last ten years (2004-2014). Most of the Nan population is Northern Thai (80%) which live mostly in the lowlands; the rest being composed of five key ethnic minority groups (the Lau, Hmong, Mien, Khmu and Mlabri). The biggest group is the Lau (42%), followed by the Hmong (31.9%). In each district, most people live outside the municipal areas (87.7%), and most of the population is of working age (70%). The dependency ratio is 0.43.

Poverty level in Nan province have been declining in recent years, falling from 212,700 (46.4%) in 2000 to 94,400 (21%) in 2012, though at a slower rate than the national poverty level. However, household debt in Nan has risen fast during over the last two decades, growing at 22.4% with average debt levels being higher than the national average. The debt to income ratio has also been increasing overtime, and had reached

0.89 by 2013. Maize production activities have contributed to the increased debt burden in the highlands.

Efforts made to reduce malnutrition at the provincial level have been successful, with the malnutrition rate in children under six being lower than the targets set out in the provincial plan. However, the situation in terms of malnutrition in the highlands is not clear, and especially that related to micronutrient deficiencies, which can usually be found in such remote areas. We could not find statistics disaggregated at the lowland and highland community levels, though interviews held with key informants across the three study villages did not find evidence of micronutrient deficiency. The informants stated that they receive regular health checks from village health volunteers.

Gender inequality is related to ethnic traditions and family life. Within the Mien and Hmong ethnic groups, men have much more power than women in terms of decision-making, as well as access to and control over resources. Hmong men have social, political and religious responsibilities, whereas Hmong women's responsibility is to meet the domestic needs of the family. On the other hand, among the Northern Thai, Lua and Tai Lue groups, women and men are commonly perceived to be equal. For the Northern Thai, Lua and Tai Lue**,** responsibilities within the household are divided according to age and gender. Women take responsibility for cooking and the household tasks, while the men are expected to carry out activities such as repair and maintain the house. Both men and women are involved in farming and make farming decisions together, though they undertake different activities based on whether the tasks are light or heavy. When compared to the past, women have a greater opportunity to access education, resources and employment, and women can now be found working as community and social group leaders.

Production Systems and Market

In 2012, the total agricultural holding area was around 0.18 million hectares. The major proportion of this was devoted to field crops (mainly maize, tobacco, beans and cassava), followed by rice, permanent crops, vegetables and flowers. The area of agricultural land under maize and rubber has increased in recent years, while that under rice has fallen (based on data from 2002 to 2013).

Traders, manufacturers and local agricultural cooperatives, both big and small, compete freely and actively in the area, meaning farmers can easily access merchants when they wish to sell their produce, in fact, quite often traders visit their farms. The agro-products market in Nan is operated by shopkeepers and companies. The most common crops grown in the area are maize, which is used as livestock feed, and also bean crops (both fresh and dried beans, mainly soybeans). There is a high demand for bean crops, but farmers in Nan province only produce small amounts of such crops.

Paddy rice is mostly grown in the lowlands as a subsistence crop, and its production period lasts from June through to November. Improved varieties of glutinous rice such as RD6 and Sun Pa Tong are also popular. The average area under planting is small (0.5-0.7 ha/farm) and the average yield is 4 tons/ha. Upland rice is also grown for subsistence by the ethnic minority groups in the highlands, which use a traditional fallow system of three to four years. Slash and burn agriculture is also practiced, to destroy weeds and pests, with land cleared during the dry season, between February and April. Direct seeding starts around June and the harvesting period is around October. The average area under planting for this system is 0.82 to 1.39 ha/farm, with the yield being between 1.44 and 2.36 tons/ha. Expansion of maize production areas reduce the fallow period of upland rice fields which results in lower productivity of upland rice.

Lowland maize is usually grown in May and harvested during August to September. With irrigation in place, a second maize crop can be grown after paddy rice in the lowlands. The average planting area in such cases is 5 ha/farm, producing an average yield of 5.94 tons/ha. Most farmers sell grains with a high moisture content at a price of 4 to 5 baht/kg to cooperatives, traders and sometime sell to a company by their own transportation. The upland maize can be grown once a year between May and November, for which slash and burn is practiced to clear the land. Direct seeding is a common way of planting maize on mountain slopes. The hybrid varieties of maize popular in the area are CPDK 888, Pioneer and Pacific. A lot of chemical fertilizer is used, to increase the productivity, and this makes production costs higher. The average maize planting area is 5.67 ha/farm, producing an average dry yield of 3.91 tons/ha, and most of the dry grain is sold to local merchants who visit the villages with threshing machines. These merchants may offer in-kind credit to the farmers, but farmers then have to sell their output to the merchants. A relatively high maize price of 8 baht/kg provides an incentive for farmers to expand their production areas, but if the price falls to 5 baht/kg or less, the farmers make no profit. The disadvantages of growing upland maize include the high chemical usage levels, as this pollutes the soil and water, as well as air pollution created by burning residues in the fields.

The number of rubber plantations in the area has increased due to subsidies being provided to local farmers and landholders by the Rubber Plantation Supporting Fund. These subsidies were given in the province in 2005. The average size of the rubber plantations is 1.89 hectares, and Phu Phiang district has the largest rubber planting and harvesting areas at 6,195 and 2,092 hectares respectively. The average, provincial rubber yield is 2.19 tons per hectare, and across the province rubber production is 12,029 tons. Different rubber tree varieties, such as RRIM 600 and RRIT 251 are commonly cultivated in Nan province. The farmers start the tapping when the rubber is six to seven years old, and sell it in the form of *cuplump* (a blanket-crepe rubber produced from the dried film sand lumps of rubber found in the tapping cups) due to the

lack of time and labor available for processing it into sheet rubber. There are two different types of marketing activity within the local rubber market; the actions of the middlemen and the auctions. The *cuplump* price the farmers receive at the auctions is around 39 to 45 baht per kilogram. At present, the market for rubber in Nan is not a major problem, and a lot of support comes from the Office of Rubber's replanting aid fund, which supports production, processing and marketing activities. However, the local rubber plantations are exposed to natural risks such as fire, lightning, storms and landslides.

The top ten vegetables by harvested area in Nan are sweet corn, pumpkin, cabbage, chili, swatow mustard (*Brassica juncea L Czernjaew*), ginger, garlic, Chinese mustard (*Brassica chinensis Juslvarparachinensis (Bailey) Tsenand Lee*), water spinach and Chinese cabbage. Of all these crops, ginger provides the highest net profit per unit of land. However, growing ginger also consumes larger amounts of cash and household labor than the other crops. Root knot nematode infections and soil-borne diseases are very important ginger crop diseases, as they cause the farmers to change the planting area every three years. Pumpkin incurs low production costs, but also provides the lowest profits when compared to the other vegetable crops. However, there is a high demand for pumpkin in Nan, from many market sources.

The top ten fruit crops harvested in Nan are lychee, longan, lime, rambutan, mango, tamarind, orange, cashew nut, banana and mulberry. The fruit crops which provides the highest net profits per rai (0.16 ha) are Si Thong orange followed by mulberry and mango (Nam Dok Mai variety). Rambutan, mango, tamarind and mulberry are considered to be fruit with a good market potential, because they are in high demand, especially in other provinces and abroad.

The main marketing channel for vegetables is the local markets in the province, but some farmers sell their produce to entrepreneurs from other provinces. The market channel for vegetables can be divided into the fresh vegetable market and the agro-product processing market. For the processing market, deals are done through local entrepreneurs and agricultural cooperatives. Most fruit are sold through local middlemen who collect the fruit and sell them at wholesale markets in other provinces, such as Talad Thai and Talad Si Mum Muang in Bangkok, markets in the northeastern region, and also markets abroad.

Farmers in Nan province grow many varieties of mushroom; for example, oyster, Phoenix Oyster and Bhutan Oyster mushrooms. Mushrooms are grown in mushroom growing houses and are usually cultivated in a bag. Mushroom growing houses can be classified into two types: temporary and long term. Most of the study farmers are equipped with machines and tools such as ribbon mixers, compacting machines and steam boilers. Farmers mainly use household labor in order to grow mushrooms, though

they also hire external labor to help with certain processes such as preparing the mushroom bags, which is a time consuming activity. Farmers can harvest mushrooms for seven to eight months a year. The problems encountered when growing mushrooms include the spores not growing and damage to the spores. Most mushrooms are sold at local markets through local traders. The price per kilogram of mushrooms varies depending on the variety. For example, the price of Lentinus Polychrous Berk is 150 to 170 baht, for Lentinus Squarrosulus it is 100 to 110 baht and for Bhutan Oyster mushrooms it is 50 to 70 baht.

Livestock production in Nan province plays a minor role when compared with crop production. About 33% of all households have some form of livestock production activity. Raising chickens is the most common livestock farming activity in Nan province, followed by pigs, ducks and beef cattle. Most chickens are raised free range in fields around people's homes; for home consumption, and the main problems experienced are poultry diseases. Pigs are raised for cash, either based on personal investment or through contract farming mechanisms. The high cost of feed and the pollution generated when rearing pigs in the community are common problems encountered by pig farms. Beef cattle are also reared, for additional farm income; however, a lack of grass is a key problem in the area.

Natural Resource Management

Nan Province has a tropical savanna climate. Winters are dry and warm, and run from December to February, after which temperatures rise until April, which is very hot and has an average daily maximum temperature of at 37 °C (98.6 °F). The monsoon season runs from late April through to the end of October, with heavy rains and somewhat cooler temperatures experienced during the day, although nights remain warm. Elevations in Nan province range from 128 meters to 2,086 meters above mean sea level. A slope map generated from an elevation map shows that Nan province has slope gradients ranging from 0% to 300%. The agro-ecological zones generated from the elevation and slope maps show that Nan province is composed of lowland, upland and highland areas; but with most of the area being upland and highland terrain, and especially in Chaloem Phra Kiat, Thung Chang, Bo Kluea and Ban Luang districts. Characteristics of agricultural land in Nan includes a depth that ranges from shallow to deep, a pH of low to very low, moderate to good drainage, low soil fertility and a high potential for soil erosion on sloping land. Based on land use map generated by the Land Development Department at the Ministry of Agriculture and Cooperatives, maize has the largest growing area in the province, followed by swidden areas which have been abandoned to help improve the soil, paddy fields and mixed fruit trees. Forested areas can be categorized into five classes: dense evergreen forest, dense forest plantations, dense deciduous forest, disturbed evergreen forest and disturbed deciduous forest. Of these groups, deciduous forest covers the largest area in Nan province, at 667,193 ha,

followed by evergreen forest at 103,201 ha (2014). Man-made water sources in Nan province cover 3,840 ha, while the Department of Agriculture supports farm ponds, which cover an area of 257 ha (2014).

Pathway Analysis

Eleven agricultural diversification initiatives in which communities, groups of small-scale farmers or individuals have successfully diversified their land use activities to promote sustainable agriculture and livelihoods were selected for this study. The aim was to investigate the relevant background to these initiatives and capture important information regarding the origins, change drivers, institutionalization and organizational activities of these projects, as well as their support and enabling factors. The analysis combined Outcome Mapping (OM) and Driver-Pressure-Impact-State-Response (DPSIR) as part of the analysis framework, the aim being to reveal and compare the pressures that drove changes in the levels of awareness of the risks associated with growing commercial crops, and to then change these agricultural practices. To do this, existing livelihood assets (natural resources, physical structures, and financial, social and human capital) were utilized, together with institutional and political structures, so as to facilitate the modification of livelihood strategies and achieve outcomes favorable to the practice of sustainable livelihoods.

The change and livelihood transformation pathways are framed and illustrated using OM; to clearly address the steps involved in successive changes, as well as the outputs/outcomes, as accompanied by important factors and the environment. The 11 selected cases include three individuals using an integrated farming system, four farmer groups specializing mainly in rice seed production, three safe vegetable and organic vegetable producing groups, and one pig farming group.

Most of the initiatives have emerged or been driven by the direct and indirect pressures or threats arising from cultivating commercial crops with unstable/fluctuating commercial prices, from a depletion of the land and also from water resource limitations, leading to a decline in crop yields and increased livelihood risk. Personal characteristics and the capability to foresee and analyze these pressures, as well as exchange points of view with neighbors and within farmers' networks, play an important role in raising concerns, perceptions and awareness, and promoting change, and all these factors were assessed during the research. Therefore, such actors of change should be considered when facilitating and expanding sustainable diversification. However, inspiration and support from other sectors are also crucial factors in driving the pathways forward. Support from diverse sectors whose tasks and agendas fit with the pathway's direction also play an important role in enabling further achievements and outcomes. Remarkably, most of the farm cases described here are either located in irrigated, lowland areas that facilitate the diversification of agricultural practices, and/or

have land title documentation making it possible to get support from the government sector. Moreover, associating with an existing network (Jogo and HMN) substantially shapes the success pathway for farmers. The common outputs and outcomes of change are reductions in agricultural input costs, increases in productivity and/or income, decreases in health risks and stronger levels of social unity. All of these are essential elements for the development of livelihood security.

Each initiative clearly reveals unique pathways and supporting factors. There is no clear, well-planned set of changes representing the first move; each step is fundamental in helping to determine and support the next move, and there is no definite end-point. Pathway analysis attempts to unfold how changes emerge from a number of supporting factors and conditions, those that come together at the right time. Therefore, such as analysis provides an example for "learning" rather than "copying". Out-scaling sustainable agriculture at first requires an understanding of the existing knowledge and practices used, and also the insight pathways formed. Any alternative approaches must be relevant to the diverse agro-ecological and socio-economically contexts present, and also effectively address the risks and vulnerabilities the farmers face. If any alternative approaches are neither compatible with the existing risk context, nor able to provide a return at least on a par with the current, undesirable practices, subsidies, compensation and/or additional incentives may be required. In addition, having the appropriate institutions, policies, rules and regulations in place is essential; to provide support and allow farmers access to the sources of capital and to the assets required to facilitate the adoption of alternatives. In Nan province, sustainable agriculture and resources conservation and management are particularly relevant, and there are a number of key actors and organizations playing an active role in this area, both individually and through the use of networks. Any new organizations entering Nan to work in this area could learn from these existing entities and their synergies; aligning with them to agree on the key issues, to develop appropriate initiative and innovations, and to form relevant interventions.

Identification of Entry Points

Based on the findings of this report, we have developed the following entry points for any research initiatives focused on the 'Humid tropics'.

1. Explore the existing knowledge on sustainable agricultural systems in the target area and develop alternatives that are both diversified, suitable for each agro-ecological zone (highlands, uplands and lowlands) and that also cover the diverse socio-economic contexts present. For example, crop choices offered to Lua farmers who live in the highlands under rainfed condition, plus who have limited financial and physical capital available, should be different from those offered to Hmong farmers living in upland areas but who do have access to irrigation and credit. Also, alternatives should be

developed that address the varied risks and vulnerabilities that farmers face. Hence, assessments of the risks and levels of vulnerability experienced by the target farmers should be carried out.

2. When developing alternatives to the cultivation of upland maize, which is considered an unsustainable crop, not only ecological and social conditions should be considered, as already mentioned, but also the economic viability and stability of alternatives to the target farmers. If the alternatives developed are neither compatible with the existing risk context, nor able to provide a financial return at least equivalent to the current, undesirable practices, then subsidies, compensation and/or additional incentives may be needed. Subsidy or compensation mechanisms should be developed based on consultation with the relevant institutions, and should provide effective incentives for farmers to switch to a more sustainable system. For example, farmers may be asked to set aside sloping land for planting forest species and fruit trees. Incentives to change should be provided during non-yielding periods. To find out what incentives should be provided to the target farmers, focus group discussions should be held with the target farmers and relevant institutions, to identify the most practicable and suitable incentives for the farmers. One example of an incentive provided in the study area was help given to farmers for them to increase soil fertility by examining their soil and providing suggestions and methods on how to increase soil fertility, as well as the tools needed to do it. The Highland Research and Development Institution (HRDI) has applied such incentives to change the behavior of farmers practicing slash and burn in the upland maize production areas of Nan province. This project was successful, as slash and burn practices stopped in the target village. However, different groups of people may have different interests in a given area, so the interests of all members of a target group should be examined before implementing any schemes.

3. As access to markets is a crucial factor in relation to land use in the highlands, then alongside new crops marketing information should be provided to the target farmers, such as product quantity and quality requirements, prices, as well as where and how to sell their crops. The creation of farmers' groups should be supported; to manage production and marketing activities, plus at the beginning of a project farmers should be trained on how to run such groups, so they can then manage the process by themselves. However, advice should continue to be provided, when needed.

4. In Nan province, sustainable agriculture and resources conservation and management are particularly relevant, and there are a number of key actors and organizations playing an active role in this area, both individually and through the use of networks. Any new organizations entering Nan to work in this area could learn from these existing entities and their synergies; aligning with them to agree on the key issues, to develop appropriate initiative and innovations, and to form relevant interventions. A holistic approach should be used to deal with area-based management issues, so that problems,

their root causes and systematic linkages can be identified. Sharing any understanding of the holistic context and issues present among relevant actors is particularly important when taking this approach; for example, any existing and effective practices and mechanisms used by the relevant parties should be identified and used, so as to fill-in any knowledge gaps and to help resolve any problems together.

About this report

This report was written within the context of Humidtropics, a CGIAR Research Program that aims to develop new opportunities for improved livelihoods in a sustainable environment. AVRDC – The World Vegetable Center was responsible for this study and contracted it to Chiang Mai University (AVRDC Contract Nr: SC-202-26). The work was supervised by Pepijn Schreinemachers, Agricultural Economist at AVRDC – The World Vegetable Center.

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Table of contents

Tables

Figures

1 Introduction

Problems experienced in Nan province such as deforestation, drought, soil degradation and air pollution are strongly linked to maize monoculture on sloping land in the area, a practice considered a key part of the upland farmers' livelihoods. The rapid expansion of hybrid maize cultivation in the highlands has also contributed to an increase in the use of chemicals on the land, leading to contamination of local water sources. Such practices are common in northern Thailand, and especially in Nan province, where maize production has expanded rapidly in recent years, leading in turn to the degradation of natural resources. These problems have certainly affected the sustainability of agricultural production on sloping land throughout the province.

Recently, a number of agencies have started working together to find a solution to the land use problems faced in the Nan highlands, the aim being to introduce more sustainable land use practices. Changing cropping systems by increasing the diversity of production systems has attracted the interest of a number of agencies and research programs, including the Humidtropics, which supported this study, the aim being to develop integrated agricultural systems by analyzing the current situation in Nan province and possible solutions to the problems experienced there. The specific objectives of this study are:

1. **Problem analysis:** To describe the problem of unsustainable land use and analyze the direct and indirect causes of it.

2. **Quantitative data collection:** To describe the current situation in Nan province in terms of the farming systems and soil fertility management practices used, as well as the markets and institutions in place with regard to maize, livestock, vegetables, fruit and mushrooms.

3. **Pathway analysis:** To describe ten small-scale agricultural diversification initiatives in Nan province, those that could serve as a model for sustainable intensification elsewhere.

2 Methods

2.1 Problem analysis (Objective 1)

This analysis provides a clear definition of why land use in Nan province is unsustainable, and identifies the direct (primary) and indirect (secondary and tertiary) causes of this. The analysis provides a balanced view, taking into account the actions of local stakeholders while also considering the relevant scientific evidence where available. As

well as reviewing the relevant literature on the topic, in-depth key informant interviews were conducted using a semi-structured approach. The guidelines followed as part of this process were as follows:

- What elements are central to the unsustainable land use problem in Nan?
- What are direct and indirect causes of such problems?
- What are local people doing to try and resolve the problems faced?

The study's key informants were drawn from several agencies working in Nan province, including the Hak Mueang Nan Foundation, the Highland Research and Development Institute and the Pid Thong Lang Phra Foundation (following the Thai King's initiatives), as well as government agricultural officers at the district and provincial levels. After synthesis problems and causes of unsustainable land use from both the literature and from key informant interviews, a problem tree was constructed, with its validity and completeness verified by leading farmers from three villages located in highland areas.

2.2 Quantitative data collection (Objective 2)

This provides a broad characterization of Nan province, including an overview of its development indicators, production systems, markets and institutions, as well as the natural resource management activities taking place there. During the research, data were collected from existing sources such as national, regional and provincial statistics, as well as from previous research studies carried out in Nan province and a more general literature review. In-depth, open-ended interviews were held with key informants, with focus group discussions also used to fill any data gaps and verify the data which had already been collected from secondary sources.

The main sources of secondary data included:

- Development indicators, collected from the Nan Provincial Statistical Office and from other annual reports and statistics (see Appendix A1)
- Data on farms were collected from provincial and district agricultural extension offices in Nan.
- Data on institutions and cropping systems were collected from previous research studies conducted in Nan province. Additional farm surveys, using a semi-structured questionnaire, were also performed in relation to mushroom production.
- Data on livestock systems were mainly collected from the Nan provincial and district livestock offices.
- Data on natural resource management, in the form of maps and attribute data, were gathered from the Land Development Department at the Ministry of Agriculture and Cooperatives. These material included maps related to topographic, land use, soils and administrative boundaries. Rainfall and

temperature data for the period 1984 to 2014 were obtained from the Thai Meteorological Department at the Ministry of Information and Communication Technology. Information on water management practices was also collected from the Royal Irrigation Department at the Ministry of Agriculture and Cooperatives. Meanwhile, data related to the management of forest resources were collected from the Royal Forest Department, which is part of the Ministry of Natural Resources and Environment.

Analysis methods:

- Descriptive statistical analysis is used here to describe the general development of the agricultural sector in Nan province, and this include the key characteristics of the current farming systems practiced in the area (both cropping and livestock systems). Also, detail will be provided on the farm management and marketing systems used for rice, maize, key fruit and vegetables, including mushrooms, the role of local government offices and the private sector in relation to agricultural extension and agricultural cooperatives.
- Geographic Information Technology was used to conduct a spatial analysis of the maps available for Nan province, focusing on natural resource management issues. An elevation map of Nan province derived from a topographic map (1:50,000 scale) was stored digitally using Arc/GIS software. The vector file created was then transformed into a raster image (Digital Elevation Model, DEM) to support image analysis using TOPOGRID. The DEM image produced was then used to carry out terrain analysis; to obtain topographic attributes such as slopes.
- Rainfall data were obtained from the Thai Meteorological Department, and this was analyzed using descriptive statistics, to produce average monthly data for the whole of Nan province.
- A land use map for 2014 was obtained from the Land Development Department, at the Ministry of Agriculture and Cooperatives. The data obtained were classified into two main land use groupings: agricultural and natural resources use (forest and water areas). Each of these was overlaid from an administrative boundary map and then summarized by district before being presented in a tabular format.
- Soil information was obtained from a soil groups map generated by the Land Development Department at the Ministry of Agriculture and Cooperatives, and this was overlaid with the administrative map for the province and broken down by district before being shown in a tabular format

2.3 Pathway analysis (Objective 3)

The research for this study focused on a number of agricultural diversification initiatives in Nan province, and also in other provinces of northern Thailand where individual, communities or groups of small-scale farmers have been able to successfully diversify

their land use activities; to promote and intensify land sustainability. Data were then collected in relation to the selected initiatives; to investigate their background and the changes they have experienced. This aim was to develop an understanding of the initiatives' origins, drivers of change, organizations, operation scales and objectives, and types of external support they have received to date. The information obtained was then evaluated before outcome maps for each case study were compared. This comparison focused on the following aspects:

- Critical enabling and limiting factors.
- Benefits for and impacts on members' livelihoods and their communities.
- The potential for up-scaling the initiatives and the possible consequences of this.

Inventory of the initiatives

The first task of the research was to collect information on the existing agricultural diversification initiatives taking place in Nan province. To do this, first the Hak-Mueang-Nan Foundation was contacted, as this organization promotes the expansion of sustainable agriculture. A list of such initiatives was then obtained, before the 'snowball technique' was used – in which one person gives the name of another contact – to gather the details of other initiatives.

Initiative selection

From the list of initiatives obtained, 11 case studies were selected, covering the diversification of rice, field crop, fruit, wood and mushroom cultivation, as well as livestock rearing. These cases included individual farmers and farmer groups.

Information gathering

For each case study, in-depth interviews were held with group representatives and individuals using semi-structured interviews (SSI), to help develop the narratives of each interviewee. The steps followed when introducing changes within each initiative were focused upon, to understand the drivers and environmental factors influencing the groups' work. Also, information regarding the institutional set-up and the support provided was obtained. The interviews covered the following topics:

The origins and historical timelines of each group, covering:

- Drivers and enabling factors (knowledge, resources and capital availability)
- Activities/production systems
- Benefits and impacts of the groups' work (e.g. income, food, risk reduction, knowledge, skills, self-confidence and social capital)
- Supporting sectors, actors and institutions, and
- Market opportunities

In the case of group initiatives, institutionalization and organization were investigated to explain:

- Membership
- Rules/regulations
- Potential for up-scaling the initiative and the consequences of this (e.g. on market competition).

Pathway and livelihood outcomes analysis

The information derived from the interviews was then analyzed, in order to formulate the pathway of success displayed by each initiative and using a combination of outcome mapping (Earl *et al*., T. 2001), Driver-Pressure-Sate-Impact-Respond or DPSIR (DFID, 2001), and the theory of change frameworks (Taplin and Clark, 2012). The pathways of the 11 initiatives were then generalized to represent the critical success factors and their supporting elements. A comparison of the initiatives was conducted using the sustainable livelihoods framework, to systematically reveal and compare risk dimensions and the vulnerability context, as well as assess the livelihoods of those involved in the initiatives, the transformation structures used and the processes that have driven and supported changes in livelihood strategies, those aimed at achieving outcomes in support of sustainable livelihoods.

3 Problem Analysis

3.1 Sustainability of land use in Nan province

Nan province is located in the eastern part of northern Thailand, with Lao PDR located on its eastern border. Approximately 85 per cent of the province's total land area is mountainous. It is the origin of Nan watershed, one of the 25 main watersheds in Thailand. Lowland areas constitute only 2.51% of total land. Agriculture is the main source of income for local people, but areas suitable for agriculture are limited.

A land use and land cover change study in Nan province carried out over the period 1995 to 2012 found that after the national logging ban was introduced in 1989, natural forest areas declined from 856,246 ha in 1995 to 500,439 in 2012 or 41%, whereas agricultural areas increased by 51.1%, from 342,997 ha in 1995 to 518,257 ha in 2012 (Wongtui, 2014). These figures show that the expansion of agricultural areas led to a decrease in forest cover. Especially on steep slopes (>35%), areas which require protection for watershed conservation purposes, natural forest areas declined from 39.31% of the total land area covered in 1995 to 19.40% in 2012, and the most severe deforestation occurred during the period 2009 to 2012 (Wongtui, 2014).However, this deforestation figure is higher than the official data provided by the Nan Agricultural Office. GISTDA also

analyzed land use change for the period 2002 to 2013, but only in three sub-districts in Santi Suk district and one sub-district in Pua district (see district map in Figure 1). The results showed that some natural forest areas had been changed to agriculture over that period. This land use change occurred in 23% of national park areas, 11% of reserved forest areas and 14% of class 1A and 2 watershed areas, those preserved as protected forest areas and commercial forests respectively (Sal forest, 2013).

Maize as a commercial crop was being introduced to farmers in Nan around the same time as the commercial logging concessions started in 1973 (NIAS, 2001). Maize cultivation has expanded rapidly since 2007; for example, by more than double from 60,597 hectares in 2007 to 127,754 hectares in 2010 (Nan Agricultural Office, 2015). The areas into which maize cultivation has extended have been steep slopes in the uplands, causing a major decline in natural forest areas.

Changes in land use (deforestation) are causing significant environmental problems in the study area, including soil and water erosion, a loss of soil fertility, sedimentation of water courses, drought and loss of biodiversity, all of which affect the ability of biological systems to support human needs (Lambin *et al.*, 2003). As a consequence, land degradation has also led to the more intensive use of inputs for maize cultivation.

Over the last decade, land use change in Nan has impacted on people's livelihoods. Farmers now depend more on the use of chemicals to boost production, and this has had an impact on human health. Growing maize in highland areas requires a lot of chemicals to be used over several stages. Chemicals are mixed with the seeds to protect them from fungi and insects, plus are used to boost growth rates as well as to control weeds. By 2009, chemicals used for maize production activities constituted 82.8 per cent of total chemical use in Nan province (Sal forest, 2013). Slash and burn agriculture is also used to eradicate weeds prior to cultivation and evidently adds to the north of Thailand's air pollution problem, which is serious during the March to April period.

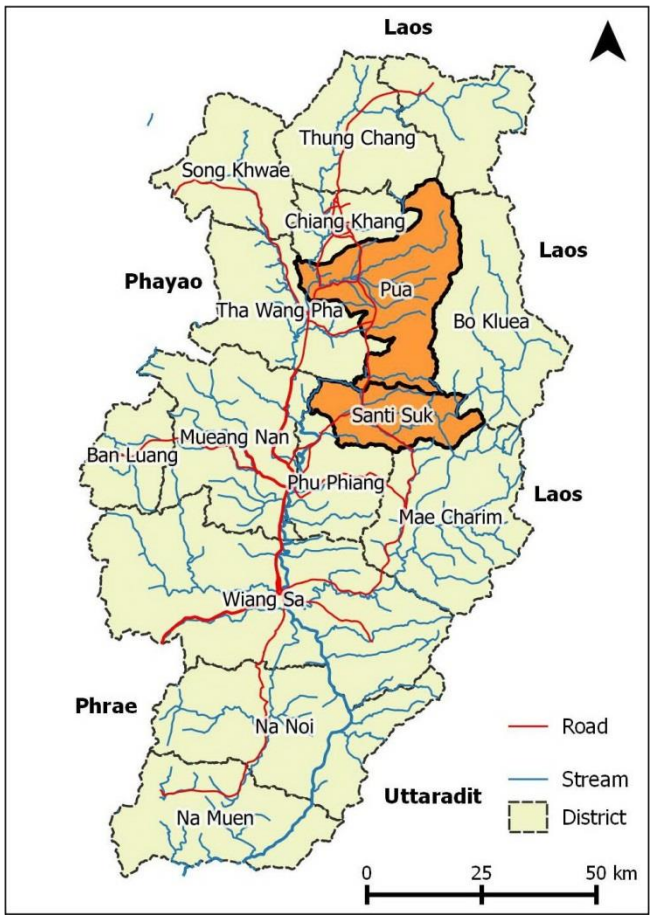

Figure 1: Map of Nan province showing district boundaries

In response to unsustainable land use patterns, Nan development policies have been adjusted to align with the government of Thailand `sufficiency economy principle', and a strategic plan has been developed to achieve green growth, whereby economic development is achieved through the sustainable consumption of natural resources. Accordingly, rubber tree and other cash crop plantations have been promoted over maize, in an effort to establish crops which have a comparatively lower negative impact on the environment. However, the suitability of such a policy has been questioned, stirring up controversy among involved stakeholders in the province (TEI, 2012).

3.2 Causes of unsustainable land use

The causes of unsustainable land use in Nan described here are mainly drawn from the reviewed literature and from key informant interviews. Focus group discussions with farmers in Nan (see Appendix A2) were also conducted in order to verify the validity of the data captured. All the key informants said they are concerned about the problems caused by unsustainable natural resource management and land use in Nan province. The organizations spoken to are working to resolve or alleviate the problem within their

jurisdiction using their own resources, though they said they would be willing to collaborate with other institutions.

The causes of unsustainable land use in the area represent the forces driving farmers to use land in such a way that its fertility cannot be restored or replenished by natural processes or external inputs. In other words, such land use practices cannot continue indefinitely. There were found to be three direct causes of unsustainable land use, as follows:1) The expansion of upland maize farming on steep slopes 2) The low adaptation of conservation practices in the highlands, and 3) Poor natural resources. In this study, the root or underlying causes, which are usually the main drivers of unsustainable land use, are presented under each direct cause.

3.2.1 Expansion of upland maize farming on steep slopes

Deforestation in the form of forest clearance for logging concessions–which allows for agricultural expansion–has been identified as one of the main causes of unsustainable land use in Thailand. However, based on the description of unsustainable land use contained in the previous section, the main agricultural activity in the Thai highlands is maize cultivation, so the aim of this study is to establish the underlying causes of the expansion of maize cultivation on steep slopes in Nan province.

- **Economic pressure**

HRDI Watershed Management Unit officers and members of staff from the Pid Thong Foundation, plus provincial extension officers, agreed that economic pressure is one of the main causes of the expansion of maize cultivation in Nan province. Due to the success of economic development in Thai rural areas, most farmers require cash to improve their livelihoods. Their children need to go to school, and so expenditure needs to take place on education related activities such as transportation, clothes and equipment. In addition, access to public facilities such as roads, electricity and modern communications has led to greater aspirations and, as a consequence, a greater demand for increased incomes, thus increasing economic pressure. Maize is a good commercial crop from the farmers' point of view, as it can provide a fast return at relatively low risk.

- **Indirect promotion of maize cultivation in highland areas**

In recent years, the growing of maize has been promoted in Thailand's highland areas, not directly by any private company, but through local merchants who offer in-kind credit to farmers, regardless of the environmental impacts of their agricultural practices. Due to a high demand for maize from the animal feed industry, improved varieties have been developed in order to increase maize productivity levels. Hybrid seed varieties with drought and disease tolerances developed by private companies have been adopted

widely across Nan's highland areas, as maize can grow well without additional equipment being required. For highland farmers it is an easy-to-grow crop and requires minimal care. As a result, when growing maize farmers have time to participate in other social or leisure activities, plus farm inputs in the form of seeds, fertilizers and other chemical inputs can be obtained from local merchants based on credit. No cash is needed to obtain the inputs required. In addition, the output market is assured, as farmers can sell maize to local merchants at market prices. These merchants visit their farms, which is convenient for the farmers and means that no cash is required for transportation. So, maize is a fast growing, easy and convenient crop to grow for highland farmers. Furthermore, alternative crops to maize are not able to compete with maize on these factors.

However, maize productivity has recently decreased due to land degradation. Farmers have been applying more and more fertilizers, impacting upon production costs, while the selling price depends on the market. The interviews held with lead farmers revealed that some farmers are in debt due to cultivating maize, but have continued to grow the crop because they need the money to pay back their debt to local merchants. They therefore, find themselves in a form of debt and poverty trap.

- **Supportive government policies on output prices**

Government policies encourage farmers to grow commercial crops to help alleviate poverty, and this has led to a change in agricultural production systems, as the farmers have moved towards monoculture practices, especially in the highlands (Talerngsri, K and Pongkijvorasin, S., 2012). The Thai government supports maize prices through mortgage and price guarantee schemes introduced over the period 2008 to 2010. These schemes have played a significant role in providing economic incentives to farmers to produce maize, since the price risk is quite low. Officers from the Watershed Management Unit of Nan province mentioned that maize is also a politically important crop in Thailand, for if the crop yields fail due to natural disasters or a drop in market prices, farmers usually gather in front of a government office to demand support be provided to them, and farmers in the province tend to get what they ask for.

A similar issue has developed with regard to other crops such as rubber. In 2004, the Thai government promoted rubber planting in new areas across the north and northeast of Thailand, with a target set of expanding the crop to cover one million rai. Since then, the land area covered by rubber plantations has expanded rapidly in the north of Thailand, including in Nan province. However, rubber planting is also a monoculture; hence, there is some justified skepticism whether it is a sustainable form of land use.

- **Limited market information and access to alternative crops**

HDRI's development bureau director mentioned that access to the market is a crucial factor influencing land use in the Thai highlands. Farmers have only limited access to market information, and only use land to grow crops that have an assured market. Due to this lack of or limited access to information, local farmers tend to be risk averse, and are unwilling to accept the high risks associated with growing a new crop. Replacement crops would have to provide a better level of income and have a guaranteed market, as well be supported by the government, in order to be adopted. HRDI identified the three conditions as being required as: 1) the crop can be rainfed, 2) the crop is easy to transport, and 3) the market for the crop is certain. For highland farmers, the growing of maize meets these three conditions, and this is the reason why maize is preferred.

3.2.2 Low adoption of soil conservation practices

A number of agencies promote soil conservation among farmers in the Thai highlands, but they have found that farmers' rates of adoption are quite low. The underlying causes of this low level of adoption can be summarized as follows:

- **Land rights**

Tenure security provides incentives for long-term land investment activities such as planting trees and the building of soil and water conservation structures (Feder, 1987 and Alston *et al.*, 1995; cited in UNDESA, 2012). But in the highland areas of Nan province, most farmers cultivate without land title (an absence of legal rights). In frontier areas, deforestation is a common practice, as it is carried out in order to secure tenure. An absence of land rights usually leads to unsustainable land use activities, as there is no incentive to invest in the land. Both district and provincial extension officers, as well as the Pid Thong Foundation and Hak Mueang Nan Foundation, all agree on this point. They suggest that community land title is a good solution to the insecure land rights issue.

There have been studies undertaken showing that investments by farmers with customary land tenure are comparable to or greater than investments by farmers holding land with secure title deeds (leasehold or freehold) (Toulmin and Quan 2000; Deininger 2003). Hence, providing customary land tenure to highland farmers may act as an incentive for them to invest in conservation practices.

- **Forest related policy**

In Thailand, forest policy and governance is based on a top-down decision-making structure, including the actions and methods of state forest institutions (Lebel *et al.*, 2004). In order to halt deforestation, the Thai government began demarcating protected

areas very rapidly, and often without having carried out field surveys in advance, leading to conflicts between the state and local people.

Hak Mueang Nan's former chairman said that the forest laws and forest officers' practices are outdated and not consistent with present-day livelihoods in the highlands. He added that farmers wish to transform their sloping land into terraces in order to grow rice, but that they are not allowed to use tractors within the forest reserve areas. However, in practice these areas have been used to cultivate maize for a long time, with no problems arising because maize is seen as a temporary crop, while transforming land into paddy fields is seen as a long term land use strategy. As a result, farmers have not been allowed to act in a way which suggests they occupy the land.

- **Negative attitude towards the economic benefits of the forest**

Due to forest legislation and the protection of the forests from other forms of activity, and especially economic activities, negative attitudes have developed regarding the economic benefits of forests. If farmers do not realize that the forest can provide them with economic benefits, they may be less willing to protect it, especially poor farmers. The head of and staff from the Watershed Management Unit in Nan province said that people do not see value in the forest and lack the knowledge required to use the forest in a sustainable manner in terms of its economic use. Also, government policies are not focused on the economic links that exist between trees and people's livelihoods. For example, the food, fiber, forage, fuel wood, pharmaceutical products and bio-chemicals that can be derived from the forest can provide sources of income to local people. Therefore, agro-forestry that combines agriculture and forestry technologies to create more diverse, productive, profitable and sustainable land-use systems, could be integrated into highland livelihoods.

- **Attitudes and cultures of the ethnic minorities**

HDRI, the Pid Thong Foundation and the Watershed Management Unit all said that the ethnic minorities also contribute to unsustainable land use. They added that each ethnic group has a different way of life; their attitudes and cultures are different. Some ethnic groups, especially the Lua (the largest ethnic minority group in Nan), are relatively conservative and risk averse, and as a result, it is difficult to promote new crops or conservation techniques among them when compared to some of the other groups. If wishing to introduce a new technique, a pilot project has to be run through a contact person who has the potential to make it succeed. The Pid Thong Foundation said that some villages have good leadership and are more willing to learn and develop than others.

We interviewed the leaders of a Lua village, and they said they have no time to undertake conservation activities such as making organic fertilizers – a skill they have been instructed on. So, although they have adopted organic farming techniques, they prefer to buy their fertilizer from the market, saying they have no time to make it.

3.2.3 Poor management of natural resources in the highland areas

A former chairman of the Hak Mueang Nan Foundation (Somruay Phadphon) said that the poor management of natural resources is the key cause of unsustainable land use in Nan province, and that the more effective management of natural resources would help overcome this. However, he added that the root cause of this poor management of resources seems to be the characteristics of the resources themselves.

- **A lack of water resources**

A lack of water resources in the highlands was mentioned by the Hak Mueang Nan Foundation (Provost Pithaknanthakoon), the Pid Thong Lang Phra Foundation and HDRI as being one of the key causes of unsustainable land use in the area. As water is an important factor in helping to determine what crops can be grown in an area, the lack of it means farmers have little choice when wishing to grow crops other than rainfed maize. In areas where water is readily available, people can invest in water distribution systems with the help of NGOs, and farmers can then cultivate other crops. However, in the uppermost reaches of the Thai highlands, where little water is available, farmers have little choice but to carry out rainfed maize monoculture.

- **Low soil fertility**

Most of the land in Nan province is mountainous, and based on soil group information provided by the Land Development Department (for more detail see section 4.3), most soils in the area have a naturally low fertility level and are at a high risk of being eroded away on sloping land. As a result, most soils in the area are not suitable for agricultural activities.

The results of a problem analysis carried out in relation to the study area are shown in Figure 2 in the form of a problem tree.

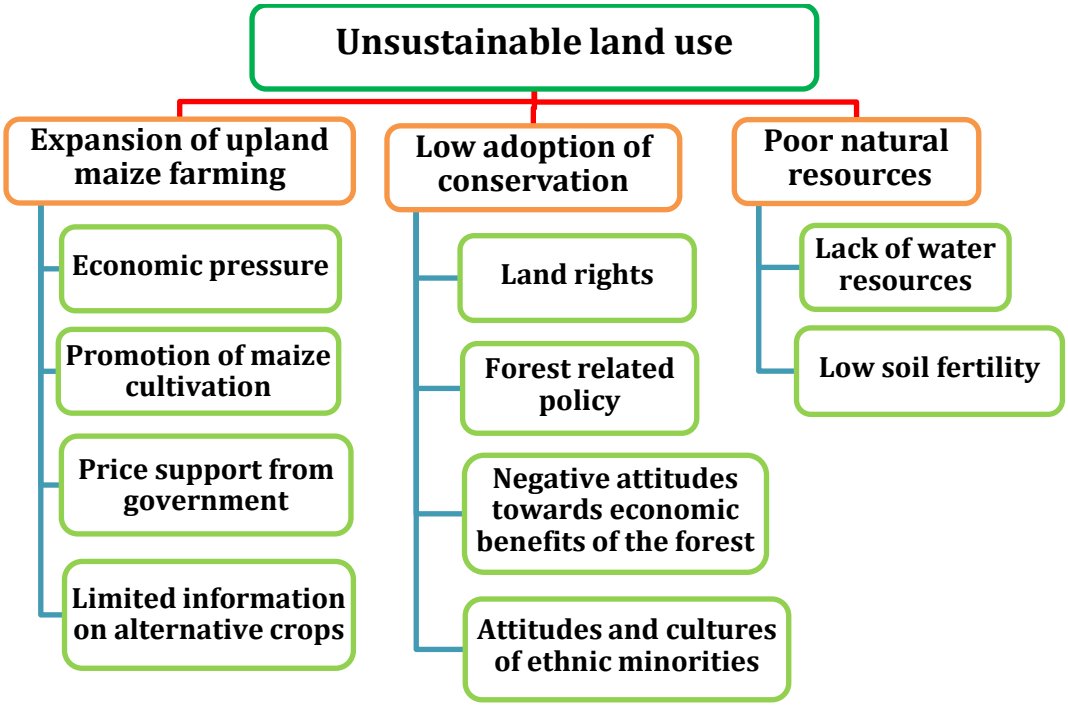

Figure 2: Problem tree regarding the root causes of unsustainable land use in the study area

4 General characterization of agricultural development in Nan province

4.1 Development overview

4.1.1 Population and ethnic minorities

Nan has a population of 478,264, of which 50.3% is men and 49.7% is women (Department of Provincial Administration, 2014). Statistics for the period 2004 to 2014 show that population growth in Nan is almost zero, at 0.06%. There are 157,881 households in the province, of which 63% is represented by farm households. The province's population density is 42 persons per square kilometer, much lower than other areas of northern Thailand (average of 69 persons per square kilometer) and the country as a whole (124 persons per square kilometer). There are five districts in Nan for which the population density is higher than the provincial average, these being Mueang Nan (100), Mae Charim (100), Ban Luang (98), Na Noi (72) and Pua (70).

In 2012, 70% of the total population in Nan was of working age (15-59 years old), and this has been increasing over time, as the same figure was 64.9% in 1992 and 67.7% in 2002. However, the age balance in Nan is also changing. The proportion of children in the

province has been declining over recent years, having been 27.8% in 1992 and 16.6% in 2012. On the other hand, the proportion of elderly people is increasing; it was 7.3% in 1992 but had risen to 13.4% by 2012 (see Appendix B1.) The dependency ratio is 0.43 and has been decreasing in recent years, falling from 0.54 in 1992 to 0.48 in 2002. (National Statistical Office, 2015)

Nan has a low urbanization rate, with only 12.8% of the total provincial population living in the city of Nan (mueang district). In each district, most people also live outside the municipal areas (87.7%), and most local people depend on agriculture for their livelihoods. Most of the population is constituted of northern Thais (80%) living in the lowlands alongside rivers, while the remainder is comprised of five ethnic minority groups (Hmong, Khmu, Lau, Mien/Yao and Mlabri) who live mostly in the highlands. Statistics provided by the Social Development Center (Unit 25) for Nan province show that the largest of these groups is the Lua (representing 42% of the ethnic minority population in Nan province), followed by the Hmong (31.9%), Mien (11.4%), Khmu (8.4%) and Mlabri (0.3%) (see details in Appendix B2). Most of the Lua live in Bo Kluea (29,4%), Pua (21.8%) and Chaloem Phra Kiat (18.5%), whereas most Hmong live in Pua (18.6%), Mueang Nan (16.6%), Thung Chang (13.3%) and Wiang Sa (12.3%).

To analyze the socio-economic status of the ethnic minority groups, Village Basic Information (NRD2C) and Basic Minimum Needs information was obtained from the Community Development Department. The data are based on a sample of 58 ethnic minority villages from three districts with the largest populations of ethnic minority members, these being Pua, Bo Kluea and Mueang Nan districts. The data show that the average annual household income among the ethnic minorities (2014 figures) is the highest in Mueang Nan district at 201,891 baht, followed by Pua district at 185,723 baht and Bo Kluea district at 152,718 baht. The average per capita income across all three districts is above the poverty line for Thailand. In addition, the average household income for the three districts is higher than the average household expenditure (see Table 1, and for more details see Appendix B3-1, B3-2 and B3-3). Data on land use (2013) shows that the average amount of agricultural land held per household is 19.31 rai or 3.1 hectares, and about half of the total sample households grow upland rice and maize. The average planted area for rice is 16.41 rai or 2.63 hectares per household, while for maize it is 12.10 rai or 1.94 hectares per household (for details see Appendix B4). With regard to education, 53% of the respondents completed compulsory education (i.e. to the 9th grade), while 28.56% said they are still studying and only 1.84% said they have a degree. Meanwhile, 7.72% said they are illiterate (for more details, see Appendix B5).

Table 1: Annual income and expenditure in selected ethnic minority villages in Nan province (2014)

District	Annual Household Income (baht)	Annual Household Expenditure (baht)	Per Capita Income (baht/year)
Mueang Nan	201,891	113,000	48,526
Pua	185,723	108,939	43,818
Bo Kluea	152,718	59,483	36,781
Mean	180,111	93,807	43,041

Source: Basic Minimum Needs Data base; collected in 2014 and obtained from the Community Development Department, Nan province

4.1.2 Poverty

Recently, Thailand has updated its national poverty line based on consumption pattern information from 2011. The new poverty line for Nan has been set at 2,197 baht/person/month, which is a little lower than the average figure for the north of Thailand (2,226 baht/person/month), and also lower than the national figure of 2,492 baht/person/month (Office of the National Economic and Social Development Board, 2014). There has been a clear decline in the instance of poverty in the province over the last decade, with the poverty rate dropping from 46.4% (212,700 people) in 2000 to 21% (94,400 people) in 2012. This aligns with the national picture, as the poverty rate fell from 42.3% in 2000 to 12.64% in 2012 (see Appendix B6). According to a Nan household income survey comparing incomes against basic needs, the proportion of households living below the basic needs line (set at 30,000 baht/person/year (2013) has fallen sharply in recent years, declining from 76.53% in 2002 to only 0.83% in 2013 (from a survey of 92,082 households) (TEI, 2012 and Nan Governor's Office, 2014).

Bureecam (2003) studied poverty among ethnic group farm households in the highlands of upper northern Thailand, and found that 75% of the households surveyed were under the provincial poverty line. He also found that the causes of poverty were related social factors (household head characteristics and the dependency ratio), production and marketing factors (access to irrigation, off-farm work, ability to transport farm produce to the local market), and factors related to access to government services for health insurance, health services and access to formal credit.

4.1.3 Malnutrition

Malnutrition is closely linked to both poverty and a lack of knowledge on health related issues. Preventing malnutrition is one of the main goals of any poverty alleviation program. In Nan, the rate of malnutrition in children under six years of age (no specific

type of malnutrition identified) is low, as it is taken into account in the provincial strategic plan. It is also not significantly different to the national average (7% for Thailand as a whole) (World Development Report, 2012–cited in Bureau of Policy and Strategy, Ministry of Public Health, 2013). Child malnutrition among those under six years of age increased slightly over the years 2006 to 2012, rising from 6.03% to 8.0%, before declining again to 6.7% in 2013.According to surveys conducted over the period 2012 to 2014, the proportion of children between six and fourteen who are slightly underweight is declining, falling from 7.54% in 2012 to 6.21% in 2014. Meanwhile, the proportion of those who are stunted increased slightly from 10.33% in 2012 to 10.85% in 2013, before dropping again to 9.66% in 2014 (see Table 2). There is no national level data available with which to compare these provincial figures.

Table 2: Nutritional status of children under six years old in Nan province (2012-2014)

Nutritional status	2006	2007	2008	2009	2010	2011	2012	2013	2014
Malnutrition in children under 6 yrs of age (%)	6.03	6.72	6.42	6.55	7.34	7.79	8.02	6.72	n.a.
Children aged 6 to 14									
- Number (persons)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	16,586	32,897	22,719
- Underweight (%)							7.54	6.92	6.21
- Stunting (%)							10.33	10.85	9.66

Source: Nan Province Public Health Office, 2015

Previous relevant studies into micronutrient deficiency in the highlands of northern Thailand include a study of folate status among women and children in Chaloem Phra Kiat district, Nan province (Kwanbunjan*et al.*, 2008), a study into vitamin A levels among Karen children in Chiang Mai province (Tienboon, P. and Wangpakapattanawong, P., 2007) and a study of malnourished children in the Akha villages of northern Thailand (Donovan, J.M., 2006). Kwanbunjan, *et al.* (2008) carried out a study in Nan province and found that the nutritional status of women was worse than that of children. Anemia was seen in 2.9% of the young women and 7% of the older women, while depleted levels of stored folate were found in 11.9% of the younger women and 41.1% of the older women. Donovan (2006) found some degree of iron deficiency/anemia in all three study Akha villages (levels of 15.8%, 46.8% and 62.4% child anemia). Tienboon and Wangpakapattanawong (2007) found quite a high percentage (63%) of children with vitamin A deficiency (VAD) in one Karen village out of the three villages studied, but that children from all three villages were at risk of VAD. However, none of the three studies mentioned above investigated the underlying causes of malnutrition among the highland ethnic groups covered.

To help fill the data gap regarding micronutrient deficiency in the highlands of Nan province, in this study key informant interviews were held across three ethnic minority villages in two districts: Chiang Khang and Pua. Village leaders said there was no micronutrient deficiency problems found in their villages, which they explained from the fact that each village has a village health volunteer (VHV) selected by the villagers, and these VHVs receive relevant training from the Ministry of Public Health. The VHV plays a leadership role in helping to change the dietary behaviors of the villagers, as well as resolve villagers' health problems.

4.1.4 Household debt

Nan's household debt has risen fast over the last two decades. A study comparing the household debt situation in Nan province when compared to the northern region and Thailand as a whole found that over the period 1997 to 2013, the average growth in debt levels among Nan's households (22.4%) was higher than that for the northern region as a whole (16.9%) and also the whole of Thailand (14.2%). Since 2004, the average debt level in Nan has been higher than the national average, except in 2006 and 2011 when it was slightly lower (Figure 3) (National Statistical Office, 2015) (for more detail, see Appendix B7).

To assess the household debt burden, average household debt is compared to average household income, producing a debt to income ratio. In 2000, this ratio was 0.6 and after four more years had risen to 0.95, staying at around 0.9 until dropping to 0.65 in 2011. It then rose again to 0.89 in 2013 (Figure 3). Over the 1996 to 2013 period, average household debt increased by 3.6 times, compared with average income which increased by 2.4 times and also expenditure, which increased 2.1 times (National Statistical Office, 2015) (see Figure 4) (for more detail, see Appendix B8).

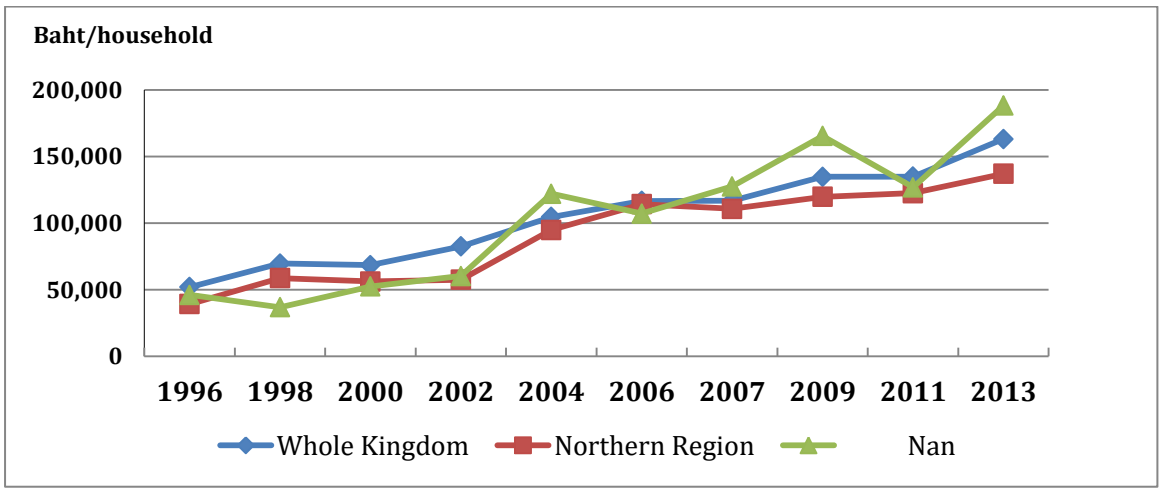

Figure 3: Average debt per household in Nan, northern region and Thailand, 1996-2013

Ekasingh *et al.* (2014) conducted focus group discussions in a highland village in Santi Suk district in 2013, in which they discussed the villagers' livelihoods. The villagers said that growing maize has increased their debt burden but that the income generated has allowed them to expand their maize growing areas, in the hope of generating more income. However, in order to expand they have taken out informal loans at very high interest rates (5 to 6% per month), due to their limited access to formal credit. As a result, they now have a sizeable debt and will have to continue investing in maize, as they have limited alternatives in the absence of irrigation.

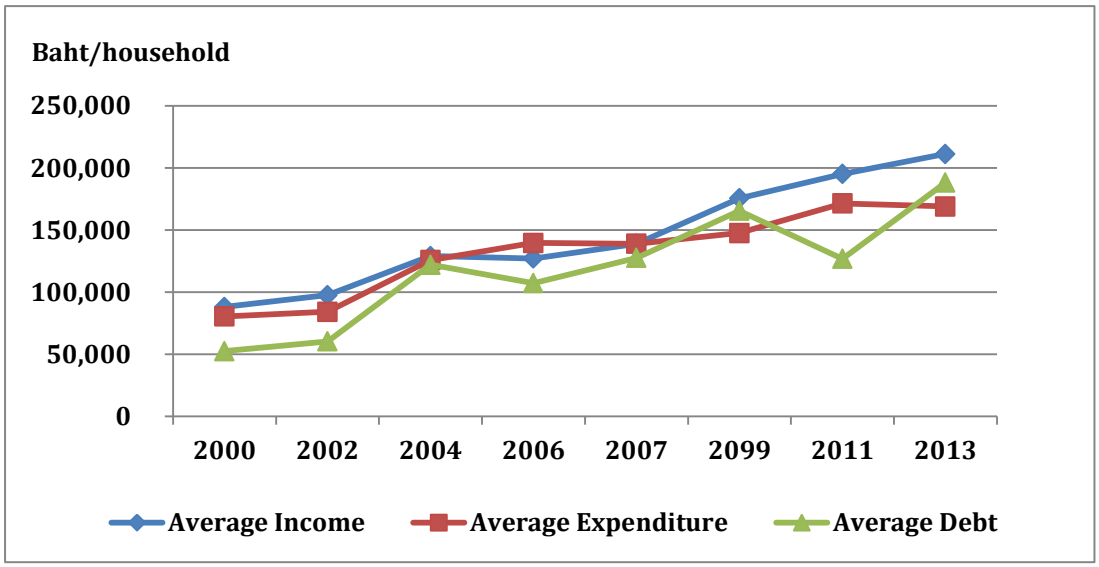

Figure 4: Average income, expenditure and debt levels per household per year in Nan province, 2000– 2013

4.1.5 Gender

Women play a vital role in household livelihoods, but control over family and decision-making issues varies depending on the ethnic group. Chirawatkul and Sawancharoen (2011) explored the perceived well-being of women across four minority ethnic groups (Lua, Tai Lue, Mein and Hmong) in Nan province, and found that women's well-being was related to ethnic traditions and family life. The culture of the Lua and Tai Lue is matrilineal, whereas that of the Mien and Hmong is patrilineal. Lua and Tai Lue women therefore exert more control over family and community life than those from the Mein and Hmong. In Lua and Tai Lue societies, people perceive men and women as equals, while responsibilities within the household are divided according to age and gender. Women mainly perform the household tasks while the men are expected to repair and maintain the house. Also, on the farm both men and women are expected to contribute. On the other hand, Mien and Hmong women face greater inequality, as the men from both groups have much more power than the women in terms of decision-making as well as access to and control over resources (Chirawatkul and Sawancharoen, 2011). However,

Mien women are able to control reproductive activities, as they can choose how many children they want and Mien girls also receive the same educational opportunities as boys. As a result, the highly educated Mien women are accepted as leaders of the community. Meanwhile, Hmong women seem to come out worst among the four ethnic groups, due to the Hmong's strong, traditional beliefs. Forced marriage is occasionally practiced among the Hmong, and after marriage, Hmong women are cut-off from their own families and must join, practice and honor their husbands' beliefs. In Hmong society, boys are preferred over girls, and if a wife does not have a male child, her husband will often look for a new partner, as Hmong men are allowed to have multiple wives. The Hmong men have social, political and religious responsibilities, whereas Hmong women's sole responsibility is to meet the domestic needs of the family.

Among the northern Thai majority, men and women are perceived as being equal both in terms of culture and policy, though the men are regarded as the household heads and main decision-makers. In the agricultural sector, both men and women are equally involved in farm activities and decision-making, though the roles of men and women differ slightly in terms of labor activities. Women are more likely to work on light, more detailed tasks, while the men tend to do the more arduous work. For example, men harvest fruit and carry the fruit from the field to the vehicles used to transport them, while the women grade the fruit. With planting activities, the men dig holes while the women sow seeds. As a result, the wages paid to men and women differ according to the activity carried out. Within the social field, northern Thai women are able to lead community activities; in 15 of the lowland villages surveyed here, three have a female village leader. Also, women have the power to become committee members within a number of social groups. Within the Nan 'R4D' platform (research for development platform in Nan province established in 2014), male members said that the men and women are equal across all activities, though the women said that they have fewer opportunities than the men when it comes to employment, though they agreed that women are more empowered now than they were in the past.

4.2 Production systems and markets

4.2.1 Farms

In 2012, the total area covered by agricultural holdings in the study communities was around 0.18 million hectares, or about 19.72% of the total land area in Nan province, which is 1.15 million hectares. Of this figure, the majority (53%) was represented by field crops (mainly maize, tobacco, beans and cassava), followed by rice (20%), permanent crops (19%), and vegetables and flowers (0.27%). Between 2002 and 2012, the area of land under cultivation increased by 0.11 million hectares or 94.7%, this increase mainly due to more field crops (especially maize) and permanent crops (especially rubber) being grown. In contrast, the area of land under cultivating rice as a proportion of the total

agricultural area decreased by around 10% between 2002 and 2013 (Figure 5).For land tenure, in 2002 the majority of farmers farmed their own land, representing 71% of the total agricultural land area, but this had decreased to 19% by 2011. The land classified as 'free of charge', meaning land reclaimed from the forest, increased from 15% of the total agricultural land area in 2002, to 67% in 2011 (Figure 6).

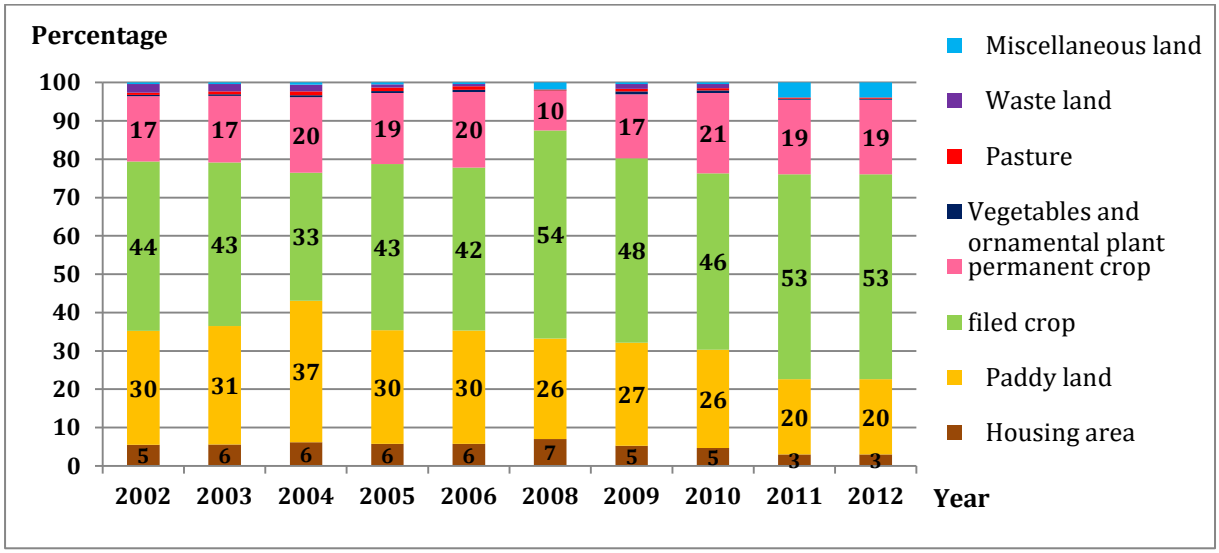

Figure 5: Land use profile for Nan province, 2002-2012 (except 2007)

Source: Nan Provincial Agriculture and Cooperative Office, 2014.

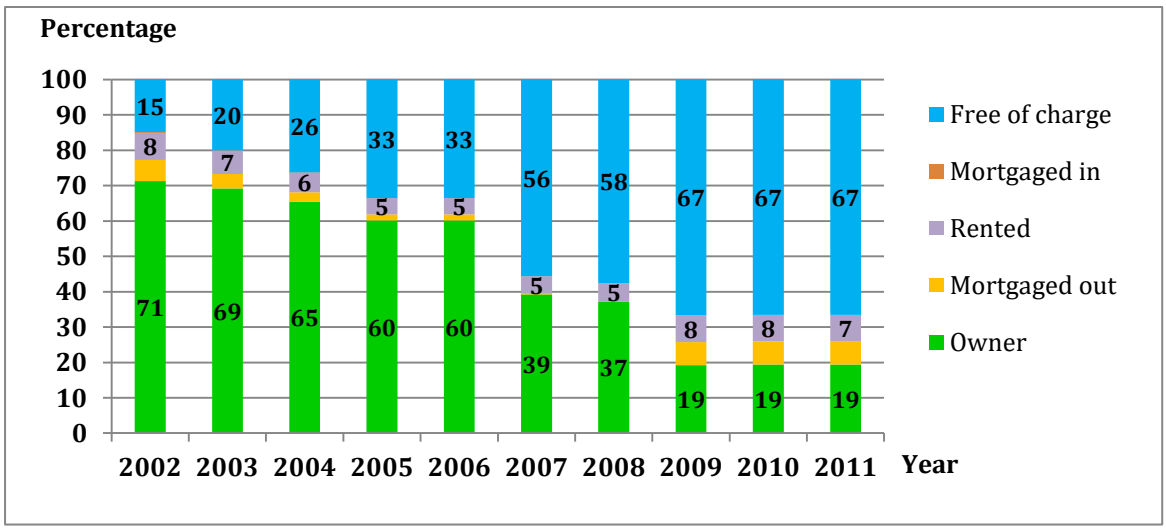

Figure 6: Land tenure profile for Nan province, 2002-2011

Source: Nan Provincial Agriculture and Cooperative Office, 2014.

The total number of households in Nan is 157,177, and approximately 59% of these (92,420 households) earn most of their living from farming. Chaloem Phra Kiat district has the highest percentage of agricultural households at 86%, while Mueang Nan district has the lowest at 37% (Appendix Figure B1). Concerning the number of agricultural households and the land area covered by them, this study found that the average agricultural holding is 2.45 hectares (2014). Furthermore, Ekasingh *et al.* (2014) surveyed two villages in Santi Suk district, finding that the average land holding per household is about 4.8 hectares.

4.2.2 Institutions

The private sector has played an important role in the development of agriculture in Nan province. The Nan economy, as elsewhere in Thailand, has benefited from having access to competitive markets for its agricultural products, meaning traders, manufacturers and agricultural cooperatives, both big and small, have been able to compete freely and actively. Farmers can find their merchants easily in order to sell their produce, and often traders visit their farms. With a good infrastructure, market access is good for farmers in the province, and though some areas of Nan are quite remote, traders can find their way to the farms, and especially in the case of maize (Suebpongsang and Kitchaicharoen, 2014).

The private sector remains primarily focused on agro-businesses, and has established strong forward and backward linkages for agricultural products. Such linkages have helped farmers improve production through the delivery of inputs and technology, and by providing markets (TEI, 2012).

The agro-products market in Nan is operated by shopkeepers or other companies. Most of the crops purchased are field crops such as maize – which is grown to provide food for livestock. In addition, there is a high demand for bean-family crops (both fresh and dried beans, but mainly soybean), but farmers only produce low volumes of these crops. To encourage farmers to grow more bean crops, the variety of beans grown should be selected in accordance with market demand. As well as field crops, there are also market channels open in the area for fruit, but there are not many fruit traders. The fruit most in demand are the Nam Dok Mai mango and sweet tamarind, both of which are exported (Suebpongsang and Kitchaicharoen, 2014).The estimated value of the horticultural crop market in Nan (calculated from interviews with 11 local entrepreneurs) is about 125 million baht (2014), with the vegetable market being 60 million baht (data provided by four local traders), and the fruit market representing 83 million baht (data provided by nine local traders) (Suebpongsang and Kitchaicharoen, 2014).

There are 23 local agricultural cooperatives in Nan province which offer small agricultural producers with a wide range of services, including improved access to markets, information, communications, technologies, credit, training and warehouse

operations. These cooperative also negotiate better contract farming terms and lower prices for agricultural inputs such as seeds, fertilizers and equipment. For example, most of the vegetables grown in the contract market are sold as inputs to the food processing sector; for example, sweet corn, bush beans and leaf mustard. The agricultural cooperatives in each district of Nan act as agents; collecting the products and sending them to the food processing factories based on an agreed quota. Members of the agricultural cooperatives agree a price guarantee and can also access credit for buying inputs. The market value of the contract vegetable growing market in Nan province is around 55 million baht (calculated based on information obtained from six agricultural cooperatives for the year 2014), while the contract fruit market has a value of 19 million baht (Suebpongsang and Kitchaicharoen, 2014).

4.2.3 Cropping systems

- **Rice**

There are two main rice production systems in Nan province: irrigated paddy rice and rainfed upland rice. Paddy rice can mostly be found growing on the lowland plains and is a subsistence crop for the lowland Thais. However, paddy rice using a terrace system can also be found in the highlands, but only where water can be stored, such as in Pang Yang village (a Lua village) in Pua District where 65% of households farm paddy rice terraces (Sangchaiyoswat *et al.*, 2013). Upland rice is a subsistence crop grown by the ethnic minority groups in the highlands, and traditionally follows a fallow system, in which fields are cultivated for one to three years and then left fallow for three to four years, depending on the soil fertility level and the availability of land (Sangchyosawat *et al.*, 2013).

Cultivation practices

Paddy rice: Lowland farmers start to prepare their land for planting paddy rice during June, using a tractor to plow the land. Ekasingh *et al.* (2014) described how paddy land is prepared in Santi Suk district. The first plowing is carried out to eradicate weeds and to dry the soil so that weeds will not grow, plus to break-apart the larger soil clods and incorporate plant residues. About one week before planting begins, the fields are irrigated and allowed to flood for one to two days, after which the second tillage is carried out using a rotary tiller and by harrowing. Rice seedlings are then manually transplanted, 25 to 30 days after seeding begins. The average planting area is about 0.5 to 0.7 hectares per farm (Sangchyosawat *et al.*, 2013 and Ekasingh *et al.*, 2014) (for more detail of rice production area see Appendix B9).

Upland rice: Slash and burn is still a common method used to clear land for planting upland rice, as it help skill insect pests and mice, as both can adversely affect rice yields. The land is cleared during the dry season (around April). Direct seeding starts with the

first rains during June, and harvesting takes place around October (see Appendix Figure B2). Data from the highland villages in Santi Suk district show that the average planting area is about 0.82 hectares per farm (Ekasingh *et al.*, 2014 and Kuson *et al.*, 2014), whereas in Pua district the average is higher at 1.39 hectares per farm (Kuson *et al.*, 2014).

Soil fertility management

Paddy rice: In some areas, farmers grow mungbean or sun hemp (*Crotalaria juncea* L.) as green manure to improve soil fertility, especially in areas under the Royal Project where bean-family crops were previously introduced to farmers to improve soil fertility (Ekasingh *et al.,* 2014).

Upland rice: Most upland farmers leave their rice fields fallow for four to six years to improve soil fertility levels; however, currently the fallow period is shorter at three to four years, due to the expansion of upland maize cultivation. As a result, farmers now need to add chemical fertilizers to their rice fields to increase productivity (study focus group discussion).

Technologies

Paddy rice: Lowland Thai farmers grow glutinous rice for home consumption, with the most popular varieties being RD6 and Sun Pa Tong (Ekasingh *et al.*, 2014). Weed control is carried out using both manual methods and herbicides, depending on the characteristics of the weed population. Chemical fertilizer 15-15-15 is applied 60 days after rice has been planted (Ekasingh *et al.*, 2014).

Upland rice: Local seeds are used to cultivate upland rice, and weeds are controlled manually through the use of household labor, though some farmers spray herbicides on the rice after planting to control weeds. Traditionally, chemical fertilizers have not been used when growing upland rice, but since the expansion of maize cultivation, which has reduced fallow periods, chemical fertilizers have been applied to increase productivity.

Average yields

Paddy rice: The average yield for paddy rice varies between 3.91 and 4.13 tons/ha (Sangchyosawat *et al.*, 2013 and Ekasingh *et al.*, 2014). Paddy rice in Nan is mainly grown for household consumption, and seeds are reused for two years before new seeds are purchased.

Upland rice: The average yield for upland rice varies between 1.44 and 2.36 tons/ha (Ekasingh *et al.*, 2014 and Kuson *et al.*, 2014). Most upland rice is grown for household consumption (95%). The rest is kept as seed for the following year (Ekasingh *et al.*, 2014).

For more detail information about costs and returns of paddy rice and upland rice production see Appendix B10-B13

Sales of farm produce

Paddy rice: Farmers sell paddy rice when there is a surplus, or to a neighboring farmer who needs seeds (key informant interview and focus group discussion). As well as from neighbors, new seeds can be bought from farmers' groups who grow rice and from agricultural cooperatives. A few farmers also sell their rice on the market, and over the period 2011 to 2013 prices were quite high, at 12 to 14 baht/kg (Ekasingh *et al.*, 2014, Sangchyosawat *et al.*, 2013 and Nan Provincial Agricultural Office, 2015), though the price decreased to 9 to 11 baht/kg in 2014 (Nan Provincial Agricultural Office, 2015).

Upland rice: Upland rice is only sold to neighbors within a village; to those who do not have enough rice for household consumption. Upland rice is sold at an average price of 11 baht/kg in Santi Suk District (Ekasingh *et al.*, 2014).

Risks, challenges and opportunities

Paddy rice: In general, lowland paddy rice farmers experience no production or market problems. However, problems with seeds such as shortages and quality problems were mentioned by the farmers in Santi Suk district as having occurred in 2012/13 (Ekasingh *et al.*, 2014).

Upland rice: The expansion of maize cultivation has led to a reduction in the fallow period used for upland rice and so an increase of weed pressure and soil infertility, in turn impacting on upland rice productivity and ultimately food security in the Nan uplands.

- **Maize**

There are two different maize production systems used in Nan province, according to the areas used for cultivation. The first system involves maize grown in the lowlands using water from natural sources and from local irrigation systems. This maize is grown about two to three times a year, depending on the availability of water, or is grown as a second crop after paddy rice. Another system involves rainfed maize being grown on steep upland slopes, this crop is grown just once a year during the wet season. Most maize in Nan province is grown in the uplands, where there are limited opportunities to grow other crops.

Cultivation practices

Lowland maize: In Nan, the first lowland maize crop is usually grown in May. Land preparation using a tractor begins in May after the first rains and is carried out twice before sowing. The crop is commonly planted using mechanical seeders to save on labor (TEI, 2012).

Harvesting starts at the beginning of August and carries on through September (see Appendix Figure B2). A second maize crop can be grown after the rice has been harvested. The land is tilled after the rice has been harvested in October or November, and sowing begins in December. This second maize crop is then is harvested between March and April (TEI, 2012). The average maize growing area is Nan province is 5.04 ha/farm (Kusone*t al.*, 2014).

Upland maize: Farmers plant upland maize once a year during the early wet season, between May and June. Slash and burn is still practiced in order to clear the land during the late dry season (March/April), as with upland rice. However, in some villages, such as in Sri Bun Rueang village where rubber is grown near to the maize fields, slash and burn is not practiced as it can adversely affect the rubber trees (Ekasingh *et al.*, 2014). Direct seeding is the most common method used to plant maize on mountain slopes, and harvesting takes place between October and November. The average area under upland maize is 5.76 ha/farm in the uplands of Nan province (Talerngsri, K. and Pongkijvorasin, S, 2012 and Kuson *et al.*, 2014).

Men and women help each other to grow maize. Men mostly prepare the land and do the carrying and transportation, plus drive the tractor and spray pesticides, while the women do the light work such as seeding and applying fertilizers. Both men and women help out with the harvest.

Soil fertility management:

Lowland maize: After harvesting the lowland maize and before growing other crops, lowland farmers in the area plow the land to incorporate crop residues, rather than burning. In Santi Suk district during 2013, soil from the maize fields was taken to a laboratory to have its properties analyzed. The results showed that farmers should add soil amendment**s** to improve its physical properties; however, the farmers have since not followed this recommendation as they wish to minimize production costs (Ekasingh *et al.,* 2014).

Upland maize: Soil fertility is very low in the upland maize fields. The farmers in the study area have tried to increase productivity by applying several types of chemical fertilizers in varying amounts (Ekasingh *et al.*, 2014). The lead farmer in Pang Yang village, Pua district, said that some farmers apply organic fertilizers to increase their upland maize productivity, as they know that using the land to grow maize every year, without allowing for a fallow period, would decreased soil fertility.

Technologies

Several hybrid maize seed varieties have been used in Nan province in support of both lowland and upland maize production, with the popular varieties being CPDK 888, Pioneer and Pacific (TEI, 2012 and Ekasingh *et al.*, 2014). These varieties respond very

well to fertilizer use, resulting in high productivity. These hybrid varieties are also drought tolerant. The maize seeds are mixed with chemicals to protect them from fungi and pests. Farmers spray herbicides first after sowing and a second time when weeds proliferate.

Average yields

The average lowland maize yield using fresh grain is 5.94 tons/ha (Talerngsri, K. and Pongkijvorasin, S, 2012), whereas the average dry grain yield for upland maize is 4.69 tons/ha in WiangSa district (Talerngsri, K. and Pongkijvorasin, S, 2012) and 4.10 tons/ha in Santi Suk district (Ekasingh *et al.* (2014). However, the average maize yield for the province as a whole is only 3.91 tons/ha (2012 figures; Office of Agricultural Economics, 2014)

Sales of farm produce

Lowland maize: Most lowland maize farmers sell their produce immediately after harvest as fresh grain with a high moisture content. The price of fresh grain is 4-5 baht/kg lower than that of the dry grain. Dry grain with a maximum moisture content of 14.5% ranges between 7 to 8 baht/kg (Ekasingh *et al*., 2014). Lowland maize farmers have more channels through which to sell their output. For those farmers who are members of an agricultural cooperative, they can sell their output to the cooperative at a good price and also receive a dividend later. For those farmers who have their own vehicles, they can transport their maize and sell it themselves to buyers at a higher price. However, only 10% of farmers sell their grain to traders at the district and provincial levels; most sell only to local traders (TEI, 2012).

Upland maize: Dried upland maize grain is sold to local traders who visit the upland fields with their threshing machines. Those farmers who take in-kind farm input credit from traders are obliged to sell their output to the same traders, with the loan amount deducted from the total revenue generated. However, most farmers prefer to buy their input materials themselves, as they realize that buying inputs from the traders costs more than when they buy at the market (interviews with farmers). At a selling price of 8 baht/kg, a net income of 5,375 US$/ha provides enough to incentive farmers to expand their maize production area. However, if the dry grain maize price falls to 5 baht/kg, the farmers make a loss and so it is not worth them growing maize anymore (Sangchaiyoswat *et al*., 2013).

For more detail information about costs and returns of maize production see Appendix B14-B15

Risks, challenges and opportunities

The downside to growing maize, especially in the uplands, is that it requires a lot of chemicals, which pollutes the soil and water. Furthermore, the slash and burn practices used to eradicate weeds prior to cultivation cause air pollution in the form of smoke and

dust, which adversely affects people's health. In response to these problems, Charoen Pokphand Group (CP)– Thailand's largest animal feed company–made a public statement saying that it does not support farmers growing maize in the upland forests (online news: www.manager.co.th). CP added that it does not want to simply stop buying upland maize in these areas, but that it would like to resolve the problem alongside other agencies and the upland farmers themselves.

The farmers in Santi Suk district said that the low price of maize (less than 5 baht/kg in 2013) and a lack of negotiating power with the traders (Ekasingh *et al.*, 2014) are the main problems they face, and that they do not know how to resolve these issues. They added that the local traders have no standard grading system for the maize, such as for the moisture content level.

- **Rubber**

Rubber plantations have increased in number in recent years due to subsidies being provided to local farmers and landholders by the Rubber Plantation Supporting Fund. These subsidies were first provided in the province in 2005 (Thailand Environment Institute, 2012). Rubber plantations have become an attractive option to farmers, financially, and so have continued to expand in the area. In 2005, the area under rubber in Nan province was 1,390 hectares (with a harvested area of 137 hectares), but this has since increased to 28,650 hectares of planted area and 5,665 hectares of harvested area (Office of Agriculture and Agricultural Cooperatives in Nan, 2014). Phu-Pieng district has the largest area of planted rubber, at 6,195 hectares, with a harvested area of 2,092 hectares. Nanoi district and Mueang Nan district are second and third in terms of the planted and harvested rubber area. Overall, the average size of a farm planting rubber is now 1.89 hectares (Nan Provincial Agriculture and Cooperative Office, 2014).

Cultivation practices

The area selected for rubber cultivation must be cleared of any wild growth, and in hilly areas with a gradient of more than 15 degrees, the farmers plant in rows following the contour lines and establishing terraces. Some farmers use plants to create groundcover on the terraces, to retain the soil's moisture content. The rubber trees in Nan follow a plantation pattern of 2.5 or 3 meters by 7 or 8 meters (Ekasingh *et al.*, 2014 and Thailand Environment Institute, 2012). The holes in which to plant the saplings must be 50 centimeters in depth, length and width. Some farmers in Nan province make the hole a little smaller than it should be due to a lack of time and labor, and add organic fertilizer before planting (Ekasingh *et al.*, 2014). The holes are dug 10 to 15 days before planting of the saplings, and the topsoil and lower soil should be kept separate when making the hole. Planting is normally carried out before the wet season starts. The Nan rubber production calendar is shown in Appendix Figure B3. The cost of a sapling is the largest investment a rubber farmer has to make. In 2013, the price of a rubber sapling was 20

baht (Ekasingh *et al.*, 2014), though some farmers get their saplings free under the Rubber Plantation Supporting Fund. A number of the farmers intercrop rubber with maize, particularly during the first three years, before the rubber canopy closes, preventing the growth of light-demanding crops. Weeding is carried out between the trees, especially when the trees are small, and the trees are pruned on a regular basis.

Soil fertility management and technologies

Different rubber varieties such as RRIM 600 and RRIT 251 are commonly cultivated in Nan province, and both organic and mineral fertilizers are applied every year, depending on the farmer in question. The mineral fertilizers used include 20-10-12, 30-5-18, 0-0-60 and 15-15-15 (Sitthi *et al.*, 2014and Ekasingh *et al.*, 2014).

Average yields and transportation

In 2014, the Office of Agriculture and Agricultural Cooperatives in Nan province (2014) reported that the average rubber yield was 2.19 tons/ha. The farmers start tapping or harvesting the rubber when the trees are six or seven years old. Farmers prefer to tap the rubber in the early morning, every one or two days. Annual rubber production in Nan has now reached 12,029 tons (Office of Agriculture and Agricultural Cooperatives in Nan, 2014). The Office of the Rubber Replanting Aid Fund (ORRAF) (2015) has recently reported that rubber production in Nan in the form of latex is around 200 tons per day. The farmers sell rubber in the form of *cuplump* (a blanket crepe rubber produced from the dried films and lumps of rubber found in the tapping cups) due to the lack of time and labor available to process it into sheet rubber (Ekasingh *et al.*, 2014). Even though the *cuplump* is easy to sell, it can cause problems during the transportation. The liquid spilt during transport can cause road accidents and has a bad smell (ORRAF, 2015).

Selling of farm produce

The marketing structure for rubber in Nan province can be divided into two sales channels, as follows: (1) Middlemen; who visit the villages and negotiate directly with the farmers. (2) Auction markets. These auctions take place at the Nan office of the Rubber Replanting Aid Fund twice a month during March and April. Most farmers sell their rubber at these auctions, either through their cooperative or a farmers' group. Farmers transport the *cuplump* to the collection points and make appointments with the traders to pick it up. There are collection points in each district. The *cuplump* price the farmers receive from the auctions is around 39 to 45 baht/kg (Ekasingh *et al.*, 2014).

Risks, challenges and opportunities

At present, the market for rubber in Nan is not a problem; moreover, a lot of support is provided by the Office of Rubber Replanting Aid Fund for production, processing and marketing activities. However, the rubber plantations themselves face risks such as fires

from lightning strikes, storms and landslides. In some cases farmers can manage these risks; for example, by preparing fire breaks near their plots. Apart from natural disasters, the farmer also have to deal with sales price fluctuations, and one way to mitigate this risk is to sell rubber in the form of sheeting, as this fetches a higher market price.

- **Vegetable production**

The vegetable varieties with the largest harvested areas in Nan are sweet corn, pumpkin, cabbage, long green chili pepper, hybrid bird pepper, swatow mustard (*Brassica juncea L Czernjaew*), ginger, garlic, Chinese mustard, water spinach, Chinese cabbage, kale, eggplant, cucumber, baby corn, yard long bean, green bean/French bean, sugar pea, shallot and cauliflower (Office of Agriculture and Agricultural Cooperatives in Nan, 2014)(for more detail information about the calendar of vegetables production see Appendix Figure B4).

Suebpongsang and Kitchaicharoen (2014) studied the production and marketing of 11 vegetables from the above group, revealing that ginger is the crop that gives the highest net profit per unit of land. However, it also requires more cash and household labor to be invested than the other crops. Long green chili pepper, garlic, Chinese mustard, sugar pea and eggplant give the second highest income per rai, and of these, eggplant production has the lowest cash investment requirement per rai, resulting in the highest profit margin. Cucumber production on the other hand requires little cash investment and the income is still high; however, it requires more household labor to be used, resulting in a low net profit. Cultivating green bean also requires relatively little cash investment, and the income to be made is higher than for the hybrid bird pepper, swatow mustard and pumpkin crops. However, these latter crops are labor intensive, leading to a lower net profit than for the other crops. Growing pumpkin is a relatively low cost activity, but also gives the least profit when compared to the other vegetables (see Table 3).

The outlets for these vegetable are the local markets in Nan, markets in other provinces and the contract market which supplies raw materials to the food processing factories. The local market in Nan sells cucumber, long green chili pepper, hybrid bird pepper, Chinese mustard, garlic and sugar pea, while pumpkin, garlic and eggplant are sent to markets in other provinces such as the wholesale markets in Phitsanulok and Uttaradit provinces, in the northeastern region to Roi et and Nakhonratchasima provinces, and in Bangkok to *Simummueang* and *Talaadthai* markets. Ginger, swatow mustard, long green chili pepper, hybrid bird pepper and green bean/French bean are sold on the contract market, in which agricultural cooperatives and/or traders act as middlemen (Suebpongsang and Kitchaicharoen, 2014).

Pumpkin and ginger are considered to have the best market potential because they are in high demand and can be sold both at the local and provincial markets, and also on the contract market (Suebpongsang and Kitchaicharoen, 2014). This study will therefore

describe the production and marketing processes for pumpkin and ginger in more detail, based on the data generated by Suebpongsang and Kitchaicharoen (2014).

Table 3: Investment costs, income and revenue levels of the key vegetables grown in Nan province (baht per rai)

Item	Cash costs	Total costs	Revenue	Profit over cash costs	Net profit
Ginger	22,304	41,868	95,718	73,414	53,850
Sugar pea	8,526	13,899	37,569	29043	23670
Garlic	16,300	19,500	43,167	26867	23667
Long green chili	13,002	22,102	43,837	30835	21735
Chinese mustard	3,845	14,320	31,275	27430	16955
Eggplant	4,278	14,970	30,250	25972	15280
Swatow mustard	9759	14191	28477	18718	14285
Hybrid bird pepper	14,875	26,976	35,602	20727	8626
Pumpkin	2,521	3,751	9,457	6,936	5,706
Cucumber	7,030	41,190	44,640	37610	3450
Green bean	11,153	34,788	34,135	22,982	-653

Note: Revenue = price x sales volume. Profit over cash costs= revenue - cash costs. Net profit = revenue - total cost. Source: Suebpongsang and Kitchaicharoen, 2014.

- **Pumpkin**

Suebpongsang and Kitchaicharoen (2014) interviewed seven farmers and found that those in the lowlands use tractors to prepare their land, plus add herbicides during the land preparation phase. Some farmers choose to weed instead of using herbicides. Most farmers divide the land into two to three plots, and each plot is planted over a period of seven days. The reason the farmers divide their land is to help manage the labor required for the harvest. The average farm size is 1.6 hectares per those households planting pumpkin. The farmers generally plant the pumpkins in March, and there are two varieties of pumpkin based on the growing period required; a 'short' variety (50 to 60 days) and a 'long' variety (120 to 180 days). Due to the lack of water, most farmers only plant one or two pumpkin crops a year. Fertilizer (15-15-15) is used one or two times per crop cycle, and the water needed to grow the crop is transferred from streams by gravity and into the fields using PVC pipes. The farmers need to water the pumpkin plants in particular when they start bearing fruit. The average yield for pumpkin is 9,375 kg per hectare (Department of Agricultural Extension, 2014). Nanoi and Maejarim district have the highest pumpkin growing area in the province (data for 2013; Department of Agricultural Extension, 2014). The farmers in these two districts sell their pumpkins to local traders and these traders then sell them to markets in other provinces. The price paid depends on the grade, which is given based on the pumpkin's weight and skin condition. Prices for pumpkin vary between 2 and 12 baht/kg (data for 2013; Suebpongsang and

Kitchaicharoen, 2014). The pumpkin market has good potential because the crop can be sold in other provinces. Suebpongsang and Kitchaicharoen (2014) also reported that there is a high demand for pumpkin within Nan province at a number of markets. Moreover, the production costs for pumpkin are not high when compared to the other vegetables mentioned (Table 2).

- **Ginger**

The largest ginger growing areas are in Mueang and Thung Chang districts (data from 2013; Department of Agricultural Extension, 2014). Suebpongsang and Kitchaicharoen (2014) interviewed two farmers and found that they start growing ginger in March or April using the rhizomes. The farmers change the planted area every three years (and leave that land fallow for six years before using it for growing ginger again) because they want the soil to stay relatively free of root knot nematode infections and soil-borne diseases, those which cause rhizome rot and bacterial wilt (Suebpongsang and Kitchaicharoen, 2014). Most farmers buy the rhizomes to make sure they are free of pests and diseases. In 2013, ginger rhizomes were 30 to 40 baht/kg. The seeding rate is 4,376 to 6,250 kg/ha, depending on the spacing used by the farmer. Two cultivations are needed; the first to control the soil moisture content and the second to turn the soil into a fine tilth; to provide the ideal environment for germination. After planting, the farmers cover the top soil with rice straw to help retain the moisture. The farmers also use etridiazole or quintazone to control root rot. Ginger planted in the uplands is non-irrigated. The farmers harvest the ginger after six to eight months, with the longer growing period before harvesting attracting a higher price but with a greater risk of the ginger suffering from disease (Suebpongsang and Kitchaicharoen, 2014).

Ginger production gives a high net profit to the farmers and also has many marketing channels through which it can be sold, such as at local markets, provincial markets and to the ginger preserves producers. The farmers are able to choose when to sell their ginger crops (depending on whether it is young or old ginger). The younger ginger is used to make ginger preserves. The producers of ginger preserves are located in Chiang Rai, Phayao and Phitsanulok provinces. To sell ginger to the ginger preserve companies, farmers need to sell it to a trader registered with the producer. The ginger preserve producers control the volume produced by limiting how much ginger they buy based on a quota system. The price of young ginger is around 30 baht/kg (mixed grade), while the price of old ginger is 20 to 50 baht depending on the grade (2013 figures). The ginger graded as ‘good’ tends to be large and undamaged i.e. has no cuts or breaks (Suebpongsang and Kitchaicharoen, 2014).

- **Fruit production**

The ten fruit varieties with the largest harvested areas in Nan are lychee, longan, lime, rambutan, mango, tamarind, orange, cashew nut, banana and mulberry (Office of agriculture and agricultural cooperatives in Nan, 2014)(for more detail information about the calendar of perennial crop production see Appendix Figure B5).

Suebpongsang and Kitchaicharoen (2014) studied the production and marketing activities for a range of fruit by using harvesting data. The results of their analysis showed that the cash investment required for each of the fruit is similar, though the household labor use varied. They found that the fruit variety which gives the highest net profit per unit of land is the *Si Thong* orange, while the second highest fruit production's revenue comes from growing mulberry and *Nam Dok Mai* mangoes; the profit per unit area for these fruits was found to be very similar (Table 4). However, the cultivation of *Nam Dok Mai* mangoes employs more household labor (to make the carbon-paper wrapping and to do the harvest, which needs to be done slowly and with care) resulting in a low profit level per rai. However, the profit gained from selling the fruit is similar to lychee, lime and longan. Other varieties of mango provide a lower profit margin than *Nam Dok Mai* mangoes. The production of sour tamarind and cashew nuts requires low levels of investment, but the profit margins are also low. Lastly, *Nam Wa* bananas require relatively low investment in terms of farm management, but the net profit per rai is the lowest among the fruit varieties discussed here (Suebpongsang and Kitchaicharoen, 2014).

Table 4: Investment costs, income and revenue levels for key fruit in Nan province (baht per rai)

Item	Cash costs	Total costs	Revenue	Profit over cash costs	Net profit
Tangerine	6,196	10,223	36,180	29,984	25,957
Mulberry	1,716	5,580	28,300	26,584	22,720
Rambutan	2,070	4,021	22,233	20,163	18,212
Sweet tamarind	3,978	5,134	21,871	18,793	16,737
Mango (Nam Dok Mai)	4,315	15,266	24,065	19,750	8,799
Mango (other varieties)	3,309	4,237	20,240	16,931	16,004
Longan	3,294	4,543	12,164	8,870	7,620
Lychee	4,352	5,381	11,708	7,356	6,327
Lime	1,405	3,655	9,098	7,693	5,443
Cashew	1,827	2,858	4,404	2,577	1,547
Sour tamarind	1,007	1,673	4,000	2,993	2,327
Banana	120	1,110	2,370	2,250	1,260

Note: Revenue = price x sales volume. Profit over cash cost = revenue - cash cost. Net profit = revenue - total cost. Source: Suebpongsang and Kitchaicharoen, 2014.

The markets for these fruit varieties are local markets in Nan, in provincial and wholesale markets and the fruit processing sector. The local markets are not the main market for the fruit as the markets in other provinces have higher buying volumes. The key provincial wholesale markets include those in Bangkok, Chiang Mai, Phitsanulok, Uttaradit, Chianrai, Chonburi and Nakhonratchasima, among others. Fruit such as mango and tamarind are exported. For example, mango is exported to Japan and Vietnam, and tamarind is exported to China and Myanmar. Lychee, longan, mulberry and cashew nut are supplied to the fruit processing sector inside and outside Nan province (Suebpongsang and Kitchaicharoen, 2014). Rambutan, mango, tamarind, cashew nut and mulberry are considered to have the greatest market potential because they are in high demand at the provincial markets across Thailand and because they are exported (Suebpongsang and Kitchaicharoen, 2014). This study will now describe in detail the production and the marketing processes for these fruit.

- **Rambutan**

Suebpongsang and Kitchaicharoen (2014) interviewed 14 farmers in *Tawangpa, Thongchang, Nameuan* and *Maejarim* districts, and found that the farmers there plant a Thai rambutan variety called *Rongrien,* the most popular in Thailand (Marketing Organization for Farmers, 2015). The farmers plant saplings rather than seeds. In Maejarim district, more farmers have started to plant rambutan based on a recommendation from the Highland Research and Development Institute (HRDI). Most farmers have only a small area under rambutan, with farm sizes being not more than 1.6 hectares per household and with an average of 0.76 hectares per household (Department of Agricultural Extension, 2015). Farmers prepare the land for planting by digging the hole and placing manure in the bottom. Farmers plant around 156 rambutans per hectare, and fertilizer (15-15-15) is applied once a year, plus farmers use *gibberellin* to help with flowering. Only the big farms can afford to invest in a sprinkler system, while the small farms do not use irrigation. The farmers carry out pruning after the harvest. The average yield obtained is 5,942 kilograms per hectare in 2014 (Department of Agricultural Extension, 2015). The main production risk for rambutan is heavy rain, as this can cause fruit drop.

Farmers who have only a small area planted with rambutan (less than ten trees) normally plant only for home consumption, and if they want to sell then they sell in front of their house. Those farmers with a larger planted area have their own marketing channels; for example, farmers from Nameuan district sell to a trader from Phrae province at a price of 10 to 13 baht/kg (2013 prices). The farmers in Thong Chang district also sell to the local trader, who then sells to traders in the other provinces (Suebpongsang and Kitchaicharoen, 2014).

- **Mango**

Mangoes are planted in many districts across Nan province; for example, Phu Phiang, Wiang Sa, Santi Suk and Na Noi districts. The average planted area of mango was 0.47 ha per household (Department of Agricultural Extension, 2015). Many varieties of mango are planted in Nan province, such as *Mangiferaindica* (Khiao Sawoey, in Thai), Phim Sen, Nam Dok Mai and Chok Anan.

Suebpongsang and Kitchaicharoen (2014) reported that farmers in the area prepare the young plants by seeding local varieties which they then graft onto market varieties. The farmers prepare the land for planting by digging holes and placing manure in the bottom. The farmers then prune before the harvest, in order to shape the tree. Fertilizer (16-16-16) is applied during this period also. The mango trees start flowering in January or February, and the harvesting period is around May. After the harvest, the farmers will apply chemical fertilizer (16-16-16) mixed with organic fertilizer twice, in June and November. Weeding is also important, so farmers weed around three times a year. To cover the mango with newspaper or plastic bags is important during the fruiting period, in order to protect the fruit from insects and ensure the fruit have a good skin color.

Mangoes in Nan are sold for both the domestic and export markets. The domestic market includes markets throughout Nan province and markets in other provinces such as Chiang Mai, Phitsanulok, Angthong and Bangkok. Some farmers sell directly to consumers at these markets, while some farmers sell through traders. Traders from other provinces also come to Nan to buy mangoes, either direct from the farmers or from the local traders. Nam Dok Mai is the mango variety exported to Japan and Korea through Thai export companies; however, these countries only import during April and at the beginning of May, which is not a time when mangoes are normally ready for sale, leading to low export volumes. Khiao Sawoey has been exported to Vietnam since 2013 by a Vietnamese trader. The price of mangoes depends on the variety, grade (by size) and the market in question. For example, Nam Dok Mai for export fetch a price of between 35 and 65 baht/kg, while on the domestic market the price is 15 to 18 baht/kg. Meanwhile, the Khiao Sawoey variety fetches 10 to 18 Baht/kg on the domestic market (Suebpongsang and Kitchaicharoen, 2014).

- **Tamarind**

Ban Luang, Wiang Sa and Na Noi districts are important tamarind growing areas, and the average tamarind growing area here is 0.48 ha per household (Department of Agricultural Extension, 2015). Si Thong and Sri Chomphu varieties, both local varieties, are popular in these districts.

Suebpongsang and Kitchaicharoen (2014) interviewed nine farmers in Ban Luang district and found that the farmers there prepare the land for planting by digging a hole and

placing manure in the bottom. The farmers plant around 156 trees per hectare, and apply fertilizer (15-15-15) once a year. In the fourth year, the tamarind start flowering and the farmer uses the *gibberellin* to help with the flowering process. The farmers do not use irrigation and this leads to low yields due to fewer flowers developing. On the other hand, if there is heavy rain when the trees are fruiting, it can also cause low yield as the tamarind may be knocked off the trees. The tamarind harvest takes place in August and the farmers can sell around two to three times during that month based on the ripening of the fruit. The farmers prune the trees after the harvest.

The tamarind in Nan is grown for both the domestic and export markets. The domestic market mainly consists of other provinces such as Bangkok, Chiang Rai, Phetchaboon, Ratchaburi and Sakaeo. Most farmers sell their tamarind to local traders, who then sell to other provinces. For example, the fruit is exported to China and Myanmar through traders who visit from Chiang Rai province. The price range for tamarind is 20 to 65 baht/kg, depending on the variety and grade (by size). Si Thong varieties fetch a higher price than Sri Chomphu varieties (Suebpongsang and Kitchaicharoen, 2014). The farmers received a higher price in 2014 than in other recent years, but the tamarind price fluctuates a lot. For mixed grade fruit, the price per kilogram was 22 baht in 2010, then 38 baht in 2011, 35 baht in 2012, 28 baht in 2013 and then 40 baht in 2014 (Department of Agricultural Extension, 2015).

- **Mulberry**

The mulberry referred to here is the mulberry fruit grown for consumption. In Nan province, the average planted area for mulberry is 0.75 hectare per household (Department of Agricultural Extension, 2015).

Suebpongsang and Kitchaicharoen (2014) interviewed five farmers in Chaloem Phra Kiat district and found that the farmers there have been growing mulberry since 2003 under the Thai Queen's Project, and have also established a mulberry farmers' group. The Queen's Project provided each member farmer with 100 young plants (Chiang Mai varieties) per rai (0.16 hectares). The farmers' group controls the area planted by its members, restricting them to not more than 0.64 hectares and 100 mulberry trees per rai in order to control production volumes. There are now 160 members of this group who account for a total of 325 rai (52 hectares). Mulberry can be harvested in its fourth year after planting, and good cultivation practices have a positive effect on yields, and especially pruning and weeding (at least twice a year). If there is a problem with stem borer, farmers will inject a saline solution into the borer hole in the stem, and if the mulberry fruit is eaten by worms, farmers will cut the fruit from the tree without using pesticides. Mulberry fruit can normally be harvested during March or April. If a farmer uses compost and chemical fertilizer twice a year, he or she will be able to harvest during the wet season, in September and November.

The farmers sell their mulberry fruit to the group at a price of 25 baht/kg (mixed grade) and have two marketing channels. The first is selling their fruit to the Second Royal Factory (which trades under the brand name Doi Kham) in Mae Chan district, Chiang Rai province. The second is selling to the mulberry juice processing group based in Chaloem Phra Kiat district. Farmers can also sell directly to local traders and tourists in the area (Suebpongsang and Kitchaicharoen, 2014).

- **Mushrooms**

There are no statistical data available for mushroom production in Nan province. Therefore, the following details regarding mushroom production and marketing in Nan province are based on interviews held with seven farmers (see Appendix A3) across four districts (Chiang Klang, Pua, Tha Wang Pha and Mueang districts). The farmers grow many mushroom varieties; for example, oyster, phoenix oyster, Bhutan oyster, jew's ear, *Lentinuspolychrous Berk*, *Lentinussquarrosulus* and *Yanagimatsutake* mushrooms. These mushrooms are in high demand and are easy to grow.

The mushrooms are grown inside mushroom growing sheds and are commonly cultivated inside plastic bags. There are many sizes of shed; from those which can hold 4,000 bags to those with a capacity of 10,000 bags. The sheds can be classified into two types: those built for temporary use or those erected for long term use. The temporary ones are made of wooden poles and netting (for shade), and need to be replaced on a regular basis. The more permanent ones are made of iron and roof tiles. The farmers said they replace the temporary sheds every two to three years. With the different materials used, the cost of a mushroom shed can range from 8,500 to 40,000 baht.

Most of the study farmers use machinery and tools like ribbon mixers, compacting machines and steam boilers. The ready-to-fruit mushroom bags are mixed with sawdust (from rubber trees) containing rice bean, calcium hydroxide, Epsom salt, brown sugar and molasses. Some farmers use glutinous flour and effective micro-organisms (EM). Each farmer has their own recipe. The growing bags are sterilized in a steam boiler then left to cool to an ambient temperature, then injected with spores. Each bag is then left for around a month in the mushroom shed then opened to allow the mushroom to grow. The farmers mainly use household labor to grow mushrooms; however, some farmers hire labor to help with certain processes such as preparing the mushroom bags, as this takes a lot of time. The farmers can harvest the mushrooms after around seven or eight months. The main problems encountered when growing mushrooms are that the spore do not grow or are damaged.

For small mushroom farms (production less than 20,000 mushroom bags per year), the total cost per mushroom bag is around 9.08 baht, with the fixed costs (mainly depreciation of the machinery and tools) being 0.83 baht and the variable costs being 8.25 baht. The average revenue is 24.04 per mushroom bag. For the big mushroom farms

(production of more than 20,000 mushroom bags per year), the total cost per mushroom bag is around 7.93 baht, with the fixed cost (mainly depreciation of the machinery and tools) being 0.86 baht and the variable cost being 7.07 baht. The average revenue is 19.57 per mushroom bag (Table 5).One mushroom bag can produce around one kilogram of mushrooms.

Most of the mushrooms are sold at local markets through local traders. If there is a very high demand (which does not happen so often), farmers will sell their mushrooms directly to consumers at a small market near their farm. The price per kilogram of mushrooms varies depending on the variety; for example, the *Lentinus Polychrous Berk* price is 150 to170 baht, while the *Lentinussquarrosulu*s price is100 to 110 baht and a Bhutan Oyster Mushroom fetches 50 to 70 baht.

Table 5: Costs and benefits of mushroom cultivation in baht (2015)

Items	baht per mushroom bag	
	Small farm <=20,000	Medium sized farm >20,000
Fixed costs (Depreciation)	0.83	0.86
Mushroom shed	0.45	0.14
Rope	0.29	0.22
Concentrate machine	-	0.15
Mixing machine	-	0.16
Steam tank	0.09	0.19
Variable costs	8.25	7.07
Mushroom spores	0.33	0.33
Rubber tree sawdust	2.52	1.59
Epsom salts	0.06	0.12
Calcium hydroxide, lime	0.04	0.08
Rice bran	0.23	0.41
Glutinous flavor	0.07	0.20
Molasses	0.03	
Brown sugar	-	0.24
Effective Micro organisms (EM)	-	0.08
Bottle tops	0.20	0.20
Plastic bags	0.45	0.45
Instant mushroom food	0.38	0.13
Firewood	0.34	0.17
Water	-	0.11
Wages	3.60	2.99
Total	9.08	7.93
Revenue	24.04	19.57
Profit (Revenue - Total Cost)	14.96	11.64

Source: Study survey

4.2.4 Livestock systems

Data in relation to the livestock rearing systems used in Nan province for 2014 (Department of Livestock Development at the Ministry of Agriculture and Cooperatives) shows that in total 52,360 households carry out livestock rearing activities. Linked to this, the privately owned pasture used to grow forage crops, to feed the livestock, covers 955 ha, while public pasture land covers 1,687 ha (Table 6). The most common livestock raised in this area are chickens, as there are 1,829,938 of these, followed by pigs, ducks and beef cattle, of which there are 52,011, 47,629 and 32,307 respectively (Table 7). Most of the farmers (about 90%) raise their livestock in fields.

Chickens: Local chickens are mainly raised for home consumption; normally five to 30 chickens per household (Nan Provincial Agriculture and Cooperative Office, 2014). Some farmers also sell their chickens to generate income, especially during festival celebrations (about 10%). The main problems encountered when raising chickens in Nan province are Newcastle Disease, infectious bronchitis and fowl cholera. As well as local chickens, egg laying hens, broilers and hybrid chickens are raised commercially, mostly in Muang Nan and nearby districts.

Pigs: Most of the pig farmers raise about two to five pigs around the house, to earn additional farm income (Nan Provincial Agriculture and Cooperative Office, 2014). The pig feed used represents a mix of concentrated feed and local feed such as bran, broken-milled rice and maize. However, commercial pig farms can also be found; either based on individual investment or contract farming. The main problems encountered when raising pigs in Nan province are the high costs of feed, since farmers have to buy it from a nearby province. Also, the pollution created when raising pigs causes considerable problems within the local communities.

Cattle: Most farmers in Nan province who raise cattle also cultivate rice, and they keep them in the rice fields after harvesting activities have ended. Rice straw is used as cattle feed in the dry season, though some cattle are also raised in the degraded forest. Cattle are raised in all districts of Nan province, but most can be found in Thung Chang, Bo Kluea, Mae Charim, Chaloem Phra Kiat and Wiang Sa districts. The main problem faced by the beef cattle farmers in Nan province is a lack of land and grass, since most farmers use their land ostensibly to grow maize.

Buffalo: In the past, most farmers in Nan province raised buffalos, mainly to use as farm labor, but nowadays cash crops are the main source of income, so buffalo are raised to generate additional farm income. Information from the key informant interviews held shows that in 2010, raising buffaloes began to be promoted among highland farmers in the area by the NGO Pid Thong foundation in 2010. Under this initiative, buffalo calves were provided free to farmers for two to three years, until they also calved, then the new

calves were given to the farmers. Buffaloes are raised in all districts, but mostly in Bo Kluea, Na Muen and Chaloem Phra Kiat districts.

Table 6: Number of farming households and forage crop areas by district, 2014

District	No. of households	Forage crop areas (ha)	Public pasture land (ha)
Mueang Nan	5842	22	212.5
Mae Charim	2,592	6.6	430
Ban Luang	2,333	0	0
Na Noi	4,744	267.3	0
Pua	4,647	0.4	0
Tha Wang Pha	5,256	300	234.7
Wiang Sa	9,579	6.36	17
Thung Chang	3,284	19.8	5.5
Chiang Klang	2,132	1.8	143.5
Na Muen	2,156	0	0
Santi Suk	2,265	0.5	0
Bo Kluea	1,695	312.1	0
Song Khwae	1,212	0	0
PhuPhiang	3,149	17.6	644
Chaloem Phra Kiat	1,420	0	0
Total	52,306	954.4	1,687

Source: Department of Livestock development, 2015.

Table 7: Number of livestock by district in Nan province, 2014

District	Beef cattle	Cows	Buffalo	Pigs	Chickens	Ducks	Goats	Sheep	Others
Mueang Nan	3,056	10	207	8,251	257,374	5,128	0	69	3,392
Mae Charim	3,746	0	388	2,255	51,084	1,018	0	0	85
Ban Luang	741	0	347	691	47,763	959	0	0	280
Na Noi	1,536	0	980	754	123,849	1,396	0	0	0
Pua	1,727	0	495	6,068	202,422	7,527	153	0	517
Tha Wang Pha	1,221	2	254	4,955	229,985	10,861	13	0	6,351
Wiang Sa	3,674	0	727	13,083	250,207	6,284	46	0	414
Thung Chang	4,353	0	864	2,746	66,477	3,506	0	0	31
Chiang Klang	1,466	0	105	1,292	55,920	367	0	0	16
Na Muen	680	0	1,325	616	48,455	247	0	0	13
Santi Suk	248	0	95	1,280	47,029	1,280	0	0	36
Bo Kluea	4,184	0	1,429	1,798	35,097	3,429	487	0	19
Song Khwae	501	0	61	1,814	21,903	816	14	0	41
PhuPhiang	1,517	45	85	5,699	340,737	3,787	28	0	12
ChaloemPhraKiat	3,657	0	1,283	709	51,636	1,024	2	0	0
Total	32,307	57	8,645	52,011	1,829,938	47,629	743	69	11,207

Source: Department of Livestock Development, 2015.

From the livestock meat production data for Nan province shown in Table 8, it can be seen that a large amount of meat is sold at the local markets, either as carcasses or offal. The largest number of carcasses imported into Nan province is from chickens, followed by cattle, ducks and pig offal. However, some livestock products are sold to provinces outside of Nan such as bone, bone-marrow and skin (Table 9).

Table 8: Livestock production in Nan province, 2014

Chicken carcasses		Duck carcasses		Cattle carcasses		Cattle entrails		Pig carcasses		Pig entrails	
tons	1,000 baht	tons	1,000 baht	tons	1,000 baht	tons	1,000 baht	tons	1,000 baht	tons	1,000 baht
3,417	119,612	76	2,658	32	2,531	31	2,440	828	66,272	197	9,860

Source: Department of Livestock Development, 2015.

Table 9: Livestock products sold outside Nan province, 2014

Bone and bone-marrow		Cattle/Buffalo skin	
tons	1,000 baht	tons	1,000 baht
85	255	78	1,950

Source: Department of Livestock Development, 2015.

The price of cattle carcasses has been increasing steadily over recent years, and this has created an opportunity for farmers to improve their production processes using crossbred cattle and also preparing the land by growing pasture. Since maize is the dominant crop in Nan province, its by-products can be used as cattle and pig feed. Introducing and raising local chicken varieties is also important, since they are in high demand on the local market, and especially during festivals. This has also helped raise the price of local chickens.

4.3 Natural resources management

Land degradation is a serious problem globally, and especially in developing countries and for the poor who live there. Land degradation tends to be caused by a lack of appropriate land management in such areas, with deforestation considered one of the primary causes. It is not possible to conserve all forests at all times, as people have to eat, plus cultivate agricultural and forest products. Uncontrolled and unwarranted deforestation; however, is perhaps the greatest of all ecological dangers, as it leads to unstable crop productivity. It is difficult to give general guidelines on the quality and kind of deforestation which is allowable under certain conditions, unless local and regional possibilities and requirements are determined through an integrated process of land evaluation. This has led to the study of landscapes developing for land use planning and sustainable resource management purposes.

The landscape can be defined as the surface of the earth with all its phenomena including landforms, soils, vegetation and attributes that are influenced by humans. These characteristics are not static, because most processes that take place influence the living conditions experienced by humans and other organisms. Thus, the study of the landscape may be summarized as the study of the spatial relationships that take place between phenomena and processes in the landscape, including between communities of plants and humans.

4.3.1 Topography

The province of Nan covers approximately 12,200 square kilometers, and is located in the north of Thailand. Its mountainous eastern border adjoins the Lao People's Democratic Republic (Lao PDR). The province's topography consists of mostly highlands and mountainous areas (Figure 7). The elevation map of Nan province shown in Figure 8 was generated using aerial photography data from the Land Development Department at the Ministry of Agriculture and Cooperatives, at a resolution of five meters. The map also provides an idea of the topography and contours for Nan province. The land elevations in Nan province range from 128 to 2,086 meters above mean sea level. Figure 8 shows these elevations using different colors.

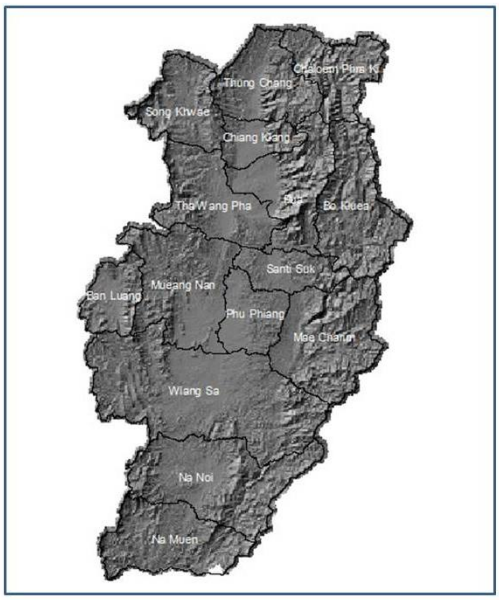

Figure 7: Topography of Nan province

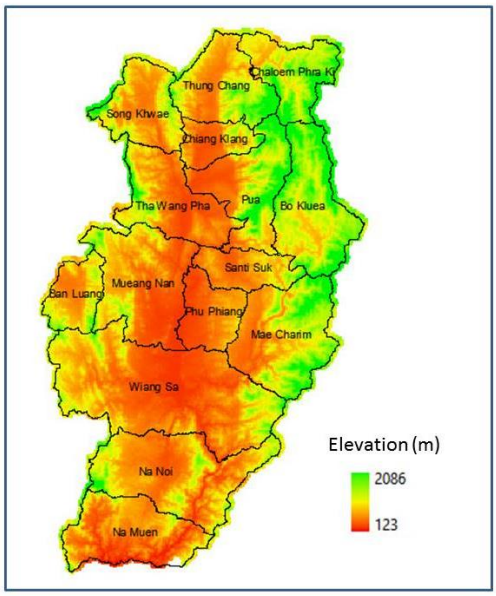

Figure 8: Elevation map for Nan province

In order to develop a topographic characteristics map of Nan Province, first the contour lines were interpolated to produce the surface elevations and generate slope data layers. It was found that Nan province has slopes ranging from 0 to 300% (Figure 9).

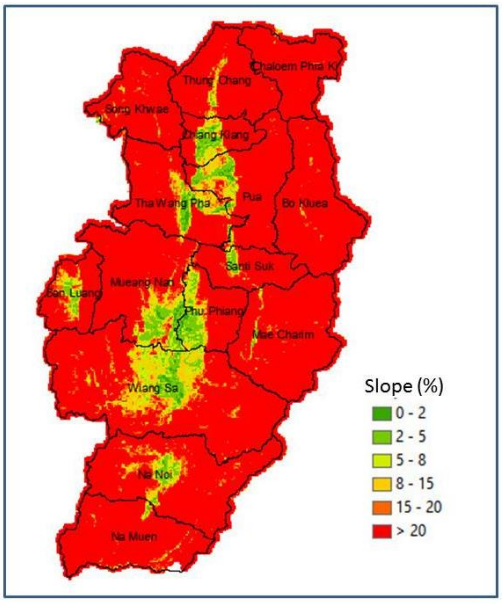

Figure 9: Slope map of Nan province

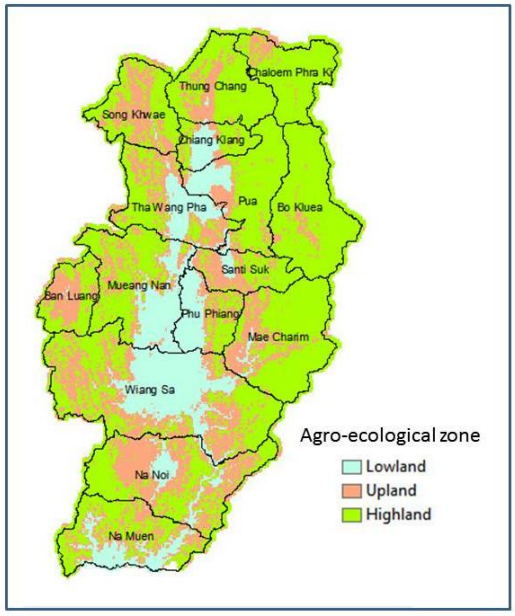

Figure10: Agro-ecological zones in Nan province

Table 10: Agro-ecological zones in Nan province, by district

District	Area (ha), % of total area		
	Lowland	Upland	Highland
ChaloemPhraKiat	219 (0.39)	11,864 (20.89)	44,701 (78.72)
Chiang Klang	10,795 (34.32)	10,085 (32.06)	10,573 (33.62)
Tha Wang Pha	25,252 (32.22)	33,092 (42.22)	20,034 (25.56)
Thung Chang	2,025 (2.86)	27,847 (39.34)	40,921 (57.80)
Na Noi	19,496 (16.09)	66,710 (55.05)	34,967 (28.86)
Na Muen	25,181 (29.54)	37,406 (43.88)	22,661 (26.58)
Bo Kluea	589 (0.64)	13,509 (14.61)	78,376 (84.76)
Ban Luang	2,557 (6.70)	22,443 (58.79)	13,175 (34.51)
Pua	15,396 (19.15)	19,060 (23.71)	45,934 (57.14)
PhuPhiang	22,212 (49.87)	17,096 (38.38)	5,232 (11.75)
Mueang Nan	38,414 (36.13)	39,651 (37.29)	28,261 (26.58)
Mae Charim	5,712 (5.50)	33,946 (32.70)	64,140 (61.79)
Wiang Sa	75,350 (35.98)	87,938 (41.99)	46,133 (22.03)
Song Khwae	1,653 (2.76)	34,695 (57.86)	23,613 (39.38)
Santi Suk	6,058 (15.35)	22,489 (56.98)	10,922 (27.67)

Based on elevation and slope maps, agro-ecological zones could be generated, composed of lowlands (elevation < 310 m. or slope < 2 %), uplands (elevation between 310 and 750 m., or slope between 2 and 25 %) and highlands (elevation > 750 m., or elevation between 310 and 750 m, with slope >25%) (Figure 10). It was found that most of the province is covered by upland and highland areas, and especially in Chaloem Phra Kiat, Thung Chang, Bo Kluea and Ban Luang districts (Table 10).

4.3.2 Soils

Based on the soil group information provided by the Land Development Department at the Ministry of Agriculture and Cooperatives, it was found that most of Nan province is covered by slopes greater than 35%, and this has led to soils developing which are a part of soil group No. 62. No information is available for the soils in this group, and no agricultural activity is allowed on land in which such soils are present. However, soils in the agricultural areas of the province mostly belong to soil groups 29, 46 47 and 48, which have the following characteristics:

Soil group No. 29 (covers approximately 32% of the total agricultural area)

Deep soil with a clay texture; the pH is low to very low (acid soil). Drainage is moderate to good, soil fertility is low and the soil is prone to erosion on sloping land.

Soil group No. 46 (covers approximately 10% of the total agricultural area)

Shallow soil made of coarse sand; the pH is very low (acid soil). Drainage is good, soil fertility is low and is prone to erosion on sloping land.

Soil Group No. 47 (covers approximately 20% of the total agricultural area)

Shallow soil made of coarse sand; the pH is very low (acid soil). Drainage is moderate to good, soil fertility is low and is prone to erosion on sloping land.

Soil Group No. 48 (covers approximately 10% of the total agricultural area)

Shallow soil containing coarse sand; the pH is very low to normal. Drainage is moderate to good, soil fertility is low and is prone to soil erosion on sloping land.

4.3.3 Climate

Nan Province has a tropical savanna climate. Winters are warm and dry. The temperatures rise between January and April to an average daily maximum of 37°C (98.6°F). The wet season runs from late April through to October, with heavy rain and somewhat cooler temperatures during the day, although nights remain warm (Table11).

Table 11: Climate data for Nan province (1981–2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	30.8 (87.4)	33.4 (92.1)	36.2 (97.2)	37.0 (98.6)	35.0 (95)	33.5 (92.3)	32.4 (90.3)	32.2 (90)	32.7 (90.9)	32.5 (90.5)	31.2 (88.2)	29.6 (85.3)	33.04 (91.48)
Average low °C (°F)	14.2 (57.6)	15.6 (60.1)	18.9 (66)	22.3 (72.1)	23.5 (74.3)	24.0 (75.2)	23.8 (74.8)	23.6 (74.5)	23.3 (73.9)	21.9 (71.4)	18.5 (65.3)	14.5 (58.1)	20.34 (68.61)
Rainfall mm (inches)	4.4 (0.173)	11.9 (0.469)	32.7 (1.287)	99.6 (3.921)	177.3 (6.98)	133.8 (5.268)	200.7 (7.902)	273.2 (10.756)	203.5 (8.012)	70.3 (2.768)	18.1 (0.713)	8.6 (0.339)	1,234.1 (48.588)
Average rainy days (≥ 1 mm)	1	2	3	9	17	16	20	22	18	11	4	1	124
Average humidity (%)	76	70	65	68	76	79	82	84	84	82	80	78	77

Source: Thai Meteorological Department ***(1981-2014)***

Table 12: Land use in Nan province, by district

District	Area (ha)									
	Paddy Rice	Maize	Rainfed Rice	Vegetables	Para Rubber	Oil Palm	Coffee	Mixed Fruit Trees	Teak	Swidden Fields
Chaloem Phra Kiat	143	13,169	984	20	6	0	0	162	3	1,028
Chiang Klang	3,191	4,523	1,189	0	175	0	4	1,876	379	683
Tha Wang Pha	5,495	20,746	163	0	1,775	21	211	3,681	1,435	5,351
Thung Chang	895	10,861	687	607	320	4	0	1,455	300	1,468
Na Noi	2,797	26,547	2	585	4,462	5	0	4,412	951	289
Na Muen	1,045	10,573	9	0	1,333	0	0	646	328	428
Bo Kluea	723	6,821	4,461	0	1	0	17	476	13	7,936
Ban Luang	1,785	6,593	0	0	1,022	3	0	3,014	706	476
Pua	5,455	11,683	3,124	129	350	1	0	2,147	420	6,191
PhuPhiang	2,457	11,086	2	0	3,130	1	0	2,483	1,966	1,550
Mueang Nan	4,755	24,256	19	0	9,023	0	0	4,313	3,033	5,285
Mae Charim	775	15,749	528	0	509	0	0	741	450	3,980
Wiang Sa	6,846	48,300	12	0	5,785	0	1	8,726	4,343	2,718
Song Khwae	451	9,940	1,486	0	365	4	0	1,041	20	5,885
Santi Suk	1,048	12,543	87	0	1,715	4	0	542	817	1,893
Total	36,816	220,849	12,666	1,341	28,255	39	234	35,173	14,350	43,269

4.3.4 Land use

Agriculture has long been the main economic activity carried out in the province. Based on a land use map generated by the Land Development Department at the Ministry of

Agriculture and Cooperatives for 2014, maize has the largest growing area in Nan province, followed by swidden areas which have been abandoned for soil improvement purposes, paddy fields and mixed fruit trees (Table 12). Cash crops play a prominent role in contributing towards economic development, especially maize which seen a boom since 2007. Success in the agricultural sector has also been due to support provided in the form of private investments for the supply of seeds, fertilizers and pesticides. In addition to this, rubber plantations have also become an attractive option and have gradually expanded in area, and now cover an area comparable with maize. This increase in the size and number of rubber plantations has also been due to subsidies provided to local farmers and landholders by the Rubber Plantation Supporting Fund. These subsidies were first provided in the province in 2005.

4.3.5 Forest and Water Resources

Areas for growing maize and other cash crops have been expanding in the province over recent years, leading to a major decline in natural forest areas. The remaining natural forest can mostly be found within conservation areas, which are currently popular and well-known tourist attractions. Other patterns of land use have not changed much; however, there has been a noticeable increase in community forests. Based on the land use map generated by the Land Development Department for the year 2014, the forested areas in Nan Province can be broken down into five classes, these being dense evergreen forest, dense forest plantations, dense deciduous forest, disturbed evergreen forest and disturbed deciduous forest (Figure 11). Deciduous forest covers the largest area in Nan province, as it covers 667,193 ha of land, followed by evergreen forest which covers 103,201 ha (Table 13).

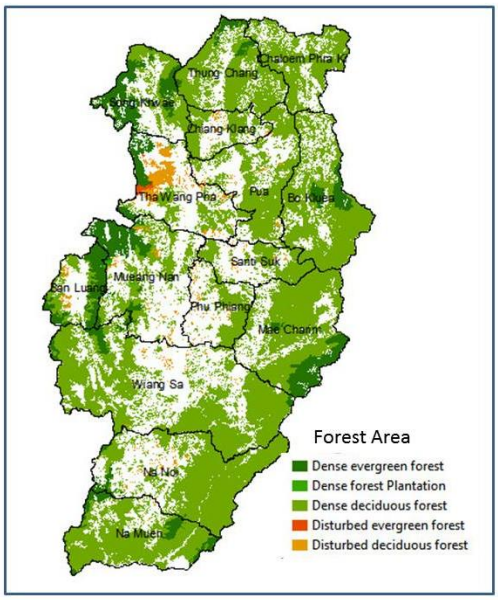

Figure 11: Map of forested areas in Nan province

Due to the potential for water shortages in the area, the Royal Irrigation Department provided support in the form of man-made water resources in Nan province, and these water bodies cover an area of 3,840 ha. Furthermore, in 2014 the Department of Agriculture Support provided farm ponds covering an area of 257 ha (Table 13).

Table 13: Water and forest resource in Nan Province, by district

	Farm Ponds	Reservoirs	Bamboo	Pasture and shrubs	Forest Plantations	Deciduous Forest	Evergreen Forest
Chaloem Phra Kiat	0	2	1	28	0	40,452	340
Chiang Klang	18	119	46	350	22	17,583	0
Tha Wang Pha	13	107	213	17	150	27,748	9,053
Thung Chang	4	19	85	235	9	47,970	5,231
Na Noi	5	185	0	492	0	76,906	3,476
Na Muen	4	2,533	0	0	0	58,442	8,158
Bo Kluea	1	0	1	1	0	64,030	6,860
Ban Luang	12	61	1	153	122	11,829	13,002
Pua	21	102	173	518	31	47,612	0
PhuPhiang	43	199	9	0	0	18,445	0
Mueang Nan	42	100	4	458	605	31,339	17,160
Mae Charim	12	50	0	345	9	65,655	14,205
Wiang Sa	79	268	0	1,084	75	118,924	5,845
Song Khwae	3	27	0	21	0	20,281	19,871
Santi Suk	0	66	4	168	0	19,975	0
Total	257	3,840	533	3,869	1,022	667,193	103,201

In response to unsustainable land use, a strategic plan for the province has been developed which embraces the province's new vision of achieving green growth, and where economic advancement is achieved through the sustainable use of natural resources. Following this change in policy, rubber trees and other cash crop plantations have been promoted over maize in an effort to establish crops which have comparatively less negative impact on the environment. However, the suitability of such a promotion has been questioned, stirring-up controversy amongst involved stakeholders in the province. Most of the local inhabitants are concerned about problems arising from such a policy due to unsustainable natural resource management and land use. They have realized that changes in land use patterns can lead to a variety of problems, particularly when trying to manage the consequences of natural disasters and disease outbreaks. Furthermore, it has been found that some farmers are now aware of the negative impacts on the environment of such actions and are looking for an alternative source of income. However, a majority of farmers are unlikely to seek other options and will continue to expand their cultivation areas in an unsustainable manner in order to increase production volumes and earn higher incomes.

5 Pathway to Sustainable Diversification

5.1 Existing agricultural diversification initiatives in Nan province

The work required to promote diversified and sustainable agricultural practices in Nan province was initiated by the HMN, which is now a key focal point with regard to the knowledge on and practice of sustainable agriculture and natural resource management. The HMN was established by a monk named Phra-Kru-Pitak-Nanthakhun, who observed the decline in forest land and the degradation of natural resources, and that these changes were impacting directly on the livelihoods and well-being of people in Nan. From an initial effort made to protect forest land and also water, the movement has extended to the promotion of agricultural practices that are environmental friendly. HMN has also extended its alliance network among individuals and farmers' groups, in order to promote the ideas and practice self-sufficiency, sustainable agriculture, and resource and environmental conservation. Over two decades of effort and an expansion of the HMN alliance, the knowledge and practices gathered have been disseminated to individuals, groups and communities, and new initiatives have been absorbed into the network. Along the way, concrete outcomes have been observed and have gained attention, as well collaboration and support, from a wide range of government agencies and the private sector. These concrete actions have allowed HMN to drive the success of many other initiatives in Nan. The Pid Thong Lang Phra Foundation (the Royal Initiative Discovery Foundation or RIDF),which is based on the Thai King's sufficiency economy concept, is an organization that has been pushing hard to support local people's well-being, in parallel with restoring degraded resources.

As a result of the work of the HMN, RIDF and collaborative efforts from their alliances, as well as the government, nowadays there are a number of local farmers' schools, which act as centers of learning for diverse agricultural practices, and showcase good agricultural and natural resource conservation practices. However, most of these initiatives are either individuals who have diversified their land use activities, or groups of locals who collectively focus on one particular agricultural activity (e.g. rice seeds or animal husbandry). As a result, there are few group initiatives in place related to land use diversification.

Nevertheless, many initiatives have linkages and have built networks among one another. Information obtained from the Provincial Agricultural and Cooperative Information Center, the RIDF Knowledge Center and HMN reveals that altogether 27 learning centers either publicly recognized or officially institutionalized have been set up. These centers focus on a wide range of issues associated with rice, food banks, backyard poultry, fish, medicinal plants, backyard vegetables, mushrooms, organic fertilizers, soil conservation practices, fruit orchards, swine, bamboo, upland agricultural practices, self-sufficient economic practices, crickets, papaya, frogs and other animal husbandry activities. In

addition, 17 individual, or so-called "local wisdoms" specializing in either a single agricultural activity or a diverse range of activities have been created, including three groups of individuals specializing in agricultural enterprises focused on rice seed production, organic rice and swine, and one individual's group focused on the safe cultivation of vegetables. None of these initiatives has been officially institutionalized; they have instead emerged from either individual or collective efforts to reduce impacts and risks based on support coming from existing networks, as well as the private and government sectors. Since being set up, many have been recognized by the public and have thus become 'official' centers of learning and local wisdom.

There are three types of initiative in Nan province, based on the classification of the inventory process, these being:

1. Individual initiatives focused on mixed cropping livestock producing systems (or integrated farming system)
2. Group-based initiatives specializing in an agricultural activity
3. Group-based initiatives focused on crop diversification

All of these groups serve as learning bases; open to those who would like to learn, practice and exchange, and are linked together either locally or through relevant government offices in Nan.

5.2 The selected initiatives

Eleven initiatives were selected and investigated as part of this study (Table 14). Three (#1, #2, #3) are individuals focused on integrated farming systems, four (#4, #5, #6, #7) are farmers' groups specializing mainly in rice seed production activities, and three (#8, #9, #10) are focused on safe vegetable and organic vegetable production, and the last initiative (#11) is a pig producing group.

Table 14: The eleven study initiatives

Initiatives/Contact info.	Specialization/activities	Landscape
1. Integrated farming – local wisdom Mr.Chamlong Jaikliang 47 M.7 Nampaag, Tanchum, Thawangpha, Nan. Tel: 084-724-8616	- Integrated farming - Chinese local pigs (Meuai Xan) - Mixed fruit orchards (longan, banana, lemon) - Vegetables - Bamboo, rattan, *arenga* palm - Fish - Bio-fermented juice, bio-compost	- Upland Slopes

Initiatives/Contact info.	Specialization/activities	Landscape
2. Integrated farming– local wisdom Mr.Sathit Tanchucheep Wangpha, Lae, Thung Change, Nan Tel: 081-023-9212	- Integrated farming - Paddy rice - Fattening pigs and sows - Egg laying hens, locally bred broilers (*kai pradoo*) - Crickets - Fish - Mixed fruit orchards - Organic vegetables	- Lowland paddy land - Farm ponds
3. Ban-Rai-Plai-DoiLearning Center Mr.Prakit Wongputthakham 63 M. 4 Muangluang, Muangjang, Phuphiang, Nan Tel: 085-718-5591	- Integrated farming - Mixed fruit orchards (Lychee, lemon, mango and longan) - Vegetables (home garden) - Fattened pigs, sows - Chickens, ducks, fish	- Upland slopes
4. Community Small & Medium Enterprise (SME) – Rice seed and Soybean producing group Mr.Sujarit Wuthisawat Theumtong, Theumtong, Muang, Nan Tel: 085-240-4579 (PayomWuthisawat)	- Rice seeds - Soybean seeds	- Irrigated lowland paddy fields
5. ThungkongFarmer School Ms.Phin Khamsaen, Mr. KietKhamsaen 42 M.5 Thunghong, Yom, Thawangpha, Nan Tel: 081-035-0847	- Organic rice farming - Rice seed production - Cattle	- Irrigated lowland paddy fields
6. Pa-oy Rice Seed Producing Group Ms.Amphai Wongkhatiya 83 M.4 Pa-oy, Pa-Laewluang, Santi Suk, Nan Tel: 089-853-8040	- Rice seeds - Bio-fertilizers	- Irrigated lowland paddy fields
7. Organic-rice Producing Group Mr.Seenoon Khamseekaew 57/3 M.2 Bunruang, Lai-nan, Wiangsa, Nan Tel: 081-602-0902	- Organic-rice and rice seed production - Bio-compost, bio-fermented juice	- Irrigated lowland paddy fields

Initiatives/Contact info.	Specialization/activities	Landscape
8. Silapetch Farmer School and Safe Vegetable Group Mr.Sanit Panyawannarak 167 M.1 Nakham, Silapetch, Pua, Nan Tel: 086-193-9439	- Organic rice farming - Safe vegetables - Bio-compost, bio-fermented juice	- Irrigated lowland paddy fields
9. Nong-Phuk Integrated Farm and Safe Vegetable Producing Group Ms.Khreuwan Suropan Nong-Phuk, Peua, Chiangklang, Nan Tel: 084-894-7591	- Safe vegetables - Vegetable seeds - Bio-compost	- Irrigated lowland paddy fields
10. Bankad Maewang SME – Organic Vegetables Producing Group Mr.Rangsan Kantiya Bankad, Maewang, Chiang Mai Tel: 087-460-2371	- Organic vegetables	- Irrigated lowland paddy fields
11. Muangjang Pig Raising Group Mr.Samit Aphairoon Muangjang, Phuphiang, Nan Tel: 089-757-6087	- Fattened pigs, sows, semen and artificial insemination	- Upland slopes

5.3 Pathway analysis

5.3.1 Case #1: The integrated farm of Mr. Jamlong Jaikliang

Mr. Jamlong Jaikliang is a local farmer in Tan-chum sub-district, Tha-wang-pha district, who had to leave his farm because his commercial crop cultivation activities failed due to a low product price. He then spent 17 years working in Bangkok. He returned to Nan province with substantial savings and so was able to resume farming. Due to the experience and knowledge he had gained in Bangkok, and his ability to observe, learn and experiment, he was able to recover his 1.2 ha of upland land and create an integrated farm which grows organic and non-organic longan, bananas, pineapples, oranges, lemons, vegetables, bamboo, rattan and oil palm, as well as rears pigs, backyard chickens and fish. Also, the RIDF provided him (and some neighbors) with piglets, plant seedlings and fish fingerlings. Other important support provided to him and other farmers in this community from RIDF included water source and knowledge training and field visits. To reduce chemical usage, he now produces his own compost, bio-fermented liquid fertilizer and bio-pesticide, and applies these to his crops

Nowadays, this integrated farming system provides him and his family with food (vegetables and fish), cash income (vegetables each day, bananas weekly, lemon grass,

galangal and banana leaves monthly, pigs and piglets every two months, and longan, pineapples, lemons and oranges annually. For example, the organic longan (800 trees) can earn him almost 800,000 baht a year and he can earn 25,200 baht a year from selling 26 45-day-old piglets (RIDF, 2013). Moreover, his practices have improved the local soil's fertility and structure and reduced his chemical input costs. All this has resulted in greater well-being and happiness for his family. The following diagram illustrates the pathway to success of this case.

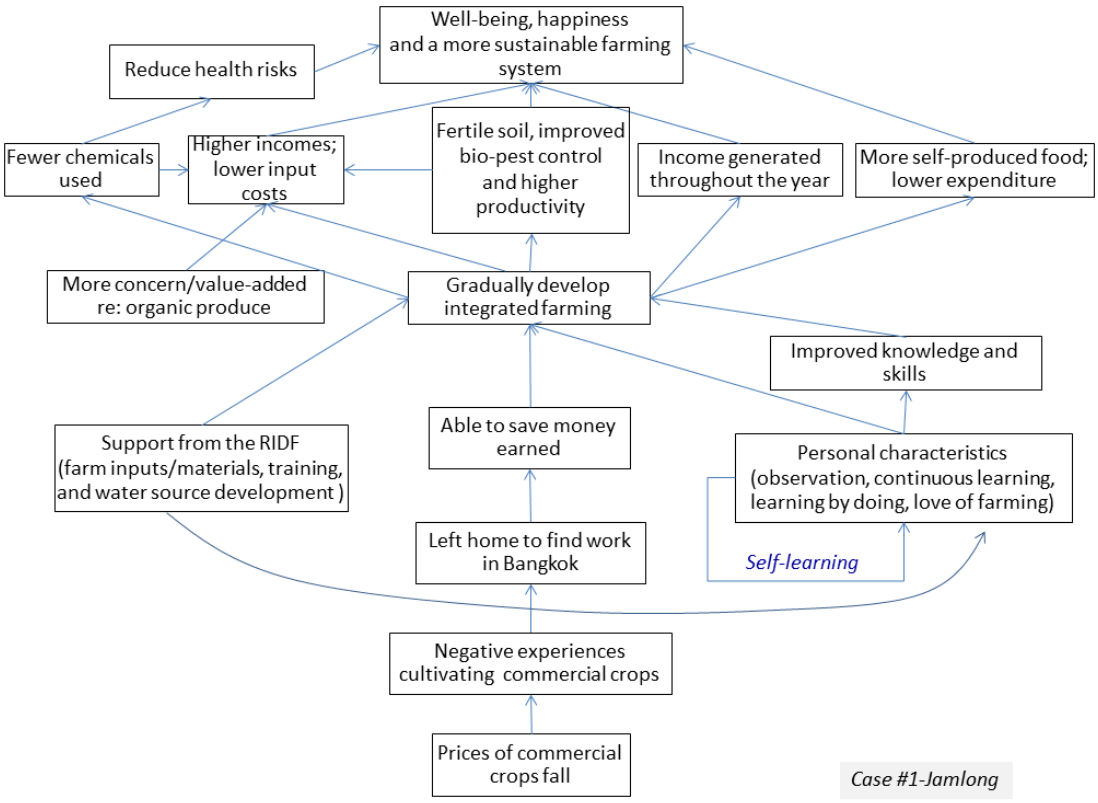

Figure 12: Case #1 Change and outcome pathways

5.3.2 Case #2: The integrated farm of Mr. Sathit Tanchucheep

The drivers behind Mr. Sathit Tanchucheep changing from cultivating upland rice and commercial crops such as cotton, tobacco, maize and oranges, to running a more sustainable and integrated farming system, were similar to those for Case #1; high input costs and price fluctuations, with a high dependency on chemicals and a lack of control over the market price.

Mr. Sathit's negative experiences shaped his vision; to take less risk and become more sustainable. As a result, he accumulated knowledge and information on better agricultural practices by attending agricultural knowledge training sessions provided by the government sectors (extension, livestock and fisheries local offices), learned about local wisdom, plus experimented with new practices. Gradually, he turned his 11 rai (6.25

rai = 1 hectare) into four rai of paddy fields producing for household consumption, nine farm ponds on three rai of lowland land, to rear fish and supply water to his crops and animals, and four for raising pigs, hens for eggs, local chickens and crickets, as well as grow vegetables and soybean. This integrated farming system requires only low level chemical fertilizers and no pesticides; leading to lower risk in relation to chemical usage, uncertain produce prices, increased household food security using self-produced and safe food, plus generates more of a regular income.

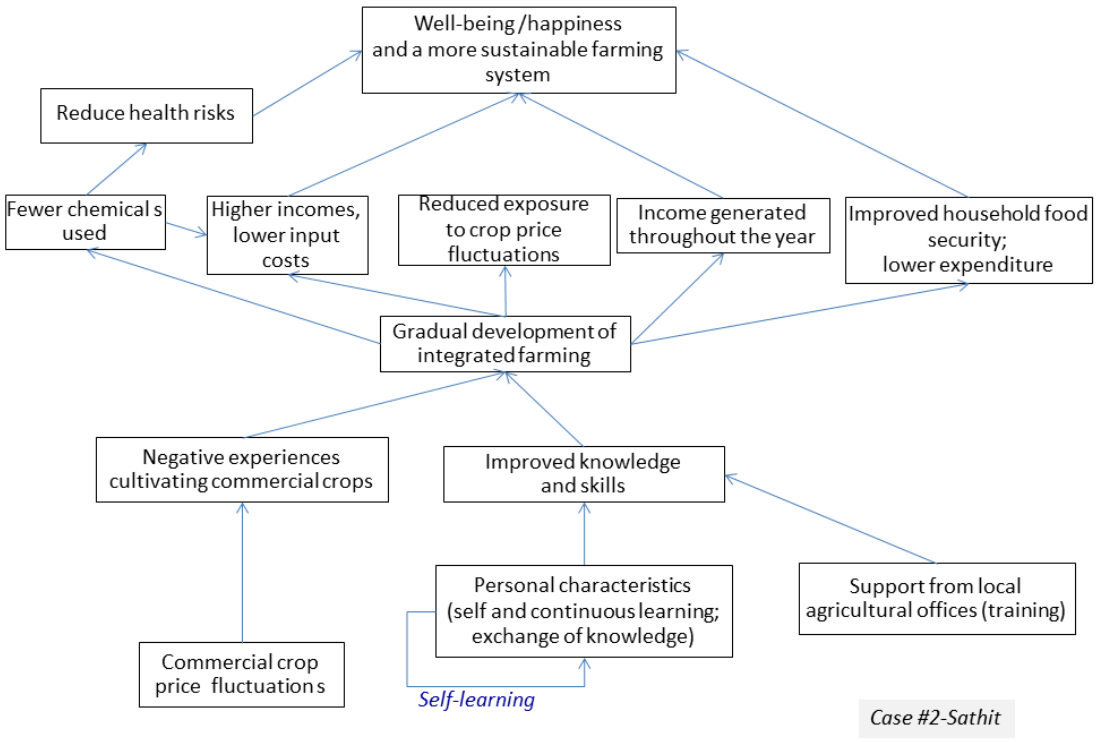

Figure 13: Case #2 Change and outcome pathways

5.3.3 Case #3: Ban-Rai-Plai-Doi learning center

Ban-Rai-Plai-Doi is a farm set on sloping land which belongs to an active and leading farmer called Mr. Prakit Wongputthakham, and is now covered by a variety of fruit trees such as lychee, lemon, longan, mango and santol trees, home gardens, pig shelters and chicken coops, space for local chickens to run around, and ponds set on low elevation land next to a narrow valley. These ponds host a small-scale fishery and supply water to storage tanks located on elevated land, for use by the farm.

Before being turned into an integrated farm, the land belonged to Mr. Wongputthakham's father. As well as three rai of lowland paddy fields producing rice for household consumption, the land was used for growing cash crops such as maize and oranges, and some lychee trees. Growing maize and oranges required the intensive use of chemical

fertilizers, herbicides and insecticides, especially for the oranges that are susceptible to insects and diseases, and also the hiring of labor. At that time the market price was not reliable. After returning from Bangkok, Mr.Wongputthakham saw that many farmers in the area faced a vicious cycle of growing commercial crops to earn money using a lot of chemicals and local credit, while facing fluctuating market prices and having to rely on external food sources. All of this meant these farmers faced significant financial and health risks. This situation made the case study farmer seek a 'better way' of running a farm. Being a community volunteer as a sub-district head assistant and being in charge of working with the *Sor-Por-Kor* office (Land Reform Office), he had the chance to visit several farms displaying good agricultural practice, those belonging to the Royal Project, and gathered knowledge on how to use these practices on his upland farm and transform his land. The most important factor driving his need to avoid the vicious cycle faced by others was his changed point of view, as he aimed to "grow things for food" instead of "grow things for cash". In the end, his sales did exceed his costs, in accordance with the Thai King's "sufficiency economy" principles.

In order to support farm transformations in Nan province, a community-based pig farming project was implemented in 2005 by Chulalongkorn University in Nan. Knowing the Jogo learning center from having been working as the vice sub-district head, Mr. Wongputthakham, was able to link with this project. He was the first person in the area to be trained on pig rearing and artificial insemination techniques. Pig rearing then became an additional activity on his farm, and he now has 60 to 70 pigs. He has also trained other farmers in the area at the Jogo Learning Center, and Mr. Samit (see Case #11) was one of the first farmers to be trained by him.

The strategic farm management processes he has helped implement include:

1. Adjusting farmers' way of thinking; aiming for food self-sufficiency
2. Growing crops to cover the soil and maintain soil moisture content
3. Adjusting and applying knowledge to fit the land in question, and
4. Using and applying on-farm materials; to create an internal supply chain.

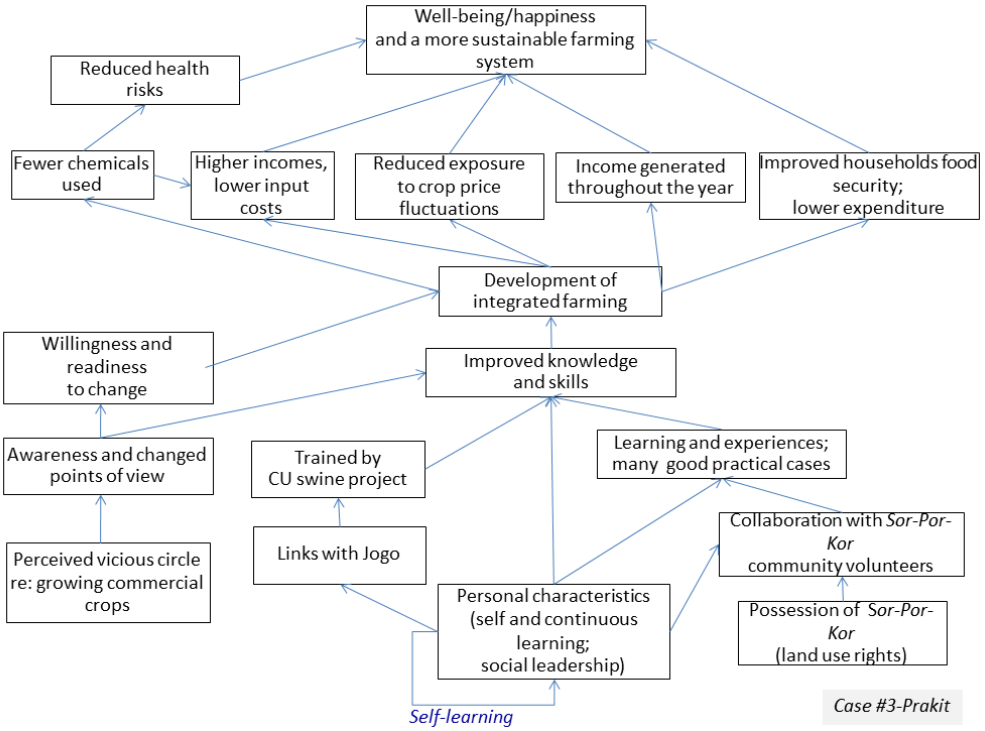

Figure 14: Case #3 Change and outcome pathways

5.3.4 Case #4: Community SME – Rice seed and soybean seed producing group

The former cropping patterns of communities in Theumtong sub-district involved irrigated paddy fields, with mainly soybean planted after the rice and some maize and cassava. Soybean was the main source of cash income. Before 2004, there was a scarcity of rice seeds and so low quality was a common problem, as most farmers depended on external seed sources. One community leader met with HMN and Jogo, suggesting that the local farmers should learn appropriate rice seed producing techniques and practices. This knowledge, once imparted, was then transferred to other farmers in the community. During the early seed producing period, during which time individuals produced the seeds, the farmers had problems hiring a threshing machine, and this forced them to group together and invest in a machine for use by the community. A community SME group was then established in 2005, comprised of 35 members. This SME group was able to draw support from local agricultural offices (for good seeds, fertilizers and training, as well as certification of seed products), and this strengthened the management of the group. Later on, the group began to produce soybean seeds. Jogo was and is the main actor linking the group to other sources of knowledge and support, such as for new rice varieties, for which the Samoeng Rice Research Station in Chiang Mai also provides support. Jogo also helps with marketing activities.

Nowadays, the group produces enough rice seeds to supply all its members, with surplus sold on the open market. The soybean seed producing group now has 1,500 members

(500 from local communities and 1,000 from elsewhere). Each year, the group supplies 60 to 70 tons of soybean seeds to seed companies in Chiang Mai. The rules and regulations around group member participation are as follows:

- Members must hold at least ten bonds (at 100 baht each), but not exceed 200 bonds
- All members must attend the field inspection activities as scheduled
- Labor must be shared among group members for growing and harvesting activities
- Members must attend monthly meetings
- Members have first priority over use of the threshing machine
- The group will provide financial support for special incidents and occasions, such as sickness among the members, plus cultural and ritual events, and
- The group will provide public/community support.

Theumtong is one of the strongest development communities in Nan province; one community member is manager of the HMN and has close linkages with Jogo and other networking partners. This situation represents important social capital, helping to support and strengthen the group as well as a number of other initiatives in the Theumtong sub-district (Social Management Institute, 2012; PPT, 2010).

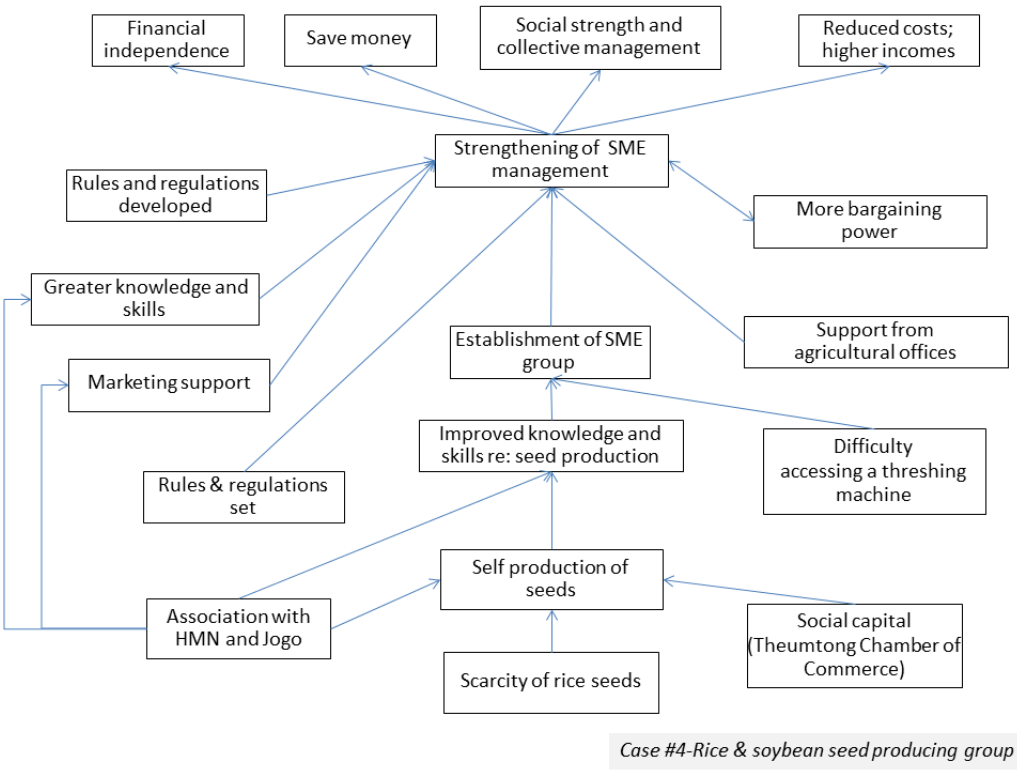

Figure 15: Case #4 Change and outcome pathways

5.3.5 Case #5: Thungkong farmer school

This farmer school came about due to the personal interest of Ms. Phin, who in the past observed her father selecting and producing rice seeds. She then adopted the rice seed producing techniques and practices from her father, including being able to experiment with the seeds. Over her lifetime she has noticed a gradual decline in the number of local rice varieties available, as they have been replaced by new commercial hybrid varieties that are less suitable to local growing conditions and so require more fertilizers and pesticides. However, according to her perception, these new varieties would yield less than the local varieties if grown without the use of chemicals. This situation has motivated her to conserve and maintain local rice varieties, and pass this "local treasure" on to the next generation.

Initially, a group of 18 rice farmers got-together informally to discuss how to introduce local rice varieties. One of the groups knew the Jogo center, so asked them to help with training and materials. The group is now officially registered, as this allows it to seek support and also provide training to other farmers. The group's members, especially Ms.Phin, specialize in all the steps involved with growing rice, from seed selection and the use of seedlings, through to transplanting using a single rice seedling, pollination and harvesting. By collecting rice seeds and exchanging them with other local rice seed experts using the Jogo network, around 40 local varieties have been conserved and collected. The group has also started collaborating with a local school, running a course on rice growing among high school students. The group receives little financial support, as its work is based on the personal enthusiasm of its members to pass on knowledge and practices to the younger generation.

New innovations in relation to growing rice have helped to reduce seed use by 50%, saving both time and labor, as well as helping to increase the strength of the rice plants. This has resulted in higher yields when compared to conventional methods. Moreover, not so many chemical inputs need to be used, reducing investment cost and health risks.

5.3.6 Case #6: Pa-Oy farmer school rice seed producing group

After a big flood occurred in 2004, this group of farmers experienced difficulties getting hold of rice seeds of a suitable quality and purity. At that time, the HMN had already established the Jogo Knowledge Center, which put-together a rice seed producing package and disseminated local wisdom. A local agricultural extension officer linked this group of farmers with the center, and with the support of the *Sor-Por-Kor* (Land Reform Department, LRD), learned about good rice seed producing practices from another farmers' group also linked to HMG and Jogo. After the training, none of the farmers dared to implement what they had learned, because it did not align with their previous beliefs and practices. However, based on guarantees coming from a local LRD agricultural extension officer, the group eventually agreed to introduce the new methods, and once it

had gained experience, passed on the knowledge to their neighbors and neighboring villages. By continuing to practice new methods and network with other rice seed producing groups, the group has become a well-known knowledge center for rice seed production in Nan. Moreover, the group has created linkages with other supporters, such as rice seed specialists from research and academic institutions, and this has helped strengthen the capacity of the group and motivated its members to explore producing other rice varieties and to introduce organic rice growing practices. In addition, the group has extended its practices within the community, bringing about greater social cohesion and unity. For example, a rice-related ritual has been re-introduced to help strengthen social bonds. At present, the group has 23 members and produces enough rice seeds for the whole village. It also sells its seeds outside the village, as demand is much higher than supply. So, the rice seeds produced serve both household consumption and cash income generation needs. As a result of the group's work, the status of the external market at any given time is of minor concern to local people.

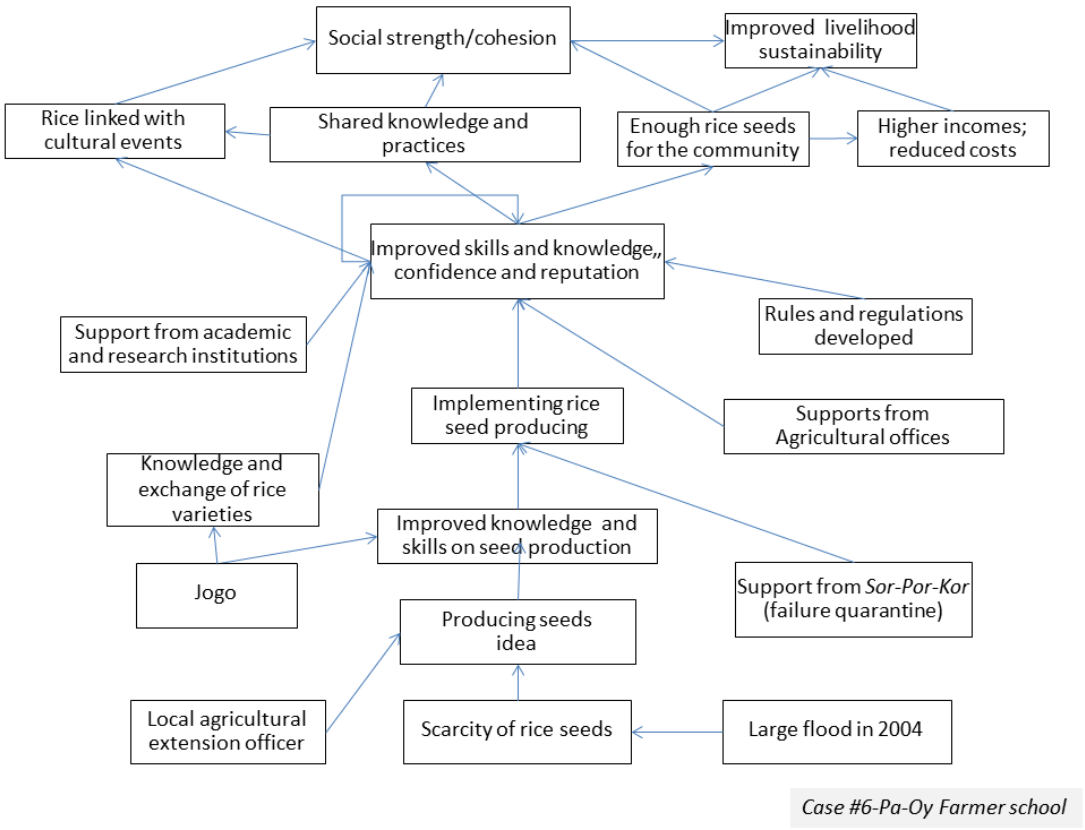

Figure 16: Case #6 Change and outcome pathways

5.3.7 Case #7: Organic rice producing group

The way this group started is similar to that of the other cases described. Mr. Seenoon was the key actor in getting this organic rice producing group up and running. He had been suffering from cultivating crops that were highly dependent on the use of chemicals.

At that time he was a volunteer 'soil doctor', a community volunteer who collaborates with the Land Development Department office in helping to disseminate news, knowledge and technology related to soil and fertilizer management. In this role, he was able to observe the negative consequences of continuously applying chemical agents, with the soil "dying" as a consequence – becoming hard and difficult to plow, rice yields declining over time, and fish dying in community ponds due to pesticides and herbicides leaching in from the local farmland. As a result, he looked to introduce more sustainable farm practices to the area. He had already heard about organic farming, so started to farm organic rice using organic compost, producing better rice yields after just two years. His rice yield increased from 60 tang per rai (one tang is around 10 to 12 kg) to 75 tang per rai after the first year, and steadily increased to reach 120 tang per rai in the following years. The health of fish in the local pond was also restored. Thereafter, 18 farmers formed an official group based on a suggestion made by the Tambon Administration Organization (TAO), and this group was eligible to receive support from the local government, such as for buying manure and compost tanks. Group rules and regulations were then introduced; to define members' responsibilities.

In 2010, upon the recommendation of the TAO, the group was transformed into an formal SME, so it could gain access to further support. During the same year, rice seeds were scarce, so the group–which used to buy its rice seeds from Jogo for 30,000 baht a year–sought training on rice seed production. The knowledge gained was put into practice by the group's members, as well as neighboring farmers and communities (such as Theumtong). Nowadays, the group produces sufficient rice seeds to meet community requirements, and sells any excess seeds to nearby communities. The compost the group produces is also used in members' backyard vegetable plots. The outputs and outcomes of the group's organic rice farming practices are as follows:

- A reduction in chemical usage, reducing health risks and decreasing input costs
- Healthier soil and cleaner water
- More income, less debt
- Safe and secure food supplies, and
- Increased contentment among group members (at seeing others happy).

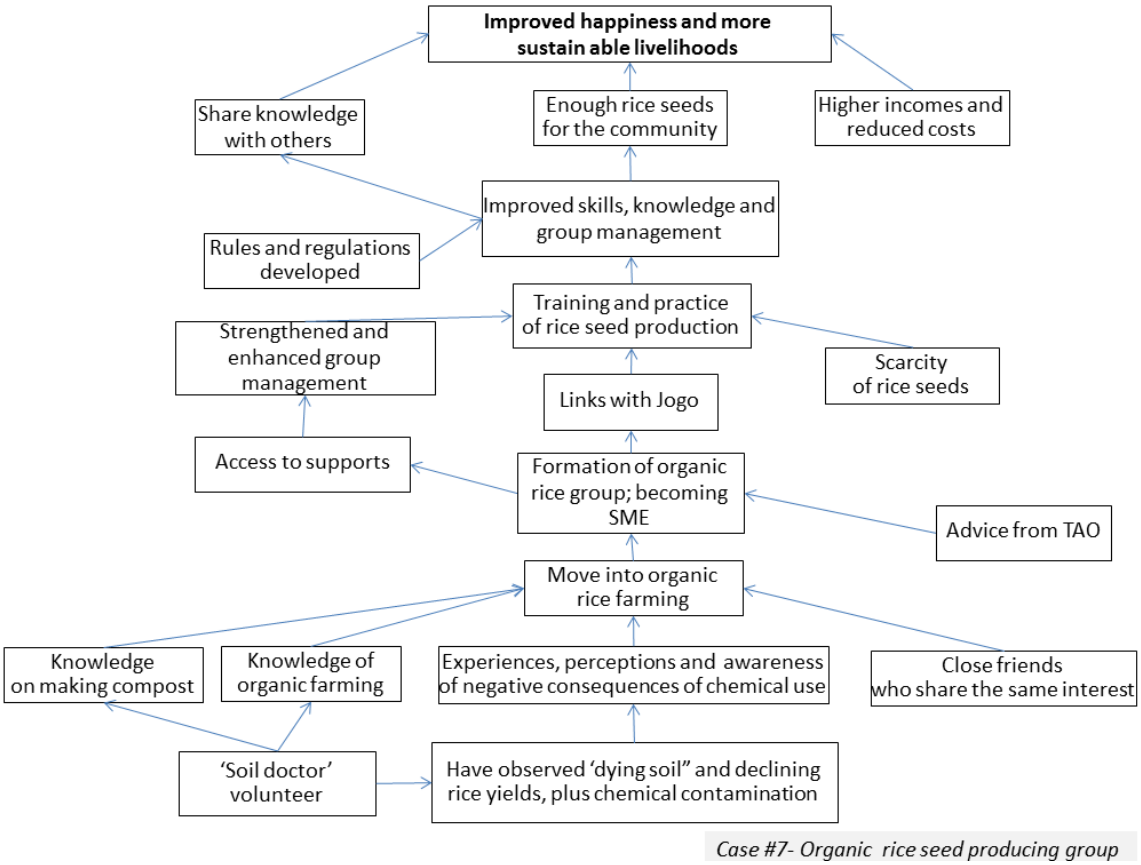

Figure 17: Case #7 Change and outcome pathways

5.3.8 Case #8: Silapetch farmer school and safe vegetable producing group

The farming system formerly used in Silapeth sub-district involved the growing of paddy rice followed by a variety of vegetables after the rice harvest, which were grown for household consumption. Over the period 1987 to 1992, farmers in the area moved into commercial crop cultivation from having been subsistence farmers particularly chili, but had to invest in more chemicals, a process driven by the introduction of chili cultivation which had been promoted by middlemen who provided a good cash income to the farmers. These new cultivation practices led to a decline in soil fertility and soil structure (referred to as 'sick soil'), disease, a decline in yields and crop failures. This problem was brought to the attention of the TAO, and experts suggested substituting chili with a variety of crops, such as peanut, soybean, cucumber, Chinese cabbage, pea and broccoli, in order to improve soil fertility and prevent crop diseases. Although this could have helped resolve the problems being experienced, a lack of collective crop selection decisions caused marketing problems; some crops faced over demand and others a lack of demand. Therefore, the vegetable farmers registered with the TAO, in order to obtain advice on crop types and farm planning.

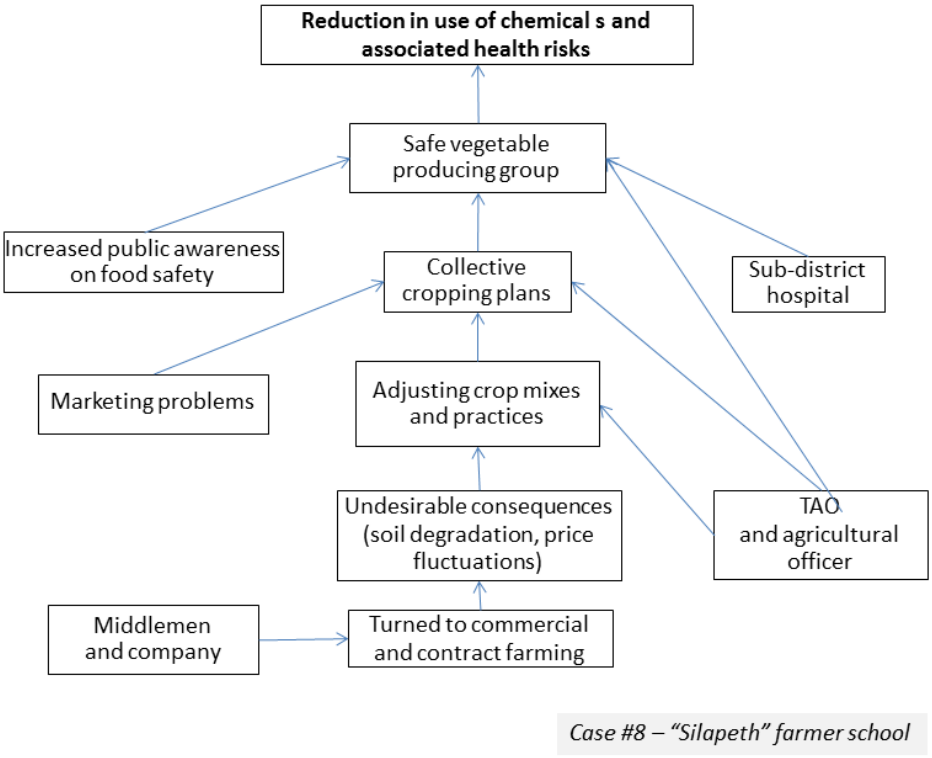

Figure 18: Case #8 Silapetch farmer school and safe vegetable producing group

Due to increasing consumer awareness on food safety issues, and a rising demand for safe produce, vegetable farmers in Silapetch established a 'safe vegetables producing group, as supported by the sub-district hospital (which carries out random blood tests for chemical residues) and the local agricultural office (which gives recommendations on the safe and appropriate application of chemical agents). Both organizations began working with the group, and this collective action and management brought the issues of safe food production and consumption to the attention of both farmers and consumers. These collective efforts resulted in a reduction in chemical use and health risks among the local population. Recently, the group's leaders have been trying to promote safe rice growing practices; to reduce and/or stop the use of herbicides and pesticides. Private farmland has been handed over to the 'farmer school', to help promote safe rice production among farmers, the younger generation and others.

5.3.9 Case #9: Nong-Phouk safe vegetable producing group

The pathway for this case evolved out of the pressures and risks faced by the local farmers, as well as their interactions with a number of key players in the relevant sectors. For a long time, this community has depended mainly on agriculture, but the crops grown and ways in which the land is utilized have changed over time due external interventions. In addition, local farmers' knowledge and experience has improved through both a self-

learning process, and due to interactions with neighboring farmers and those from other key sectors (Table 15). The crop types initially grown in the area were as follows:

Initial crop types and usages:

- Rice: Mainly used for household consumption
- Tobacco: Sold commercially
- Backyard vegetables: For household consumption.

Table 15: Nong-Phouk safe vegetable producing group – changes made

Changes/awareness	Involved actors/interventions	Factors and conditions
Hi-breed maize - Use of chemical agents - Dependence on the market price	Extension officers	Commercial crops
Cultivation of seeds (pumpkin, squash; ten farmers)	Private companies (provided seeds and knowledge)	Suitable land (and water) with skilled farmers Good cash returns
Most farmers practice seed production	Private companies	Observing the pioneer farmers Good income More cash needed for education
Awareness of the negative impacts of chemical use	Individuals Women's group leaders	Women's group leader learned from attending meetingson this issue Observation of soil degradation
Bio-fertilizer group set up (34 members)	Community development officers at the TAO Land Development Department (LDD) Officer from the District Agricultural Office (Agent 'A')	Abundant crops from the seeds produced Increased awareness
Effective micro-organisms (EM) fertilizer group established	Farmers	Labor intensive use of the bio-fertilizer

Changes/awareness	Involved actors/interventions	Factors and conditions
Bio-fertilizers used in the village	Most farmers in the village	Handover to the previous group (see above) Other villagers observed and saw the benefits
Rice seed producing group set up	Agent 'A' Other rice seed groups, HMG and its network (research scientists and rice seed specialists)	Large floods and rice damage Group's relationship with the network
Change in perceptions and peer comparisons	All the above	Interactions with other networks (field visits and study tours etc.)
Safe vegetable producing group established (the aim being to become more self-dependent)	All the above (challenged by scenario 'what if the seed company closes down?'	Assessment of past experiences and learning lessons Field visits and study tours to successful groups Support received from/given to the district hospital (win-win solution)

Benefits and changes (positive):

- Improved self-esteem, confidence and independence (due to food security) among group members; Improved community resilience
- Unity in the community
- Reduced risk
- Strong adaptive capacity.
- Continuous learning.

5.3.10 Case #10: Bankad, Maewang SME organic vegetables producing group

The agricultural system in Maewang district had been heavily reliant on the use of agricultural chemicals since the onion growing boom three decades previous, which had been followed in the 2000s by a food processing company setting-up in the area and promoting the contract farming of sweet corn. The farming practices which followed had an adverse effect on the natural food chain and local food security, causing health risks (94% of blood sampled at the time was found to contain chemical residues), and leading to farmers getting into debt due to declining yields, a greater use of inputs and higher input costs and fluctuating sales prices. The current group leader was a local politician at

that time (2005), and noted the problem, so consulted with the district agricultural officer to find a way to resolve the problems being experienced. He then underwent training in Mae-on at a well-known safe vegetable producing group, and after this, along with seven friends started producing safe vegetables, establishing the 'Bankad safe vegetable producing group'.

During the group's initial stages, the Chiang Mai Health Office launched a 'Chiang Mai Food Safety' campaign, and introduced the group to the Multiple Cropping Center (MCC) at Chiang Mai University, which had been promoting, providing knowledge and techniques on safe vegetable production. As a result, the group gained further knowledge and joined an MCC research project to demonstrate safe vegetable production processes on the group's farmland. This venture helped disseminate knowledge and know-how on safe vegetable production to other farmers in the area.

However, marketing was a key problem, as most consumers still favored good looking and cheap vegetables. In response to this, in 2010 the group and MCC asked Sanpatong Hospital (in a nearby district) to provide space for them to establish a safe vegetable market, as well as conduct blood tests to test for chemical residues; to help raise awareness of their produce among consumers, and especially hospital staff and patients' relatives, those who seemed more concerned over food safety issues. Due to its collaboration with the MCC, the group became known by and received funding from the Thai Health Office (who provided research funds to MCC on safe vegetable issues). The aim of this funding was to strengthen marketing within the group. However, this was not a success at first, until the Provincial Health Office established the 'JJ market' in downtown Chiang Mai, through which it promoted the safe vegetable campaign. The vegetables sold at the market had to go through a daily sampling and inspection routine, plus a blood testing service was offered at the market, to help raise awareness among a wider audience. The group became more well-known as a result of this initiative, and two more markets were set up, at the Provincial Agricultural Office and the Provincial Government Center.

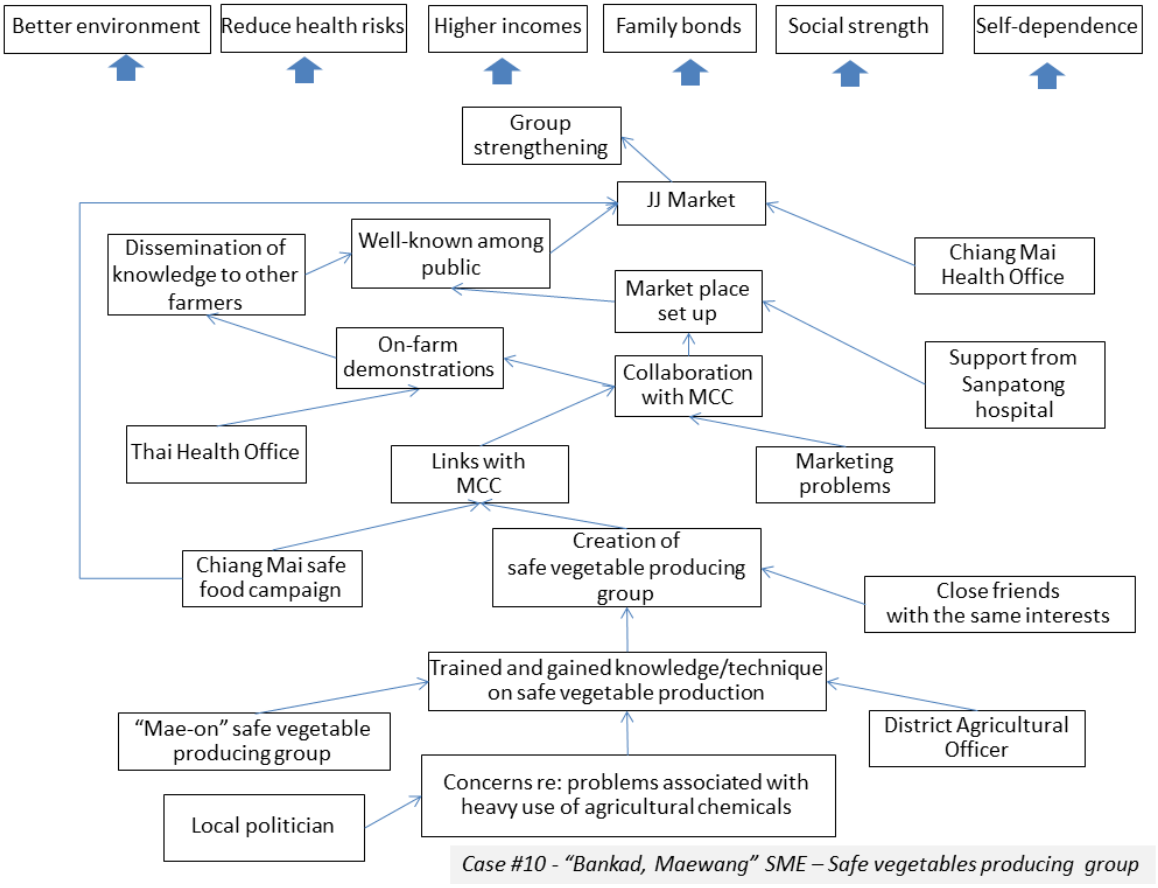

Figure 19: Case #10 Change and outcome pathways

5.3.11 Case #11: Muangjang pig raising group

The raising of pigs in backyards is common practice among Thai rural households, as the pigs provide an additional income source, as well as food and the raw materials for special cultural and ritual events. Younger farmers in Muangjang sub-district– in which the Jogo Learning Center organizes activities associated with good agricultural practices– decided to improve the existing small-scale backyard pig production system in the area; to make it more efficient and productive. At the time, Chulalongkorn University (CU) also provided training and support on small-scale swine production in Nan province (see Case#3). As a result, these young farmers, with support from Jogo and CU, were able to establish a pig rearing group, in order to exchange knowledge on good pig production, including sow and piglet management, feed management, and pig disease prevention and control). In 2011, the group became officially recognized as the Muangjang Pig Raising Group, allowing more support to flow from the Sor-Por-Kor, from Siam Concrete Group, the SCG Foundation, and CU. This support strengthened the group's management and knowledge gathering activities, and it was able to begin passing-on this knowledge to other farmers. Recently, the group has established a semen collection house and provides related services to its members.

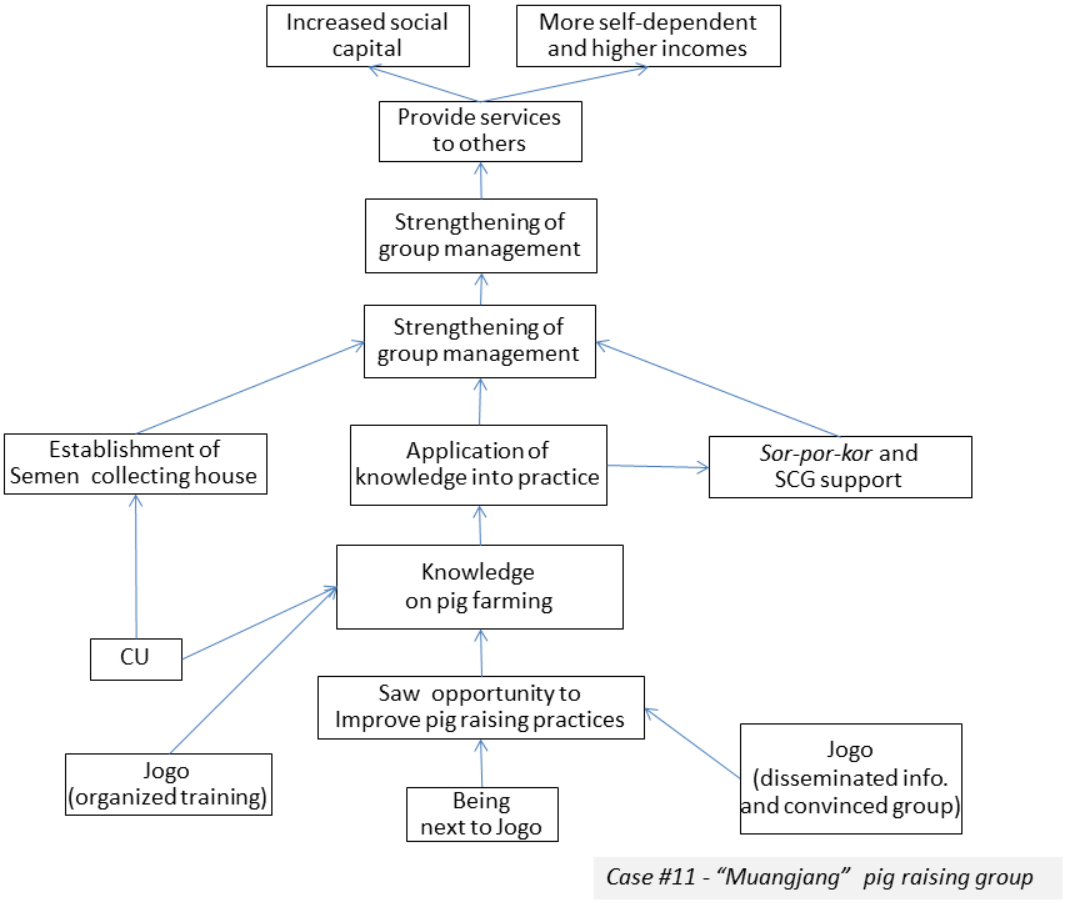

Figure 20: Case #11 Change and outcome pathways

5.4 Synthesis and Conclusion

The pathways described in the eleven cases above reveal the diverse drivers of change that existed, as well as the environmental factors, key actors and steps involved in the changes that took place in the study area. However, one cannot identify a single, common pathway allowing sustainable agricultural practices to develop, and a change in any single element along the pathways seen here might have led to different outcomes. However, it has been possible to identify the common elements that do exist within these successful pathways, using the DPSIR, the theory of change and outcome mapping frameworks.

Most of the pathways were instigated, both directly and indirectly, by pressures or threats which had led to instability, and/or by fluctuating crops prices. Although these kinds of pressure may have existed, they may not have been perceived by and/or been of concern to all the farmers. Personal characteristics and capabilities when observing and analyzing such pressures, as well as the exchange of views among neighbors and within the network, would also have played an important role. Therefore, the 'actors of change' could be considered as helping with the diversification of sustainable agriculture in these cases.

However, some farmers may have been able to perceive what was required, but did not push ahead with the changes themselves; instead they required inspiration and support to come from other sectors. This support from other sectors, whose aims and agendas fitted with the pathway, then played an important role in enabling further progress. Remarkably, most of the cases cited here are either related to the diversification of agricultural practices through the ability to build water body or access to irrigation service, and/or the farmers having had the appropriate land title/documents needed to get support from the government. Moreover, another common factor in the success of these cases was their association with existing networks such as Jogo and HMN.

Table 16 compares the drivers and pressures behind the changes in livelihood strategy introduced by the 11 case study initiatives, including the assets, and supporting actors/institution involved. A high dependency on agricultural inputs and crop price fluctuations are shown to be common drivers; as these placed pressure on the farmers, constraining their livelihoods, increasing risk and bringing food insecurity. The personal characteristics of the farmers and the ability to learn led to the farmers gaining experience and knowledge, essential human assets, along with land ownership, the availability of water, and access to livelihood assets that the individuals or farmer groups were able to employ to formulate strategies to respond to the pressures they faced. In addition, the pathways seen here were enhanced by the support actors or institutions present. The benefits and/or positive outcomes of these cases involved improved livelihood security for the individuals and groups involved, plus strengthened social capital.

Table 16: Livelihood strategies of the 11 case study initiatives – drivers, pressures, livelihood assets and supporting actors

Case #	Driver	Pressure	Livelihood Assets	Strategy/response /Change	Supporting actors /institutions
1	Crop price drops/ fluctuates	Lower profits/losses and debt	Experience, water sources, inputs support	Introduction of integrated farming	RIDF
2	Crop price drops/fluctua tes	Lower profits/losses and food insecurity	Self- learning, skills and knowledge; land and water sources	Introduction of integrated farming	Agricultural Officer
3	High dependency on inputs and market prices	Livelihood risk and insecurity	Knowledge and experience; water sources	Introduction of integrated farming	LRO, Jogo, CU

Case #	Driver	Pressure	Livelihood Assets	Strategy/response /Change	Supporting actors /institutions
4	Rice seed scarcity, difficulty in accessing a threshing machine	Farm management constraints	Social capital; land and water sources	Production of seeds; establishment of SME group	HMN, Jogo, Agricultural Officer
5	Local varieties lost	Awareness of risks and independencies	Observation and experimentation skills and experience	Conservation of local rice varieties; cultivation of organic rice; training of young farmers on rice production techniques	The person's father and Jogo
6	Floods, low quality rice seeds	Poor quality rice seeds, mixed rice production	Land and water sources	Production of seeds; knowledge/practices shared with neighbors; linking rice with culture	Agricultural Extension Officer, LRO, Jogo, research and academic institutions
7	High dependency on chemical inputs, crop price fluctuations	Lower profits/losses and food insecurity	'Soil doctor', knowledge and skills re: soil management. Self-learning	Change to organic rice farming	TAO, Jogo
8	Contract farming. High dependency on chemical inputs	Livelihood and food insecurity	Land and water sources; social strength	Grow mixed crops; Established a safe vegetable producing group	TAO, Jogo, Agricultural Officer and local hospital
9	Contract farming. High dependency on chemical inputs	Low levels of self-dependency. Livelihood and food insecurity,	Land and water sources; Knowledge and skills; social capital	Established (i) a bio-fertilizer group, (ii) a rice seed producing group and (iii) a safe vegetable producing group	Agricultural Officer, Jogo, HMN and local hospital
10	High dependency on chemical inputs	Livelihood and health risks	Leadership skills	Established a safe vegetable producing group	MCC-CMU, Agricultural Officer, Health Office.
11	Few alternative agricultural options	Livelihood , risks and independencies	Pig farming: Knowledge and techniques	Gained knowledge and established a semen collection house	Jogo, HMN, CU, LRO, SPK, SCG

The aim of this investigation into and synthesis of agricultural diversification initiatives has been to reveal the diverse pathways they have followed, and how these have been shaped and directed by a combination of change actors, external and environmental pressures, as well as the provision of support and the presence of enabling factors and conditions. The idea has been to provide strategic planning guidance for those wishing to promote sustainable diversification within varying socio-agro-ecological contexts.

6 Conclusion

Nan province's challenging topography dictates what agricultural production systems can be practiced in the area. The province consists mostly of highland areas with steep sloping land, and due to the limited natural resources available in such an area, growing hybrid upland maize varieties has been the best option for local farmers over recent years, as the crop is easy to grow and is able to provide a cash income to the farmers; allowing them to improve their livelihoods. The crop is also low risk, as the government runs a maize price guarantee scheme. However, the cultivation of upland maize has led to an increase in the use of chemicals, adversely affecting human health due to the resulting water contamination. Also, the burning of residues in the maize fields, a common land preparation practice in the area, causes air pollution, a serious problem which has an adverse impact on both the health of the people of Nan province, as well as the economy of the province and of northern Thailand as a whole.

To resolve the land use problems caused by cropping systems in the highlands of Nan province, more sustainable land use options need to be explored. These options could include the introduction of intensive small-scale home gardens, commercial mushroom cultivation, and integrating fruit trees with seasonal crops, and such options should be introduced to farmers interested in implementing integrated farming practices, since the products grown under such conditions are sought-after by the market. However, such systems have to be able to provide the farmers with cash income equivalent to that generated when growing upland maize, in order to provide the farmers with an incentive to adopt more sustainable land use practices. Rice is also a very important crop in terms of household consumption, so the introduction of alternative rice cultivation practices that are socially, economically and biophysically relevant should also be investigated. In addition, rice and other cash crops should be promoted alongside improvements in access to water resources and in soil fertility levels. The intensive use of labor should also be considered for certain sustainable farming practices. However, the most important factor to consider is the market. Market information and good levels of access to the market need to be provided to farmers at the beginning, plus farmers have to be trained how to manage markets by themselves, with the help of both government and non-government agencies.

The key pressure that drove the farmers to change commercial crop production activities to more sustainable, integrated farming practices was their high dependence on chemicals to promote crop growth, as this led to high input costs and health risks. Their switch was also caused by price fluctuations for their commercial crops on .the local and global markets. Although these kinds of pressure existed for all farmers, not all of them were concerned enough to act. So, the personal characteristics and capabilities of the individual farmers when observing and analyzing the pressures they faced, as well as when exchanging views with their neighbors and their local networks, also played an

important role in deciding whether they sought to diversify their agricultural practices. Therefore, the 'actor of change' in these cases could be considered the need to diversify into sustainable agriculture. However, it was only some of the local actors who, having noted the need to expand such activities, pushed ahead with plans to do so; seeking inspiration and support from other sectors. It was this latter group who were the crucial factor in driving the pathway forward. Support came from a range of sectors whose aims and agendas fitted with the group's pathway, and this also played an important role in enabling the group to achieve the desired outcomes.

Each initiative clearly revealed a unique pathway and set of supporting factors; there was no one clear and well-planned set of changes; each step was fundamental in determining and supporting the next move. There was also no definitive end point for each of the initiatives. The pathway analysis carried out into the initiatives described here has attempted to reveal how the changes described emerged based on a number of supporting factors and conditions, those that existed and came together at the right moment and time. Therefore, this study provides an insight into how "learning" rather than "copying" may be applied in reality. Out-scaling sustainable agriculture at first requires those involved being able to recognize the knowledge and practices that already exist, in order to develop the relevant pathway. Alternatives can then be developed, those relevant to the diverse agro-ecological and socio-economically contexts present, and which address the risks and vulnerabilities faced by the farmers involved. If the available alternatives are neither compatible with the existing risk context nor able to provide a return equivalent to the current, undesirable practices, then subsidies, compensation and/or additional incentives may be needed. In addition, appropriate institutions, policies, rules and regulations are required; to support and enable the access to capital and assets required by the alternatives adoption scenarios. In Nan province, and particularly for sustainable agriculture and resources conservation/management, a number of key actors and organization exist and have been able to play an active role, both individually and by networking with each other. As a result, new entrants to the Nan sustainable agriculture sector should seek to learn from these actors, create synergies and align with them over key issues, then develop appropriate initiatives, innovations, and interventions, those that match with their individual requirements.

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Appendix A: Data sources

Table A1: Sources and Reference Periods of Development Indicators

Indicator	Sources	Reference Period
Nan population	Department of Provincial Administration	2004-2014
Hill tribe population	Social Development Center, Unit 25	2014
Poverty line of Nan	Office of the National Economic and Social Development Board	2011
National poverty line	Office of the National Economic and Social Development Board	2000-2012
Poverty incidence	Office of the National Economic and Social Development Board	2000-2012
child malnutrition	Nan Province Public Health Office	2012-2014
Household debt	National Statistical Office	1997-2013

Table A2: List of interviewee for Problem Analysis

Institute	Interviewee	Contract	Location
Chiang Klang agricultural officers	Adisai Deetanna (extension officers)	089-6178406	Chiang Klang District
Mueang Chang Subdistrict Administrative Organization, PhuPhiang	Samruay phadphon (former chairman of Hak Mueang Nan Foundation)	086-916-9331	Mueang Chang subdistrct, PhuPhiang district
Aranyawas temple, Meaung District	Provost Phithaknanthakoon (former chairman of Hak Mueang Nan Foundation)	-	NaiWiangsubdistrict, Mueang Nan distrct
Nan Provincial agricultural officers	SanitPanyawong (extension officers)	089-7030811	Mueang Nan distrct
Village Headman	Rinlada Suta	-	Kok village Chiang Khangsubdistrict , Chiang Khang district
Assistant Village Headman	Anurak Inta	084-3664933	Pangyang village Phukasubdistrict, Pua district
Highland Development and Research Institution	Wirat Prabtook (chief of development agency)	-	Mueang Chiang Mai District, Chiang Mai province
Pid Thong Lang Phra Foundation	Hathairat Puangchoie	hatairat_p@ pitthong.org	Mueang Nan distrct
	Thanakorn Rachatanon		Mueang Nan distrct
Assistant Village Headman	KamWannachon	084-4838753	Panyang village Phukasubdistrict, Pua District
	CheunWannachon	-	Panyang village Phukasubdistrict, Pua District
Watershed management centre (2)	- Aphichart Suwanmanee	089-8816256	Mueang Nan distrct
	- Boonmee	081-9604105	
	- Surachart	081-9614769	

Table A3: List of interviewee for Mushroom cropping system

Institute	Interviewee	Contract	Location
Hua Nam Homestay	ThanakitChinkijjakarn	054-792252	Hua Nam village PuaDstrict
Mushroom grower	LuaySaoluan	085-7067544	San village Pua District
	NuanSupakeaw	085- 7145852	Danpana village Pua District
	Pen Norach		Hae village Tawangpha District
	Prasan, SuneeNaknuch	083-5706672	Khorwang village, Mueang District
	ThianPromlangka	086-0438117	Napan village, Pua district
	Ratnapong	085-6262387	Denpattana village, Pueasubdistrict, Chiang khang district

Appendix B: Supplementary data

Table B1: Population by age, Nan Province: 2004 - 2013

Age Range	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total labor	477,754	478,080	477,662	477,381	475,984	475,614	476,363	476,612	477,673	477,912
population under 15 years	124,140	118,519	114,234	112,571	96,340	78,654	74,786	71,141	68,241	64,377
Population between 15-60 years	248,890	260,807	273,431	279,392	283,217	297,941	302,518	314,303	307,395	311,943
Population over 60 years	104,724	98,754	89,997	85,419	96,427	99,019	99,059	91,168	102,037	101,593

Source: National Statistical Office, 2015

Table B2: Population Living on Highland Areas According to Tribe: Nan District

District	Lua	Hmong	Mien	Khmu	Mlabri	Muhsur	Northern Thai	Thai Lue	Other Ethnic	Total
Mueang nan	956	5,268	5,460	1,277	0	62	0	0	0	13,023
PhuPhiang	571	0	0	541	0	0	0	0	0	1,112
Wiang Sa	385	3,905	988	641	267	0	0	0	0	6,186
Pua	9,109	5,912	927	0	0	0	0	0	0	15,948
ChaloemPhraKiat	7,739	0	0	249	0	0	0	928	510	9,426
Thung Chang	3,106	4,213	0	1,295	0	0	21	0	1,143	9,778
Tha Wang Pha	0	3,520	2,770	2,002	0	0	0	0	0	8,292
Na Noi	0	2,124	0	0	0	0	0	0	0	2,124
Chiang Klang	4,105	0	0	0	0	0	0	0	0	4,105
Song Khwae	440	2,596	1,208	2,307	0	0	0	390	499	7,440
Mae Charim	1,562	2,814	0	0	0	0	0	0	0	4,376
Santi Suk	1,591	1,308	0	0	0	0	0	0	0	2,899
Bo Kluea	12,315	82	0	0	62	0	2,325	0	0	14,784
Total	41,879 (42.09)	31,742 (31.90)	11,353 (11.41)	8,312 (8.35)	329 (0.33)	62 (0.06)	2,346 (2.36)	1,318 (1.32)	2,152 (2.16)	99,493 (100.00)

Source: Social Development Center, Unit 25 Nan Province, 2015

Table B3-1: Annual household income and expenditure, and per capita income of 19 sample villages of ethnic minorities in Mueang districts

village	sub district	Annual household income	per capita income	Annual household expenditure
Num Ngao	Bo	326,137	55,526	178,386
San Ti Pattana	Bo	264,689	41,046	143,840
Sai Tong	Bo	355,035	66,997	191,910
Had Pla Hang	Bo	193,834	62,085	145,607
Sa ra Suk San	Bo	224,197	57,657	134,000
Phu Wiang	Bo	158,498	45,361	121,216
Huai Mon	Rueang	203,719	50,528	112,320
Huai Le	Sanian	138,070	32,746	95,346
Song Khwae	Sanian	191,018	36,940	96,798
Num Cong	Sanian	141,915	45,206	84,661
Pang Poei	Sanian	205,493	39,718	98,179
Huai Puk	Sanian	181,177	56,688	161,048
La Bao Ya	Sanian	254,166	60,625	101,294
Huai Hua	Sanian	130,762	35,996	49,226
Mai Nai Fan	Sanian	159,160	48,324	95,625
Klang Pattana	Sanian	212,716	58,881	111,978
Mai Charoen Suk	Sanian	195,034	36,920	106,588
Huai Ra Pe	Sanian	142,912	40,486	65,788
Samun Mai	Sanian	157,401	50,261	53,196
Average		201,891	48,526	113,000

Source: Department of Community Development: Nan, 2015

Table B3-2: Annual household income and expenditure, and per capita income of 20 sample villages of ethnic minorities in Pua districts

village	sub district	Annual household income	per capita income	Annual household expenditure
Pang Yang	Phu Kha	191,229	40,284	120,140
Khun Kun	Phu Kha	237,375	39,391	137,501
Pha Wiang	Phu Kha	140,794	36,778	52,919
Tei Klang	Phu Kha	148,121	34,623	109,394
Toei Kiw Hen	Phu Kha	138,924	35,359	86,845
Huai Pud	Phu Kha	138,928	36,432	58,736
Huai Ngon	Phu Kha	177,469	46,693	50,725
Num Pu Pattana	Phu Kha	163,209	43,552	48,429
Nam Dun	Phu Kha	151,337	38,636	90,520
Kok	Phu Kha	133,655	33,354	65,946
Sa Kad Nuea	Sakat	377,550	88,700	157,223
Sa Kad Kang	Sakat	143,905	44,708	61,440
Sa Kad Tai	Sakat	189,589	52,922	89,012
Phu Kok	Sakat	144,805	36,335	105,265
Num Pen	Pa Klang	279,688	42,662	241,554
Huai Sa Nao	Pa Klang	138,111	52,105	101,649
Kang Ho	Pa Klang	241,760	49,566	176,883
Chun	Pa Klang	181,613	43,475	161,435
Suan Sai	Pa Klang	221,597	41,005	130,606
Ta Luang	Pa Klang	174,795	39,768	132,555
Average		185,723	43,818	108,939

Source: Department of Community Development: Nan, 2015

Table B3-3: Annual household income and expenditure, and per capita income of 19 sample villages of ethnic minorities in Bo Kluea districts

village	subdistrict	Annual household income	per capita income	Annual household expenditure
Wen	Bo Kluea Nuea	127,926	33,731	49,552
Sa Lai	Bo Kluea Nuea	132,936	33,422	39,888
Num Chun	Bo Kluea Nuea	180,989	35,053	48,494
Huai Khab	Bo Kluea Nuea	105,840	33,219	36,030
Sa Le	Bo Kluea Nuea	139,203	33,766	34,382
Hang Tang Luang	Phu Fa	116,499	33,931	69,000
Pha Suk	Phu Fa	146,952	39,878	44,411
Huai Loi	Phu Fa	177,574	52,009	41,181
Huai Lom	Phu Fa	146,695	31,486	42,098
Na Kok	Phu Fa	116,513	31,988	84,439
Sa Pan	Dong Phaya	149,181	41,877	96,704
Huai Ton	Dong Phaya	180,438	36,995	55,692
Num Kae	Dong Phaya	143,497	32,753	93,527
Sa Wa	Dong Phaya	120,825	33,472	86,338
Num Mao	Bo Kluea Tai	169,241	38,878	62,853
Yod Doi Wattana	Bo Kluea Tai	173,368	41,171	61,614
Ko Kuang	Bo Kluea Tai	190,831	41,274	82,424
Num Pae	Bo Kluea Tai	235,643	39,302	54,210
Na Bong	Bo Kluea Tai	147,488	34,641	47,336
average		152,718	36,781	59,483

Source: Department of Community Development: Nan, 2015

Table B4: Land use of ethnic minorities in three districts

District	Type of cropping	Planting Area (rai)	Household	Average Planting Area (rai/household)	Percent
Muang nan district	Paddy Rice	875	188	4.65	7.84
	Maize	24,799	1,945	12.75	81.11
	Upland Rice	6,872	1,050	6.54	43.79
	Fruit	6,593	562	11.73	23.44
	vegetable	110	75	1.47	3.13
	Rubber	2,975	164	18.14	6.84
	Other	570	81	7.04	3.38
	Total	42,794	2,398	17.85	100.00
Pua district	Paddy Rice	5,611	376	14.92	18.98
	Maize	9,377	806	11.63	40.69
	Upland Rice	5,993	1,153	5.20	58.20
	Fruit	8,409	673	12.49	33.97
	vegetable	21	147	0.14	7.42
	Rubber	477	136	3.51	6.87
	Other	3,585	481	7.45	24.28
	Total	33,473	1,981	16.90	100.00
Bo Kluea district	Paddy Rice	3,267	320	10.21	16.78
	Maize	2,401	271	8.86	14.21
	Upland Rice	37,992	896	42.40	46.98
	Fruit	5	1	5.00	0.05
	vegetable	1,230	277	4.44	14.53
	Rubber	109	6	18.17	0.31
	Other	110	35	3.14	1.84
	Total	45,114	1,907	23.66	100.00
Total three districts	Paddy Rice	9,753	884	11.03	14.06
	Maize	36,577	3,022	12.10	48.08
	Upland Rice	50,857	3,099	16.41	49.30
	Fruit	15,007	1,236	12.14	19.66
	vegetable	1,361	499	2.73	7.94
	Rubber	3,561	306	11.64	4.87
	Other	4,265	597	7.14	9.50
	Total	12,1381	6,286	19.31	100.00

Source: Department of Community Development: Nan, 2015

Table B5: Education information of ethnic minorities in three districts

District	Education Level	Number	Percent
Muang nan District	Currently studying (Pre-Elementary School – Bachelor)	2,381	26.33
	Junior High School (Compulsory education)	5,036	55.68
	Senior High School	480	5.31
	Bachelor	79	0.87
	Not Graduate of Compulsory Education (6-14 year)	246	2.72
	Illegible (15-60 Year)	822	9.09
	Total	9,044	100.00
Pua District	Currently studying (Pre-Elementary School – Bachelor)	1,713	26.35
	Junior High School (Compulsory education)	3,649	56.12
	Senior High School	378	5.81
	Bachelor	134	2.06
	Not Graduate of Compulsory Education (6-14 year)	33	0.51
	Illegible (15-60 Year)	595	9.15
	Total	6,502	100.00
Bo Kluea district	Currently studying (Pre-Elementary School – Bachelor)	1,177	40.46
	Junior High School (Compulsory education)	1,094	37.61
	Senior High School	475	16.33
	Bachelor	126	4.33
	Not Graduate of Compulsory Education (6-14 year)	29	1.00
	Illegible (15-60 Year)	8	0.28
	Total	3,160	100.00
Total three districts	Currently studying (Pre-Elementary School – Bachelor)	5,271	28.56
	Junior High School (Compulsory education)	9,779	52.99
	Senior High School	1,333	7.22
	Bachelor	338	1.84
	Not Graduate of Compulsory Education (6-14 year)	308	1.67
	Illegible (15-60 Year)	1,425	7.72
	Total	18,455	100.00

Source: Department of Community Development: Nan, 2015

Table B6: Poverty head count ratio in 2003-2012

year	Whole Kingdom	Northern Region	Nan
2003	42.33	49.08	46.43
2004	32.44	41.03	56.21
2005	26.76	33.29	28.94
2006	21.94	26.11	33.27
2007	20.04	25.99	31.51
2008	20.43	29.05	31.42
2009	17.88	23.38	25.32
2010	16.37	22.33	29.16
2011	13.22	16.09	18.89
2012	12.64	17.40	21.00

Source: National Statistical Office, 2015

Table B7: Average Debt per Household by Region and Province: 1996 - 2013

year	Whole Kingdom	Northern Region	Nan
1996	52,001	39,234	46,083
1998	69,674	58,682	36,863
2000	68,405	56,199	52,457
2002	82,485	57,535	60,273
2004	104,571	94,893	122,035
2006	116,585	114,201	107,155
2007	116,681	110,702	127,524
2009	134,699	119,726	165,434
2011	134,900	122,454	126,774
2013	163,087	137,059	188,161

Source: National Statistical Office, 2015

Table B8: Average Income Average Expenditure and Average Debt per Household in Nan province: 2000 - 2013

year	Average Income (baht/hh.)	Average Expenditure (baht/hh.)	Average Debt (baht/hh.)
2000	88,008	80,388	52,457
2002	97,560	84,108	60,273
2004	129,012	125,748	122,035
2006	127,080	139,512	107,155
2007	136,884	138,936	127,524
2009	175,488	147,480	165,434
2011	195,072	171,360	126,774
2013	211,176	168,936	188,161

Source: National Statistical Office, 2015

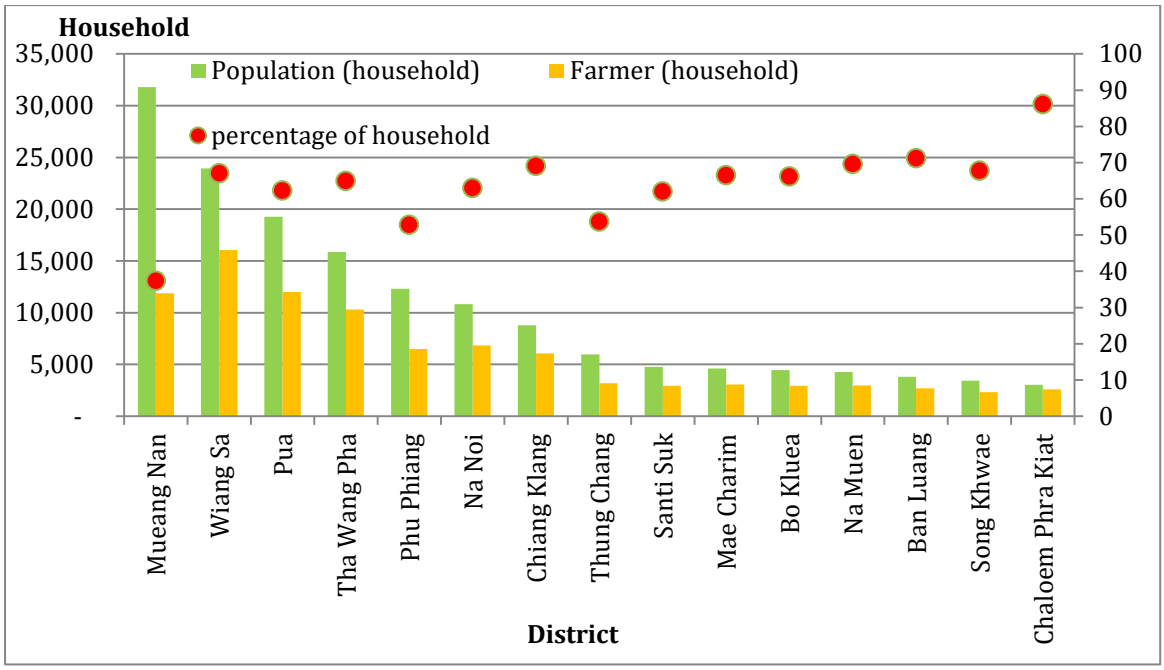

Figure B1: Number of population and farmer household in Nan province

Source: Nan Provincial Agriculture and Cooperative Office, 2014

Table B9: Rice and Maize production area in Nan province, 2005/06 to 2014/15

year	wet-season rice	dry-season rice	Upland rice	Mize
2005/06	183,743	1,131	78,563	310,387
2006/07	155,587	1,520	73,530	360,161
2007/08	154,899	1,938	86,474	378,731
2008/09	176,034	1,001	93,023	582,735
2009/10	183,495	5,466	110,680	733,658
2010/11	277,095	7,824	59,902	798,460
2011/12	228,445	7,263	29,054	673,929
2012/13	249,011	468	41,921	826,070
2013/14	249,011	4,203	na	795,482
2014/15	206,879	7,178	na	896,942

Source: Nan Provincial Agriculture Office, 2015

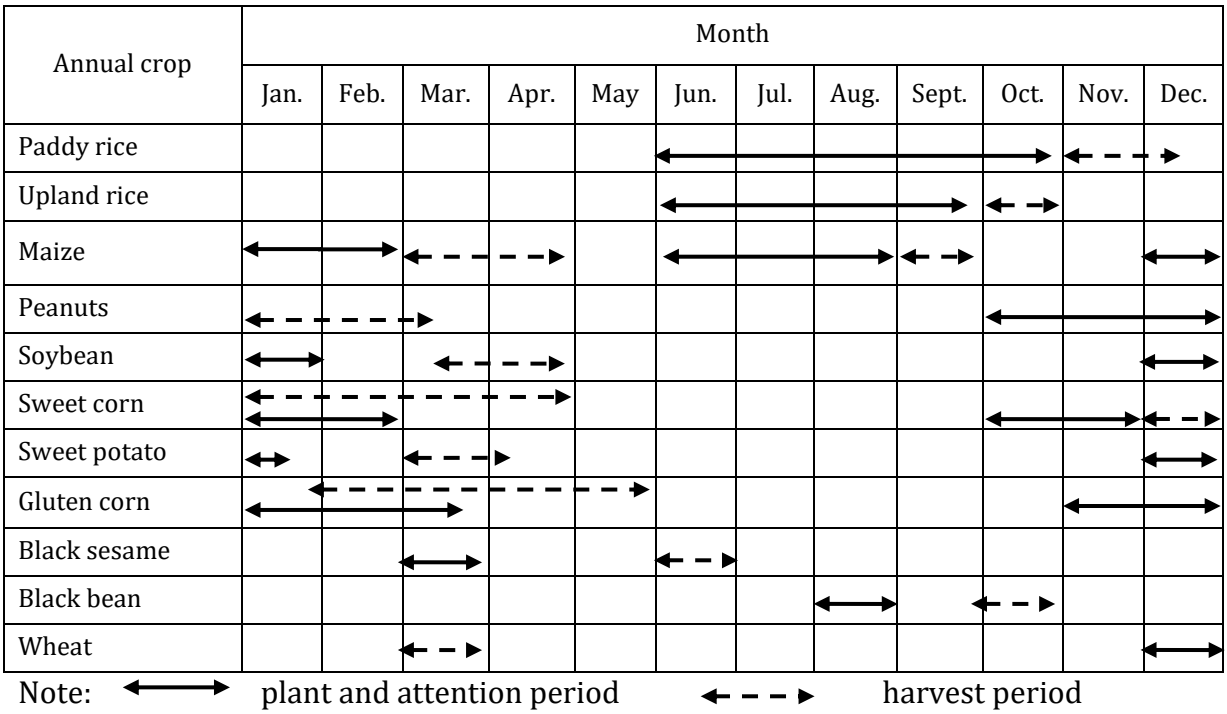

Figure B2: Calendar of annual crop production.
Source: Suebpongsung and Kitchaicharoen, 2014

Table B10: Cost and Return form Paddy Rice in Phong Khum and Pang Yang Royal Project Extension Area

Items	PhongKhum	Pang Yang
1. Number of observation (hh)	80	14
2. Average planting areas (rai/hh)	3.4	2.3
3. Production cost (baht/rai)		
3.1 Variable cost	4,306	5,085
- Material cost	880	1,063
- Labor cost	3,426	4,022
3.2 Fixed cost	179	67
3.3 Total cost	4,485	5,152
- Total cash cost	1,375	823
4. Yield per rai (kg.)	660	592
. Selling price per kg.	12.5	12.5
6. Total revenue per rai	8,250	7,400
7. Return over cash cost	6,875	6,577
8. Return over variable cost	3,944	2,315
9. Net profit per rai	3,765	2,248
10. Rate of return per rai: (%)	84	44

Source: Thongngam, Sangchyosawat and Suwannachome, 2014

Table B11: Cost and Return form Upland Rice in PhongKhum, Pang Yang and Khun Satan Royal Project Extension Area

Items	PhongKhum	Pang Yang	Khun Satan
1. Number of observation (hh)	18	32	44
2. Average planting areas (rai/hh)	5.7	8.7	5
3. Production cost (baht/rai)			
3.1 Variable cost	3,236	2,748	3,639
- Material cost	640	465	1,082
- Labor cost	2,596	2,283	2,557
3.2 Fixed cost	109	88	121
3.3 Total cost	3,345	2,836	3,760
- Total cash cost	833	267	1,060
4. Yield per rai (kg.)	303	230	378
5. Selling price per kg.	12.5	12.5	12.5
6. Total revenue per rai	3,788	2,875	4,725
7. Return over cash cost	2,955	2,608	3,665
8. Return over variable cost	552	127	1,086
9. Net profit per rai	443	39	965
10. Rate of return per rai: (%)	13	1	26

Source: Thongngam, Sangchyosawat and Suwannachome, 2014

Table B12: Comparing costs and benefits of paddy production with burning and not burning residue practices in Sri Bun Ruang villages

Items	burning	not burning
1. Number of observation (hh)	2	31
2. Average planting areas (rai/hh)	3	4.3
3. Production cost (baht/rai)		
3.1 Variable cost	7,166	6,131
- Material cost	1,196	1,013
- Labor cost	5,832	5,019
- Opportunity cost	138	99
3.2 Fixed cost	1,617	1,662
3.3 Total cost	8,783	7,793
- Total cash cost	2,476	1,794
4. Yield per rai (kg)	905	625
5. Selling price per kg.	12	12
6. Total revenue per rai	10,860	7,274
7. Return over cash cost	8,384	5,481
8. Return over variable cost	3,694	1,366
9. Net profit per rai	2,077	296

Source: Ekasingh *et al*, 2014

Table B13: Comparing costs and benefits of upland rice production with burning and not burning residue practices in Sri Bun Ruang and Don Mai villages

Items	burning		not burning	
	Sri Bun Ruang	Don Mai	Sri Bun Ruang	Don Mai
1. Number of observation (hh)	4	12	12	8
2. Average planting areas (rai/hh)	2.5	5.1	5.1	6.4
3. Production cost (baht/rai)				
3.1 Variable cost	4,510	5,415	3,187	4,088
- Material cost	833	2,129	516	1,034
- Labor cost	3,648	3,181	2,645	2,981
- Opportunity cost	29	105	26	73
3.2 Fixed cost	280	269	234	208
3.3 Total cost	4,790	5,684	3,434	4,296
- Total cash cost	692	2,416	617	334.5
4. Yield per rai (kg.)	471	428	262	11.3
5. Selling price per kg.	11	11	11	3,764
6. Total revenue per rai	5,295	4,820	2,951	4,296
7. Return over cash cost	4,603	2,404	2,334	1,669
8. Return over variable cost	784	-595	-236	-324
9. Net profit per rai	504	-864	-483	-532

Source: Ekasingh *et al*, 2014

Table B14: Cost and Return form Maize in Phong Khum, Pang Yang and Khun Satan Royal Project Extension Area

Items	PhongKhum		Pang Yang	Khun Satan
	(dry season)	(rainy season)	(rainy season)	
1. Number of observation (hh)	56	45	26	44
2. Average planting areas (rai/hh)	3.3	22.6	13.2	16.3
3. Production cost (baht/rai)				
3.1 Variable cost	4,825	3,640	3,605	3,815
- Material cost	2,324	1,645	1,128	1,666
- Labor cost	2,501	1,995	2,477	2,149
3.2 Fixed cost	165	190	105	275
3.3 Total cost	4,990	3,830	3,710	4,090
- Total cash cost	2,689	1,806	1,177	2,187
4. Yield per rai (kg)	1,102	758	488	871
5. Selling price per kg	6.6	8.2	8.2	7.5
6. Total revenue per rai	7,273	6,216	4,002	6,533
7. Return over cash cost	4,584	4,410	2,825	4,346
8. Return over variable cost	2,448	2,575	397	2,718
9. Net profit per rai	2,284	2,386	292	2,443
10. Rate of return per rai (%)	46	62	8	60

Source: Thongngam, Sangchyosawat and Suwannachome, 2014

Table B15: Comparing costs and benefits of maize production with burning and not burning residue practices in Sri Bun Ruang and Don Mai villages

Items	burning		not burning	
	Sri Bun Ruang	Don Mai	Sri Bun Ruang	Don Mai
1. Number of observation (hh)	5	23	34	5
2. Average planting areas (rai/hh)	17	-	17	-
3. Production cost (baht/rai)				
3.1 Variable cost	4,312	4,925	4,515	4,286
- Material cost	2,177	2,221	1,989	2,134
- Labor cost	1,990	2,543	2,381	1,996
- Opportunity cost	145	160	145	156
3.2 Fixed cost	269	257	239	199
3.3 Total cost	4,580	5,182	4,754	4,485
- Total cash cost	2,318	2,567	2,313	2,502
4. Yield per rai (kg.)	575	744	622	568
5. Selling price per kg.	8.12	8.02	8.17	7.44
6. Total revenue per rai	4,671	5,943	5,085	4,264
7. Return over cash cost	2,354	3,376	2,772	1,762
8. Return over variable cost	359	1,018	571	-22
9. Net profit per rai	91	762	331	-221

Source: Ekasingh *et al*, 2014

year	Activity	Jan.	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug.	Sept	Oct	Nov	Dec
1	1.Land preparation												
	2.Hole preparation												
	3.Plant												
	4.Fertilize												
	5.Pruning												
	6.Replacement of failed crops												
2	7.Fire break												
	8.Fertilize												
	9. Pruning												
3-6	10. Fire break												
	11. Fertilize												
7	12. Fire break												
	13.Tapping												
	14. Fertilize												
	15.Tapping (except shed leaves period)												
Over 8	16. Fertilize												

Figure B3: Calendar of Rubber Production

Source: Thailand Environment Institute (TEI). 2012

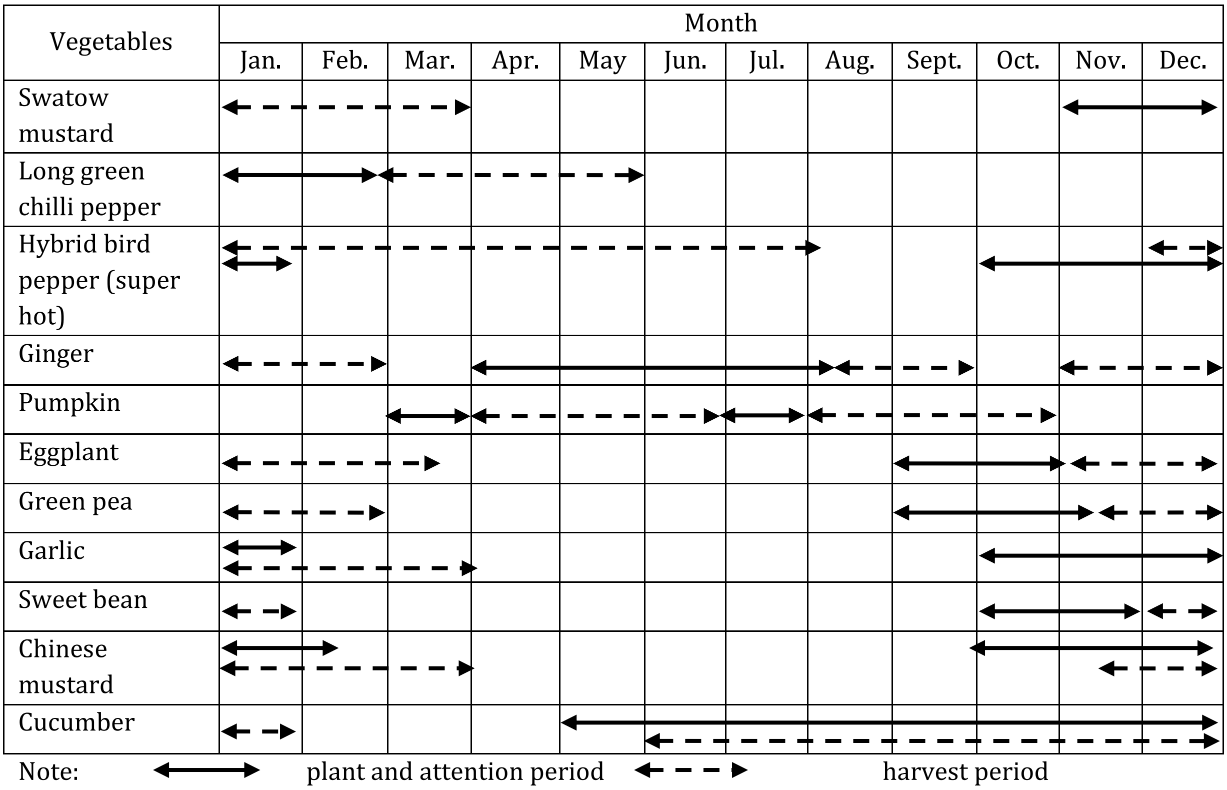

Figure B4: Calendar of vegetables production

Source: Suebpongsung and Kitchaicharoen, 2014

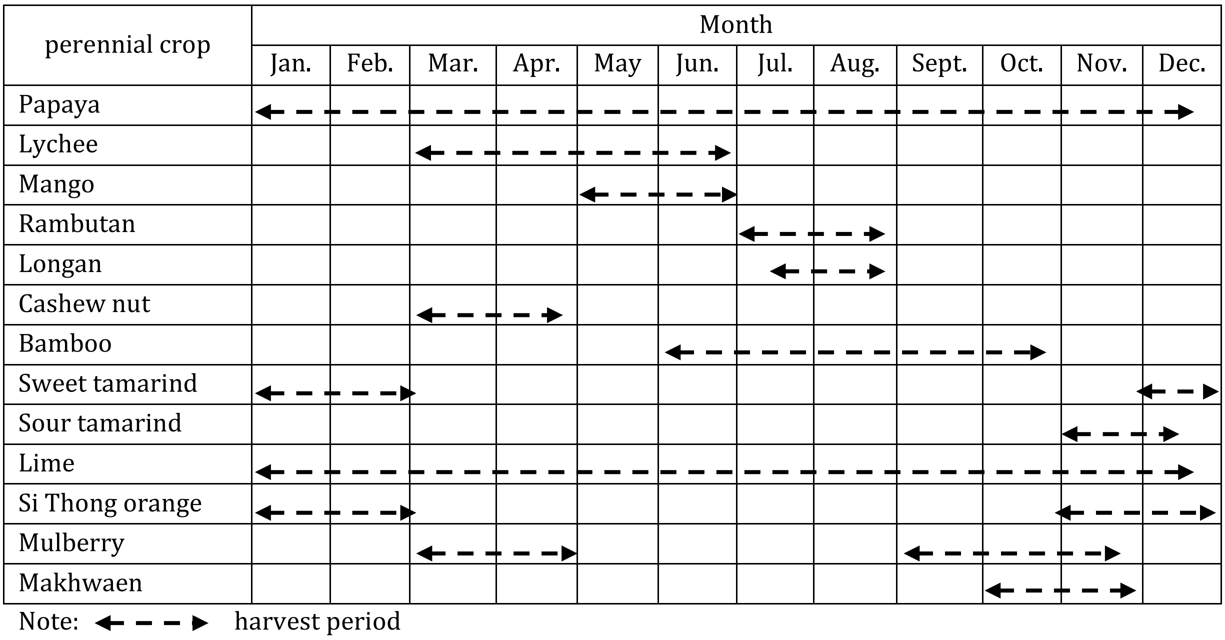

Figure B5. Calendar of perennial crop production

Source: Suebpongsung and Kitchaicharoen, 2014