Integrated Systems Research for Sustainable Smallholder Agriculture in the Central Mekong

Achievements and challenges of implementing integrated systems research

Edited by: L. Hiwasaki, A. Bolliger, G. Lacombe, J. Raneri, M. Schut and S. Staal

RESEARCH PROGRAM ON
Integrated Systems
for the Humid
Tropics

CGIAR

World Agroforestry Centre

Site characterization and systems analysis in Central Mekong

Chapter 2

Steve Staal[1*], Nelly Njiru[1], Thinh Nguyen[1*], Esther Kihoro[1], Aziz Karimov[1], Nils Teufel[1], Mark van Wijk[1*], Randall Ritzema[1]

[1] International Livestock Research Institute (ILRI)

Note: Introduction and section 2 authored by Steve Staal and Nelly Njiru; section 3 authored by Thinh Nguyen, Esther Kihoro, Aziz Karimov and Nils Teufel; section 4 authored by Mark van Wijk and Randall Ritzema

* Corresponding authors: Steve Staal s.staal@cgiar.org (Section 2), Thinh Nguyen T.T.nguyen@cgiar.org (Section 3), Mark van Wijk M.VanWijk@cgiar.org (Section 4)

1. Introduction

The systems addressed in this chapter and in the CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics) broadly include natural systems comprising biophysical, resource and climate realities; social systems made up of people, societies and their institutions; and, what some term as artificial systems built on elements of the first two (Checkland 1981). Agricultural systems, for example, modify natural systems for productive use, add infrastructure to provide markets, and modify human institutions to organize labour and services to enable the agricultural system to function. Regardless of how systems are categorized, they can be simplistically deconstructed into components and the interactions between them. In this chapter we characterize some of the Central Mekong systems, and also address some of the system dynamics, at two basic levels of resolution.

Section 2 addresses regional agricultural systems consisting of one or more districts within a country, and includes variations in natural and social systems in addition to agricultural systems. Five regional cases that reflect the diversity across the Central Mekong Action Area are examined and compared. The authors focus on systems at the community or local landscape level, particularly the individual farm household component, and the variation between households within the landscape. Variables include household agricultural practices, household resources, capacity, and links to markets and institutions.

Section 3 looks at diversity in the variables among farm households and the implications for livelihoods and well-being. Section 4 examines food security levels arising from specific farm household strategies and performance, how the two are related, and the implications for potential farm interventions. We conclude by comparing the types of systems examined, the differences in types of tools needed, and the differences in questions asked and learning generated.

Throughout this chapter, authors refer to data from reports and articles that interested readers can find in Annex I.

2. System characterization through situational analyses

2.1 Situational analyses for priority setting and shared ownership

A situational analysis under Humidtropics was the starting point for characterization and all further analysis of an agricultural setting or landscape. The situational analysis aimed to provide a broad body of data to inform and tailor the subsequent exercises, which were expected to be more detailed and in some cases focused on specific system components or addressing specific issues. Also, because Humidtropics by definition worked in a consultative manner through partners, the situational analysis also aimed to both create a joint and common understanding among all partners of the issues at hand, as well as support the process of establishing strong and sustained linkages with stakeholders at multiple levels.

Given this context, the situational analysis had three primary objectives.

The first objective was to characterize broadly all important system aspects relevant to the program within the target areas (in this case, Action Sites in the Central Mekong) and through that, generate data to inform all other program activities to better attain the intended outcomes.

The second was to harness various partner skills and experiences to develop a common and shared understanding of the issues needing to be addressed and their potential solutions, particularly between international and national partners, allowing local and global expertise to play complementary roles.

 The third was to initiate and facilitate engagement with stakeholders and partners as part of developing the multistakeholder platforms needed for the program's long-term success and scalability.

This section describes the results of five separate situational analyses conducted in selected sites in Viet Nam, Thailand and China, which in turn represent the three Triangles, or Action Sites, described in Chapter 1. The sites were selected in consultation with national partners. Before describing the situational analyses, we offer a brief note on methodology.

2.2 Methodology

Each situational analysis comprised four parts: i) Development Overview, which presents a broad overview of generic rural and human development characteristics, infrastructure and the institutional and policy context in which rural development was occurring in the target provinces; ii) Production Systems, which describes the agricultural setting, types of crops, livestock and trees, technologies employed, and returns to agricultural enterprises; iii) Markets and Institutions, which describes agricultural market structure and practices, but also collective enterprises and public institutions that support agricultural development; and, iv) Natural Resources, which describes the land, water and other natural resources.

The analyses were conducted by national agricultural research and development partners in each site with backstopping and participation by CGIAR researchers. Although the methodology varied slightly, the information gathered was generally from six different sources. These were secondary data at local/regional administrative unit level; key informant interviews; focus group discussions; household surveys in some cases; market visits; and, stakeholder consultations. The multiple data sources provided for the triangulation and validation of data collected from different sources.

Key informant interviewees were selected on the basis of their knowledge, expertise, and professional affiliation, and discussions were based on semi-structured checklists. The focus group discussions were also guided by semi-structured checklists, together with the complementary use of Participatory Rural Appraisal (PRA) tools such as Community Mapping and a Seasonality Calendar. In some cases, transect walks were conducted through the village where each focus group discussion was held. Participants included various types of agricultural producers, market agents and entrepreneurs. Villages for the focus group discussions were selected by local officials in consultation with the research teams. The findings were directly used to provide qualitative information to the report.

After the focus group discussions were completed, information gaps were still evident. In an attempt to extract more detailed information and provide an additional opportunity to triangulate the information already found, in some cases short household surveys were developed and administered to a small sample of households in the same communes where the focus group discussions were held. In addition, market visits were conducted to observe the types of agricultural products sold, types of market agents, transport infrastructure, origin and destination markets. Draft results were presented to stakeholders comprising government officials, research and development NGOs, and others. Participants were asked to review and confirm or comment on the preliminary results of the situational analyses. In addition, stakeholders were asked to provide inputs with respect to underlying system problems in the area and what possible solutions may be offered. This information was used to complement and validate the issues raised from the preliminary assessment.

2.3 Situational analyses

2.3.1 Central Highlands, Viet Nam

Development overview

The Central Highlands of Viet Nam (Tây Nguyên) are a series of plateaus 500–900 m high. The Highlands can be divided into three subregions according to topography and climate, (north, middle, south). The area consists of four provinces: Dak Lak, Dak Nong, Gia Lai and Kon Tum (Khanh et al 2015). The population is youthful but with a fairly steady elderly population. Birth rates have been slowly declining over the last 10 years while the death rate has been constant, although the infant death rate is still high. The population density is relatively low compared with other parts of Viet Nam. Ethnic minority groups are numerous and vary across the districts. Literacy is generally high with men being more literate, and many women attaining only a primary education. Some 70 percent of the total population reaches high school.

Agriculture plays a critical role. At least 85 percent of the households depend on agriculture, forestry or fisheries as major economic activities, 8–10 percent of the population is engaged in the service sector, and 1.5–3 percent in industry and construction. Many youths are employed in the latter sectors. The average income increased sharply between 2008 and 2012 but the gap between rural and urban incomes has widened rather than diminished. In addition, income levels greatly determine the household size. Malnutrition is still high. Twenty-five percent of five-year-old children are underweight, of which 2–4 percent are severely undernourished, while between 35 and 41 percent show signs of stunting.

The infrastructure is generally poor and road systems underdeveloped. While commune (village) electrification has improved, only 1–4 percent of households are connected to the grid and many do not have access to electricity. Ninety percent of households have clean water, but the proportion is lower in rural areas than in urban areas.

Production systems

Households typically hold small plots of land, between 0.5 ha and 2 ha. The agricultural production area for cereal crops did not significantly change between 2009 and 2012. Agricultural commodities include rice, maize, cassava, coffee, pepper and rubber. Yields vary among provinces and crops. Kon Tum Province has 175 irrigation schemes that can water around 5500 ha of paddy rice and 650 ha of other industrial crops, but most crops are rainfed. Crop farms seem to be evolving towards specialization due to robust coffee and pepper value chains in the area.

Livestock (cattle, pigs and poultry) is also produced, although production shows a diverging pattern. Aquaculture is also developing but differs across the provinces. Specialization levels are low, especially in livestock and fish. Crossbred cattle and pigs are common but local breeds are still widely in use, especially among more traditional smallholders and ethnic minority communities.

The agricultural sector is not highly mechanized, with many traditional practices still in use, although some value chains use sophisticated mechanization. Fertilizer and pesticides are being used but often without following established technical protocols. Risks for income losses and food insecurity are high due to drought, flooding and high postharvest losses.

Markets and institutions

Rubber, peppercorns, cassava flakes and timber products are exported from the region. While coffee and cassava flake exports strongly expanded between 2008 and 2011, rubber and peppercorns have reduced their volume in tons as has timber. Cashew nuts and sawn wood are imported, as well as machinery. Fluctuations for all these commodities were dramatic between 2007 and 2012.

Numerous institutions promote production and marketing of commodities including the International Committee of the Red Cross and local cooperatives. Vietnamese NGOs are working on research or as consultants. International NGOs and informal community-based organizations such as farmer groups are also active. Nonetheless, information is inadequate on suitable varieties and good agricultural practices for soil and crop management.

The Central Highlands has only a few large private investments in agricultural production, in part because policies for private investments are not attractive. A major constraint is poor connections among value chain actors and dysfunctional or inefficient cooperatives and farmer clubs. Additionally, markets and marketing systems are poorly developed and the poor road network adversely affects smallholders in accessing markets to sell their produce. Many producers also have limited knowledge of marketing or production.

Natural resource management and the environment

Natural forests cover a large area of the region. However, forests are declining due to destruction from extreme weather events, and in 2011 large areas were converted into agricultural land mainly for maize, cassava and sugarcane. Land degradation, soil erosion and soil infertility are serious issues.

2.3.2 Xishuangbanna Dai Autonomous Prefecture, Yunnan, China

Development overview

Xishuangbanna is a small area (20 000 km²) in a mountainous region. There is great cultural and biological diversity, with more than eight major ethnic groups and many other small ethnic groups and subgroups. The area has a subtropical climate. Infrastructure is well developed. More than 95 percent of villages have a road, running piped water and electricity. Access to affordable health care is reported to be very high, and the average life expectancy is 71 years. There is a cultural awareness of nutrition but little distinction between medicinal plants and food (Hammond et al 2015).

Formal education is low and, depending on the location, 20–40 percent of household heads are illiterate. Most women are less well-educated than their male counterparts, although among the most educated (college and university), women make up a greater proportion

than men. Many youths drop out of school because income from rubber is high and Chinese State education does not accommodate minority languages and culture. People living at high elevations tend to have less formal education.

Diversified agriculture is common where rubber or tea production dominates (90 percent of households). Other crops include rice, vegetables, fruits and maize. Livestock production is also common. Less than 10 percent of householders work in wage or salaried jobs. The average income for a rural person is approximately USD 1100 per year with great variation between the wealthiest areas (USD 3000 per person per year) and the poorest areas (USD 600 per person per year).

Production systems

The majority of agricultural land is managed by smallholder farmers with about 3 ha each for agriculture and forest cover, although there are also State-managed forest lands, village-managed community forest lands, and State-managed nature reserves. Rubber is the main cash crop grown in lowlands and sloping areas, however, forest land is still the largest area. Other crops include tea, which is usually intercropped, and bananas, which are a threat to forest land as many smallholders clear forest for its production.

Mixed farming systems are common. Although households tend to rely heavily on one or two major cash crops, they usually also raise some staple crops and livestock. The Xishuangbanna Bio-Industrial Crops Office has outlined plans for niche market high-value crops, many of which can be intercropped with forest or agricultural systems. Agricultural technology is well developed and widely available. Sixty to 70 percent of households own a small hand-operated tractor, although this is lower in the poorest areas. Modern cultivars such as rubber varieties suited to local conditions were developed and were subsidized. Fertilizer and pesticide use has increased steadily over the past 25 years. Over-fertilization is a common concern.

Markets and institutions

Land-use planning and management are disseminated to land managers via two well-organized routes: the government system and the market system. Well-established and capable research organizations also provide guidance to both government and market institutions.

There are four main classes of land management. First, smallholders who are generally free to make their own decisions. Second, community forest land managed by village leaders. Third, nature reserves under the authority of the Xishuangbanna Environmental Protection Office, and finally State forests under the authority of the Xishuangbanna Forestry Office.

The government system is hierarchically organized from province level down to individual villages, with plans made at prefectural level and passed down all the way to village leaders. However, only rules and instructions are passed through the system. Enforcement of rules is weak, contributing to illegal village-level land-use practices (e.g. clearing forest) which are not

reported back to higher levels. The market system has greater influence over farmers, who respond either to price signals or to requests and training from large-scale buyers. Newer products are introduced to farmers by companies via contract farming.

A key stakeholder is the governmental Bio-Industrial Crops Office, which works with research and business organizations in an attempt to balance the demands of the economy and the environment. A State extension service manages Agricultural Technology Stations at the township level. However, station staff are few in number, poorly trained, and can usually only provide advice on major cash crops.

Market penetration and access is good in Xishuangbanna, with four main types of value chains. For the main cash crops (rubber, tea, sugarcane) there is smallholder production with self-transport to the processing factory of the producer's choice. Banana production is informally contracted by outside entrepreneurs who pay upfront costs, sometimes encouraging illegal landclearing, and who return later to collect produce in large trucks for direct export. Contract farming systems are in place for emerging niche and high value crops. Produce for local markets such as rice, vegetables and meat is either sold directly by farmers to consumers or passes from farmers to individual market traders to consumers.

A disconnect exists in the knowledge transfer process. High-quality knowledge, techniques and strategies are developed at higher levels, but the mechanisms by which these are passed down to smallholders are neither reliable nor quick. Extension services have limited capability and the contract farming companies have a localized effect targeting only farmers in small areas.

Natural resources management and environment

Biodiversity is the major unique natural asset of Xishuangbanna, and is in decline. Xishuangbanna was originally heavily forested, but its forest cover has shrunk from 69 percent to less than 50 percent in recent years, and the important tropical seasonal rainforest shrank from 11 percent to four percent. Forest fragmentation has increased significantly, with land conversion to rubber cited as the major driver of natural resource decline. The tropical forest landscape contains large carbon stocks in the form of biomass and soil carbon. Carbon stocks are estimated to be in decline due to land conversion. Nature reserves cover 12 percent of the land area. A recently completed (2011) initiative designed and established connectivity corridors between all nature reserves in the prefecture, although the ongoing governance of these corridors is questionable. A well-established tourist industry showcases both cultural and biodiversity. However, sustainable and equitable tourism is not common and most profits benefit neither the general population nor conservationist causes.

2.3.3 Upland areas of Nan Province, Thailand

Development overview

Nan has a population of 478 264, with almost no growth (0.06 percent) over the last 10 years (2004–2014). Most of the population is Northern Thai (80 percent) who live mostly in the lowlands; the rest is composed mainly of five ethnic minority groups (Lau, Hmong, Mien, Khmu and Mlabri). The biggest group is the Lau (42 percent), followed by the Hmong (32 percent) (Kitchaicharoen et al 2015).

The urbanization rate is low, with 88 percent of the population living outside municipal areas. Most of the population is of working age (70 percent). The dependency ratio is 0.43. The poverty level in Nan Province has been declining in recent years, falling from 212 700 (46 percent) in 2000 to 94 400 (21 percent) in 2012, although at a slower rate than the national poverty level. However, household debt in Nan has risen quickly over the last two decades, growing 22 percent with average debt levels being higher than the national average. The debt-to-income ratio has also been increasing over time, and stood at 0.89 in 2013. Maize production activities have contributed to the increased debt burden in the highlands.

Efforts to reduce malnutrition at the provincial level have been successful with the malnutrition rate in children under six lower than the targets set out in the provincial plan. The situation with malnutrition in the highlands is not clear, and especially in relation to micronutrient deficiencies which can usually be found in such remote areas. 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 decision-making, as well as access to and control over resources.

Production systems

In 2012, the total agricultural holding area was around 0.18 million ha. Most 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).

Rice is grown using two production systems: irrigated paddy rice and rainfed upland rice. Modern technology is used to produce hybrid maize to increase production. However, maize production requires heavy use of chemicals. Also, vegetables and mushrooms are produced. Livestock is produced on a small scale with a total of 52 360 households carrying out livestock rearing activities. Chickens are the most reared (1 829 938), followed by pigs, ducks and beef cattle (52 011, 47 629 and 32 307 respectively). Privately owned land for pasture covers 955 ha and publicly owned covers 1687 ha.

Markets and institutions

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 fresh vegetable and agroproduct processing markets. For the

processing market, deals are done through local entrepreneurs and agricultural cooperatives. Shopkeepers or small companies operate the agroproducts market in Nan. Most of the crops purchased are field crops such as maize, which is grown as food for livestock. Market channels exist for fruit, but there are not many fruit traders. The fruits most in demand are the Nam Dok Mai mango and sweet tamarind, both of which are exported.

The private sector has played an important role in developing agriculture in the province. It has focused on agribusinesses 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. Nan has 23 local agricultural cooperatives which offer small agricultural producers a wide range of services, including improved access to markets, information, communications, technologies, credit, training, and warehouse operations. These cooperatives also negotiate better contract farming terms and lower prices for agricultural inputs such as seeds, fertilizers and equipment.

Natural resource management and environment

Areas for growing maize and other cash crops have been expanding in recent years, leading to a major decline in natural forest areas. Forested areas can be broken down into five classes: dense evergreen forest, dense forest plantations, dense deciduous forest, disturbed evergreen forest, and disturbed deciduous forest. Deciduous forest covers the largest area with 667 193 ha, followed by evergreen forest (103 201 ha). Land degradation is a thorny issue as deforestation is the main cause. However, individual and group efforts have been made based on the Nan Strategic Plan, which embraces the province's new vision of achieving green growth and where economic advancement is achieved through the sustainable use of natural resources. Rubber trees and other cash crop plantations have been promoted over maize in an effort to establish crops that have comparatively less negative impact on the environment. However, the suitability of such a promotion has been questioned, stirring up controversy among stakeholders.

2.3.4 Honghe Prefecture, Yunnan, China

Development overview

Honghe Prefecture is in the southeast of Yunnan Province adjacent to Viet Nam, and covers an area of 32 931 km^2, of which 80 percent is mountainous. The total population is nearly 4.5 million people, with approximately 80 percent living in rural areas. The annual population growth rate was 0.86 percent from 2001 to 2010. The majority (80 percent) depend on agriculture for their livelihoods. The province has the largest number of ethnic minorities and is home to 52 of China's 56 ethnic groups, 49 of them in Honghe Prefecture. Population density is high at about 136 persons per m^2 in Honghe Prefecture and 118 persons per m^2 at the provincial level. Most of the population is male. Honghe Prefecture is a socially complex region with strong traditions and heterogeneous communities. In the situational analysis, data from five counties in the prefecture (Jianshui, Hekou, Honghe, Jinping, and Yuanyang) were collected (Kaiyun et al 2016).

The education system has improved and expanded to reach children in remote areas, providing education at all levels. The number of pupils enrolled in middle and high schools has increased. However, significant illiteracy remains, particularly in rural areas, and the quality of education is comparatively low.

Although the national economy has developed significantly, poverty levels are high (38 percent), which is higher than both the provincial and national levels. Income is lower in rural areas (threefold to fivefold).

Infrastructure is poor since the area is mountainous and has an underdeveloped road system. The rate of rural household access to clean water and electricity is also low. Women are more disadvantaged and continue to lose out in the job market due to low education levels and low skills, in part through lack of access to or participation in vocational training.

Production systems

The average cultivated area per capita is relatively small (0.059 ha), much lower than the provincial level (0.091 ha). Honghe Prefecture has six State farms, where rubber and rice are produced.

Crop production and livestock are the main income sources for local farmers and account for more than 80 percent of the region's agricultural GDP. Grain, vegetables and fruit are the main agricultural products, and Honghe Prefecture is the largest fruit production region in Yunnan. Pig production (both number of animals and volume of pork) accounts for nearly 40 percent of the provincial production.

Forests, which make up a large part of the area, mainly benefit ethnic minorities in high-elevation areas. The fishery plays a relatively small part in overall production. Fish are raised in rice and winter paddy fields. Mechanization is limited. Low use of improved technologies and inappropriate use of agrochemicals further contribute to low productivity.

Honghe Prefecture has a complex topography, a distinct altitude gradient, a climate, and significant seasonal rainfall that provide unique opportunities for agricultural production. However, production systems face challenges, including a relatively low percentage of cultivated land, an increasing rate of soil erosion and degradation, pollution, disappearing natural resources, and the lack of a skilled labour force.

Markets and institutions

Monthly consumption of agricultural commodities (grain, vegetables, fruits and meat) has changed slightly during 2008–2011. Demand for grain increased and more grain was imported to meet this demand in 2012. Most agricultural products are sold in local markets or at the prefecture level, but some high-value products such as vegetables and fruits are exported to other countries in Southeast Asia, Viet Nam in particular. While prices increased from 2011 to 2013, so did prices for agricultural inputs (chemical fertilizers, pesticides, plastic farm films and agricultural electricity). Many exhibitions and trade fairs were organized to promote local agricultural products sold outside the prefecture as well as constructing new markets.

Farmer groups, including professional cooperatives and agricultural associations, have played important roles in promoting agricultural industrialization and boosting the rural economy, but many constraints limit their development and effects, such as a lack of market management knowledge, low level of team organization, and little support from policy and finance.

Natural resources management and the environment

Honghe Prefecture has ample and reliable water resources, but distribution varies by region. The Environmental Protection Agency is ensuring that water pollution is reduced. There are rich forest resources, especially natural forest resources. Forest area per capita and the forest coverage rate of the prefecture and the five counties studied are larger than those of China, though forest resources differ in each county. The Forest Department has improved forest management by regulating deforestation and punishing illegal deforestation. The area is also rich in biodiversity and agricultural genetic resources.

Land degradation and soil erosion are serious concerns caused mainly by the excessive or inappropriate use of chemical fertilizers, pesticides and plastic films. The heavy metal content in the soil is above recommended limits and is caused by discharge from various enterprises. Indigenous knowledge, which contributes to biodiversity protection, is gradually being forgotten with the passing of the older generation, and frequent natural disasters threaten the local ecosystem.

2.3.5 Northwest Viet Nam

Development overview

Rural roads and electricity: Viet Nam has implemented national programs to improve rural infrastructure, particularly rural roads and electricity systems under the auspices of Programme 135. From 1999 to 2005, the rural road system was rehabilitated, improving connectivity between communes and district towns as it finally became part of the national and provincial road network. Electricity systems were upgraded and expanded, increasing the access of communes to the national electricity grid system by 60–79 percent. The proportion of rural households with access to electricity jumped from 74 to 95 percent (ILRI 2014).

Access to piped potable water: From 2001–2010, a clean water program was widely implemented in the rural areas of the northern provinces. Approximately 90 percent of households in the urban area had access to clean water. Clean water sources were installed in more than 75 percent of rural communities. However, the rate of household access to a clean water source was still relatively low in three provinces (Lai Chau, 18 percent; Son La and Dien Bien, approximately 41 percent). Lao Cai had better access, at 77 percent.

Ethnic and cultural diversity: Viet Nam is a country where many ethnic groups live together in the same area. In the northwest provinces, more than 20 minority groups are settled in various places from the high mountainous area to the downtown areas of districts or city zones at the provincial centre.

Income levels and trends: A clear income disparity exists between urban and rural areas. The gap in average income per capita in these provinces was wide, with urban income double or triple that of rural areas. This inequality is considered a social problem, especially among ethnic minorities in remote areas.

Education and literacy: Based on official statistics, primary education is near-universal, and equality in education opportunities has improved in multiple ways. In the provinces studied, the school systems have newly built or renovated classrooms to cope with the increasing demand at all education levels. Every commune has nursery and primary schools, and lower secondary and upper secondary schools operate in every district. While the literacy rate is approximately 94 percent, it is lower in mountainous provinces.

Employment: Agricultural modernization, urbanization and industrialization have brought about dramatic changes in the lives of many Vietnamese farmers. However, farmers' livelihoods in the mountainous provinces, especially of those in remote rural areas, have been less affected.

Production systems

These northwest provinces of Viet Nam are characterized by some challenging terrain, including steep slopes in many areas and elevations reaching more than 1500 m. Nevertheless, slope and elevation do not entirely dictate where agriculture is carried out. Agricultural production is done on both small and large farms and uses mechanized, human and animal power, with differences closely associated with type of terrain and also ethnic group. Ethnic minority communities tend to adhere to traditional agricultural practices, which can constrain innovation within these significant groups. Livestock technologies are not well developed, relying mostly on traditional breeds and technologies, leading to low yields. An important and evolving feature is the rapid increase in the land area planted with maize on steeply sloped terrain, as a result of demand for feed for poultry and pigs in Viet Nam and further afield in China. Extreme erosion can be observed as a result, threatening the long-term sustainability of the land resource base.

Markets and institutions

Essential commodities in the provinces being studied were rice, vegetables, fruit, pork, chickens, beef, shrimp, fish, tea and alcohol. Some local traditional varieties of livestock and fruit are regarded as unique to the area, and attract high prices in urban markets. Consumption of fruits and vegetables is low, whereas monthly average per capita consumption of alcohol is relatively high. Many commodities are sold locally and the surpluses sent to urban areas, as some specialized products are exported to other countries. Farmers either sell directly to consumers or indirectly through collecting agencies or wholesalers. By selling directly, producers have a higher income and consumers are better informed of the product origin. State-owned institutions such as Plant Protection Units of the Provincial Department of Agriculture and Rural Development are in charge of distributing inputs and extension services to farmers. However, compared with the needs, staffing is limited and staff capacity is low.

Natural resource management and the environment

Northwest Viet Nam is a mountainous region that comprises steep mountain ranges, highland and dense river systems. Forest land accounts for the largest proportion of available land with approximately 80 percent in Lai Chau, Dien Bien and Son La and 70 percent in Lao Cai. An increasing proportion of that is under managed forests such as rubber, the production of which is growing rapidly, threatening biodiversity and other resources such as water and soils. Nevertheless, the Vietnamese Government is committed to managing natural resources and the environment and has issued a number of laws and decrees to preserve biodiversity and protect the environment as well as program 'thrusts', which have significantly increased forest acreage.

2.4 Concluding remarks

These short descriptions of the situational analyses results clearly illustrate the diversity of agricultural and rural development settings across the target sites in the Central Mekong Action Area. However, the sites also share some strong commonalities, which reflect some of the shared cultural history as well as similar physical terrain and agricultural traditions. Among the commonalities are: i) mountainous terrain characterized by some relatively remote and thinly settled locations in elevated areas, but also settled valley locations with better market access; ii) linked to this, a strong disparity in income between urban and rural populations; iii) a relatively strong presence of ethnic minority communities, many of which are politically, economically and geographically marginalized, particularly in the case of women; iv) a mix of agricultural market types, including both strong local demand but also longer distance and cross-border markets for specific products, some of which are high value; and, v) the relatively strong role of the State. In all sites, most of the population is rural and agriculture still plays the dominant role in livelihoods.

Contrasting features across the sites include: i) differential levels of development, including both infrastructure and agricultural technology, which are somewhat based on national-level development differences; and, ii) in some cases (Thailand, China) populations levels have stabilized while elsewhere such as in Viet Nam, population growth continues.

Some guidance for research and development can be obtained from these assessments, including:

- The relatively rapid changes in land use, and agricultural intensification in a region characterized by steep terrain requires investment in technologies and strategies to improve soil conservation within evolving production systems.
- The large presence of ethnic minorities with relatively poor access to extension services and to markets, and who are also characterized by lower income and literacy levels, suggests that special attention should be devoted to increasing their capacity for agricultural innovation and market access. Services need to be tailored specifically for their needs, while infrastructure development continues.

- There may be opportunities for agrotourism among ethnic minority communities, if appropriately designed to suit their interests.
- Local traditional products, crops and livestock exhibit untapped potential for high-value markets beyond the region, due to their unique characteristics and the value placed by consumers on their origin. Market-driven branding and certification systems may need to be developed, taking a public-private partnership approach.

3. Diversity among smallholder farmers in Northwest Viet Nam

3.1 Introduction

The situational analyses helped to identify some of the variables that account for the diversity among sites. This allowed us in turn to examine some of those variables among farm households and the implications for livelihoods and well-being.

A considerable variety of farm production systems are found across various cultures and landscapes, operating in differing socioeconomic, institutional, demographic and political contexts. Many external and internal factors affect farmers' decision-making on resource allocation, production and marketing. One efficient and useful approach to initially gain a clearer understanding of important farm characteristics in heterogeneous systems involves cluster analysis of farming households. Cluster analysis provides a clear descriptive picture of the existing farming structure with distributions of assets and livelihood indicators. These results may provide a basis for identifying best-bet and best-fit farm interventions and innovations in the associated product value chains with the aim of increasing smallholder productivity, thereby reducing poverty and food insecurity in the rural areas to improve household well-being. Some of these interventions are mentioned in chapters 3 and 4.

In many cases, smallholders not only show a strong heterogeneity among themselves, but are also characterized by considerable diversity of income sources and production activities. This may be due to their subsistence orientation, which is often associated with various objectives determining resource allocation and production. These objectives may include nutrient maximization, labour smoothing, consumption preferences or reducing various risks, in addition to maximizing income. As well as comparing various smallholder classes on their internal diversity, econometric analysis can further improve the understanding of how production diversity is associated with resources, income sources and livelihood indicators. A crucial indicator is the diversity of individual diets. An improved understanding helps with identifying causes, constraints and opportunities for diversification among poor smallholders who are especially vulnerable in marginal rural areas, and may deliver important information

for policy makers. The specific results from smallholders in Northwest Viet Nam will also contribute to the global discussion and the growing body of literature on farm household diversification.

3.2 Methodology

Survey background

The results presented here come from a baseline household survey conducted in Son La and Dien Bien provinces, which had initially been identified as field sites within the Humidtropics Central Mekong Action Area. A list of all communes with census data structured by administrative units (province, district) for these two provinces formed the first-stage sampling frame. Unsuitable communes, identified by extreme values for population density or classified as urban by local administration, or with extreme political and social issues, were dropped from the sampling list. These criteria led to the exclusion of 173 out of 314 communes. Based on the ratio of province populations, 10 communes were randomly selected from Son La and six communes from Dien Bien. After generating settlement and household lists for the selected communes, a total of 400 households were randomly selected. Relevant baseline data were collected using the ImpactLite survey tool (Douxchamps et al 2016) in early 2015.

Classification

Farm households were categorized into meaningful clusters by using two sequential multivariate statistical techniques: factor analysis and cluster analysis (Pacini et al 2014). With factor analysis the number of variables (most of which are correlated to each other) was reduced to a smaller set of factors that captured most of the variation within the observed variables. The retained factors from the factor analysis were then employed for cluster analysis to identify relevant farm household categories. The variables selected for classification captured three categories of important development assessments: wealth and income; productivity and innovation; and, nutrition. In particular they were:

- Wealth and income: area of cultivated land, livestock assets (measured in tropical livestock units), domestic asset index, off-farm income, household expenses.
- Farm productivity and innovation: crop and livestock productivity (production value/cultivated land), market integration (sales value/production value), land tenure status, use of innovations on cropland, use of innovations in livestock herds, period of innovation use, contacts with agricultural information providers.
- Nutrition: Individual Diet Diversity Score (IDDS), food supply sufficiency (calories consumed/calories required), food self-sufficiency (calories produced/calories consumed).

The IDDS is calculated according to Kennedy et al (2010). Accordingly, the 17 food groups included in the questionnaire are aggregated to nine groups, reflecting the probability of micronutrient adequacy of the diet. The nine groups are: starchy staples, dark green leafy vegetables, other vitamin-rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes, nuts and seeds, milk and milk products. The IDDS scores are calculated separately for the household head, the spouse and the eldest child under five years of age within the household.

Diversity indices

For this study, diversity is first determined separately for crop production, livestock production, income sources and diets. The Simpson's Index of Diversity (SID) is used to measure crop, livestock and income diversity. In effect, the SID measures the probability that two individuals randomly selected from a sample will belong to the same category. It was originally developed for measuring biodiversity, focusing on species (Simpson 1949) and was initially defined as:

$$D = \frac{1}{\sum\limits_{i=1}^{s} p_i^2} \qquad \text{Eq. 1}$$

Where p is the proportion (n/N) of individuals found in one particular category (n) divided by the total number of individuals (N); Σ is the sum over the categories; s is the number of categories.

With this index, 0 represents infinite diversity and 1, no diversity at all (all individuals belong to the same category). Therefore, the higher the value of D, the lower the diversity. This is neither intuitive nor logical. Therefore, D is often subtracted from 1 to produce the Simpson Index of Diversity (1-D). The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different categories. The lowest possible value, 0, would represent a community containing only one category. In this study, crops and species formed the categories for crop and livestock diversity, respectively, while seven income categories were defined for determining income diversity.

For dietary diversity, we employ the IDDS of the main survey respondent, irrespective of gender or household position, following the methodology described above.

Diversity analysis

To assess factors influencing various diversity indices, the Seemingly Unrelated Regression (SUR) approach, introduced by Zellner (1962) and later advanced by others (Fu et al 2016), was adopted, controlling for cross-equation correlation across the four diversity equations.

Correlation of error terms was also tested across equations using the Breusch-Pagan test of independence. Since the Simpson Index of Diversity is a fraction ranging between 0 and 1, and IDDS is a count ranging from 1 to 9, the Simpson Reciprocal Index (SRI) was employed to ensure similar distributions among all diversity measures. The SRI is the reciprocal of the original diversity index D (SRI = 1/D). The higher the SRI value the greater the diversity.

3.3 Results

Classification

Classification based on factor and cluster analysis generated four clusters of farm households. Table 2.1 presents the farming and household characteristics of these clusters.

Cluster 1 was labelled 'wealthy' and accounted for 10 percent of the total sample. Although the households in this cluster cultivated the least amount of land, they owned the largest livestock herds and had the highest non-farm incomes and household expenses. They also showed the highest diversity in income sources. It does not surprise that they also had the highest level of education and the smallest families. Their crop production was the most productive as measured by output value/ha, almost three times higher than the figure of the lowest cluster (Cluster 2). With livestock production, compared to the other clusters, these households produced at a larger scale, mainly focused on non-ruminant species, and attained the highest livestock productivity, also nearly three times the lowest productivity cluster. These households secured high production returns from rice, chickens and pigs, while showing only moderate levels of diversity in crop and livestock production (although livestock diversity does not differ greatly between clusters). This corresponded with these households being the most market-oriented, selling the highest proportion of their products, approximately one-third in the case of rice and chickens, and up to three-quarters in the case of pigs. Innovative technologies were applied widely in crop production, but only at a moderate level in livestock. This cluster showed the highest values of Individual Dietary Diversity Scores (IDDS) which together with food supply sufficiency reflect the high probability of an adequate diet.

Cluster 2 was labelled 'poor' and comprised about half of all farm households (49 percent). It was ranked lowest on almost all indicators. These households showed the lowest annual expenses among the four clusters and were headed by the youngest farmers with the lowest educational levels and farming experience. In agricultural production, this cluster was characterized by low levels of diversification, productivity and net returns. Farm products were mainly used for household consumption. The application of innovations was still at an early stage, as they had not really become accepted in this cluster. This may partly be explained by their limited exposure to agricultural information, evidenced by the low number of visits by agricultural extension agents. Diet diversity was also the lowest in this cluster by a considerable margin.

Cluster 3 was characterized as 'innovative' and constitutes 24 percent of the total sample. These households were likely to have more female heads and more farming experience than in the other clusters. They exceeded all other clusters in applying innovations in crop and livestock production, both in current extent and period of application, although the 'wealthy' cluster came close. However, this was not sufficient to allow these households to achieve the productivity levels of the 'wealthy' cluster, perhaps because they could not invest as much from non-farm incomes, which were the lowest among the four clusters, despite having the joint-highest income diversity. Nevertheless, diet diversity was nearly as high as in the 'wealthy' cluster. The caloric data on food supply, however, indicated a more precarious situation.

Finally, cluster 4, identified as 'crop-oriented', comprised 16 percent of the sample. It was characterized by the largest land holdings supporting large family sizes, but at relatively poor educational levels. Their land endowment allowed these farmers to grow the most diverse selection of crops and produce the highest value of rice and maize. Similarly, they kept the most diverse livestock. However, crop productivity was only moderate while livestock productivity was the lowest among the four clusters. Despite high production levels, more than 80 percent of the rice grown was consumed at home. Maize was the most important crop. Selling 60 percent allowed these households to achieve household expenditure levels similar to the 'wealthy' cluster at the lowest level of income diversity. Nevertheless, diet diversity was only moderate in these households.

Table 2.1 Characteristics of identified farm household clusters

Variable	Wealthy (n=39)		Poor (n=190)		Innovative (n=93)		Crop-oriented (n=62)	
	mean	se	mean	se	mean	se	mean	se
Household characteristics								
Number of household members (no.)	3.8	(0.24)	4.29	(0.10)	4.53	(0.17)	5	(0.24)
Gender of hh head (1=male, 2=female)	1.1	(0.04)	1.1	(0.02)	1.1	(0.03)	1.1	(0.03)
Age of hh head (yrs)	48.3	(1.77)	41.9	(0.99)	47.3	(1.18)	43.2	(1.13)
Education level of hh head (yrs)	7.6	(0.58)	5.4	(0.29)	6.1	(0.34)	5.7	(0.44)
Years of farming experience (yrs)	20.3	(1.87)	18.6	90.86)	23.0	(1.00)	21.7	(1.17)
Annual off-farm income (M VND)	80.2	(24.03)	26.1	(7.28)	18.1	(2.83)	33.4	(10.94)
Annual hh expenses (M VND)	47.0	(5.92)	15.5	(0.83)	30.1	(2.32)	42.9	(3.91)
Income diversity (SID)	0.47	(0.03)	0.40	(0.02)	0.47	(0.02)	0.38	(0.02)
Crop production								
Cultivated area (ha)	0.4	(0.06)	0.9	(0.05)	1.1	(0.08)	3.1	(0.24)
Share of land owned (%)	94.6	(3.06)	97.1	(0.95)	90.5	(2.49)	87.6	(2.87)
Number of crops (no.)	3.0	(0.34)	3.3	(0.14)	4.3	(0.24)	4.0	(0.29)
Crop diversity (SID)	2.9	(0.69)	2.5	(0.21)	3.2	(0.39)	4.0	(0.30)
Production value of rice (M VND/yr)	12.2	(2.08)	7.1	(0.54)	11.3	(1.14)	13.1	(2.67)
Production value of maize (M VND/yr)	13.9	(5.42)	18.5	(2.06)	19.9	(3.70)	108.4	(10.72)
Crop productivity (M VND/ha)	133.5	(1.39)	45.3	(0.21)	53.3	(0.28)	55.0	(0.30)

Variable	Wealthy (n=39)		Poor (n=190)		Innovative (n=93)		Crop-oriented (n=62)	
	mean	se	mean	se	mean	se	mean	se
Livestock production								
TLU (Tropical Livestock Unit)	10.7	(1.05)	4.1	(0.22)	8.4	(0.70)	9.2	(0.70)
Share of ruminants (%TLU)	20.8	(3.22)	41.3	(2.11)	36.7	(3.24)	40.8	(3.24)
Number of livestock species (no.)	4.4	(0.22)	3.9	(0.11)	4.6	(0.13)	5.1	(0.19)
Livestock diversity (SID)	2.7	(0.14)	2.5	(0.07)	2.7	(0.08)	2.8	(0.12)
Production value of chicken (M VND/yr)	18.1	(3.56)	4.5	(0.86)	10.7	(1.52)	9.2	(1.79)
Production value of pig (M VND/yr)	43.4	(12.09)	3.6	(0.66)	13.5	(2.24)	8.1	(2.07)
Livestock productivity (M VND/TLU)	9.53	(1.58)	4.39	(0.53)	5.43	(0.86)	3.38	(0.47)
Marketing and utilization								
Share of rice sold (%)	36.4	(7.91)	9.3	(1.76)	14.7	(3.25)	16.7	(4.96)
Share of maize sold (%)	15.3	(5.54)	28.5	(2.41)	16.4	(2.63)	60.1	(4.00)
Share of chicken sold (%)	34.3	(6.60)	11.1	(1.62)	27.1	(3.28)	12.5	(3.26)
Share of pig sold (%)	73.3	(11.32)	20.2	(3.02)	53.0	(7.17)	29.5	(6.27)
Innovation								
Use of innovation for crops (% crop area)	61.0	(3.68)	47.8	(1.44)	64.8	(2.16)	53.1	(1.69)
Use of innovation for livestock (% herd)	39.9	(3.97)	10.6	(1.07)	52.7	(2.21)	21.3	(2.38)
Period of innovation use (yrs)	5.9	(24.10)	3.3	(0.15)	8.7	(0.34)	5.3	(0.33)
Contacts for agricultural information (no./yr)	24.1	(2.13)	6.5	(3.02)	32.9	(1.51)	12.8	(1.26)
Nutrition								
IDDS main respondent	5.6	(0.20)	3.9	(0.10)	5.3	(0.15)	4.9	(0.20)
IDDS child	5.0 (n=2)	(1.00)	3.0 (n=28)	(0.34)	5.0 (n=7)	(0.69)	4.2 (n=4)	(0.63)
Food supply sufficiency	1.4	(0.08)	1.2	(0.04)	1.0	(0.04)	1.2	(0.07)
Food self-sufficiency	5.7	(1.08)	6.8	(0.43)	7.7	(0.67)	24.4	(1.86)
	High		Low					

Source: Humidtropics household baseline survey in Northwest Viet Nam (2015).

Seemingly unrelated regression analysis

The results from the four diversity equations estimated together as a system are presented below (Table 2.2). All the models are significant at the one percent level, except crop diversity, which is significant at five percent. There was a significant cross-equation correlation (p=0.06).

Table 2.2 Factors influencing various diversity indices

	RMSE	R-sq	chi²	P-value
Crop diversity	3.714	0.080	29.55	0.013
Livestock diversity	0.751	0.272	127.44	0.000
Income diversity	0.595	0.129	50.50	0.000
Dietary diversity	1.411	0.170	69.82	0.000

	Crop diversity		Livestock diversity		Income diversity		Dietary diversity	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Gender, hh head (1=male, 2=female)	-0.394	0.743	0.191	0.152	0.046	0.120	0.124	0.285
Education level, hh head (yrs)	0.170***	0.061	0.010	0.012	0.018*	0.010	0.073***	0.023
Farming experience (yrs)	0.044**	0.020	0.007*	0.004	-0.001	0.003	0.009	0.008
Cultivated area (m²)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Annual off-farm income ('000VND)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Plots cultivated (no)	-0.024	0.067	0.015	0.014	-0.008	0.011	0.021	0.026
TLU	0.002	0.045	0.023**	0.009	-0.009	0.007	0.025	0.018
Share of ruminants (% TLU)	-0.008	0.008	0.014***	0.002	-0.004**	0.001	-0.006*	0.003
Gender asset disparity	-0.043	0.093	-0.010	0.019	-0.014	0.015	0.038	0.035
Domestic asset index	0.004	0.003	0.001*	0.001	0.000	0.000	0.003**	0.001
Distance to market (km)	-0.002**	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Market integration crops (%)	-0.008	0.008	-0.003	0.002	-0.002	0.001	0.003	0.003
Market integration livestock (%)	-0.003	0.008	0.002**	0.002	0.004***	0.001	0.003	0.003
Use of crop innovations (% crop area)	0.013	0.012	-0.002	0.002	0.001	0.002	-	-
Use of livestock innovations (% herd)	-0.007	0.009	0.000	0.002	0.001	0.001	-	-
Household members (no.)	-	-	0.028	0.029	0.041*	0.023	-0.047	0.055
Livestock species (no.)	-	-	-	-	-	-	0.145**	0.071
Constant	1.796***	1.402	1.365***	0.314	1.865	0.249	2.854***	0.590

***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively
Breusch-Pagan test of independence: chi²(6) = 12.031, Pr = 0.0613
Source: Humidtropics household baseline survey Viet Nam (2015)

It appeared that crop diversity was positively associated with the education level of the household head and years of farming experience. Similarly, crop diversity increased when the distance to markets was reduced. Livestock diversity was also positively and significantly influenced by years of farming experience, though much less than crop diversity. The domestic asset index, Tropical Livestock Units (TLU), the share of ruminant livestock and the share of livestock products sold were also linked to higher livestock diversity.

All other factors held constant, income diversity was positively and significantly influenced by the household head's education level, the number of household members and the share of livestock and livestock products sold. However, income diversity was negatively influenced by the share of ruminant TLU. It appeared that households keeping more ruminants had less diverse income sources. Finally, dietary diversity was positively and significantly influenced by the household head's education level, by the domestic asset index and by the number of livestock species kept. As with income diversity, the share of ruminant TLU negatively influenced dietary diversity.

3.4 Concluding remarks

The classification of farm households in Northwest Viet Nam was based on factors related to wealth, production, marketing, innovations and nutrition. The multivariate analysis approach, combining factor analysis and cluster analysis, allowed us to identify four typical farm household classes and the socio-economic characteristics associated with their farming and market choices.

It is hoped that these results will serve as a reference for future economic analysis in Northwest Viet Nam. While agricultural technological advances contribute to increasing yields and incomes, the results indicate that this link is not straightforward in this diverse environment. The diversity in the study region is measured by crop, livestock and income diversity while quality of nutrition is measured by diet diversity. The classification results indicated that although the poorest households showed low diversity in all indicators, the economically successful households tended to specialize in market-oriented farming activities, while diversifying their income sources. Households with high production diversity were those endowed with comparatively extensive land and livestock resources.

Results of the econometric analysis highlight the important role of farmer education in association with higher production and income diversity scores. While these results are indications, they are in line with literature showing that educated farmers are good at organizing complex farming operations, accessing multiple income sources, and ensuring diverse diets. We also see that while farming experience has a positive impact on crop and livestock diversity, it is not directly linked to increased income and diet diversity. This suggests that the knowledge farmers are provided with could be made more relevant for improving their livelihoods overall, particularly targeting improvements in their nutritional status. Although the share of ruminants had a positive effect on livestock diversity, this had a negative effect on both income and diet diversity. This may be attributed to the fact that the main meats Vietnamese consume are pork (56 percent) and poultry (27 percent) (OECD 2016). Accordingly, pork and poultry also generate the most livestock income. While livestock market integration had a positive effect on both livestock diversity and income diversity, this did not significantly affect diet diversity.

These analyses indicate that promising strategies for poor rural households with limited production resources would be to diversify income sources, with an emphasis on non-farm opportunities, while also modernizing their agricultural production and focusing on market orientation. Diversifying crop and livestock production appeared to be attractive mainly for farmers with above average resources. However, further analysis would be required to better assess the complex relationships between diversity and livelihood indicators.

4. Farm strategies and farm performance: How are they related?

4.1 Introduction

In the previous sections (2 and 3), we reviewed situational analyses to characterize study sites and then examined food security levels that arise from specific farm household strategies and performance, how the two are related, and the implications for potential farm interventions. In this section, we apply a new analysis framework to quantify a simple food security indicator, specifically developed to analyse the livelihoods of smallholder farmers (Frelat et al 2016), and to assess the potential impacts proposed intervention options might have in the Central Highlands of Viet Nam.

4.2 Approach

The analysis uses data obtained with the ImpactLITE farm household survey undertaken in 2014 (see https://ccafs.cgiar.org/impactlite-tool#.V7djrfkrLIU for a detailed description). Members of 400 households in the Central Highlands of Viet Nam were interviewed. Information on household composition, farm practices, production, sales and consumption of agricultural produce and off-farm income was collected for each household.

This information was used to quantify a simple indicator of food security, called 'potential food availability'. Detailed information about this indicator can be found in Frelat et al (2016) and Hammond et al (2016), but in short, the indicator quantifies the potential of a farm household to generate enough food (expressed in kcal) to feed the family through its on- and off-farm activities (see Figure 2.1).

Information on yearly crop production, consumption and sales, livestock production and off-farm income is combined with family size and composition, to quantify an estimate of whether the family can potentially be fed, based on these activities. The indicator is easily quantifiable using the information collected in many farm household cross-sectional surveys. This food security indicator does not cover all the complexity contained in the concept of food (in)security, but is simply a potential supply indicator. The indicator provides

a continuous 'food availability scale' that allows us to quantify the contribution of key determinants of food availability for individual households within and across sites. It functions well for sites in which food insecurity is major problem, and where agricultural productivity is low and where total production is low due to small farm sizes. More detailed survey analyses have shown that food availability relates well to other indicators of food security such as diet diversity and hunger, and food insecurity access scales up to values of roughly 5000 kcal per male adult equivalent per day (Hammond et al 2016, Frelat et al 2016).

Beyond this value the results diverge, and the food availability indicator is not very useful as an indicator of food security because agricultural production is no longer the main constraint for achieving food security and a diverse diet.
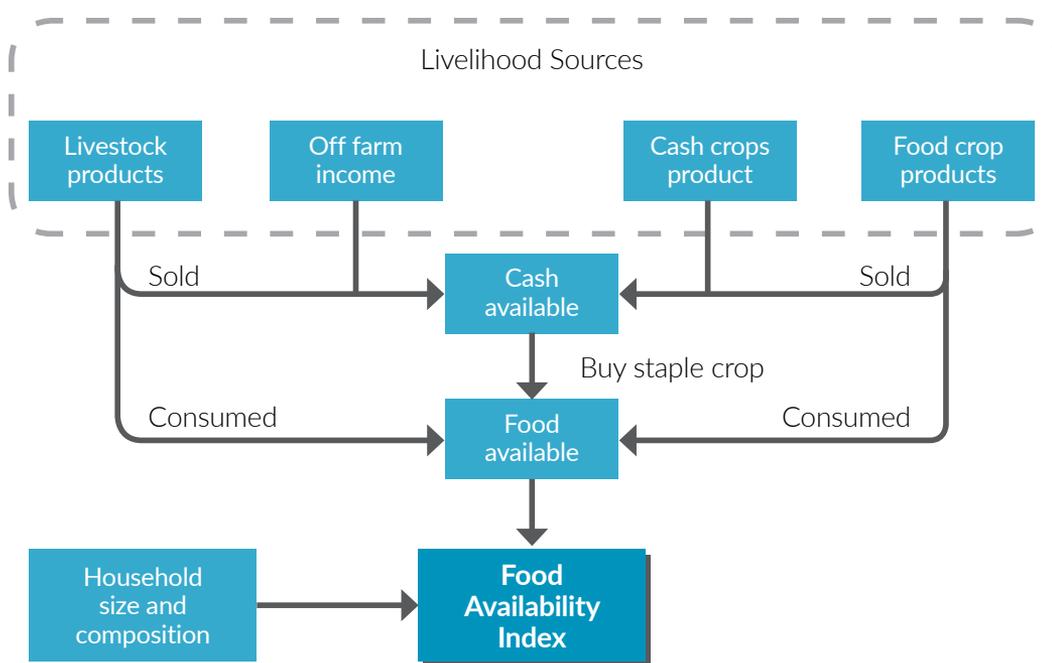
Figure 2.1 Scheme explaining the calculation of the Food Availability indicator (following Ritzema et al nd)

The analysis in this chapter follows the steps used in Ritzema et al (nd) and Paul et al (nd) in which i) a core set of interventions was identified; ii) an intervention's likely effect was defined if the intervention is adopted for productivity, market prices and land allocation; and, iii) the consequences of the changes on the simple food security indicator were quantified for each individual farm household.

The interventions studied in the Action Sites in the Central Highlands of Viet Nam and evaluated in this section were identified based on a literature overview of existing agricultural interventions and a collation of ongoing experimental work within the Humidtropics and related projects, mainly in the Northwest Viet Nam Action Area. The interventions are

presented in Table 2.3 together with assumed effect changes. The interventions listed range from introducing Son Tra (*Docynia Indica*) or the 'Hmong apple', a relatively new fruit tree species, to integrated pest management, to improved market access.

Table 2.3 Interventions evaluated in this impact assessment study together with their estimated effect changes if they were to be adopted

| Intervention	Yield estimates	Price estimates	Literature
Expansion and improvement of Son Tra fruit production	2 tons/ha average	Farm gate price ranges between: 3000-15 000 VND/kg	Hoang et al (2013)
Coffee nutrient management	Yield improvement of 29-44%	No effect	Long et al (2015)
Integrated pest management	Yield of French bean improved by 5.7%	Cost saving of ~50% from reduced fertilizer use	Long et al (2015)
Improved agroproduct market linkages through value chain development	No effect	Price increases up to 40%	Long et al (2015)
Expansion and further intensification of agroforestry systems	Overall yield increases up to 10%	No effect	World Agroforestry Centre (2015)

4.3 Results

The baseline results of the food availability analyses showed that 26 percent of the farm households were food insecure, i.e. had a food availability ratio[1] of less than 1.5, the value related to saturation of other food security indicators such as the Hunger and Food Insecurity Access Scale and Household Level Diet Diversity (e.g. Hammond et al 2016). The five interventions had only a little effect on changing this 26 percent value: improved market access (23 percent), agroforestry (24 percent) and integrated pest management (IPM) (25 percent) had small positive effects, while improved coffee management (26 percent) and introduction of Son Tra (28 percent) had no or even negative effects on this value.

Figure 2.2 presents more detailed results on the intervention analyses, where we have divided the farm household population into four groups: severely food insecure, food insecure, roughly food secure, and food secure. These results show that the interventions had differential effects across these four farm household groups. Introduction of Son Tra had a positive effect on the income of most food-insecure households, but a negative effect on the other households because its introduction on the farm meant the farmer had to replace other crops with Son Tra. In this scenario, all existing crop areas were reduced equally to make room for an allocation of 10 percent of the total arable land area to Son Tra. This worked out positively for the most food-insecure households, because they could replace part of their low-yielding and low-market price food crops, but for the more food-

---

[1]   The ratio between potential annual energy supply of food divided by the annual energy need of the family.

secure households with higher crop yields and more intensive market-oriented systems, Son Tra production did not improve the performance of the existing crops. Improved coffee management only improved the food security status of the already more food-secure households, because they were the ones currently growing coffee. Improved market access and intensified agroforestry systems increased food security across all households, with improved market access especially having large positive effects.
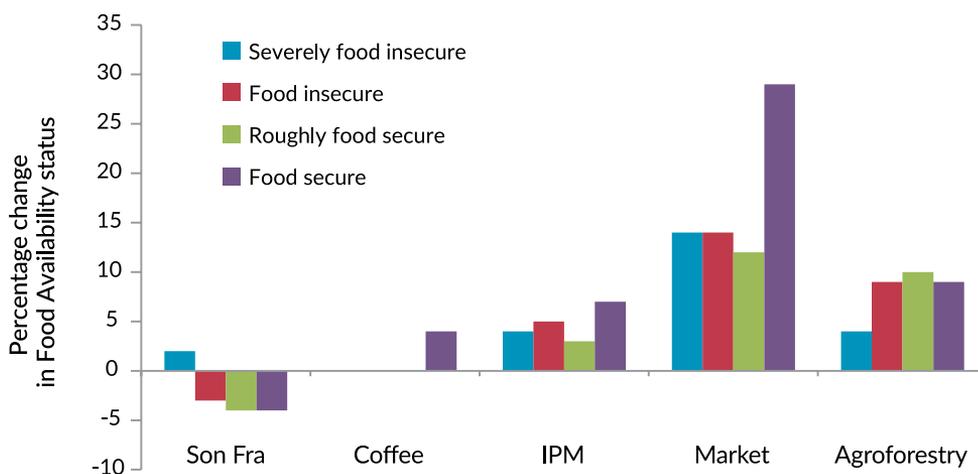
Figure 2.2 Percentage change in food availability status due to the interventions as compared to the baseline. Different colours are the different food availability classes

4.4 Concluding remarks

The simple analyses presented here shows a clear differentiation between the interventions, with the introduction of Son Tra, with the current production levels and market prices, targeting the poorest households (15 percent of the sampled population); the coffee management intervention, on the other hand, targeted the relatively food-secure households that form about 55 percent of the total population. In this way, the analysis gives a first indication of the outreach potential of different interventions, the effect they might have on food security, and how they might affect different farm groups within the overall population. This information can be used to better target interventions and better assess the efficiency of investment in supporting different interventions.

5. Conclusion

The cases presented in this chapter demonstrate examples of different levels and types of systems analysis, each with different objectives and tools, beginning with broad low-resolution analysis to increasingly focused higher-resolution analysis with narrower boundaries.

The first set of situational analyses (cf. section 1) addressed broad regional-level systems consisting of districts or provinces in a specific country. The system components were major sectors and institutions in the landscape, not individual actors. A mix of participatory, qualitative and quantitative tools was used to assess conditions and trends in general rural development, agriculture, markets and environment. The types of learning gained informed public investment in extension and agricultural development, opportunities for private public partnerships, and priorities for research.

In contrast, the next two examples of systems analysis (cf. section 2 and 3) addressed a more narrowly focused system, at the level of a group of farmers in selected communities, which could be described as a landscape. Further, the analyses only directly addressed a single component of the system, which was the individual farm household. This single component was characterized as a bounded farm household system, which included agricultural and other land-use practices, and also intrahousehold decisions, resources and capacities. Some interactions with elements outside the system were also captured indirectly, such as the degree of market orientation. The only information-gathering tool used was a quantitative survey of individual farm households. The analytical tools used in the two cases differed somewhat, however, since they asked different questions. Of key importance to both analyses was the level and type of variation between individual farm households within the landscape level system. The types of learning gained guided research and development priorities for that landscape, including what types of agricultural practices, and mixes of strategies, were most likely to lead to positive welfare outcomes for the households, and also characterized what those outcomes were likely to be, in this case livelihood and nutrition indicators.

References

Checkland PB. 1981. *Systems Thinking: Systems Practice*. Chichester: Wiley.

Douxchamps S, van Wijk MT, Silvestri S, Moussa AS, Quiros C, Ndour NYB, Buah S, Somé L, Herrero M, Kristjanson P, Ouedraogo M, Thornton PK, Van Asten P, Zougmoré R, Rufino MC. 2016. Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. *Regional Environmental Change* 1305–1317. doi:10.1007/s10113-015-0838-6

Frelat R, Lopez-Ridaura S, Giller KE, Herrero M, Douxchamps S, Djurfeldt A, Erenstein O, Henderson B, Kassie M, Paul B, Rigolot C, Ritzema R, Rodriguez D, van Asten P, van Wijk MT. 2016. Drivers of household food availability in sub-Saharan Africa based on big data from small farms. *Proceedings of the National Academy of Sciences* 113(2):458–463.

Fu L, Lei Y, Wang G, Bi H, Tang S, Song X. 2016. Comparison of seemingly unrelated regressions with error-in-variable models for developing a system of nonlinear additive biomass equations. *Trees* 30:839–857. doi:10.1007/s00468-015-1325-x

Hammond J, Yi Z, McLellan T, Zhao J. 2015. *Situational analysis report: Xishuangbanna Autonomous Dai Prefecture Yunnan, China.* Kunming: World Agroforestry Centre.

Hammond J, Fraval S, van Etten J, Suchini JG, Mercado L, Pagella T, Frelat R, Lannerstad M, Douxchamps S, Teufel N, Valbuena D, van Wijk MT. 2016. The Rural Household Multi-Indicator Survey (RHoMIS) for rapid characterisation of households to inform Climate Smart Agriculture interventions: description and applications in East Africa and Central America. *Agricultural Systems*, in press. http://dx.doi.org/10.1016/j.agsy.2016.05.003

Hoang TL, Degrande A, Catacutan D, Nguyen TH, Cuong VK. 2013. *Son Tra (Docynia indica) value chain and market analysis.* Agroforestry for livelihoods of smallholder farmers in north-western Vietnam project Technical Report No. 9. Hanoi: World Agroforestry Centre.

[ILRI] International Livestock Research Institute. 2014. *A situational analysis of agricultural production and marketing, and natural resources management systems in Northwest Vietnam*. Nairobi: International Livestock Research Institute.

Kaiyun X, Zongwen Z, Jun Z, Lei B, Tingting B, Caibin L, Jiaoyang L, Mingzhu. 2016. *Draft Situational analysis report 2008–2013: A situational analysis of agricultural production systems, markets and institutions and natural resources management in Honghe Prefecture.* Beijing: International Potato Center (CIP).

Kennedy G, Ballard T, Dop M. 2010. *Guidelines for measuring household and individual dietary diversity.* Rome: Food and Agriculture Organisation (FAO), Nutrition and Consumer Protection Unit.

Khanh TT, Long CTM, Tiemann T. 2015. *Draft Situational analysis report of Central Highlands.* Buon Me Thuot: Tay Nguyen University.

Kitchaicharoen J, Suebpongsang P, Sangchyoswat C, Promburom P. 2015. *Situational analysis in support of the development of integrated agricultural systems in the upland areas of Nan Province, Thailand.* Chiang Mai: Chiang Mai University.

Long CTM, Nam DT, Vu TTD, Quang VT, Nguyen VK, Nguyen VQ. 2015. *Enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms in the Central Highlands of Vietnam.* Report submitted to the Integrated Systems for the Humid Tropics. Dak Lak, Vietnam: Western Highlands Agriculture and Forestry Science Institute.

 [OECD] Organisation for Economic Co-operation and Development. 2016. Meat Consumption (Indicator). doi:10.1787/fa290fd0-en (Accessed on 23 August 2016).

Pacini GC, Colucci D, Baudron F, Righi E, Corbeels M, Tittonell P, Stefanini, FM. 2014. Combining multi-dimensional scaling and cluster analysis to describe the diversity of rural households. *Experimental Agriculture* 50:376–397. doi:10.1017/S0014479713000495

Paul BK, Frelat R, Herrero M, Notenbaert A, Birnholz C, Vanlauwe B, Kagobo D, van Wijk M. (nd). Potential impact of crop and livestock intensification policies on food availability and greenhouse gas emission intensities across Rwanda. *Agricultural Systems.* Conditionally accepted.

Ritzema RS, Frelat R, Douxchamps S, Silvestri S, Rufino MC, Herrero M, Giller KE, Lopez-Ridaura S, Teufel N, Paul B, van Wijk MT. (nd). A simple food availability analysis across smallholder farming systems from East and West Africa: Is production intensification likely to make farm households food-adequate? *Food Security.* Conditionally accepted.

Simpson EH. 1949. Measurement of Diversity. *Nature* 163:688.

World Agroforestry Centre. 2015. Initial results of established agroforestry trials in Northwest-Vietnam. Presentation. www.worldagroforestry.org

Zellner A. 1962. An efficient method of estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias. *Journal of the American Statistical Association* 57:348–368.

A bio-trap for home-based production of vegetables in Son La, Viet Nam. Photo credit: ICRAF/Pham Duc Thieng