

Integrated Systems Research for Sustainable Smallholder Agriculture in the Central Mekong

Achievements and challenges of implementing integrated systems research

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A review of efforts to integrate nutrition in systems research

Chapter 4

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1. Introduction

Some of the grand challenges facing the world today include unsustainable food systems, the double burden of malnutrition (undernutrition and obesity) and environmental degradation. In addition, population growth, climate change and changing consumer preferences add pressure to our current food production systems. Current agricultural practices are moving toward intensified monocultures, which increase yields in the short term, but can limit agrobiodiversity. The result is that diets are often dominated by a single staple crop (most notably rice, maize or wheat) and lack diversity in other nutrient-rich foods such as vegetables, legumes, fruit or animal-source foods (fish, milk, eggs and meat).

These grand challenges and the drivers that influence them are interconnected and require integrated system approaches to understand how people interact with their environment to achieve food and nutrition security. The CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics) sought to address nutrition and dietary issues within a broader integrated research for development (R4D) approach. It is, however, recognized that a systems project is more complex than projects focusing on specific commodities, and requires more time for partnerships and common goals, methods and analyses to evolve. This is particularly true for nutrition which is a relatively new concept to many. Benefits, including

health, from improved nutrition are influenced by several factors beyond agricultural interventions and thus require collaborations with partners beyond the agricultural sector including in education, health and anthropology.

This chapter will review research projects and evaluate tools and approaches used to address nutrition in Humidtropics in the Central Mekong Action Area between 2013 and 2016. A more detailed look into four of these projects that analyse diet or nutrition data will be presented from four case studies. The chapter will then review the efforts of multistakeholder platforms in the Central Mekong Action Area to include nutrition and will conclude with recommendations based on lessons learned to better integrate nutrition into systems research to enable positive outcomes in diets and nutrition.

1.1 Review of Humidtropics Central Mekong project portfolio and scope on nutrition

A review of Humidtropics partner research protocols, tools, activities, reports and other documents from the Central Mekong Action Area was performed with the focus on nutrition. Follow-up interviews clarified whether nutrition methods, approaches and indicators were used, and if not, to identify why. Results were circulated to researchers for review (see table online here [<http://tinyurl.com/o2lj3k2>]). It is important to note that some gaps remain, as collated information depended on the researchers' responses and any associated documentation.

The review identified seven main projects implemented in the Central Mekong 2013 to 2016 (Table 4.1). Of these seven projects, three were in Viet Nam (two in the Northwest and the other in the Central Highlands), one was in Thailand, two were in China (one in Xishuangbanna and the other in Honghe, both in Yunnan Province) and one was conducted across two countries (Viet Nam and Laos). Although each project had its own objectives, they had one commonality: to improve the livelihoods of poor rural populations.

Table 4.1 Seven main work projects conducted under Humidtropics in the Central Mekong Action Area and their respective research centres

Main work projects in the Central Mekong Action Area	Institutions involved
1. Research for development of appropriate technical innovations in integrated farming systems for scaling up in Northwest Viet Nam	<ul style="list-style-type: none"> • Soils and Fertilizers Research Institute (SFRI), • Viet Nam Academy of Agricultural Science (VAAS) • Fruit and Vegetable Research Institute (FAVRI), VAAS • Northern Mountainous Agriculture and Forestry Institute (NOMAFSI), VAAS • Centre for Agrarian Systems Research and Development (CASRAD) • The World Agroforestry Centre (ICRAF) • International Livestock Research Institute (ILRI) • International Water Management Institute (IWMI) • The World Vegetable Center (WorldVeg)
2. Improving dietary diversity and diet quality through systems innovation: A pilot study in Viet Nam	<ul style="list-style-type: none"> • Bioversity International • Center for Agricultural Research and Ecological Studies (CARES) • HealthBridge Foundation Canada • National Institute of Nutrition (NIN), Viet Nam • Wageningen University and Research (WUR)
3. Assessment of different opportunities for agricultural diversification in Nan Province, Thailand	<ul style="list-style-type: none"> • Chiang Mai University • Mae Fah Luang University • WorldVeg
4. Enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms in the Central Highlands of Viet Nam	<ul style="list-style-type: none"> • Western Highlands Agriculture & Forestry Science Institute (WASI) • International Center for Tropical Agriculture (CIAT) • ILRI • IWMI
5. Attraction in action: Using pheromones and other safe and sustainable management strategies to reduce losses from insect pests and plant diseases on vegetable legumes and leafy brassicas in Southeast Asia	<ul style="list-style-type: none"> • WorldVeg • FAVRI
6. Appraisal and innovations on diversified and sustainable rubber ('green rubber') in Xishuangbanna, China	<ul style="list-style-type: none"> • ICRAF • WUR
7. Activities for Humidtropics in Honghe	<ul style="list-style-type: none"> • Bioversity International • International Potato Center (CIP)

To assess the extent to which nutrition research was implemented in the Central Mekong, we examined both overarching work projects and separate individual activities conducted by the research institutions to see whether nutrition was included as an outcome indicator. Only three projects directly stated a primary or secondary project objective of improving nutrition (1, 2 and 4). Nutrition matters because it provides a foundation for human development, and without adequate nutrition individuals are unable to achieve their full potential (Frankenberger and McCaston 1998). The 'Sustainable Livelihoods Approach' acknowledges the integral role of nutrition, particularly through building human capital (Slater and Yeudall 2015), and is one of three CGIAR strategic goals (CGIAR 2015); however, it was not integrated into all projects.

Each project could be broken down into multiple work packages of activities that often would be running in parallel. The seven projects were further divided into 14 separate activities, of which five explicitly included improved nutrition in their objectives (these activities were in projects 1, 2 and 3). These activities often included a pathway leading to increased availability of nutritious foods, often combined with nutrition education. Education components focused on improving nutrition knowledge and attitudes to encourage behaviour change toward diversification of diets and home garden production, and urged that income generated from improved yields be used to buy nutritious foods. One activity also included participatory nutrition cooking classes, using improved recipes to motivate the production and consumption of crops or foods targeted by the project. Only one activity's research protocol included a clear description of a specific nutrition impact pathway.

Although most activities did not include improvements in nutrition as an outcome, two activities included the assessment of nutrition indicators in literature reviews or baseline assessments. One activity included a nutrition education training session without including a specific nutrition outcome objective in project or activity plans. Project 4 included nutrition in the objectives, however did not integrate nutrition-sensitive activities into its operation.

Nine out of the 14 activities listed in Table 4.2 included neither nutrition outcomes in research protocols or objectives, nor collected data on nutrition indicators. These activities' objectives focused on other agricultural technical innovations such as soil, water and pest management, and integrated farming systems to improve yields and improve market linkages. Possible nutrition impact pathways were always identifiable by the review team even when not made explicit in the original work plan or proposals. Primarily, the identified pathway to improve nutrition was through improved productivity of key crops which could then be consumed directly or sold. If sold, the projects could have included nutrition education components to encourage farmers to use income to purchase nutritious foods.

It is not realistic or always feasible that all projects or activities will have the technical or financial resources to include nutrition outcomes. However, it is important that at a minimum, a 'do-no-harm' approach is applied to ensure research activities or interventions do not negatively impact nutrition. Such an approach includes basic nutrition indicators in base- and endline assessments, helping to build an evidence base for further research.

Table 4.2 Summary of activities in the Central Mekong Action Area and their scope on nutrition

Note: A table with the full detail can be viewed online here [<http://tinyurl.com/o2lj3k2>].

Project and title	Activities	Possible nutrition impact pathways ¹	Nutrition objective or scope of project	Nutrition method or approach
1. Research for development of appropriate technical innovations in integrated farming systems for scaling up (Viet Nam)	<ul style="list-style-type: none"> • Re-establish upland farming systems • Assess techniques for nutrient management and safe vegetable production with integrating farmland systems • Evaluate soil erosion to improve quality • Establish fodder grass for livestock development (CASRAD, SFRI) 	<ul style="list-style-type: none"> • Improved diet via increased availability of nutritious foods, or by improved quality/nutrient composition of foods produced • Encouragement to use increased income from sale of crops to buy nutritious foods, if combined with nutrition education sessions • Improved food safety 	No	Not included
	<ul style="list-style-type: none"> • Improve water access for vegetable gardening (IWMI) 	<ul style="list-style-type: none"> • Improved diet if improved water management techniques improved yields 	No	Not included
	<ul style="list-style-type: none"> • Re-establish upland farming systems • Monitor impacts of intercropping and grass strips on soil erosion • Understand the social processes of agricultural innovation to improve the livelihoods of ethnic minority groups, especially women (ICRAF, NOMAFSI) 	<ul style="list-style-type: none"> • Improved diet via improved yield of specific foods, or by improved quality/nutrient composition of foods produced • Encouragement to use increased income from sale of crops to buy nutritious foods, if combined with nutrition education sessions 	No	Not included
	<ul style="list-style-type: none"> • Complete consultation on livestock, households and value chains, baseline survey, situational analysis (ILRI) 	<ul style="list-style-type: none"> • Results used to identify priority areas where nutrition needed to be addressed to guide project planning from CGIAR centres/Hu-midtropics partners 	<ul style="list-style-type: none"> • Increasing food security • Improving nutrition and health 	<ul style="list-style-type: none"> • Literature review • Qualitative 24-hour diet recall

¹ Not all projects identified nutrition impact pathways or achieved impacts on nutrition. This column provides examples of possible impact pathways that could have brought about positive changes in nutrition within the project scope.

Project and title	Activities	Possible nutrition impact pathways ¹	Nutrition objective or scope of project	Nutrition method or approach
	<ul style="list-style-type: none"> Analyse value chain and establish market linkages for vegetable products Promote safe vegetable production through integrated crop management trials Identify suitable technologies for increasing commercial vegetable productivity in Son La Develop home garden packages and increase nutrient supplies to the soil and availability from home garden produce (WorldVeg, FAVRI, NIN) 	<ul style="list-style-type: none"> Increased availability of nutritious foods for direct consumption to improve diet quality Encouragement to use increased income from sale of crops to buy nutritious foods, if combined with nutrition education sessions Improved food safety 	<ul style="list-style-type: none"> Nutrition not an objective but was included in the project scope 	<ul style="list-style-type: none"> Literature review Anthropometric measurements Knowledge attitude and practice survey Quantitative 24-hour diet recall
	<ul style="list-style-type: none"> Assess how interventions and species promoted in the home gardens (part of a multistakeholder platform collaborative research project in the first phase) can be adapted or improved to better increase dietary diversity Provide input to improve home garden production be more relevant to identified dietary needs Use results to outline some enabling/inhibiting factors along impact pathway from production to household consumption of selected key species (WUR, Bioversity International) Note: This was planned but never funded 	<ul style="list-style-type: none"> Home garden interventions designed to target local community dietary gaps increased the availability of nutritious foods for direct consumption Production barriers overcome to increase availability of nutritious foods for consumption 	<ul style="list-style-type: none"> Improvement in dietary quality and diversity Increased consumption of particular species for diet optimization 	<ul style="list-style-type: none"> Farm DESIGN Identify barriers and opportunities for improved consumption of nutritious food

Project and title	Activities	Possible nutrition impact pathways ¹	Nutrition objective or scope of project	Nutrition method or approach
<p>2. Improving dietary diversity and diet quality through systems innovation: A pilot study (Viet Nam)</p>	<ul style="list-style-type: none"> • Test 'best-bet' interventions and provide capacity building support options to improve dietary diversity and answer the following questions: • How does locally available biodiversity correspond to dietary diversity and nutrition? • How does a household's production diversity and availability and access to market and wild diversity influence dietary diversity and nutrition? • What nutrition knowledge, attitudes and practices exist and how do they affect dietary and production diversity? • What key household and landscape system elements can be leveraged to improve dietary diversity and quality? (Bioversity International, CARES, HealthBridge, NIN, WUR) 	<ul style="list-style-type: none"> • Increased availability of nutritious foods for direct consumption that target local dietary gaps to improve diet quality • Nutrition education sessions to encourage production and purchasing of nutritious foods 	<ul style="list-style-type: none"> • Improvement in dietary diversity • Improvement of consumption of particular species for diet optimization 	<ul style="list-style-type: none"> • Quantitative 24-hour dietary recalls • Nutrition Knowledge, Attitudes and Practices (KAP) survey • Key informant interviews • Focus group discussions • Anthropometric measurements • Gender (decision making power)
<p>3. Assessment of different opportunities for agricultural diversification in Nan (Thailand)</p>	<ul style="list-style-type: none"> • Conduct workshops on improved management of home gardens, including seedling preparation and integrated pest management • Conduct experiments on mushroom production • Complete research on fruit tree orchard established • Complete comparative study on different inter-crops (Chiang Mai University, Mae Fah Luang University, WorldVeg) 	<ul style="list-style-type: none"> • Home garden interventions could have made more nutritious foods available for direct consumption • Encouragement to use increased income from improved yield to buy nutritious foods, combined with nutrition education sessions. • Improved food safety 	<ul style="list-style-type: none"> • Nutrition not an objective but was included in the project scope 	<ul style="list-style-type: none"> • Literature review

Project and title	Activities	Possible nutrition impact pathways ¹	Nutrition objective or scope of project	Nutrition method or approach
4. Enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms (Viet Nam)	<ul style="list-style-type: none"> • Provide scientific backstopping and research on soils • Assess household vulnerability • Provide extension for forages • Conduct whole-farming modelling climate scenarios (CIAT, WASI, IWMI) 		No	Not included
	<ul style="list-style-type: none"> • Conduct a value chain assessment • Assess the viability of beef cattle (ILRI) 	<ul style="list-style-type: none"> • A component on nutrition in the value chains assessment could have been included to identify commercial opportunities to improve nutrition (for example via improved processing to increase nutrient content or food safety) 	No	Not included
	<ul style="list-style-type: none"> • Implement home garden trials (WorldVeg) 	<ul style="list-style-type: none"> • Improved nutrition through training courses, which included nutrition education • Increased yield and production diversity could improve diet quality 	Yes	<ul style="list-style-type: none"> • Quantitative 24-hour dietary recalls • KAP survey • Key informant interviews • Focus group discussions

Project and title	Activities	Possible nutrition impact pathways ¹	Nutrition objective or scope of project	Nutrition method or approach
5. Using pheromones and other safe and sustainable management strategies to reduce losses from insect pests and plant diseases on vegetable legumes and leafy brassicas (Cambodia, Laos and Viet Nam)	<ul style="list-style-type: none"> Quantify baseline indicators for evaluating project outcomes in 35 years including: Pesticide use, crop yield losses from pests, and gross margin (as an indicator of the economic reward for farmers to follow integrated pest management) Farmers' knowledge, attitudes, and practices in integrated pest management (WorldVeg) 	<ul style="list-style-type: none"> Increased availability of nutritious foods for direct consumption to improve diet Increased availability of nutritious foods for sale, combined with nutrition education sessions, to encourage income generated to be used to buy nutritious foods Improvements in food safety 	No	Not included
6. Appraisal and innovations on diversified and sustainable rubber ('green rubber') in Xishuangbanna (China)	<ul style="list-style-type: none"> Scale up green rubber (ICRAF, WUR) 	<ul style="list-style-type: none"> Nutrition education sessions could have been used to encourage income generated from improved yields to be used to buy nutritious foods 	No	Not included
7. Activities for Humid-tropics in Honghe (China)	<ul style="list-style-type: none"> Conduct a situational analysis Assess the status of biodiversity Assess the status of nutrition, dietary diversity and food systems Assess and identify the potential innovation platform on integrated systems (Bioversity International, CIP) 	<ul style="list-style-type: none"> Results identified areas where nutrition needed to be addressed to guide project planning from CGIAR centres/Humid-tropics partners 	<ul style="list-style-type: none"> Assessing dietary diversity norms 	<ul style="list-style-type: none"> 4-cell focus group method Focus group discussions

2. Approaches and indicators

The projects and activities that did include nutrition within their scope used a wide variety of approaches and indicators (projects 1, 2, 3 and 4), including diet quality and food security indicators, that were operationalised across different scales (community, household, individual) and different target groups (women, young children, older children, households) (Table 4.3). Only a few internationally validated nutrition indicators were used, including anthropometric measurements (wasting, stunting, underweight, BMI), dietary diversity, food consumption score and breastfeeding (De Onis and Habicht 1996, WHO 2007, WFP 2015, FAO 2016). Other indicators have not been validated for their sensitivity to nutrition and diet quality outcomes, and it is not understood to what extent they accurately measure nutrition elements. In many cases it was found that indicators of household food security (access) such as a Household Dietary Diversity Score (HDDS) have inappropriately been used as a proxy for diet quality or nutrition. It was also evident that some indicators were applied at a different scale than what has been validated (for example, application of the Food Consumption Score at the individual level, rather than the validated household level). This is a common error often evident in agriculture research projects that attempt to include nutrition, however it is important to note that validating these indicators is within the scope of household food security (access) (Vellema et al 2016). Each activity tended to use unique indicators, and thus indicator data could not be easily compared across Central Mekong Action Area activities. Only a few indicators (anthropometric and dietary diversity) were used by two or three activities in the Humidtropics research portfolio. Furthermore, only one activity, intending to capture gender empowerment variables related to nutrition, included nutrition-sensitive gender indicators.

2.1 Data collection methods

Different data collection methods were used to collect an array of nutrition indicators including surveys, anthropometric measurements, focus group discussions and other rapid appraisal methods, key informant discussions and literature reviews. The surveys included household or individually administered surveys to capture qualitative or quantitative diet recalls over different time frames (24 hours or seven days), annual household consumption of produced foods, nutrition knowledge, attitudes and practices and household food production. Anthropometric measurements were collected either directly by the research teams or from community health records. Two activities used quantitative diet recalls with similar methodologies, and one used a qualitative 24-hour recall. Only one project used a representative sample sufficient to capture dietary changes.

Only three of the 14 activities documented across the Central Mekong project portfolio included testing innovations that specifically targeted improving nutrition. These focused on innovations around home gardens and nutrition education. Unfortunately, at the time of writing, these activities had not completed endline surveys or innovation testing, and no data was available to assess the impact or effectiveness of these innovations.

Table 4.3 Summary of nutrition indicators used in Central Mekong Action Area research activities

Indicator level	Indicators to capture nutrition in Central Mekong projects*
Children aged 12-24 months	<ul style="list-style-type: none"> • Inadequate micronutrient intake • Proportion of children meeting minimal dietary diversity requirements • Ratio of animal protein consumption • Anthropometrics (wasting, underweight, stunting)
Children aged above 24 months	<ul style="list-style-type: none"> • Caloric consumption per day • Ratio of animal protein to total protein consumption, iron and vitamin A needs • Anthropometric measurements (wasting, underweight, stunting) • Ratio of animal protein consumption
Children aged 6-14 years	<ul style="list-style-type: none"> • Anthropometrics (underweight and stunting)
Women of reproductive age (15-49 years)	<ul style="list-style-type: none"> • Early initiation of breast feeding • Continued breastfeeding at two years • Breastfeeding or complementary feeding practices • Nutrition knowledge and attitudes • Daily estimated energy requirements reached • Chronic energy deficiency (BMI) • Minimum dietary diversity • Individual dietary diversity score • Food consumption score • Relative frequency of foods consumed • Proportion of energy from proteins, carbohydrates and lipids • Inadequate micronutrient intakes • Mean daily intake of key macro- and micronutrients • Average number of meals and snacks • Mean quantity of key species from key food groups consumed
Individual	<ul style="list-style-type: none"> • Trees used for food • Supply sufficiency • Self-sufficiency of calories and protein production • Monthly average per capita consumption of key commodities • Consumption of vegetables (in grams) per day
Household	<ul style="list-style-type: none"> • Caloric consumption per day • Diet diversity score • Agricultural products used for household consumption • Household food insecurity access scale • Gender (decision-making power) • Food consumption score
Community	<ul style="list-style-type: none"> • Number of households and frequency of foods consumed • Taste preferences of men, women and young children for local food

* Not all indicators applied are validated for nutrition or diet quality outcomes. Often household food security indicators were inappropriately used (e.g. household food insecurity access scale, Household Diet Diversity Score)

3. Case studies

Four case studies are presented to illustrate how projects and activities used different methods to approach nutrition in systems research.

3.1 Case study 1: Piloting a systems approach to improving nutrition with Thai minority communities in Mai Son district, Son La Province, Viet Nam, using a local food system approach to bridge dietary gaps

This case study is derived from project 2 (table 4.2): Improving dietary diversity and diet quality through systems innovation: A pilot study in Viet Nam.

Background

The study was designed to identify the current status of dietary diversity and nutrient intake among women of reproductive age (15-49 years) and children aged between 12-23 months, and to determine if there is a link to locally available biodiversity in selected Thai villages in Mai Son District in Northwest Viet Nam. In Mai Son, five ethnic groups represent approximately 80 percent of the ethnic population. The study's pilot phase focused on one minority group, as each minority ethnic group has unique farming and food cultures. The research was intended to demonstrate that engaging households in a full community-based participatory research cycle to diversify production through a systems perspective and improve nutritional knowledge can improve dietary diversity and quality for women of reproductive age and young children. Children in the 12-23 months age bracket were selected as they are within the critical 1000-day period (WHO 2013), able to eat whole foods and in many cases the same foods as adults. The cycle of participatory research ensures that the results obtained during the research project are derived through the community and the benefits are returned directly to the community for direct application to achieve the desired outcomes.

The original study design centred on a repeated cross-sectional study, with the baseline conducted in 2014 and an endline planned in 2017 to assess the impact of a nutrition systems intervention during the study period. Unfortunately, due to the announcement that Humidtropics as an independent CGIAR Research Program would finish at the end of 2016, the research had to be redesigned, limiting the intervention to one year with an endline assessment to be conducted in November 2016. At the time of writing, the endline assessment had not yet been done and as such, the results presented are from the baseline study, together with an explanation of how these results were used to design a systems intervention to improve nutrition.

The case study objective is to provide examples of participatory approaches available to identify local dietary gaps, and identify food systems solutions designed to improve multiple systems dimensions.

Methods

The null hypothesis to be tested was: dietary diversity (as measured by the diet diversity score) of women of reproductive age and young children (12-23 months) is not improved by improving availability and access to more diverse products and nutritional knowledge.

The sample communes were randomly selected using criteria that included population size (at least 50 percent of households were from a Thai ethnic group), and rural livelihoods (agriculture was the main household income source). Four communes (Co Noi, Muong Chanh, Chieng Chan and Chieng Luong) were selected from 15 eligible communes in Mai Son District, Son La. The key target population was women of reproductive age and children aged 12-23 months.

A total of 400 households were sampled for a baseline. The sample size was estimated based on the prevalence of children aged 6-23 months who consumed foodstuffs from four or more food groups in the 24 hours before surveying in Son La Province in 2012 (Gibson and Ferguson 2008, Gorstein et al 2007, NIN 2012).

Surveys collected dietary data from women using quantitative 24-hour dietary recalls (with a repeat on a non-consecutive day for a subsample of 25 percent of selected households), nutrition knowledge, attitudes and practices, and household food insecurity. To capture seasonal variation in the diet and in household food security, dietary intake assessments and household food security assessments were conducted in both the wet and dry seasons in 2014 (August/September and November/December, respectively). Anthropometric measurements were taken for women and children in the dry season only.

In addition to the dietary data, a comprehensive household production survey was conducted with the household head. Inventories of all species produced on-farm or hunted or collected in the wild were taken, per-plot type (home garden, sloped, paddy, forest) and per growing season, to develop an in-depth view of the availability of locally produced foods. In addition, a market diversity survey was conducted in the main market of each commune.

Results

Nutrition knowledge

Women responded that the causes of malnutrition were insufficient quantity and quality of food; complementary food² with a consistency that was too thick (making it difficult to swallow) and that did not contain sufficient nutrients; illness; and, poor childcare (64 percent, 17 percent, 11 percent and five percent respectively; three percent of responses were categorized as 'other'). More than 18 percent of women stated that they did not know why malnutrition occurred. When asked to state different methods to prevent child malnutrition, just under 75 percent of women were able to provide a correct suggestion including giving the child more food, increasing feeding frequency, and providing more diverse foods (59 percent, 23 percent and 18 percent respectively). A quarter of the women responded that they did not know how to prevent malnutrition.

² A complementary food is food or drink introduced to a child from a recommended six months old to supplement breastfeeding. At this age, breastfeeding is no longer sufficient on its own to provide all the nutrients required.

Knowledge of dietary diversity in feeding infants and young children

Knowledge about dietary diversity was limited. A full 58 percent of women had never seen the food pyramid, only 33 percent had heard of 'colouring the porridge plate'³, and only 1.4 percent (six households) could name the four food groups associated with a 'balanced meal' (starches, protein, fat and vegetables). While 85 percent of women believed a diversified diet was important, 36 percent reported it was difficult to provide one for their children. The main barriers were reported as a lack of locally available foods (51 percent), lack of money to buy different foods (37 percent), lack of time to prepare the foods (28 percent) and lack of capacity or skill on how to prepare some foods (11 percent). While 95 percent of women believed providing several meals to children each day was important, 19 percent said it was difficult to do so.

Nutrition status

The rates of stunting and underweight children in the Thai community were high at 20 percent and 14 percent, respectively. Child wasting was one percent. The rates of underweight, overweight and obesity in mothers were eight percent, 16 percent and seven percent, respectively, using BMI as the indicator (≤ 18.5 , 23-25 and ≥ 25).

Women and children's dietary intake and gaps

In terms of individual dietary diversity, children consumed 3.7 out of seven food groups, compared to the minimum of at least four food groups as recommended by WHO (2013). Women consumed 4.8 out of 10 recommended food groups. The percentage of women and children reaching minimum dietary diversity (MDD) (FAO 2016) was 59 percent and 58 percent, respectively. The percentage of women who reached MDD (consumed a food from five or more food groups) during the wet and dry seasons was almost the same at 58 percent and 59 percent, respectively. For children, 57 percent and 58 percent reached MDD (consumed four food groups or more) in the wet and dry seasons, respectively. The least consumed food groups over both seasons were legumes, nuts and seeds, dark green leafy vegetables and vitamin A-rich fruits (Table 4.4).

³ 'Colouring the porridge plate' is a concept promoted by the Viet Nam National Institute of Nutrition (NIN 2013).

Table 4.4 Percent of young children and women by food group consumed, separated by season

Indicators	Wet season (August-September)		Dry season (November-December)	
	% consumed food groups		% consumed food groups	
	Children (N=350)	Women (N=350)	Children (N=411)	Women (N=411)
Starch staples	99	100	100	100
Legumes*	16	17	16	17
Nuts and seeds	2	3	2	3
Dairy product	11	0	6	1
Flesh foods	81	89	83	88
Egg	37	25	43	28
Dark green leafy vegetables	12	26	11	31
Vitamin A rich vegetables	37	74	31	70
Fruits rich in vitamin A	5	3	3	3
Other vegetables	41	85	42	85
Other fruits	30	35	32	28
Fats & oil	14	30	15	32
Sweets	81	12	75	10

*High-nutrition target food groups in red

Baseline results to identify system solutions to nutrition

A participatory consultation process with farmers was conducted to identify a set of underutilized, locally available crops from the under-consumed food groups (vitamin A-rich vegetables and fruit; dark green leafy vegetables; and, legumes, nuts and seeds) to act as the cornerstone of the interventions designed to improve diversity in the diets and landscape. The results from the baseline product survey produced a shortlist of locally available foods per food group that could be used complementarily at different times of the year to ensure stable supplies of that food group. The shortlist included foods favoured by both men and women, as results suggested that men's food preferences influenced what women grew in the home garden.

The farmers were asked to list the positive and negative aspects associated with each of these species (per food group) in terms of production (availability and access of inputs, knowledge of management best practices, seasonal availability, and pests and diseases) and consumption (taste, ease of preparation). Foods from each food group were then ranked comparatively using the pairwise ranking method to identify the top foods from each group. Village nutrition clubs were used to connect both the nutrition education and agricultural capacity components of the intervention. These clubs, facilitated by village health workers, met once every two months. They consisted of women with young children from each village who volunteered to learn more about how to diversify their home garden and their diets. Nutrition education material was developed in consultation with the National Institute of Nutrition and other national partners to ensure that fundamental nutrition messaging was in line with national priorities, and to encourage a link to nutrition-sensitive agriculture that was relevant to the dietary gaps and local biodiversity in the landscape.

Discussion and conclusion

Measuring food intake from quantitative 24-hour food recalls can be challenging. To obtain the best quality data, several techniques were applied, including developing simple guidelines for a multipass 24-hour recall adapted from several authors (Gibson and Ferguson 2008, Arimond et al 2010, FAO 2011) and repeating the data collection from a subsample of households on a non-consecutive day. Trained enumerators asked open-ended questions, and gathered quantitative data using a combination of digital scales, graduated measuring jars, modelling clay and shredded paper as measuring tools to estimate food intake amounts. Surveys took an average of 60 minutes (combined, including the time for the women to report on both their own and their child's diet).

To address language barriers that can affect data quality, Thai enumerators were recruited from a local health school in Son La. In some cases, the name of a species or a variety of food reported during the diet intake survey was not known, beyond the common name used in a village (names could change from village to village). Where possible, samples were provided to the local agriculture partners to identify, combined with cross-checks with local agriculture or health staff to identify the common name, sometimes based on their description or using pictures for confirmation if a sample was not available. Some foods from the wild were too difficult to identify and could not be included in the analysis.

Data analysis required a database and an updated food composition table. The software for data analysis developed by the National Institute of Nutrition based on Microsoft Access was not user-friendly; however, this software has been adapted to fit the quantitative recall method described above. Further efforts should include making the database more user-friendly, so it can be used by a broader audience.

In Son La, the commune-level government health centres are responsible for monitoring the nutrition status of children under five years old using periodic anthropometric measurement. No system currently exists to monitor dietary diversity. The local food system approach will be evaluated at the end of the intervention trial for lessons learned, so that they can be used with other minority groups in Son La Province (more than 50 groups), each having a different context and dietary diversity status than the Thai group.

The participatory approach tested in Mai Son was able to successfully identify local dietary gaps, and work with communities to design and operationalise local solutions to bridge these gaps with innovative approaches using locally available agrobiodiversity. The innovations are expected to diversify local home garden production and improve the diet quality and diversity of women and children who participated in the diversity club sessions. Local nutrition and healthy diet capacity and knowledge was also developed by female and male farmers who participated in the diversity clubs, but also of the health and agriculture extension workers who helped to implement and facilitate the clubs.

3.2 Case study 2: Links between dietary diversity and other farm household characteristics in the Central Highlands of Viet Nam

This case study is derived from project 4 (table 4.2): Enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms in the Central Highlands of Viet Nam.

Background

The Central Highlands of Viet Nam are home to some of the poorest and most marginalized people in the country, including a significant population of ethnic minorities. As such, it was one of the focus areas for the Humidtropics activities in the Central Mekong.

Humidtropics (in cooperation with the German Federal Ministry for Economic Cooperation and Development (BMZ) and the CGIAR Research Program on Livestock and Fish), conducted household-level research in the Central Highlands to begin to understand various aspects of household welfare status and related drivers, and to inform subsequent interventions and development strategies. This research focused on the use of a suite of household indicators that are comprehensive in scope and supported by data that can be easily and rapidly collected.

Within this context, the case study objective is specifically to develop some initial understanding of correlations between dietary diversity and other household indicators, based on primary household survey data. Such understanding is useful in discerning the drivers of household dietary diversity, as well as the direct and indirect effects of farm level interventions on household dietary diversity.

Methods

A survey of 310 households was conducted in December 2015 in two locations in the Central Highlands of Viet Nam: 1) Ea Tyh Commune, Ea Kar District, Dak Lak Province; and, 2) Dak Dro Commune, Krong No District, Dak Nong Province. Survey respondents were randomly selected, and were comprised of a mixture of Kinh, the majority ethnic group in Viet Nam, and other ethnic minorities.

The survey was implemented using the Rural Household Multi-Indicator Survey (RHoMIS) tool, a digital survey and analysis platform designed to rapidly characterize farm households using a suite of 16 standardized indicators. These indicators range from poverty, food security and market orientation, to agricultural intensification, gender equity in the control of household resources and greenhouse gas (GHG) emissions. RHoMIS is implemented using an Android device (tablet or smartphone), and data is uploaded automatically to a cloud server. RHoMIS survey results are used to calculate values for each indicator on a per household basis. A full description of each indicator is not given here, but can be found in Hammond et al (2016). Of special interest is the Household Dietary Diversity Score (HDDS), which has been adapted to capture the frequency and seasonal differences of household access to diverse foods, and can be used as a proxy indicator for dietary diversity (Hammond et al 2016). Respondents were asked how often food from each of 12 food groups had

been consumed within the previous four weeks. Possible respondent choices were 'daily', 'weekly', 'monthly', or 'never'. HDDS results are on a scale of 0 to 12, where 12 equates to consumption of food from 12 food groups on at least a weekly basis.

Simple statistical analysis on household indicators is used to discern household welfare status, and links between household dietary diversity and other household characteristics. In addition, a regression analysis of HDDS as a function of the other indicators employed a stepwise simplification procedure to exclude non-significant parameters, producing a parsimonious first order linear regression model for HDDS.

Results

Results presented in Table 4.5 provide both an initial assessment of farm household welfare status and suggest links between dietary diversity and farm household characteristics. Indicators with the strongest correlation to HDDS across the full set of households (as suggested by both the Spearman Correlation Coefficient and regression parameters) are the negatively correlated Household Food Insecurity Access Scale (regression $p=3.8e10$) and the positively correlated Value of Farm Produce (regression $p=6.19e6$). Intensification and Food Availability also have high correlations to HDDS, though they were excluded from the linear regression model. Parameters with the weakest correlation to HDDS were Off-farm Income, Family Size, and Gender Equity. While most indicators trended monotonically across HDDS groupings, a few did not, e.g. Off-farm Income.

The RHoMIS tool, implemented by enumerators from the Western Highlands Agriculture and Forestry Institute (WASI), performed well in terms of rapidity of data collection and in the quality of data produced. Equally successful surveys using RHoMIS were subsequently conducted in Cambodia and Laos, also in the Development Triangle of the Humidtropics Central Mekong Action Area, enabling an opportunity to conduct a three-site analysis following this case study.

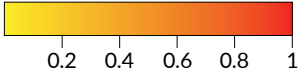
Discussion and conclusions

Dietary diversity in the Central Highlands is most strongly correlated to food security. As perceived food insecurity drops, dietary diversity predictably increases. High correlation with the Intensification indicator may suggest that sustainable intensification options may lead to improved dietary diversity. Surprisingly, Off-farm Income is not correlated with dietary diversity. Further exploration of the link between the Value of Farm Produce indicator and dietary diversity is needed, as this finding is not accompanied by a parallel and equally strong correlation with Market Orientation. Together, these results may indicate that dietary diversity is more closely tied to on-farm production than off-farm income in the Central Highlands.

These results suggest areas for further in-depth research that will be reported in subsequent peer-reviewed journal articles. One such area is to assess whether indicator values differentiate substantially by ethnicity, and if so, what the implications may be related to the degree of marginalization that these minorities may be experiencing.

Table 4.5 Farm household indicator values and correlations to Household Dietary Diversity Score (HDDS) from two locations in the Central Highlands region of Viet Nam (n = 310)

Indicator	Median Value	Corr Coeff to HDDS	Medians		
			Low-HDDS group	Mid-HDDS groups	High-HDDS group
Farm size (ha)	1.5	0.26***	1.0	1.2	1.9
Livestock ownership (Total Livestock Units [TLU])	0.7	0.24***	0.2	0.6	1.2
Family size (Adult Male Equivalent [MAE])	3.1	0.043	3.6	2.8	2.8
Crop diversity (number of crops grown)	2	0.16***	2	2	2
Intensification (kg N _{fert} -ha ⁻¹)	1500	0.36***	1000	1100	2000
Market orientation (0–1)	0.76	0.12***	0.59	0.75	0.79
Food availability (kcal-MAE ⁻¹ -day ⁻¹)	4.07e4	0.34***	2.01e4	3.60e4	5.84e4
Livestock contribution to food availability (kcal-MAE ⁻¹ -day ⁻¹)	0.014	0.11*	0.00014	0.014	0.017
Farm productivity (Mcal-ha ⁻¹ -yr ⁻¹)	2.56e7	0.20**	1.72e7	2.60e7	2.80e7
Household Food Insecurity Access Scale (HFIAS [0–27])	5	0.41***	9	7	3
Progress out of Poverty Index (PPI [0–100])	66	0.25***	45	66	70.5
Off-farm income (USD-yr ⁻¹)	327	0.048	318	371	254
Value of farm produce (USD-yr ⁻¹)	2570	0.36***	1410	2180	4320
Gender equity (0–1)	0.5	0.016	0.5	0.5	0.5
GHG emissions (kg CO ₂ eq-household ⁻¹ yr ⁻¹)	8300	0.30***	5010	6340	14100
GHG emissions intensity (kg CO ₂ eq-kcal ⁻¹)	0.26	0.054	0.36	0.23	0.27



Mean indicator values are presented for the full data set, and Spearman Correlation Coefficient values indicate the degree of correlation between each indicator and HDDS. Median indicator values are also reported for households falling within three groupings: those with HDDS values greater than 7, those with HDDS values from 5 to 7, and those with HDDS values less than 5. Heat map colouration, as indicated by the legend, reflects the relative value of those medians to the 90 percent quantile value for each indicator: dark red shading suggests that a median value is at or near the 90 percent quantile for that indicator, while yellow shading shows the value is among the minimum calculated indicator values. Indicator labels highlighted in yellow indicate highly-significant parameters in the HDDS regression model. Significance levels are denoted by * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$.

3.3 Case study 3: Application of theory of change to identify potential interventions contributing to improved diets and nutrition in Northwest Viet Nam

This case study is derived from project 1 (table 4.2): Research for development of appropriate technical innovations in integrated farming systems for scaling up.

Background

Northwest Viet Nam, one of Humidtropics' Action Sites in the Central Mekong, is an agrarian, mountainous region rich in ethnic diversity and natural resources. However, poverty and malnutrition remain prevalent due to geographical challenges and poor infrastructure limiting access to markets, resources and healthcare. Sustainable interventions in the agrifood system can directly improve local agricultural development, rural livelihoods and nutritional well-being. The complexity of the issues in Northwest Viet Nam's food system requires stakeholders from agriculture, marketing, nutrition and health, private and public sectors and local leaders to work together in finding feasible solutions.

Nutrition is incorporated in food systems research at the onset of project planning. A multistakeholder meeting was held to develop a food systems theory of change to achieve nutritional outcomes in Northwest Viet Nam. From the list of proposed priority interventions, a home garden pilot study was selected and designed to improve household food production and consumption. Results showed the home garden model can improve household nutrition through increased vegetable supply and consumption.

The case study objective was to demonstrate the sequence of incorporating nutrition in food systems research from planning to achieve tangible results.

Approaches

Multistakeholder meeting

Humidtropics' cross-cutting nutrition component, jointly led by Bioversity International, the World Vegetable Center (WorldVeg), and Wageningen University and Research (WUR), facilitated a multistakeholder platform to address nutrition outcomes of food systems research in Northwest Viet Nam. The first meeting, held in December 2014, introduced the theory of change as a tool for stakeholders to develop solutions in the current food system that incorporate and maximize nutritional benefits for consumers. The objectives of the meeting were to:

- Visualize potential nutrition pathways of change for Humidtropics in Northwest Viet Nam.
- Identify assumptions leading to successful results of the proposed theory of change.
- Identify possible interventions resulting in improved nutrition outcomes.
- Facilitate a networking and communication platform among stakeholders to improve diets and nutrition in Northwest Viet Nam through systems research.

Twenty-eight regional, national and international agriculture, nutrition, marketing and economics experts from the public and private sector, NGOs and government institutions participated in the stakeholder meeting.

Developing a theory of change and identifying nutrition interventions for food systems research

Nutrition objectives were clearly defined in the stakeholder meeting. The stakeholders agreed on the long-term outcomes as improving rural livelihoods and overall household nutrition. To address different food system components, the stakeholders were divided into three groups: Production, Market, and Consumption. Backward mapping was applied to create a pathway of change by determining preconditions for achieving long-term outcomes. Underlying assumptions for each group's pathway of change were discussed to test the feasibility of the theory. Lastly, each group proposed two to three priority interventions. Throughout the meeting, ideas were exchanged and discussions provided feedback to the theory of change.

The proposed interventions were:

Production: 1) enhance crop productivity; 2) implement integrated pest management; and, 3) diversify production systems.

Market: 1) establish information sharing systems for producers, market actors and consumers; 2) create local markets; and, 3) establish wholesale selling points.

Consumer: 1) nutrition education and information dissemination; 2) training on income generating skills; and, 3) create off-farm income opportunities.

Based on a priority setting exercise, home gardens were selected as the intervention deemed most appropriate.

Selected intervention: home garden

A multi-approach home garden intervention package was designed as a pilot study following the discussions and proposed interventions of the stakeholder meeting. The home garden package consisted of three main interventions: nutrition-focused home garden training, seed distribution, and monitoring and evaluation. Ten intervention and 10 control households (n=20) participated in the study, with households equally shared among two ethnic villages (Rung Thong in Muong Bon and Xum 1 in Chieng Mung) consisting of Hmong and Thai minorities in Son La Province, Northwest Viet Nam. Intervention households received the home garden package while control households only had monitoring and evaluation. Both groups participated in data self-reporting on their home garden production and situation. At the end of the study, control households were offered home garden training and received vegetable seed kits.

The main intervention was the nutrition-integrated home garden training. Training materials were developed by WorldVeg in partnership with the Fruit and Vegetable Research Institute (FAVRI) and the National Institute of Nutrition (NIN) in Viet Nam. Nutrition education was incorporated in home garden practices and materials were produced and taught in the local language. Training was done at two levels: training of home garden trainers, and training of home garden participants. The training modules were designed to include both theory and

hands-on interactive activities to enhance the learning experience, knowledge retention, and practical application. Topics included nutrition principles; feeding the family; planning and growing a nutritious garden; and, post-harvest food preservation and utilization. An important aspect of the home garden training was designing a nutritious garden that includes fruits and vegetables that maximize diet diversity and nutritional benefits, is suited to family preferences, and ensures a year-round food supply. Participants consulted training experts to create a suitable layout for their household. In the training, they also engaged in gardening and nutrition activities from preparing the soil and drainage to sowing, recording growth, seed conservation, food preservation and cooking nutritious meals. At the end of the training, participants completed a training evaluation form to ensure concepts were understood, and that participants were ready to apply the learning and receive feedback on the quality of the training.

Home garden seed kits were given to participants to help kickstart their gardens. The kits were customized for each household according to the vegetables chosen for their garden layout. WorldVeg partnered with FAVRI to prepare locally adapted seed kits from high yielding and nutritious varieties. Participants requested seeds for at least 20 different vegetables for their home gardens, and introduced new vegetables to their home gardens for the first time.

Participating households were monitored throughout the study. Surveys, interviews and participant self-reporting was used to collect data on crop varieties, planting and harvesting dates, weight of weekly harvest by crop, use of harvested produce, role of women and men in various home garden activities, and home garden constraints.

Results

The total vegetable harvest (in kg) from the home gardens was recorded during the 49-week study period from July 2014 to June 2015. The intervention households produced 5.8 times more vegetable supply than the control households ($P < 0.01$). When adjusted for area, the intervention group produced 1.7 times more vegetables per square metre than the non-intervention households ($P < 0.01$; Table 4.6).

On average, intervention households produced 226 kg of vegetables compared to 39 kg in control households during the study period. The daily vegetable and vitamin A supply per person was also significantly higher in the intervention group (122 g and 391 mcg RE, retinol equivalent of vitamin A supply) compared to the control group (22 g and 94 mcg RE; $P < 0.01$). In fact, intervention households had a daily supply of 5.5 times more vegetables and 4.2 times more vitamin A per person than control households. Among ethnic groups, the differences were apparent and significant for total vegetable supply per household and daily vegetable supply per person for Hmong and Thai households, and vitamin A supply for Thai households only. The home garden package improved the supply of vegetables and plant-based micronutrients in both ethnic groups. The most prominent improvement in home vegetable production was seen in the Hmong households who initially participated minimally in home gardening.

A high percentage of the vegetables grown in the home gardens were consumed by household members: 49 percent and 84 percent in intervention and control households, respectively. Figure 4.1 shows continuous harvests from July 2014 to June 2015 from the intervention group's gardens. On average, about 4.6 kg of vegetables were harvested per household per week which was equivalent to 164 g/person*day for a family with four members. For the control group, the traditional garden provided 28 g/person*day for a family with four members.

Intervention households also gave more produce as gifts compared to the control households. Increased gift-giving in the intervention group may be due to their abundant harvests. During the harvest period, vegetable supply was more than sufficient for the family's consumption and any additional vegetables were shared with neighbours. Gift-giving is a cultural universal and is known to increase social interactions with neighbours and mental well-being for the gift giver (Saad and Gill 2000, Joy 2001).

The intervention group showed higher plant diversity and grew 42 different vegetables compared to the control group of 24 vegetables. Increased home vegetable production has also contributed to increased supplies of many types of nutrients, including vitamin A, multiple types of vitamin B, vitamin C, iron, calcium, magnesium potassium, manganese, phosphorus and selenium, and other health promoting phytochemicals. The nutrient content of vegetables was retrieved from the Vietnamese Food Composition Table (FCT). For those vegetables not present in the Vietnamese FCT, values were instead derived from WorldVeg's Nutrient Database.

Discussion

The proposed interventions resulting from the theory of change approach successfully incorporated nutrition in food systems research at the program planning stage. Women and smallholder farmers could benefit from the interventions through improved household nutrition and reduced local poverty. Interventions encompassed diversification of production and potentially livelihoods through income-generating skills for women, improved natural resource management, increased production of nutrient-dense locally adapted food varieties, creation of retail and wholesale markets, and nutrition education for local households. Theory of change was a relatively new approach for the stakeholders. Multiple meetings were required to refine the pathway of change, ensure assumptions were feasible and define indicators to measure program achievements. The first meeting's priority was to introduce theory of change thinking into effective program planning and to facilitate communication between stakeholders of diverse disciplines and backgrounds. Multistakeholder program planning requires regular brainstorming and discussion sessions before taking practical steps to design relevant and suitable interventions for implementation. This is time-consuming and requires a considerable shift in the way people think about program and project planning.

The home garden model in this study shows promise for improving household food production, nutrient supply and diet diversification. The model is worth scaling up and could be modified for other malnourished rural regions to improve household nutrition. Sustainability of home gardens can be achieved with the support of agricultural, rural development and nutrition policies and programs. Research and development of high-yielding vegetable seed kits for different regions and subsidized seed prices would encourage the adoption of home gardens. Government and non-governmental initiatives to facilitate scaling should focus on providing financial assistance; building infrastructure to improve access to roads and water supply; training and technical assistance; and, sufficient monitoring, evaluation and adaptation of home garden programs. Stakeholders mentioned these challenges when discussing assumptions, yet they were not addressed in the priority interventions. Advocacy for food system and nutrition policies and a country action plan would further enable interventions to be adopted.

Table 4.6 Total vegetable supply for home garden intervention for Thai and Hmong communities compared to control groups from July 2014 to June 2015 in Northwest Viet Nam (n=20)[^]

Households (N=20)	Total vegetable supply per household (kg)			Daily vegetable supply per person (g)			Daily vitamin A supply per person (mcg RE)			
	I ^a	C ^b	P value ^c	I	C	P value	I	C	P value	
All ^d	mean	226	39	<0.001***	122	22	0.002**	391	94	0.003**
	SD	102	26		72	12		230	73	
Hmong	mean	179	29	0.004**	114	17	0.042*	408	110	0.052 ^{ns}
	SD	62	22		73	11		245	93	
Thai	mean	245	49	0.045*	97	26	0.011*	290	79	0.024*
	SD	115	28		30	12		110	51	
P value ^e	0.36 ^{ns}	0.23 ^{ns}		0.64 ^{ns}	0.24 ^{ns}		0.37 ^{ns}	0.54 ^{ns}		

*** Significant at < 0.001. ** Significant at < 0.01. * Significant at <0.05 c [^] Results are from project reports and do not necessarily reflect analysis conducted.

Four Thai households and five Hmong households were in the intervention group. Five Thai and five Hmong households were in the control group. I^a = intervention group, C^b = control group. All^d includes one additional Kinh household for the intervention group. P values^c from t-tests comparing the means between intervention and control groups. P values^e in this row are from t-tests comparing the means between Hmong and Thai households within a treatment group.

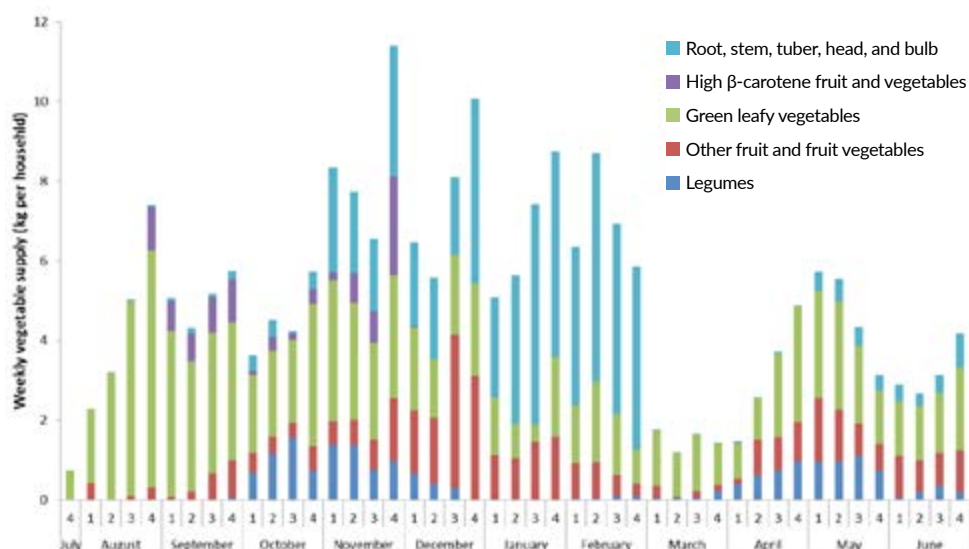


Figure 4.1 Average weekly harvest (kg) per household for home garden intervention for Thai and Hmong communities compared to control groups from July 2014 to June 2015 in Northwest Viet Nam (n=20)

3.4 Case study 4: Exploring the potential of agrobiodiversity to improve human nutrition, resource management, and farm productivity and profitability

This case study is derived from project 2 (table 4.2): Improving dietary diversity and diet quality through systems innovation: A pilot study in Viet Nam.

Background

The study aim was to evaluate alternative foods and crops identified as entry points based on their beneficial contribution to nutrition and health, and their impact at farm and landscape level. This analysis established the effect of adopting alternative foods and crops at the system level. Based on diagnosing the farm and household's current situation, it examined the potential joint effects on nutrition, environmental indicators, labour-leisure time, profitability and household budget. This provided insights into the desired foods that could be grown on the farm, collected from the landscape or purchased from the market. Such adoption and adaptation decisions could be informed by an ex-ante assessment of the impacts on the farm and household dynamics; the impact on the costs and revenues of cultivation versus purchasing costs; demands for labour for cultivation or collection; quantification of required inputs; cycles and losses of nutrients and the resulting soil fertility; and, other environmental indicators.

The study implemented the participatory DEED approach (Giller et al 2011) as an overarching methodological framework guiding integration of project components for the landscape assessment (Groot et al 2007, 2010). DEED employs four consecutive steps for the analysis and design of existing and future landscapes:

1. Describe: description and characterization of the current farm or landscape configuration in land use, farming practices, household activities and socioeconomics, and nutrition.
2. Explain: determination of landscape performance through productive, socioeconomic and environmental indicators.
3. Explore: exploration of the trade-offs and synergies at the farm, household and landscape levels. At this step the suitability of new options or entry points within the given livelihood objectives and constraints can be explored.
4. Design: fine-tuning of selected alternatives in the farm or landscape after combining the collected information from the previous steps.

Here we present an overview of the case study analysis in two villages in Son La Province in Northwest Viet Nam. We characterize the households and farming systems, identify shortages in nutrition, and explore the potential for improving nutritional performance, while analysing the effects of implementing new crops, technologies or practices on productive, socioeconomic and environmental farm performance.

Method

A landscape and farm analysis was performed in two communities that differed in landscape and crop diversity. Doan Ket village is characterized by a flat topography and cultivation of maize and vegetables for the market. Na Phuong village is situated in a hillier environment with maize cultivation in the uplands (sold as animal feed) and rice in the lowlands. In this village, the cropping pattern is less diversified and households rely on home gardens for nutrition. In Na Phuong village, the possibilities for off-farm income generation are less than in Doan Ket.

Landscape mapping was done to position the fields. Resource flow mapping was used to identify sources of water, firewood, foods and feeds harvested from open and common areas in the surrounding landscape and to make an inventory of interactions with markets.

Focus group discussions were held to characterize the cropping patterns and sequences and the associated labour allocation throughout the year. Crop productivity was assessed. Moreover, the desirability of potentially promising alternative crops was discussed in the focus groups. The criteria for crop evaluations were productivity, nutritional values and resource demands (water, fertilizer, labour, etc.).

Ten farms in each village (n=20) were characterized using the Impact LITE survey instrument (<https://ccafs.cgiar.org/impactlite-tool>). This provides an overview of farming activities (crops, animals, gardens). Additionally, a food frequency survey was conducted in each household.

The FarmDESIGN model (Groot et al 2012) was used to calculate biophysical and socioeconomic farm and household indicators. The model was extended with modules to quantify nutrition indicators (dietary diversity scores, nutritional functional diversity, food group consumption patterns), household labour allocation and household budget. The model employs a Pareto-based evolutionary algorithm to perform multiple objective optimization that is used to generate and select alternative farm configurations to improve the performance of selected indicators.

Data

With the ImpactLITE survey we made an inventory of crops, trees and animals that were kept and cultivated and extracted from the farm as well as collected from the landscape, or purchased from the market. Within the ImpactLITE survey, 24-hour recall surveys were also performed; these were followed up with food frequency surveys in the focus group discussions. The frequency at which households consumed products was measured and this data was used to calculate the functional dietary diversity of the households in the two villages.

Results

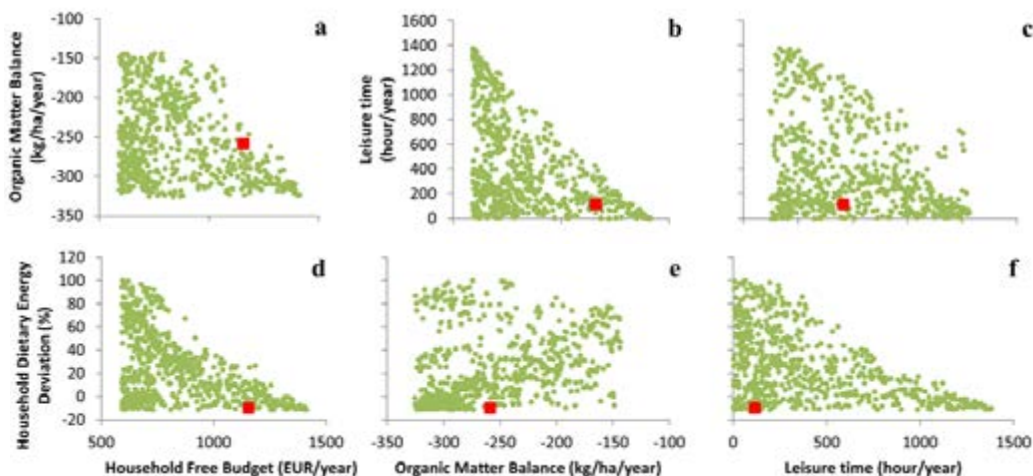
Households in Doan Ket were smaller than in Na Phuong (on average 4.5 and 5.1 household members, respectively), but cultivated larger farms (1.95 ha versus 1.20 ha) and used more labour on the farm (5556 h/year versus 4964 h/year). The average household income was not different between the two villages, but varied considerably within the communities and was mostly derived from farming. A large proportion (50–90 percent) of the household budget was spent on food purchases. The functional dietary diversity did not differ between the households in the two villages.

The main crops cultivated in Doan Ket were maize, French beans and onions, but only a few households had a home garden. In Na Phuong, all households cultivated a home garden. These were diverse and contained as main crops and fruit trees: onions, cabbage, pak choy, papaya, guava, mango, pomelo and banana. In both villages organic matter inputs into the soil did not compensate for losses, leading to a negative organic matter balance, while fertilizer inputs were relatively high (exceeding the crop demand and uptake), thus leading to considerable accumulation in the soil with a risk for nutrient losses.

In exploring possible nutritional outcomes, we evaluated the effects of incorporating various new crops into the home gardens: mustard greens, pumpkin, yellow-flesh sweet potato and water spinach. Even though home garden areas were small, reconfiguration of the cropping areas could contribute to alleviating shortages of micronutrients and vitamins. Our explorations suggest that gains in some nutrients, like magnesium and iron, were more easily attained than gains for vitamins A and C. For instance, reconfiguration that replaced eggplant and papaya areas with sweet potatoes resulted in an almost tenfold increase in iron yield, while vitamin A only doubled. Some trade-offs were also observed. For instance, by increasing the area for growing sweet potatoes at the expense of vegetables such as tomatoes and eggplants, the model predicted gains in vitamin A and iron production, but with a reduced household budget and small decreases in soil organic matter.

Explorations focusing on interactions between labour use, household budget and food consumption highlighted trade-offs in household budget against household leisure time and food consumption. The key factors are hired labour hours, field size of food crops and the amount of food consumed. With more labour hired, the household leisure time (household labour balance) would increase but the household budget would decrease; with more food consumed by the household, the nutrition indicator would increase but the household budget would decrease. Nutrition and household leisure time were linked when the farm household cultivated its own food crops. For instance, in our case, the farm household

produced rice only for home consumption and a trade-off existed between household leisure time and household dietary energy deviation because rice cultivation is labour intensive (Figure 4.2). If the labour requirement of the food crop is less than other crops grown on the farm, a synergy may exist between nutrition and household leisure time.



Note: Red squares indicate current performance; green dots are alternative farm configurations.

Figure 4.2 Windows of opportunity and trade-offs between four objectives for maximization of organic matter balance, labour balance, dietary energy availability and free budget for a representative farm household in Na Phuong

Discussion

The analysis provided detailed insights into farm and household configurations in contrasting villages. Both villages were characterized by large variations, but in general the income levels were low and dependence on farming was high. There were large nutrition deficiencies, but the proposed interventions in home gardens by adding new crops had the potential to alleviate these constraints, although in some cases trade-offs with household budget or soil fertility were found. In general, the model-based exploration demonstrated large windows of opportunity for further improving farm performance and the income and nutritional status of the households in the case study villages.

The detailed analysis was demanding in terms of data collection, and depended strongly on secondary data to establish nutrient composition of foods. Future research efforts will use only selected modules to reduce the data requirements and the duration of the analysis.

4. Multistakeholder platforms and nutrition

A key component of systems agricultural research for development (R4D) in Humidtropics was the use of platforms to engage multistakeholders in the design, implementation, monitoring and recommendations resulting from activities. Multistakeholder platforms enable local problems to be analysed along with the identification of feasible interventions

to address the issues. Stakeholders (researchers, the private sector, farmers and other local and national actors) met regularly to discuss and agree on collaborative actions, which were followed up outside the multistakeholder platform meetings. This multistakeholder and local approach facilitated links between stakeholders and encouraged innovative approaches, transferred information and technology, and empowered communities by applying participatory and locally appropriate solutions. The Humidtropics Central Mekong Action Area had launched multistakeholder platforms in four Action Sites: in Northwest Viet Nam; Central Highlands, Viet Nam; Nan in northern Thailand; and Xishuangbanna in Yunnan Province, southwest China.

At the outset, a meeting with stakeholders and research centres was conducted to identify the geographical areas where interventions were needed. A situational analysis (see Chapter 2) was conducted with platform members and was presented at platform meetings. These meetings established a better understanding of the priority problems related to rural livelihoods and identified entry points for interventions. This enabled areas where the platform should focus its efforts to be recommended. After the local problems and possible solution entry points had been identified, the platform members collectively decided how to assign the different roles and responsibilities for implementing, testing and evaluating the impact of innovative solutions generated by the platforms.

Northwest Viet Nam

The multistakeholder platform in Northwest Viet Nam was launched initially in August 2013. The platform, led by partnering centres ICRAF and the Department of Agriculture and Rural Development (DARD), facilitated further partnerships and collaboration between national and international research institutions, NGOs, extension centres, actors in the private sector, and local farmers. At the initial meeting were participants from Humidtropics core partners namely ICRAF, ILRI, CIAT, IWMI and WorldVeg, and national research institutions and universities such as FAVRI, NOMAFSI, Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD), CASRAD, AFRI, NIN, Viet Nam National University of Agriculture (VNUA) and the Forest Science Centre for Northwestern Viet Nam (FSCN). The focus was on productivity and environmental stability. An NGO that focused its work in Viet Nam was also at the initial meeting (HealthBridge Foundation Canada). The event was also attended by national agencies from Europe (Centro Europeo di Ricerca e Promozione dell'Accessibilità ITALIA (CERPA) and CIRAD) and provincial government departments, agencies and associations (Son La Plant Protection Division, Son La Crop Production Division, DARD, local farmer associations and women's unions). These representatives raised the issues and challenges that the platform needed to address with future projects and research. Partners including NIN, Healthbridge Canada, FAVRI, Bioversity International and WorldVeg brought a nutritional perspective to the platform and encouraged the inclusion of nutrition and diet in each stage of the platform's activities.

A situational analysis (see Chapter 2) was then conducted by platform members (SFRI, Centre for Sustainable Rural Development (SRD), FAVRI, CASRAD, ILRI - leading, Bioversity International and ICRAF) and included a review on nutrition using secondary data collection from the NIN. These data showed trends in malnutrition (stunting, underweight and wasting), iron deficiency, vitamin A deficiency, prevalence of women of reproductive age (15-49 years)

with chronic energy deficiency (BMI <18.5kg/m²), rate of individuals being overweight or obese, proportion of children meeting minimal dietary diversity requirements (at least four of seven food groups consumed), and breastfeeding practices (NIN 2010, 2012). The situational analysis recommended that improving dietary diversity should be a priority research area in the Northwest, and recommended diversifying production systems and establishing nutrient-rich niche market value chains as key entry points.

Two initiatives were formulated through this multistakeholder platform: 1) A multistakeholder platform research project; and, 2) a local-level multistakeholder platform for commercial vegetables in the area. Since the platform was revitalized in March 2015, two meetings have taken place: one in March 2015 and another in October 2015. The final meeting for Humidtropics was planned for October 2016. One outcome the platform research project set out to achieve was an improvement in dietary diversity and basic nutritional status. Data collection was conducted by four partners, and WorldVeg included pathways for how and where nutrition could be affected, such as two one-day nutrition education training sessions for 10 households.

Central Highlands, Viet Nam

The multistakeholder platform established in the Central Highlands of Viet Nam was launched in September 2014 by WASI and supported by CIAT. The platform fostered further partnerships and collaboration between international research organizations or organizations that work internationally (Australian Centre for International Agriculture Research (ACIAR), BMT, CIAT, CIRAD, Commonwealth Scientific and Industrial Research Organisation (CSIRO), ILRI, ICRAF, Wageningen University and Research (WUR), WorldVeg); and local and national research organizations and universities (WASI, DARD, Tay Nguyen University (TNU), Hue University, Department of Science and Technology (DoST) and the National Institute of Animal Sciences (NIAS)). The only centre with a nutrition/diet framework was WorldVeg, though no national or local nutrition institutions were in the partnership.

The multistakeholder platform addressed nutrition during the situational analysis conducted by a select number of platform members: TNU, WASI and CIAT, funded by ILRI. The situational analysis report included a review of the existing regional and national nutrition data for the Central Highlands published by the NIN. This information came from a General Statistics Office survey from 2009, 2010 and 2011. The data included the proportion of children less than five years old who were underweight, severely undernourished, or who exhibited severe signs of stunting, or had clinical vitamin A deficiency; the proportion of individuals who suffered from anaemia; dietary energy (kcal); protein and fat intakes. The situational analysis concluded that the nutrition status of children should be improved and suggested that this could be achieved by focusing on underdeveloped livestock and fish sectors as entry points.

Two projects were operationalised through this platform: a farmers' group on cattle development, and a multistakeholder platform research project titled 'Enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms in the Central Highlands of Viet Nam'. Only the platform research project included improving diets as an objective through WorldVeg's implementation of improving home gardens.

Nan, Thailand

The multistakeholder platform located in Nan, Thailand was launched in May 2014. The team was led by WorldVeg and Chiang Mai University, with the participation of Chulalongkorn University. The launch meeting was attended by 41 people representing 21 stakeholders, including: CGIAR centres (ICRAF and ILRI); representatives from educational institutions (Chiang Mai University, Chulalongkorn University, Mae Fa Luang University, Mae Jo University, Nan Community College, and Tanchum High School); international organizations (WorldVeg), national organizations and governmental departments (the Department of Agricultural Extension and the Land Development Department); provincial government organizations and departments (Muang Jung Subdistrict Administrative Organization, Nan Agricultural Extension and Development Center, and Nan Provincial Administrative Organization); funding agencies for agricultural development and productivity (Royal Initiative Discovering Institute, Thai Research Fund, Hag Muang Nan Foundation, Pong Kum Temple Learning Community Encourage Foundation, Bank for Agriculture and Agricultural Cooperatives) and a private sector representative from Hongsa Power. The only platform member who participated at the initial meeting and had a background in diet and nutrition was WorldVeg; no national nutrition stakeholders were present.

The situational analysis conducted by WorldVeg, Chiang Mai University, and ICRAF put together data collected through key informant interviews as well as a literature review (see Chapter 2). The results were presented at the multistakeholder platform meeting. Diet and nutrition information relevant to the population was in the executive summary and included the proportion of children underweight, stunted, and with deficient folate and iron intake. Although data were presented on nutrition, improvements in nutrition or diet were not included as recommendations. Despite this, the activities developed and carried out by various platform members did include some scope on nutrition, including WorldVeg's work in introducing and improving home garden management.

Xishuangbanna, China

The final multistakeholder platform, in Xishuangbanna, China, was launched in September 2014 and led by ICRAF. Fifty-three participants from various government, research, business and non-government organisations attended the initial meeting. Stakeholders included international and national (ICRF and Syntao); provincial and prefectural (Xishuangbanna Bioindustrial Office, Yunnan Green Foundation, Xishuangbanna Tropical Crops Institute, Yunnan Institute of Insect Resources, Xishuangbanna Tianyun Linzhong Herbal Medicine Growers Ltd, Meteorological Bureau of Xishuangbanna, Yunnan University, Xishuangbanna Development and Reform Office, Yunnan Forestry Investment Company, Yunnan Tea Institute, Yunnan Forestry Bureau, Xishuangbanna Tropical Botanical Garden, Yunnan Business Institute, Yunnan Environmental Science Institute); and, other public and private sector stakeholders (Nabanhe National Nature Reserve, Xuandali Cropping Company Ltd, and Sunbird Ecotourism). No stakeholders with expertise in nutrition participated.

At this meeting, the platform collectively decided that a baseline survey would not be conducted. Instead, key stakeholders had the task of impressing the regional issues on the meeting's members. Nutrition was not considered an entry theme or priority issue to be

tackled by the platform at that time. Later, the platform conducted a situational analysis, but no information on diets or food was included in that report (see Chapter 2). The report does however acknowledge that the review had blind spots and that further investigation regarding livelihoods should be conducted. The activity that came out of the platform, titled 'Appraisal and Innovations in Xishuangbanna, China', did not include any recommendations on nutrition or diet improvement, nor did it capture such data.

4.1 Cross-site comparison

This chapter analyses seven main initiatives in the Central Mekong in Viet Nam, China, and Thailand undertaken by the Humidtropics core partners and their national and local partners. These initiatives all had one centralized objective: to improve farmers' livelihoods. Although the partners shared a common objective, they approached the objective differently and focused on different aspects. The work was initiated in similar fashion in all projects with situational analysis and meetings with key stakeholders to identify the areas where research was needed. These meetings were conducted through the multistakeholder platforms established in each Action Site, with key stakeholders identified and invited to join. After the main livelihood issues were described and entry points for interventions identified, separate projects and activities were developed to best address the issues and potential of each region.

The three projects and activities that included aspects of nutrition or diet in work plans employed various approaches and indicators with little harmonization across projects, making it difficult to collate data or conduct cross-site analysis. Often, indicators more specific to food security (access) were used (e.g. Household Dietary Diversity Score (HDDS) and household food production) indicating a lack of knowledge and experience on how to select appropriate indicators specific to nutrition and diet quality-related outcomes. From the numerous indicators implemented, only seven are internationally validated for nutrition and diet-related outcomes (see section 2 for more detail).

Tools and methods used to collect nutrition and diet-related data also varied across projects and activities. This included household or individual surveys, anthropometric measurements, focus group discussions and other rapid appraisal methods, key informant discussions and literature reviews. The surveys included qualitative or quantitative diet recalls over different time frames (24 hours, seven days) and at different scales (individual or household), annual household consumption of produced foods and different versions of the FAO Nutrition Knowledge, Attitudes and Practices questionnaire (FAO 2014). Anthropometric measurements were collected either directly by the research teams, or through review of community health records. However, the consistency between approaches necessary to compare data between activities was lacking. This can be explained by different stakeholder interests and levels of nutrition understanding in the multistakeholder platforms. It takes time to evolve a common goal and working methods and this is based upon trust built around activities. Because the Humidtropics project was truncated due to funding constraints and the CGIAR Consortium's decision to end the project early, this was not achieved.

Most projects and activities in the Central Mekong were initiated through multistakeholder platforms, or by building on existing bilateral projects carried out by the core partners. This highlighted how critical it was to have a diverse stakeholder representation including representatives from provincial or local entities and organizations with diet and nutrition experience, at the initial meetings where strategy was formulated. The purpose of the multistakeholder approach was to ensure each area of development and livelihoods was represented, and to ensure priorities were well evaluated and representative of a wide range of rural development dimensions.

The lack of multistakeholder platform partners with experience in diet and nutrition was a weakness, particularly in representation from provincial or local entities and organizations. In almost all platforms, no local nutrition representation was present at meetings.

In Northwest Viet Nam, four of the 21 stakeholders had a background in nutrition and diet (NIN, Healthbridge, WorldVeg and Bioversity International); 12 focused directly on improving agricultural productivity; four focused on other types of community and environmental development. In the Central Highlands of Viet Nam, of the 16 stakeholders represented at the initial meeting, one had a background in nutrition and diet (WorldVeg), 11 focused directly on improving agricultural productivity and one focused on other types of community and environmental development.

In Thailand, of the 21 stakeholders represented at the initial platform meeting, two had a background in nutrition and diet (WorldVeg and ICRAF), 10 focused directly on agricultural productivity, and three focused on other types of community and environmental development.

In China, of the 20 stakeholders represented at the initial meeting, none had a background in nutrition and diet, three focused on agricultural productivity, and 12 focused on other types of community and environmental development.

Diversity across stakeholders represented in multistakeholder platforms, particularly in relation to nutrition, is a major area for improvement for future applications of systems research. Reaching out to the different levels in each sector is also imperative to understand what the issues are locally as well as nationally, and to facilitate the sharing of examples of innovations and solutions that have had success in different regions to overcome local problems.

5. Recommendations for future systems research for nutrition based on lessons learnt in the Central Mekong Action Area

Of the seven projects analysed in this chapter, three included nutrition in their objectives. Of the 14 activities summarized, five included nutrition as an outcome while two included nutrition and food security indicators and seven activities did not include nutrition. The main reason nutrition was not included in the scope of projects was that the lead researcher

felt that they (or their institute) did not possess the capacity to work on nutrition and the topic was beyond the scope of their mandate or expertise. Additionally, nutrition was not prioritized by the multistakeholder platforms or during situational analyses. Of key importance is the infrequent participation of local nutrition stakeholders in multistakeholder platforms; this is likely the main reason why nutrition was not raised as a priority area for intervention more frequently. Nutrition was also less familiar to many stakeholders than other indicators. Having platforms that did not prioritize nutrition resulted in projects and activities that did not work directly to improve nutrition.

Within the nutrition inclusive research efforts that did occur, the wide range of nutrition indicators and data collection highlights the need for more coordinated guidance at the CGIAR Research Program level regarding which indicators and methods to implement. Having a wide array of different indicators and data from different sites makes it extremely difficult to conduct cross-site comparisons and analysis. As a minimum, anthropometric measurements and qualitative dietary recall information could be used to better understand how diets and nutrition are affected by production increases or other agriculture-related outcomes that the different research centres wanted to address.

For systems research to have a positive impact on nutrition, it is critical that future multistakeholder platforms have active local nutrition partners, such as members from the National Institute of Nutrition (NIN) or the Department of Nutrition and Health, or non-government organizations with experience, understanding and expertise on local nutrition issues. Such coordinated efforts will help to ensure that activities include the minimum nutrition indicators needed to evaluate impacts on nutrition and diet that are critical to the well-being of poor rural households.

The recommendations proposed could have been addressed if Humidtropics had continued and if fully functional multistakeholder platforms had been sustained and further evolved around tangible sets of activities.

References

- Arimond M, Wiesmann D, Becquey E, Carriquiry A, Daniels M, Deitchler M, Fanou-Fogny N, Joseph M, Kennedy G, Martin-Prevel Y, Brouwer I. 2010. Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource poor settings. *Journal of Nutrition* 140:11 2059S–2069S
- [CGIAR] Consultative Group on International Agricultural Research. 2015. CGIAR Strategy and Results Framework 2016 – 2030. Montpellier: CGIAR. Available at <https://library.cgiar.org/bitstream/handle/10947/3865/CGIAR%20Strategy%20and%20Results%20Framework.pdf?sequence=5>
- De Onis M, Habicht J-P. 1996. Anthropometric Reference Data for International Use: Recommendations from a World Health Organisation Expert Committee. *The American Journal of Clinical Nutrition* 64:650–658. Available at <http://ajcn.nutrition.org/content/64/4/650.short>
- [FAO] Food and Agriculture Organization of the United Nations. 2011. *Guidelines for measuring household and individual dietary diversity*. Rome: Food and Agriculture Organization of the United Nations.
- [FAO] Food and Agriculture Organization of the United Nations. 2014. *Guidelines for assessing nutrition related Knowledge, Attitudes and Practices*. Rome: Bioversity International.
- [FAO] Food and Agriculture Organization of the United Nations. 2016. *Minimum Dietary Diversity for Women*. Rome: Food and Agriculture Organization of the United Nations.

- Frankenberger TR, McCaston MK. 1998. The household livelihood security concept. *Food, Nutrition and Agriculture* 22:30–35.
- Gibson RS, Ferguson EL. 2008. *An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries*. Washington DC and Cali: International Food Policy Research Institute (IFPRI) and International Center for Tropical Agriculture (CIAT).
- Giller KE, Tittone P, Rufino MC, van Wijk MT, Zingore S, Mapfumo P, Adjei Nsiah S, Herrero M, Chikowo R, Corbeels M, Rowe EC, Baijukya F, Mwijage A, Smith J, Yeboah E, van der Burg WJ, Sanogol OM, Misiko M, de Ridder N, Karanja S, Kaizzi C, K'ungu J, Mwale M, Nwaga D, Pacini C, Vanlauwe B. 2011. Communicating complexity: Integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. *Agricultural Systems* 104(2):191–203. doi:10.1016/j.agsy.2010.07.002
- Gorstein J, Sullivan KM, Parvanta I, Begin F. 2007. *Indicators and methods for cross-sectional surveys of vitamin and mineral status of populations*. Atlanta (GA): Micronutrient Initiative (Ottawa) and the Centers for Disease Control.
- Groot JCJ, Rossing WAH, Jellema A, Stobbelaar DJ, Renting H, Van Ittersum MK. 2007. Exploring multiscale trade-offs between nature conservation, agricultural profits and landscape quality – A methodology to support discussions on land use perspectives. *Agriculture, Ecosystems & Environment* 120(1):58–69. doi:10.1016/j.agee.2006.03.037
- Groot JCJ, Jellema A, Rossing WAH. 2010. Designing a hedgerow network in a multifunctional agricultural landscape: Balancing trade-offs among ecological quality, landscape character and implementation costs. *European Journal of Agronomy* 32(1):112–119. doi:10.1016/j.eja.2009.07.002
- Groot JCJ, Oomen GJM, Rossing WAH. 2012. Multiobjective optimization and design of farming systems. *Agricultural Systems* 110:63–77. doi:10.1016/j.agsy.2012.03.012
- 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>
- Joy A. 2001. Gift-giving in Hong Kong and the continuum of social ties. *Journal of Consumer Research* 28(2):239–256.
- [NIN] National Institute of Nutrition. 2010. *General Nutrition Survey*. Hanoi: National Institute of Nutrition. http://www.unicef.org/vietnam/resources_21138.html
- [NIN] National Institute of Nutrition. 2012. *Statistical data on the nutrition situation of children over the years*. Hanoi: National Institute of Nutrition. Available at <http://viendinhduong.vn>
- [NIN] National Institute of Nutrition. 2013. *Family Nutrition Handbook*. Han Noi: National Institute of Nutrition.
- Saad G, Gill T. 2000. Applications of evolutionary psychology in marketing. *Psychology and Marketing* 17(12):10051034.
- Slater J, Yeudall F. 2015. Sustainable Livelihoods for Food and Nutrition Security in Canada. A Conceptual Framework for Public Health Research Policy and Practice. *Journal of Hunger & Environmental Nutrition* 10(1):121. <http://dx.doi.org/10.1080/19320248.2015.1004220>
- Vellema W, Desiere S, D'Haese M. 2016. Verifying Validity of the Household Dietary Diversity Score. *Food and Nutrition Bulletin* 37(1):27–41.
- [WHO] World Health Organization. 2007. *Evidence of long-term effects of breastfeeding: systematic reviews and meta-analyses*. Geneva: World Health Organization.
- [WHO] World Health Organization. 2013. *Essential Nutrition Actions: improving maternal, newborn, infant and young child health and nutrition*. Geneva: World Health Organization.
- [WFP] World Food Programme. 2015. *Food Consumption Score Nutritional Quality Analysis Guidelines*. Rome: World Food Programme.



A Thai household with cattle and fish pond in Northwest Viet Nam. Photo credit: ICRAF/Pham Duc Thieng