Participatory identification of climate-smart agriculture priorities

Working Paper No. 175

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

With the concept climate-smart agriculture (CSA) being relatively new, there is a need to test and develop practical and systematic methodologies and approaches for documenting and evaluating CSA practices in the field. The implementation of CCAFS' Climate-Smart Villages (CSV) involves identifying, assessing and selecting climate-smart farming practices. This report contains three sections: (i) a framework for identifying and assessing CSA in the field with a long list of CSA indicators in identifying and monitoring CSA interventions; (ii) cost-benefit analysis of some selected climate-smart farming systems; and (iii) the participatory process of prioritizing CSA options with the villagers. The work builds on our experiences from the My Loi CSV and its scaling domains in Ky Anh district, Ha Tinh province, in the north-central region of Viet Nam.

Keywords

Climate-smart agriculture (CSA); cost-benefit analysis; participatory approaches; agricultural practices; Climate-Smart Village (CSV); My Loi; Viet Nam

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Contents

Acronyms

ACIS	Agro-climate Information Services (ACIS) for Women and Ethnic Minority farmers in Southeast Asia
AFLI	Agroforestry for Livelihoods of Smallholder farmers in Northwest Viet Nam
AVRDC	World Vegetable Center
CABI	Centre for Agriculture and Biosciences International
CBA	Cost-Benefit Analysis
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
CSA	Climate-smart agriculture
CSV	Climate-Smart Village
DARD	Department of Agriculture Rural Development
DONRE	Department of Natural Resources and Environment
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gas
IAE	Institute for Agricultural Environment
ICRAF	World Agroforestry Centre
IMHEN	Institute of Meteorology, Hydrology and Environment
IWMI	International Water Management Institute
UNIDO	United Nations Industrial Development Organization
VBS	Village baseline study

Introduction

The CCAFS Climate-Smart Village (CSV) program started globally in 2011 and in Southeast Asia in 2014. The CSVs function as testing grounds for identifying scalable climate-smart practices. Hence, not only the village but also the surrounding landscapes and administrative areas are important impact areas. The My Loi CSV in Ha Tinh province represents upland farming systems in the northern-central region of Viet Nam that are exposed to temperature and water stresses, as well as storms (Le et al. 2014, Le et al. 2015). Farming systems with cassava, peanut and acacia dominate the uplands. Rapid assessments and earlier research in the area highlight opportunities to diversify crops, introduce more intensive systems, and intercropping with crops or trees.

Climate-smart agriculture (CSA) by definition aims to derive synergies between the three pillars of food security, adaptation and mitigation (FAO 2013). The usual criterion for food security is increased yields and/or incomes. In countries such as Viet Nam, which is one of the top global rice exporters, food security (when counted as rice per capita) is no longer perceived a problem. However, malnutrition persists, particularly in remote rural areas. Hence, food nutrient status is sometimes included in food security indices, and assessed as direct farm outputs or indirectly if farming households can sell some products in order to buy other foodstuff. The links between adaptation and food security is not always obvious. In theory, food security can also be evaluated in terms of reduced yield or income losses during climatic stress, such as a drought period or heavy rainstorm. Recent research shows that farms with agroforestry can have shorter economic recovery period after natural disasters than farms without (Simelton et al. 2015).

By definition, CSA is context-specific. However, if there is no one model that fits all, can there then be generic indicators to evaluate existing and improved climate-smart farming systems? Scholars are still debating on the definition of CSA, and methodologies are still in the infancy stage. Several steps for prioritising CSA were outlined by the International Center for Tropical Agriculture (CIAT)[1] (Figure 1). In short the CSA prioritisation followed four phases: (1) an initial assessment of CSA options which resulted in a long list of CSA options; (2) the first workshop to identify the priority among top 5-10 practices; (3) calculating costs and benefits of the top CSA options; and (4) the second workshop to develop CSA investment portfolios based on identified opportunities and constraints. Phase one was included in the

[1] CIAT. https://ccafs.cgiar.org/climate-smart-agriculture-prioritization-framework#.VmtzZo9OLDd

baseline studies for CSVs. The methodology for phase two was expanded in Vernooy et al. (2015). The cost-benefit assessments followed conventional methodologies but are challenged by the following issues: (i) practices may be new to farmers or the particular geography, hence, the costs and benefits are not known; and (ii) many CSA options involve integrated farming systems or landscape scale – where indirect competition-complementary effects may be misjudged. In developing a CSA portfolio, not only on-farm costs-benefits need to be considered but also market assessments.

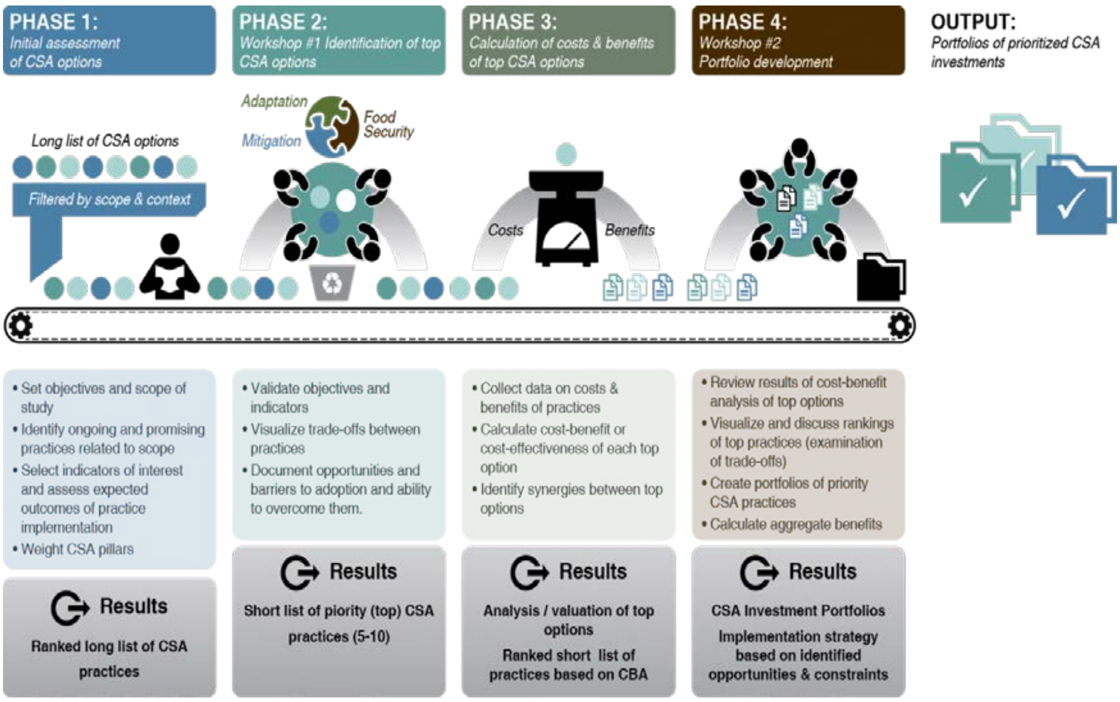


Figure 1. CSA investment prioritisation framework process

Source: CIAT (https://ccafs.cgiar.org/climate-smart-agriculture-prioritization-framework#.VmtzZo9OLDd)

In this paper, we reflect on our experiences in working through the phases (Figure 1) in My Loi CSV. For wider uptake of the approach, we argue that more focus needs to be paid to the potential of existing farming practices to become smarter (Chapter 1). While the existing long lists of scientific indicators for CSA (Rosenstock et al. 2015) can be used to inform monitoring schemes for implemented practices, many indicators are too costly and time-consuming for rapid field assessments and scoping in (pre-) phase 1. Furthermore, while there are participatory tools for analysing drivers of land use change (Van Noordwijk 2010; Emerton et al. 2015), there are no indicators for conducting inventories and assessment of the 'climate-smartness' of practices that farmers already adopt.

This report presents: (1) an updated framework for identifying and conducting rapid assessments of the "climate-smartness" of existing farming systems in the field; (2) an example of quantitative and qualitative cost-benefit assessments to evaluate in particular the economic resilience of current and improved farming systems; and (3) the process for participatory prioritisation of climate-smart options in My Loi CSV, in Ha Tinh province.

1. Rapid Inventory and Assessment of CSA in the field

This section presents a framework for making inventories and documenting CSA practices and technologies in the field. We describe how these were derived and present some results.

As the baseline work in the CSV progressed over 2014-15 and the team engaged with potential partners and donors in the region, our attention was drawn to the representability and scaling potential of the CSA options to be tested in the CSV. In trying to identify, systematically document and rapidly assess farmers' current practices in order to elaborate 'smarter' interventions, we recognised the lack of tools or frameworks in the body of literature on CSA that is only beginning to accumulate.

Literature review of CSA indicators

The CSA Sourcebook by the Food and Agriculture Organization of the United Nations (FAO) lists and rates several practices that are considered climate-smart globally (FAO 2013), such as agroforestry, alternate wetting and drying in rice, modifying farming calendar, no-tillage and irrigation techniques to maximise water use. Various attempts to derive criteria for CSA from the scientific literature, and what aspects they cover have been reviewed by Rosenstock et al. (2015). While the sources provide useful lists of potential practices and indicators, the FAO's list is rather generic and Rosenstock et al. is resource and knowledge intensive for large-scale inventories. There is also some inconsistent use of the terms 'CSA practices' and 'CSA technologies'.

In short, CSA offers similarities and differences with conservation agriculture, agroecology and ecosystem-based adaptation approaches. However, farmers do not make those semantic distinctions; therefore, if farmers find an indicator important that is not CSA, it should be included in the evaluation. Branding a practice climate-smart is not the end goal in itself, the indicators should rather be used for guiding the process and help prioritise indicators to evaluate its performance.

A framework for rapid visual assessments in field to CSA practice

Figure 2 illustrates the framework which characterises the current situation and potential limiting factors in the field, in the context of improving practices and investigating their scaling potential. The fundamental requirements are that characterisation and proposed interventions would be straightforward to use in the field, applicable for extension staff and practitioners, low-cost and thus allowing for, but not requiring technical, laboratory or statistical investigations.

The framework, thus, consists of a participatory field inventory to establish the baseline situation (upper light blue section) and a long list of CSA indicators to identify and prioritise the main problem areas. At this stage the main question to ask is “Why is this not a climate-smart practice?” from a productivity/food security, climate suitability and environmental sustainability perspective.

A tentative long list of CSA indicators is provided in Appendix 1.2. The long list should first be reduced and adapted so that it is relevant to the context. Farmers, extension and other actors shortlist at least one indicator per CSA pillar, that they perceive being a critical sign of a practice’s performance.

The design of the proposed CSA practice goes parallel with the prioritised corresponding evaluation criteria (lower light blue section). For example, the practice may differ depending on whether the main limiting factor is low productivity or unstable yields, and the food security indicator should reflect this as productivity increase or reduced yield variability, and the adaptation indicator whether the main objective is e.g. drought or flood resistance. These indicators will be monitored and evaluated. The design and prioritisation of CSA practices may also involve considerations of (i) technical feasibility and knowledge needs, (ii) credit access/investment needs, (iii) anticipated profitability, (iv) marketability of products, and (v) sustainability.

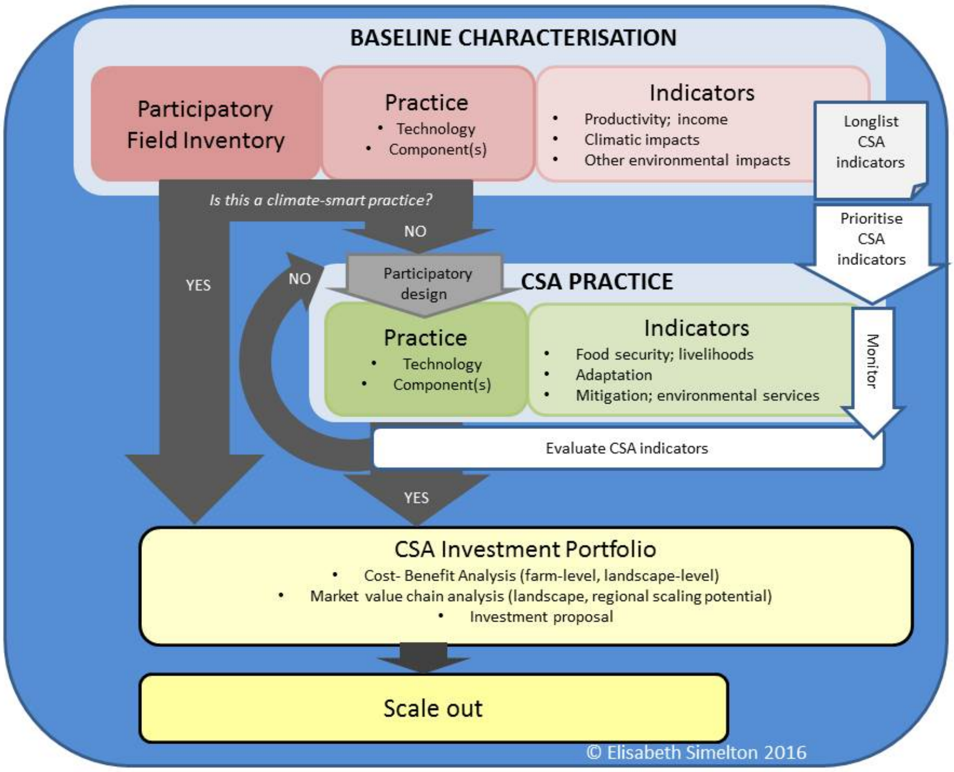


Figure 2. Framework for deriving a baseline and scalable improved CSA practices

There are two possible pathways towards scaling: either the practice can be considered ‘smart’ (according to local and scientific criteria) and scalable without further changes, or it has been adapted until it satisfies the CSA criteria. The upward returning arrow indicates that the practice failed to meet CSA criteria and needs further redesign.

The CSA portfolio contains a number of practices with cost-and-benefit analyses and market-value chain assessments to inform the investments for scaling of a certain practice and/or maps of potential areas suitable for particular CSA-practices.

In the inventory table (Table 1, Table 2), we view a CSA-practice as consisting of a *technology* and *components*, i.e. how it grows versus what grows. Typically the technology is *generic* (while many components are *context-specific*. For each practice, its performance criteria with regards to its contributions (and/or shortcomings) to food security, adaptation and mitigation benefits are identified. Based on this the potential for replication or scaling is considered. The ranking is based on qualitative assessments (Table 2) that may be merged into ranks from high to low ranks for easier visualisation purposes.

Taking as example (Table 3) intercropping cassava with peanut; intercropping is a considered a generic CSA-technology as it can be done in most places, while the spacing of plants and management is specific for a particular context. The components cassava and peanut may also be common; however, the specific varieties should be selected to match with the local context. Depending on practice and component, the context may be determined, for example, an agro-ecological zone, slope degree, natural hazard, or group of farmers.

The potential for replication and scaling may be added after the field evaluation, as donors and external investors may be most interested in this aspect. However, such assessment requires specialist inputs for assessing cost-benefits at farm level, climate impacts, and evaluating policy and market potential. We give a few examples how this may be done below.

Table 1. Inventory for summarising CSA practices after merging performance indicators with examples (For more detail on performance criteria see Table 2)

CSA practice			CSA performance criteria			Potential for replication and scaling [high – low]
Technology	Components	Details e.g. spacing, management	Income and Food security [high – low]	Adaptation potential [high – low]	Mitigation potential [high – low]	
Intercropping	*cassava, peanut*	*No herbicide or inorganic fertiliser*	*higher than monoculture*	*high*	*medium-high*	*high*

More details on performance criteria see Table 2 and Appendix 1.

Indicators

For each of the CSA pillar, we selected indicators that (i) can be observed directly by the scientist/practitioner or asked the landowner or an adjoining group of farmers, (ii) are possible to monitor and follow up, and (iii) are locally relevant. A detailed topic guide for coming up with the criteria and evaluations for Table 1-3 is available in Appendix 1. The topic guide results are summarized into a number of weighted key performance indicators for each of the three CSA pillars. The weights may be subdivided as a Likert scale ranging from very high to very low performance. The long list of CSA indicators is also provided in Appendix 1.

If sufficient information is available about local challenges for food security, adaptation and mitigation, the indicators may be derived through consultations between scientists and farmers or first proposed by scientists and tested in the field. If the inventory is done during a scoping survey or during the early stages of a project, indicators can be verified through focus group discussions on what aspects are important for farmers and, if necessary, followed up and adjusted later. Regardless of the stage the inventory is done, it is important to facilitate gender and socially differentiated groups as these groups may prioritise differently (see sections 3). In this study the indicators and the definitions of high and low performance were derived after three years of research in the district, drawing on observations, discussions, household surveys, baseline and situation analyses (Le et al. 2014, Le et al. 2015, Simelton et al. 2015).

Evaluating the CSA

Each practice is documented (see Appendix 1) and its performance is evaluated based on a number of indicators representing the three pillars (categories) of CSA. As they fill multiple purposes, some indicators are repeated. Table 2 summarises the performance indicators.

Table 2. Example checklist of indicators for summarizing CSA field assessments for a particular practice (See Appendix 1 for topic guide)

Category	Indicator	High performance	Poor performance
Economics	Yield	Stable	Unstable, low
	Income	High value crop, profit	Low/fluctuating price
	Labour input	Low, equal	High, gendered
	Food security	High diversity, improved health	Low diversity, reduced health
Adaptation potential	Sensitivity to weather impact	Insensitive Stable yield Biological pest control	Sensitive, narrow climatic optimum Unstable yields Pest and disease
Mitigation potential	Carbon sequestration	High above- and-below ground biomass	Low above- and below ground biomass
	GHG emission	Long rotations	Short rotations
	Manure	Low soil erosion Irrigation control	High soil erosion Sprinkler irrigation
	Energy	Biogas	Eutrophication, leakage, no manure treatment
		Low-input, renewable sources	High-input, fossil fuel

Environmental impact	SALT-technologies	Yes	No
	Soil erosion	No visible impact	Visible impacts
	Ecosystem	N-fix species	High input NPK
	functions	Multifunctional - high biodiversity, clean water	Few functions - low biodiversity, water pollution

In Appendix 1 we have collected a long list of potential indicators for each of the three CSA pillars. Here we elaborate on a few of the indicators.

For the **food security** pillar, the following are the indicators and evidence of performance considered.

- Yield – an indication of high performance is stable or increasing yield and of poor performance unstable and/or low yields.
- Income – high performance may be evident through stable or increasing net incomes, high value crop versus low and/or fluctuating prices; net income may increase through reduced input costs or increased price of products.
- Labour inputs – a high performance practice (a) can (at least in theory) be executed by anybody in the household, (b) allow more flexible timing of management during a day or season, and/or (c) require less labour demand, while a poor performance is gendered, unsuitable or unacceptable for certain groups in the household or community, it locks up labour periodically or over longer periods and/or is labour intensive. An improved practice should aim to reduce labour requirement or increase labour efficiency, in particular for members of a household or groups in a community that already are overloaded with duties.
- Food security – performance is judged by high versus low diversity of products. Nutrient status and health aspects are important aspects of food security. The food security indicator is particularly important for households with high level of subsistence farming or communities that risk being cut off from external support periodically by natural disasters or crop failures. We expect that more diverse production and/or higher income is reflected in a more diverse, and thus nutrient-rich, food intake.

For adaptation potential we focus on the sensitivity of practices to current weather impacts as this is what farmers and practitioners can judge and understand in the field. Although exposure to climate change may be discussed in the field, we consider assessing the suitability of the farming system under intermediate climate change and variability perspectives as the primary role of scientists (see scaling potential below). While talking with farmers about weather and crop impacts, it is important to clarify what has actually changed. For example, the physical environment nearby (e.g. hydropower dams, irrigation channels or sluice systems, deforestation, reforestation) may have caused changes in the hydrological cycle, micrometeorology and the farm outputs. Farmers may have changed a variety that is more or less sensitive to a particular weather stress, or had changes in the labour available for timely management (Simelton et al. 2015).

- Weather stress - High performing practices are insensitive to current relevant weather stress while low performing farming systems have a narrow climatic optimum (tolerate a narrow range of temperature or water stress) – this is sometimes referred to as resilient systems.
- Yield stability – stable yields versus unstable yields, stable yields are indicative of resilient farming systems.
- Pest and disease - as pest and disease are common side-effects of certain weather situations, high performance systems are multifunctional with inherent biological pest controls versus low performance systems that are prone to pests and disease. Monoculture is often associated with higher prevalence of pests and disease.

For mitigation potential, we consider systems that contribute to carbon sequestration and greenhouse gas emission reduction.

- Carbon sequestration – high performance systems enhance sequestration by long-duration and/or permanent tree cover (rotations) with selective cutting (or thinning) to reducing soil erosion. Indicative of low performance systems would be short tree rotations, clear-cutting that leave soils bare particularly during heavy rain seasons.
- Greenhouse gas emissions (GHG) – evidence of high performance are practices with low or reduced emissions, e.g. alternate wetting and drying of rice, sustainable intensification, drip-irrigation, no burning of straw or slash in the fields. Low performance may be evident as inefficient use of resources and burning of biomass in the field (see also energy below).
    - Above and below-ground biomass – above ground biomass may be estimated by measuring tree density, diameter (at 150 cm height) and height and convert to carbon using standard tables in a few sample areas (Condit 2008).
    - Manure and waste treatment – for high performance systems or farms in this inventory, we looked for systems contributing to biogas and biochar solutions (improved cooking stoves), organic compost. In contrast, for low performance systems, there was no manure or waste treatment, biomass was burned in the fields.

- Energy inputs – low-input versus energy demanding farming and post-harvest production systems (in particular of fossil fuels). Evidence of recycling, reuse and resource use efficiency was noted.

Key **environmental impacts** have been added to the three traditional CSA-pillars as healthy ecosystem functions and biodiversity generally reduce the sensitivity of farming systems to biotic and abiotic stress, but sometimes seem to be overlooked by the focus on direct GHG emissions, in particular carbon. These indicators have some similarities with pre-CSA practices, such as conservation agriculture, agroecology and ecosystem-based adaptation. Conservation agriculture[2] involves three principles: minimal soil disturbance (no or minimal tillage), permanent soil cover such as green cover crops, and crop rotations. These principles are particularly focused on sustainable soil and agriculture practices. SALT technologies (FAO 1998) - for uplands, the existence of Sloping Agriculture Land Technologies is a sign of attempts to combat soil erosion. They may include terraces, micro-terraces, and different combinations of trees-crops-livestock.

- Soil status – is there evidence of soil erosion and soil degradation? ‘No’ for high performance systems and ‘Yes’ for low performance systems. Reasons for absence of soil erosion may be to look for evidence of conservation agriculture and SALT-technologies, nitrogen-fixing species, green manure and mulch, fallow, manure input. In low performance systems, we expect high and increasing inputs of inorganic fertilizers (a likely example of declining soil fertility), use of pesticides and herbicides (which reduces the organic matter and soil structure), no manure treatment leading to eutrophication, algae production and/or freshwater contamination. We consider soil erosion a sign of poor adaptation.
- Ecosystem functions – high performance systems are multifunctional, that is, they contribute many ecosystem functions in the field and the landscape as a whole: high biodiversity, clean water, and carbon-rich systems. Low performance systems have few ecosystem services such as low biodiversity and poor water quality.

Both quantitative and qualitative indicators are possible for this inventory: (a) longitudinal studies of actual yield, yield variability, profit, labour inputs, and livelihood indicators; (b) relative comparisons of risk or preference to another practice, for instance, monoculture, or over time, previously versus now; (c) spatial documentation of *in situ* and *ex situ* impacts (field versus landscape). While environmental functions are quite straightforward with

[2] FAO. http://www.fao.org/ag/ca/

farmers (Simelton and Dam 2014), mitigation indicators can be implicit. Hence, during the preparatory desk study, make use of existing national or subnational GHG inventories to ensure that indicators for key emitters are covered, for instance, livestock, paddy rice, land use conversion. Participatory carbon monitoring methods can guide the relative carbon stock. An example from a CSA field survey in Ky Son commune is presented in Table 3, with a few practices used for identifying and developing the CSA options in Chapter 3.

Table 3. Selected examples of current farming practices in Ky Son commune, Ha Tinh province

CSA practice			**CSA performance criteria (See Table 2)**			
Technology	Components	Details e.g. spacing, management	Income and Food security [high – low]	Adaptation potential [high – low]	Mitigation potential [high – low]	**Comments for improving and scaling CSA**
Fast growing timber tree plantation	Acacia	1x1 meter Harvested within 3-5 years	+ stable income - low income and diversity - primarily male activity	+ dense planting allegedly less sensitive to windbreak - forest-fire risk	+ Above-ground carbon sequestration nitrogen-fixing species - Short-term, underutilised below-ground carbon	Demonstration models with multistrata to monitor weather resilient Agroforestry systems (see Chapter 2)
Inter-cropping	Cassava and peanut	3-4 rows of peanut between 1-2 rows of cassava	+ two yields - low income	+ peanut reduce soil evaporation and weed	+ Peanut is N-fixing hence reduce need for inorganic fertiliser	Optimising the combination of rows; reduce tillage or plough in peanut leaves as green manure
CSA practice			**CSA performance criteria (See Table 2)**			**Comments for improving and scaling CSA**
Inter-cropping	Cassava, peanut, maize	As above adding 1-2 rows of maize	+ maize adds extra income and feed	+ different plant heights provide more support and reduce competition for light and soil-water-nutrient	+ N-fixing species reduce need for fertiliser + plant by-products can be used for compost or mulch	Diversify the third intercrop to keep incomes high, rather than all copying the same model
Mono-culture	Rice Fallow	Rainfed, 1 crop per year	- low unstable yields, unused land	- rice is suboptimal due to water shortage	+ lower emission compared to constantly irrigated fields	Identify drought tolerant species, higher value crops or agroforestry
Rotation	Rice Peanut Bean	Rainfed	+ diversity - low yields (poor soil and water access)	+ sequence of short-term crops, flexible planting and harvest depending on weather	- short-term crops, tillage risk soil erosion	Explore crops suitable for no-tillage

While the field inventory is comparatively straightforward, **the potential for replication (scaling)** requires specialist inputs for assessing cost-benefits at farm level (Chapter 2), climate impacts, and evaluating policy and market potential (Table 1, Table 3). The climate impact assessment for near-future scenarios includes farmers ranking the suitability of trees and crops against particular extreme weather events, and under given adaptation measures (Simelton et al. 2013, Simelton et al. 2015). Such participatory impact assessments are only valid for the range of existing crops and trees, experienced weather situations, and implemented adaptation interventions. Those findings may or may not be indicative for nearby areas.

If the proposed CSA interventions involve changing crops, particularly into high value and industrial species, the recommendation should follow a market assessment just like any other intervention. The scaling potential is good if components are already in place and the CSA-change is only about improving a practice, such as the example below, shifting from monoculture to intercropping cassava and peanut. Longer-term suitability typically includes computer simulations of crop performance under certain climate change scenarios (Challinor et al. 2010, Zhao et al. 2015). Some open-source models can be run for basic indicative analyses with relatively little need for data inputs, such as FAO-GAEZ[3] and EcoCrop[4] models. While CSA typically involves integrated systems, one limitation of most crop models is that they only capture monoculture crop rotations. When it comes to simulating integrated systems, the demand for data inputs and modelling skills increase. One simpler freeware for modelling integrated tree-crop interaction is WaNuLCAS[5].

Market-value chain analyses follow specific methodologies (Haggblade et al. 2011, UNIDO 2011) that can be linked with ICT-tools that give farmers more authority to link up with markets by themselves[6]. For scaling several factors are relevant to explore such as available funding and land tenure (Matocha et al. 2012). Analyses may include a review of policies supporting CSA, donor and organisational mapping (Schiffer and Waale 2008).

Limitations and next steps

The boundary for what is to be considered generic and context-specific depends on the geographical scope of the study. As long as the purpose is to document and make inventories of CSA practices, the structure is universal. For analytical assessments, we are currently testing to subdivide the inventory into agro-ecological coherence and landscape scales.

[3] FAO. http://www.fao.org/nr/gaez/about-data-portal/agricultural-suitability-and-potential-yields/en/

[4] CIAT. http://gisweb.ciat.cgiar.org/ClimateChange/EcoCropFB/

[5] World Agroforestry Centre. http://worldagroforestry.org/regions/southeast_asia/resources/wanulcas

[6] ICT for Ag. http://ictforag.org/

The social dimensions of CSA deserve more attention than what was done in this field assessment, for example, real and potential impacts on gender and social inclusion of current and proposed practices. An important part of the smartness is documenting the learning process. Smart farmer practices can be divided as autonomous or externally introduced and adopted. It is often revealing for scaling purposes to understand how a particularly promising practice started? What prerequisites or resources were/are required? Such questions can easily be added as a new category or covered in focus group discussion when the team has an overall bigger picture of the inventory results.

Conclusion

This CSA framework with participatory field inventory and CSA practice identification is the result of a trade-off between detailed technical costly assessments and random bias-prone field inventories. As such, we expect that the field inventory will help provide more systematic documentation of farming systems. Without comparing the same indicators, the CSA-evaluation runs the risk of being biased towards what exists rather than what is missing, or towards particular aspects of CSA (typically productivity) rather than the synergies.

The rating may be useful for illustrative and relative purposes, but there needs to be real values behind the sign in order to compare and provide relevant inputs for a cost-benefit analysis or climate-impact assessment.

The main priorities for smallholder farmers at the margins of poverty are income and yield. The CSA-interventions on adaptation and mitigation therefore need to directly translate into income (food security). However, this need not exclude neither adaptation nor mitigation pillars, only provide an alternative angle for farmers to see the links. The easiest way to do this in Ha Tinh seems to be by sustainable intensification with short-term crops, which meant risks were reduced by a flexible farming calendar. Better-off farmers with larger fields had a different perception of risk and could afford longer-term investments, such as planting fruit trees.

2. Cost-benefit assessment of key climate-smart practices

This chapter presents an example of cost-benefit analysis (CBA, Phase 3 in Figure 1) of two agroforestry systems proposed by two gender-separated farmer groups in My Loi CSV, in Ky Son commune, Ha Tinh province. The purpose was to explore potential differences in tree selection, landscape design and argumentation between women and men.

Comparing farmer’s practice and agroforestry

First, we compare agroforestry systems (AFS) designed by farmers in Ky Son with business-as-usual (BAU) practices. The site chosen for the system is exposed to a range of climatic risks (storm, temperature and water stress) and impacts (drought, landslide, flooding and pests) thereof throughout the year, which is reflected in the layout and species selected.

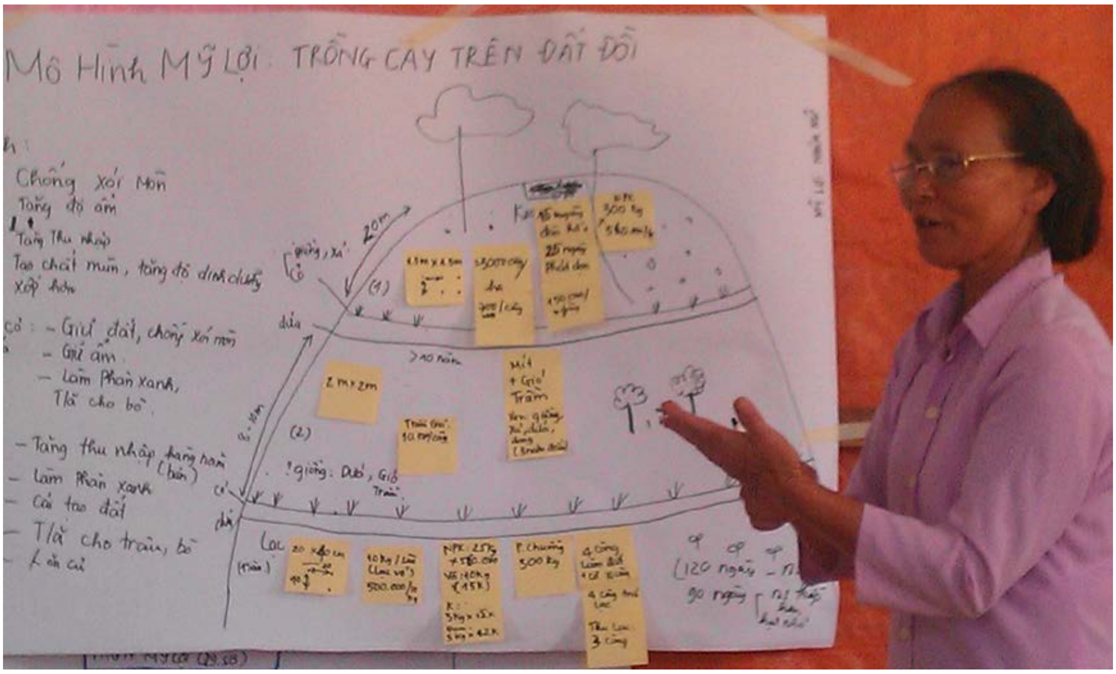


Figure 3. A farmer presents the improved agroforestry system designed by women in a focus group discussion. *Photo: Elisabeth Simelton/ICRAF.*

Cost-Benefit Assessment

The CBA involved three steps. First, farmers participated in an interactive lecture on extreme events, climate change and agroforestry systems. This involved a field visit to select a bare or mono-cultured hill that would serve as model for the adapted design. Next, participants were divided into women and men focus groups, facilitated by a female and a male, respectively. The role of the facilitator was not to influence the decisions, but to ask questions and support with technical information if required so that each group could design an agroforestry system, estimate the input costs, and assess the potential benefits and risks of the system. Then the group shared their systems and discussed the designs. When the groups presented back their systems, there were open discussions with well-founded arguments and questions regarding appropriate spacing and suitability of the chosen species. Some new insights from the preceding introduction to agroforestry were well-integrated during the discussions. The detailed information for the CBA was collected through key informant interviews at the commune. Reference data from the literature and other ICRAF project sites were also used for comparison.

There are several indicators for analysing the economic performance of an agricultural practice. Here, we used net present value or NPV.

The net present value (NPV) analysis is an economic analysis technique where all future net income streams from a particular practice are discounted to reflect their current or present value (Zerbe et al. 1994). In this case, the indicator was used to assess the economic performance of a particular agroforestry system. The NPV of an agroforestry practice, e.g. cassava intercropped with acacia, was compared to the NPV of other alternatives, such as cassava monoculture, to see which practice was more profitable economically. Assuming each practice is discounted over the same time period and at the same discount rate, the highest NPV would indicate the most economically beneficial alternative.

The NPV was calculated using the following formula:

$$NPV = \sum_{t=1}^{T} \frac{(Income_t - Cost_t)}{(1+i)^t}$$

Where

NPV = Net Present Value

T = total number of years (from the year putting AFS into practice until the year of harvest)

i = discount rate, or the opportunity cost of investing. For example, assuming the money invested in an agroforestry practice could have been used for another activity with an expected return of 10% of the original money, the opportunity cost of the agroforestry practice would be 10%.

$Income_t$ = total income in year t

$Cost_t$ = total cost in year t

Due to complex species combinations, CBA assessment for agroforestry systems is more complex than for monoculture systems. Several factors affect the inputs and outputs of AFS, such as the spacing of trees and crops. Furthermore, the timing of harvest and returns vary over time. Here, spacing is based on the current practice or assumed maximized output. For each AFS, the costs analysed included: agricultural inputs (seeds, seedlings, fertilizers, pesticides) and labour for planting, tending and harvesting. Benefits included incomes from selling harvest, non-timber and timber products. Non-economic benefits of the agroforestry systems are discussed, in particular, environmental services such as climate regulation. All values were collected and measured in Vietnamese currency in September 2015 (VND22 000 = 1US$).

Does agroforestry help secure farmer's income?

CBA was made for two agroforestry systems based on acacia mixed with annual and perennial crops compared with the business-as-usual (BAU) practices. BAU1 consists of monoculture acacia, and BAU2 has cassava planted in rotation with green bean (Table 4). The acacia monoculture calculation was based on one hectare with 4 900 trees. Thinning was done after 2-3 years, and harvested on the 8th year. The cassava-green bean system was for one hectare with a two-year crop rotation cycle (first with cassava and second with green bean). Details of the improved AFS designs are presented in Table 4. The calculations are all for one hectare each.

Table 4. Agroforestry systems identified by the female group (AFS 1) and male group (AFS2)

Relative slope location	AFS1 (female group)		AFS2 (male group)		Objective
	Description	Detail	Description	Detail	
Top	Acacia Planting density: 2 500 plants per hectare (Distance per plant: 0.5m * 0.5m). 500 trees planted. Harvest after 7 years.				Prevent soil erosion and landslides.
Contour line	Strips of ginger Harvest 70% of the ginger, once per year and leave the rest for self-reproduction in the next season (to keep the advantage of reducing soil erosion)				Reduce soil erosion and maintain soil moisture.

Middle	Intercropping jackfruit and aquilaria, understorey ginger Jackfruit: 100 plants per hectare, 30 trees planted (10m * 10m) Aquilaria: 625 trees per hectare, 188 trees planted (0.25m * 0.25m)	Cassava and peanut Rotation Cassava year 1-2, 4-5 and 7 Peanut year 3 and 6 (one crop/year)	AFS 1: Prevent soil erosion, maintain soil moisture and soil nutrients. Economic AFS 2: Improve soil fertility, maintain soil moisture and soil nutrients; economic
Contour line	Strips of ginger Harvest 70% of the ginger, once per year and leave the rest for self-reproduction in the next season (to keep the advantage of reducing soil erosion)		Reduce soil erosion and maintain soil moisture.
Foot	Rotation peanut (March – May), green bean (June – August), fallow (September-March) Fallow due to heavy rain from September to November and cold temperatures in winter	Cassava and peanut Rotation cassava year 1-2, 4-5 and 7; Peanut year 3 and 6 (one crop/year)	Soil fertility; spread harvest time; economic

The improved AFS identified by the women group had acacia plantations on the upper slope, and strips of ginger, a section of multistrata and rotation of annual crop in the foothill. The men's group choose a similar system for the upper slope, with acacia and peanut as rotation for the lower part of the hill (Table 4).

Table 5. Summary of cost-benefits for BAU 1 & 2, and agroforestry (AFS) options designed by men and women

	System components	Gender	Period	Net benefit for the period (1 000 VND) per hectare
BAU 1	Acacia monoculture	N/A	7 years	≈ 6 000
BAU 2	Cassava (1 crop/year) rotation with Green bean (2 crops/year)	N/A	7 years	≈ 75 000
AFS 1	Acacia, peanut, green bean, ginger, jackfruit, aquilaria	Female	7 years	≈ 141 000
AFS 2	Acacia, peanut, cassava, ginger	Male	7 years	≈ 147 000

The net benefit from AFS is twice as much as the annual crop rotation, and over twenty times more than monoculture acacia plantation. The NPV of both AFS outweighed that of monoculture acacia (Table 6). The economic performance was highest for AFS2 with about VND100 million/ha (Table 7) and AFS1 with VND75 million/ha - these are 1.5-2 times higher than the conventional rotation of cassava and green bean, which is only about VND50 million/ha. The poor performance of monoculture acacia is due to the high density of trees, and shortened period that farmers grow them - farmers usually harvest trees even after three years for home use.

Table 6. Cost-benefit analysis for AFS1 in comparison with acacia plantation (Unit: 1 000 VND/ha)

Year	Monoculture acacia			AFS 1		
	Cost	**Income**	**Net benefit/(loss)**	**Cost**	**Income**	**Net benefit/(loss)**
1	19 225	0	(19 225)	104 327	47 400	(56 927)
2	5 160	0	(5 160)	19 657	47 400	27 743
3	4 680	0	(4 680)	19 700	47 400	27 700
4	2 400	0	(2 400)	19 752	51 600	31 848
5	2 400	0	(2 400)	19 813	52 200	32 387
6	2 400	0	(2 400)	19 813	52 200	32 387
7	2 400	44 625	42 225	19 813	65 950	46 137
Total	*38 665*	*44 625*	*5 960*	*222 875*	*364 150*	*141 275*
		NPV (*i* = 10%)	(8 074)			75 807

Table 7. Economic performance of AFS2 compared to monoculture cassava (2 years) and green beans (1 year) (Unit: 1 000 VND/ha)

Year	Crop rotation			AFS 2		
	Cost	**Income**	**Net benefit/(loss)**	**Cost**	**Income**	**Net benefit/(loss)**
1	22 126	33 525	11 399	20 358	32 160	11 802
2	22 126	33 525	11 399	17 845	32 160	14 315
3	34 340	43 320	8 980	22 755	54 600	31 845
4	22 186	33 525	11 339	17 725	32 160	14 435
5	22 186	33 525	11 339	17 155	32 160	15 005
6	34 340	43 320	8 980	22 755	54 600	31 845
7	22 186	33 525	11 339	18 285	32 160	27 625
Total	*179 490*	*254 265*	*74 775*	*136 878*	*283 750*	*146 872*
		NPV (*i = 10%*)	52 204			97 813

The income from peanut was low compared with cassava, as autumn rains and low winter temperatures only allow for one crop per year. However, farmers intercropping peanut with cassava found that it added one extra yield/income without negatively affecting cassava. In terms of the indirect gains, farmers already acknowledge the value of peanuts for soil and water conservation. By visual observation, the growth of cassava intercropped with peanut was significantly better than the monoculture cassava during the two-month spring drought in 2015. The improved systems have strips of ginger, which prevented soil erosion if not all are harvested at the same time. Planting ginger (which requires shade) in association with trees and grass strips was also suggested by farmers in a neighbouring village. Preliminary findings from on-farm agroforestry trials in northwest Viet Nam show that grass strips with trees along contour lines could reduce soil erosion by up to four times, which translates into real money by saving costs for fertiliser (AFLI, unpublished data). Studies have indicated that acacia-cassava intercropping are less sensitive to weather-stress, and reduce the period needed to recover financially (Simelton et al. 2015). Several studies have highlighted that jackfruit is one of the trees least sensitive to extreme weather events (Nguyen et al. 2013, Simelton et al. 2015). For example, during the tornado in 2015, trees lost their flower and resulted in less fruits, however, the main trunk and branches remained intact, compared to acacia-plantations, which had many broken and bent branches (Le and Simelton 2015). The AFS presented here had similarities with those identified in neighbouring villages. In all cases, the women's groups tended to choose a higher diversity, and higher value trees and crops than men.

Limitations of the study

After one full 7-year cycle, both agroforestry systems reach a higher NPV than the monocultures through more diverse production. A longer return period would render even higher values from trees such as aquilaria and jackfruit in AFS2. However, the CBA results may not be comprehensive, and can be misleading due to fluctuations in price, market-demand and the influence of middlemen.

Where one agroforestry system is ecologically suitable to a particular region, adoption depends on the available opportunities to access financial and technical support, as well as availability and stability of market. A clear agroforestry strategy developed in collaboration with farmers, researchers, business communities and local governments can avoid many of the traps (Thang et al. 2015).

Conclusion

This sample CBA shows that agroforestry systems provide higher profit (2-20 times higher) after seven years compared to monocultures. Depending on the mix of species, simple agroforestry systems in this study were profitable within two years. Furthermore, there is evidence that integrated systems can reduce the risks of crop failures compared to monocultures. The economic benefits of agroforestry are easily observed; nevertheless, farmers stay with monocultures due to lack of capital for initial investment and management guidance from extension. Farmers generally know little about what combinations of trees and crops have higher complimentary effects. This points to the need for information and demonstration models. Prudent sequential planning of agroforestry should be done to minimise economic risks, as well as weather impacts.

3. Participatory prioritisation of climate-smart practices

This chapter presents the participatory process to identify and prioritise Climate-Smart Agriculture (CSA) practices in My Loi village. The process includes developing a long list of needs and solutions, modifying the options into a portfolio of CSA options, and the prioritisation event. This section provides detailed information of the portfolio of prioritised CSA practices in My Loi village.

Method – Deriving the CSA long list

This sections describes how the long list of CSA needs was derived, the CSA assessment (Table 3) that was refined into a portfolio of CSA options and prioritised by villagers (Figure 1).

Making a list of CSA practices

As part of the Village Baseline Study[7] (VBS) conducted in 2014, My Loi villagers identified their needs and possible solutions that could be addressed through CSA interventions (Table 8). The long list of topics can be described as an initial basket of promising technologies based on suggestions from women and men farmers who attended the focus group discussions, government and non-government organisations, and other relevant stakeholders with good knowledge of the issues at stake, the local history and context, and of the experiences with past technology interventions (Vernooy et al. 2015). The 13 original options presented in Table 8 were short-listed to 10, through a series of activities, including consultations with male and female villagers, local leaders and experts, field visits, and CBA until August 2015.

The CSV-team paid attention to what particular problems the different CSA-options were set out to address and the dimensions of climate-smartness, potential negative consequences, and expected costs and benefits. Options with unsecure ownership were discarded for the time being, like cage fishing. By modifying the methodology introduced by Vernooy et al. (2015) in identifying CSA options, the portfolio included a mix of practices that can be implemented at the household level or at a landscape scale--the latter thus require collective action.

The 10 CSA options and their main pros, cons and “smartness” objectives are summarised in Table 10. Compared to the items listed in Table 8, the CSA portfolio was refined into actions

[7] A standard part of the CCAFS baseline survey.

for specific farming systems or land uses. Many options were kept flexible to provide entry points to other practices (see Figure 5.a and 5.b) and ensure that the villagers' priorities were considered from different angles that were important to them.

Table 8. CSA priorities identified through participatory village meetings with some concrete opportunities to link to CCAFS and partners (2014)

Gaps in knowledge/ current constraints that could provide opportunities/niches for CCAFS and partners	**Opportunities for research (CCAFS)**	**Opportunities for Action Research (CCAFS partners)**	**Development Interventions (Partners)**
Drought-tolerant varieties, esp. peanut		*X*	
Adapting farming calendar to avoid crop failure and spread harvest time (e.g. cassava)	*Opportunities for collaboration across CCAFS and other projects in the province, engaging local businesses*		
Improved weather forecast	*CCAFS Flagship project on agroclimate information systems: ICRAF, CARE, IMHEN*		
Enhance soil and water conservation		*IWMI and Lao CSVs*	
Water harvesting methods and crop combinations for rainfed upland fields	*Learning from ICRAF sites, And IWMI*		
Water management and land use planning, esp. for vegetables and fruit trees	*ICRAF, IWMI, AVRDC*		
Testing cage-fish in the reservoir		*Worldfish*	
Demonstration models for livestock (cattle, pig, chicken)	*Demonstration sites in Ha Tinh And Philippines (Flagship 1.3)*		
Train Farmer Union staff on livestock disease and food safety	*X*	*X*	
Test new higher value species, e.g. macadamia, avocado, mandarin, and custard-apple		*ICRAF projects*	
Waste management for bio-energy, small scale compost production		*IAE bio-char cooking stove*	
Diversify acacia market value chain (i.e. plywood)			*X*
Food and feed safety, e.g. pest monitoring	*ILRI Flagship 2; CABI*	*Aflatoxin content in peanut rice*	

Source: Le et al. (2015)

The CSA options were prepared on large posters and presented to the farmers. The posters are available in Vietnamese in Appendix 3. While the methodology proposed by Vernooy et al. (2015) recommends to describe technologies "as precisely as possible", the My Loi team realised there was a trade-off between presenting too much detail and allowing for the proposed interventions to be open and flexible to account for local knowledge to solutions and also recognising that priorities may change quickly.

Before the CSV technology fair, the research team invited a pilot group of 10 farmers (5 men and 5 women) with diverse farming activities to elicit feedback on the technologies and ensure that the posters are understandable. The group also tested the scoring card for voting

(Table 9). The My Loi CSV team had simplified and reduced the number of questions as earlier experiences during the training had indicated that the scoring card suggested in the methodology was overly complex and time consuming. After discussing with the participants, the team decided that an even simpler voting system would be more feasible for such a large group of participants. The revised scoring card tested with farmer test group was useful as topic guide for group discussion but discarded as too complicated for getting individual responses in a large group. With uncertain budgets for the following years, the one primary objective being to raise awareness about CSA without raising expectations that could not be met, and simply, to know what CSA practices the villagers prioritised, and whether women and men prioritised differently.

Figure 4. Village test farmers are scrutinising the CSA posters before the CSA fair.
Photo: Elisabeth Simelton/ICRAF.

Table 9. The revised scoring card

	□ Nam □ Nữ	□ Man □ Woman	CSA practice 1	CSA practice …
	Kỹ thuật này	**This practice**		
1	có thể tăng năng suất	can increase productivity		
2	có thể tăng thu nhập	can increase income		
3	phù hợp với thời tiết ở Mỹ Lợi	is suitable for the weather in my village		
4	cả nam và nữ có thể làm	both women and men can do		
5	có thể cải thiện chất lượng đất	can improve soil fertility		
6	**Kỹ thuật này…**	This practice…		
A	gia đình chúng tôi đã làm rồi	..my family already does		
B	phù hợp với những hệ thống nông/lâm nghiệp của gia đình, và chúng tôi có thể làm ngay	..is suitable for the family's farm and we can do it immediately		
C	tôi rất thích làm, nếu … gia đình có nhiều công …có hỗ trợ đào tạo hoặc kỹ thuật …hỗ trợ vốn hoặc đầu tư	… I would like to do if we … have enough labour … can get technical support or training … can get loans or financial support		
D	tôi không muốn làm kỹ thuật này bởi vì … mất nhiều công … đầu tư nhiềunhiều … không đủ đất	I don't want to do this because … it's too labour demanding … requires too much investment …we don't have enough land		

☺ = đồng ý = agree; 😐 = không biết = don't know ☹ = không đồng ý = disagree

The CSA fair

The CSA prioritisation fair was organised in the commune hall as an open event for all villagers. The village leader announced the event using the village's loudspeaker system. Over 200 villagers attended the event, with slightly more women than men. The posters with CSA technologies were hanged on the walls for pre-reading while people were waiting to get seated. Using a projector, the research team presented each of the technologies and interacted with the farmer pilot group, asking them to clarify. This created an open and relaxed atmosphere for participants to discuss each CSA practice. The participants could raise their hands and interrupt with questions at any point during the meeting.

After a final overall question and answer session, participants were asked to walk through the posters where members of the research team would clarify further if needed. Finally, the participants voted for the practice that seemed applicable to most of them. The votes were colour-coded for gender, and participants simply wrote the number of the practice and their names, so that the team could contact them later. The posters with options were pasted on the village board so that farmers could refresh their minds in their own time after the CSA fair.

The priority CSA portfolio

The CSA portfolio

Table 10 provides a summary of the CSA portfolio with 10 practices, and their anticipated pros and cons. Below, we give some additional background and rationalisation for the practices, based on consultations with villagers in My Loi, local leaders and experts and the final results.

Table 10. Portfolio of ten CSA practices

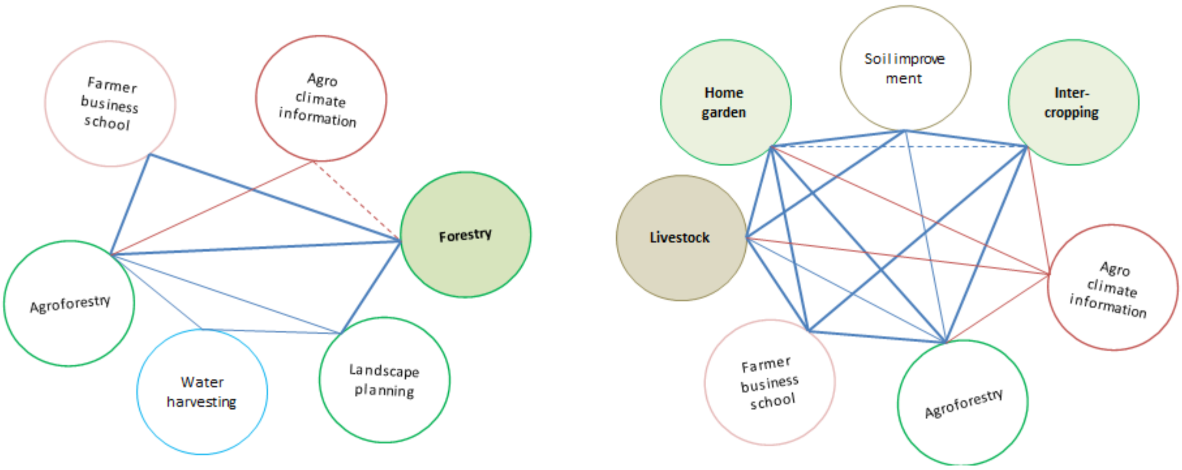
Practice name Description of intervention	Pros	Cons	CSA "smartness"	Individual and/or group activity
Home garden intensification Fruit tree diversification Village nursery, fruit tree management e.g. pruning, grafting	- Income and food diversification (high quality fruits, control diseases) - Improved environmental functions (tree shade, windbreak trees)	- High initial investment - Select fruits with low or diversify risks of weather impacts - Requires technical training - Uncertain markets	Market-smart* Weather-smart Nutrition-smart Gender-smart*	I
Intercropping Annual (see sustainable intensification) or mix annual-perennial (see agroforestry) crops	- More efficient use of land - Potential to reduce pest - Spread risks and adjust farming calendar according to weather - Weed control - Improve soil fertility - Soil erosion control	- Different models needed depending on location - Need to study competition effects not to cause yield reductions	Water-smart Soil-smart Gender-smart*	IG
Forestry Forest enrichment, species diversification, tree domestication Village nursery Forestland allocation (see possibilities to include with landscape planning)	- After establishment, improved micro-climate (wind, humidity, temperature) - Soil improvement - Protect soil and water resources - Pollinators and biological pest controls	- High investment for nurseries - Risk of storm fell during establishment phase	Weather-smart Carbon-smart Soil-smart Market-smart* Gender-smart*	G
Sustainable intensification (See intercropping annual crops) Diversification with short-term cash crop to fill gaps in farming calendar	- Crop diversification - Adjustable according to weather - Potential to incorporate legumes, soil improving cover crops	- Weather impacts higher than intercropping and agroforestry - Uncertain markets	Market-smart* Soil-smart Weather-smart	I
Agroforestry (see also intercropping, livestock, forestry and home garden) Targeting new systems, multipurpose species and new locations especially upland areas Planting along contour lines, windbreak trees	- Multipurpose trees and crops, efficient use of land - Landscape conservation - Long-term income diversification - Biophysical pest control - Improving environmental functions	- High initial investment - Time consuming to establish - May require large coherent area or group of farmers - New models require study of competition effects to avoid yield loss	Soil-smart Weather-smart Nutrition-smart	I(G)

Practice name Description of intervention	Pros	Cons	CSA "smartness"	Individual and/or group activity
Landscape planning Larger scale climate-smart interventions, e.g. contour planting, catchment management and forest land allocation plan (see also forestry)	- Improving environmental functions - Windbreak - Improve soil and water quality - Fodder-grass	- Requires farmers groups - Take time to see impacts	Water-smart Soil-smart	G
Soil improvement Biochar production, composting, vermiculture Grass strips to reduce soil erosion	- Improve soil quality - Increase yield - Reduced costs for fertiliser	- High initial investment in bio-char	Energy-smart Soil-smart	I
Livestock Feed, animal health and manure management (biogas) cattle, pigs and indigenous chicken Growing fodder grass and bushes, testing new grass varieties Livestock disease forecast	- Opportunities to increase and spread income over the year - Improved animal health	- Requires training - Requires establishing cooperation with meteorological department and veterinary station	Soil-smart Energy-smart	IG
Water harvesting and management (see landscape planning) larger scale interventions such as water ponds on slopes to ensure irrigation during dry periods (intercropping) smaller scale interventions to collect rainwater and reduce soil evaporation	- Reduced loss caused by droughts	- High initial investment cost - May require farmer group	Water-smart	IG
Farmer business school Make business and investment plans for longer-term planning Farmer logbooks and monitoring weather and farm economics	- More effective farm decisions - Manage loan and income efficiently	- Requires training	Knowledge-smart Market-smart*	IG
Weather forecast Agroclimate information system with a seasonal and updated weather forecast, agricultural advisory and scenario planning in farmer learning networks (This option will be implemented as CCAFS flagship project. It was excluded from the voting and was only introduced to inform villagers about the activity.)	- Part of the project activity - Improved chances to avoid or recover from natural disasters	- Requires farmer interest groups - Forecasts can be wrong	Weather-smart Knowledge-smart Gender-smart*	G

** Market and gender-smart considerations were added by CCAFS-SEA.*

CSA prioritisation results

The village chose four CSA priorities namely, home garden improvement, livestock raising, intercropping, and forestry (Figure 6). Livestock and home garden improvement indicate the needs and wishes for higher value products and/or less labour demanding practices that raise incomes. We notice a clear gender difference. Women voted primarily for options that can reduce their labour and time, in particular in distant fields to work closer to their homes, and raise incomes from home gardens and plains. More men preferred forestry options.



a) b)

Figure 5. Clear overlaps (thick line) and potential linkages (hatched line) between prioritised CSA options (filled circle) (a) forestry, and (b) home garden, livestock and intercropping, and non-prioritised CSA options (white circles). The red circle and lines denote the CCAFS project on agro-climate information, which was presented as a CSA but not included in the voting.

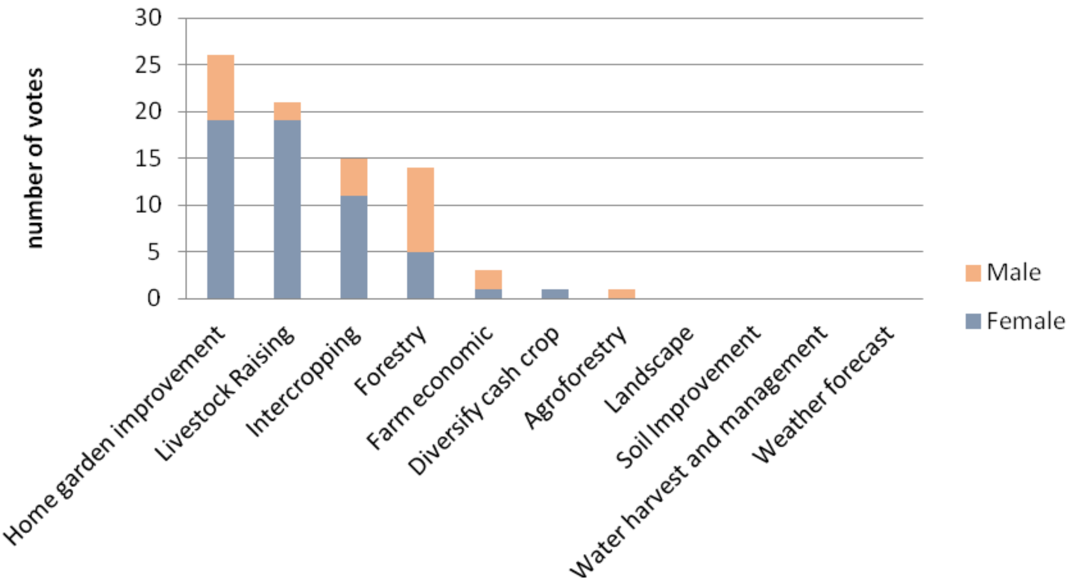


Figure 6. Distribution of votes for CSA topics options in My Loi CSV (n=81)

Rationale for the four CSA priorities in My Loi CSV

This section presents the rationale for the four selected CSA priorities in My Loi CSV (from the CSA portfolio). In terms of agricultural production, the commune Ky Son is dominated by cassava and peanut production (530 ha and 220 ha, respectively), while there is only 164 ha of paddy field (on average 10-15 ha per village). Of this, My Loi had 40 ha cassava, 30 ha peanut including some home gardens, and only 8.5 ha for rice. The plain fields are suitable for rice, sweet potato, maize and green beans; however due to water limitations (there is only 1 km cemented irrigation channel), only two fields could produce two crops per year. Rice was never considered because the area is small, and farmers preferred higher value crops or to leave the land as fodder grass fields, which is common in other parts of the province.

Soil quality and irrigation availability were perceived to restrict farming in both home gardens and crop fields. Suggestions for CSA have included enhanced use and production of organic fertiliser such as backyard livestock (as source of manure) and composting. Biochar cooking stoves were introduced by the Institute for Agricultural Environment (IAE) and will be tested for soil improvement in cassava and peanut cultivation as energy- and soil smart option.

Home garden improvements

Palm tree has traditionally been one of the most important trees in home gardens. However, with more permanent housing construction material available, palm leaves are no longer used for roofs. Due to its low economic value, farmers were interested in planting higher value trees. In particular, they would like to test the suitability of macadamia, avocado, local varieties of citrus such as mandarin and “Chanh” orange, alongside annual crops such as vegetables while continuing with maize, soybean and peanuts for the local market. A local variety of sweet potato (which sells at VND 10000/kg compared the conventional VND 7000/kg) is also of interest.

Establishing tree nurseries for home garden, agroforestry, and forest is a necessary step to ensure seedling supply of a wide range of species that contribute to nutrient-smart systems (especially for home gardens and agroforestry). Tree selection, grafting and pruning techniques are known to be good practices that provide quicker returns to investment, often with higher yields and fruit quality, making the option ‘market-smart’.

Intercropping and sustainable intensification

Existing examples of intercropping illustrate that farmers know how to spread economic risks across the year, e.g. cassava and peanut or cassava, peanut and maize (Table 3). Cassava is normally harvested between October and December for 10-12 month varieties. During the baseline studies in 2014, the local VEDAN factory (cassava starch production) wanted farmers to extend the harvest time in order to have more regular supply. However, with low prices, lack of quality seeds and capital to invest, farmers expressed little interest. Instead, they intercropped cassava with peanuts to get extra income. The observed benefits of intercropping cassava with peanut included reduced soil evaporation, nitrogen-fixing roots, and weed suppression. The benefits show that farmers are aware and do, what might be called, climate-smart practices. Having such examples opens up opportunities for testing other intercropping options, such as grasses or fodder shrubs as a potential approach to also intensify the land use that currently is left to fallow during the year (Section 2). The cassava option for CSA will most likely be reconsidered as it was announced after the CSA prioritisation workshop that the VEDAN factory will close down in 2016.

Intercropping with legumes as cover crop has wider environmental benefits. In particular, during spring droughts with foehn winds, a type of dry, warm, down-slope wind that occurs in the lee (downwind side) of a mountain range, and tropical rainstorms, cover crops can prevent wind and soil erosion, reducing sedimentation in dams and reservoirs. There are many opportunities for intercropping and intensification that enable farmers to select species according to local biophysical and socioeconomic conditions. Finding a list of suitable species, such as peanuts, beans and grasses can thus, qualify as soil-smart, water-smart, and weather-smart interventions.

Forestry (agroforestry)

Ky Son commune has both natural and planted forests. The natural regeneration forest consists of small trees and regrowth rather than full-grown trees. Farmers in My Loi recognise that forests are important for retaining surface and groundwater, avoiding landslides and microclimate regulation. Non-timber forest products for handicrafts such as *Coryphe-Saribus* for hat making, rattan and bamboo, as well as medicinal plants contribute to household incomes.

Acacia and cajuput for paper pulp production dominate the planted forest areas (approx. 0.5-2 ha/household) with a 3-year cycle. While bamboo-plantations and grass strips were proposed by villagers to reduce soil erosion from the sand mines.

It is expected that about 800 ha of communal forest will be allocated within the next few years, in which 200-300 ha is in My Loi village. This provides an opportunity to introduce sustainable forest management with mixed species and agroforestry. There was currently no local nursery for tree seedlings for either acacia or other timber and fruit trees. Establishing smallholder nurseries (within the framework of the land use planning and flagship crops) would reduce the cost for seedlings and provide a business opportunity for farmers.

Water harvesting methods could span from farm scale by reducing soil evaporation through intercropping. Landscape interventions such as water ponds on hills were not considered a high priority in My Loi. One reason could be that farmers had not seen good examples of the practice, and therefore perceived upland irrigation not worthwhile. The same was found in nearby Ky Trung commune, where tea producers preferred harvest losses due to drought over irrigation costs.

Livestock raising

Farmers continuously expressed interest in raising more livestock in particular pigs, which could provide a more stable income throughout the year. The options would involve producing feed (i.e. grass and banana) through grass strips to prevent soil erosion as well as ensuring safe drinking water. Lessons can be drawn from the 19 farmers in the commune who already have established household biogas systems. According to them, the waste from 5 - 10 pigs supplies 1-2 households for cooking and light; cattle and buffalo manure can further be used to feed vermiculture.

The livestock option requires close collaboration with local veterinary authorities for disease advice and feed production. Weather-related animal diseases are a severe challenge for livestock. Hence, opportunities to inform animal disease and management through the forecast and agroclimate information will be sought through the ACIS project and other flagship projects.

Limitations of the approach

While the overall methodology (Figure 1) proposes an iterative process of workshops to derive prioritised CSA options, Vernooy et al. (2015) documented one particular stage of this process, the so-called CSA fair. In the context of My Loi, besides the uncertainties with the CCAFS project budgets, two key external market-related events happened that made the team cautious against provoking any impression that the vote was a definite decision or promise. First, the closing of the cassava factory will change the cassava-dominated land use. Second, two large-scale cattle farms will likely start operating in the province, of which, at least one in the district – this will affect local farmers activities significantly, opening up potential for feed suppliers. Such events happen in many other places than My Loi CSV, which demonstrate that crop diversification and integrated farming systems are viable market-smart CSA options for smallholder farmers.

In addition, to provide farmers a fair chance to understand and know what CSA options they were evaluating and voting for, we strongly believe that a series of workshops, demonstrations and field visits would need to be undertaken. Our approach was thus to have flexible rather than very detailed options, to widen and challenge their imagination about CSA, and for the voting, to provide different entry points to similar CSA solutions.

Conclusion

For wider scaling of the prioritisation framework (Figure 1) approach, we highlighted two focus areas. Firstly, as a step prior to Phase 1, before setting the priorities—document existing practices (Chapter 1). At the same time, start scoping the investment opportunities available through government policies, donors and partner organisations. In Phase 4, with the results from the farmers' prioritisation exercise, the team can approach relevant authorities for assessing the market potential and (a stage that is missing in the prioritisation framework, Figure 1) and agencies for co-investments. The use of score cards in the CSA prioritization methodology was modified with farmer groups to come up with a simpler voting approach.

To implement CSA options, ICRAF and partners may take advantage of existing development and public support programs. For example, the New Rural Development Program[8] supports VND 20 million to selected households in establishing demostration home gardens in order to achieve one of 19 the program's criteria. Value-chains also need to be better understood to bridge partnerships between farmers and agribusiness, exploring a more diverse portfolio of suitable integrated systems.

In the next steps, the CSV team, farmer group representatives and leaders from the village, commune and district will (i) ensure that the CSA portfolio is available to inspire other villages, and (ii) integrate with local land-use plans (developed as part of the CCAFS CSV project). Some interventions may require further climate impact assessments to analyse their long-term feasibility. The interventions that will be implemented in My Loi in 2016 will collaborate with other flagships to identify generic research questions across CSV-sites, as well as site-specific research in connection with agro-climate information systems (Flagship 2), and test community innovation fund as an approach to co-fund the interventions.

[8] *New Rural Development Program: The new rural area building, initiated by the Vietnamese Government in 2010, sets 19 criteria on socio-economic development, politics and defense, aiming to boost rural development. The list of criteria also covers the development of infrastructure, the improvement of production capacities, environmental protection and the promotion of cultural values.*

Synthesis: Lessons learned

A systematic and constructive framework

Productivity increases is often considered as farmers' primary performance and evaluation criteria, therefore seed producers, practitioners and donors argue that farmers will not adopt new CSA-practices unless these increase incomes. This monolithic idea may lead to inventories of CSA-practices that could be biased towards a particular aspect of CSA only. Focusing too single-handedly on short-term gains that may not be maintained for the longer-term, considering progressive impacts of climate variability or financially viability if practices are replicated and out-scaled would flaw the idea of looking for co-benefits and the whole concept of CSA.

Farmers already adopt CSA

The rapid field guide for identifying climate-smart practices in the field is useful as a topic guide to keep in the back of the head during scoping surveys. Its criteria can easily be complemented with indicators relevant for farmers or from a particular CSA aspect. However, only because farmers do one practice and think it works, it is no guarantee for its sustainability. The CSA documentation of current practices (Session 1) should be complemented with near-future biophysical and climatic suitability assessment.

Who benefits from CSA?

Here, Section 1 focused primarily on biophysical aspects although it is recommended that socioeconomic indicators are added. The intention of the original scoring card was to inquire about gender and socioeconomic consequences, however farmers may have difficulties anticipating how an unknown practice will affect their lives. Instead, the focus group facilitators have the responsibility to raise awareness about social aspects of the practice, especially if a CSA option is implemented, whose responsibilities, influence, and labour time may be affected, and how.

Agroforestry performs well

With marginal error, the CBA for agroforestry shows that, if farmers had the necessary start-up investments, agroforestry systems give a return over ten times that of monocultures over a seven-year period. Nevertheless, farmers perceive that it requires too much capital investment and/or takes too long before becoming profitable. CSA practices in agroforestry should therefore provide shortcuts to faster and higher yields for example, grafting, pruning.

Gender matters for CSA priorities

Both the CBA and the prioritisation clearly show that women and men both want trees, but women preferred fruit trees and home garden development while men were more interested in forestry development. Compared to focus groups discussion with mixed groups, the women were more outspoken in the women-only groups.

CSA interventions are no-regret options

CSA options need to be flexible as the economic, social and environmental contexts that farmers are operating in change rapidly. For example, in the case of My Loi with the closing of VEDAN factory, it is difficult to anticipate what affects this will have on cassava cultivation. The CSVs need to be open for such changes and be supportive and adapt options accordingly. The example from My Loi stresses that the development of the CSA options cannot be done in isolation, but rather requires inclusive consultations with local authorities, enterprises and donors. The interventions need to feed into existing development plans and support programmes.

Appendix

Appendix 1.1: List of baseline and improved CSA interventions

Current practices					
Practice	**Technology**	**Components**	**Livelihood (yield, income)**	**Effected by what extreme weather events**	**Other factors (for ex: soil, water, pesticide, market ….)**
Practice 1 : Annual crop-based farming system (maize, peanut ….) in home garden					
Baseline	Mono crop	Maize only	Yield = 3 ton ha-1	Affected by drought	Pets and disease …
	…				
Improved CSA intervention "practices"					
Practice	**Technology**	**Components**	**Food security/ livelihood**[1]	**Adaptation**[2]	**Mitigation/ ecosystem functions**[3]
Practice 1 : Improved home garden system (CSA)					
Improved	Alley cropping 1 (agroforestry)	Maize + pomelo	Expect to increase into 5 ton ha-1 maize and 11 ton ha-1 pomelo	Adding pomelo can reduce affect of drought and storm	
	…				

Appendix 1.2 Long list of CSA indicators

Before introducing this list to farmers, deselect irrelevant indicators and add or edit the remaining for the shortlist

[1]Food security / Livelihoods

- ☐ Increase yields
- ☐ Increase income
- ☐ Stabilise yields (reduce difference between seasons)
- ☐ Stabilise incomes (reduce variability over the year/between years)
- ☐ Diversify nutrient intake
- ☐ Start business development (income generation)
- ☐ Develop new marketable products (market-smart)
- ☐ Improved capacity of farmers to take action (knowledge smart)
- ☐ Interventions contribute to intra-household equal labour/income distribution (gender smart)
- ☐ ...

[2]Adaptation

- ☐ Reduce losses due to cold spell
- ☐ Reduce losses due to hot spell
- ☐ Reduce losses due to drought
- ☐ Reduce losses due to flooding
- ☐ Reduce losses due to landslide, soil erosion
- ☐ Reduce losses due to salt water intrusion/salinity
- ☐ Reduce storm impact
- ☐ Micro-climate regulation
- ☐ Increase soil moisture content
- ☐ ...

[3]Mitigation/Environmental services

- ☐ Reduced/more efficient use of fertilizer (reduce greenhouse gas emissions)
- ☐ Reduce methane gas emissions (reduce greenhouse gas emissions)
- ☐ Increase in tree cover (increase above ground carbon stock)
- ☐ Reduce soil erosion/soil loss (increase below ground carbon stock)
- ☐ Improve soil nutrient status
- ☐ Biological pest management (pest-smart)
- ☐ Reduced use of inorganic pesticide and/or herbicide (pest-smart)
- ☐ Reduce tillage (increase below ground carbon stock)
- ☐ Increase number of permanent plants (increase below ground carbon stock)
- ☐ Water regulation
- ☐ Clean water production
- ☐ Increased biodiversity
- ☐ Water conservation/water harvesting (reduce water consumption)
- ☐ Convert to non-fossil fuel/energy (reduce greenhouse gas emissions, energy-smart)
- ☐ Reduced fossil fuel/energy consumption (reduce greenhouse gas emissions, energy-smart)
- ☐ Interventions linked to REDD+
- ☐ Interventions linked to PES/PFES project
- ☐ Interventions counted to INDC reporting
- ☐ ...

Appendix 2: Topic guide for field reconnaissance of farming system

I. Farming system, detailed description of practice (Desk study, Observation)

1. What crop(s) are grown? What months? Harvest time? Growing area and yield? Average area per capita?
2. Monoculture (spatial and temporal rotation) or integrated systems (intercropping, alley cropping, ...)
3. How are they grown (row/alley, strips, mixed, relay; along contour lines; spacing)
4. Main benefits: economic stability, cash flow, diversification, environmental sustainability, aesthetics

II. Landscape location (Observation)

1. GPS-reference point
2. Slope, aspect, altitude
3. Soil type, colour, status and compactness,
4. Prevailing wind direction, soil water status
5. Distance to windbreak or forest, fenced?

III. Agronomic problems (Observation, interview)

1. Evidence of poor crop health status (miscoloured leaves, poor root systems, weak stems, pest attack, lodging, disease ...)
2. Nutrition deficiency, soil erosion?
3. Are agronomic problems related to
    - 3.1. Meteorological events (humidity, high/low temperature, excess/absence rain, variation in rainfall, storm, hail, ...),
    - 3.2. Environmental indicators (erosion, compact soil, water access, polluted water, absence/presence of competing species...),
    - 3.3. Household situation (household composition, age, size of farm, economic situation, non-farm incomes/work, debts, remittance, and lack of labour ...)
4. How common is the problem:
    - 4.1. Spatially (are other crops nearby affected)?
    - 4.2. Temporarily - How frequently does this happen? (What time of year? only this year? – Why? Regularly – why is nobody doing anything about it?)

IV. Agronomic good examples - Reference crops (Observation, interview)

1. What factors differ from fields/households/locations with agronomic problems? *See above agronomic problems*
2. Is the practice resilient to meteorological events (humidity, high/low temperature, excess/absence rain, variation in rainfall, storm, hail ...)?
3. Has the practice been changed recently in response to weather or to increase yields?

V. Inputs (Interview)

1. What seeds, variety? How much per unit area? How are they planted (by hand, machine)?
2. Planting density?
3. Nutrition deficiency, soil erosion?
4. Where do they get seed/seedling?
5. Nutrient inputs: What? Manure, NPK (what specific brand), Compost (what share) How much? When? Recommendations by extension service?
6. Water: Rainfed or irrigated (temporary or regular access?) or rainfed – what happens during droughts? During floods? What kind of irrigation system? Groundwater levels?
7. Labour inputs: Who does what? Gender inequalities?

VI. Outputs (Interview)

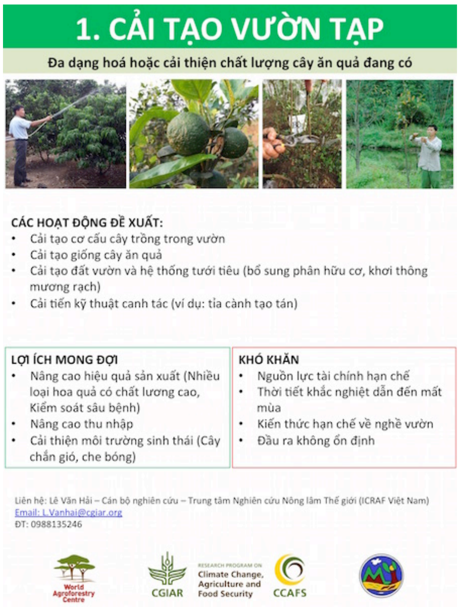
1. Yield (quantity per unit area, variability between years, and variation between fields? – why?)
2. Quality of yield/product
3. Market? Who has control over outputs, prices and market decisions (within household, middlemen, cooperatives, state-owned or private enterprises)? Price fluctuations over the past years?

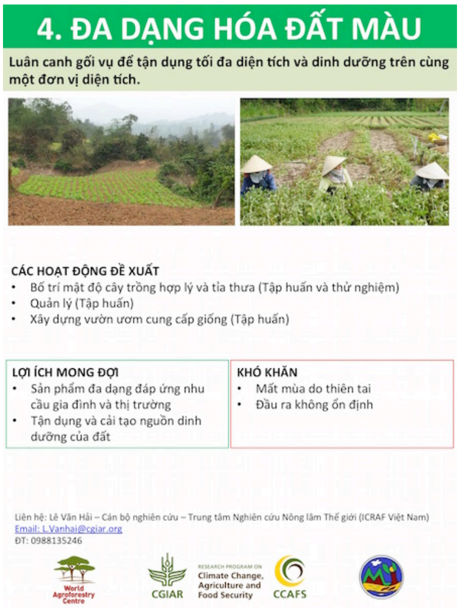
VII. Potential improvements (realistic, detailed)

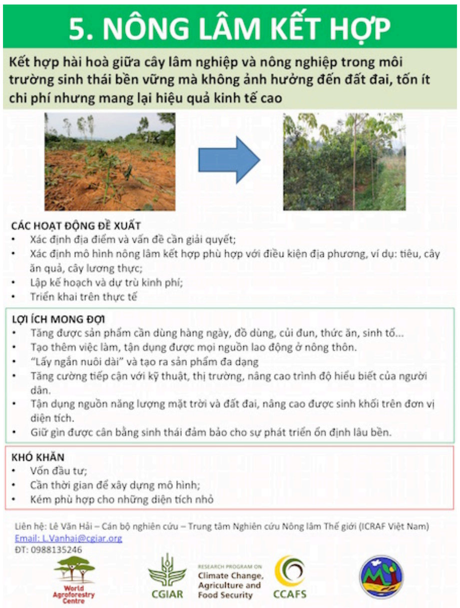
1. Farmers own views on improvements s/he have done (what was the outcome of that?), would like to do (but can't because of...?), will do (provided that ...)
2. Your own views on what could be improved? What may be wrong with the practice? The inputs, timing of planting/nutrients, site selection ... Exposed to natural hazards?
3. Do farmer keep logbook? (if yes, ask if you may borrow it and look)

Appendix 3: CSA Posters

1. Home garden diversification
2. Intercropping
3. Forestry
4. Cropland diversification/intensification
5. Agroforestry
6. Landscape planning







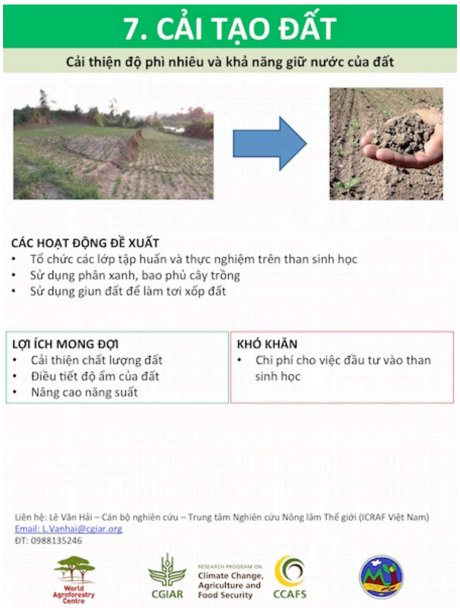
7. Soil enrichment

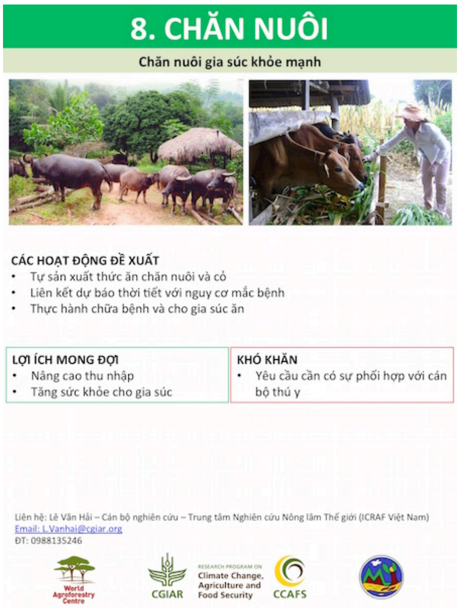
8. Livestock

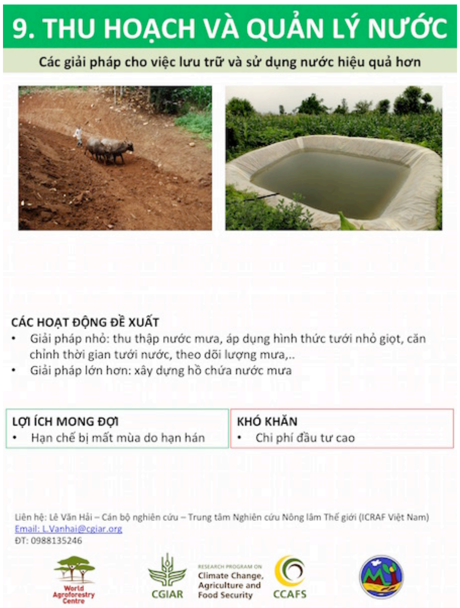
9. Water harvesting and management

10. Farm business management

11. Weather forecast and climate change adaptation







References

Challinor, A. J., E. S. Simelton, E. D. Fraser, D. Hemming, and M. Collins. 2010. Increased crop failure due to climate change: assessing adaptation options using models and socio-economic data for wheat in China. Environmental Research Letters **5**:doi:10.1088/1748-9326/1085/1083/034012.

Condit, R., 73 pages. . 2008. Methods for estimating aboveground biomass of forest and replacement vegetation in the tropics. Center for Tropical Forest Science and ForestGeo. Smithsonian Tropical Research Institute.

Emerton, L., K. Snyder, and J. Cordingley. 2015. Evaluating Land Management Options (ELMO): a participatory tool for assessing farmers' sustainable land management decision preferences and trade-offs. . International Center for Tropical Agriculture (CIAT), Nairobi, Kenya.

FAO. 1998. Forage Tree Legumes in Tropical Agriculture.*in* R. Gutteridge and H. Shelton, editors. The Tropical Grassland Society of Australia Inc, St Lucia, Queensland, Australia.

FAO. 2013. Climate-smart agriculture - Sourcebook. Page 570. Food and Agriculture Organization of the United Nations, Rome.

Haggblade, S., V. Theriault, J. Staatz, N. Dembele, and B. Diallo. 2011. A Conceptual Framework for Promoting Inclusive Agricultural Value Chains Michigan State University. Department of Agricultural, Food and Resource Economics Chicago.

Le, V. H., M. T. Duong, T. H. Do, K. H. Le, H. L. Phan, and E. Simelton. 2014. Village Baseline Study - site analysis report for My Loi, Ky Anh district, Ha Tinh province - Vietnam (VN02). Copenhagen, Denmark.

Le, V. H., M. T. Duong, and E. Simelton. 2015. Situation analysis and needs assessment report for My Loi village and Ha Tinh province - Vietnam (VN02). Copenhagen, Denmark.

Le, V. H. and E. Simelton. 2015. Documentation of hail and tornado episode, Ky Son commune, Ky Anh district, Ha Tinh province, Vietnam on 29 March 2015. ICRAF - CCAFS Technical Report No 1, Hanoi, Vietnam.

Matocha, J., G. Schroth, T. Hills, and D. Hole. 2012. Integrating climate change adaptation and mitigation through agroforestry and ecosystem conservation. Springer Science+Business Media, Dordrecht.

Nguyen, Q., M. H. Hoang, I. Oborn, and M. van Noordwijk. 2013. Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. Climatic Change **117**:241-257.

Rosenstock, T., C. Lamanna, S. Chesterman, P. Bell, A. Arslan, M. Richards, J. Rioux, A. Akinleye, C. Champalle, C. Corner-Dolloff, J. Dohn, W. English, A.-S. Eyrich, E. Girvetz, A. Kerr, M. Lizarazo, A. Madalinska, S. McFatridge, K. Morris, N. Namoy, A. Poultouchidou, H. Ström, K. Tully, and W. Zhou. 2015. The scientific basis of climate-smart agriculture: A systematic review protocol. Climate Change, Agriculture and Food Security (CCAFS), Copenhagen.

Schiffer, E. and D. Waale. 2008. Tracing power and influence in networks. Net-Map as a tool for research and strategic network planning. International Food and Policy Research Institute (IFPRI), Washington DC.

Simelton, E., B. V. Dam, and D. Catacutan. 2015. Trees and agroforestry for coping with extreme weather events - experiences from northern and central Vietnam Agroforestry Systems **89**:1065-1082.

Simelton, E. and V. B. Dam. 2014. Farmers in NE Vietnam rank values of ecosystems from seven land uses. Ecosystem Services **9**:133-138.

Simelton, E., V. B. Dam, R. Finlayson, and R. Lasco. 2013. The talking toolkit: how smallholding farmers and local governments can together adapt to climate change. World Agroforestry Centre (ICRAF), Ha Noi, Vietnam.

Thang et al. 2015; AJAEES, 5(3): 158-165, 2015; Article no.AJAEES.2015.049

UNIDO. 2011. Pro-poor Value Chain Development: 25 guiding questions for designing and implementing agroindustry projects. United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

Van Noordwijk, M. 2010. Rapid appraisal of Drivers of Land Use Change (DriLUC) Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA). A negotiation support toolbox for Integrated Natural Resource Management. World Agroforestry Centre, Bogor, Indonesia.

Vernooy, R., A. Bertuso, V. L. Bui, H. Pham, L. Parker, and Y. Kura. 2015. Testing climate-smart agricultural technologies and practices in Southeast Asia: a manual for priority setting CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

Vuong, V. Q. 2011. Water and soil conservation over forest status. Vietnam Forestry University, Ha Noi, Vietnam.

Zhao, G., S. Siebert, A. Enders, E. Rezaei, C. Yan, and F. Ewert. 2015. Demand for multi-scale weather data for regional crop modeling. Agricultural and Forest Meteorology **200**:156-171.

Zerbe, Jr., R., and D. Dively. 1994. Benefit-Cost Analysis: In Theory and Practice. New York: Harper Collins.

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