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Value Chain Analysis of Climate-smart Shan Tea Production in the Northern Mountainous Region of Vietnam[1]

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Abstract

Agricultural production in the face of climate change requires a transformation and reorientation in agricultural systems and policy making. Climate-smart agriculture (CSA) is such a transformative approach that aims to sustainably increase food security, by improving adaptation to climate change and capturing potential mitigation co-benefits. CSA approach goes beyond field level practices and encompasses value chains, food systems as well as enabling environments and policy. This paper provides a site-specific analysis of the contributions of organic and conventional Shan tea value chains (VCs) to CSA objectives by using a interdisciplinary approach.
Our findings show that both organic and conventional Shan tea VCs simultaneously contribute to food security and adaptation. Shan tea plays a vital role in securing household income and has a strong potential in helping households to coping with extreme weather events. Potential mitigation options are mainly in the processing stage (GHG emissions from coal burning).

Key words
Shan tea, value chain analysis, food security, agroforestry, climate change adaptation and mitigation

Introduction

Agricultural production in the face of climate change (CC) requires a transformation and reorientation of agricultural systems to supply adequate food for the increasing world population (FAO, 2013; Lipper et al, 2014; Campbell et al, 2014). Adversely, agriculture is also a key contributor to planetary warming. CSA is an approach to sustainably drive such

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system transitions at the global level. CSA has three objectives: sustainably increasing agricultural productivity and food security (FS); building resilience and adaptation of agri-food systems to CC; and decreasing GHG emissions and increasing carbon sinks where possible (FAO, 2013; FAO and CCAFS, 2014). In developing countries, where populations are more vulnerable to the effects of climate change due to their dependence on agriculture, FS and adaptation would be the priority of a CSA approach, while mitigation co-benefits can be captured if relevant. As the impacts of climate change on agriculture and food security are very site-specific, contextual research is essential to build evidence-based CSA policies. This paper addresses this need by providing evidence on the contributions of Shan tea value chains (VC) to the CSA objectives in the Northern Mountainous Region (NMR) of Vietnam, where poverty is wide-spread and climate change is already having a negative impact on livelihoods.

Vietnam is the fifth biggest tea exporter in the world with an export volume of 130,000 tons in 2014. The NMR is the largest tea producing area, accounting for more than 70% of tea production in the country (GSO, 2015); it has a varied topography with high slopes and deep valleys (Sen, 2012) and remains one of the poorest areas with highest concentration of ethnic minorities in Vietnam (World Bank, 2013). Together with rice and maize as annual staple food crops, perennial coffee and tea are the main cash crops for rural smallholder households (HHs) in the region. *Shan Tuyet* tea (Shan tea) is a key indigenous perennial crop. It significantly contributes to incomes and FS of local minorities, while improving landscape and ecosystem services.

There are two distinct Shan tea agricultural systems in the NMR: organic and conventional. The former is common at high altitudes (above 800 m.a.s.l.). It is practiced by ethnic minorities (i.e. H'mong, Thai, Dao) by leaving the trees naturally scattered with a low density (1,000 to 3,000 trees ha^{-1}). It is often seen as an agroforestry system, where Shan tea is integrated with rain-fed maize or rice in croplands; or with other perennials in home gardens (Lua et al, 2013; Sen et al., 2015). In conventional systems, Shan tea is predominantly planted in lowlands (below 1,000 m.a.s.l.). Shan bushes are planted from seedlings or cuttings with a high density (ranging from 10,000 – 13,000 plants ha^{-1}) and typically grown with shade trees (e.g. pointed leaf Acacia) to improve tea quality and yield (Branca et al., 2015). Intensive input technologies (fertilizers, pesticides, growth regulators and harvester) are only applied in the conventional systems, whereas organic Shan tea is grown with traditional low-input methods.

Research objective, questions, sites and scope

Research objective and questions

The objective of this research is to assess the synergies between FS, CC mitigation and adaptation in smallholder Shan tea production systems of NMR and to evaluate the economic and environmental tradeoffs between organic and conventional systems. The following research questions are addressed:

i) How could value addition and distribution in the VCs improve smallholders' income?

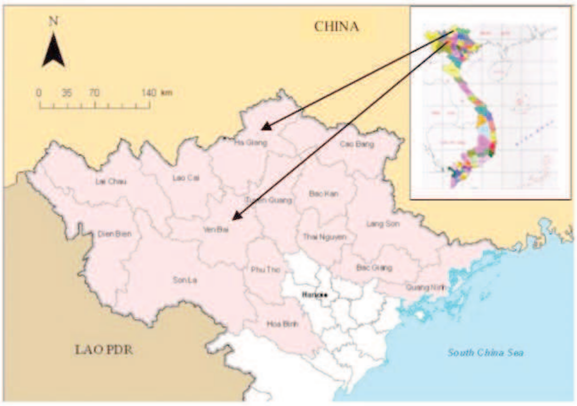
ii) To what extent extreme weather events (EWEs) may impact adaptive capacity of Shan tea producers?

iii) Where are the best opportunities for reducing GHG emissions in Shan tea VCs?

This study uses a holistic approach to look at CSA components throughout all VC segments of tea production. It employs a bio-climate-economic approach to combine natural resources and economic aspects with climate-related elements into analysis.

Research sites

Shan tea production is concentrated in 6 NMR provinces: Ha Giang, Lao Cai, Yen Bai, Dien Bien, Son La and Lai Chau, accounting for about 25% of the country's tea area. In this study, we focus our analysis on key Shan tea production areas, i.e. Ha Giang Province (Tien Nguyen Commune, Quang Binh District for organic tea and Viet Lam Town, Vi Xuyen Dictrict for conventional tea) and Yen Bai Provinces (Suoi Bu Commune for organic tea and Nam Bung Commune for conventional tea, both in Van Chan District).



Research scope

Studying about sustainability may include ethical and health dimensions (Gava et al., 2014, Galli et al., 2015). However, in this study, our analysis focuses on the CSA concept which includes social, economic and environmental dimensions with elements presented in Table 1.

Table 1. CSA dimensions and elements for assessment

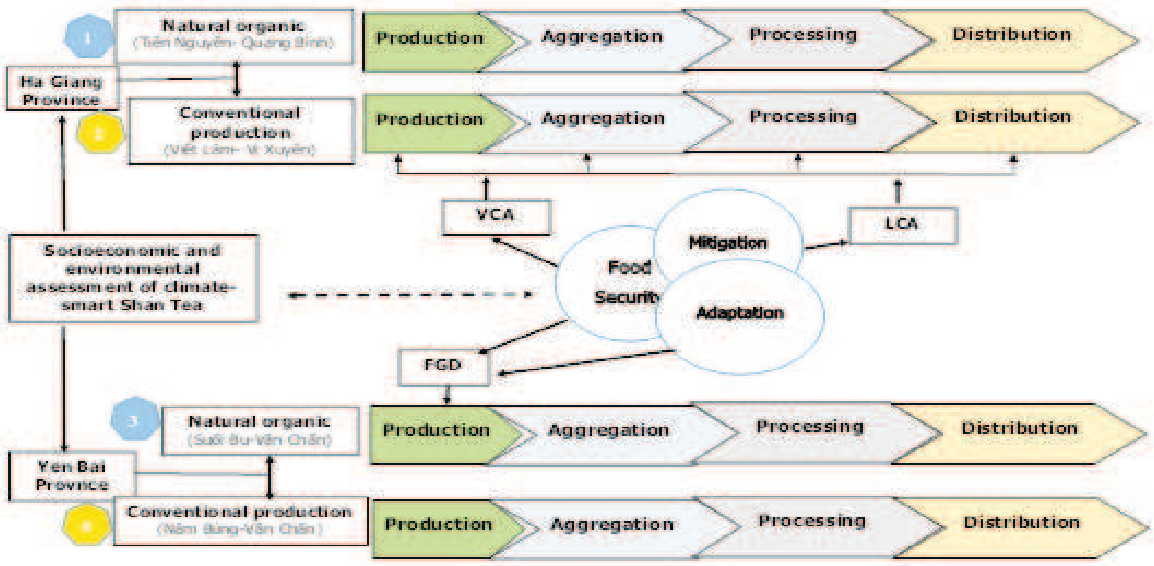
Dimensions	Elements	Where in VCs
Social	Info sharing and labor connection	All stages
	Food security	All stages
	Equality	All stages
Economic	Farmer's income and value added received	Production
	Value distribution	All stages
	Profitability	All stages
Environmental	GHGs emissions	All stages
	Adaptation potential	Production

Source: Adapted from Galli et al., 2015

Methodology

We analyze social, economic and environmental aspects of *Shan* tea VCs using primary and secondary HH survey data collected from upland provinces of Ha Giang and Yen Bai. A set of three methodologies is employed here, in line with the three CSA pillars: (i) value chain analysis (VCA); (ii) focus group discussions (FGD); and (iii) product life cycle carbon footprint assessment (LCA) (see Figure 1). FS and CC mitigation analysis is performed at VC level while CC adaptation analysis is carried out only at farm level.

Figure 1. Overall Methodological Framework



VCA is used to map Shan Tea VC in the study sites and impact on smallholders' Food security. This research adopts the global VC approach (M4P, 2008) and some principals of sustainable food value chain development (Neven, 2014). The VCA involves following steps: mapping VC actors, product and information flows; identifying value addition distribution; exploring upgrading options; and understanding governance mechanisms (Kaplinsky and Morris, 2001). Data for VCA are conducted by field survey and key informant interviews in selected sites. Intermediate costs, value added and net value added are estimated for all segments of the chain using equations (1) and (2) below.

Value added = (quantity x selling price) – intermediate costs (e.g. input materials) (1)
Net value added = Value added – additional costs (e.g. labor, energy) (2)

The contribution of Shan tea production to HH's income and CC adaptation has been assessed through FGDs. Robinson (1999) defines focus group as an in-depth, open-ended group discussion of 1-2 hours' duration that explore a specific set of issues on predefined and limited topic. This research method can generate more critical comments than interviews (Watts and Ebbutt 1987) and the information is expressed in participants' own words and context without having external interference. Focus group has been used in various research areas and contexts, ranging from market, health, educational research (Robinson, 1999) to agroforestry in coping with EWEs (Simelton et al., 2015) and VCA of tea and coffee (FAO EPIC[2], 2015).

In this research, we run four FGDs, each with 8-10 farmers, in four villages representing four communes in selected research sites, namely: Bu Cao Village–Suoi Bu Commune; Nam Cuom Village–Nam Bung Commune; Tay Son Village, Tien Nguyen Commune; and Group 12, Viet Lam Town. In each FGD, a combination of ICRAF[3] community-based tools (Simelton et al, 2013) has been applied to explore local farming systems and EWEs affecting the area. In order to assess the CC adaptation potential of Shan tea to these EWEs, we facilitated farmers to understand and then to rank the climatic suitability of all trees and crops in their farming systems to EWEs.

In order to assess the Shan tea importance for the level of income and for the stability of income in HH's livelihood activities, we used the modified Analytical Hierarchy Process (AHP) to analyze pair-wise comparisons between HH's income-generators. AHP is an alternative form of the multi-criteria assessment procedure that based on hierarchic levels of aggregation (Saaty, 1980). The method organizes the decision problem into sub-problems for easier judgments (Bartolini and Viaggi, 2010). In our study, such a judgment is structured as a pair-wise comparison between one of income generating activities (e.g. rice production) placed in the same hierarchical level and expressed their importance to HH's livelihoods, to each of other livelihood activities placed at the upper hierarchical level (e.g. tea production). We adapted the modified AHP using a five weighting scale instead of a nine scale guided in Saaty's AHP (Dewi and Martini, 2013). Microsoft Excel following Bunruamkaew's guidelines (2012) has been used for AHP data processing.

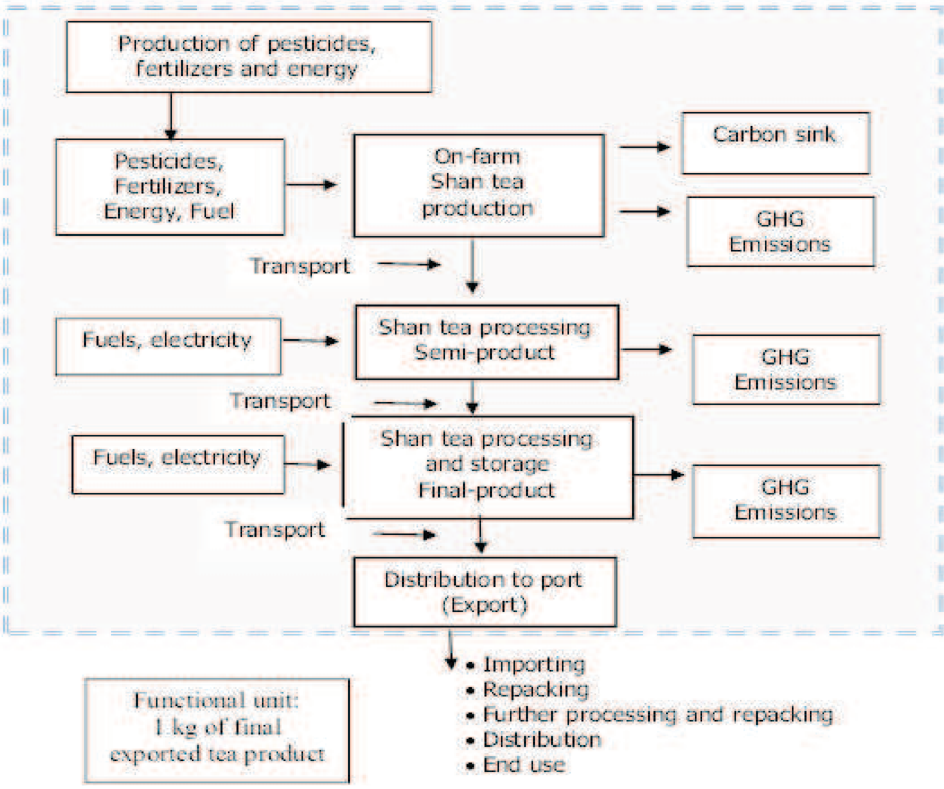
LCA approach is used in order to estimate CC mitigation contribution (Figure 2). We conduct a partial CF LCA (from cradle to gate) of tea product following ISO 14067:2013 "Greenhouse Gases – Carbon footprint of products – Requirements and guidelines for quantification and communication" and using emission factors (EFs) from Ecoinvent 2.2[4] and IPCC Tier 1 (2006)[5]. Life cycle or 'cradle-to-grave' is one of environmental management approaches. In ISO[6] 14040 (1997 & 2006) LCA, as defined, is "*Compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle*". Given the objective of this work, we only take global warming aspect with regard to carbon footprint (CF) into account. CF is an international standardized indicator of GHG emissions and has become a manageable tool for identifying areas of emissions reduction, particularly in the wine industry (Rugani et al., 2013).

Site-specific data have been collected from tea growers, agricultural inputs providers, processors, exporters operating in the VC. Secondary data, estimations and assumptions reviewed from the literature have been used as a complement. Next, GHG emissions (CO_2

[2] EPIC - Economics and Policy Innovations for Climate-Smart Agriculture
[3] World Agroforestry Center
[4] Ecoinvent is the Centre for Life Cycle Inventories who provides LCI databases, www.ecoinvent.org
[5] IPCC: Intergovernmental Panel on Climate Change
[6] International Standard Organization

and others) are quantified by multiplying inventory data and EFs. Finally, emission data are converted into CO_2 equivalents) and aggregated for the whole VC on a functional unit (FU), i.e. one kilogram of processed tea ready for exporting. LCA inventory data are processed by the GHG Protocol tools (WRI, 2015) and then converted into Microsoft Excel model for CO_2e calculations.

Figure 2. LCA system boundary for Shan tea

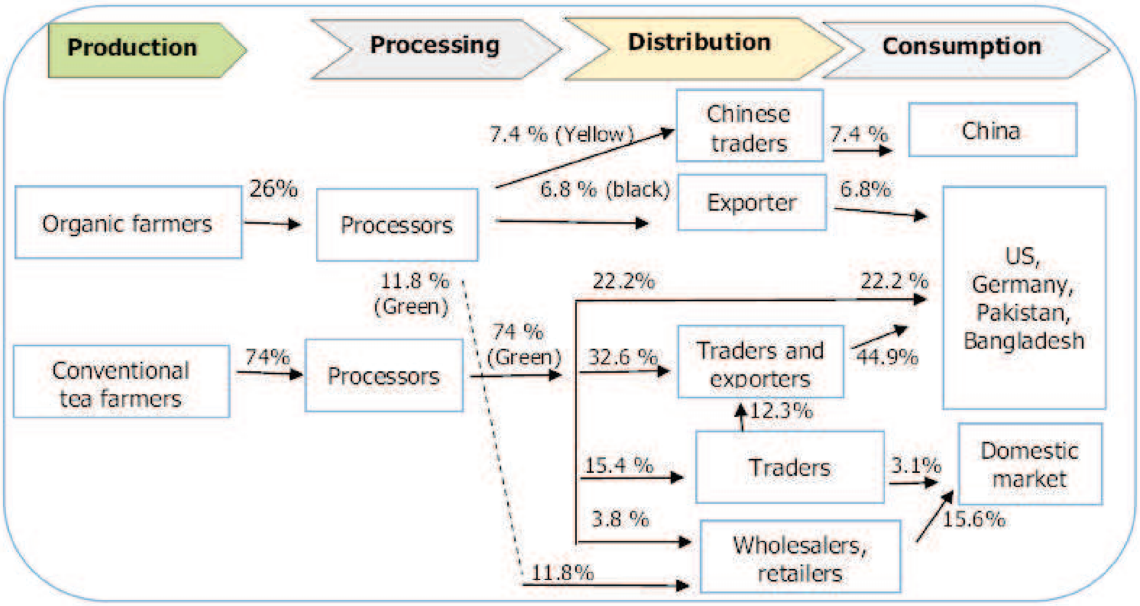


Results

Food security and socioeconomic aspects

VC map of both natural organic and conventional Shan tea in Van Chan District, Yen Bai Province is presented in Figure 3. There are three main actors playing three distinct functions: *Production*, which involves about 3,500 HHs, producing tea on about 1,420 hectares and supplying roughly 3,225 tons of fresh leaves; *Processing*, which comprises of 60 registered processors and a hundred of family-run mini workshops processing about 675 tons of dried tea; and *Distribution*, which includes about 300 local and provincial traders/retailers and 10-15 exporters who distribute products from processing stage to markets. In the organic VC, farmers contribute to only 26% of the total volume but their materials can processed into 3 categories of black, green and yellow tea[7] for exporting to China and other organic markets. Conventional tea growers have a much larger market share (74% of total market volume) but their leaves are only processed into green tea. It is noticeable that more than 80% of mass products of both VCs flows abroad, comprising of more than half of organic tea and about 95% of conventional tea. Organic Shan tea, however, is more demanding than the conventional one in Vietnam because of its premium quality.

Figure 3. Generic Shan tea value chains in Van Chan District - Yen Bai Province



Source: own elaboration, 2015.

As Shan tea flowed in 2 separate VCs, two export-oriented case studies, representing the two systems, are selected: Organic Shan (Figure 4) and Conventional Shan *(Figure 5)* in Van Chan District. In the former case, Shan tea farmers in the "highland areas" of Suoi Bu, Nam Lanh, Phinh Ho communes (producer) together with "Van Chan Shan tea Cooperative" (processor), and Vi Vang Co., Ltd (exporter) are among actors (Figure 4). Growers in Nam Bung Commune (producer), Gia Phu Co, Ltd (processor), Vinh Phuc Joint Stock Company (processor and packer) and Lien Son Joint Stock Company (exporter, also is the mother company of Gia Phu Co., Ltd) are those partners participated in the conventional case (Figure 5).

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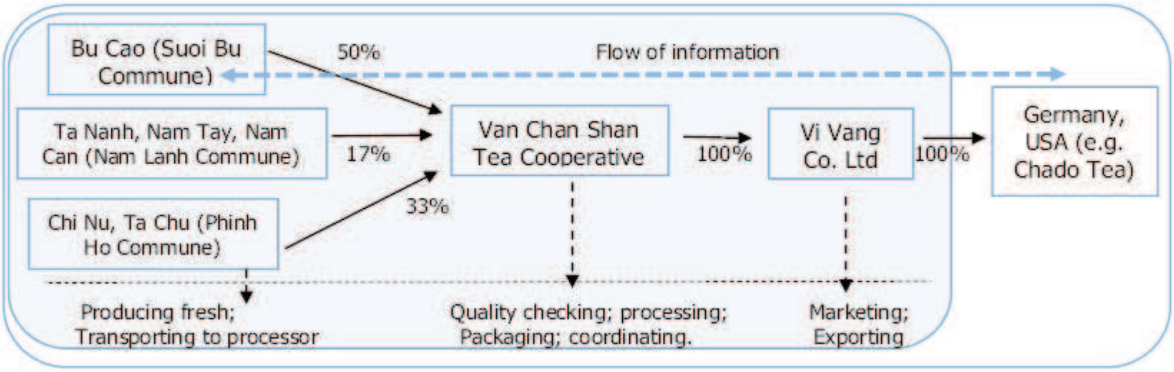
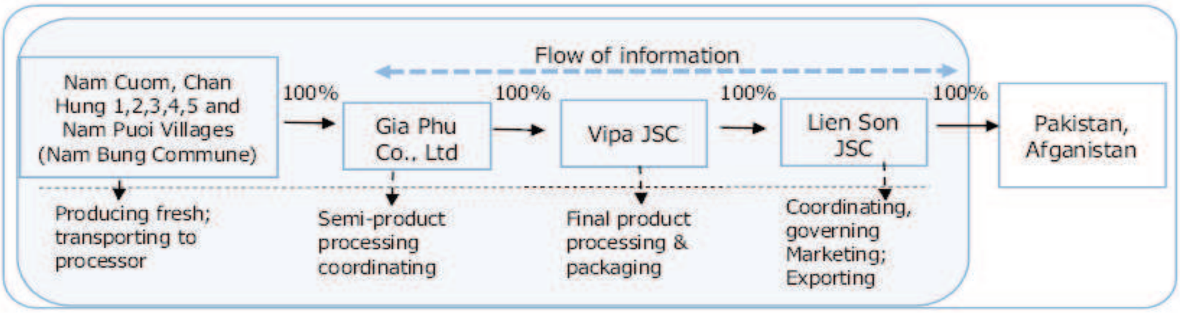
[7] Green tea: Fresh materials are lightly withered and then pan-fired without fermentation. Green tea is typically consumed in countries like China, Japan and Vietnam.
Black tea: Fresh leaves are withered and fully enzymatic oxidized (fermentation) before drying. Black tea is consumed in nations such as England, Scoland, India.
Yellow tea: Fresh tea is also withered but semi enzymatic oxidized. In this research, yellow organic Shan tea is processed in Vietnam and then sold to China for further processing into Pu-erh tea, a well-known Chinese ancient tea.

Figure 4. Organic Shan value chain in Van Chan (black tea)



Source: own elaboration, 2015.

Figure 5: Conventional Shan value chain in Van Chan (green tea)



Source: own elaboration, 2015.

Note: Gia Phu Co., Ltd is a branch of Lien Son JSC; Vipa JSC just provides final processing and packaging service.

Value addition and distribution among VC actors are presented in Table 2. At production stage, about 180 HHs and 280 HHs (out of total tea HHs in these communes) participated in these organic and the conventional VCs, respectively. We randomly interviewed 10-12 farmers in each commune and then cross checked the answers with local officers, buyers and secondary data (e.g. buyer's records, communal reports) to obtain average farm-level figures. Table 2 shows that both value added and net value added for 1 kg of exported tea are higher for organic than conventional. Overall, producers create more values than other actors, accounting for 87 % and 94.7 % of net value added in organic and conventional VC respectively. However, this value is distributed among a big number of farmers. A single HH benefits only of 3.6 % and 5.3 % of value added in organic and conventional VC, respectively. Most value added is captured by downstream actors, including processors and exporters.

In assessing the importance of HH's livelihood activities for the level and the stability of income, AHP results in Table 3 show that Shan tea has achieved, on average, the highest rankings, playing the most important role, of both discussed dimensions, in both production systems. Interestingly, Shan tea, buffalo and rice share similar importance in the organic system, both in terms of level and stability because rice is vital for HH's daily foods while Shan tea provides cash for ordinary expenses and cattle is the reserve capital. This implies that rice-tea-livestock system is likely an income and risk-management strategy for smallholders.

Table 2. Value addition and distribution among VC actors

Value chain actor	Value added		Net value added		Average output product (kg/ actor)	Value distribution	
	USD/ 1 kg exported tea	Ratio (%)	USD/ 1 kg exported tea)	Ratio (%)		USD	Ratio (%)
Organic Shan tea VC							
Farmer	2.12	73.3	1.61	87.0	225	361.4	3.6
Van Chan Shan Tea Coop.	0.47	16.3	0.09	5.1	40,000	3,773.6	37.7
Vi Vang Co., Ltd	0.30	10.4	0.15	7.9	40,000	5,867.9	58.7
Total:	2.89	100.0	1.85	100.0		10,002.9	100
Conventional Shan tea VC							
Farmer	1.34	66.0	0.95	94.7	560	529.5	5.3
Gia Phu Co., Ltd	0.44	21.9		-	150,000	-	-
Lien Son JSC	0.25	12.1	0.05	5.3	150,000	7,967.0	79.6
Total:	2.03	100	1.00	100		8,496.5	100

Source: own elaboration, 2015. Calculation based on 2014 data

Note: In organic VC: on average, each farmer averagely supplies 1,015 kg of fresh leaves or 225 kg of dried tea; VC output is 40,000 kg; In conventional VC: each farmer averagely supplies 2,630 kg of fresh leaves or 560 kg dried. The price of fresh tea is at processor's gate.

Table 3. Ranking the importance of livelihood activities for income and income stability

Income generator	Organic (Tay Son, Ha Giang)		Conventional (Group 12, Ha Giang)		Organic (Bu Cao, Yen Bai)		Conventional (Nam Cuom, Yen Bai)		Average	
	Level	Stab.	Level	Stab.	Level	Stab.	Level	Stab.	Level	Stab.
Rice	2	3	6	4	3	1	3	2	3.5	2.5
Maize	6	7	5	3	1	3	5	4	4.3	4.3
Shan Tea	3	1	1	1	1	2	1	1	1.5	1.3
Soybean/ Peanut	8	6	-	-	-	-			8.0	6.0
Cassava	7	4	7	2	-	-	6	6	6.7	4.0
Raising cattle (Buffalo)	1	2	-	-	2	1	2	3	1.7	2.0
Raising cattle (Bovine)	4	4	-	-	-	-	-	-	4.0	4.0
Raising cattle (Pig)	-	-	4	6	-	-	4	5	4.0	5.5
Poultry (chicken, duck)	5	5	3	5	4	4	-	-	4.0	4.7
Ginger	9	8	-	-	-	-	-	-	-	-
Off-farm	-	-	2	7	-	-	-	-	-	-

Source: own elaboration, 2015. Note: Rankings are synthesized from AHP standardized and normalized eigenvalues; range goes from the most important (1st) to the least important (i^{th}) with i is the number of livelihood activities in the village.

Climate change adaptation

We analyze adaptation aspects only at the production stage as tea farmers are likely the most vulnerable for EWEs' exposure in the VCs and also because that EWEs are crucial in NMR due to the geo-climatic conditions (e.g. sloping land, erosion risk). FGDs results show that drought, flooding, frost & cold spell, and hot spell are ranked among the most hazardous EWEs in all Shan tea growing communes (Table 4). Shan tea is ranked at the highest degree of climatic suitability to these EWEs, especially to drought and cold spell as compared to other crops, showing its strong adapting potential to extreme events. Rice and maize are among the most important food crops for the local people, nevertheless, ranked at the lowest degrees of suitability to EWEs, indicating their high vulnerability to CC. Agronomically, it is also because that rice and maize are shallow-rooted and grass species which require more favorable soil moisture and air temperature during seeding and flowering.

Table 4. Rating suitability of crops and trees to EWEs

Commune	Crops and trees	Ranking suitability to EWEs							Average
		Flooding, Landslide/ flash slide	Drought	Hot spell	Hail	Frost & Cold spell	Laos' wind	Storm, rain/ typhoon	
Tay Son, Ha Giang (Organic)	Rice	2	1	-	1	-	-	-	1.3
	Tea	2	5	-	3	-	-	-	3.3
	Maize	3	2	-	2	-	-	-	2.3
	Soybean	3	2	-	2	-	-	-	2.3
	Peanut	3	2	-	2	-	-	-	2.3
	Cassava	2	5	-	5	-	-	-	4.0
Group 12, Ha Giang (Conventional)	Tea	4	4	5	-	4	-	-	4.3
	Rice	1	2	2	-	2	-	-	1.8
	Maize	1	2	3	-	3	-	-	2.3
	Cassava	1	5	5	-	5	-	-	4.0
Bu Cao, Yen Bai (Organic)	Maize	2	-	2	-	4	-	2	2.7
	Rice	3	-	3	-	3	-	5	3.0
	Tea	4	-	3	-	5	-	5	4.0
Nam Cuom, Yen Bai (Conventional)	Rice	-	3	3	-	3	4	-	3.3
	Maize	-	2	2	-	5	2	-	2.8
	Tea	-	3	3	-	5	3	-	3.5
	Cassava	-	5	5	-	5	4	-	4.8

Source: own elaboration, 2015.

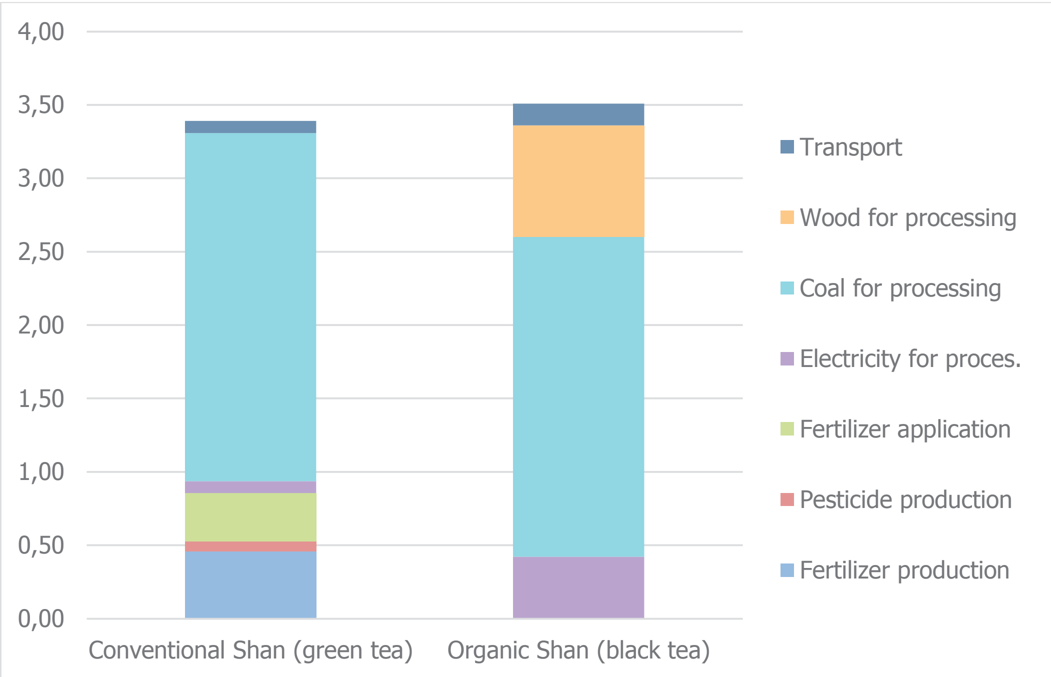
Degree of suitability: 1-unsuitable; 2-less suitable; 3-suitable; 4-more suitable; and 5-very suitable

Results in Table 3 and Table 4 imply that Shan tea provides an important contribution to HH income diversification. Tea farmers in the organic systems, where ethnic minorities dominate, are likely to have more income diversification than those in the conventional farming, where Kinh people are predominant, because off-farm paid work is a considerable source of HH's income besides returns from tea. Also in the organic system, cash returned from Shan tea can help farmers affordable to pay for short-term needs and to invest in food crops.

Climate change mitigation

Based on site-specific inventory data (Annex 1), LCA results show (Figure 6) that total emissions to produce one FU of green tea in the conventional Shan tea VC is 3.39 kg CO_2e, comprising of 0.86 kg CO_2e from on-farm fertilizer application, upstream production of pesticide and fertilizer. For black organic tea, emissions per one FU are slightly higher (3.50 kg CO_2e) even though farmers do not apply any fertilizer and pesticide. This is due to the fact that the black tea processor has consumed more electricity and wood as energy sources during processing procedures. The reason is that with high quality materials, carefulness is needed in every processing steps with a slow-drying speed to ensure the high quality of dried tea as contracted. In both systems, coal used in processing stage is the main hotspot of GHG emissions, accounting for 62% and 70% of total emissions per FU of organic and conventional tea, respectively. Emissions from distribution stage in both VCs are insignificant, accounting for only 4% and 2% of the total emissions.

Figure 6. Total and breakdown distribution of GHGs (kg CO_2e/FU)



Source: own elaboration, 2015.

Note: Emission values in transport, electricity, mobile and stationary combustion are calculated by GHG Protocol tools (World Resources Institute, 2015).

Conclusions

The paper reports preliminary results of organic and conventional Shan tea VC analysis in the NMR of Vietnam. It provides a site-specific analysis of the contributions of organic and conventional Shan tea value chains to CSA objectives by using an interdisciplinary approach.
Results show that tea production can create value along the chain therefore contributing to overall FS. The organic tea production can create higher value than the conventional production system (1.85 USD/kg versus 1.0 USD/kg) and is, therefore, a better FS option in meeting CSA objectives. Conventional VC, however, creates overall much more output and value than organic VC which is more quality oriented. Also, most value is generated at production level (between 87 and 94%). Nevertheless, since each single farmer contributes to a very limited extent to overall product volume, distribution of the value among the farmers is very unfair (between 3.6 and 5.3%). Most value benefits go to downstream actors along the chain where most of the market power is concentrated.
Shan tea production has important CSA implications. Tea cropping is perceived by farmers in the NMR as a crop with high adaptation potential to extreme climatic events. Tea is also grown as agroforestry system with benefits in terms of sustainable land management. Under conventional Shan production, fertilizer application is the second best option for reducing emission as it accounts for almost a quarter of GHGs emitted in producing green tea. Coal burned for heating in processing stage is the highest emission hotspot in both Shan tea VCs and is the best opportunity for GHG emissions reduction in tea industry. Adoption of more energy efficient technology and equipment in processing stage is among recommended mitigation solutions.
Most environmental costs of tea industry are generated off-farm, contributing to CC which is then affecting many farmers who produce raw materials for the industry. On the contrary, value added benefits in the VCs are mostly gained off-farm by a few processors and exporters. Appropriate policies to remunerate low-income producers and to re-distribute product value along the chain could be promoted within the CSA frame.

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Annex 1. LCA inventory data in Shan tea production, processing and distribution

Parameter	Value for conventional VCs (Lien Son JSC)	Value for organic VCs (Van Chan Shan tea Cooperative)	Emission factor
Production stage: -Ammonium sulphate production -NPK 5:10:3 production -Pesticides production -N fertilizer application	750 kg/ha (157.5 kg N/ha) 1000 kg/ha (50 kg N, 100 kg P_2O_5, 30 kg K_2O 10 litters herbs and 2.4 litters different pesticides/ha 207.5 kg N/ha	- - - - -	2.69 kg CO_2-e/ kg N 3.3036 kg CO_2-e/ kg N, 1.5716 kg CO_2-e/ kg P_2O_5, 0.497130 kg CO_2-e/kg K_2O 9.4 kg CO_2-e/ kg pesticides 1 kg N_2O/100 kg N
Processing stage: -Coal -Wood -Electricity (purchased)	1.3 kg subbituminous coal/ kg product 0.2307 kWh/kg product	1.1 kg subbituminous coal/ kg product 0.4 kg wood/kg product 1.2 kWh/kg product	96000 kg CO_2, 300 kg CH_4, 1.5 kg N_2O / TJ 112000 kg CO_2, 300 kg CH_4, 4 kg N_2O / TJ Grid electricity of VN2012
Transport: -Farm to semi-processor: Distance	2 km	½ mass: 2.5 km;	Motor: 1 litter of

Transport mode	Motor	½ mass: 22.5 km Motor	gasoline/100 km; Light truck: 30 litters diesel/100 km; Container: 40 litters diesel/ 100km. Motor gasoline: 69,300 kg CO_2/ KJ; Diesel oil: 74,100 kg CO_2/ KJ
Load per motor	70 kg	Light truck (2.5 T) 50-100 kg	
Load per truck	-	1.7 tons	
-Semi-processor to company's storage:			
Distance	30 km	-	
Transport mode	Light truck (10)		
Load per truck	7 tons		
-Storage to final-processor:			
Distance	165 km	-	
Transport mode	Light truck (10)		
Load per truck	7 tons	-	
-Final-processor to port:			
Distance	160 km	300 km	
Transport mode	Container 20 feet	Container 20 feet	
Load per truck	9 tons	5 tons	

Source: own elaboration, 2015. EFs for fertilizer, pesticide production and fertilizer application are from Ecoinvent 2.2; other EFs from IPCC 2006. KJ- kilojoules.