CLIMATE-SMART AGRICULTURE AND SUSTAINABILITY: COST-BENEFIT ANALYSIS IN CULTIVATION OF THE SEEDLESS PERSIMMON IN HA GIANG

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ARTICLE INFO

Received: 12/01/2022

Revised: 16/02/2022

Published: 24/02/2022

KEYWORDS

CSA
Climate-Smart Agriculture
Cost-Benefit Analysis
Persimmon
Ha Giang

ABSTRACT

Climate-Smart Agriculture (CSA) helps ensure food and nutrition security and increasing food demands under a changing climate. This article reviews the application of CSA practices to seedless persimmon in Na Khe commune, a poor mountain community in Ha Giang province, since 2017. The Cost-Benefit Analysis (CBA) should, as far as possible, take into account the full potential of private and government intervention, the social and environmental benefits and/or the costs of the CSA practices. The research method is an analysis and calculation method based on the actual data of the project in two trial years 2016-2017. The internal rate of return is as follows: financial analysis is only 7.4%, economic 12.4%, social 14% and environmental 16.6%. It is very clear that CSA projects should not only be analyzed economically and financially, but should also be comprehensively considered under social and ecological aspects in order to prioritize projects with CSA techniques and to effectively support sustainable agricultural development.

NÔNG NGHIỆP THÔNG MINH VỚI BIẾN ĐỔI KHÍ HẬU VÀ PHÁT TRIỂN BỀN VỮNG: PHÂN TÍCH CHI PHÍ - LỢI ÍCH TRONG TRỒNG HỒNG KHÔNG HẠT Ở TỈNH HÀ GIANG

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THÔNG TIN BÀI BÁO

Ngày nhận bài: 12/01/2022

Ngày hoàn thiện: 16/02/2022

Ngày đăng: 24/02/2022

TỪ KHÓA

CSA
Nông nghiệp thông minh với khí hậu
Phân tích chi phí lợi ích
Cây hồng
Hà Giang

TÓM TẮT

Nông nghiệp thông minh với biến đổi khí hậu (CSA) giúp đảm bảo an ninh lương thực và dinh dưỡng cũng như nhu cầu lương thực ngày càng tăng trong điều kiện khí hậu thay đổi. Bài báo này đánh giá kinh tế việc áp dụng các thực hành CSA đối với cây hồng không hạt ở xã Na Khê, một cộng đồng miền núi nghèo ở tỉnh Hà Giang, từ năm 2017. Phân tích chi phí-lợi ích (CBA) trong trường hợp này phải tính đến toàn bộ tiềm năng của sự can thiệp của tư nhân và nhà nước, các lợi ích xã hội và môi trường và/hoặc chi phí của các hoạt động CSA. Phương pháp nghiên cứu là phân tích và tính toán dựa vào số liệu thực tế của dự án trong hai năm thử nghiệm 2016-2017. Tỷ suất hoàn vốn nội bộ như sau: phân tích tài chính chỉ 7,4%, kinh tế 12,4% xã hội 14% và môi trường 16,6%. Qua đó thấy rất rõ, dự án CSA không chỉ nên phân tích về mặt kinh tế và tài chính, mà cần phải được xem xét rộng theo các khía cạnh xã hội và môi trường nhằm ưu tiên phát triển các dự án CSA và đưa nền nông nghiệp truyền thống theo hướng phát triển bền vững.

DOI: https://doi.org/10.34238/tnu-jst.5432

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1. Introduction

Climate change (CC) is happening everywhere and has a major impact on agriculture [1], [2]. The relationship between CC and agriculture is reciprocal and complex. Agriculture is affected by CC and in turn emits greenhouse gases (GHGs) such as methane from cattle and rice fields, carbon dioxide or nitrous oxide from high use amounts of artificial fertilizers. For this reason, the concept of Climate Smart Agriculture (CSA) was proposed in 2010 and received special attention from national governments and the international donor community. CSA is an integrative approach that helps guide actions to transform agri-food systems towards green and climate resilient practices and also is based on three principles or pilars: mitigating GHG emissions from agriculture, adapting agricultural activities to CC, and sustaining or increasing agricultural productivity [3]. It is therefore widely used in practice [4]-[7].

Vietnam is considered as one of the countries most heavily affected by CC. According to the National Strategy, Vietnam faces droughts, floods, saltwater intrusion, sea level rise, erosion,... about 10-12% of the population of Vietnam are directly affected and the country will lose about 10% of GDP. The impacts of climate change on Vietnam pose serious threats to the cause of poverty reduction, the achievement of the Millennium Development Goals and the country's sustainable development [2]. Recognizing this problem, Vietnam is one of the active countries that are rapidly adopting CSA practices in the agricultural sector. However, according to [4], lack of synergies in targets, and conflicts between the long-term interests of CSA and the immediate benefits of agricultural growth are key challenges to facilitating and scaling-out CSA. Almost 90% of agricultural expenditure has been on adaptation, whereas *mitigation efforts are largely neglected*. In addition, most CSA technologies have a *low or medium adoption rate* in Viet Nam (60%). The barriers often relate to low availability of required inputs (such as seeds for improved varieties, or water scarcity during droughts), high costs of installation (e.g. of improved irrigation facilities) which limited acess to credit and market, high labor costs and limited level of technical knowledge and skills. Addressing those barriers will be a key requirement for successful out-scaling of CSA practices. Therefore, the question that arises in practice when investing in CSA is "Are CSA practices economically desirable?" [8]. This question relates to the application of the Cost-Benefit Analysis (CBA). Therefore, according to [9], it was proposed to apply aggregate CBA for the calculation and evaluation of small projects supporting infrastructure construction, production support and training & servicies. To overcome the detailed economic calculation, in [10], there is a proposal to apply CSA-RA (rapid appraisal) for prioritizing a CSA project/technology. It is a mixed-method approach that draws on participatory bottom-up, qualitative, and quantitative tools to assess the heterogeneity of local contexts, and prioritize context-specific CSA options. The various international literature on CBA for CSA can be found in [11]-[14].

From 2015 within the framework of the VIAIP project of World Bank (*Vietnam Irrigated Agricultural Improvement Project*, WB7) almost 49 CSA models with different practices were carried out in seven provinces (Ha Giang, Hoa Binh, Phu Tho, Thanh Hoa, Ha Tinh, Quang Tri and Quang Nam) with small and medium scale (piloting from a few hundred square meters to several tens of hectares) [14]. The long-term aim of this project is to develop typical CSA models in the provinces and then replicate locally over the next 5-10 years. In addition, this CSA pilot has great implications for Vietnam's agricultural reforms that the government has launched in the direction of "Gaining More for Less" [15] as well as in line with the global goals in climate protection of agricultural production. However, the real question when investing in these CSA models is whether they are economically viable? Probably not because the VIAIP project supports farmers in the pilot area for the first three years with investments in improving irrigation facilities and building field infrastructure, supporting fertilizers and certified seeds as well as technical advice. But in other respects, this investment is still profitable in many respects. So what aspects do they include and how, let's see the following example of CSA practice on seedless persimmons in Ha Giang province, a province in the northern mountainous region.

The objectives of this paper are: (1) Overview of CBA and implementation steps, (2) Presentation of the CSA practice for persimmon trees in Ha Giang, (3) Evaluate the economic performance of the project through financial, economic, environmental and social CBA analysis, and (3) Discussion.

2. Overview of Cost-Benefit Analysis

There are two separate types of Economic Impact Assessment (EIA): (1) Regional Impact Analysis (RIA), which is used to describe the size and nature of the effects on local, regional and state economies; and (2) Cost-Benefit Analysis (CBA), which is used to identify the costs and benefits of the project, an intervention. Both are expressed in terms of money. CBA is the most common mainstream approach to project appraisal. In CBA, there is a distinction between outcome and impact, and between counterfactual and contribution of other factors. There are four main approaches you can use to capture the counterfactual: the hypothetical approach, the before-and-after approach, the stakeholder-based approach and the comparative approach [16]-[18].

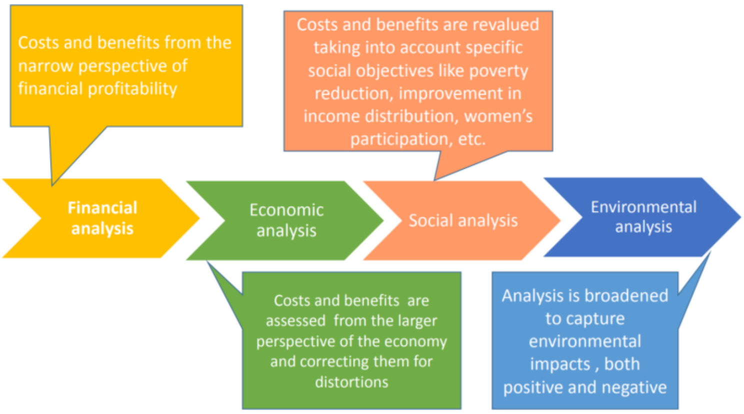

Figure 1. *Different types of CBA* [16]

However, as noted above, CSA practices have marked social and environmental impacts or benefits. For example, a CSA practice that reduces poverty rates in the community/region or minimizes erosion of farmland, or enables village women to work in the village (take care of their orchards or rice field). Especially the mountainous ethnic women do not need to leave their mountain village to work in industrial zones/centers.

2. Materials and Methods

2.1. Material - Background of the CSA model and data

2.1.1. Location and the socio-economic characteristics

According to [1] in term of the regional vulnerabilities to CC, Ha Giang is assessed to have low exposure and high emergency with the following characteristics: (1) main physical vulnerabilities: landslides, flash floods, droughts, storms from East China Sea, and (2) the main social vulnerabilities: 49% poverty in the Northwest region; the province dominated by diverse ethnic minorities; high illiteracy rates and large families; low rates of female education; many remote areas with poor road access; high rates of subsistence and rainfed agriculture. Most households in Ha Giang are dependent on non-irrigated agriculture, corn and upland rice are the dominant crops.

Persimmon (scientific name: *Diospyros kaki*; Vietnamese: quả hồng) is called "Unique oriental products" and is grown in the mountain provinces of Vietnam (e.g. Bac Can, Lao Cai, Ha

Giang, Da Lat, Lam Dong, etc.), but the commercial production is still low and the growing area is small.

Na Khe commune is located in a mountainous area with a steep slope, at risk of landslides and degradation (Figure 1). The socio-economic characteristics of Na Khe are shown as follow:

- Total area: 57.37 km^2 (agricultural land 31.3% and other 68.7%).
- Agricultural land 1,263.92 ha, in which: Rice 16.3%, Maize 6.9%, Persimmon 3.3%, Other crops (peanuts, bean, sugar cane, cassava, …) 73.6%.
- Income structure: Agriculture 86.0%; Services and commercials 13.2%; Handicraft 0.8%.
- Population/density (person/km^2) in which: 4,298/55; Most residents are ethnic Hmong.
- Poverty rate: Over 40% (the percentage of the poor and near-poor households of the ethnic minorities in Northern Midlands and Mountains is 25.5% and 15.6% respectively. These figures are very high compared to other provinces in Vietnam (data of GSO).

Ha Giang province

Figure 2. *Location of Yen Minh district (Ha Giang province) and the piloting area of persimmon cultivation*

2.1.2. Implementation of CSA models

The CSA application was carried out in the following steps:

a) *Step1 - Selection of CSA model option* based on: (1) Proposal of different CSA model options (location, area, goals, inputs, outputs and specifications of the model); (2) Assessment of natural, socio-economic and agricultural production situation at all sites where CSA model is intended to be built; and (3) Selection criteria.

b) *Step 2 - Design of CSA model*: (1) Field investigation (e.g. soil, plants, water availability, soil erosion ...); (2) Discussion and consultation with farmers and agricultural cooperatives about the CSA model design that is expected to be implemented on site; (3) Detailed design for on-site development (flattening of fields, distribution of parcels, arrangement of irrigation systems); (4) Infield road planning; (5) Design of irrigation systems (overflow, sprinkler and drip irrigation); (6) Design of infrastructure and equipment needed for CSA project (seed production, post-harvest handling, production equipment, ...); (7) Required cost estimates.

c) *Step 3 - Suggestions for detailed technical measures used in CSA model (Table 1) such as the combination of*: ICM, IPM, IDM, IWeM, INM and IWaM.[1] All of them can be thought of as components of ICM focusing specifically on the pests, disease, weeds and nutrient management aspect, respectively, of crop production [20]. All technical measures are based on different results of step 2.

d) Step 4 - Implementation: The results of the two-year pilot phase are presented in Table 2.

2.1.3. Data

The data sources used in this paper include: (1) Design documents of the CSA model in Na Khe commune; (2) Guidelines to practicing CSA model; (3) A quarter monitoring report of

[1] ICM (integrated crop management), IPM (integrated pest management), IDM (integrated disease management), IWeM (integrated weed management), INM (integrated nutrient management), IWaM (integrated water management).

VIAIP; (4) Data on production of farmers inside and outside the pilot area for the period 2017-2019; (5) In-depth interviews with farmers and commune leaders about CSA related to knowledge, practices, and attitudes; (6) Willingness to the adoption of the CSA model, and (7) Willingness to pay (WTP) for irrigation water.

3.2. Methods

The calculation scheme is shown in Figure 3. The mathematical expression is in equations (1), (2) and (3). Different options (financial, economic, ecological and social) are compared with each other, whereby the financial option is the basis.

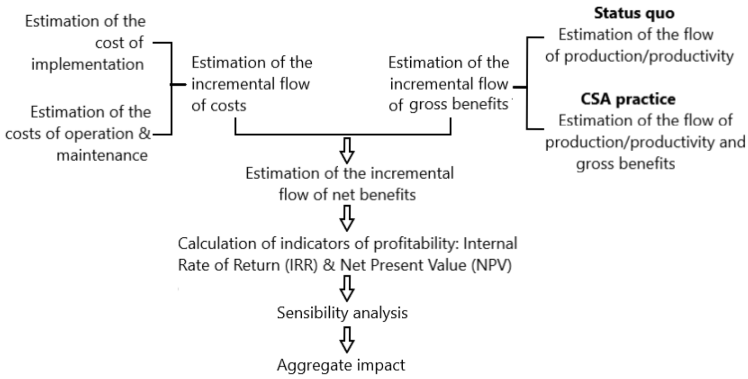

Figure 3. *Steps of CBA*

$$\Delta Nbe_t = \left[\sum_i \left(\left(Be_i^{CSA} - Be_i^{CP}\right) - \left(C_i^{CSA} - C_i^{CP}\right)\right)\right]_t \quad (1)$$

$$NPV = \sum_t^T \frac{\Delta Nbe_t}{(1+r)^t} \quad (2)$$

$$IRR = \sum_t^T \frac{\Delta Nbe_t}{(1+IRR)^t} = NPV = 0 \quad (3)$$

Where:

ΔNbe_t	Net benefit of time/year t by using CSA practice
t	Time (year) and T (the entire lifecycle of the CSA practice)
i	Indicator of persimmon, social or environment
Be_i^{CSA}	Benefit of i by CSA practice
Be_i^{CP}	Benefit of i by conventional production (CP)
C_i^{CSA}	Cost of i by CSA practice
C_i^{CP}	Cost of i by CP

Table 1. *Summary of agro-technical measures in comparison between CP and CSA*

Technical measures	Conventional production (CP)		CSA practices		CSA vs. CP
	Conventional practices	Status quo	CSA practices	Status quo	
1. Design of mix plant pattern	No design of a mix plant ecosystem (main plants and others)	No optimal land use, increased soil erosion and soil degradation.	Persimmons in combination with various Tephrosia purpurea.	Green manure, avoidance of water loss and evaporation, as well as of soil erosion.	Meet the production needs of farmer.
2. Pruning technique	Pruning according to household/farmer experiences or without pruning	The tree has an unbalanced canopy. Most trees are too high for the canopy diameter, which leads to difficulties in care and harvesting.	Pruning according to the technical procedure, also after every period of bud development or every 3 months	Plants have a well-balanced and ventilated canopy, reducing pests, diseases, pesticides and fertilizers during cultivation.	As before
3. Nutrition regime and fertilizer	Use mainly chemical fertilizers	Plants grow and develop disproportionately, buds do not focus on a specific time. There is a situation where the annual harvest fails, the productivity and fruit quality are not high.	According to the scientific process (results of soil survey), add fertilizers with microorganisms and organic fertilizers.	Improvement of plant growth and productivity.	As before
4. Weeding	Herbicide abuse (only some households do weeding manually)	Spraying herbicides makes the model area free of weeds, but is toxic to organisms and humans. Manual weeding is time consuming and does not completely remove weeds.	Did not use herbicides, weeding with mowers, use green manure crops to cover the soil to limit weeds.	Reducing economic losses from the use of herbicides, non-toxic to humans and the environment, green manure crops improve cropland and improve plant growth.	As before
5. Irrigation and drainage	No irrigation system yet, just rainfed fields.	Did not meet the water requirements of seedless persimmons.	Using an advanced and economical irrigation system.	Meet the water requirements of plants.	As before
6. Pest and disease management	mainly chemical pesticides in application; their dosage and procedures not follow the instructions.	Pesticide residues.	Using biological baits and pesticides of biological origin (dosage and types according to VietGAP process).	Minimize toxicity to humans and biological organisms, reduce economic losses.	As before
7. Harvest	Manual harvest and no storage possibilities.	The rate of damaged fruit war high and economic loss.	Harvest with tools (e.g fruit picking sticks) and storage containers.	Reduction of damaged fruit and improvement of economic value.	As before
8. Dealing with by-products	No treatment of agricultural by-products.	There is a lot of agricultural by-products in the model area.	Collection and treatment of by-products.	Reduction of GHG emissions and improvement of rural sanitation.	Environmental & ecological protection requirements.
9. Market access	Individual market access of household, no marketing.	The price is unstable. Sometimes cannot be sold.	Cooperatives and municipalities support the fruit sale.	The output and price of fruit are stable, improving the income of villagers.	Improvement of economic efficiency.

Table 2. *Economic analysis in household- or farm-level - Comparison between CSA and CP*

Plants in CSA model	Average area per HH (ha)	Increase of CSA vs. CP			Increase/reduction of CSA vs. CP (%)		
		Net benefit per ha (Mill. VND/ha)	Increased net income per ha (Mill. VND/ha)	Increased net income per HH (Mill. VND/HH)	Productivity	Production cost	Income
Fruits (orange, permission, Taiwan pear)	1.46	133.99	17.03	24.92	+9.08	-13.52	+12.71

Table 3. *Summary of variables for calculating EIA & CBA and the estimation methods in seedless persimmon of Na Khe*

Variable	Description of variable	Estimation methods	
		Calculation	Assumption
A1	Pilot area (7.8 ha)	Land use planning map	No
C1 C2	Cost for construction of hydraulic head works, laying of the pipeline … Investment capital for 1 hectare	Actual cost C2 = C1 / A1	No
C3	Cost for O&M of hydraulic head works and the in-field infrastructure	No	1÷1.5% of C1
C4: C41-C44	Input subsidies to farmers within pilot area in 3 years 2017-2019: *Seedlings, Fertilizers, Pesticides, Production tools (fruit picker & others)*	Actual costs are based on results of field research and soil survey	No
C5	Cost for training for core and general extension (training, visit FFS, meeting, leaflet, poster, …)	Actual costs of training and communication program	No
T	Life cycle of project (the entire lifecycle of the CSA practice)	-	Assumption: 15 years
Be1 Be11 Be12 Be13	Main benefits from production: - Productivity and output of fruits. - Production of young persimmon trees, seedlings of various tephrosia by farmers/households. - Create high quality branded products in the implementation of the OCOP (One Commune, One Product) program	Actual output and price of fruits; Price of young persimmon trees and various Tephrosia purpurea (in the first year); Highest price of persimmon as an incentive to the movement OCOP	No
Be2 Be21	Social benefits: Strengthening the role of women in the family through cultivation of persimmon (local employment, instead of migration to the city or industrial areas).	No	HH survey (in-depth interview). Replace with the woman's labor time for persimmon & the labor cost from 150-200 thousand VND/day
Be3 Be31 Be32 Be33	Environmental benefits: - Soil erosion & degradation (soil fertility). - Saving water & improving water efficiency. - Use less chemical fertilizers, more organic fertilizers & by-product.	No	HH survey: (1) Replacement of tephrosia to green the soil & increase soil fertility, (2) WTP for irrigation water, and (3) No consideration

3. Results and discussion

According to [21], the farm-level economic efficiency of CSA model has been significantly improved throughout Ha Giang province (Table 2). For fruit trees, the average productivity increased by 9.08%, production cost decreased by 13.52% and economic efficiency increased by 12.71%. As for vegetables, it can increase productivity, production costs and economic efficiency (10.96%, 21.23% and 15.89% respectively). This means that vegetable crops are more efficient, but if roads are not improved in cities or urban centers, it is difficult to encourage development. On the other hand, in addition to profit at the farm level, it is necessary to take into account the aggregate community impact disaggregated by different groups of farmer typologies with specific socio-economic features is derived from the adoption rate estimated by the relative advantage of practices and the income level of each group. Based on [22] and [23], Hmong farmers in Na Khe commune can improve their livelihood thanks to CSA practices on fruit trees, i.e. the increased net income per hectare and per household is 17.03 Mill. VND and 24.92, respectively. After expanding the CSA area, the Hmong community in Na Khe commune and then in Yen Minh district will be significantly improved.

Table 3 summarizes the variables for the EIA & CBA calculations and specific estimation methods. The most difficult of these is the estimate of Be2 (social benefit) and Be3 (environmental benefit). In the Be2 group, Be21 "Strengthening the role of women in the family through persimmon cultivation (local jobs, staying at home to take care of the family and children, not migrating to cities or industrial zones)" estimated through in-depth interviews with households. The replacement by the number of workdays for women to spend persimmon garden is done and labor cost is increased from 150,000 VND/day to 200,000.

In the Be3 group, focusing on the criteria Be31 “Soil erosion and degradation” (soil fertility), Be32 “Save water and improve water efficiency” and Be33 “Use less chemical fertilizers more organic fertilizers & by-product". Soil erosion has been mentioned in various research papers. According to [24], the costs of land degradation is estimated using methods, such as: (1) Lost productivity due to land degradation on arable land: based on the crops seen to suffer a fall in productivity over the period and market price; (2) Lost productivity due to degradation of pastures: based on lost milk production; (3) Increase costs of remedial measures (increase use of fertilizers to replace lost nutrients, adoption of less erosive but more costly management practices, repairs of damaged structures, and others.

Table 4. *Comparison of profitability between 4 types of CBA: financial, economic, social, and environmental analysis (financial analysis is the basic option)*

Criteria	Financial	Economic	Economic & Social	Economic, Social & Environmental
NPV (Mill. VND)	-402	432.4	741.6	1342.3
IRR (increase, %)	7.4 (100%, base)	12.4 (+67.6%)	14 (+89.2%)	16.5 (+123.0%)

However, in Na Khe, in the household survey, the planting of Tephrosia purpurea[2] in addition to green manure is also considered as the main crop used as a cover crop, preventing soil erosion in the hilly and mountainous areas. They are intercropped with many other plants in agriculture and forestry. Therefore, the annual number of labor days for planting and tending Tephrosia purpurea is considered the value of the benefit Be31. In terms of "saving water and improving water efficiency", it is rated based on people's willingness to pay (WTP) for irrigation water in a limestone mountainous area that lacks water. The simple WTP-choice method was used. Table 4 shows the results of CBA calculations in terms of financial, economic, social and environmental

[2] Tephrosia purpurea is a species of flowering plant in the pea family, Fabaceae, that has a pantropical distribution. It is a common wasteland weed. In many parts it is under cultivation as green manure crop.

analysis. A complementary environmental and social analysis significantly increases project returns and helps define agricultural strategies and policies for the next decades to move towards climate adaptation and sustainability.

4. Conclusion

As of December 2021, GACSA - an inclusive, voluntary and action-oriented multi-stakeholder platform on CSA that aims to catalyze and create transformative partnerships to drive action - has 534 members who are governments, research institutions and NGOs. But the German government in particular is not a member of the GACSA. Why so? Because to this day, after a decade of using CSA, there are still views that CSA is "greenwashing" or simply "Trojan horse" [26]. It enables large agro-food companies to offer solutions that are arbitrarily considered a CSA. This allows them to sell fertilizers, pesticides, plant varieties and genetically modified products.

However, in the case of Vietnam and the specific example in Ha Giang, CSA has much in common with other approaches to sustainable agriculture. This means that addressing CC does not require us to discard or reinvent everything that has been learned about agriculture and sustainable development in recent decades. In fact, CSA is built upon a technical foundation that largely already exists and a range of sustainable agricultural approaches - such as sustainable agriculture, sustainable intensification and conservation agriculture - are the cornerstones of implementing CSA in practice.

In terms of macro-level policy, "to support the objectives of sustainable, climate-friendly and productive agriculture, reforms are needed at the international, national and sector levels to correct misaligned incentives and redirect policy efforts to specific investments in pursuit of these explicit objectives" [27 and [28]. Immediately after a series of CSA projects are completed, the question that always arises to investors and farmers is whether such relatively expensive CSA projects are economically viable. Answering this question is critical to prioritize the limited investment volume and encourage the replication of these CSA models across the region.

Through the specific example of the seedless persimmon planting project in Na Khe commune (Ha Giang) has clearly demonstrated the above statements. According to the evaluation of [19] and [21], the replication of this model will be conducted easier and cheaper. This is a good development direction of the CSA project.

ACKNOWLEDGEMENT

Our special thanks go to the colleagues of PIC-Component 3 of VIAIP-WB7 and of PPMU of Ha Giang province for their support.

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