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Assessing Climate Change Impacts and Prioritizing Adaptation Measures Using Climate-Smart Agriculture Rapid Appraisal (CSA-RA): A Case Study in Thuong Bang La Commune, Van Chan District, Yen Bai Province

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Abstract

Overwhelming scientific evidence shows agriculture is heavily impacted by negative climate change effects. While agriculture is affected, the sector is also the second-largest contributor to climate change, creating challenges in adaptation and mitigation strategies. Climate-smart agriculture (CSA) is a holistic approach to managing landscapes, utilized to guide farmers in the context of a changing climate. CSA is an attractive option for Vietnam, an agricultural country extremely vulnerable to the impacts of climate change. Farmers and communities in Vietnam are facing significant risks. Changes in farming conditions, climate, and productivity threaten agriculture and livelihoods. The aim of the current study was to assess the effects of climate change on the people and agricultural systems in Thuong Bang La (TBL) commune, Vietnam, utilizing climate-smart agriculture rapid appraisal (CSA-RA) tools. The results indicated that agricultural production has been negatively impacted, with erratic and varied weather patterns causing outbreaks of disease, and reductions in the yield and productivity of livestock and cropping systems. Disasters including flooding, storms, and droughts are a prominent threat, leaving farmers unsure of how to cope. Through a showcase of CSA technologies, farmers were able to highlight their preferences for practices including mulching, drip irrigation and conservation agriculture in orange groves, bio-fertilizers and integrated pest management (IPM) in rice production, and using biological bedding in chicken raising. The study showed immediate openings to initiate context-specific CSA interventions and building the resilience of the agricultural systems in the development of one of the first climate-smart communes in Vietnam.

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Introduction

The intimate link between agriculture and climate change is indisputable. Although the impacts will vary across regions and by crop, issues including elevated CO_2 concentrations, sea-level rise, and variations in temperature and precipitation have far-reaching implications for the agricultural sector. These events trigger serious issues such as CO_2 fertilization, increased levels of surface water runoff, reduced agricultural output, and potentially, reduced food security (Ray *et al.*, 2015; Karimi *et al.*, 2018). Coincidentally, whilst agriculture has its vulnerabilities, it is also the second-largest contributor to climate change (Aggarwal *et al.*, 2018). Agriculture desperately needs to adapt to ensure productivity, longevity, and food security for an expanding population.

Increasing agricultural performance and production will, however, result in increased emissions based on the standard business as usual pathways (Lipper *et al.*, 2018). Therefore, any gains or improvements need to be achieved through sustainable mechanisms. Climate-smart agriculture (CSA) plays a pivotal role in ensuring this happens. CSA can be defined as any adaptive agricultural practice aimed at reducing and or mitigating greenhouse gas emissions (GHGs) and the negative effects of climate change (Eam *et al.*, 2018). CSA is an all-encompassing approach and centers on human development and the empowerment of people and communities. A cornerstone of the CSA approach is achieving food and nutritional security for all people - at all times, while enhancing productivity and the incomes of agricultural communities who are, in fact, under the most pressure to adapt. CSA aims to identify and implement appropriate financing mechanisms, facilitate technology transfer, and support the development of enabling policies (FAO, 2018).

In Vietnam, the strengthening of agricultural systems using the CSA approach is particularly poignant, because like the rest of the global south, agricultural productivity and incomes are low, the population is increasing, and farmers have a lower adaptive capacity. Agricultural systems in Vietnam are threatened by climate change and environmental stresses (Aggarwal, 2008; Hertel and Lobell, 2014; Shirsath *et al.*, 2017). Vietnam is one of the countries that is worst affected by climate change. For instance, sea-level rise threatens agriculture, land area, GDP, urban extent, and wetland areas (Dasgupta *et al.*, 2009). Vietnam has experienced an increase in the frequency and intensity of events and disasters such as floods, droughts, landslides, and saltwater intrusion. These events put pressure on the agricultural system, which currently facilitates the employment of 54% of the working population, with both men and women being equally involved (Tran, 2016; Irish Aid, 2017; Nguyen *et al.*, 2017; Tran *et al.*, 2017).

Undoubtedly, it is the rural and agricultural communities of Vietnam that are facing some of the hardest challenges in the context of a changing climate. While overall poverty levels in Vietnam have declined from 20.7% in 2010 to 9.8% in 2016, some regions continue to have much higher poverty levels, placing those communities at a higher risk. In the Northern Mountainous region, Dien Bien, Son La, and Ha Giang provinces have poverty levels of 44.8%, 31.9%, and 38.8%, respectively, meaning communities there are up to 4.5 times more likely to experience poverty (Ministry of Labour Invalids and Social Affairs, 2017; World Bank, 2018). This higher poverty level is attributed to issues such as the lack of production resources, market instability, accessibility, natural disasters, and epidemic diseases. Climate change exacerbates these, increasing the burdens, stresses, and difficulties for the agricultural workforce and communities (Jost *et al.*, 2015).

There is an urgent need to better support rural and agricultural communities. It is argued here that the widespread uptake of CSA in Vietnam can be achieved, while having far-reaching, positive implications (Nguyen *et al.*, 2013). This potential is recognized by the government of Vietnam through national plans and policies such as the National Climate Change Strategy, whereby CSA is specifically mentioned as a strategic mission in adapting to climate change. Therefore, CSA can be recognized and utilized as a tool in reducing poverty levels, increasing gross output, and reducing emissions in Vietnam (Socialist Republic of Vietnam, 2015; Thang *et al.*, 2017). CSA will play a crucial part in plans and programmes such as the New Rural Development programme, which is a national, governmentally funded programme aimed at improving and upgrading facilities in rural regions. For a locality to qualify for the New Rural Development programme, a set of nineteen criteria must be met. Examples of criteria include the commitment of a region to the improvement and development of transportation systems, boosting incomes, and ensuring poverty levels are below a certain threshold. The New Rural Development programme is concerned with environmental issues and sets out to facilitate easier access to clean water, create waste collection sites, and assist in improving the attitudes of local people toward the environment. Agricultural communities such as those of Thuong Bang La (TBL) commune can benefit from partaking in programmes such as New Rural Development, which has placed CSA as a fundamental element in the period of 2021-2030 (Bui Le Vinh & Vu Thanh Bien, 2020; Bui Le Vinh, 2021). With enhanced governmental support, CSA programmes can be utilized in transforming agricultural systems and communities, enhancing livelihoods, and fighting climate change.

However, for any CSA programme to succeed, an understanding of the trade-offs and synergies between agricultural production, incomes, resilience, and emission reduction is required. Any intervention must meet multiple shared goals and be context-specific, and this requires an analysis of the barriers to its success (Shirsath *et al.*, 2017; Thornton, Aggarwal, & Parsons, 2017; Aggarwal *et al.*, 2018). These barriers may be physical, technical, structural, financial, or social in nature. Moreover, some barriers are hidden or discrete and may be socio-cultural, cognitive, or historical in origin (Shackleton *et al.*, 2015; Menike & Keeragala Arachchib, 2016; Ayanlade, Radeny, & Morton, 2017). Overcoming barriers, and facilitating CSA uptake, requires a deep understanding and appreciation of the living realities, including the opportunities, constraints, and the enabling environments across sectors (Basak, 2016; Campbell *et al.*, 2014; Campbell *et al.*, 2016). Therefore, it is imperative to understand how climate change and its impacts are perceived by farmers, as perceptions have been shown to affect farmers' responses, behaviours, and coping strategies (Li *et al.*, 2013; Abid *et al.*, 2015; Sipho *et al.*, 2015).

The objective of this study was to understand the risks that climate change poses to the agricultural community of TBL commune, Vietnam, with the aim of developing a suitable CSA programme for uptake. The study aimed to pinpoint vulnerabilities within the agricultural sector there, while simultaneously exploring any barriers to CSA uptake. Another aim of the study was to effectively communicate and introduce novel agricultural practices to farmers in the community, thus informing the farmer prioritization process. A participatory approach as described by Mwongera *et al.* (2017) was utilized to perform situation analysis and needs assessment, and was employed during farmer workshops and expert interviews. The findings of this study will contribute to CSA programme development and advancement in the commune, while retaining relevance to other, similar developing and developed communities facing comparable threats.

Methodology

This study employed the methodological framework of the CSA-RA approach (Mwongera *et al.*, 2017), with primary and secondary qualitative and quantitative data collected during focus group discussions, key informant interviews, expert interviews, and farmer workshops. It was a bottom-up, mixed-method approach, using the principles of rapid rural appraisal (RRA) and participatory rapid appraisal (PRA).

The CSA-RA tools utilized included the climate calendar, historical calendar, organizational mapping, resource mapping, key informant interviews with village heads, farmer interviews, and expert interviews with four local climate change and agricultural scientists. 'Activity clocks' as described by the Food and Agriculture Organization (FAO) were utilized. Gender was disaggregated by conducting male or female only focus group discussions (FGD).

Study area

The study was conducted in TBL commune in Van Chan District, Yen Bai Province, Vietnam, which is inclusive of an area of about 92.43 km^2 (**Figure 1**). TBL commune was selected as the study site because it is most vulnerable to the impacts of climate change, and agriculture is the predominant occupation in the area (TBL commune leaders, 2019).

Within the commune, the villages of Nong Truong, Muong, and Thien Buu were purposefully chosen in accordance with the district and commune leaders' decisions. Together, these villages contained typical characteristics of all villages in Van Chan district. Therefore, any prioritized CSA technologies and practices (T&Ps) had the potential to be disseminated quickly and effectively to the remainder of the commune. The primary crops in the region are orange, rice, and to a lesser extent, tea. Nong Truong is a major producer of oranges in TBL, while Thien Buu mainly produces rice. In Muong, farmers are involved in forestry and the production of livestock.

Sample populat ion characteristics

The study employed purposive sampling of sixty participants. Village heads worked alongside the agricultural extension officer of TBL, selecting farmers willing to participate. To ensure representation of all groups in the region, farmers were selected based on ethnic diversity, age range, and variety of agricultural involvement.

Framework for the identification of CSA priorities using CSA-RA tools

CSA priorities were identified using the framework presented in **Figure 2**. The situation analysis and needs assessment (SANA) facilitated an understanding of the climate-related constraints farmers are facing, their perceptions of changing weather patterns, and potential barriers to the adoption of CSA. Collating scientific evidence and knowledge from experts in the field was fundamental to the SANA report (Pham *et al.*, 2015).

Proposed CSA T&Ps were selected using methods including CSA workshops, cost-benefit analysis (CBA), and market value chain assessment, ensuring the appropriate options were implemented.

The purpose of each CSA-RA tool used in the framework (**Figure 2**) is briefly described below.

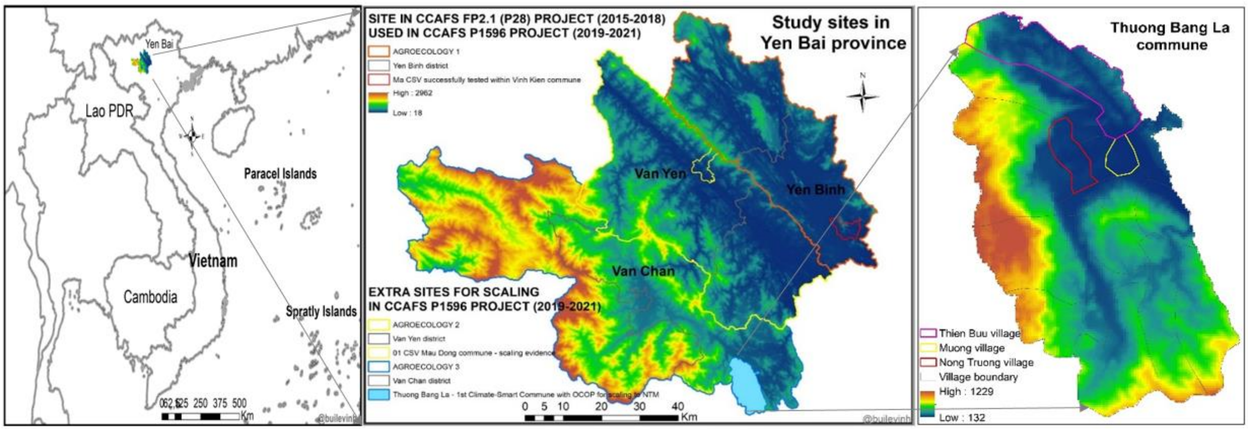

Figure 1. Study site in Thuong Bang La (TBL) commune (solid, eggshell blue fill)

Source: VIBE (2018)

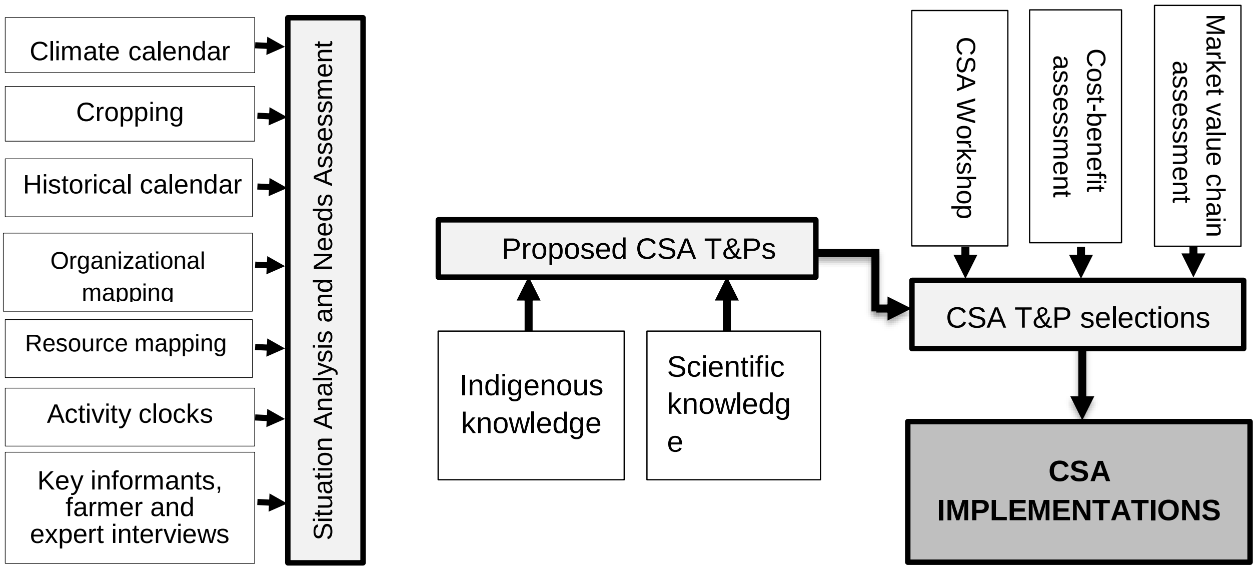

Figure 2. The process of identification of CSA priorities

Climate calendar

Climate calendars were used to identify typical weather patterns in the commune, including classification of seasons, average temperatures, and rainy and dry months. Participants discussed periods of stress, impacts, and vulnerabilities within the agricultural systems. This enabled the exploration of perceptions of farmers and how they cope with variability and stresses.

Cropping calendar

Participants identified the main crops and livestock in the commune. A cropping calendar was completed for each of the main crops and the process was repeated for livestock. Participants listed all the activities surrounding each crop or livestock. Once completed, participants were asked who was responsible or perceived to be responsible for each task, thus providing insight into gender dynamics in the community.

Historical calendar

The mapping of historical events was carried out to gain an understanding of climate change impacts, and climate change-induced disasters. Participants anonymously identified and recorded years wherein a 'historical event' such as a flood or storm has occurred. The results were then shared with participants, and conversations ensued regarding overall impacts.

Organizational mapping

Venn diagrams showed the organizations present or working in the region, and the extent to which farmers were aware of and utilized their services. The inner circle of the Venn diagram comprised the community itself, with the named organizations in the surrounding circles. The importance of each organization was determined by the participants, and perceived linkages between them were mapped. Participants were given three votes each to decipher which organizations were most valuable.

Resource mapping

Resource mapping was used to understand the distribution of resources, including major cropping areas, water resources, roads, forested land, pastureland, and social structures such as the community hall.

Participants were grouped according to their village of origin and asked to draw a map of their village. These maps were then merged to form an overall map of the commune. Participants discussed changes in resources over time, and pinpointed agricultural areas that were most vulnerable to disasters such as flooding or drought.

Activity clocks

Activity clocks were used to understand the daily activities of participants, examining perceived and actual gendered workloads. This helped to determine the impact of CSA interventions.

Key informant and farmer interviews

Key informant interviews were carried out with the village heads to gather secondary baseline socioeconomic data using semi-structured interviews. The village population, number of families, composition of ethnic groups, education levels, decision making power, income levels, and agricultural data were gathered. The history of the villages, and the perceptions of climate change and its effects were also discussed.

The agricultural extension officer in the commune, a male farmer, and a female farmer were interviewed using semi-structured interviews. Questions on climate risks and perceptions, agricultural tasks and challenges, income, varieties of crops and social issues were included.

Expert interviews

Following the completion of the SANA at the community level, potential CSA options for orange, rice, and livestock were identified by the authors. To determine the suitability level of each proposed practice, semi-structured interviews with local climate change experts were conducted.

The suitability of each practice was ranked as low, medium, or high, equating to a score of 1, 2, or 3, respectively. The sum of all the expert's answers for each CSA practice was determined and an average score was obtained (highest rating = 3).

The top ranking and most suitable CSA practices were then selected.

Farmer prioritization workshop

Informational posters for each CSA T&P were numbered and displayed during the farmer's workshop. An introduction into each CSA T&P was provided, allowing participants to raise questions and examine the posters.

Participants were invited to give one vote to their favoured practice in each category, namely, orange, rice, and livestock production. Voting cards were coloured with distinct colours for men and women.

Cost-and-benefit (CBA) analyses and market value chain assessments

To improve the adoption and scaling of CSA, it was essential to better understand the choices and trade-offs that farmers are making. Therefore, CBA analyses and market value chain assessments were used to assess the probability of investment for CSA T&P. Results will not be presented in this study.

Results

Climate change-related impacts on farming and agricultural systems

The results showed that the TBL community has witnessed and experienced changing, erratic weather patterns, which they associate with climate change. Assessing these changes using CSA-RA tools showed that farmers and the agricultural systems are vulnerable and at risk of the negative impacts of climate change. Participants reported that they were unsure of how to cope and which methods to use.

Climate calendar

The climate calendars showed there are two seasons in TBL commune, a rainy season and a sunny season (**Figure 3**). Slight gendered differences existed between men and women regarding perceptions of seasons and weather patterns.

All participants identified two types of rainfall occurring in the rainy season. Those being "Mua Dam", which was described as a persistent drizzle occurring most days in a month, and "Mua to", a sporadic, heavy rain occurring some days of the month. All participants stated there were major disruptions in agricultural production in February caused by persistent drizzle, resulting in low pollination

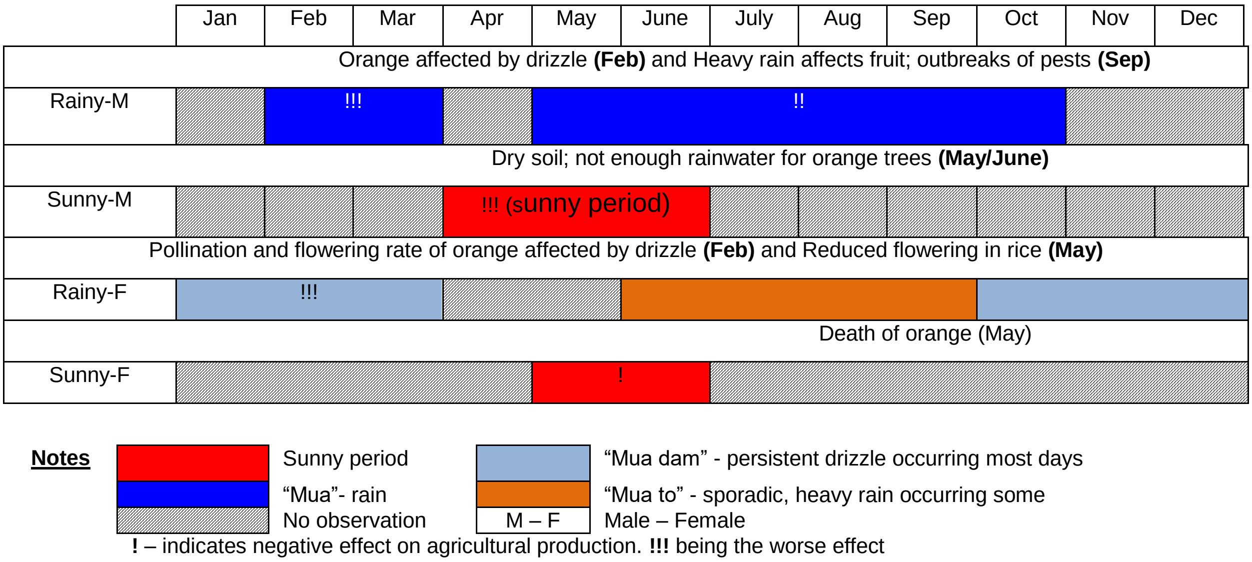

Figure 3. Results of the FGDs using a climate calendar in the CSA identification and prioritization study in TBL commune as detailed by the male (M) (n=8) and female (F) (n=7) participants

and flowering rates in orange. The women reported that heavy rains occurred for fifteen consecutive days in May, negatively impacting flowering in rice, and reducing productivity by 50%. The men collated both types of rain into one single rainy period, from July to September, with the worst effects on orange being felt in September when orange trees begin to bear fruit. Outbreaks of pests were also observed after heavy rains. The women detailed that in April, acid rain caused worms to surface and die, orange trees to perish, and tea leaves to become damaged.

All the participants reported highest temperatures in May and June, reaching 37˚C and 39˚C, respectively. This led to dry soil, lack of rainwater for orange trees, and was often attributed as the cause of death of orange trees. A cold spell was also recorded by male farmers in November and December, wherein temperatures fell to 4-5°C.

In addition, the participants suggested that communication within the commune be improved. They reported that most agricultural information is taken from television broadcasts. However, farmers wished to receive local and relevant communications such as forecasting, warnings, and general agricultural advice, suggesting this could be achieved by improving the quality, quantity, time of broadcasts, and location of the speakers within the commune.

They hoped to receive specific advice surrounding agrichemical use, orange production, how to cope with climate change, and the most appropriate varieties of crops.

Historical calendar

The results of the historical calendar exercise showed that TBL has been affected by numerous climatic shocks and events. Droughts, heatwaves, storms, and heavy rains have triggered disasters including floods and landslides, and the destruction of houses, land, vehicles, crops, and livestock.

All the participants acknowledged that weather patterns are changing and described that their lives, livelihoods, and agricultural systems are all negatively impacted. For instance, Mưa nắng thất thường (MNTT), a phenomenon categorized by very sunny and warm weather with the sudden onset of heavy rains, has become more frequent, occurring in both 2017 and 2018. This phenomenon is associated with root rot, and subsequent death in both orange and rice. MNTT was also deemed to have caused increased incidences of diarrheal diseases in chickens. One farmer lost 4000 chickens in October and November of 2018.

Heavy rains were recognized across both groups as a severe threat, causing landslides, damaging crops, and washing away freshly applied agrichemicals. Landslides occurred in 2005 during storm No. 7 which was noted as a historical event by all the participants. Rice fields and crops were destroyed by landslides and livestock were killed. The extremely powerful storm caused major damage to vital assets such as an important bridge, vehicles, televisions, and homes. This storm also claimed the lives of ten people from Nghia Lo district and one person from TBL commune.

Heatwaves and droughts are becoming more frequent in TBL commune. A heatwave in 2014 resulted in temperatures reaching 40 °C, causing many orange trees to die. Higher temperatures caused livestock and cattle to seek shade and farmers observed that grazing is disrupted.

All the participants were concerned by drought and lack of water for irrigation. The results showed there were disparities regarding access to water in the commune. For example, some farmers have access to tanks and do not experience drought, yet those who gather water downstream, find that during the dry season there is a serious lack of water. In some instances, these disparities have led to conflict.

Cropping calendars

Regarding GDP, orange is the most important crop in the region, while rice is mainly produced for home and local consumption. Farmers outlined current practices carried out for all crops and noted who was responsible. Data was collated and presented in **Figure 4**.

- *Orange*

The main activities associated with orange production are pruning, weeding, application of agrichemicals (fertilizers, pesticides, flowering agents), and harvesting. Men and women typically share responsibilities for most tasks, however, men are responsible for pesticide application and weeding. Farmers with large areas of land hire labourers to complete tasks.

Orange has been negatively impacted by climate change. Precipitation patterns affect

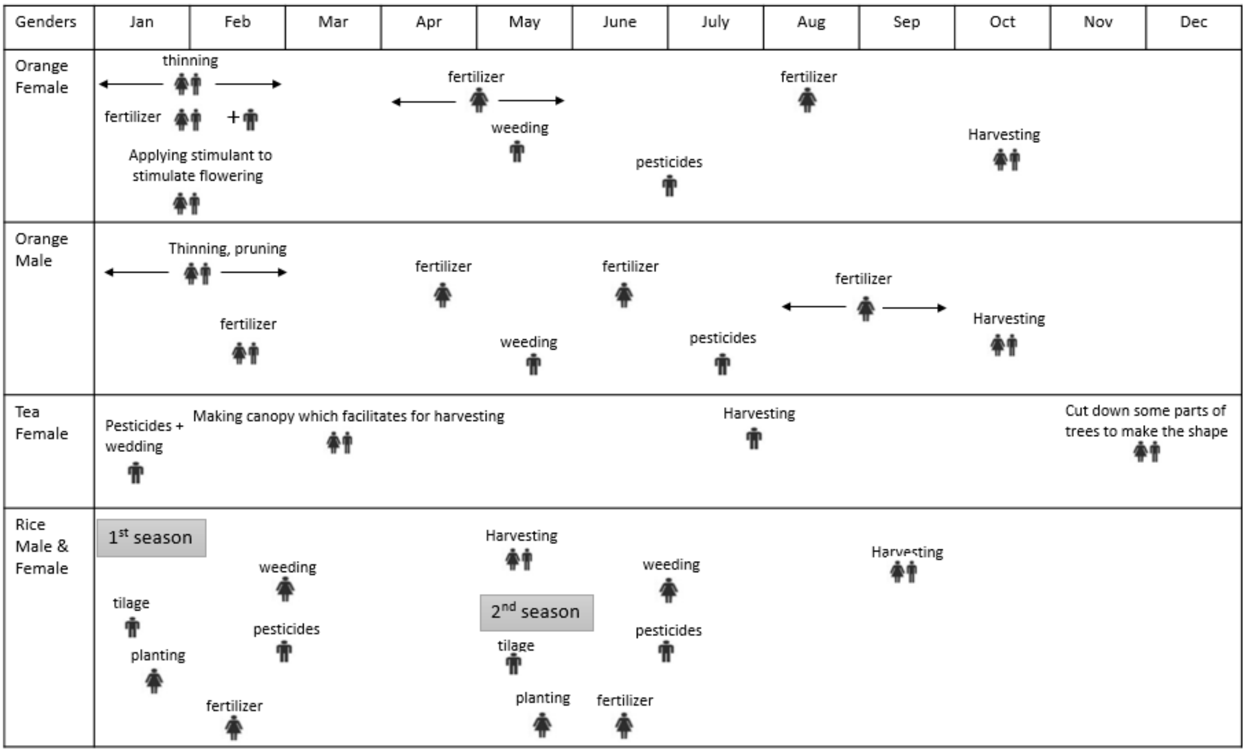

Figure 4. Crop management activities as detailed during the FGD

flowering and fruiting and there have been outbreaks of fungal diseases, root rot, and stink bugs. Farmers stated that production can be expensive and the price received for their produce is reliant on the variety of orange grown and how well this variety performs.

- *Tea*

Only the women's group discussed the tea cropping calendar. Primarily, women are responsible for tea production, yet they stated the associated labour is shared equally between men and women. Farmers stated that tea requires less maintenance than orange and rice but explained that the monthly weeding is labour intensive.

Many tea trees were removed to make way for orange groves but in the past year (2019), prices for tea have risen and farmers who previously intended to remove tea have decided to keep it. The women have noticed the effects of shifting weather patterns, stating that acid rain has occurred in the previous two consecutive years, damaging tea leaves and leaving them unable to use or sell the affected plants.

- *Rice*

The results of the rice cropping calendars show two cropping seasons for rice: January-June and June-September/October, depending on the variety grown. All the participants listed land and seedling preparation, transplanting of seedlings, fertilizer application, and harvesting as the main activities during production. Land preparation or ploughing is carried out mechanically via two mechanisms, "cay" and "bua". "Cay" is a physical turning of the soil and "bua" is the levelling of the soil. Farmers hire a person who owns this machine and pay them 500,000 VND m^{-2} to carry out the ploughing.

Farmers did not identify gendered responsibilities as labour is shared equally. Women stated that growing rice is essential to the production of food for their families. The main varieties of rice grown in the commune are "Khang dan rice" and "Bac thom 7 rice". These varieties are subject to change every two to three years as crops typically become less productive over time.

In the first growing season, the death of rice seedlings was attributed to cold spells. As the season continued, the farmers described how heavy rains, high humidity, and lack of sunshine resulted in increased incidences of disease, a reduced rate of flowering, and a decreased ability of the plants to photosynthesize. The inability of rice grains to swell or fill was attributed to heavy rains. These high levels of rainfall have caused flooding in the rice fields situated in the lowest-lying regions of the commune. This has, in some cases, resulted in the complete loss of the crop.

- *Livestock*

The results showed the main livestock in production are cattle, fish, poultry, pigs, and buffalo. There are two types of pigs, one for consumption and one for breeding. Pig farming provides a source of income as pigs are sold annually, or when they have been fattened to the desired level for slaughter.

Changes in weather and climate are directly affecting livestock. Hot weather and heatwaves are seen to caused higher rates of intestinal and lung infections in pigs, the death of fish in ponds due to lower oxygen levels in the water, and the developmental disruption in chicken eggs. Cold weather also affected the development of chickens as they are more susceptible to diarrheal diseases.

Resource mapping

The results of resource mapping showed the main agricultural, forested, and residential areas in the commune. The participants highlighted important resources including bridges, major and minor roads, mountains, rivers, streams, and local amenities such as the commune leader grounds and the community hall in each village.

Nong Truong is the largest producer of orange and has about 100 ha of land reserved for agriculture. Thien Buu produces significant amounts of orange and rice. In Muong village, rice is produced on 20ha of land, with maize being grown in these areas (and hilly areas) during the winter months. There is small-scale production of orange, pig, and chicken in the village.

The participants discussed how resources in their villages have changed over time and have been negatively impacted by disasters and climate change. Floods have destroyed rice paddies and orange trees across all villages. Farmers attributed the death and disease of many orange trees to root rot and fungal disease caused by the heavy rains associated with MNTT. Heatwaves and droughts have led to a lack of water for irrigation and personal use.

All farmers wished to receive new information regarding farming technologies and methods, as at present, they continue the use of traditional approaches. The farmers were unhappy with the current orange varieties in production and want updated information regarding more suitable varieties. They felt that growing one standard variety would support the sharing of information and technology among farmers in the commune. The farmers' livelihoods have been impacted by the low price they receive for rice. This price is not reflective of the costly and labour-intensive work associated with the production of rice, causing some families to abandon their fields completely.

Activity clocks

The results of the activity clock exercises showed no major differences between the men's and women's daily activities with both genders aware of each other's routines. Depending on the crop and the season, all the farmers typically spend six to eight hours partaking in agricultural work. The results showed that the women take care of children and elderly family members. Typically, the women are responsible for the preparation of all meals throughout the day and the household cleaning chores, leading them to rise earlier and go to bed later than men. The men will help with the children's homework and so duties are perceived to be equal by both groups.

Organizational mapping

The results of the organizational mapping showed that farmers in the commune have an awareness of and have formed relationships with organizations working in the area. Seventeen organizations were identified by farmers. Eight of these were acknowledged by all the participants, however nine organizations were identified by the men only and two were identified by the women only. The organizations and institutions were placed into three broad categories, concerning livestock and crop cultivation, forestry, and the social and political sphere.

The commonly mentioned organizations were the Youth Union, Women's Union, Veteran's Association, Elderly Association, Farmer's Union, VietGAP, agrichemical companies, and the Agricultural Extension Service of Van Chan. The men also mentioned the Forest Protection Department, the Institute of Vegetables, the Institute of Post-harvest, the World Bread Organization, the District Veterinary Department, the District Agriculture Department (DARD), and the Farmers Union of Van Chan District. The women mentioned the "middlemen" to whom they sell their oranges.

Organizations such as DARD set directives for the commune. The Agricultural Extension Services work in conjunction with farmers to implement the appropriate agricultural practices. The presence of agrichemical companies is crucial in ensuring good quality products are reaching the farmers. Furthermore, "informal" organizations such as the Farmer's Association enable farmers to acquire low-interest loans, fertilizer, and money. Moreover, when there is a climatic shock or a disaster, members of the Youth Organization assist the farmers.

Identification and prioritization of CSA for TBL Commune

The results of the SANA at the community level informed the development of the proposed CSA T&Ps for prioritization and were presented to experts. The results of the expert interviews and practices selected for showcasing at the technology fair are presented in **Table 1**.

Results of the farmer workshop

Forty-eight farmers participated in the CSA technology fair, twenty-six men and twenty-two women. The results of the voting exercises are presented in **Figures 5, 6, and 7.**

Discussions

The CSA–RA methodology was central to this exploratory study. The rapid, participatory approach effectively encouraged farmers to share their stories, advice, and wisdom, while providing the authors with an opportunity to explore local agricultural systems and practices, climate change impacts, and openings for CSA programmes.

Impacts of climate change on the communities and agriculture in TBL commune

The farmers in TBL commune have experienced the negative impacts of climate change, both personally and agriculturally. Weather patterns, seasons, and climate are erratic and unpredictable, and are wreaking havoc on agricultural systems and livelihoods. The farmers observed increasing levels of rainfall, acid rain, and higher temperatures resulting in vulnerabilities such as a decreased fruiting rate in orange, decreased flowering and yields in rice, mass death of orange trees, pests and disease outbreaks, and heat stress of livestock. There were concerns surrounding low soil quality and overreliance on potentially low-grade agrichemicals. A lack of access to superior quality crop varieties, fair market access, and

Table 1. Proposed CSA T&P as ranked by experts and presented at the technology fair in TBL commune

Crop	CSA T&P	Expert ranking for each CSA T&P	Potential benefits of each showcased CSA T&P
Orange	Drip irrigation	2.75	Improve access to water, enhance plant health (stress reduction), improve soil moisture, and reduce cost
	Mulching	2	Improve soil quality, reduce soil erosion, improve weed management, stabilize soil moisture content, reduce costs, reduce waste, and enhance biodiversity
	VietGAP (Vietnamese Good Agricultural Practices)	2	Produce can easily penetrate the market; product has a higher market value; increase consumer's confidence in the quality of products; promote environmental responsibility; and limit risk of diseases
	Conservation agriculture	3	Improve soil quality; reduce soil erosion; reduce labour, and conserve water
	Intercropping with legumes	2.75	Improve soil quality, reduce soil erosion, labour reduction, water conservation, provide protection of cash crops through repelling pests/biocontrol, protection against wind/sunlight, reduce cost, nitrogen fixation, improve weed management, and enhance biodiversity
Rice	ICM	1.75	Improve crop production, quality and yields, reduce use of chemical inputs through enhancing use efficiency, redesigning cropping systems; reduce waste; optimize local resources; and reduce external inputs and costs
	Upland mulching with rice residues	2.25	Improve soil moisture and quality; reduce soil erosion; enhance water use efficiency; reduce waste; reduce inputs/cost and maximize incomes
	IPM	2.25	Minimize the use and exposure to pesticides; reduce inputs and cost; suppression of pest populations; and minimize environmental impact and risks
	Fertilizers - organic waste	2.75	Reduce reliance on chemical fertilizers and associated cost; improve incomes; reduce organic waste, e.g., manure and crop residues; and improve crop yields
Livestock	Vermi-culture	1.75	Improve organic waste management; improve soil condition; expand feedstocks in chicken rearing; and improve incomes
	Biological bedding for chickens	3	Reduce disease in chicken rearing; develop biofertilizers; reduce reliance on chemical fertilizers; improve quality of meat, enhance nutrition; and improve incomes

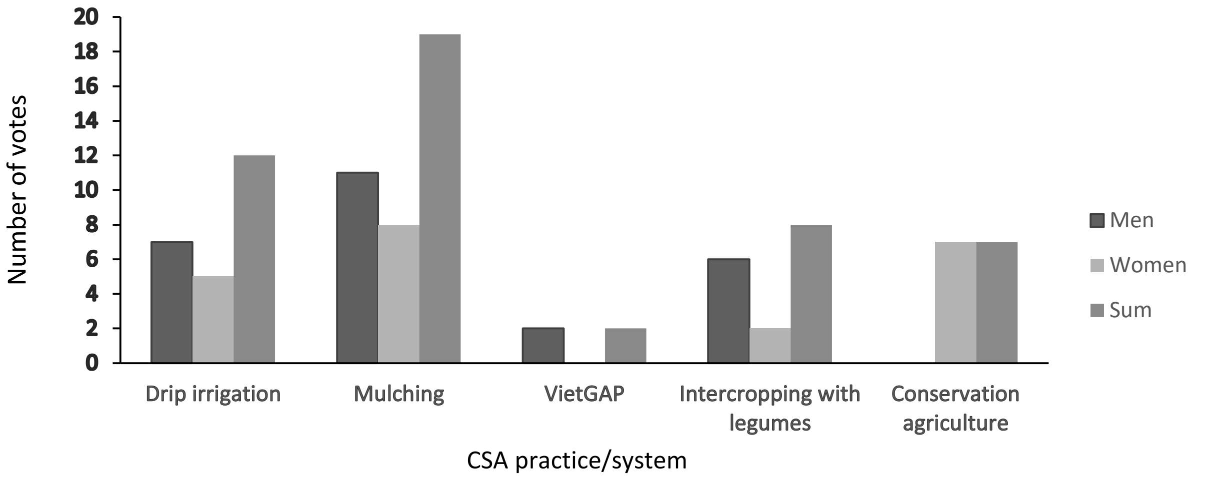

Figure 5. Results of the farmers' prioritization of CSA T&Ps for **orange production** (n = 48; Men (M) = 26; Women (W) = 22). Results disaggregated by practice (Drip irrigation - sum of votes = 12; M(7) W(5); Mulching - sum of votes = 19; M(11) W(8); VietGAP - sum of votes = 2; M(2) W(0); Intercropping with legumes - sum of votes = 8; M(6) W(2); Conservation agriculture - sum of votes = 7; M(0) W(7)).

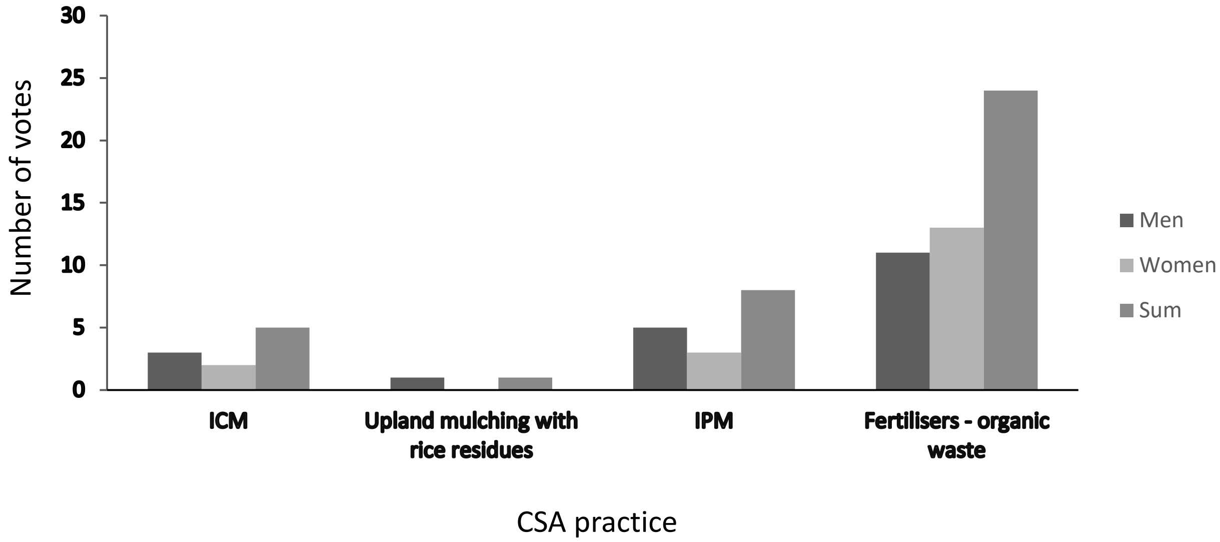

Figure 6. Results of the farmers' prioritization of CSA T&P for rice production during the CSA technology fair (n= 38; Men (M) = 20; Women (W) = 18). Results disaggregated by practice (ICM - sum of votes = 5; M(3) W(2); Upland mulching with rice residues - sum of votes = 1; M(1) W(0); IPM - sum of votes = 8; M(5) W(3); Turning organic waste into fertilisers - sum of votes = 24; M(11) W(13)).

access to information and support were the major concerns and are potential barriers to the adoption of CSA (Shackleton *et al.*, 2015; Shirsath *et al.*, 2017).

Shocks such as drought have led to increased pressure, including a lack of water for irrigation and personal use. At times this has led to conflict, a finding reflected in the literature (Shirsath *et al.*, 2017; Eam *et al.*, 2018). It is suggested here that this conflict may be correlated with the disparities found in the commune regarding access to water. Some farmers in the commune have access to pipes and water storage tanks and do not experience drought, yet those that do not have access, experience drought. This enhanced ability to adapt by some farmers was demonstrated during the study, where some of the men who farmed over 6-7 ha of orange have access to a water tank installed by one of the participants. Although this demonstrates a collective action in the community, it consequentially highlights that those farmers

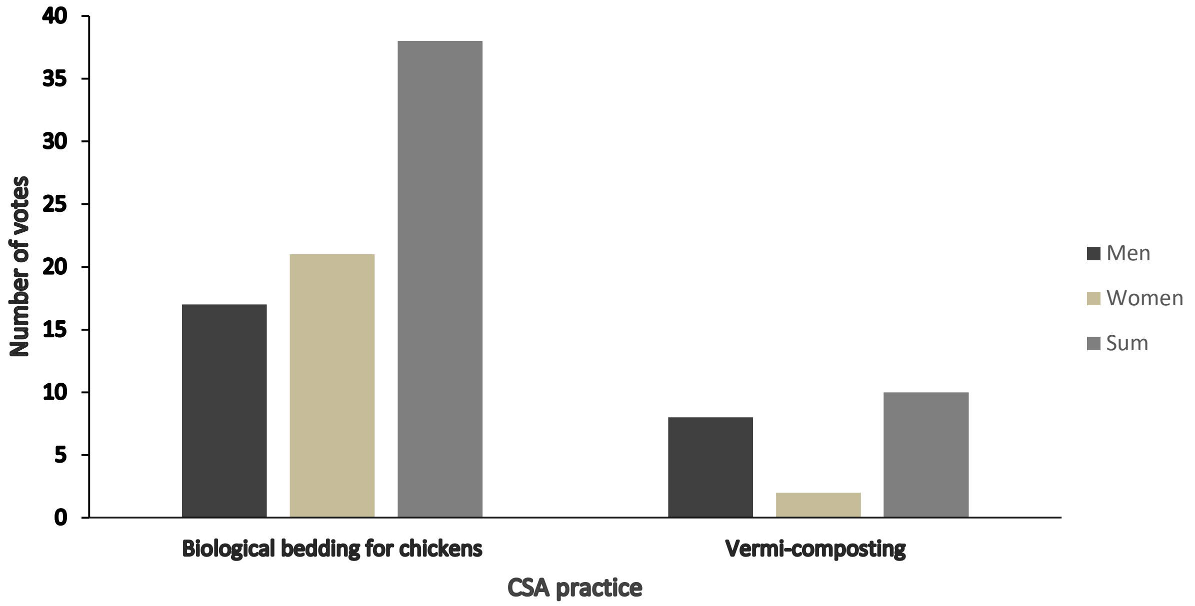

Figure 7. Results of the farmers' prioritisation of CSA T&P in livestock production (n = 48; Men (M) = 26; Women (W) = 22). Results disaggregated by practice (Biological bedding for chickens - sum of votes = 38; M(17) W(21); Vermi-composting - sum of votes 10; M(8) W(2)).

with smaller areas of land and lower incomes may be excluded, leaving them more vulnerable to the effects of drought and furthering the negative effects on their livelihoods (Sahua & Mishra, 2013).

Moreover, the lives of people are at risk because of storms and floods, which have already claimed lives in the past. These historical events place people in a vulnerable position as they lose assets, land, and homes. These events contribute to the overall resilience of people, and can keep them in a continuous cycle of poverty and vulnerability (Hertel & Lobell, 2014).

Prioritization of CSA T&Ps

Currently, farmers do not utilize any agricultural practices that can be considered CSA on a large scale. Farmers stated that they do not know how to cope with climate change and its associated negative effects.

The concept of CSA was novel in the commune, therefore the CSA T&Ps showcased during the farmer workshop have the capability of being employed across multiple cropping systems. For instance, conservation agriculture and ICM are blanket terms that include some of the showcased practices including keeping the grounds of orchards mulched with weeds, intercropping with legumes in orange groves, and upland mulching with rice residues.

The farmer prioritization of CSA T&Ps demonstrated a preference for the mulching of orange orchards (40%) and drip irrigation in orange (25%) (**Figure 5**). Mulching can be considered a "best practice" as it helps to alleviate issues such as dry and bare soil, trap moisture, and harbour biodiversity, for example (Ramakrishna *et al.*, 2006). Irrigation has been cited to enhance the resilience of farmers to climate variability and change (Sahu & Mishra, 2013). Therefore, the uptake of drip irrigation in the commune would aid in the capacity building of the farmers. However, it can be a costly endeavour that may require financial support from the government. Intercropping with legumes in orange groves and conservation agriculture received similar levels of preference by farmers.

The study showed there is a requirement for more "nutrient smart" practices in the commune. Incoming projects ought to draw on CSA practices that reduce the overuse, overreliance, and uncertainties associated with agrichemical use (Pretty, 2008; Aggarwal *et al.*, 2018; Campbell *et al.*, 2016). This need was reflected in the prioritization of the "treatment of organic waste to make fertilizers" practice by 63% of the farmers, in correlation with previous findings regarding concerns about the quality, quantity, overuse, and washing away of agrichemicals. Moreover, exploring the quantities and categories of agrichemicals being utilized in the commune will result in improved mitigative strategies while enabling farmers to become less reliant on them.

Farmers showed preference for biological bedding for chicken raising during the workshop, capturing 79% of total votes (**Figure 7**). This was expected because during the FGDs many people highlighted the spread of diseases, which this practice would help to alleviate. Additionally, biological bedding enhances the weight and health of chickens, enabling the production of better products. This practice has the bonus of becoming a source of bio-fertilizer after six months of usage for vegetables, fruit trees, and crops (Vernooy *et al.*, 2015). Vermi–composting received 21% of the overall votes, and although it was not the highest-ranking, it has the potential for implementation since this practice has been successful in Ma village, another CSA site in Vietnam.

Perceptions surrounding climate change are personal, context-specific, and influenced by many factors (Niles & Mueller 2016). The practices prioritized by the farmers are pivotal to the uptake and continuation of adaptation and mitigation practices, yet these may not be the most feasible and appropriate solutions. Moreover, the experts' decisions need to be guided by local knowledge and interests. The results of the study indicated that there are immediate openings for the uptake of CSA T&Ps and the following practices are highly recommended: vermi-composting, changing organic wastes to fertilizer, biological bedding for chicken raising and conservation agriculture, the mulching of orchards with weeds (orange, maize, and upland rice), and intercropping with legumes in orange groves. With appropriate funding, the input of organizations, the development of projects, and the political will, there is great potential for the uptake of many more CSA T&Ps, such as drip irrigation and the production of animals and crops complying with VietGAP. The farmers hoped that future projects would provide training on agricultural planning and practices. They hoped incoming projects will work with existing organizations such as the agricultural extension association of Van Chan and the Farmers Association. The results indicated that the relationship between the community and these organizations is pivotal in ensuring the productivity and health of agricultural systems, and the overall wellbeing of the community.

Conclusions

This study presents a comprehensive overview of climate change impacts experienced by farmers in TBL commune, Vietnam and prioritizes CSA T&Ps for immediate uptake. A deep understanding of the enabling environments and potential barriers to the uptake of CSA is required, warranting further study. Programmes and policies should ensure farmers have access to affordable credit to facilitate enhanced responsiveness to climatic conditions, thus strengthening resilience. This will take some time, effort, and the involvement of incoming projects, governmental and village leaders, and farmers alike. Organizations and institutional bodies play a leading role in the identification and prioritization of suitable CSA options, which was evidenced through this study. Developing partnerships is the foundation of any successful CSA intervention, and therefore, building relationships with key organizations working in the area, such as VietGAP, could enable farmers to access information, support, and markets.

It is expected that the uptake of the CSA options in the study region will improve agricultural productivity, enhance incomes, and result in the adaptation of agricultural systems, contributing to the development of the first climate-smart commune in Vietnam. This study has evidenced the power of participation and people working together to combat the adverse effects of climate change, building a more resilient and empowered community.

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