

Agricultural cooperatives and climate change adaptation - Case study in Son La, Vietnam

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Abstract:

Adaptation to climate change is an urgent task not only on a national level but for all nations around the world. Within Vietnam, the Son La province has emerged as a successful example of cooperative development. This study aims to confirm the role of agricultural cooperatives in climate change adaptation in order to provide recommendations to cooperative developments as solutions in environmental protection. Based on the concepts of climate change adaptation in updated reports from the Vietnam National Determination Contribution in 2020, this study applies diagnostic and cause-effect analysis to concentrate on highlighting contents and pointing out evidence of Son La cooperatives' roles. The findings show that these cooperatives have significant responsibilities in the orientation of green and safe production, and strongly contribute to reducing negative activities that destroy agricultural ecology. Additionally, cooperatives are also effective actors in linking officers and farmers in the implementation of environmental protections and are leading applicants of solutions for mitigation and adaptation to climate change in rural areas and in agricultural production.

Keywords: Son La agricultural cooperatives, Son La climate change adaptation, Son La cooperatives.

Classification numbers: 2.2, 4.1

1. Introduction

As a result of the Industrial and the challenges and strengths it brought to social economic development, the pursuit of building a sustainable world is becoming a strong focus both nationally and internationally. Climate change is the most urgent concern in the field of sustainability as mentioned by the Intergovernmental Panel on Climate Change (IPCC) co-chair Panmao Zhai: "Climate change is already affecting every region on Earth, in multiple ways. The changes we experience will increase with additional warming [1]". Actually, the average weather conditions and weather variability of a region (or the planet in general) are changing and will continue to change with time. These changes are monitored by variations in temperature, precipitation, wind, storms, and other indicators such as sea level, which are also used to measure climate change. Much of these variations may also change the type, frequency, and intensity of various crop and livestock pests, the availability and timing of irrigation water,

and the severity of soil erosion. In other words, the agricultural sector is one of the most vulnerable sectors to the impacts of climate change [2].

As a managed ecosystem, agricultural systems directly influence production and food supply. Thus, understanding accurate climate change impacts in short and long-term agricultural development is crucial [3]. For example, land degradation, agricultural area loss, low productivity, and air pollution often appear in the short term whereas global threats to food security are long-term threats. Under these conditions, it is necessary to adapt to climate change to reduce damages as well as increase survival.

For suitable pathways, agricultural cooperatives are mentioned as a business form that strongly concerns community and farmer benefits. This is because these cooperatives have been established by farmer groups (e.g., Farmers' Voluntary), including a majority of smallholders at extremely poor or grass-roots levels [4]. The cooperatives serve their members through the following main actions: (a) Supplying farm input

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services like seeds, fertilizer, and machinery; (b) Marketing services such as transportation, packaging, distribution, and product marketing; and (c) Credit services to facilitate farming activities [5]. Moreover, agricultural cooperatives can link rural communities with higher scale public and private institutions including governments, development agencies, and agribusiness companies. These partnerships can help limit greenhouse gas emissions from cooperatives and, by their definition, are a possible channel to promote local adaptation and mitigation measures to climate change. Cooperatives are in solidarity with the surrounding community to reduce negative impacts of climate change on people and the environment by following environmental standards and promoting local production and marketing as opposed to long distance transport among consumers and producers. Per the conclusion of the Sustainability Solutions Group (2014), cooperatives represent a systemic solution to global challenges in energy, transportation, housing, retail, employment, and the economy. This indicates that a good solution to confront climate change is through cooperative enterprises [4, 6].

Son La is a mountainous province in northwest Vietnam. Since 2015, Son La's cooperative development has been in the top 10 highest rate of growth by province out of the entire country. The rapid growth of cooperatives, with 192 cooperatives in 2015 to 661 cooperatives in 2020 [7], means that the increasing number of members partially contributes to benefits for farmers as well as adaption to climate change. In legal terms, cooperative development policies are considered a key agenda of not only provincial but also national policies to improve the rural sustainability economy. Recently, at the national level, Resolution No.20-NQ/TW by the 5th National Committee in 2022 confirmed that continued efficiency innovations and cooperative developments that are oriented toward value chains are to be the mainstream of agricultural improvement [8]. In line with the provincial regulation, Resolution No.23-NQ/TU by Son La People Committee enacts that the development of cooperatives directly follows the green economy and circular economy as prioritized in the action plan of Son La [9].

Unfortunately, a preliminary survey shows that most members' motivation for taking part in cooperatives is not to adapt to climate change, not

working together as originally intended. Meanwhile, the agricultural ecosystem has been strongly damaged by climate change in recent decades. According to a report by the Son La Provincial People's Committee (2019), during the last 10 years many flash floods, landslides, and hailstorms occurred causing heavy losses of lives and livelihoods and especially agricultural products. During the period 2018-2019, extreme climate events damaged more than 2,600 hectares of rice; 1,900 ha of maize and crops; more than 1,200 hectares of fruit trees; and dozens of tons of aquatic products that were washed away.

In terms of advancing the cooperative response to climate change by cooperative development, the aim of this study is to find solutions for agricultural cooperative development in Vietnam. Wherein, the following three main objectives are identified: (i) Highlight concepts behind the roles of cooperatives in adapting to climate change; (ii) Point out evidence of cooperatives' attention to environmental concerns in agricultural production; and (iii) Suggest some viewpoints and orientations for farmers/households to become cooperative members to adapt to climate change in Vietnam.

2. Methodology

2.1. Approach description

In this study, prior research in climate change and multiple cooperatives' roles in sustainable development were reviewed as secondary data to collect adapted solutions through cooperative models. This was the background to design the survey/fieldwork in the next steps. The roles of cooperatives in supporting its members for adaptation to climate change in each stage (i.e., input, production, and postharvest) were observed to identify the advantages of the cooperative model in terms of reducing impacts from climate change. Literature such as academic journals or research reports (formal and informal) were gathered from different sources including national and local government offices and available internet data.

In the context of adaptation, a study based on reports from the National Determined Contribution (NDC) at the Conferences of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) was updated and published by the Vietnamese Government in 2020 [10]. Indeed, the

adaptation component is defined as the minimization or reduction of damages from climate change by applying appropriate prevention methods and using efficiency resources.

Moreover, for the purpose of supplying practical evidence for the argument made in this article, participatory action research (PAR) was applied to three cooperatives as emerging study cases in Son La. Interviews were conducted to call attention to the functions/roles of cooperatives in adapting to climate change. Each PAR interview lasted at least 90 min and followed up on specific, academic questions while secondary data were collected mainly during 2020-2021 with partial updated figures done in 2022. Diagnostics and cause-effect analysis were combined to provide findings or recommendations to the local government in cooperative development.

2.2. Framework analysis and limitation (Fig. 1)

With the results of the literature review as a guide, the authors conducted field trips to document evidence of climate change adaptation by the cooperatives in Son La. To verify the findings from prior research, this study collected data and information based on semi-structured questions in PAR interviews of local officers, cooperative members, households, and farmers. Any activities or achievements by the cooperatives to reduce climate change was identified as a contribution to adaption in this model. Consequently, this research's limitation is that any available samples, rather than the quantity of samples, proves the role of cooperatives in climate change.

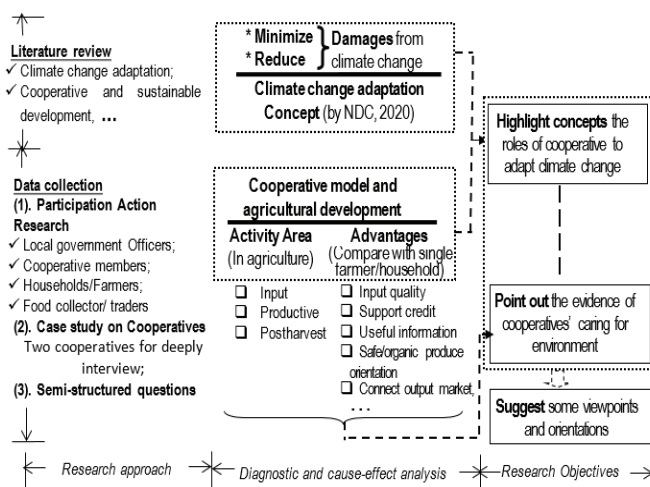


Fig. 1. Research framework analysis.

To compile the evidence, this study documented the authentic situation of three specific cooperatives that were introduced by local officers as having activities that reduce damages made by climate change. These cooperatives are described in the following case boxes to examine the existing roles or action plans that cooperatives use to better climate adaption than an individual household or farm. The concept of a cooperative's role in adapting to climate change is revealed by diagnostic and cause-effect analysis. These results are significant references for issuing recommendations as a part of our research objective.

3. Results

3.1. Climate change situation in Son La province

One of the most obvious aspects of climate change is global warming. In the period of 1986-2020, the average temperature of Son La tended to increase over the whole province. Bac Yen was the lowest average temperature of all districts in Son La. However, over the past 30 years, the average temperature of Bac Yen has increased significantly. The average temperature in Bac Yen in 1986 was 20.5°C and in 2019 and 2020 it was 22.3°C and 21.8°C, respectively. The average temperature in Bac Yen has increased by 1.3-1.8°C during the period of 1986-2020 (Fig. 2). Meanwhile, in Yen Chau, with one of the highest annual average temperature districts in Son La, the average temperature in 1986 was 22.8°C. This number had risen to 24.7°C and 24.4°C in 2019 and 2020, respectively, increasing by 1.9°C and 1.6°C compared to 1986) shown in Fig. 3.

According to the climate change scenario of Son La province (2021), the average temperature will continue to increase into the 21st century. Correspondingly, the average annual temperature of the early 21st century (2015-2035) will increase by 1.64°C (range from 1.15 to 2.00°C). In the middle years of the 21st century (2046-2065), the average temperature will rise by 2.09°C (range between 1.88 and 2.22°C). Finally, at the end of the 21st century (2066-2099), the average temperature will expand by 2.73°C (range from 2.38 to 2.88°C) compared to the period of 1986-2005 (Fig. 4).

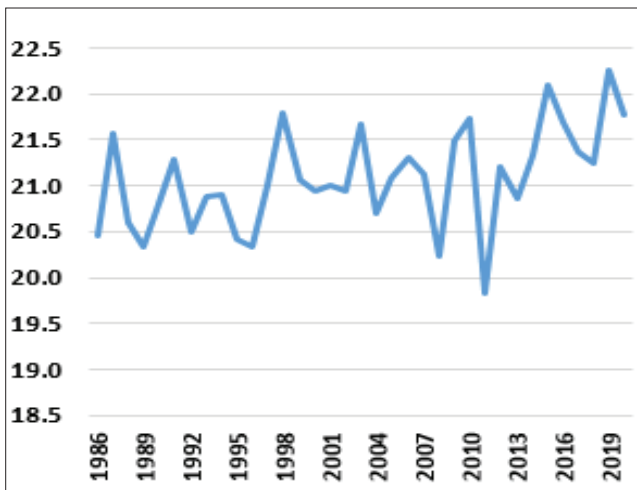


Fig. 2. Average temperature at Bac Yen in the period of 1986-2020. Source: [11].

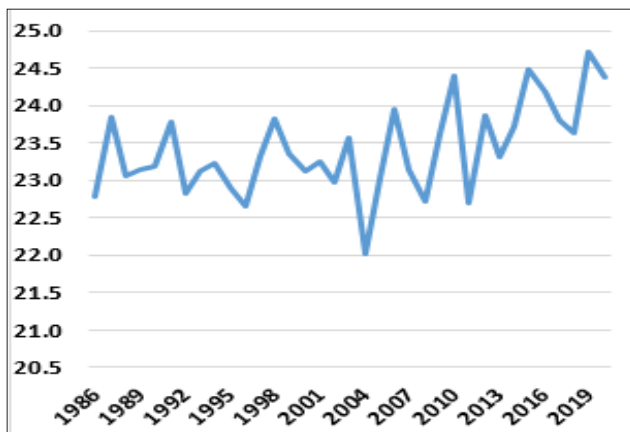


Fig. 3. Average temperature at Yen Chau in the period of 1986-2020. Source: [11].

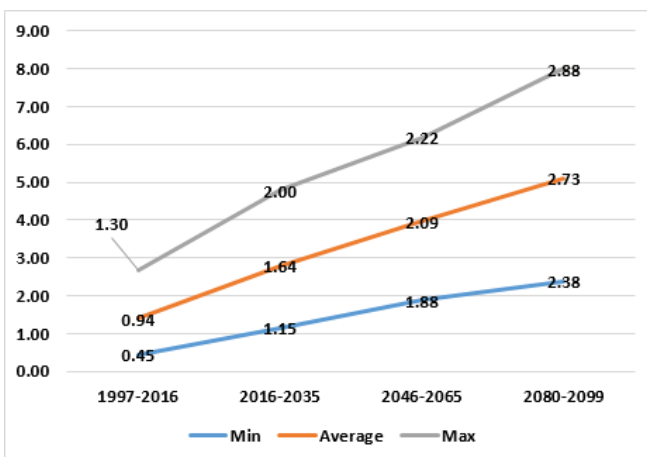


Fig. 4. Temperature scenario during the 21st century in Son La province. Source: [11].

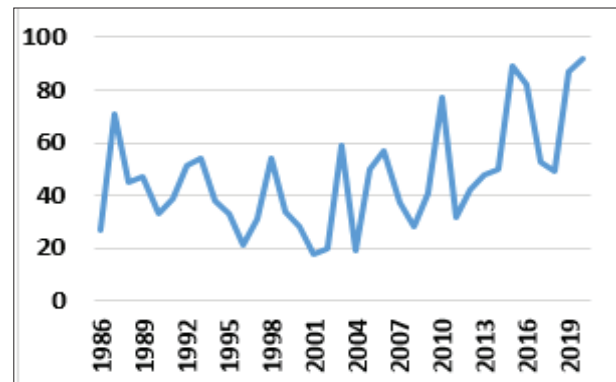


Fig. 5. Number of hot days ($\geq 35^{\circ}\text{C}$). Source: [11].

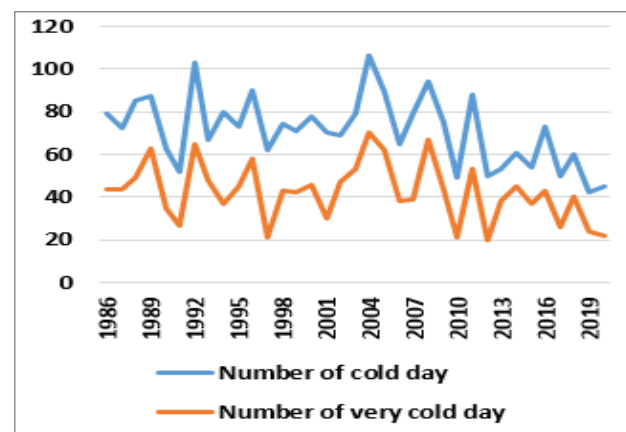


Fig. 6. Number of cold ($\leq 15^{\circ}\text{C}$) and very cold days ($\leq 13^{\circ}\text{C}$). Source: [11].

In parallel with the escalation of average temperature, the hot weather season (summer) in Son La will begin earlier and end later, while the cold weather season (winter) will start later and end earlier. During the period of 1986-2020, the number of hot days ($\geq 35^{\circ}\text{C}$) measured by all the hydro-meteorological stations in Son La province tended to increase (Fig. 5). Meanwhile, the number of days of chilling cold ($\leq 15^{\circ}\text{C}$) and biting cold ($\leq 13^{\circ}\text{C}$) tended to decrease (Fig. 6). The change in average temperature has directly impacted farmers' production timetables, especially in cultivation. Some plants may ripen or be harvested at unusual times, and there could be earlier as well as longer cultivation times. Therefore, farmers may pay more fees or work longer during cultivation.

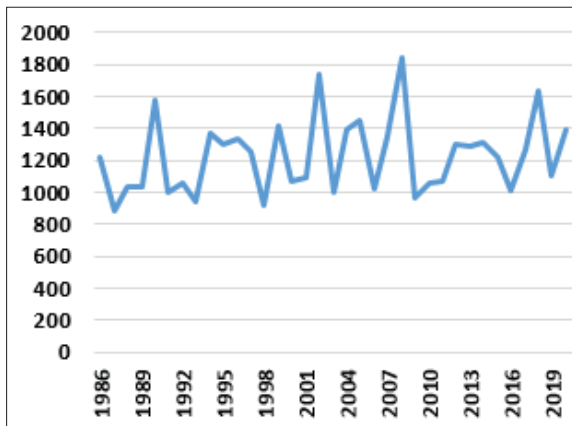


Fig. 7. Rainfall in Son La in the period of 1986 to 2020. Sources: [12].

From 1986 to 2020, the total annual rainfall did not have significant fluctuations, but the rainfall occurred irregularly (Fig. 7). In 1986 and 1998, the rainfall was low (less than 1,000 mm). Conversely, the rainfall increased dramatically in 2008 (more than 1,800 mm). However, rainfall was mainly concentrated in the rainy season (from April to September), which accounted for more than 80% of the rainfall for the entire year. The abundant rainfall is mainly in July and August (Fig. 8). Rain occurred capriciously and the total amount of rain remained constant while the rain period was short, causing floods, droughts, and greatly affecting human life and agricultural production.

3.2. Current status of agricultural cooperatives in Son La

Son La has been one of the top ten leading provinces in terms of the number of cooperatives in Vietnam in recent years. The growth rate of the number of cooperatives in Son La is nearly two times higher than the national average growth rate [13]. In 2020, the number of cooperatives in this province was 661 of which 85% were agricultural cooperatives [7]. During the past 10 years (2010-2020), the number of newly established and active agricultural cooperatives in Son La increased sharply from 90 to nearly 600 in 2020 (Fig. 9).

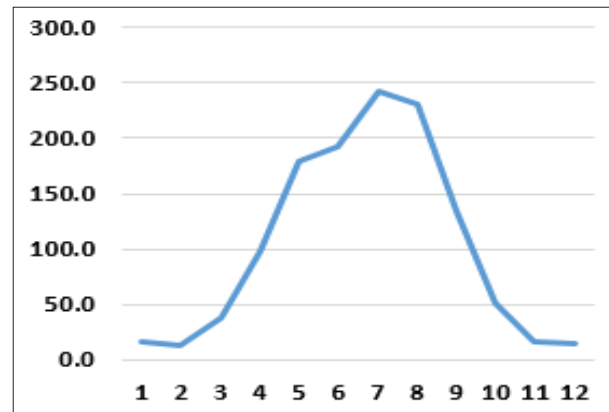


Fig. 8. Distribution of rainfall by month in Son La province. Sources: [12].

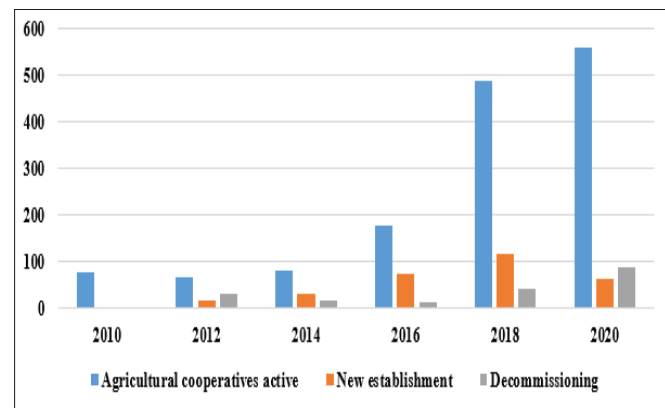


Fig. 9. Number of agricultural cooperatives in Son La over the period 2010-2020. Sources: [12].

The Son La agricultural cooperatives take part in all stages of the production process from input, production, and output stages. Although the proportion of profitable cooperatives is not high, accounting for only 34% of the total number of agricultural cooperatives in 2019, lower than the national average [13], by their specific activities, they have initially played a role in supporting their members in all stages of the production process (Fig. 10). Typically, low input price as well as the advantages of output market linkage have attracted many farmers to be participants of cooperatives. Meanwhile, the supporting local and national policies for agricultural development such as funding, exporting schemes, or high-tech applications have been motivations of agricultural cooperative establishments rather than other forms of cooperatives in Son La.

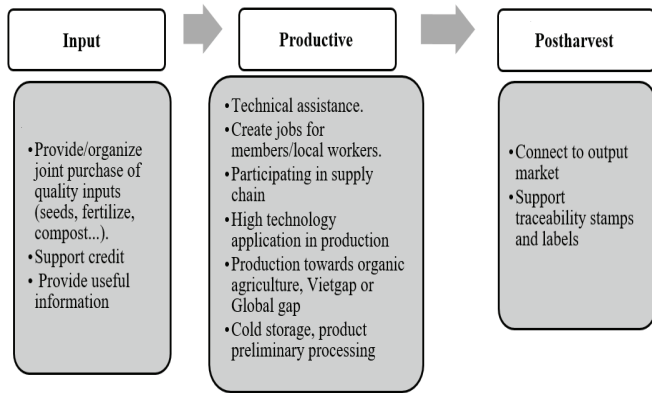


Fig. 10. How agricultural cooperatives support their members during the production process.

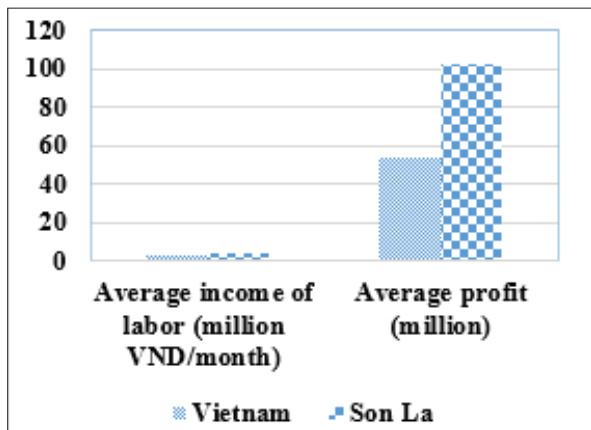


Fig. 11. Performance of agricultural cooperatives in Son La and Vietnam in 2019. Source: [14].

During 2015-2022, many local governments have released plans to encourage agricultural cooperative development such as policies to support the development of production, processing, and consumption of safe agricultural products in the period of 2018-2021 (Resolution No.76/2018/NQ-HDND) (Table 1); policies to encourage the investment in agriculture and rural areas (Resolution No.128/2020/NQ-HDND); etc. Unfortunately, the majority of agriculture cooperatives in Son La are small in terms of assets, capital, and size of members. The average assets and revenue per cooperative are 1.07 and 2.00 billion VND, however, average profit and income per labour of agricultural cooperatives in this province are higher than the national average (Fig. 11).

Table 1. Performance of agricultural cooperatives in Son La, 2018-2020. Source: [14].

Criteria	Year		Compared	
	2018	2020	+/-	%
Total number of members (person)	5,804	6,588	784	14
Average number of members per cooperative (person)	12	12		
Total management (person)	1,800	2,720	920	51
Average number of managers per cooperative (person)	4	4		
Board of manager per cooperative (person)	2	2		
Accountant per cooperative (person)	1	1		
Control board per cooperative (person)	1	1		
Average assets per cooperative (million VND)	921	1,070	149	16
Average revenue per cooperative (million VND)	1,700	2,000	300	18
Average of profit (million VND)	133	200	67	50
Average income of a regular employee (million VND/month)	2.5	4	1.5	60

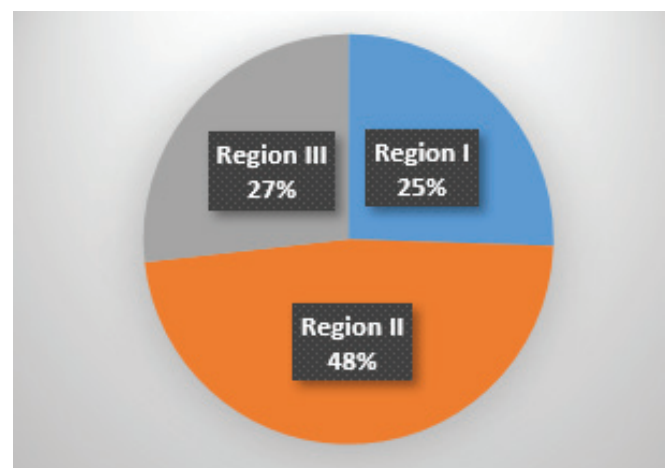


Fig. 12. Proportion of cooperatives under different regions in 2020. Source: [14].

Most agricultural cooperatives are concentrated in Regions 2 and 3, where the economy and other conditions are still difficult as they remain vulnerable to the impacts of climate change (Fig. 12). In addition to supporting members in all stages of the production process, the average income of agricultural cooperative members and labours in 2020 was 4 million VND/month, more than twice higher than the average income of people in this province which is 1.7 million/month [15]. Therefore, the development of cooperatives in this area also plays an important role in ensuring social security, increasing income, and improving the capacity of households to better adapt to climate change.

Cooperative members agree that the benefits they receive when joining cooperatives are buying better quality input, increasing their awareness of technology, complying with environmentally friendly production regulations, or reducing production costs.

3.3. Cooperatives and adaptation of climate change

3.3.1. Performance of adapting to climate change

The change in weather and climate is becoming increasingly extreme. Meanwhile, climate change impacts on agricultural production in particular and people's life in general are increasing. Agricultural production has applied many measures and strategies to cope with the impacts of climate change such as access to climate information and forecasting to build appropriate seasonal plans; choosing new crop varieties that are more drought resistant, have good low-water-use efficiency, or are pest resistant [16, 17]; crop diversification [18]; planting varieties of trees and employing agroforests systems to minimize risk [11]; diversifying farmers' income to improve adaptive capacity [16, 19]; cropping adjustments, changing the growing and harvesting calendar to respond to the changing of climate [19, 20]; applying technology innovations like drip irrigation technology [21] and planting new varieties and breeds with high productivity [22, 23]; adopting new production management and practices [16, 20]; and re-using inputs, reduce greenhouse gas emissions to mitigate climate change. Among them, a very important solution is to improve people's adaptive

capacity through increasing capital (human, social, political, financial, natural, and cultural capital) and resources (technology and infrastructure, information, knowledge, institutions, and the capacity to learn) [11] for long-term living with climate change, which can turn the above solutions into a reality.

Many researchers indicate that, at the individual level, the application of these measures to adapt to climate change have faced many barriers. One of the main factors pointed out is lack of finance [19]. Households with small production scale, lack of access to finance is limiting for innovation and technology investment to respond to climate change [17]. Furthermore, lack of access to timely forecast information [18, 23]; limited knowledge about new farming techniques; poor skills; lack of information about availability and access to government support [4]; inadequate access to input/output market information [23]; lack of training; and even lack of motivation to pursue are constraints to Asian farmers' adaptation. In addition, some adaptation methods such as crop rotation, good agricultural practices and the use of organic fertilizers are often costly, can take a long time to apply, and have not been effective in the short term, leading a smallholder to give up easily.

Cooperatives operate at collective economic models and play as a significant actor in addressing these difficulties of the household level. They contribute to changing members' awareness of climate change and its impacts by sharing and providing weather information, organizing training courses or acting as a bridge for members to participate in training courses organized by government and non-governmental organizations. Agricultural cooperatives choose scientific results such as new varieties, new farming techniques, and new technologies in accordance with their members' status to cope with climate change. They guide eco-friendly processes and support techniques for members [6, 24] and encourage members to pursue good agricultural practice [24], thereby contributing to changing production and business habits of each member that may be harmful to the environment. In addition, the cooperative also acts as a bridge to mobilize and attract financial and social resources from both public/private institutions and NGOs to promote investment in climate-smart agricultural activities. Thus, cooperatives

have contributed to improving adaptation capacity, changing awareness, and enhancing resilience to climate change for members [6, 24, 25].

3.3.2. Adaptation in Son La cooperatives

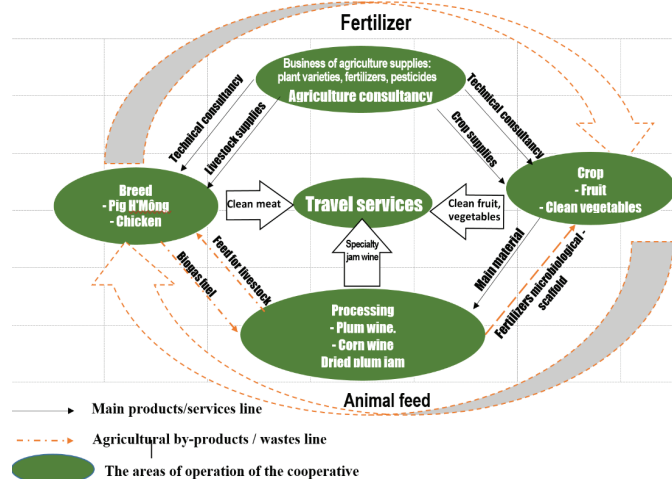
Agricultural cooperatives in Son La province, through their activities, are direct and indirect support to farmers to improve capacity and find solutions to confront climate changes.

(1) *Encouraging green and safe production*

According to the report of the Son La Provincial People's Committee (2021), over 56% of agricultural cooperatives in this province are vegetable and fruit cooperatives in which nearly 16% of production cooperatives have VietGAP or Global GAP certificates. Through good agricultural production practices according to the VietGAP and Global models, like reducing the use of pesticides and chemical fertilizers and reusing inputs at each stage, agricultural cooperatives in Son La province are directly contributing to the promotion of green production, environmental, and agro-ecosystems protection. Fruit cooperatives contribute to afforestation of hillsides to avoid soil washout. In addition, with successful cooperative models, they create a positive spill over effect, contributing to educating and promoting members and communities to pursue environmentally friendly production activities.

Case 1: 19/5 Agriculture and Services Cooperatives, Son La (Source: Survey, 2020).

The circular economy model contributes to: (1) protecting agro-ecosystems; (2) crop/business diversification; and (3) sustainable development. The 19/5 Agr Coop was established in 2000 in the Moc Chau district. They have run diversity business fields including agricultural production, processing, and providing agricultural tourism services. They apply good practices for livestock and farming, maximizing the reuse of waste products at each stage as an input for the next stage. For instance, the vegetables and tubers leftover from cultivation, waste from processing become feed for livestock, and waste from livestock can make fertilizers for cultivation, fuel/biogas for processing, and fresh products for farming and processing provided to tourists and traders.



Their activities not only decrease waste and minimize carbon emissions to the environment, but also reduce about 15% of the production costs. In addition, the pursuit of clean, environmentally friendly production as well as diversification of activities helps cooperatives better adapt to risks. This contributes towards sustainable development of cooperatives, especially in the current context of climate change and pandemics.

(2) *Enhancing adaptive capacity for members*

Case 2: Ngoc Hoang Cooperative in Mai Son, Son La (Source: Survey, 2020).

In order to support farmers to combat against increasing pests and diseases in their crops and to have success in supplying output products and collecting more funds for next crop, the Ngoc Hoang Cooperative was established including 10 optimal members in 2016. Notably, this cooperative works to provide all inputs including seeds, materials, fertilizers, and pesticides to members with guaranteed quality at a price about 5% lower than the market price. In cases when their members faced financial difficulties, the cooperative sent to them the policy of buying first - paying later.

Moreover, the cooperative also promises to buy all member products at least 10% higher than the market price. In addition, the cooperative promulgates the production process, training, and guidance for members to reduce pests and diseases, increase productivity, and ensure quality. As a result, since joining the cooperative, the average income of members reached 6-8 million/person/month by 2020 with some households having revenues around

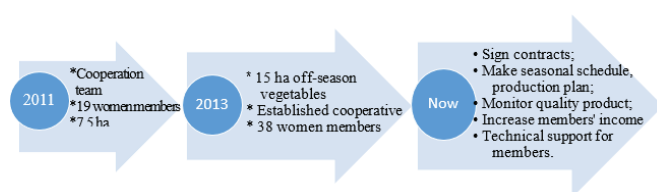
500-600 million/ha/year. Many household members have escaped poverty and increased their financial and technical capacity actively to effectively adapt the climate change. At the end of 2020, the number of members increased to nearly 200.

As mentioned above, agricultural cooperatives support members through all stages of the production process from supplying inputs, organizing joint purchasing, and supporting production to connecting outputs. Specifically, cooperatives provide information about quality inputs at reasonable prices or introduce new varieties, which are suited to the vagaries of the climate. Cooperatives also instruct and assist members in production techniques and output connection. According to the report of Son La Provincial Cooperative Alliance in 2020, there were 171 models of agricultural production and business cooperatives associated with value chains in the province, which have supported members to promote production and product consumption. Those activities have contributed to decreasing producing cost, increasing member income, and enhancing members' adaptive capacity and resilience.

(3) Promoting the application of new technologies and techniques to proactively adapt

Under the impact of climate change and the influence of extreme weather phenomena on agricultural production, the cooperatives have applied adaptation measures to minimize damages and to become proactive and ready to cope.

Case 3: Tu Nhlen Cooperative in Moc Chau, Son La.



This cooperative model has been successful in planting off-season vegetables and adapting to the weather in Moc Chau. To confront the change of weather, link production of clean vegetables, and ensure product output, this cooperative has selected new higher quality vegetable seeds like chocolate tomato, strawberries, cabbage, cauliflower, and so on, as well as change their seasonal calendar

to adapt to local weather. The cooperative actively cooperates with stakeholders to organize training sessions on transferring and applying technology according the VietGAP by using microbial fertilizes. They invested in high-tech applications for producing like sprinkler, rotary, and drip irrigation systems to reduce water loss. They control and monitor the production process in accordance with the VietGAP process, ensuring product quality. The cooperatives' products have been consumed in large supermarkets, industrial kitchens, and schools inside and outside the province thereby increasing income for members by 10 times that of old crops like rice or maize.

In particular, to reduce damage caused by hail, acid rain, and pests, the agricultural cooperatives have applied high-tech cultivation like using nets/net houses to reduce fruit drop caused by hail; or covering crops to minimize water evaporation; and using drip irrigation systems and automatic irrigation to adapt to water shortages and drought. Crop diversification, crop rotation, and intercropping are applied to reduce vulnerability and improve resilience. Short-term crops such as beans and peanuts are intercropped with fruit trees, helping to increase income for producers. In addition to coping with extreme weather, the cooperatives have changed their seasonal calendar and crops. Poor drought-tolerance crops are replaced by varieties, which confer tolerance to drought such as replacing rice and maize by citrus fruit trees. The use of new varieties, which are more resistant to pests and diseases for higher economic efficiency, is also one way that cooperatives choose to adapt to climate change. Agricultural cooperatives have also increased training for members to improve their capacity to transform crops to adapt to climate change.

(4) Improve climate change knowledge of members

Under current local and national policy for cooperative development, training programs including agricultural technique, financial accounting, and administrative management have been annually conducted for members of cooperatives not only in Son La but also in almost every province. Actually, according to annual report of Son La Provincial Cooperative Alliance, during 2019-2020, this Alliance did successfully organize 49 courses in business administrative management for 2,684 learners and 5 courses in agricultural

producing techniques for 184 learners. The funds of these courses were supported mostly by the Cooperative Assistance Fund (CAF), local governments, or NGOs.

Through these courses, besides providing safe or organic producing knowledge, fieldtrip or farm tours or visits are conducted to share good practical models. Consequently, many participants of cooperatives have been enriched in knowledge about climate change. Fortunately, many of them perceived that they need to improve their current production to adapt to climate change in order to increasing success. Moreover, each of them also becomes a trainer to innovate or share experiences with other members to produce more safely and with higher quality.

Additionally, depending on the local government, some departments at the commune level have been found to provide climate change knowledge for farmers or members. It is a typical case in the Quynh Nhai Commune of Son La, where an Aqua-cultural Consulting Office has been established as specific local government department in 2016 to guide most Fishery cooperatives in keeping a clean water environment or to use qualified feeds as a reaction to climate change.

4. Discussion and recommendations

4.1. Discussion

4.1.1. Orienting to green and safe agricultural production to adapt to climate change

Under conditions of safe or organic cultivation, chemical fertilizers have been reduced or eliminated, therefore, the soil and water system have suffered from fertilizer poison previously [26]. According to ICA (2014), in some cases, the technique of organic production can lead to a significant program of climate change adaptation to identify strains or methods that are more resilient to changing climate conditions. The requirements, however, of these cultivations are often from a Vietnamese farmer or household resource, especially in the land area prerequisite. Meanwhile, the cooperative model can solve these obstacles because of gathering multi-individual resources as farmer group. From an ICA report in 2014, an organic cooperative successfully developed a farmer-owned wind farm and their operations do not use synthetic fertilizers. This means that cooperatives applying safe cultivation often strongly influences green production orientation on their members.

In fact, the research observation in the case of the 19-5 Cooperative that applied the circular economy model (including safe and organic cultivation), each member taking cooperatives needs to agree to keep cultivation safe by reducing the use of pesticides, increasing the use of biological products, and contributing to afforestation of hillsides to avoid soil washout. The members of cooperative have conducted many positive operations for climate change adaptation. Typically, the cooperative also maximized the re-use of waste products at each stage, which is used as an input for the next stage, limiting emissions to the environment, protecting land, water, and air resources under the context of green production. As a significant achievement, through this cooperative, the farmers as the cooperative members have benefits in not only the input material price but also agro-ecosystem protection, at least compared to non-members at the same location.

4.1.2. Effectively innovate in the community to adapt to climate change in rural areas

The original purpose of a cooperative is to include any person who has similar motivations and conditions of earning money, that is willing to improve her/his economic condition, agrees the general principles of cooperative as a volunteer, and is considered to be participant or cooperative member. Actually, under the current law on cooperatives (2012), one cooperative needs at least 7 members in minimum for startup. Many cooperatives in Son La have members who are also members of a family. These members join together in almost all activities of the cooperative, therefore, operation in climate change adaptation or mitigation by cooperative impacts their members greatly and can easily inspire the benefits of adaption to those in or outside of organization. As mentioned in ICA (2014), cooperatives are a source of stability for communities [24].

During the fieldtrip to Son La, the study collected information from many farmers who were at first not a member of cooperative, but after observation of the good practice cooperative model they had a desire to become a member of a cooperative. According to N.T. Huong (2021) [27], not only in Son La but also in many other provinces, the farmer takes part in the cooperative when her/his relatives are also members of agricultural cooperatives. Many of them are motivated by the green innovation of agricultural

cooperatives [27]. Therefore, it is no doubt that the cooperative model is a good way to effectively innovate the community for adaptation to climate change in rural areas.

4.1.3. Link officers and farmers in implementations of environmental protections

Normally, any government policy that has been brought into practice needs substantial support from actors on the national and local level. It is difficult for farmers to be in compliance with a national law without guidance being implemented. According to OECD (1998), implementing policies through organized groups is often more effective or less costly than through individual agents. Research by P.B. Duong (2012, 2015) [28, 29], indicates that cooperatives can link up with rural communities with higher scale public and private institutions including governments, development agencies, and agribusiness companies. The similar idea of OECD (1998) to sustainable agriculture was the cooperative approach [30]. This means the cooperative has solidarity to reduce negative impacts on people and communities from climate change. Along the same lines, especially in agricultural policies of environment protection, Vietnam cooperatives have also emerged as a potential entity to transfer these regulations to farmers and households by their advantages in structure and characteristics in relationships among members [28]. Actually, in both case boxes in this study, many government policies have supporting funds for training sessions or to apply high technology for farmers who have to be the members of agricultural cooperatives. In deep interviews of these two cooperatives, the study explored that farmer activities in climate change adaption are accomplished by imitating other members rather than complying with regulation. This evidence proves the role of the cooperative as the connector of farmers and government officers to implement environmental policies.

4.1.4. Reduce negative activities that destroy agricultural ecology

Frequently, a farmer who has tended to cultivate using the same technique as other member taking part in a cooperative is able to contribute to reducing damage to the agricultural ecology [24]. For instance, the farmer groups under cooperative members can recycle thousands of tons of animal manure and

inedible food waste from a single farmer collection or local grocery store into renewable power for the grid using a biogas generator. Research by D.V. Cong (2017) shows that Son La releases about 136.88 thousand tons of rice straw and 130.92 thousand tons of corn cob every year [15]. However, under cooperative agreement, the member needs to follow the cooperative regulation in green production, which are at least of not burning and completing recycling to protect the environment as the cases of two specific cooperatives in this research.

4.1.5. Apply solutions for climate change adaptation

The positive advantages in land area, capital, and funding support from the government push the cooperative model to create more convenient situations than a single farmer. For instance, the opportunities of applying smart or high-tech cultivation techniques are more than what an individual household receives by local government incentives. Under local government projects, with priority conditions to the cooperative, the state budgets including funds for climate change adaptation are often sent to the member of a cooperative instead of the single farmer [13, 28]. As in the case of the 19-5 Cooperative or natural safe vegetable cooperatives, crop cover facilities and net houses were applied to effectively minimize water evaporation or reduce damage caused by rime, hail, acid rain, and pests. The farmers did not necessarily have to consider much in terms of capital investment or how to apply it in their fields. These situations faced by cooperatives have many solution options for adapting rather than other business forms, at least during 2015-2020 in Son La [13].

4.2. Recommendations

Cooperatives, from the findings of this study, are an emerging form to adapt to climate change. For the purpose of increasing climate change adaptation, the cooperative development has been a good solution. The number of farmers in cooperatives is increasing more and more as the methods of adapting to climate change are applied in the agricultural sector. To encourage farmers to take part, the stimulation of good practice cooperative cases needs to be conducted in different ways. The following solutions should be prioritized to obtain achievements in adaptation to climate change in Son La:

(1) Support technology for the safe and green production through the cooperative model: The numbers of cooperatives are selected to support transparent conditions that will be motivation for many cooperatives to run well. Consequently, their members also perceive their benefits to enjoy and apply adapting methods;

(2) Supply agricultural services for using safe input: This is a direct way to reduce damages in agricultural infrastructure. By using compost, seeds, pesticides, etc. as safety cultivation, the farmer contributes to environmental protection.

(3) Be the wholesalers or centre agents for selling outputs (post-harvest), etc.: Consider that any farmer only agrees to be a member of a cooperative if her/his benefits are protected or increased. One important warrant for members' benefits is a solution for selling their products. In this case, a cooperative operates as being centre agents and the cooperative easily attracts many farmers to be members as volunteers. This is a good situation for effectively applying adaptations to climate change.

(4) Improve local and national government policies, especially in raising funds, better administrative procedures, and promoting good agricultural products, etc. The analysis of cooperative roles in the last sections shows that government policies are very important to establish good practice models. For example, a stimulated regulation for implementation strongly contributes to a good motivation for farmers taking part in cooperatives. Therefore, more improvement in policies is necessary for climate change adaptation not only in Son La but also in other provinces in Vietnam.

5. Conclusions

Farmers and householders face complex decisions every day relating to their cultivation in the context of climate change. With the desire to create a document encouraging membership in a cooperative to place farmers in good positions to adapt to climate change, this study concentrated on confirming the active roles of cooperatives in applying methods to reduce damages from the impacts of climate change. Through case studies and cause-effect analysis, significant evidence was uncovered demonstrating the functions of cooperatives in agricultural production. Indeed, some of the advantages of cooperatives in adapting to climate change are: green and safe production;

innovation; good practice model to community; effective linkage among officers and farmers by implementing national and local policies; and strong contributions to adaptation of climate change or reductions in negative activities associated with climate change. In order to stimulate climate change adaption, more members in a cooperative should can be obtained by raising funds and applying for support in implementing smart techniques and safe input materials. Moreover, models of good practice cooperatives should be exhibited to help form new cooperatives.

CRediT author statement

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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