APPLYING PARTICIPATORY ACTION RESEARCH METHODS IN COMMUNITY-BASED ADAPTATION WITH SMALLHOLDERS IN MYANMAR

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Applying Participatory Action Research Methods in Community-Based Adaptation With Smallholders in Myanmar

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The effects of climate change to agriculture being largely location specific, it is crucial that adaptation measures recognize the value of targeted, context-specific, community-based strategies and processes. This research deployed participatory action research relying on a diverse range of socio-technical methods for facilitating community-level adaptation in climate-smart villages. Smallholder farms in four unique agro-ecologies in Myanmar were targeted. Results and insights from the 3-year, participatory action research effort chronicle how the climate-smart village approach was implemented in the four targeted climate-smart villages (CSVs). The key support systems needed for effective community engagement in implementing the CSVs are discussed. Social learning helped nurture capacities of farmers to find solutions and test and improve adaptation options. Using a combination of socio-technical processes, smallholder farmers, researchers, and facilitators improved their understanding of climate change, drivers of vulnerability, and coping activities. With this knowledge and understanding, the farmers in the CSVs identified a menu of adaptation options that they would test and adopt (and scale). This "portfolio approach" to deriving adaptation options ensured that there were opportunities for men, women, and landless households to participate in the community adaptation process. This approach allowed farmers to determine what was their preferred entry point. Invariably, such approaches nurture incremental adaptation with associated incremental learning. The research suggests that land tenure regimes influence the nature of the adaptation options and their eventual uptake. In villages with high incidence of landlessness, the adaptation options were limited to homesteads, the small patch of land around the household dwelling. A more secure tenure status provided farmers with freedom to engage in diversified and long-term production systems. Poverty and wealth levels of households were other factors influencing the uptake of adaptation options, especially those aimed at diversifying production for reduced risks.

Keywords: smallholder agriculture, Myanmar, community-based adaptation, climate smart agriculture, climate smart village, socio-technical methods, participatory action research, adaptation platforms

INTRODUCTION

Climate change in smallholder agriculture presents new risks as well as new opportunities (Wright et al., 2014). There are 570 million farms in the world, and more than 80% of these are farms with sizes below 2 hectares and 500 million farms are considered family farms (Lowder et al., 2016).

Smallholder farmers are more vulnerable to climate change. The production processes of smallholder farms are not only exposed to shocks and stresses of climate change and variability but also compounded by degradation of ecosystem services, insecure land tenure, and inadequate health and food security due to poverty (Cohn et al., 2017).

There are only a few case studies focusing on the situation of smallholder farms in specific regions in Myanmar. For example, Oo et al. (2017) found that in the dry zone of Myanmar that experienced more severe droughts in recent years, farmers have noted a negative impact of climate on agriculture. The majority of farmers do not have the adaptive capacity to cope with the deteriorating situation. In another study, the same group of researchers (2018) examined the circumstance in Myanmar's delta region that experienced more hydro-climate disturbances such as saltwater intrusion and coastal flooding. They concluded that the lack of adaptive capacity of farmers, poor farm households' access to infrastructure, and limited opportunities for additional income from the farm can all increase the vulnerability of local producers. However, studies on climate impact on Myanmar's agriculture in general are scarce.

Climate change adaptation is typically presented either as "autonomous adaptation" at the individual, household, or farm level or as "planned adaptation" at the level of national governments. These levels of adaptation complement each other (Adger et al., 2003; Eriksen et al., 2011).

The effects of climate change to agriculture being location-specific often implies that community-based and needs-driven approaches, with increased levels of community participation and engagement, are needed. It is therefore crucial that adaptation measures recognize the value of targeted, location-specific, community-based strategies and processes. There is increasing mention in the literature about the important contribution of community-based and community-led initiatives in effective adaptation efforts of smallholder farmers (Heltberg et al., 2009; Reid et al., 2009; Kansiime, 2012).

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) developed the climate-smart village (CSV) approach, working with a range of partners to test a range of social and technical interventions within CSVs. These efforts sought to fill knowledge gaps and stimulate the scaling of climate-smart agriculture (CSA). CSA approaches at community levels can include a combination of components such as farm management, crop varieties, trees, small livestock, and fisheries. These are implemented at different scales—from farms to landscapes. CSA puts a premium on landscape restoration, soil, water, and agro-biodiversity conservation, to create more conducive and sustainable agro-ecological conditions for more climate-resilient farms. CSA also includes activities that strengthen service providers such as providers

of capacity development and finance that will allow farmers to make the shift toward CSA (CCAFS and UNFAO, 2014). CCAFS started piloting the CSV approach in 2012 in Africa and South Asia and then extended to Latin America and Southeast Asia in 2014 (CGIAR, 2017).

Early results from Asia, Africa, and Latin America of CSVs demonstrate the high potential for scaling out and scaling up promising CSA technologies, practices, and services in high-risk areas (Aggarwal et al., 2018). In some cases, the CSV approach is closely monitored and eventually adopted by national governments. For example, the Nepal government has confirmed the implementation of the CSV approach as part of the national strategic plan for agricultural development and environmental conservation. In Senegal, CSV results have been used to mainstream CSA technologies in the nation's Accelerated Program for Agriculture (Aggarwal et al., 2018). After seeing the positive outcomes, the Haryana government in India is now promoting hundreds of new CSVs where they promote integrated actions for climate change with a strong, participatory approach (CGIAR, 2017).

In Southeast Asia, CCAFS established 7 CSVs located in Laos, Vietnam, Cambodia and the Philippines. CCAFS also developed and promoted a systematic approach to setting-up CSVs in the southeast Asian context (Sebastian et al., 2019). The International Institute of Rural Reconstruction (IIRR), a strategic NGO partner of CCAFS, first implemented the CSV approach in the Philippines in 2015. IIRR's CSVs in the Philippines are now part of the network of CSVs in 17 regions in the Philippines (Barbon et al., 2017). IIRR's CSV in Guinayangan served as a focal point for roving workshops to capacitate the Philippine Department of Agriculture's own network of CSVs (called AMIA villages) (Koerner et al., 2019). The CSVs as implemented by IIRR serve as local platforms for community-based adaptation in smallholder agriculture communities. It is an approach for identifying and testing location-specific strategies for addressing climate risks and challenges and subsequently scaled up. The process involves not only farming communities but also the local governments, and the local research community. The CSV is a demonstration of how (process) to assist local communities adapt to climate change in addition to incubating a portfolio of CSA options.

The CSVs in Myanmar were introduced in 2016 through CGIAR-CCAFS and IIRR in support of the Myanmar Climate-Smart Agriculture Strategy (MCSAS). The MCSAS laid out the long-term as well as short-term strategies and priorities to promote climate change adaptation in Myanmar agriculture (Hom et al., 2015). This research was funded through a grant from the International Research and Development, Canada.

In this paper, experiences, results, and insights from a 3-year participatory action research on community-based adaptation in four CSVs representing four unique agro-ecologies of Myanmar are presented. Specifically, how the CSV approach was optimized and implemented in the four CSVs is presented and discussed. We will also present the key support systems that are needed in bringing effective community engagement in implementing the CSVs in Myanmar.

METHODS

Participatory Action Research

The overall approach that IIRR used in the implementation of the four Myanmar CSVs is participatory action research (PAR). This choice is anchored on the core tenets and principles of the organization on "people-centered development." In their publication in 1992, Barnsley and Ellis defined PAR as a "community directed process of collecting and analyzing information on an issue or a situation for the purposes of taking action and making change" (Barnsley and Ellis, 1992).

A number of authors further deconstructed this definition by saying that PAR as a community-directed research process means that members of the community work together with a researcher in empowering themselves as they jointly investigate the community issues and challenges. PAR enables the participants to build capacities and create ownership and autonomy (Maguire, 1987; St. Denis, 1992; Hoare et al., 1993).

Based on processes of PAR, the CSV approach followed a three-step process of participatory assessment to understand the context and needs, joint identification and co-designing adaptation options, and social learning between external agencies and community members.

The **Step 1** in community adaptation is to foster an understanding of how climate change affects the local agriculture systems, including climate risks, vulnerabilities, and existing capacities for coping. This is an important step as this will be the basis for identifying potential options for addressing these risks and vulnerabilities. Consistent with the PAR, IIRR used the method of participatory climate risk and vulnerability assessment (PCRVA).

The PCRVA is a community engagement process involving 2–3 days per village, utilizing a diverse range of participatory tools such as community mapping, seasonal calendar, timeline, problem tree analysis, and focus-group discussions. The information and analysis gathered in the PCRVA are description and characterization of the agriculture production systems (e.g., crops grown, cropping calendar, issues and concerns in production), climate change risks (e.g., changes that affected production), and finally the role of men and women in the agriculture, food security, and nutrition.

From this understanding, a process is facilitated to enable communities to do **step 2** which is to identify adaptation options or responses to the identified climate change-induced risks and vulnerabilities. The IIRR approach to adaptation options takes on a portfolio approach—developing a menu of technological and practice options where people can choose those that they believe will work well within their own agroecological and socioeconomic and cultural context.

In its programming for CSVs, IIRR has ensured that the identified options also provide developmental co-benefits and outcomes, including better livelihood, nutrition, and income. Adaptation is not accomplished through a single intervention, rather it is a continuum, requiring an overarching approach that addresses the underlying drivers of vulnerability, those designed exclusively to respond to climate change impacts (Jones et al., 2010). With a portfolio approach, diversification and

intensification objectives can be achieved, especially for small holders and those with marginal landholdings.

Finally **Step 3** builds on the derived evidence and knowledge, from the testing of adaptation options, to plan for out-scaling within the CSVs. In its work on the CSVs in the Philippines, IIRR has learned the importance of establishing proof-of-concept sites, where scale is demonstrated and an evidence base is established, for purposes of or for further supporting the uptake of the adaptation options at other scales.

In the course of the 3-year PAR, a menu of socio-technical methodologies and tools have been developed, to facilitate engagement with members in its Myanmar CSVs. The use of socio-technical methods and tools is consistent with the principles of PAR, which is that research also empowers the participants in taking climate adaptation action. **Table 1** summarizes the different socio-technical methods that IIRR has used to facilitate the establishment of the Myanmar CSVs.

These are referred to as socio-technical methodologies and tools because it is a combination and complementation of agriculture research (technical) and social mobilization and organizing (socio). This complementation is critically important, because for adaptation to be sustainable, the subjects (farmers, households, and villagers) have to own the process of adaptation. True resilience cannot be bestowed to farmers; true resilience has to be inculcated within the farmers' mindsets. It is invariably manifested in their attitude and practices toward farming. This is where the value of social mobilization, social learning, and organizing is pivotal.

Recognizing the value of technologies dimensions as well, IIRR worked with different research organizations within the CGIAR system and the Department of Agriculture Research (DAR) through their field research stations located near the CSVs. This way, technologies and practices and on-farm adaptation work are backed by scientists, specialists, and practitioners.

The Myanmar CSVs as Study Sites

Based on the experiences of CCAFS CSVs in Southeast Asia, IIRR used the following criteria to narrow down the list of villages in Myanmar to be designated as CSVs to be studied:

- The village is a representative of a key agroecological region of Myanmar and has a high risk for climate change impacts,
- The village needs to be accessible in order to facilitate visits by other farmers, government officials, researchers, donors, and partners.
- The village has to be of manageable size in terms of population; the ideal size is a village with 100–250 households.
- The village is also least served by NGOs or government programs on agriculture to reduce challenges in attribution of the results.
- The village is accessible by local organizations that IIRR trained to implement the CSV approach.

After the CSVs were identified, initial activities called as "opening wedge activities," similar to a "soft launch," were undertaken. These activities engage farmers in onsite testing of technologies

TABLE 1 | Summary of socio-technical methodologies and tools in the Myanmar CSVs.

Steps in the CSV establishment	Methods/tools	Purpose	Socio	Technical
Social preparation	Opening wedge activities	To build community trust and initial interest to participate	●	
Assessment of agriculture systems and climate change risk	Household surveys	To facilitate targeting and monitoring outcomes	●	
	Participatory vulnerability assessments and gender analysis	To collectively identify and analyze climate risks to agriculture and gender To build awareness of climate change risks	●	●
Identification of options for adaptation	Focus-group discussions (sector-based)	To develop a menu of options based on local knowledge	●	●
	Secondary research	To identify latest technologies and practices developed by scientists		●
Multilocation and participatory testing of identified options	Participatory varietal selection	To field test new varieties of major crops To characterize new varieties vis-a-vis specific climate conditions		●
	Crop trials	To field test introduced crops to the system		●
	Demonstration	To field test integrated systems (e.g., trees, small livestock, gardens)		●
	Setting up an adaptation fund	To support strategic adaptation options	●	
Social learning *via* farmer-to-farmer learning	Farmer learning groups Farmer field days	To share knowledge and materials To develop farmer specialists	●	
Scaling out CSVs	Roving workshops	To build awareness of policymakers and NGOs	●	

identified during the initial scoping missions. The primary purpose of these activities was to build good will and trust between the community members and the facilitators of the CSV activities. These activities are referred to as part of social preparation to set the stage for a more systematic implementation of the CSV approach. As a result of the scoping missions to potential villages, consultation with partners, and interest of villagers, four CSVs were selected. These are presented in **Table 2**.

Figure 1 shows the location of the CSVs vis-a-vis the climate map of Myanmar. The four CSVs represented four key agroecological climate zones in the country as follows: hilly upland (Sakta CSV), central drylands (Htee Pu CSV), upland plateau (Taung Khamauk (TKM) CSV), and delta, lower Myanmar (Ma Sein CSV). Each of these agroecologies also represent unique socioeconomic contexts. For instance, the agriculture system in Chin state, given its isolation as a hilly mountainous location, is more driven by household food security needs. This is different from the agriculture systems in Delta and Dry Zone where production is driven by markets. The agriculture system in Shan is driven for both food consumption and markets (as they are close to the trading centers). The farmers in these four CSVs also experience climate change impacts differently. These contextual differences are an important basis for ensuring location specificity in climate change adaptation in agriculture.

Household Surveys

Aside from conducting PAR and qualitative data collection, household surveys were undertaken over the 3-year research period. The surveys were conducted in 2018 (baseline) and in 2020 (to serve as end line). The year 2019 was devoted to

further introductions of CSA and related monitoring within the CSVs. To ensure comparability, the two household surveys were conducted around the same time, toward the end of the monsoon season in October-November. Despite the COVID-19 pandemic hitting in Myanmar, household surveys were conducted as the field researchers were already embedded in the CSVs. Infection prevention protocols were observed, including the conduct of the interviews outside the house, observing physical distancing as well as wearing of masks. The research engaged and relied on the assistance of local development organizations, thus ensuring continuity during crisis times.

The data collection is full enumeration; all HHs in the CSV participated in the data collection. This is done to also build a database of household information that is also useful for future targeting of program participants.

The questionnaire captures household information related to:

- demographics
- livelihoods including land ownership
- impacts of climate change
- coping activities
- extension services

The questionnaire was prepared in English and translated to the Myanmar language. It was also pretested with farmers from nearby communities (not the target CSVs). A group of local survey enumerators were recruited by IIRR and the local NGO partners, trained, and supervised. Following full enumeration (collecting data for 100% of the total households per CSV), a total of 527 households were included into the datasets for analysis. These households have both 2018 and 2020 survey data,

Name of village	Sakta	Htee Pu	Ma Sein	Taung Khamauk
Agroecology	Highlands	Dry Zone	Delta	Upland
Major crops	Rice, corn, vegetables	Groundnut, pigeon pea, green gram	Rice	Rice, millets, corn
Township (Tsp)	Hakha	Nyaung-Oo	Bogale	Nyaungshwe
State/region	Chin	Mandalay	Ayeyarwady	Shan
Total households	200	275	103	94
Total population	865	11,180	453	405
Female	445	603	249	215
Male	420	577	214	190
Distance from Tsp. nearest	32 km	35 km	11 km	20 km
Ethnic group	Chin	Burmese	Burmese	Pa-o

thereby creating a panel data to do a one-to-one household level analysis. Some households were excluded in the analysis as they do not have either baseline or end-line data. This happens when households either relocated outside of the CSV in 2020 (no 2020 data) or relocated into the CSV in 2020 (no 2018 data). The survey data were then encoded in MS Excel sheets, and the data analyses were done using the Statistical Package for Social Sciences (SPSS). This paper will present the analysis of the survey data in 2018 and 2020.

Statistical Analysis

The data collected from household surveys were prepared into a panel data set to allow for a one-to-one, before-and-after analysis of the data. A number of statistical tests were deployed:

a) *Descriptive statistics* includes frequency distribution, percentages, mean, and median.

b) *Tests for significant difference* to test for significant difference between 2018 and 2020 data. As the data are presented as proportions (percentages), we used the *McNemar's test.* This test is used to analyze pretest-posttest study designs, as well as being commonly employed in analyzing matched pairs and case-control studies hence very useful in before and after studies. We also used the *Fisher's exact test* is a statistical significance test used in the analysis of contingency tables in the case of determining the difference of responses between male and female survey respondents.

c) *Measures of association* to determine the relationship or correlation of several two-way combination variables. There were four methods applied depending on the type of measurement of each variable in every analysis. The types of measurements are nominal, ordinal, and continuous. The phi coefficient was used if both variables are nominal. If one variable is nominal and the other one is ordinal, the *rank biserial correlation coefficient* was used. On the other hand, if one variable is nominal and the other one is continuous, the *point biserial correlation coefficient* was applied. In cases where paired variables either are both ordinals or one is ordinal and the other one is continuous, the *Spearman rank coefficient* was used. The *Pearson correlation coefficient* was used if both variables are continuous. The coefficients of all of

these measures of correlation range from −1 to +1. A positive coefficient means that both variables have a direct relationship and tend to move in the same direction, either both increasing or both decreasing. On the other hand, a negative coefficient means that the two variables have an inverse relationship in which one variable increases as the other decreases and vice versa.

RESULTS AND DISCUSSION

The Socioeconomic Context of the Myanmar CSVs

The first set of information collected in the survey included key socioeconomic characteristics of households in each of the CSVs. **Table 3** shows that all four CSVs have equal proportions of men and women's populations. In terms of age distribution, except for Htee Pu CSV, the villages have large proportions of younger people (0–18 years old). Combining the age groups that can do farming (19–45 years old), all four CSVs showed that these two age groups dominate the population. This would imply the potential for expanding agriculture production to generate livelihoods for this age group.

In most CSVs, the majority of households own farm lands, except for Ma Sein, Htee Pu (80.25%), TKM (91.76%), Ma Sein (24.14%), and Sakta (95.54%).

Land ownership is considered a key factor in the promotion of CSA options in the CSVs. For instance in Ma Sein, in the absence of farming land, households in Ma Sein have to maximize the small land area they possess around their house. IIRR refers to these land resources as *homesteads*. In presenting the various promoted CSA options, one will note that some options are for farms, while others are for homesteads including for the landless. This is to create equal opportunities for more people to benefit from the implementation of the CSV. Achieving social inclusiveness is an integral part of a successful climate change adaptation for the rural poor.

This research also confirms the importance of land in shaping the livelihood profile of the CSVs. In Ma Sein village, given its lack of access to farming land, the most dominant sources of income are domestic work and casual labor. Casual labor in the context of Myanmar is temporary employment in the nearby towns and
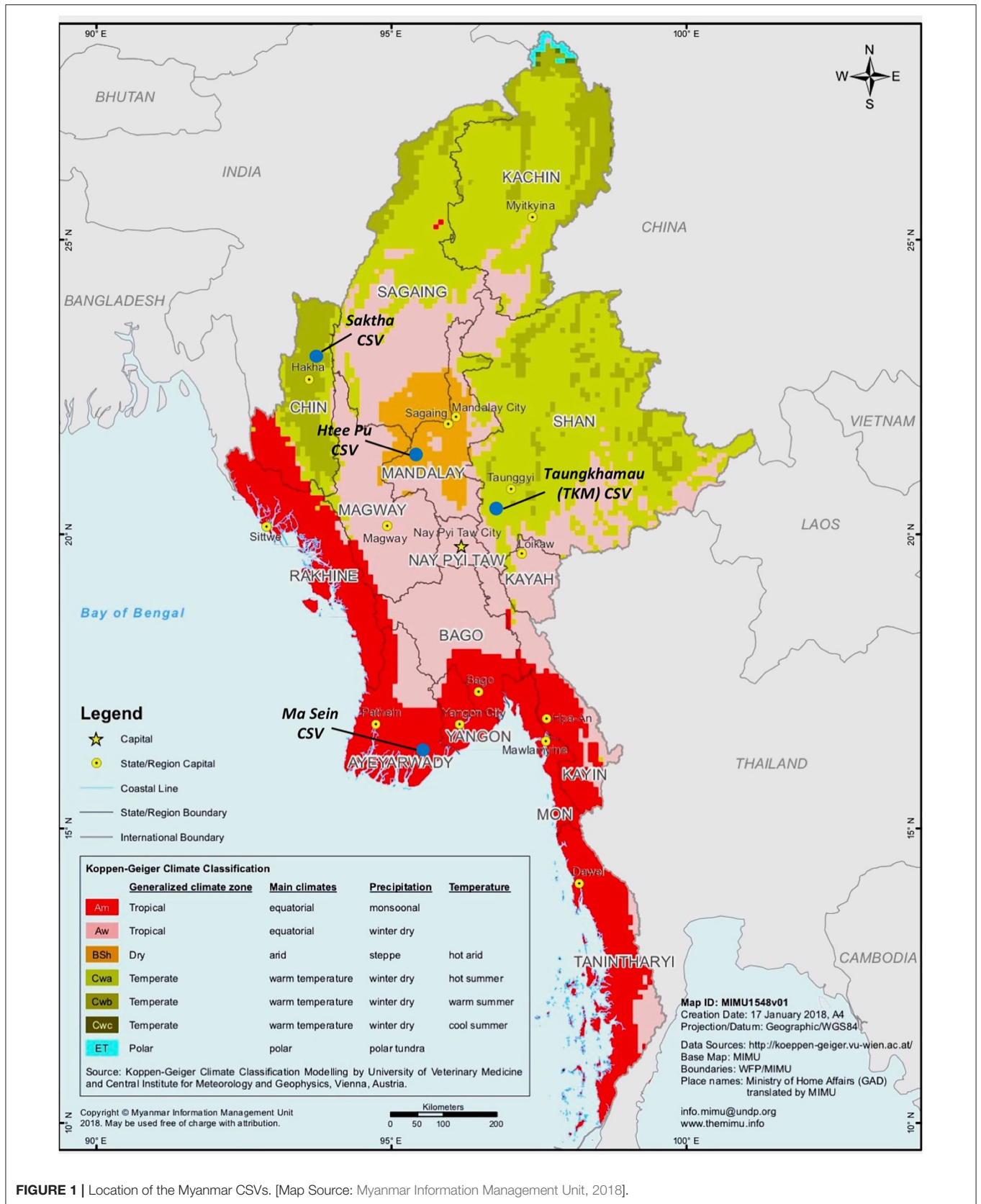
FIGURE 1 | Location of the Myanmar CSVs. [Map Source: Myanmar Information Management Unit, 2018].

TABLE 3 | Sex and age distribution in the Myanmar CSVs, 2020.

Demographics	Htee Pu	TKM	Ma Sein	Sakta
1. Sex (%)				
Male	46.63	53.39	49.37	48.43
Female	53.37	46.61	50.63	51.57
2. Age (%)				
0–18	17.54	35.06	29.56	38.59
19–30	20.70	22.13	17.92	20.96
31–45	25.82	19.54	24.53	15.96
46–60	19.61	16.38	19.81	14.84
60–above	16.34	6.90	8.18	9.65
3. Land ownership				
Yes	80.25	91.76	24.14	95.54
No	19.75	8.24	75.86	4.46
4. Livelihood activities (%)[a]				
Domestic work	70.87	83.04	44.34	99.70
Farming	62.39	83.48	11.32	99.70
Livestock	65.11	73.48	11.01	99.70
Fishing/hunting	3.70	10.43	0.00	1.18
Business/IGA	26.96	22.17	5.97	6.51
Casual labor	35.43	72.17	34.91	10.65
Unskilled formal	4.13	1.30	0.00	0.89
Skilled formal	2.50	0.43	0.63	2.66

[a]Only adult members were included in the analysis.

paid on a daily wage. With access of farming lands, the dominant livelihood activities are farming and livestock.

Assessment of Risks, Vulnerabilities, and Coping in the CSVs

PCRVA methods were used. The PCRVA is a community engagement process involving 2–3 days per village, relying on a range of participatory tools including community mapping, seasonal calendar, timeline, problem tree analysis, and focus-group discussions. The discussion and insights from the PCVRA sessions in the 4 CSVs are captured in several briefs produced by IIRR Myanmar (Gonsalves et al., 2018a,b,c,d). Below are the highlights of the results of the PCRVA process, undertaken in each of the CSVs.

Htee Pu CSV (Dry Zone)

Half of the 275 households in Htee Pu CSV are engaged in farming as a form of livelihood. Another 15% households are engaged in livestock rearing (goat, cattle, and pig). Htee Pu farmers primarily grow pigeon pea, tomato, sesame, and groundnut, which they plant during the rainy season. However, agriculture in this village faces several challenges that are aggravated by climate change. Htee Pu CSV is in Myanmar's Dry Zone, where degradation and desertification are prevalent. Desertification is driven by deforestation, soil erosion, and salinization. Deforestation occurs because of the high demand for fuel wood and other forest products. Soil erosion is intensified due to heavy rainfall and rapid surface runoff. Rainfall in the Dry Zone is not only more intense than in other areas but also

highly variable. This leads to droughts and floods that limit crop production and quality and expose farmers to various pests and diseases.

Ma Sein CSV (Delta)

Rice cultivation is the main livelihood of Ma Sein CSV residents. They also plant coconut and betel nut trees in their cultivated lands, which cover 397 hectares. Those without access to the lands are engaged in backyard animal husbandry, small-scale fishing and aquaculture, and betel nut and coconut trading, among others. Ma Sein CSV is in Ayeyarwady Region, a low-lying, flood-prone area in Myanmar. Aside from floods, the people in this region regularly face storms and other natural disasters. The constant exposure of Ayeyarwady to these disasters contributes to its high landless rates, recorded at 50% for poor households and 24% for non-poor households in 2010 (Integrated Household Living Conditions Survey in Myanmar (IHLCA), 2011). Gender issues also prevail in the region, specifically in Ma Sein CSV, where only 17 out of the 249 women are actively engaged in village development and social welfare activities.

Sakta CSV (Mountain Highlands)

This CSV is situated in Hakha Township in Chin State, considered as the poorest state in Myanmar. One of the drivers of poverty in this state is a lack of access to markets, which is exacerbated by a lack of road infrastructures and poor quality of available roads. These roads are often blocked due to landslides during the monsoon season. This inadequacy of infrastructure hinders the delivery of agricultural extension services to Sakta CSV such as planting materials and inputs. These services are critical to Sakta CSV, wherein more than 90% of the households work in the agricultural sector. The sector, though, now faces intensified floods, droughts, and rain infestations, among others, leading to food insecurity.

TKM CSV (Uplands)

TKM is the village under Tone Lae village tract, Nyaungshwe Township, which is situated in the southern part of Shan State, and it is about a 1-h drive from Nyaungshwe. There are a total of 94 households and 405 people in the village, and all belong to the Pa-o ethnic group. The village is situated above a 3,000-ft elevation above sea level. Most (80%) of the village members depend on agriculture and livestock rearing for their livelihoods. The agricultural season regularly starts with a rainy season in May. There is only one cropping season in this village because of lack of water resources. Variability in the rainfall is the main climate change risk affecting the village. Heavy rainfall also led to soil erosion and degradation. Lack of rainfall is also becoming more frequent and severe. Farmers often experience the delayed onset of rainfall, resulting in a shifting of the sowing time resulting to low yields and crop failures.

Relying on household survey data from 2018 and 2020, before-and-after comparison and analysis of indicators of climate change were undertaken. The McNemar's test was used to determine significant differences (climate change) between 2018 and 2020. These are presented in **Table 4**.

TABLE 4 | Changes in the environment experienced by CSV, Myanmar.

Changes in the environment experienced	Htee Pu			Taung Khamauk			Ma Sein			Sakta		
	2018 (%)	2020 (%)	MN test (*p*-value)[a]	2018 (%)	2020 (%)	MN test (*p*-value)[a]	2018 (%)	2020 (%)	MN test (*p*-value)[a]	2018 (%)	2020 (%)	MN test (*p*-value)[a]
Too much rainfall causing flooding in the village and in the farm	0.41	0.82	1.000	75.29	82.35	0.307	54.02	43.02	0.165	80.56	26.79	0.000[**]
Too less rain, making it difficult to grow crops and animals as well as secure water for the household	96.71	90.95	0.018[*]	82.35	92.94	0.078	21.84	18.6	0.700	62.04	50.89	0.194
The rains are not coming as we expected; sometimes they come late and sometimes they come early	99.18	92.18	0.000[**]	84.71	94.12	0.096	57.47	19.77	0.000[**]	65.74	44.64	0.006[**]
The daytime temperature is getting hotter than before	99.59	96.3	0.021[*]	77.65	90.59	0.035[*]	70.11	45.35	0.002[**]	83.33	67.86	0.040[*]
Some new pests and diseases are happening to the crops, animals, and people	83.54	94.65	0.000[**]	81.18	88.24	0.286	29.89	6.98	0.001[**]	53.7	41.07	0.169
The weather and climate conditions are getting better now that we can now grow more and new crops in our farms	2.47	9.05	0.003[**]	24.71	37.65	0.063	4.6	1.16	0.375	16.67	12.5	0.584

[a]*The McNemar's test was conducted to determine if there is a significant difference on the proportion (increase or decrease) over time.*
[*]*If p-value < 0.05, then the proportion is statistically significant at 5%.*
[**]*If p-value < 0.01, then the proportion is statistically significant at 1%.*

For Htee Pu CSV, the perceived changes in perceptions showed a significant decrease in 2020 in percentages of households reporting reduction of rainfall, delayed rains, and high daytime temperatures. There is however a significant increase in percentage of households reporting that new pests and diseases are happening to crops. For TKM CSV, there is a significant increase in the percentage of households, reporting rising daytime temperatures than in 2018. For Ma Sein CSV, there is a significant decrease in the perceptions related to variability of rainfall, hotter daytime temperatures, and appearance of new pests and diseases. However, in Ma Sein, too much rainfall and hotter daytime temperatures are still the key perceived changes in the environment in 2018 and 2020. For Sakta CSV, the percentages of households reporting experiencing too much rainfall, delayed rains, and daytime temperature rising (getting hotter) have significantly reduced in 2020.

All of these changes in the perceptions of households of climate changes are indicative that climate change risks are not static—some years are too wet and some years too dry. This also suggests that climate is experienced uniquely (differently) by the four CSVs, depending on their location and agroecology. For instance, the dry zone has consistently not identified too much rainfall as a change compared to Ma Sein CSV. Consistent across the CSVs is the experience of hotter daytime temperatures and the uncertainty of rainfall.

Our analysis suggests that a combination of PAR approaches such as the PCRVA coupled with household survey data collected at baseline and end line will provide local village leaders and communities and participating researchers and facilitators information on farmer perceptions of climate change, the drivers of their risks, and coping activities that can serve as starting points for intervention and support. Communities and researchers can then better identify and co-develop adaptation options in response to these unique local challenges.

Identification of CSA Options

The assessment of risks, vulnerabilities, and capacities served as the most important basis for identifying adaptation options for each of the four CSVs. Consistent with the PAR approach, IIRR worked with the farmers and leaders in the village to identify solutions to the identified challenges. IIRR developed a simplified "participatory scoring tool" to be used by facilitators to help farmers to identify and prioritize options.

A set of criteria was discussed and agreed upon by farmers in the CSVs. This process of criteria building contributed to the greater ownership of the adaptation options. The main criteria that were agreed and accepted in all four locations were as follows:

Criteria 1: Is it climate-smart?
Criteria 2: Is it ecosystem-friendly (environment-friendly)?
Criteria 3: Is it nutrition-sensitive?
Criteria 4: Does it address food insecurity?
Criteria 5: Is it gender-friendly?

The highlights of the PCRVA and the results of the baseline survey were also presented in these village workshops to serve as basis for identifying "solutions" (adaptation options), which

needs to be done to address the specific needs and challenges caused by climate change in the village. This process resulted in a long list of adaptation options—some are new practices and some technology-related such as using improved varieties. The community facilitator then conducted separate discussions of men and women in the village to prioritize the list of options guided by the criteria agreed at the start. Finally, the facilitator brought together the groups of men and women to compare notes and scores and agree on the final set of adaptation options. These processes are important to help ensure ownership by both men and women in the CSV.

IIRR also secured the support of local research stations for seeds and technical guidance in response to expressed interests in village workshops. These technologies include specific crops and varieties that have been tested in the research stations. On the part of the research stations, they valued that the CSVs were testing their varieties, outside of on-station research, in real-life settings and diverse environments. This process reaffirms the socio-technical nature of this PAR in the four CSVs. A portfolio of CSA options identified per CSV is presented in **Table 5**.

Adopting a portfolio approach to climate change adaptation provides different entry points for the household depending on its socioeconomic conditions. A landless household will still have adaptation options that do not require owning farm lands. The aim of targeting different "spaces" or niches for the adaptation options—farms, homesteads, and schools—is a response to the differential nature of prevalent land tenure security. Land tenure security can influence the nature and the extent of adoption. For example, in Htee Pu and TKM CSVs, they have the best land tenure security regime, hence the huge interest of farmers in these CSVs for more long-term adaptation options in farms such as agroforestry using fruit trees. Specific to TKM CSV, there is a surplus of lands that the forestry department of Myanmar is willing to give to the farmers for agroforestry. In Sakta CSV in Chin state where land tenure security is based on ethnic customary laws, farmers are hesitant to engage planting fruit trees in farms as these lands are considered "commons" per customary laws, and instead villagers in Chin would plant fruit trees around homesteads. In Ma Sein CSV where there is high incidence of landlessness, the only available option for most households is to intensify production in homesteads. This is the value of taking a portfolio approach to climate change adaptation options—there is an option to each unique context of the community and to the context of the individual household. This also makes the portfolio approach more socially inclusive, addressing equity issues. Studies have also shown that allowing farmers to adjust crops and livestock within agricultural land can result in higher overall productivity and economic growth (Haggblade et al., 2014).

A portfolio approach also allows for incremental adaptation, taking one easy to implement CSA practice which later based on the success will lead to more adoption of practices, leading to long-term transformation of the production practices of the household. Related to this is the possibility of bundling climate-smart practices which will make the production system much more stable. For example, small livestock production at home

TABLE 5 | List of climate change adaptation options for the farms, homesteads, and community levels.

Climate smart village	Agroecology	Climate change effects	Options for farms	Options for homesteads	Options for community support initiatives
HTEE PU CSV	Central dry zone	Increasing variability of rainfall, increasing temperature, climate extreme events such as long dry season, degradation of soil from lack of organic matter, soil erosion from rainfall and high temperatures, pest and diseases, delays in planting, lower yields, crop death, animal diseases	• Use of short duration, drought-tolerant varieties of pigeon pea and groundnut • Promoting climate-smart agronomic practices in farms ○ Crop rotation ○ Mulching ○ Cover cropping ○ Integrated pest Mgt ○ Intercropping of pigeon pea, corn, and groundnut • Dryland horticulture of fruit trees • Boundary planting of Cassia to improve soil organic matter and as wind breaks • Reintroduction of sorghum and millets to double as source of fodder	• Vegetable gardening with fruit trees • Livestock raising (Bagan goats and chickens)	• Seed propagation and banking for groundnut, pigeon pea, sorghum • Livestock multiplication centers for Bagan goats and chicken • Repair of tube well, ponds, and rainwater harvesting canals in the villages • School vegetable garden
Taung Khamauk CSV	Upland (1,000 masl)	Heavy rainfall, longer monsoon season, too less rainfall, increasing variability of rainfall, pests and diseases to crops, low yield, diseases in cattle and animals	• Diversify use of varieties of: ○ Upland rice ○ Ground nut ○ Millet • Integration of soybean, oil seeds (sunflower), and wheat into the primary system • Improve soil and water management in farms with *Gliricidia* spp., sun hemp, and compost • Integration of avocado fruit trees and other fruit trees in the farms	• Homestead food production ○ Sweet corn and corn ○ Vegetables ○ RTB ○ Fruit trees (e.g., jackfruit) • Low-input chicken and pig production with alternative feed system with planting of fodder crops, e.g., Trichanthera spp.	• Livestock multiplication centers for pigs and chicken • Vaccination programs for livestock • Renovation of rainwater collection ponds and canals to distribute water • School vegetable garden
Ma Sein CSV	Lower floodplains, delta	Climate variability, increasing temperatures, saline intrusion due to sea level rise, climate extremes such as cyclones (deadliest was Cyclone Nargis), crop losses due to flooding, difficulty of drinking water, low income	• Organic matter improvement of rice farms using sun hemp, Gliricidia and Sesbania as green manure • Diversifying rice varieties for flood tolerance and saline tolerance	• Diversification of homestead-based low-input production of: ○ Vegetable production ○ Testing trichodarma + EM5 for fungus mgt for betel leaf prod. ○ Duck rearing for eggs. Testing for locally grown feeds ○ Fish production in backyard runnels ○ Low input pig/chicken production with homestead fodder production (Trichanthera, root crops/taro, tubers and banana) ○ Homestead Fruit trees, lime, papaya, water apple, pineapple • Coconut husk fiber processing (e.g., coco coir)	• Livestock multiplication centers for pigs • Fish propagation centers • School vegetable garden

(Continued)

TABLE 5 | Continued

Climate smart village	Agroecology	Climate change effects	Options for farms	Options for homesteads	Options for community support initiatives
Sakta CSV	Hilly uplands (1,200 masl)	Heavier rainfall causing floods and landslides, increased temperatures, cooler winters, stronger winds, erratic rainfall patterns, food insecurity during non-production months, crop losses, animal losses due to diseases	• Diversify use of varieties for: ○ Rice (Tarpegu and Upland 2) ○ Corn (Yezin 1 and Ekery) ○ Millets • Fish propagation in "forest" ponds with fish propagation centers • Integration cash crops such as EFY ○ Planting *Alnus nepalensis* trees in farms	• Vegetable gardening with root crops, tubers, and banana • Livestock raising (local pigs and chicken)	• Seed production and banking for Tarpegu and Upland 2 • Seed production and banking of Yezin 1 and Ekery varieties • Livestock multiplication centers for pig and chicken local varieties • Improving water storage facilities • School vegetable garden

can be bundled by planting fodder trees in the field. Finally, a portfolio approach to adaptation is a risk-aversion strategy: it calls for diversification and spreading risks across various sources of livelihoods—field crops, small animals, backyard vegetable production, and fruit trees.

Multilocation Testing of CSA Options

The adaptation options identified in the four CSVs share common features. The most notable feature is diversification in farms by introducing new crops, trees, and animals into the system. Another feature is sustainable and climate-adaptive intensification by slowly introducing climate-resilient, improved varieties of the crops otherwise traditionally grown in the villages. In this CSV approach in Myanmar, IIRR added a new location for intervention—homesteads. Homesteads are defined in the Myanmar context as the space of land surrounding the dwelling of the household. The homestead areas are typically used for keeping animals, storing seeds for the next season, and storing farm produce for selling. In many cases, women use this space for supplemental agriculture production such as raising small livestock, for growing vegetables and fruits, and in the case of Ma Sein in the delta, for betel leaf (*Piper betle*) production or ornamental plant production.

In order to create the momentum to move from prioritization of adaptation options to actual implementation and testing, IIRR established the "CSV Adaptation Fund" which involved allocating a lump sum of funds for each of the CSV. The purpose of this fund was to catalyze the implementation of one or more of the options. Asking farmers to change technologies and practices in farming is difficult without any incentivization in kind. The four CSVs belong to one of the poorest communities in Myanmar, so typically farmers do not have sufficient financial capital plant fruit trees, start crop trials, purchase small livestock, or set up vegetable gardens in homesteads. This mechanism has been well-received in all the countries where IIRR has established forms of adaptation fund that allow farmers to create productive assets.

Aside from the CSV Adaptation Fund which is a grant mechanism for early adopters of the options, IIRR also conducted accompanying training and capacity development activities. Local researchers and crop experts were invited to provide this training to the villagers. IIRR also developed posters to present the basic principles and methods in implementing the identified options. IIRR also deployed a full-time field researcher who worked on site, with the farmers in each of the CSVs, providing technical inputs and documenting the experiences. **Table 6** presents the number of farmers who have adopted the CSA options identified for each CSV. IIRR's approach is to consider these small groups as catalyzers of innovation and associated processes.

The commonly implemented option across all four CSVs was the integration of trees into farms or homesteads, intensive use of homesteads, and the growing of small livestock. These options created opportunities for women to contribute to economic activities. Landless households and female-headed households were deliberately targeted in order to enhance social inclusiveness and equity outcomes from CSA work.

TABLE 6 | Numbers and location of adopters of identified adaptation options, Myanmar, 2020.

Climate change adaptation options supported by the CSV adaptation fund	No. of individual adopters (unless otherwise indicated)			Climate-smart villages where the options are implemented			
	2018	**2019**	**2020**	**Htee Pu**	**Taung Khamauk**	**Ma Sein**	**Sakta**
1. Participatory varietal selection (PVS) for new improved varieties	38	65	122	•	•		
2. Diversification of farm production with vegetables; legumes with crop trials for new introduced crops	30	61	80	•	•		•
3. Integration of fruit tree in farms (avocado, mango, banana, jackfruit, oranges)	70	109	125	•	•	•	•
4. Planting of legume trees in farms and along boundaries (*Alnus* spp., *Casia* spp., *Gliricidia* spp.)	17	13	89	•	•		•
5. Homestead production of vegetables, fruits, and cash crops	40	70	132	•	•	•	•
6. Small livestock production in homesteads	32	44	150	•	•	•	•
7. Aquaculture (homestead and farm ponds)	7	21	20			•	•
8. Community-based animal propagation centers (pig, chicken, duck, and fish)	0	16	1	•	•	•	•
9. School gardens (vegetables, fodder, fruit trees)	3 sch	4 sch	4 Sch	•	•	•	•
10. Improving water storage facilities (at HH)	0	1	7				•

Variables	Type of data	CSA adoption (1—yes, 0—no) Nominal
• Age (years)	Continuous	0.017
• Education (level)	Ordinal	0.167**
• Wealth index score	Continuous	−0.191**
• Ability to meet basic needs (Likert scale) [a]	Ordinal	−0.094**
• Membership in community organization (1—yes, 0—no)	Nominal	−0.018
• Land ownership (1—yes, 0—no)	Nominal	−0.009
• Land size (0—non-owned land, <=1 acre, 1.1 to 2.0 acres, >2 acres)	Ordinal	−0.059
• Coping to environment changes: change the crops and animals that we are growing, trying new crops as well as crops we grow before (1—yes, 0—no)	Nominal	0.029

[a] 1-Doing well, 2-Doing just OK/breaking even, 3-Struggling, 4-Unable to meet household needs.
**Significant at 1%.
Measures of correlation.
Point biserial correlation coefficient—continuous vs. nominal.
Rank biserial correlation coefficient—ordinal vs. nominal.
Phi coefficient—nominal vs. nominal.

The 2018 and 2020 household survey data were analyzed to understand the factors that influence the adoption of adaptation options in the CSVs. **Table 7** shows the key factors identified to have a very weak correlation with CSA adoption by households. While this is true, it is worth noting the direction (whether positive or negative) of the correlation. For example, the wealth index score of the household exhibits a very weak significant negative correlation with CSA adoption—as the wealth index score increases or households become wealthier, they will tend not to adopt CSA options. As reported by Win (2018), in Central Myanmar and Southern Shan state, a shift to a diversified farming system would require higher and adequate levels of financial investment (i.e., credit).

Another variable to note was land ownership and land size—although showing a very weak negative correlation, the direction of the correlation indicates that as land area increased, the more likely it is that CSA will not be adopted.

Investigating this further, for land ownership and land sizes, the survey data of 2018 and 2020 were compared. **Table 8** shows that in the Htee Pu CSV, the percent of households owning land had not changed. In TKM and Sakta CSVs both with upland agroecologies, respondents in the CSVs indicated an increase in the number of households owning land. On the other hand, the Ma Sein CSV in the floodplains/delta showed a significant reduction in land ownership. For those owning land, all four CSVs have indicated an increase in the size of landholdings from owning 1 acre or less to 2.1 to more acres. As land tenure security improves, farmers are more likely to protect their land for years to come, which can both mitigate climate change effects and add resilience to individual farms (Runsten and Tapio-Bistrom, 2011).

The extent of diversification and intensification of agriculture production in the four CSVs was also studied. In **Table 9**, the change in the number of households that are cultivating crops and raising animals was noted. The freedom to select one's crops, choose one's agricultural land use, and fallow one's land

is advantageous for farmers and for the broader sustainability and productivity of Myanmar agriculture (Anderson et al., 2017).

In Htee Pu, we note the significant increase of households who are now planting pigeon pea, sorghum, and tomatoes. IIRR and the dryland research station nearby had introduced improved varieties of groundnut/peanut, pigeon pea, and sorghum. There was a significant reduction in the number of households growing sesame. Village meetings revealed that this is mainly driven by increasing climate variability especially the late onset of the first rains, when sesame is usually grown. With regard to animals, an increase in households owning chickens, goats, and cows was noted. Of special interest are chickens and goats where women are mostly the recipients of support from the CSV Adaptation Fund. Small livestock are appropriate for homestead production where women are the primary beneficiaries. This observation is of special interest, given the importance of farmers acquiring natural assets as a resilience-building measure.

In TKM CSV, an increase in households growing corn, groundnut/peanut, pigeon pea, upland rice, sesame, and tomatoes was noted. There was however a significant decrease in households owning small animals—chicken, cows, and pigs. In 2020, there was an outbreak of the African Swine Fever affecting Shan state (Myanmar Times News, 2020); this probably contributed to reduction in ownership of pigs. Another possible driver is the COVID-19 pandemic where in the event of food shortages due to the slowing down of trade and markets, small animals provide food for the household.

For Ma Sein CSV, rice remains to be the primary crop produced, but in 2020 there is a reduction of households growing rice. This aligns to the earlier findings of the increase in households not owning land. Chicken/poultry (duck in the case of Ma Sein CSV) and pigs are still the main small animals raised by households. Households owning pigs have also reduced. This can be due to consumption or *via* emergency selling for cash in the midst of the COVID-19 pandemic.

TABLE 8 | Change in the land ownership and land sizes between 2018 and 2020.

Parameters	Htee Pu			Taung Khamauk			Ma Sein			Sakta		
	2018 (%)	2020 (%)	p-value)[a]	2018 (%)	2020 (%)	p-value)[a]	2018 (%)	2020 (%)	p-value)[a]	2018 (%)	2020 (%)	p-value)[a]
Land ownership												
• Yes	80.25	80.25	1.000	87.06	91.76	0.344	55.81	24.14	0.000	80.56	95.54	0.001**
• No	19.75	19.75		12.94	8.24		44.19	75.86		19.44	4.46	
Land size [b]												
• Less than or equal to 1 acre	5.64	0	0.001**	24.32	21.79	0.839	29.17	9.52	0.002**	52.87	37.38	0.018*
• 1.1 acre to 2 acres	20.51	13.85	0.112	43.24	33.33	0.025*	22.92	38.1	0.008**	34.48	30.84	0.871
• 2.1 acres or more	73.85	86.15	0.001**	32.43	44.87	0.023*	47.92	52.38	0.011*	12.64	31.78	0.000**

[a] The McNemar's test was conducted to determine if there is a significant difference on the proportion (increase or decrease) over time.
[b] Only households who owned land were included in the analysis.
* If p-value < 0.05, then the proportion is statistically significant at 5%.
** If p-value < 0.01, then the proportion is statistically significant at 1%.

For Sakta CSV, the increase in the percentage of households growing corn, elephant foot yam (considered cash crop), and fruits (compared to 2018 data) was noted. The CSV Adaptation Fund promoted the planting of an improved corn variety called *Ekery* which was sourced from the local research station in Myanmar. For animals, there was an increase in the percent of households growing chickens and pigs compared to 2018.

In general, there is an increase in the production of crops and animals promoted as adaptation options in the four CSVs. While this is true, challenges were also noted by the field researchers who have worked alongside smallholders farmers implementing the CSVs. Climate variability remains the key challenge. This was pronounced in the 2019 growing season in the dry zone where yields for peanut were reduced (due to the late onset of the monsoon). Another challenge was the inadequate community extension and support systems. For example, there is not yet a seed production system to produce at volume seeds of the corn variety Ekery which is found to be very resilient in Sakta CSV. All of these challenges are recognized are subject for further studies and interventions in the future.

Social Learning and Scaling

Social learning is a key component of community-based adaptation where community members assess and generate learning toward improving the identified and tested adaptation options. Social learning is aimed at nurturing the capacity of farmers to find solutions and testing and improving them. The other purpose was to share the experiences and good practices (derived from the testing and demonstration of the identified adaptation options).

At the local level, the implemented social learning activities included farmer field days (FFD) and roving workshops (RW). The FFD was targeted to farmers in the CSV and from nearby villages to further promote the field-tested adaptation options. The RV was for farmers and township-level stakeholders such as government officials, researchers, and NGOs working in the same township or region. The aim was to build awareness of the CSV approach and activities with the hope that these agencies will integrate this approach into their own community development programs and activities.

These local-level social learning activities are leading to the emergence of farmer specialists in the CSVs; these farmers have become local experts and resource (e.g., provider of seeds of the improved crop varieties) that other farmers can go to learn more about the adaptation options. These local social learning activities also opened up opportunities for the villagers to engage with the local extension offices to get technical support and to scale out the practices or options. Key learning themes discussed in these local social learning activities included the following:

- Varieties of crops they have tested which are suitable and performing well in their farms;
- Intensification of homestead production with gardening and small livestock including small-scale fish culture;
- Challenges that farmers experienced during the testing of these options. These are also opportunities to innovate in the next season; and

TABLE 9 | Percentage of households who cultivated crops and owned animals by village and by year, Myanmar.

Crops and animals grown	Htee Pu (n = 243)		Taung Khamauk (n = 85)		Ma Sein (n = 87)		Sakta (n = 112)	
	2018	2020	2018	2020	2018	2020	2018	2020
Crops								
Corn	6.17	0.00	75.29	77.65	0.00	0.00	22.32	42.86
Elephant foot yam	0.00	0.00	0.00	0.00	0.00	0.00	28.57	49.11
Fruits	0.82	2.47	3.53	0.00	0.00	0.00	16.96	25.00
Groundnut/peanut	68.31	67.49	75.29	81.18	0.00	0.00	0.00	0.00
Pigeon pea	18.11	29.63	7.06	10.59	0.00	0.00	0.00	0.00
Rice	0.00	0.00	63.53	85.88	26.44	19.54	30.36	16.96
Sesame	34.16	5.35	2.35	22.35	0.00	0.00	0.00	0.89
Sorghum	0.00	22.22	0.00	0.00	0.00	0.00	0.00	0.00
Tomato	13.58	27.16	0.00	20.00	0.00	0.00	0.00	0.00
Vegetables	0.00	3.29	15.29	4.71	8.05	0.00	80.36	60.71
Other crops	2.06	4.94	29.41	11.76	32.18	8.05	12.50	19.64
Animals								
Chicken/poultry	22.22	49.38	14.12	4.71	28.74	27.59	55.36	73.21
Cow/ox/buffalo	44.86	46.09	51.76	17.65	0.00	0.00	42.86	13.39
Goat	7.82	18.93	0.00	0.00	0.00	0.00	0.00	1.79
Pig	8.23	6.17	36.47	10.59	40.23	18.39	34.82	60.71
Other Animals (horse, mythun, fish, rabbit)	2.06	2.06	0.00	0.00	0.00	0.00	10.71	2.68

● Potential support from other agencies including government to further support the initiative; most support are in the form of technical advice on how to improve the implementation of these options.

At the national level, the social learning events included seminars, training courses, and policy dialogue events. These events are implemented in collaboration with the Food Security Working Group (FSWG) of Myanmar, the largest alliance of NGOs implementing programs of agriculture development and food security (Barbon et al., 2019). These national-level events raised awareness as well as provided basic orientation on the concepts and the socio-technical tools on CSVs for them to design and implement their CSV project. To support these local and national social learning events, IIRR also developed publications such as primers, brochures, and posters in the Myanmar language to maximize uptake of knowledge.

CONCLUSION AND IMPLICATIONS

This research sought to demonstrate the relevance of PAR as applied in the CSV approach, using different socio-technical methodologies, for facilitating and promoting community-level adaptation in CSVs in Myanmar.

Preliminary studies and analysis have highlighted the importance of intervening agencies to take into consideration the land tenure regimes of the target village, the levels of poverty and wealth, and the unique risks and vulnerabilities of targeted sites. The analysis of the land tenure regimes in the four CSVs showed that it influences and determines the nature of the adaptation options and their eventual uptake. A more secure tenure status, and freedom to make decisions about how land is used, influences the decision of farmers to engage in diversified ventures which feature both short-term and long-term adaptation practices. Where farm lands are traditionally considered "communal" as per customary laws, farmers tend not to invest in long-term adaptation options such as agro-forestry.

This research demonstrated that poverty and wealth levels are important factors determining adaptation options. Villages with higher poverty incidence will have very limited capacity to diversify production (crops including fruit trees and animals), thereby spreading risks.

This complexity of the Myanmar context in terms of land tenure, poverty, and climate risks and vulnerabilities sets the stage for the importance of the "portfolio approach" to adaptation. In the experience with the four CSVs, it was noted that the adaptation options differ based on agroecological niches and locations: e.g., farms and homesteads. This approach ensures that there is an opportunity for every household whatever is its context—land and wealth status. This portfolio approach allows for opportunities meeting gender equity goals (where both men and women have equal opportunities to engage in climate-adaptive economic activities). Finally, recognizing that within a typical Myanmar village many are the ultra-poor, purposive targeting for the delivery of support becomes very important. Geographic and social targeting considerations are important considerations in designing pro-poor agriculture.

The CSV Adaptation Fund helped catalyze the implementation and adoption of options by households in the four CSVs. The training and capacity building and nutrition education support galvanized this engagement in nutrition and CSA options. The CSV Adaptation Fund when used strategically and in a targeted manner can serve to incubate ideas, catalyze action, and deliver a minimal degree of scale ("critical mass")

and the momentum that fosters the spontaneous spread of adaptation options.

It also helped that IIRR partnered with local non-government organizations (NGOs) whose staff are embedded in the four CSVs. This allowed for close monitoring, coaching, and handholding early adopters of the adaptation options. These local NGOs also provided training and awareness building in the local language of the CSVs. This research further confirmed that local NGOs when given the resource, opportunity, and capacity building support can become an effective part of the government's promotion of climate change adaptation in agriculture.

These social learning events are anchored on the concept of farmer-to-farmer extension (*via* FFD) and experiential learning (*via* RW). Incremental adaptation and eventual transformation require an investment of time and associated social and educational services. We recommend more attention to this dimension in future research and action in relation to CSA and community-based adaptation efforts in Myanmar.

DATA AVAILABILITY STATEMENT

The data supporting the conclusions of this study are available upon reasonable request from the authors, with the exception for data that identifies the personal information of the research participants.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by International Development Research Center Canada. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

WB, RV, and JG contributed to the conception and design of the action research. CM supervised data collection and building the database for statistical analysis. WB and JG conducted statistical analysis and qualitative analysis. WB wrote the full manuscript with inputs from CM, RV, PT, EM-O, and JG. All authors contributed to the manuscript revision, read, and approved the final submitted version.

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