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First Experiences with Participatory Climate Services for Farmers in Central America: A Case Study in Honduras

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Abstract

While climate services for small-scale farmers are gaining recognition for contributing to adaptation and resilience to climate variability and change, their provision in developing countries remains a critical challenge. Effective climate services consider why and how farmers of varied socioeconomic background make relevant decisions avoiding the traditional prescriptive forms of transfer that merely focus on delivering climate information. Evidence from sub-Saharan Africa shows that climate services for agriculture generates transformations in how farmers access and use climate information, as well as changes in farmer decision-making. In this paper, we address the question of whether the same effect is also seen in Latin America, where farming systems, farming decisions, socioeconomic contexts and non-climate constraints are very different to those of Africa. A group of 209 farmers in the dry corridor in Honduras was studied. We find that 98% of the trained farmers did uptake and use the climate information, and some 73% expressed that the agroclimatic information was key to the success of their harvest despite the challenging 2019 season. Some 43% of the farmers made changes in farming practices. In particular, farmers changed the crop they grew, the crop and land management, the planting dates, inputs and crop varieties. These changes reportedly had positive effects on their food security, and income. These findings support the hypothesis that Participatory Integrated Climate Services for Agriculture (PICSA) plays a positive role in providing effective climate services in Central America, improving decision-making, and enabling farmers to make their own decisions based on the analysis of information and their demands regardless of their level of literacy. We pose that participatory climate services in agriculture can catalyse processes of long-term transformation in farming systems, notably through lifting farmers out of poverty and food insecurity and providing an integrated approach to make informed decisions in the face of climatic variation.

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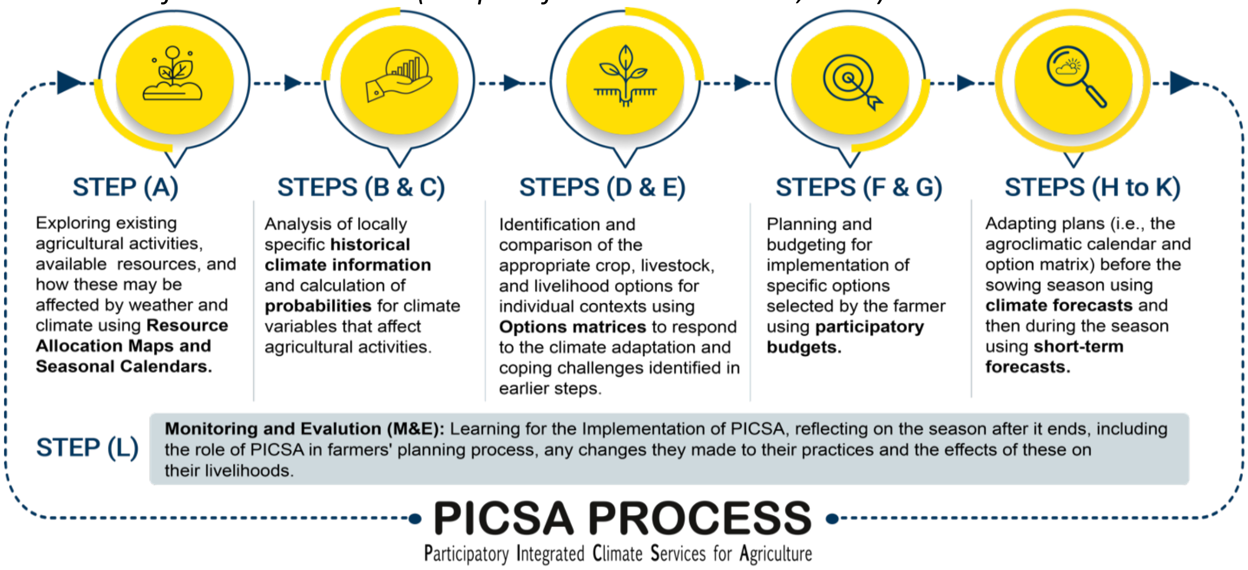
Introduction

Farmers must be considered as active recipients of weather and climate information, products, or derived services. They express needs, discuss and share ideas with their family and peers, and then use or apply such services in their decision-making on their farms. They also provide feedback on the usefulness of services within their environmental and social contexts. Climate services in the agriculture sector are gaining recognition due to the need to support communities' adaptation planning for, and resilience to, the adverse impacts of climate conditions (FAO, 2021). Across Latin America, as a region with substantial exposure and vulnerability to climate variability and extremes, there is a solid commitment (through policies, development and research projects) to developing and providing climate services (Vaughan et al., 2019). Despite progress, many climate services implementations lack or have limited consideration of user capacities, decision-making dynamics and constraints, as well as of the existing networks of cooperation and information flow within and between farmer communities (Born et al., 2021; Kolstad et al., 2019). Furthermore, climate services must "fit" the information needs of farmers, enable the use of shared knowledge, and build on existing institutional arrangements. With these considerations in mind, effective climate services for agriculture therefore allow farmers to make decisions that improve their resilience to climate variability and change while considering the complexity of the socioeconomic context and heterogeneous household dynamics.

A challenge is that the main goal of climate services is considered by many providers to be the delivery of higher-quality data (e.g., information and products) rather than to provide an integrated process for improved decision-making (Findlater et al., 2021; Lourenço et al., 2015), involving and encouraging farmers to make their own decisions based on the analysis of information and their demands. Addressing this challenge requires climate services to emphasise which decision-making processes demand what information or why farmers need it and the factors influencing these decisions at the ground level (Singh et al., 2016). Participatory Integrated Climate Services for Agriculture (PICSA) is an agricultural extension and climate services approach that supports farmers in making plans and decisions tailored to each farmer's own "context" in their production systems (Dorward et al., 2015). It highlights the importance of prior knowledge, trust building, innovative learning spaces for collaboration, opportunities for networking, and active participation for experimentation and reflection regardless of their level of literacy. PICSA is implemented by facilitators (e.g., extension officers, nongovernmental organisation field staff, community volunteers, and researchers) through a series of meetings with groups of farmers that integrate a set of structured information and participatory tools, as described by Dorward et al. (2015) and summarized in Figure 1.

Figure 1

Flow Chart of the PICSA Process (Adapted from Clarkson et al., 2022)



Most PICSA implementations have been carried out in Africa (e.g., Clarkson et al., 2019; Dayamba et al., 2018). Rwanda was the first country to demonstrate the feasibility of scaling up the delivery of rural climate services through a participatory process of PICSA at the national level (Grossi & Dinku, 2022). In this paper, we document one of the first experiences with PICSA in Latin America—the dry corridor of Honduras. Various studies have provided evidence of the potential of weather and climate information to support farmers' decision-making in Honduras. Examples include the use of climate information for identifying the factors and strategies that households use to cope with seasonal food insecurity (Alpízar et al., 2020), and the identification of Climate Smart Agriculture projects about farm technologies/practices together with incentives to make changes (Bonilla Findji et al., 2016). However, these projects took a "one-size-fits-all" approach which is unlikely to benefit all farmers because decision-making processes are complex and involve a series of factors including (a) the type of decision required; (b) the relevant information available; (c) the type of farmers; and (d) the timescale for making the decision (Singh et al., 2016; Stringer et al., 2020).

Using the dry corridor of Honduras as a case study, this research seeks to address the question of whether participatory climate services, as established through PICSA, have positive effects on farmer decisions and therefore benefit farmers. To answer this question, we evaluate (a) whether farmers found the approach useful in their planning and decision-making (why and how decisions are made and by whom); (b) how those decisions affected households (their food security or income), and (c) limitations and opportunities for PICSA in Central America (for effective and practical implementation at large scale). Addressing this question is crucial in advancing farmer climate risk management and adaptation in Honduras and more broadly in Latin America because it counters the traditional top-down and information/technology-transfer approaches that limit farmers' participation that currently prevail in these contexts.

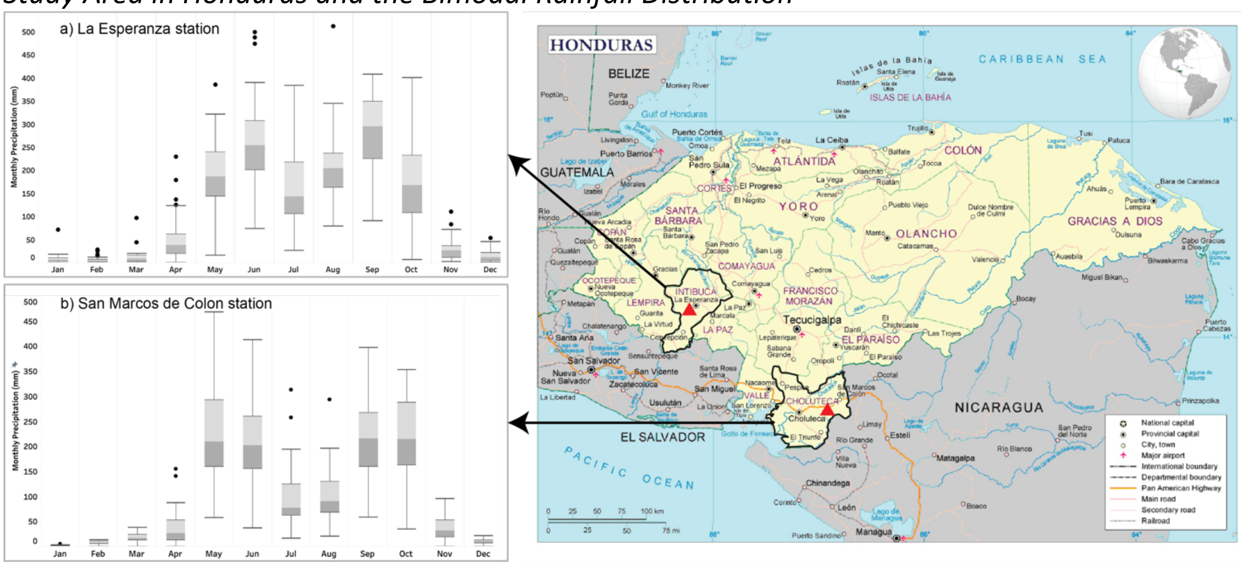
Methods

Study Area

To explore the effects of PICSA on small-scale farmers in a rainfed context, this study was conducted in the villages of Hato Viejo, La Anona, Baldoquin, and Santa Isabel (13°17′N 87°2′W, average 712 m above sea level) in the Choluteca Department and Los Naranjos, Buenos Aires, Cataulaca, Zarzal, La Ceibita, and Brisas de Azacualpa (14°19′N 88°11′W, average 1224 m above sea level) in the Intibucá Department of Honduras. Figure 2 presents the bimodal rainfall distribution in the two departments, which coincides with the two main growing seasons—*Primera* (May–July) and *Postrera* (August–October).

Figure 2

Study Area in Honduras and the Bimodal Rainfall Distribution



Note. Map of Honduras showing PICSA sites (red triangles) and monthly box plots of rainfall for the 1981–2018 period for (a) La Esperanza station in Intibucá and (b) San Marcos de Colon station in Choluteca.

The dry season extends from November to April and the rainy season extends from the middle of May to October, altered by the midsummer drought, locally known as the *canícula*; specifically, a decrease in rainfall occurs between early July and late August, which significantly influences planting dates and crop yields (Magaña et al., 1999). The climate of the Choluteca is characteristic of the Pacific Coast of Central America, with an annual average rainfall of 1,100 mm and average temperature of 27 ºC (minimum = 23 ºC, maximum = 34 ºC). By contrast, Intibucá receives an annual average rainfall of 1,400 mm and has an average temperature of 20 ºC (minimum = 13 ºC, maximum = 24 ºC). According to Duron et al. (2021) and Paz Delgado (2016), prolonged droughts, high temperatures, and heavy rainfall are the climatic threats most reported by the inhabitants of Intibucá and Choluteca.

PICSA Field Implementation

In Choluteca, PICSA was performed with 92 small-scale farmers (40% men, 60% women) from March to May 2019 before the *Primera* season, and in Intibucá it was performed with 117 small-scale farmers (29% men, 71% women) from July to September 2019 before the *Postrera* season. PICSA was implemented with a total of 209 farmers in the two departments. Four meetings were carried out in each village to complete the PICSA process with a clear, logical flow (Figure 1). Each meeting had a duration of three to four hours.

The first meeting focused on step (A), where the farmers individually or with their families drew a map of their resources (e.g., crops, livestock, and water sources) and how they allocated them to their farm using a *resource allocation map (RAM) tool*. In addition, the farmers drew a "dream farm," which contained the objectives, goals, and plans that each farmer had for their farm over next few years; the consensus was for basic grains over two to three years and coffee over four to five years in the planning. Another activity in step (A) aimed to capture farmers' perceptions and local knowledge of the climate in each month. Using this, farmers then identified the specific activities performed on their main crops and how these have been affected by the weather and climate using an *agroclimatic calendar tool***.**

The second meeting focused on steps (B) and (C). To ensure that the farmers understood how the historical climate information is collected at the meteorological stations, a demonstration was conducted to measure a millimetre of water and how to build the average climatology graphs. Then, the farmers analysed the historical climate records and compared them with their perceptions, which were reflected in their agroclimatic calendar through a participatory discussion. The aim of this activity was to build farmers' confidence in the information collected from meteorological stations to enable them to use it in their decision-making processes. Once the farmers understood historical graphs to reinforce their perceptions regarding how climate is changing—awareness of climatic events and trends (Dorward et al*.,* 2019; Osbahr et al*.,* 2011), probabilities for specific climate events (dry or wet years) were calculated to understand the likelihood of such events occurring in their area.

The third meeting focused on step (D) using an *options matrix tool***.** Specifically, farmers created a matrix of crop and livestock practices by time to identify options for their own individual context that could help them to achieve their "dream farm" and to respond to the climate challenges identified in the agroclimatic calendar. Once the matrices were completed, a group discussion was held involving questions such as who participates in the implementation of the practice; the potential benefits of the practice; and risks and disadvantages. Next, farmers analysed the time, the resources used and received (labour, cash, and food stocks) to implement the options identified in the matrix using the *participatory budget tool***.** In some villages, developing a budget with family members and sharing it with peers in the next meeting was set as homework.

The fourth meeting focused on steps (F) to (I). Building on the understanding of probability achieved during steps (B) and (C), the farmers explored and interpreted terciles and forecasts. Various activities were performed with coloured balls, coins, bean grains, and soccer games to explain that a forecast is not a "divination process," but that it is necessary to have clues or historical data. In Honduras, the *climate and short-term forecasts* were provided by Meteorological Service of Honduras (SMHN) – CENAOS-COPECO (Centro de Estudios Atmosféricos, Oceanográficos y Sismológicos – Comisión Permanente de Contingencias). The forecasts were disseminated just before and throughout the growing seasons using agroclimatic bulletins and channels such as WhatsApp, radio, and workshops. During the meetings, the forecasts were explained and discussed with the farmers, who then identified and selected possible responses. The selection of responses emphasised that each farmers' situation and context is different, which enabled them to adjust their plans (i.e., the agroclimatic calendar, option matrix, and participatory budgets) in the lead-up to the growing season.

Data Collection and Analysis

This study employed a mixed-methods approach (Clarkson et al., 2019; Staub & Clarkson, 2021), combining a quantitative survey with qualitative case studies. This approach enabled complementary analyses to identify changes and decisions that the farmers made following their participation in the PICSA meetings, understanding of the process of information use, and the evaluation of the farmers' lessons, successes, and challenges. We used local independent enumerators in each department. The enumerators were provided with an in-depth explanation of and training on PICSA. The survey and case study protocols were approved by the University of Reading's Research Ethics Committee. For the data collection, each farmer was linked to a unique farmer survey ID, of which the first letter corresponds to (C) Choluteca or (I) Intibucá (e.g., C52716764F). The eight numbers were assigned in the Open Data Kit (ODK) software. Lastly, the second letter at the end indicates the farmer's gender—(F) female or (M) male.

Quantitative Surveys

All 209 farmers who participated in the PICSA meetings in 2019 were surveyed individually, five weeks (in Intibucá) and ten weeks (in Choluteca) after the meetings concluded. The surveys were held in villages in Choluteca from July to September 2019 and in those in Intibucá from November 2019 to February 2020. The quantitative survey was designed to understand whether farmers engaged with, understood, and used the tools and information from PICSA in their planning and decision-making process. Questions included whether farmers had made changes due to the PICSA meetings and, if so, what those changes were and what the effects of those changes had been. Data were collected using ODK, and the results were plotted using Tableau. In order to test for independence, statements that were measured on a five-point Likert scale were combined into two categories. More specifically, "agree" and "strongly agree" were combined into "agree"; whereas "disagree" and "strongly disagree" were combined into "disagree." The Mann–Whitney U test was run to assess the significance of the differences ($\alpha = 0.05$) in the two departments for women and men to understand whether PICSA effects differed based on gender.

Qualitative Case Studies

For the case studies, 19 households that had received PICSA training were randomly selected based on the quantitative survey to ensure equal representation in Choluteca (women = 6, men

= 4) and Intibucá (women = 5, men= 4). The case studies were documented in October 2020 in the two departments using semi-structured interviews (taking approximately two hours) to explore the how and why of changes and effects reported in the surveys resulting from PICSA. The qualitative case studies involved open-ended questions to capture the farmers' reflections and experiences and participatory activities using budgets and effects diagrams (Clarkson et al., 2019) to understand the perceived benefits (e.g., yields, food security and income) that they had made as a result PICSA. The case study responses were recorded and transcribed. Content analysis was conducted to identify key themes and illustrative farmer quotes, to complement quantitative analyses and to triangulate findings.

Findings

Farmer Demographic and Socioeconomic Context

Table 1 presents a summary of the socioeconomic characteristics of the farmers in the two departments of Honduras. In Intibucá, a large proportion of the survey respondents who participated in the PICSA approach were women. By contrast, in Choluteca there was more balance in the number of men and women participating in the PICSA process. In terms of size, some farmers in Intibucá (<10%) reported having farms larger than 3 ha. Most (83–92%) survey respondents in Choluteca had some level of primary education, whereas only half of the respondents had primary education in Intibucá.

Table 1

Socio-economic Characteristics of Survey Respondents by Department and Gender

Socio-economic variable	**Choluteca** (*n = 92*)		**Intibucá** (*n = 117*)	
Household size (mean)	5		5	
Farm size (ha)	1.0		1.5 – 2.0	
Migration (%)	21.7%		36.7%	
Gender	**Female** (*n = 55*)	**Male** (*n = 37*)	**Female** (*n = 83*)	**Male** (*n = 34*)
Gender (%)	59.8%	40.2%	70.9%	29.1%
Mean age (years)	41.9	47.4	42.6	46.8
Farming history (years)	19.3	29.4	14.4	26.1
Primary education (%)	92.7%	83.7%	56.6%	50%

Intibucá, where institutions have promoted spaces for the participation of women, has the highest number of women who are independent workers (Muller & Sousa, 2020). Many organizations are represented by women who have experienced mass migration of their husbands and sons, leaving them in charge of agricultural production (Jaramillo et al., 2021). Accordingly, the data revealed a high percentage of migration (37%) in Intibucá. When farmers were asked about the main reasons that led family members to migrate, 52.1% mentioned job opportunities and 25% mentioned escaping poverty. Less than 2% gave violence, drought, or crop failure as the main reasons.

The PICSA Approach was Useful to Most Farmers

Overwhelmingly, the respondents stated that the training they received (98%) had made them more confident in planning and making decisions about their farming and livelihood. Furthermore, there were no significant differences based on gender. Table 2 presents the proportion of farmers trained in each of the PICSA tools who agreed that they found those steps useful for their planning and decision-making. All tools were found useful by most (75–100%) farmers in both localities, except for the short-term forecast in Choluteca (46.7%). The most valued tools were the resource allocation maps, crop information and option matrix, and seasonal forecast. A significant difference existed between Intibucá (98%) and Choluteca (47%) in the use of short-term forecasts for planning and decision-making as well as the participatory budget tool (72% in Choluteca vs. 100% in Intibucá).

Table 2

Proportion and Numbers of Farmers Trained in each of the PICSA Tools and Their Usefulness in their Planning and Decision-making by Department and Gender

	Trained (%)		**Planning and decision-making (%)***			
			Choluteca *(n = 92)*		**Intibucá** *(n = 117)*	
PICSA tool	**Choluteca** *(n = 92)*	**Intibucá** *(n = 117)*	*Women (n = 55)*	*Men (n = 37)*	*Women (n = 83)*	*Men (n = 34)*
Resource allocation map	97.8%	98.2%	89.0%	97.3%	86.7%	82.3%
Historical climate info	97.8%	100%	78.1%	81.0%	75.9%	91.1%
Probabilities and risk	90.2%	98.2%	78.1%	64.8%	77.1%	85.2%
Crops information	94.5%	99.1%	85.4%	91.8%	96.3%	97.0%
Option matrix tool	96.7%	99.1%	83.6%	83.7%	87.9%	97.0%
Participatory budgets**	78.2%	100%	72.7%	67.5%	85.5%	91.1%
Seasonal forecast	97.8%	99.1%	92.7%	89.1%	89.1%	94.2%
Short-term forecast**	46.7%	98.2%	47.2%	40.5%	89.1%	97.0%

Note. * The *n* is different for each tool and corresponds to the number of people that reported that they had been trained and found those steps useful for their planning and decision-making
**p values were calculated using the Mann-Whitney U test ($\alpha = 0.05$)

Overall, case study results indicate that the design of the tools does address the range of needs and expectations from farmers in the study region, and that several of these tools aid farmer decision-making processes. Consistent with the overall perceived usefulness of the individual tools, the RAM, the option matrix tool, and participatory budget, and the seasonal forecast were highlighted by farmers. The farmers mentioned that the *option matrix tool* helped them (a) to know what practices to implement and to plan them using the resources available on the farm (C52722694F); (b) to learn to integrate soil protection, care for the environment, and family work (C52722688F); and (c) to have a portfolio of practices that help increase economic income (I53522042M). With regards to the *participatory budget tool***,** farmers mentioned that it was helpful for (a) planning a budget, which is required to understand all the expenses, ultimately enabling one to determine whether it will be profitable (C52688472M); (b) planning and having an estimate of what they can invest (I55876919F); and (c) keeping track of what they spend, which it is not easy (I55806058M).

The seasonal forecast is a crucial component in the PICSA approach, because if well understood, it allows farmers to foresee climate conditions during the rainy or cropping seasons and use that information to make tactical and strategic management decisions (Dayamba et al*.,* 2018). At the time of the implementation of PICSA in 2019 (March–May), the Honduran government had issued alerts due to the El Niño event, expected to affect the *Primera* season. These conditions are conducive to drought, which added to an already ongoing dry period. Overall, the *seasonal forecast* improved farmers' understanding of the risks for the upcoming season, boosting their confidence during planting time and harvest planning, as reported through surveys and case studies. Seasonal forecasts, as well as the short-term forecasts were deemed critical to the success of the harvest and allowed farmers to better understand the amount of water that falls and determine suitable crop and varieties, and planting times (C46944052F). Additionally, farmers reported an improved comprehension of the forecast generation process and how to interpret the results.

In Choluteca, the CENAOS-COPECO seasonal forecast for the first rainy season of 2019 was presented (Rodríguez, 2020) and then communicated through PICSA to the farmers; 73% of the farmers considered the climate forecast valid and helpful to integrate into the decision process (women = 80%, men = 62%). Although the forecast was fulfilled and there were significant losses in basic grain crops in Honduras (FEWS NET, 2019; WFP, 2019), the farmers who participated in PICSA were able to use the information provided in the meetings to plan their sowing and reduce the risk of crop loss. In general, the farmers adopted the optimal sowing dates that were presented at the beginning of the season. Those who sowed early did well on their crops. The farmers expressed in the surveys and case studies that the agroclimatic information was key to the success of their harvest.

The various case studies showed that the farmers who participated in PICSA were able to use the information provided in the meetings to plan their sowing. For example, a farmer C51619585F said the following: "The [*Primera*] rains ended much earlier than expected. Maize could not be harvested. However, PICSA was very useful to me because the bean harvest was excellent." In Intibucá, farmers who participated in PICSA mentioned that the 2019 Postrera season was normal. For example, farmer I53522037F stated the following: "The *Postrera* season 2019 was normal. The forecasts were used, maize and beans were planted, and there were good yields. In coffee, there will also be a good production."

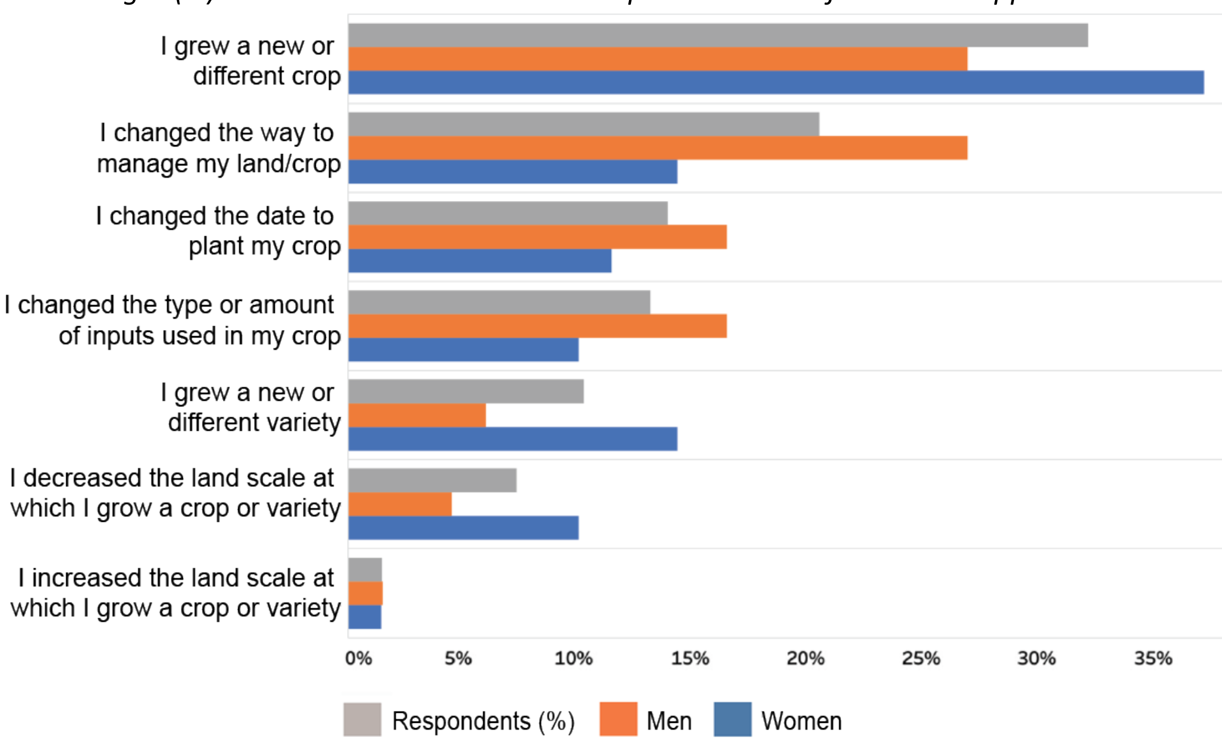
It is noteworthy that while farmers found the provided climate information very useful, they also reported other information related to weather and climate that they would like to have received from PICSA meetings. In Intibucá, a large proportion of farmers (50%) wanted to receive information on the moon's phases, which contrasted with Choluteca, where only 8% stated that they wanted such information. Furthermore, in both departments, the farmers wanted to receive information about the mid-summer drought or *canícula* (34%), followed by information about wet spells (30% in Choluteca and 9% in Intibucá). Temperature and winds were other types of information that the farmers wanted to receive from the PICSA.

Farmers Made Changes in their Farms Based on the PICSA Approach

In general, farmers stated that following the PICSA meetings (80%), felt better able to cope with bad years caused by weather and climate. Yet it is important for us to learn what changes farmers made in their crop, livestock, or farm as a result of PICSA meetings and tools (Figure 3). Farmers were thus asked in the surveys and case studies whether they had made any changes in their crops, livestock, and livelihood enterprises as a result of the PICSA meetings received. Despite the challenging 2019 season, 43% (*n* = 90) of the farmers said that they had made changes, with a large difference existing between departments. Most of the farmers (81%, *n* = 75) in Choluteca had made at least one change in their farming. On the contrary, only 18% (*n* = 21) had made changes in Intibucá. Farmers who did not implement practices indicated that PICSA should have been conducted earlier in the season to allow more time for planning and making changes before the start of the season. Farmers made changes in their crops (84%), followed by changes in livestock (14%). Only women in Choluteca (2%) reported changes in other livelihoods.

Figure 3

The Changes (%) that Farmers Made to their Crops as a Result of the PICSA Approach.



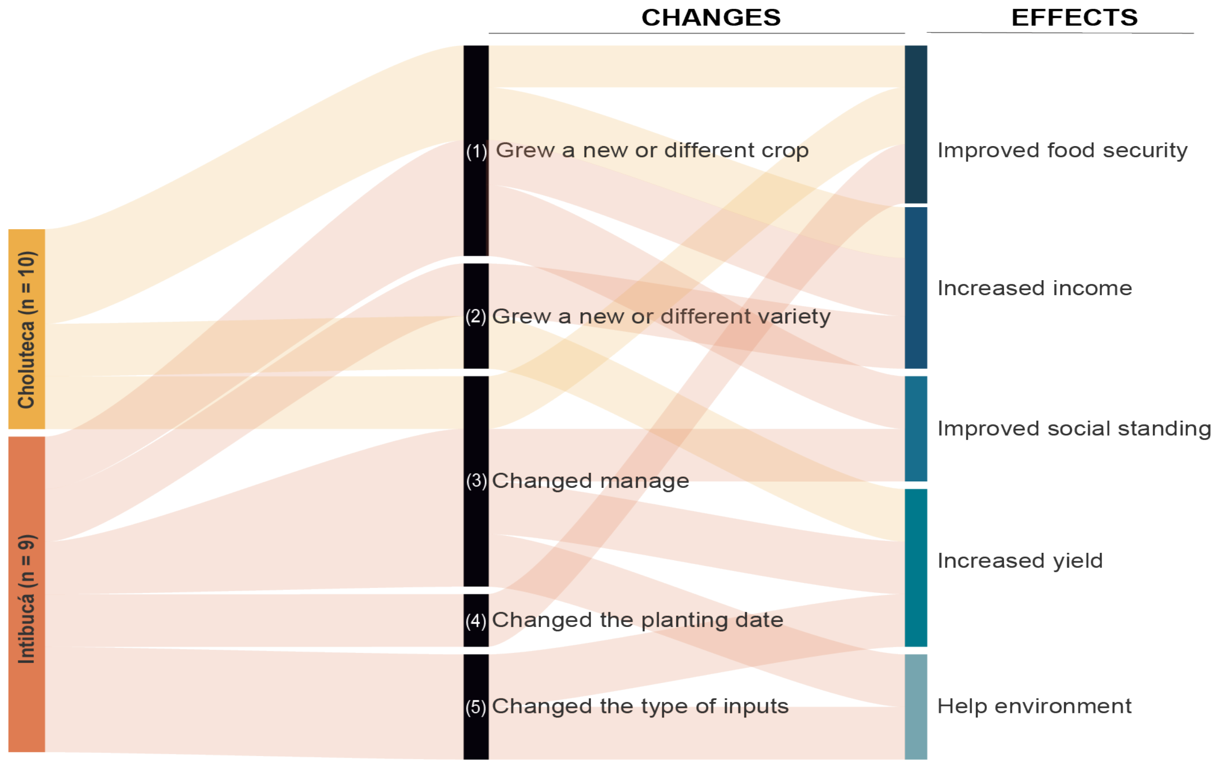
Note. The grey bars indicate the percentages of total respondents (men + women) in each category (*n* = 135).

A total of 135 changes were made to crops with some significant differences when gender is considered. The most frequent change was the growing of a different crop, followed by changes in crop or land management, changes in planting dates, inputs, varieties, adjustments in land distribution, and others (Figure 3). This order changed depending on gender, with women prioritizing changes in crop type, followed by changes in crop variety, and changes how land or crop management. For men, changes in crop type and crop management were equally frequent (27%), followed by changes in planting dates and inputs. Choice of crop was a very frequent change. Farmers reported planting beans and maize outside of the regular growing season, followed by cassava and sorghum. Women in Choluteca (66%) reported planting a new crop and were more likely to diversify (e.g., sweet potato, garlic, or tomato). Farmers in Choluteca also planted an improve varieties of maize. In Intibucá, farmers grew a new bean variety under the government bonus program. It would therefore appear that removing constraints regarding access to seeds of crops that are suitable in the region, would enable farmers to adapt in response to seasonal climate variations.

The case study analysis helped explore in more detail how PICSA influenced and supported the farmers' decision-making process and how the changes they made affected their households. Figure 4 summarises the farmers' changes and their effects—food security, income, social standing, yield and environment—influenced by PICSA approach in both departments, the farmers' changes are grouped by (a) grew a new or different crop; (b) grew a new or different variety; (c) changed the way they managed the land/crop; (d) changed the planting date; or (e) changed the type of inputs used in the crop. The changes reported in the surveys and case studies came from the options matrix tool and from farmers ideas (e.g., reducing chemical use, reducing deforestation).

Figure 4

Diagram of Farmers' Changes and their Effects Influenced by PICSA in Both Departments, Case Studies = 19.



A smaller number of farmers made changes to their livestock (14%), the majority in Choluteca; women (71%) were significantly more likely to make changes to livestock than men (29%). The most prevalent change for all those who changed in livestock concerned the way the households manage their livestock (57%) due to the information they learned during the PICSA. Some farmers also started a new livestock enterprise (28%). The women explained how the process behind the PICSA had encouraged them to diversify their sources of income. Farmer C51619584F stated the following:

> Thanks to PICSA, I implemented poultry farming [March 2020] and bought a pig to raise and sell [August 2020] to improve food security and household income. I feed them with homemade concentrate. The income generated by the pig will be for my son's graduation and studies expenses […] I built a barn for my chickens; those are only for reproduction.

Furthermore, farmer C51619585F stated the following:

> With a farmers group, we carried out the participatory community budget, and it was there that we realised that it was feasible to have poultry […] I spoke with a neighbour about improving the corral and the production of eggs with better feeding and hydration for my chickens.

Limitations on Making Changes

Overwhelmingly, the farmers reported that they would have liked to have made more changes on the back of the PICSA meetings that they received. In the surveys, Intibucá farmers and enumerators identified several factors contributing to the low percentage of farmers (18%) who made changes due to their participation in PICSA. These factors included (a) the farmers were highly uncertain about planting in *Postrera* season, stemming from losses in the *Primera* season; (b) PICSA focused more on annual crops, whereas their primary source of income is coffee; and (c) the gender balance (more women participated), where decision-making often involves the entire family. However, male migration, such as during the 2019 migratory caravan (Phillips, 2019), can lead to a shift in responsibilities within the household. In the case studies, overall, the farmers in Intibucá mentioned that they would have liked to make changes as a result of the PICSA meetings but were unable to due to a lack of financial resources. In Choluteca, farmers in the case studies mentioned, for example, that they want to have vegetable gardens and to plant fruit trees, but due to their family's economic situation they have not been able to do so (C51783783F and C51619585F). Moreover, farmer C51619584M stated the following: "I have not yet been able to build a tank to store water because I do not have the necessary resources, and it is one of my projects drawn on the dream farm."

PICSA benefitted farmers in terms of household income and food security

A combination of Likert statements was used in the surveys, and participatory budgets and effects diagrams in the case studies, to understand if and how the changes the farmers made to their enterprises had affected their household income and food security (Figure 3.) The farmers indicated that using the PICSA approach had improved their household food security, with 91% in Intibucá and 74% in Choluteca responding with "agree." In Choluteca, 80% of the women reported that using the PICSA approach had improved their household food security. These women farmers had specifically decided to plant a new crop, have a garden, and diversify. Examples included sowing sweet potato. Farmer C51619585F stated the following: "I made this change to vary my children's diet and provide them with more nutrients." Farmer C51783832M mentioned the following: "I obtained higher yields planting improved maize, and it is resistant to pests and diseases as well as drought. Also, I ensured my family's food for a few months and obtained the seed to sow in the next cycle."

In Intibucá, the farmers were very uncertain about planting due to the losses in the *Primera* season. However, the government promoted the planting of beans by providing a bonus (seed and fertilizers) to farmers (El Heraldo, 2019; El Mundo, 2019), which coincided with a good rainy season that favoured a good harvest in the Postrera season. The government bonus was one of the reasons for the low percentage of farmers in Intibucá who made changes due to PICSA, since the government (not PICSA) triggered the changes. Choluteca farmers (70%) agreed that they perceived tangible benefits (in yields and income) where the PICSA had encouraged them to diversify their sources of income—new crops and new livestock enterprises (i.e., poultry farm and pigs) —through using the participatory budget and RAMs. By contrast, Intibucá farmers stated that they did not improve their income due to the PICSA (73% disagreed). The latter was because the survey, which was applied slightly early (starting in November), was unable to capture changes in income, especially for those whose main source of income was coffee. However, the case studies in Intibucá indicated that where farmers had been able to make changes, they also had improved their income and yields.

Conclusions, Discussion, and Recommendations

Effective Climate Services for Farmers

In Central America, decision-makers recognize the relevance of climate services in supporting adaptation plans of smallholder farmers (Donatti et al*.,* 2017). However, top-down one-size-fits-all climate services are not appropriate for meeting the diverse needs and contexts of farmers in Honduras and have not been successful to date (Müller et al*.,* 2020). Our findings demonstrate that the PICSA approach played an important role in Honduran farmers' planning and decision-making, generating income and food security benefits. The surveys and case studies reported here revealed that (a) most farmers were able to integrate information (e.g., climate and crop) and participatory tools into their planning and decision-making; (b) in Choluteca, with a high percentage of primary education level and lower migration rates compared with Intibucá, most farmers made changes in their crops and livestock with effects on their food security and income; (c) PICSA motivated the farmers to discuss and share ideas with their families and fellows, made them more curious to seek help through social networking with their field officers and other sources for improving their agricultural practices; and (d) bringing together farmers, field officers, national meteorological services, and other stakeholders within the PICSA process, contributed to farmers becoming more aware of their demands and that establishing new decision-making processes. These results reinforce previous findings (Findlater et al*.,* 2021; Lourenço et al*.,* 2015) and have important implications for the provision of climate services in Honduras and Latin America. These are discussed below.

First, our results highlight that a new era of climate services is needed to integrate climate information with other information (such as budgets and resource endowment, constraints to decisions, access to market) driven by demand. Specifically, results reveal that farmers considered different time scales, including a long-term "vision" through the use of the dream maps and shorter-term seasonal and short-term views, connecting their local knowledge through participatory tools (e.g., agroclimatic calendar and option matrix). At the same time, PICSA helped farmers think logically through considering their farm as an integrated and dynamic system in the context of weather and climate, and other factors, and identify and plan what they consider best for their individual contexts (farm, socioeconomic situation, and beliefs).

Second, understanding farmers' perceptions of climate risk was an integral part of the PICSA process of how to provide and connect relevant weather and climate information to their decision-making dynamics (Osbahr et al., 2011). In line with previous studies (Clarkson et al*.,* 2022; Dorward et al*.,* 2019; Loboguerrero et al*.,* 2018), the historical climate information plotted and analyzed by farmers built their confidence in the climate science data to enable them to use it in their decision-making processes. This confidence then allowed identifying and selecting possible responses on the basis of the forecast, which in turn helped farmers reduce risk from the forecasted drought stemming from a negative ENSO phase.

Finally, it is well recognized that providing effective climate services is a substantial challenge where most farmers in Latin America are older people (particularly regarding production of staple crops) with low literacy levels and little motivation to change their current practices (FAO, 2021). Despite the challenging 2019 season, this study revealed that most of the farmers, especially in Choluteca, used the PICSA tools and information to make a great variety of changes in their practices regardless of their literacy level. It is noteworthy, however, that changes in practices in Intibucá, where literacy levels are lower, occurred much less often across the group of farmers. Our results demonstrated not only that literacy challenges can be overcome by discussion and training, but also that farmers were appreciative of the bottom-up participatory approach that enabled them to be at the centre of the decision-making process. At the same time, farmers need time to experiment with different practices, validate some of them, and adapt them to local conditions, as well as receiving technical assistance, to ensure the correct use of inputs at the optimal time (Chiputwa et al*.,* 2022; Loboguerrero et al*.,* 2018).

Climate services for drought-related food security management in Central America need to move from reactive crisis response to proactive planning and decision-making (Keller et al*.,* 2018; Müller et al*.,* 2020). During a challenging 2019 season, the farmers expressed that the agroclimatic information was key to the success of their harvest. We showed that in Honduras, the changes made by the farmers reportedly led to positive effects on food security and income and increased their confidence in their abilities to plan and deal with climate variability and change in the short and long-term. These findings are promising in the context of socio-economic development in Honduras and Latin America to manage agricultural risk, forecast seasonal changes and transform their agricultural systems by creating the conditions so that farmers can choose their own development path. For this potential to be realized, work needs to be done to address farmer constraints to changing their practices. However, climate services for better decision-making should go closely together with supporting institutional and governance processes for effective and sustainable implementation (Müller et al*.,* 2020). Notably, the findings suggest that access to finance would enable farmers to make changes in their practices if such finance were coupled with extension and advisory involving a PICSA-like approach. We highlight that the PICSA process in Honduras achieved an improved integration of existing weather and climate information into agricultural extension structures and approaches, which helped stakeholders and farmers to learn from each other's experiences and expertise, understand challenges in information use, create innovative learning spaces, build trust, and provide networking opportunities.

Scaling up the PICSA approach by adapting it to local and knowledge contexts requires time and financial investment for the capacity development of staff in institutions but can then fit within the operations of existing structures. A relevant result was the inclusion of the PICSA approach within the Climate Resilience Plan of the national bean chain in Honduras (Obando et al., 2021) and the exploration of gender dynamics in the rural sector of Guatemala (Mosso et al*.,* 2022). Furthermore, the PICSA implementation herein described led to spillover effects whereby farmers shared their ideas more broadly with their community and field workers. While this emphasized the need of further investigating the role of farmers and organisational networks in climate information flows and communication, it also shows that a network of indirect beneficiaries can arise from a PICSA implementation. This information seeking and sharing, ideas, and lessons among farmers and local stakeholders is particularly critical in Latin America, where the extension system is limited and the national level organizations have not been effective in addressing local agroclimatic challenges. The PICSA approach and its tools can be part of a broader transformation of the institutional, knowledge, and innovation networks in the region.

Limitations and Future Research and Action

Although the implementation of PICSA (in number, time, and content of the meetings) in both departments was the same, the number of farmers in Intibucá who made changes was much lower than in Choluteca. The survey in Intibucá was applied early (five weeks), before the farmers may have seen the benefits of the changes, which may have reduced the number of changes reported. Practical constraints can influence implementation in development initiatives and unpredictable environments, including a nationwide shutdown of economic and transport activities leading to a delay in the process (Phillips, 2019). The lower number of changes in Intibucá could also be associated with sociodemographic factors—lower education levels and higher migration rates in Intibucá than in Choluteca. For example, the Intibucá respondents mentioned that they had a household member who had migrated, mainly men, leaving women in charge of agricultural production and decision-making (Jaramillo et al., 2021) which explains the high proportion of women participants (71%) in the PICSA meetings. More research is needed to better understand the farmers' decision-making processes regarding the intersection of climate, food security, and migration, as well as the linking of climate services with off-farm livelihoods and the role of remittances in households' decision-making.

Looking at wider opportunities, the results of this study have the potential to be applied to the national scale and contribute to the commitments of Honduras including the Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change. This is especially significant with regard to the social inclusion component by 2030—contingency and risk management plans with a gender approach to climate risks built in a participatory manner—and the adaptation component by 2025—that is, innovation, research, technology, and agriculture adapted to the climate. Furthermore, a large step in long-term sustainability is to build capacity within the national government to help them achieve the NDC, including incorporating this approach into the national plan and policies.

The COVID-19 pandemic forced a massive increase in online engagement and delivery in the climate service arena, with large constrains in participatory approaches. However, this also opened an opportunity to transition from face-to-face to online training beyond these "intermediaries"—i.e., the extension service, NGO staff or farmers' associations who are already working directly with farmers— and had restrictions carrying out their work in the field. An important learning from Honduras, which is applicable to many rural areas of Latin America is that ICTs can also, with less digitally connected farmers play a supporting and complementary role after the PICSA implementation (e.g., farmer and extension WhatsApp groups). However, creating opportunities for young farmers using climate services (Giraldo et al., 2021) provides a strong starting point for discussion and further research into ICTs, which will encourage young people to become a bridge between farmers and intermediaries in facilitating PICSA implementation in the field and will enable more farmers to access and use ICTs without the need for facilitators as a complementary approach to a PICSA field implementation in a scalable manner.

Conclusion

The main conclusion is that the PICSA approach supported farmers in making their own decisions by incorporating tools, weather and climate information with their knowledge, and supported them to make changes in their livelihoods with positive effects on their food security and income. Further, the approach fuelled farmers' longer-term vision development and motivation to enhance their farming systems. Our study aims to help fill the knowledge gap on the participation of the farmers in climate services development, making the information more transparent to the farmers, enabling them to gain ownership over the process, integrating various aspects of the decision-making process (e.g., budgeting, farm dynamics, socioeconomic conditions), and creating relationships between science and decision-making. Transforming climate services that better account for why and how farmers make relevant decisions could represent a new era in the climate action for agriculture with important implications for future adaptations in Latin America, building capacity and expertise in local communities to manage their resources and implement measures for climate adaptation in a systematic and effective way.

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