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# Exploring Women's Differentiated Access to Climate-Smart Agricultural Interventions in Selected Climate-Smart Villages of Latin America

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**Abstract:** Much of the literature examining the role of gender in processes of climate change adaptation in the agricultural sector has focused primarily on differences between male and female farmers, implicitly treating men and women as homogenous groups. Where heterogeneity exists within these groups which impacts climate change adaptation efforts and outcomes, an understanding of such intersectionalities is vital to the design of effective and equitable policy. The objective of this study is to investigate whether interaction effects among socio-economic factors are meaningful drivers of observed differences among female farmers in their adoption of climate-smart agricultural (CSA) practices, as well as their use of climate information and financial services. This study employs data from farmer surveys in three Climate-Smart Villages in Latin America, analyzed using ordinal logistic regression and canonical correspondence analysis. The results indicate that important interaction effects are present: the relationship between higher educational attainment and increased adoption of CSA practices, for example, is conditional on the degree of livelihood diversification. The relationship between greater educational attainment and increased use of climate forecasts is likewise conditional on age. These results suggest the need for researchers and policymakers to anticipate potential intersectionalities when designing research efforts and development interventions.

**Keywords:** gender; intersectionality; climate-smart agriculture; Climate-Smart Village; Latin America

## 1. Introduction

Despite increasing global policy efforts towards protecting the rights of rural women, and the prominent place of gender equality in the Sustainable Development Goals (SDGs), gender inequalities in the agricultural sector continue to be pervasive and are at risk of being exacerbated by the threats and constraints that climate change poses to rural populations [1]. These gender inequalities have important consequences not only for the women themselves, but for their entire families, communities and, ultimately, for the economic development of rural areas and of nations [2]. Policy and development initiatives that aim at addressing gender inequalities in agriculture and in climate change adaptation have, more often than not, considered women as homogenous groups whose rights needed to be brought to par with those of rural men [3]. This has often meant "one-size-fits-all" interventions that were thought to benefit all women equally, independently from other social dimensions such as their socio-economic status, education, age, race, religion, etc.

However, promoting more equitable development in rural areas demands understanding what constraints and needs different types of women living in those areas have, so that gender equality strategies can be more targeted and effective. Development interventions that consider women as a homogenous category and do not cater for specific needs and opportunities are likely to not reach their maximum potential or may even cause unintended negative consequences for some groups of women. As such, making agricultural and climate change interventions more effective and tailored for rural women demands a deeper examination of the heterogeneity among rural women, with a conscious effort at examining the different socio-economic factors driving such heterogeneity and the interactions within them. While the importance of considering how gender intersects with other social dimensions to create different degrees of vulnerability in agricultural development and in climate change adaptation is well established in the literature, these aspects of intersectionality are rarely explored in a thorough manner in practice [4].

In this study we aim at providing a more nuanced understanding of issues surrounding climate change adaptation processes for female smallholder farmers in selected Climate-Smart Villages of Latin America, using the case of Honduras, Guatemala, and Colombia. The share of formal female employment in agriculture in these countries varies from 6.6% in Colombia to 8.3% in Honduras and 9.8% in Guatemala, although this number is significantly larger when accounting for informal forms of female engagement in the sector [5]. Rural livelihoods in these Latin American countries are both increasingly threatened by climate change and climate variability [6] and face high levels of gender inequality [7–9]. Though this research, we examine different socio-economic and demographic factors that affect women's differentiated access to and employment of climate-smart agriculture (CSA) practices, financial, and climate information services. Specifically, we study female farmers living within the geographical limits of the 'Climate-Smart Villages' (CSV) located in these three countries. CSVs are sites of participatory testing and evaluation where researchers, local organizations and farmers work together to generate local evidence and draw out lessons to scale out and up CSA technical interventions (e.g., practices or services) and institutional interventions [10]. CSA interventions are based on three pillars: (1) sustainably increasing agricultural productivity of farmers, reflected in an increase of their income, food security and development; (2) enhancing adaptive capacity and building resilience to climate change; and (3) reducing and/or removing greenhouse gas emissions from agricultural activities, where possible [10–12].

The agricultural sector is particularly vulnerable to climate change and to climate variability [13]. In Honduras, Guatemala, and Colombia, recent climate models of Prager et al. [6] anticipate decreases in the suitability of cash crops such as banana (Colombia, Guatemala) and coffee (Colombia, Guatemala, Honduras), and predict increased biophysical vulnerability of staple crops such as maize (Colombia, Guatemala) and potato (Colombia). Vulnerability to climate change is especially acute for smallholder farmers in areas that predominantly practice rainfed agriculture and thus are highly dependent on weather conditions [14]. In Central America, smallholder farmers are already facing critical challenges with climate change, including adapting to rising temperatures, unpredictable rainfall patterns and extreme weather events [15,16]. Social differentiation factors such as gender play an important role in determining smallholder farmers' vulnerability and adaptive capacity to climate change [17]. In Latin America, gender, race, ethnicity, and socioeconomic status are among the factors that are predicted to be of key importance considering the increase in the region's vulnerability to climate change [18].

In the Global North [19] as in the Global South [20], women and men have been portrayed as having gender differentiated roles, preferences, needs, and challenges that are important to consider in order to design gender-responsive interventions that help them adapt to climate change. Climate change is expected to widen the gender inequalities that already exist in the agricultural sector [21]. These pre-existing gender inequalities in the agricultural sector include, for example, differences in the access to, and ownership of, productive assets [22,23], in the access to extension services and agricultural productivity [24], and in decision-making power [25,26], among others. Several socio-economic factors such as social and gender norms, education and poverty levels can influence differences in vulnerabilities and adaptive capacities of male and female farmers [27–29]. In Colombia, Guatemala and Honduras, different studies have also found gender differences in the access and use of climate information, including weather and seasonal forecast [30]; on the willingness to invest agriculture income or credit in solutions to adapt to and mitigate the impacts of climate change and variability [30]; on decision-making power on the adoption of climate-smart practices [30,31], and on the use of income generated from these practices [31].

However, portraying women as a homogenous group and as the most vulnerable sector of the population to climate change might be misleading and not always accurate for certain geographical or cultural regions. For example, in Eastern Uganda, Balikoowa et al. [32] found that female-headed households were more vulnerable to climate change than male headed households, while the exact opposite was found to be the case in a study conducted in different Latin America countries [33]. However, both studies [32,33] only considered women living in female-headed households and did not study climate change vulnerability for the women living in male-headed households, leaving out an important part of the female population in the study regions. Climate change adaptation and climate-smart agriculture research can thus benefit from the use of intra-household data, including the implementation of intra-household surveys examining decision making and smallholder agricultural production, including the adoption of climate-smart agricultural practices (e.g. [34]). In fact, there is the recognition that for climate-smart agricultural interventions to be sustainable and effective, they must address gender inequality and other forms of social discrimination [12].

Women have been a considerable focus of study in climate change adaptation processes and are generally described as having a differentiated level of vulnerability to changing weather patterns, as compared to that of men [21]. However, as already emphasized, not all women present the same level of vulnerability to climate change. The adoption of technologies that can help female smallholder farmers adapt to climate change and to improve their resilience to climate variability is also affected by a series of social factors. For example, in a study conducted in Ethiopia, Tsige et al. [35] found that female smallholder farmers' uptake of conservation agriculture and small-scale irrigation schemes was affected by access to credit, extension, restricted membership in cooperatives and water user associations, lack of access or user rights to land, skill training, information, and restricted mobility. Similarly, in the Philippines, Harman Parks [36] found that the three main gendered constraints to the adoption of conservation agriculture were the lack of access to secure land tenure, capital, and training. Differences among regions, villages, or among landscapes can also account for differences in adaptation, vulnerability, or empowerment levels among women. For example, in a study in two Indian CSVs, Hariharan et al. [37] found that overall women in the Bihar CSV had a lower degree of empowerment than women in the Haryana CSV when measured using the "Gender Empowerment Index", which assesses men's and women's progress in both the use of sustainable farming practices and economic returns from agricultural enterprises as well as improvements in social and political engagement. The authors attributed that fact to the broadly lower level of empowerment among both men and women in Bihar.

The adoption of climate change adaptation options (whether practices, inputs or services) can also bring unintended negative consequences for women. For example, in a study conducted in Ethiopia, Cholo et al. [38] found that the implementation of a larger number of sustainable land management practices increased on average the number of working hours of women, while it did not affect the working hours employed by men. To avoid agricultural development and climate change adaptation strategies that may bring unintended negative consequences for women, or for certain groups of women, more in-depth gender studies need to be conducted which include examinations of the intersections between gender and other social dimensions. Understanding intersectionality is also of paramount importance in contexts such as in Central America or Asia where climate-induced migration, which is predominantly male, is leaving women in charge of managing, on their own, the households and farms with reduced resources and labor, contributing to further widening their vulnerability [39,40]. Having a more nuanced picture on the challenges and needs of different categories of women could aid the design of more targeted and effective climate change adaptation strategies to help increase their resilience.

This study constitutes an examination of the intersectionalities among socio-economic and demographic factors characterizing smallholder female farmers in three CSVs in Latin America. It investigates whether interaction effects among socio-economic and demographic factors are meaningful drivers of observed differences among female farmers in their adoption of climate-smart agricultural (CSA) practices, as well as their use of climate forecasting and financial services. We employed original data from CSA monitoring surveys conducted in the three CSVs in 2019 (Colombia) and 2020 (Honduras, Guatemala) and apply ordinal logistic regression and canonical correspondence analysis as the two main methods for data analysis. Specifically, the objective of this research is to examine differences and commonalities among women in the CSVs in terms of (1) the number and type of CSA practices they employ; (2) their access to, and use of, climate information services; and (3) their access to, and use of, financial resources and services (specifically as they relate to adaptation and recovery to climate change induced shocks and stresses on farming enterprises).

In answering these questions, we pay particular attention to the interactions between these socio-economic and demographic factors. By doing so, we draw attention to the implications that such differences between different groups of women have both for the experimental design of research for development initiatives aiming at closing gender gaps in agriculture and in climate change adaptation, and for the development of more tailored policy interventions targeting specific groups of women.

The outline of the study is as follows: Section 2 details the methodology followed, describing the study sites, and presenting the data analysis employed. Section 3 presents the results concerning climate-smart practices, climate finance, and climate services. Finally, Section 4 discusses the findings and Section 5 presents the conclusion and policy implications for improved research design and policy formulation of interventions aiming at closing the gender gap in agriculture and climate change adaptation.

## 2. Methodology

### *2.1. The Climate-Smart Village Approach*

Climate-Smart Villages (CSVs) are sites of local action and experimentation, where farmers' groups, researchers, local partners and policy makers work together to test, select and scale out locally appropriate technologies and interventions that aim at raising agricultural productivity and incomes, increase climate resilience and enable climate change mitigation [41]. As such, CSVs are considered as a key approach for the agriculture research-for-development (AR4D) agenda aiming specifically at addressing climate change challenges for agricultural production and food security [42]. The CSVs are normally composed of a group of townships, a small landscape or 10 $km^2$ grids [10]. Typically, a CSV approach is comprised of six main components: climate information services and insurance; climate-smart practices and technologies; local and national public and private institutions; climate and agricultural development finance; farmers' knowledge; and national and sub-national plans and policies [10].

Central to the strategy of a CSV is to build an understanding on the effectiveness of different climate-smart agricultural interventions—be they practices, technologies, programs, policies or services—with an emphasis on the socio-cultural, biophysical and gender aspects that might constrain, enable, or otherwise condition the adoption of these interventions [10]. It is within this framework that this study aimed at examining socio-economic and demographic considerations to understand which type of women might face more challenges in the adoption of these climate-smart agricultural interventions. Complete descriptions of the specific climate-smart agricultural practices associated with each of the three CSVs can be found in Bonilla-Findji et al. [43], Bonilla-Findji et al. [44] and Bonilla-Findji et al. [45].

*2.2. Study Sites and Data Collection*

The study was conducted within three different CSV sites in Latin America, namely, “Cauca” in Colombia, “Santa Rita” in Honduras, and “Olopa” in Guatemala, all of which were established in 2014 (Figure 1) by the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS). The CSV of Cauca is located within the municipality of Popayán, in the Colombian Department of Cauca in the country’s southwest. Seven communities from the Cauca CSV were targeted by the CSA monitoring: San Antonio, La Mota, Los Tendidos, Las Mercedes, Los Cerrillos, El Danubio, and San Rafael. Los Cerrillos, Las Mercedes, El Danubio and Los Tendidos are where most of the CCAFS activities were focused (considered as “CCAFS direct beneficiaries”) while the ones located in the other villages were considered as potential “non adopters” or “non-beneficiaries”. The initial sample target included (as much as possible) a revisit of the initial households visited for the CCAFS Baseline in 2014 [46] and all the direct CCAFS beneficiary households (directly involved in CSA implementation activities). In the CSV of Cauca, the two main weather-related events affecting household productivity and income are droughts and hail [47].

The CSV of Olopa is located within the ecological region of Trifinio, in the Chiquimula Department of Guatemala. Eight communities from the Olopa CSV were originally selected to be covered by the CSA monitoring: Valle Nuevo (1), Tituque Tishmuntique (3), Prensa arriba (4), Tuticopote abajo el bendito (5), Guayabo el tercer caserio (6), Nochan (7), La Prensa centro (8) and Tuticopote centro (9-newly added). Of those, five (1, 3, 7, 8 and 9) were the communities where most of the CCAFS PAR activities took place in 2019 (most households considered as “CCAFS direct beneficiaries”). The other communities (4, 5 and 6) included mostly “non-beneficiaries” or potential “non adopters” households; however, due to the COVID emergency they could not be surveyed. In Olopa, ongoing droughts are the main weather-related event negatively affecting farmers’ agricultural productivity and income, followed by episodes of intense rainfall [48].

Finally, the CSV of Santa Rita is also located within the ecological region of Trifinio but in the Department of Copan, in Western Honduras. Ten communities from the Santa Rita CSV were originally selected to be covered by the CSA monitoring: Tierra Fria (17), Aldea Nueva (19), Mirador (23), Vado Ancho (36), La Hermosura (52), La Arada (58), Rastrojitos (76), La Casita (20), Villanueva (21) and Queseras (22). In 2019, most of the CCAFS activities took place in the communities 17, 19 and 20 (most households considered as “CCAFS direct beneficiaries”). Thus, five communities (23, 36, 52, 58 and 76) represented mostly “non-beneficiaries” or potential “non adopters”, and due to the COVID emergency they were under surveyed. In Santa Rita, prolonged drought is the main weather-related event negatively affecting farmers’ agricultural productivity and income, followed by strong winds [49].

The survey data used in this study were collected through the ICT-enabled environment called Geofarmer, designed to support monitoring and feedback systems for data collection in agricultural research for development projects globally [50]. For each household, the CSA Monitoring survey [51] was administered to two adults of opposite sexes involved in agricultural activities on their farms, with one of them being the main person involved in deciding and implementing on-farm activities. This study only focuses on the female respondents, and thus uses a subset of the original data. In total, this study examines data from 326 women: 99 women in Cauca (Colombia), 98 in Olopa (Guatemala), and 129 in Santa Rita (Honduras)**.** The survey, designed to tackle CSA adoption and outcomes at household level, had thematic modules on demographics, agricultural systems, climate events, climate services, climate-smart practices and food security. The specific CSA practices being promoted in each CSV are enumerated in the Results. In addition to this, the survey conducted in Santa Rita also had an additional module on financial capacities and services due to the fact that there were local initiatives planned in this CSV regarding improved access to financial resources and improved financial capacities to help local farmers cope with the effects of climate change and climate variability.

In all three locations, the survey was administered by locally trained enumerators. Data were collected in August 2019 for the Cauca CSV [47] and February 2020 for the CSVs of Olopa and Santa Rita [48,49]. The data in these monitoring surveys represents a randomly selected sub-sample of the households living within the different CSV sites covered by the CCAFS program baseline in 2014, as well as all the households directly involved in the participatory testing. The monitoring survey was not designed either to constitute an impact assessment or program evaluation or to be fully representative of farmers in these regions or nations, but rather for the purpose of continuous evidence gathering and learning on access and use of climate information and climate-smart agriculture in the CSV sites. This naturally limits the scope of the inferences which can be drawn and the extent to which any findings are generalizable to other farmers or communities. Nevertheless, the data do provide a reliable basis on which to examine the drivers of variation, and interactions among them, in the number and type of climate-smart practices employed by female farmers in the CSVs as well as their access to and use of both financial resources and services and climate forecasting services.

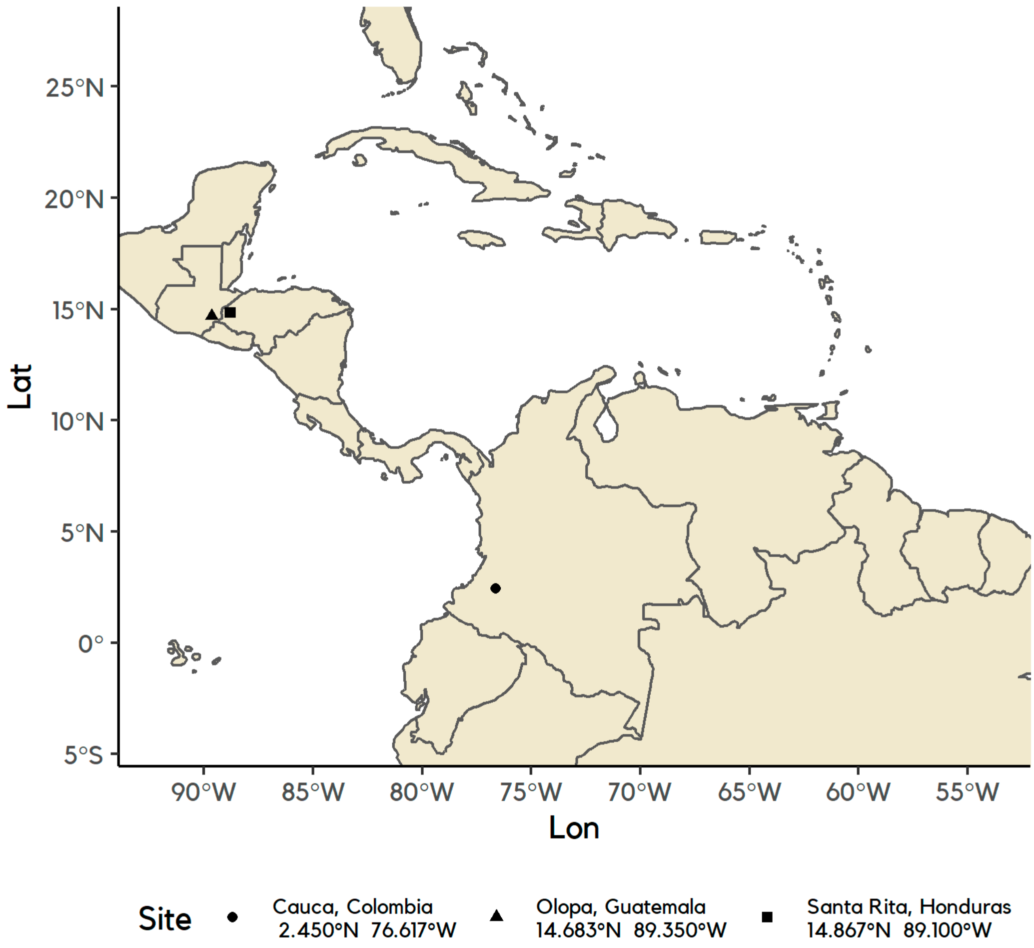


**Figure 1.** Location of the Climate-Smart Villages (CSV) included in this study.

### *2.3. Data Analysis*

#### 2.3.1. Ordinal Logistic Regression

Ordinal logistic regression (OLR) was employed to identify the socio-economic and demographic factor(s) among female survey respondents associated with (1) the number of CSA practices employed; and (2) the level of access to, and use of, climate forecasting services, including forecasts delivered via radio, TV or public announcement, printed media or community bulletin, cellphone or internet, or via social groups or personal contacts. Count data such as the number of practices employed would typically be modeled as following a poisson or negative binomial distribution. However, here we treat the number of practices employed by a given farmer as an ordered categorical variable rather than counts per se, based partly on the fundamentally qualitative nature of the practices themselves and partly on the lack of either a reliable standard for, or measure of, the scale and/or intensity of implementation. This analysis does assume that the use of more CSA practices is always preferable to the use of fewer, which may be untenable once a farmer is already employing many of the practices being promoted at a CSV, since the marginal benefit or even applicability of the remaining practices is likely to be very low. Nevertheless, this simplification may hold reasonably well at the other extreme, for a population of farmers in which most employ few, if any, CSA practices. The method, as implemented in the ordinal package for R [52,53], provides estimates of the probabilities that a woman would, for example, employ at least some number of practices or level of access. Calculation of the back-transformed marginal means for select main and/or simple effects was undertaken with the emmeans package [54] and plotted with ggplot2 [55]. In keeping with recent recommendations from the American Statistical Association [56,57], the presentation, interpretation and discussion of the results aims to avoid giving undue weight to p-values, both by eschewing binary distinctions between statistically significant and non-significant results and by considering the relative strength of evidence against null hypotheses of no effect in conjunction with measures of effect size and their practical implications.

The fixed effects included as predictor variables in these two analyses were: total cultivated land (in hectares), land tenure (mostly or entirely owned, mostly or entirely rented, without formal tenure), age (in years), main household income source (primarily agriculture, primarily non-agricultural, or mixed), household status (single-headed household or dual-headed household) and education level (none, primary education, or more than primary education). Country, village and ethnicity were also included in these models but as random effects. Since an exploration of the intersectionalities among socio-economic and demographic factors characterizing female farmers in the CSVs was a principal aim of the study, and in recognition of the fact that no stepwise model selection procedure is guaranteed to find the optimal set of model terms (as measured by Akaike Information Criterion, AIC), it was decided to instead fit models with all ($2^{10} = 1024$) combinations of the ($\frac{5\times(5-1)}{2} = 10$) first-order interactions among the fixed effects [58]. Of these, the models with the lowest AIC values were then employed in the final analysis, which for the number of CSA practices adopted included interaction terms household status x age, land x age, education x main household income source, and land area x land tenure. In the analysis of access to and use of climate forecasting services, interaction terms retained in the final model included household status x education, household status x land tenure, age x education, and age x land tenure.

#### 2.3.2. Canonical Correspondence Analysis

Canonical correspondence analysis (CCA) was employed in studying the relationship(s) between the same five socio-economic and demographic factors and (1) the implementation of specific CSA practices and (2) access to and use of financial resources and services, with specific reference to their use in the management of farm enterprises to prepare for and adapt to climate related stresses and shocks. The former analysis was undertaken separately for each of the three sites, since the specific practices inquired about in the surveys differed somewhat among the locations, while the latter analysis was undertaken only with data from Santa Rita, Honduras, as it was the only location for which the survey included the relevant module. In both cases, village and ethnicity were again included as random effects.

CCA can serve to identify synergies or trade-offs which might exist among sets of practices, or specific practice(s) which are associated with particular resource endowments/constraints or livelihood strategies. Besides being informative in its own right, the CCA on the implementation of individual CSA practices could also serve to provide additional nuance to the results of the OLR analysis. More specifically, CCA is a constrained ordination technique, a method enabling not only dimensionality reduction and the identification of major gradients within a multivariate data set, but to also the identification of the associations between those gradients and those of a set of predictor variables: "a hybrid between ordination and multiple regression" [59]. Orthogonal axes, composed as linear combinations of the predictor variables, which account for the greatest amount of variation in the response variables, are identified, enabling a measure of the extent to which the former account for the latter. The Euclidean distance between scaled variable coordinates (or the cosine of their angle, in the case of continuous predictor variables) thereby becomes a measure of the correspondence between those variables (*ibid*). A multivariate approach such as this one allows us to avoid the assumption that each farmer's decision (e.g., whether or not to employ a certain practice) is independent of that farmer's decisions regarding the use or non-use of all other practices, which would be implicit if separate models were fitted for the use of each individual practice. Model fitting was undertaken in R with the *vegan* package [60].

Access to and use of financial services were modeled with a set of binary variables indicating whether the respondent received an income from agriculture, whether they were able to accumulate savings from that agricultural income, whether and what type of recent investments they had made in their farm enterprise (i.e., investment to prepare for climate change, investment to recover from climatic stresses or shocks, or investment for other reasons), and whether they had recently received a loan to finance farming operations and the how the loan was used (i.e., loan for climate change preparation, recovery or other). Other questions related to financial resources and services (i.e., the source of the loan, whether investment went to labor or inputs) either had insufficient numbers of respondents for each category or were so consistent across informants as to be uninformative, and were not employed in the analysis.

## 3. Results

Socio-demographic information provides useful insights to contextualize the results. Women in the Honduran and Colombian CSVs belong to the Chorti and Ladino ethnicities (Table 1). In Guatemala, women were predominantly from the Chorti ethnicity while in Honduras women were predominantly Ladino. Women in the CSV of Colombia identified predominantly as campesina (peasant). The average age among all respondents was 43.7 years, ranging from a mean of 37.9 in Honduras to a mean of 52 in Colombia. Mean total cultivated area of the farms ranged from 0.3 hectares in Guatemala to 1.02 and 1.60 hectares in Honduras and Colombia, respectively.

### *3.1. Adoption of Climate-Smart Agricultural Practices*

#### 3.1.1. Descriptive Statistics

Table 2 shows the number of female respondents reporting implementing each type of CSA practice in each of the three CSVs. Women in the Guatemala CSV reported the highest rates of practice use, 3.5 on average, while women in the Honduran and Colombian CSVs reported approximately 1.5 practices each, on average. There is also evidence of considerable variability in use among the different practices, with no women reporting employing drip irrigation, while more than one in eight women in each CSV report employing rainwater harvesting.

**Table 1.** Summary statistics of socio-demographic characteristics of survey respondents by country.

| | Colombia | | | | Guatemala | | | | Honduras | | | | All | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **%** | **Mean** | **Std. Dev** | **N** | **%** | **Mean** | **Std. Dev** | **N** | **%** | **Mean** | **Std. Dev** | **N** | **%** | **Mean** | **Std. Dev** |
| **Age** | 99 | | 52.0 | 14.5 | 98 | | 43.0 | 16.1 | 129 | | 37.9 | 13.4 | 326 | | 43.7 | 15.7 |
| **Land Area (ha)** | 99 | | 1.60 | 1.06 | 98 | | 0.31 | 0.21 | 129 | | 1.02 | 0.77 | 326 | | 1.00 | 0.92 |
| **Land Tenure** | | | | | | | | | | | | | | | | |
| *Mostly/Entirely Owned* | 57 | 57.6 | | | 77 | 78.6 | | | 69 | 53.5 | | | 203 | 62.3 | | |
| *Mostly/Entirely Rented* | 3 | 3.0 | | | 16 | 16.3 | | | 46 | 35.7 | | | 65 | 19.9 | | |
| *No Formal Tenure* | 39 | 39.4 | | | 5 | 5.1 | | | 14 | 10.9 | | | 58 | 17.8 | | |
| **Main Household Income Source** | | | | | | | | | | | | | | | | |
| *Primarily Agriculture* | 58 | 58.6 | | | 46 | 46.9 | | | 99 | 76.7 | | | 203 | 62.3 | | |
| *Mixed (Agriculture & Non-Agricultural)* | 26 | 26.3 | | | 28 | 28.6 | | | 12 | 9.3 | | | 66 | 20.2 | | |
| *Primarily Non-Agricultural* | 7 | 7.1 | | | 13 | 13.3 | | | 12 | 9.3 | | | 32 | 9.8 | | |
| *No Data* | 8 | 8.1 | | | 11 | 11.2 | | | 6 | 4.7 | | | 25 | 7.7 | | |
| **Education** | | | | | | | | | | | | | | | | |
| *None* | 2 | 2.0 | | | 44 | 44.9 | | | 36 | 27.9 | | | 82 | 25.2 | | |
| *Primary Education* | 66 | 66.7 | | | 52 | 53.1 | | | 85 | 65.9 | | | 203 | 62.3 | | |
| *Secondary Education or Higher* | 31 | 31.3 | | | 2 | 2.0 | | | 8 | 6.2 | | | 41 | 12.6 | | |
| **Household Status** | | | | | | | | | | | | | | | | |
| *Dual-Headed Household* | 79 | 79.8 | | | 80 | 81.6 | | | 109 | 84.5 | | | 268 | 82.2 | | |
| *Single-Headed Household* | 20 | 20.2 | | | 18 | 18.4 | | | 20 | 15.5 | | | 58 | 17.8 | | |
| **Ethnicity** | | | | | | | | | | | | | | | | |
| *Chorti* | | | | | 65 | 66.3 | | | 10 | 7.8 | | | 75 | 23.0 | | |
| *Ladino* | | | | | 33 | 33.7 | | | 116 | 89.9 | | | 149 | 45.7 | | |
| *Campesina* | 90 | 90.9 | | | | | | | | | | | 90 | 27.6 | | |
| *Other* | 9 | 9.1 | | | | | | | 3 | 2.3 | | | 12 | 3.7 | | |

**Table 2.** Reported use of CSA practices among female respondents in each of the three Climate-Smart Villages. Practices denoted by "-" are not applicable because they were not promoted at the CSV, to distinguish from true zeroes, where the practice was introduced but not employed by any respondent.

| CSA Practice | Colombia | | Guatemala | | Honduras | | All | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Rainwater Harvesting | 17 | 12.6 | 63 | 18.1 | 30 | 17.5 | 110 | 16.8 |
| Living Barriers | 6 | 4.4 | 57 | 16.3 | 15 | 8.8 | 78 | 11.9 |
| Organic Pesticides | - | - | 51 | 14.6 | 20 | 11.7 | 71 | 10.8 |
| Homegardens | 5 | 3.7 | 5 | 1.4 | 54 | 31.6 | 64 | 9.8 |
| Crop Rotation | 8 | 5.9 | 50 | 14.3 | - | - | 58 | 8.9 |
| Ditches | - | - | 54 | 15.5 | - | - | 54 | 8.2 |
| Minimum Tillage | - | - | 52 | 14.9 | - | - | 52 | 7.9 |
| Intercropping | 46 | 34.1 | - | - | - | - | 46 | 7.0 |
| Improved Varieties | 16 | 11.9 | - | - | 18 | 10.5 | 34 | 5.2 |
| Water Resevoirs | - | - | 17 | 4.9 | 10 | 5.8 | 27 | 4.1 |
| Crop Shading | - | - | - | - | 24 | 14.0 | 24 | 3.7 |
| Organic Fertilizers | 24 | 17.8 | - | - | - | - | 24 | 3.7 |
| Mulching | 13 | 9.6 | - | - | - | - | 13 | 2.0 |
| Drip Irrigation | 0 | 0.0 | - | - | - | - | 0 | 0.0 |

Table 3 details how the number of practices employed are distributed among women in the three CSVs. Notable is the fact that whereas in Colombia and Honduras the share of women reporting employing a given number of practices declines steadily as the number of practices rises (and where more than one-third of respondents report employing zero practices), a very different pattern is evident in Guatemala, where more women report employing six practices than report employing only one practice and the mode of the distribution is at four practices.

**Table 3.** Reported number of CSA practices which female respondents report employing in each of the three Climate-Smart Villages.

| Number of CSA Practices Employed | Colombia | | Guatemala | | Honduras | | All | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| 0 | 34 | 34.3 | 6 | 6.1 | 51 | 39.5 | 91 | 27.9 |
| 1 | 26 | 26.3 | 7 | 7.1 | 29 | 22.5 | 62 | 19.0 |
| 2 | 18 | 18.2 | 15 | 15.3 | 23 | 17.8 | 56 | 17.2 |
| 3 | 12 | 12.1 | 17 | 17.3 | 16 | 12.4 | 45 | 13.8 |
| 4 | 8 | 8.1 | 20 | 20.4 | 7 | 5.4 | 35 | 10.7 |
| 5 | 1 | 1.0 | 18 | 18.4 | 0 | 0.0 | 19 | 5.8 |
| 6 | 0 | 0.0 | 14 | 14.3 | 1 | 0.8 | 15 | 4.6 |
| 7 | 0 | 0.0 | 1 | 1.0 | 2 | 1.6 | 3 | 0.9 |

#### 3.1.2. Socio-Economic and Demographic Drivers of Increased Use of CSA Practices

The results of the ordered logistic regression model (Table 4) indicate that, among the socio-demographic predictors of increased use of CSA practices, educational attainment (edu) and the extent of cultivation (land) positively influence the increased use of CSA practices. The results also highlight that educational attainment and the extent of cultivation are subject to interactions with factors whose main effects are not by themselves important predictors of increased use of CSA practices. Specifically, there is strong evidence that the degree to which the extent of cultivation predicts increased use of CSA practices is dependent on the type of land tenure (land: land_tenure); cultivating a larger land base is associated with employing a greater number of CSA practices, but only among those women who own most or all of their land, while for women who rent most or all of their land a larger extent of cultivation is not associated with employing more CSA practices (Figure 2). There is also somewhat weaker evidence that the relationship between educational attainment and employment of more CSA practices is conditional upon the women's primary source of income (edu: mhic) (Table 4).

The importance of accounting for such interactions, especially where the main effect of one factor has a high p-value, is illustrated in Table 5. The top panel in Table 5 shows that there are differences in the average number of CSA practices employed by women with no formal education (2.1 practices) compared with those who at least completed secondary school (3.5 practices), for an overall difference between the highest and lowest levels of education of 1.4 practices. The lower panel is further disaggregated by income source, and the difference in the mean number of practices employed is much smaller among those with primarily agricultural livelihoods (women with at least a secondary education employ, on average, 0.5 more CSA practices) and much larger among those with primarily non-agricultural livelihoods (women with at least a secondary education employ on average 1.6 more CSA practices). This pattern—expressed in terms of the probability that a women will employ at least a given number of CSA practices—is expressed graphically in Figure 3: only among households whose income is not primarily agricultural does a woman's level of education make a discernable difference in the number of CSA practices she employs.

**Table 4.** Analysis of deviance for best fit ordered logistic regression model of women's use of CSA practices.

| Factor | LR Chisq | Df | Pr (>Chisq) |
|---|---|---|---|
| land | 5.92 | 1 | 0.015 |
| edu | 7.27 | 2 | 0.026 |
| land_tenure | 3.88 | 2 | 0.144 |
| mhic | 1.20 | 2 | 0.550 |
| age | 0.28 | 1 | 0.594 |
| hhstatus | 0.04 | 1 | 0.833 |
| land:land_tenure | 8.02 | 2 | 0.018 |
| age:land | 4.65 | 1 | 0.031 |
| edu:mhic | 8.13 | 4 | 0.087 |
| hhstatus:age | 2.33 | 1 | 0.127 |

**Table 5.** Estimated marginal mean number of CSA practices employed by women, disaggregated by educational attainment level or by both education and main household income source (MHIC).

| Mean number of CSA practices employed by women, disaggregated only by educational attainment level | | | | | |
|---|---|---|---|---|---|
| **Education** | | **Mean Practice Number** | **SE** | **Lower 95% CI** | **Upper 95% CI** |
| None | | 2.1 | 0.79 | 0.54 | 3.62 |
| Primary | | 2.5 | 0.91 | 0.73 | 4.29 |
| Secondary or Higher | | 3.5 | 1.08 | 1.39 | 5.63 |
| Mean number of CSA practices employed by women, disaggregated by educational attainment level and main household income source (MHIC) | | | | | |
| **Education** | **MHIC** | **Mean Practice Number** | **SE** | **Lower 95% CI** | **Upper 95% CI** |
| None | Agricultural | 2.5 | 0.92 | 0.66 | 4.27 |
| Primary | Agricultural | 2.7 | 0.95 | 0.82 | 4.57 |
| Secondary or Higher | Agricultural | 3.0 | 1.04 | 0.91 | 5.00 |
| None | Mixed | 1.8 | 0.71 | 0.39 | 3.17 |
| Primary | Mixed | 2.7 | 0.99 | 0.79 | 4.69 |
| Secondary or Higher | Mixed | 3.9 | 1.18 | 1.63 | 6.25 |
| None | Non-Agricultural | 2.0 | 0.82 | 0.38 | 3.61 |
| Primary | Non-Agricultural | 2.1 | 0.85 | 0.42 | 3.77 |
| Secondary or Higher | Non-Agricultural | 3.6 | 1.23 | 1.22 | 6.06 |

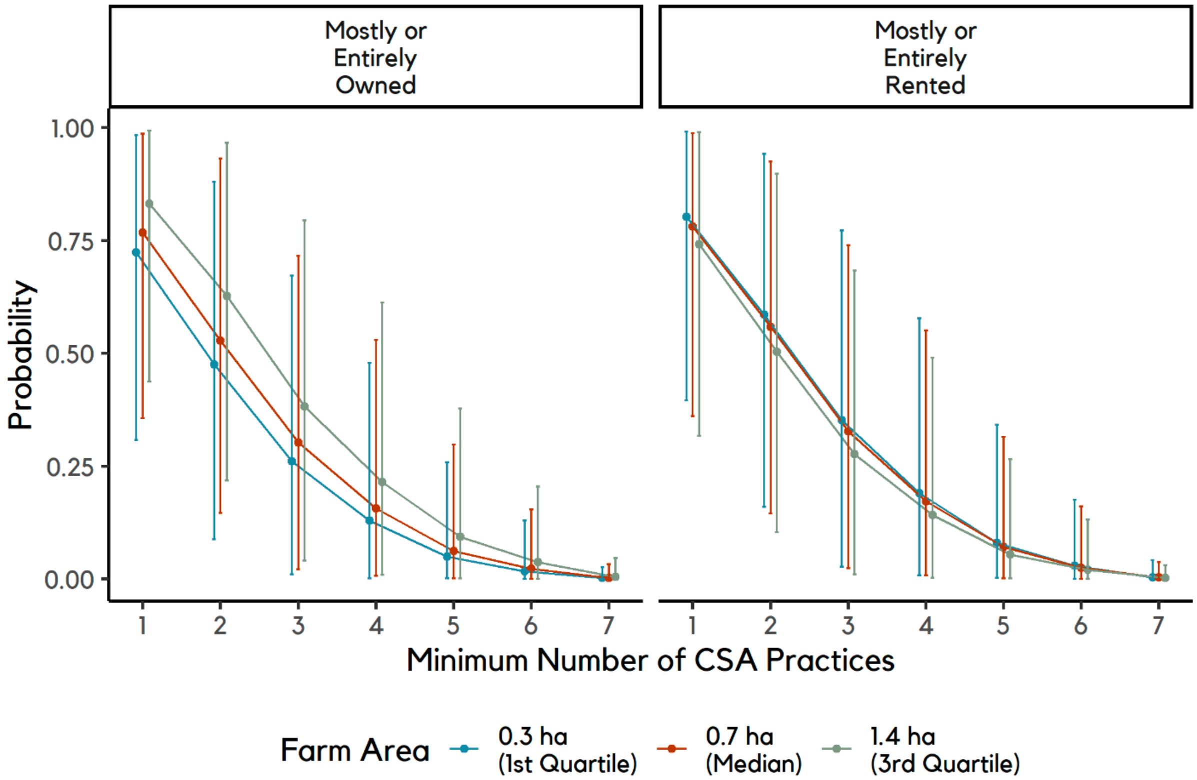


**Figure 2.** The probability that women with a differing land tenure and extent of cultivation will adopt at least some number of CSA practices (i.e., the probability of employing one or more practices, two or more practices, etc).

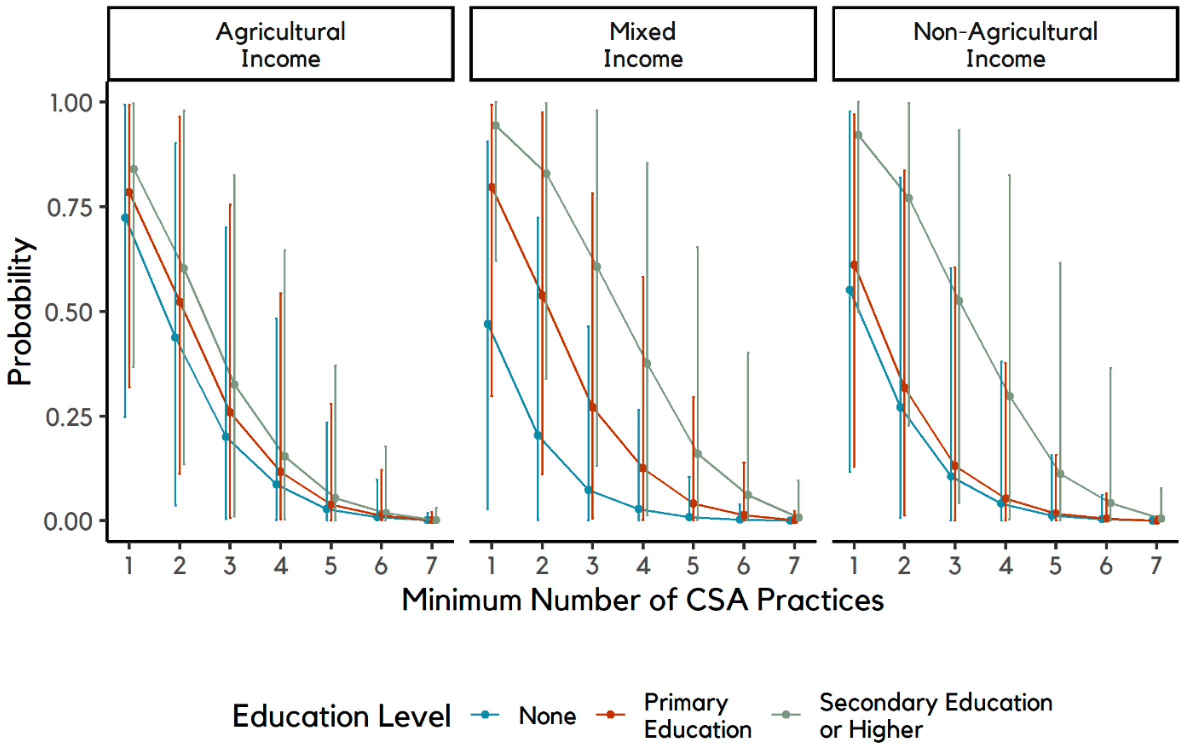


**Figure 3.** The probability that women with a given educational background and main household income source will adopt at least some number of CSA practices (i.e., the probability of employing one or more practices, two or more practices, etc). The rightmost panel shows broadly similar patterns of CSA practice use among women whose primary source of income is agriculture, regardless of their level of educational attainment. Among those with mixed (agricultural and non-agricultural) incomes, those with more education are more likely to employ a higher number of CSA practices.

#### 3.1.3. Socio-Economic and Demographic Drivers of the Implementation of Specific CSA Practices

This subsection presents the results from the canonical correspondence analysis conducted for each individual location: Santa Rita (Honduras), Olopa (Guatemala), and Cauca (Colombia). The analysis of deviance (Table 6) suggests that only in the case of Cauca were the socio-demographic factors included in the model capable of meaningfully explaining the variation in adoption of specific CSA practices among women. Considering this, only a cursory outline of the results will be presented for the models fitted for Santa Rita and Olopa.

**Table 6.** Analysis of deviance for canonical correspondence analysis of CSA practice use among women in the Climate-Smart Villages.

| Site | | DF | Chi Square | F | Pr (>F) |
|---|---|---|---|---|---|
| Cauca, Colombia | Model | 9 | 0.671 | 1.820 | 0.005 |
| | Residual | 42 | 1.721 | | |
| Olopa, Guatemala | Model | 9 | 0.124 | 0.948 | 0.570 |
| | Residual | 59 | 0.854 | | |
| Santa Rita, Honduras | Model | 9 | 0.162 | 0.736 | 0.905 |
| | Residual | 46 | 1.124 | | |

#### 3.1.4. Santa Rita, Honduras

Table 7 shows the proportion of inertia—a measure analogous to variance—accounted for by the random effects ('Conditional'), fixed effects ("Constrained") and residual ("Unconstrained") in the CCA analyses at each site. In Santa Rita, conditional inertia is fairly high at over 30% of the total, while the proportion of constrained inertia is quite low, at approximately 6% of total inertia. The proportion of unconstrained inertia thus is around 60% of the total. This implies that differences among villages and, to a much lesser extent, ethnicity, account for more of the differences in the adoption of specific practices among women than individual-level socio-demographic factors (results not shown). This would be consistent, *inter alia*, with a situation in which village-level socio-economic factors (e.g., state of transportation infrastructure and accessibility of markets), village-level agro-climatic factors (e.g., microclimates, soil chemistry), and/or social norms or network components (e.g., gender norms, existence of and engagement with farmers' cooperatives or farmer field schools) are driving differences in the uptake of CSA practices. It is also the case that there has been some degree of variation among the CSVs in the frequency and intensity of engagement efforts and demonstration programs.

**Table 7.** Partitioning of inertia for canonical correspondence analysis of CSA use among women in the Climate- Smart Villages.

| Site | Component | Inertia | Proportion |
|---|---|---|---|
| Cauca, Colombia | Total | 2.898 | 1.000 |
| | Conditional | 0.506 | 0.175 |
| | Constrained | 0.671 | 0.232 |
| | Unconstrained | 1.721 | 0.594 |
| Olopa, Guatemala | Total | 1.153 | 1.000 |
| | Conditional | 0.175 | 0.152 |
| | Constrained | 0.124 | 0.107 |
| | Unconstrained | 0.854 | 0.741 |
| Santa Rita, Honduras | Total | 1.977 | 1.000 |
| | Conditional | 0.663 | 0.336 |
| | Constrained | 0.118 | 0.059 |
| | Unconstrained | 1.196 | 0.605 |

3.1.5. Olopa, Guatemala

In Olopa, Guatemala, the proportions of constrained inertia (associated with socio-demographic fixed effects) are similarly small, but the proportion of conditional inertia (associated with random effects of village and, to a lesser extent, ethnicity) are also low, at approximately 15%, or roughly half the amount observed in Santa Rita. This may simply be a result of the fact that—as suggested by both the higher reported rates of practice use and the greater relative uniformity in the number of women adopting practices there (Tables 2 and 3)—that there is simply greater homogeneity in Olopa in terms of the portfolio of CSA practices employed by women there. This greater homogeneity could be linked to the more consistent implementation of climate-smart interventions and demonstrations that occurred in the CSV of Olopa, when compared to that of Santa Rita.

3.1.6. Cauca, Colombia

In contrast to the two regions just considered, in Cauca we observed that while the proportion of conditional inertia is intermediate between Santa Rita and Olopa, the proportion of constrained inertia—at over 23%—is substantially higher. In Table 8, a more detailed breakdown of the explained inertia is accounted for with reference to each practice in the first two canonical axes, which indicates that a substantial portion of the variability of uptake in several CSA practices is accounted for, including home gardens, mulching and crop rotations. Of these practices, specifically, we can see from Figure 4 that mulching—which almost 10% of the women surveyed in Colombia report using—is associated with older farmers and, especially, those cultivating larger areas, and possibly with being a single-headed household as well. Home gardens appear to be associated with having no education, and the practice is far removed from (does not co-occur) other practices; only five women report using home gardens, however, and only two reported having no education. Finally, crop rotations are associated with younger farmers.

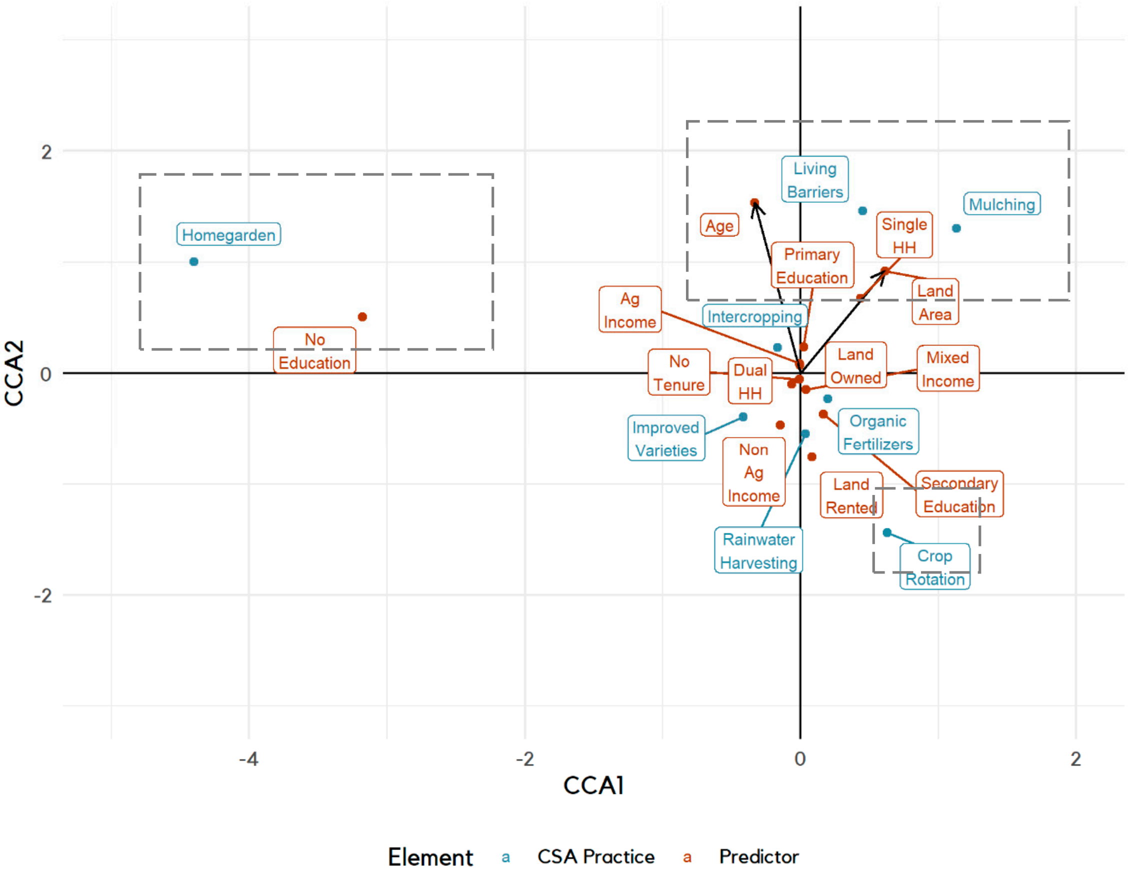


**Figure 4.** Canonical correspondence analysis of CSA practice use: association between CSA practice use among women and selected socio-demographic characteristics (Cauca CSV, Colombia).

**Table 8.** Cumulative proportion of inertia accounted for by the first two canonical axes, for each CSA practice use (Cauca CSV, Colombia).

| Practice | CCA1 | CCA2 |
|---|---|---|
| Homegardens | 0.266 | 0.279 |
| Living Barriers | 0.012 | 0.125 |
| Improved Varieties | 0.027 | 0.050 |
| Rainwater Harvesting | 0.000 | 0.068 |
| Crop Rotations | 0.027 | 0.161 |
| Intercropping | 0.023 | 0.063 |
| Organic Fertilizer | 0.016 | 0.036 |
| Mulching | 0.144 | 0.321 |

### *3.2. Socio-Economic and Demographic Drivers of Access to, and Use of, Climate Forecast Services*

Table 9 presents the number of women reporting each level of access to or use of climate forecasting services which, given its largely conditional nature (e.g., forecast use is predicated on access, agro-meteorological forecasts are defined as a climate forecast which *also includes* specific recommendations for farm operations) was treated as an ordered categorical variable in subsequent analysis. Use of forecasts, in this context, refers specifically to women reporting employing the information to make decisions regarding agricultural production activities. Table 9 shows that lack of access to climate forecast services was substantially higher in Cauca, Colombia, than it was in either Olopa, Guatemala, or Santa Rita, Honduras. In Honduras, fully half of female respondents indicated that they had access to and employed a climate forecast service, while in Guatemala a quarter indicated using agro-meteorological forecasts.

**Table 9.** Summary of women's access to and use of climate forecasting services in the Climate-Smart Villages.

| | Colombia | | Guatemala | | Honduras | | All | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| No Forecast Access | 68 | 68.7 | 28 | 28.6 | 42 | 32.6 | 138 | 42.3 |
| Forecast Access, Not Used | 11 | 11.1 | 21 | 21.4 | 19 | 14.7 | 51 | 15.6 |
| Forecast Access & Used | 10 | 10.1 | 25 | 25.5 | 64 | 49.6 | 99 | 30.4 |
| Agro-Forecast Access & Used | 5 | 5.1 | 24 | 24.5 | 3 | 2.3 | 32 | 9.8 |

The results of the ordered logistic regression model (Table 10) indicate that the land area (land) in women's CSV positively influences access to climate forecast services. In addition, interactions between land tenure and both household status and age have a positive influence on climate forecast services. Specifically, women who report cultivating larger land areas consistently report improved access to climate forecasting services, independently of any other factor. Weaker evidence exists to suggest that those with at least a secondary education and who own most or all of their land also report greater access to climate forecasting services, but both of these are subject to interactions. Women from dual-headed households have greater access only among those who primarily rent their land. Among women who report owning most or all of their land, access to forecasting services is greater among women in single-headed households. The interaction between age and land tenure suggests that among women who own most of their land, being younger is associated with greater access, whereas the pattern reverses among those without formal tenure: for these women, it is the older farmers who report greatest access to and use of climate forecasting services. Somewhat weaker evidence also exists for an interaction between age and education, illustrated in Figure 5, which suggests that the youngest quartile of women surveyed (those less than 31 years old) who have at least a secondary education have greater access to, and make greater use of, climate forecasting services than do either their older or less educated peers.

**Table 10.** Analysis of deviance for best fit ordered logistic regression model of women's access to, and use of, climate forecasting services in the Climate-Smart Villages.

| Factor | LR Chisq | Df | Pr (>Chisq) |
|---|---|---|---|
| land | 50.91 | 1 | 0.000 |
| land_type | 5.60 | 2 | 0.060 |
| edu | 4.86 | 2 | 0.088 |
| mhic | 3.49 | 2 | 0.175 |
| hhstatus | 0.22 | 1 | 0.638 |
| age | 0.19 | 1 | 0.664 |
| hhstatus:land_type | 12.19 | 4 | 0.016 |
| age:land_type | 8.01 | 2 | 0.018 |
| age:edu | 5.36 | 2 | 0.069 |
| hhstatus:edu | 4.36 | 2 | 0.113 |

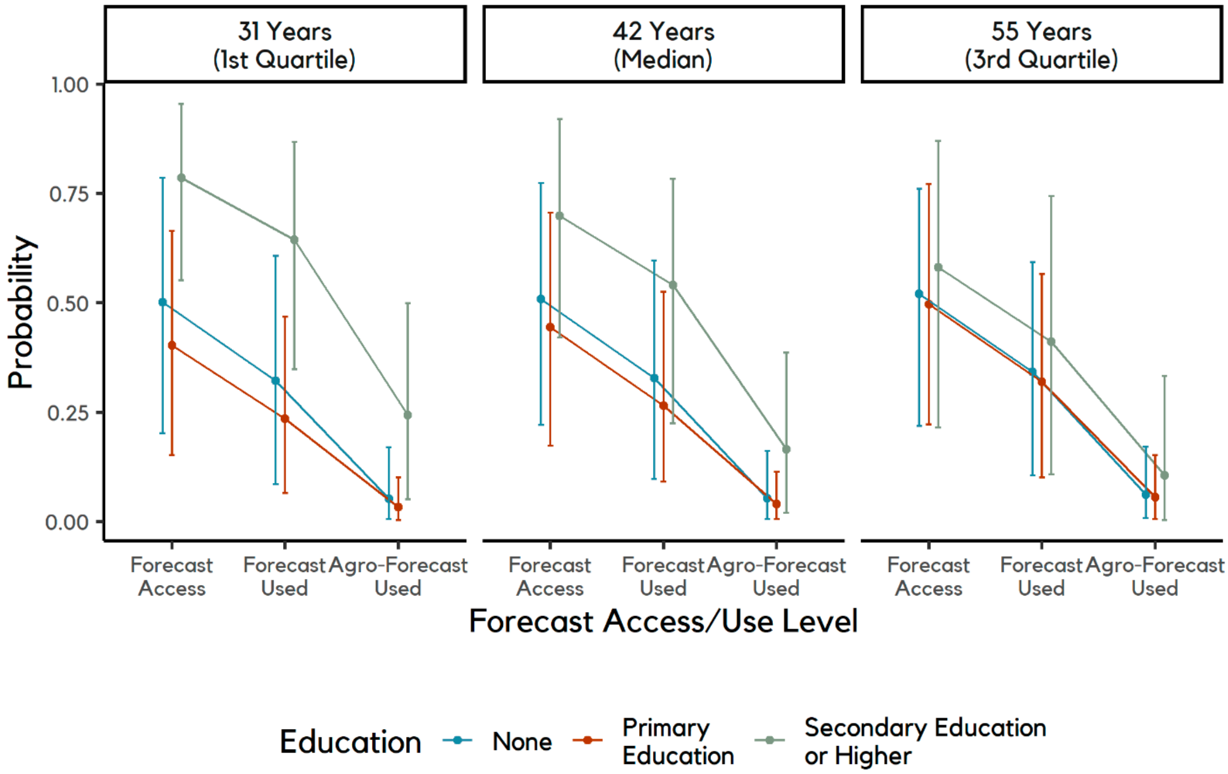


**Figure 5.** Probability that women with a given educational background and age will have at least some level of access to and use of climate forecasting services.

### *3.3. Access to and Use of Financial Resources and Services for Climate-Change Induced Effects on Farm Enterprises*

Only the survey conducted in Santa Rita included a section on financial resources and services, so the analysis could only be employed for this location. Table 11 presents a tabulation of the types of financial resources and services available to female respondents from Santa Rita and how they used them, specifically in reference to preparation for and recovery from climatic stresses and shocks to their farming operations. Not surprisingly, substantially more women report receiving income from farming (nearly 80% of respondents) than being able to make savings from that income (nearly 50%), and fewer still received a loan to finance farm operations (approximately 25%). Somewhat more surprisingly, however, is that more than half of respondents (54%) reported making recent investments in their farming operation and nearly half of these—almost one in four of all respondents—reported investing specifically in recovery from a climatic stress or shock.

**Table 11.** Summary of female responses regarding access to and use of financial services and resources among women (Santa Rita CSV, Honduras).

| | N | % |
|---|---|---|
| **Recived Income from Farming** | | |
| *Yes* | 102 | 79.1 |
| *No* | 27 | 20.9 |
| **Saved Money from Farming** | | |
| *Yes* | 61 | 47.3 |
| *No* | 68 | 52.7 |
| **Received Credit for Farm Operations** | | |
| *Yes* | 32 | 24.8 |
| *No* | 97 | 75.2 |
| **Purpose Made of the Credit Received** | | |
| *Prevention of climate related stresses/shocks* | 16 | 12.4 |
| *Recovery from climate related stresses/shocks* | 5 | 3.9 |
| *Other purpose* | 11 | 8.5 |
| **Made Investments in Farm Operations** | | |
| *Yes* | 59 | 45.7 |
| *No* | 70 | 54.3 |
| **Purpose for the Investment in Farm Operations** | | |
| *Prevention of climate related stresses/shocks* | 14 | 10.9 |
| *Recovery from climate related stresses/shocks* | 31 | 24.0 |
| *Other purpose* | 24 | 18.6 |

In running the model specification and fitting the canonical correspondence analysis, there was extremely high consistency in the answers to questions such as the term (long or short) for loans and investments, the use of the loans (for inputs, labor or other), etc., so it was determined that these should be dropped. The analytical process also does not permit the inclusion of individuals with all zeroes (i.e., women who reported no agricultural income and thus no agricultural savings, took no loans to pay for farming operations and reported no investments in agriculture), which caused 16 respondents to be dropped from the analysis.

While the analysis of deviance for the overall model had a p value of 0.014 (Table 12), the proportion of total inertia explained by the socio-demographic effects, both overall (results not shown) and for specific practices (Table 13) were low, suggesting the model has low predictive and/or explanatory power. The decision to make any agricultural investment (Investment—All), 17.8% of the inertia of which is accounted for in the first two canonical axes, is associated with younger women working smaller farms, as well with having no education (Figure 6). Having a mixed income also appears associated with investment, but the number of women reporting having mixed incomes in Santa Rita was very small.

**Table 12.** Analysis of deviance for canonical correspondence analyses of women's access to financial services and resources (Santa Rita CSV, Honduras).

| Site | | DF | Chi Square | F | Pr (>F) |
|---|---|---|---|---|---|
| Santa Rita, Honduras | Model | 9 | 0.180 | 1.527 | 0.014 |
| | Residual | 77 | 1.009 | | |

**Table 13.** Cumulative proportion of inertia accounted for by the first two canonical axes for financial resources and services (Santa Rita CSV, Honduras).

| Financial Resource | CCA1 | CCA2 |
|---|---|---|
| Income | 0.003 | 0.007 |
| Savings | 0.017 | 0.028 |
| Credit-All | 0.098 | 0.104 |
| Credit-Preparation | 0.125 | 0.127 |
| Credit-Recovery | 0.050 | 0.115 |
| Invest-All | 0.100 | 0.178 |
| Invest-Preparation | 0.001 | 0.060 |
| Invest-Recovery | 0.122 | 0.140 |

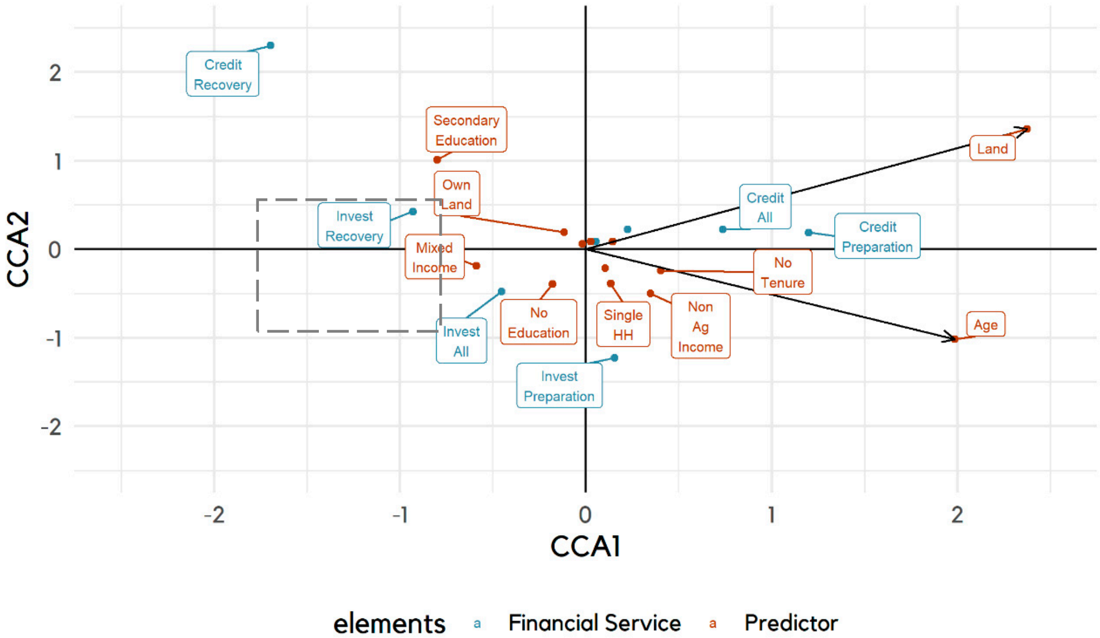


**Figure 6.** Canonical correspondence analysis of access to, and use of, financial resources and services for agricultural climate change adaptation and recovery: association between financial services and resources and socio-demographic characteristics among women in the Santa Rita CSV (Honduras).

## 4. Discussion

This study has highlighted the importance of studying socio-economic factors in interaction and thus the relevance of applying intersectional lenses in climate-smart agricultural research. The study found that women's implementation of CSA practices are positively associated with educational level and extent of cultivation, but these associations are conditional on the extent of livelihood diversification and the type of land tenure, respectively. Regarding the extent of livelihood diversification, other studies have shown that diversified livelihood strategies which include non-agricultural sources of income can support uptake of CSA and other good management practices at least in part by providing crucial operating capital for investment [35,61]. Both this study and previous research have also suggested that education facilitates the uptake of CSA practices and can lead to employing greater numbers of practices [62,63]. This study builds on such findings, and further demonstrates that socio-demographic factors such as education and agricultural land may not be sufficient, by themselves, to foster greater uptake of CSA practices among women. Correspondingly, policies or development interventions which are predicated on, or seek to leverage, either education or livelihood diversification alone would risk inefficiency and reduced effectiveness.

The positive association observed in this study between the extent of cultivation and women's implementation of more CSA practices is consistent with women with larger farm sizes - which can be seen as a proxy for wealth - possessing more resources to invest in improved practices. That this pattern is less pronounced among those who rent compared with those who own most or all of their land is also consistent with farmers being more willing to invest in long-term land improvements when their tenure is more secure, as is suggested by a large body of theoretical and empirical work in the field of agricultural economics (e.g. [64]). However, in this case, the effect is less pronounced and further research is clearly needed. It is also important to recognize that, given the fact that CSA practices are highly context-specific, they need to be locally adapted to each geographical and socio-economic context [10]. As such, it may not be valid to assume that an increase in the number of CSA practices necessarily implies better outcomes in adaptive and mitigation capacity and improved productivity for women, even in instances where the suite of CSA practices being promoted has been developed in partnership with researchers and other stakeholders. Furthermore, it is important to highlight that the distribution of CSA practice adoption is also affected by, inter alia, gendered patterns in the division of labor, gendered time use patterns, and social norms, and that these are highly context-specific and might therefore change from one CSV to another [65].

As with the case of uptake of CSA practices, increased education and extent of cultivation were seen to predict greater access to and use of climate forecasting services, along with owning most or all of one's land. In the case of land area, no evidence was observed of an interaction between extent of cultivation and any other socio-demographic factors; this pattern is consistent among the women surveyed as a whole and can meaningfully be considered in isolation. In contrast, there is some modest evidence to suggest that greater education and land ownership are both associated with greater access, but this pattern is most pronounced among young women and increasingly less pronounced among older women. A recent review examining access to rural climate information services also identified age and literacy levels as conditioning access to and use of ICT, with younger and more literate men and women able to make greater use of such services [66]. It is also important to highlight that the medium through which the climate forecast services are delivered (e.g., mobile phone, internet, television, radio, printed media, etc.) is itself gendered, and needs careful consideration in the design of climate-smart interventions targeting improved access to and use of climate forecast services [67]. Furthermore, in local contexts where women's access to and use of climate information services is sound, improved use of these services could also be driving an increase in the uptake of CSA practices (e.g. [68]). This is a relationship that would be worth exploring in future studies.

The investigation into the uptake of specific CSA practices or combinations of practices by women found, in the case of the CSV in Guatemala, no clear association between any of the explanatory variables considered and the use of any practices. In the CSV of Honduras, the results suggest greater variation between individual communities than as a function of the socio-demographic factors included in the analysis. Finally, in the CSV of Colombia, some association was found between socio-demographic factors and the use of specific practices, for example with mulching being associated with older farmers cultivating larger land areas. Results regarding women's access to financial resources and services found no strong associations between the socio-economic and demographic factors considered and patterns of savings, borrowing and investment, thus providing little explanatory power for the use of any of the specific resources or services.

Overall, the surveys' limited sample sizes have partly restricted the statistical power of the analysis to discern certain interactions among socio-demographic factors that may be influencing women's uptake of the CSA technical interventions in the CSVs of interest. Additionally, the socio-economic and demographic factors influencing these aspects that this study has uncovered, and the associations found between them, could also be further contextualized and explained with follow-up in-depth qualitative research in these areas.

Whereas studies using differences between men and women have undeniably been critical in raising awareness of the gender gap that exists in many fronts in rural development, agriculture, and climate change adaptation arenas (e.g., decision-making, access and control of productive resources, access to extension and climate services, etc.), closing these gender gaps will require a deep understanding of the needs and challenges that different groups of women face. However, identifying the needs and challenges of diverse groups of women have important research design and funding implications. Researchers will need to explicitly anticipate such potential differences among men and women as well as between them if data collection procedures which can be assured of detecting and measuring such differences are to be developed. It is crucial for researchers to make survey sample size calculations using formulae appropriate for the design and objectives of the study. For example, a study seeking to detect differences among subpopulations may require a vastly different number of respondents than is needed for a purely descriptive study [69], and this difference can be compounded in the context of significant higher-order interactions. Statistical power analyses and careful consideration of optimum, or at least more efficient, sampling strategies will be particularly important in this regard, and confirmatory studies may also require substantially larger sample sizes than is common in routine program monitoring efforts [70].

On the other hand, funding limitations in agricultural research for development has in practice meant that, often, the research design that would allow for the data richness needed for more tailored gender interventions has been compromised on one or several fronts. For example, gender in agriculture and climate change researchers have often needed to reach compromises in sample sizes, duration and depth of case studies, or in the ability to conduct longitudinal studies of a certain population group. The latter is critical in gender transformative research examining how discriminatory and detrimental gender norms can be influenced and changed, since changes in social norms can span long periods of time which often exceed the duration of a research or development project.

Overall, oversimplified gender analysis can lead to misleading conclusions that in turn might translate into poorly designed development programs or create difficulties in the implementation of such programs. For example, in the areas where this study was conducted, an analysis only examining main effects would have identified education as a significant factor influencing the number of CSA practices being adopted by women, but would have missed the point that education level only makes a difference among those women whose primary source of income is not agriculture.

Portrayals of women and men as homogenous groups, at least when examining gender differences in adaptive capacity in agriculture, have already widely permeated to policy spheres and to development agencies [71]. That policy and development programs oversimplify this social-differentiated vulnerability and capacity to adapt to climate change runs the risks of providing blanket statements and overly general policy solutions that might not be adequately targeting the specific needs of different groups of men and women. This is particularly true for the Central American region, where a recent study identified that food security, agriculture and climate-smart policy interventions for gender equality remain largely unspecific, with no clear indicators to monitor progress in closing the gender gaps in agriculture and climate change adaptation [72]. There is thus a gap in climate change adaptation agricultural research and policy design, and a more nuanced understanding of the social factors influencing or explaining farmer behaviors in climate change adaptation will be needed in the immediate future.

## 5. Conclusions

This study has examined women's differentiated access to climate-smart technical interventions (i.e., practices or services) in selected CSVs located in Latin America (i.e., Cauca CSV in Colombia, Olopa CSV in Guatemala, and Santa Rita CSV in Honduras). The study has showcased a series of socio-economic and demographic factors influencing the adoption of CSA practices in the selected CSVs, as well as the access to, and use of, climate-smart forecast information services and climate-smart financial services. The study highlights that important interaction effects are present. Key among these is the relationship between higher educational attainment and increased adoption of CSA practices, which is conditional on the degree of livelihood diversification or the effect of cultivating a larger area which is conditional on the type of land tenure. Another important interaction effect that the study uncovers is the relationship between greater educational attainment and the increased use of climate forecasts, which is conditional on age.

The results and analysis presented in this study have shed light on the fact that only comparing sex-disaggregated data is not sufficient to understand the interacting factors affecting or constraining women's differentiated access to and use of CSA options and the ensuing consequences that this has in designing agricultural and climate adaptation initiatives for women's empowerment. This is especially important for regions with increasing incidences of male-outmigration, which is resulting in increased involvement of women in agriculture. There is therefore a need to better understand the intersectional elements that dictate the vulnerability of such groups and understand how adaptation will be different in these cases. While this study has focused exclusively on examining women's differentiated access to CSA technical interventions (i.e., practices or services), a similar exercise examining the differentiated needs of different groups of men would also prove fundamental in designing policies and interventions that aim at addressing men's differentiated needs. With this, climate change adaptation interventions will be most likely to work for the benefit of all.

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