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Uncovering the intersection of women's empowerment and gender equality for climate-adaptive capacities in climate hotspots in Zambia

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COVER PHOTO CREDIT: Forest foods in Zambia are diverse and nutrient rich. At a food fair in Luwingu, Zambia, in April 2017, women display items they regularly forage and cultivate. Photo by Joe Nkadaani, CIFOR.

ABOUT CGIAR GENDER IMPACT PLATFORM

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Abstract

Women in agrifood systems in low- and middle-income countries are more likely than men to be adversely affected by climate change. They also have more limited climate-adaptive capacities due to socioeconomic and cultural factors, such as restricted access to resources, information and technology, discriminatory gender norms, and limited decision-making power. This study examines the extent to which women's empowerment in the household is associated with intrahousehold gender equality for climate-adaptive capacities and practices in places experiencing significant climate change hazards and stressors. It also explores the strength of the association of different dimensions of women's empowerment with gender equality in climate-adaptive capacities. The study concentrates on the Luapula and North-Western provinces in Zambia, where women face high climate change risks. The study uses gender-disaggregated intrahousehold data that captures information about access to, and knowledge and adoption of, practices that support climate-adaptive capacities, women's empowerment and perceived climate change. This data was collected from 199 households headed by a married or partnered couple, and regression analysis was applied to the data to test two hypotheses. The results support the first hypothesis of a positive correlation between women's empowerment and intrahousehold gender equality to climate-adaptive capacities and, more specifically, access to technical advice on climate-smart agricultural practices. The results also support the second hypothesis that various dimensions of women's empowerment—attitudes toward violence (norms), intrinsic agency, instrumental agency and collective agency—are associated with intrahousehold gender equality in climate-adaptive capacities in varying ways. The study's findings highlight the complexity of the relationships between women's empowerment and gender equality to climate-adaptive capacities in climate change hotspots, and emphasize the need for context-specific analyses and solutions.

Keywords: *women's empowerment, intrahousehold gender equality, climate-smart agriculture, climate information services, food systems outcomes*

Data statement

The data used in this study are published as part of the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) Zambia Baseline Survey 2022 (Zambezi District, North-Western Province and Kawambwa District, and Luapula Province) (Gbegbelegbe et al. 2022).

A pre-analysis plan has been registered here https://osf.io/m25et.

Replication data and code files are available on Mendeley datasets as: "Replication data: Gender Equality in Climate Resilience Capacities in Climate Hotspots in Zambia." DOI:10.17632/67kv49684m.1 (available online from 26/7/2024. Prior to that, they are only available on request).

1. Introduction

Climate change, which manifests itself in changes in average and variability of temperature, rain and/or wind, is putting substantial stress on agrifood systems, including crop farming, livestock, forestry, fisheries and aquaculture (Rao et al. 2019; IPCC 2023). Despite contributing minimally to greenhouse gas emissions, sub-Saharan Africa faces significant threats to its agrifood systems by recurring climate hazards, shortened growing seasons and water shortages. These threats are likely to reduce crop productivity and yields, increase livestock vulnerability and reduce fish catch (Bezner Kerr et al. 2022). In many regions across the globe, including sub-Saharan Africa, significant proportions of the population depend on agrifood systems and the surrounding natural environments for their livelihoods. These populations face risks of livelihood loss, food insecurity, hunger or malnutrition due to the exposure and vulnerability of the agrifood systems to significant climate hazards (Bezner Kerr et al. 2022)

Generally, population groups that face social, economic or political disadvantages also face higher risks of livelihood loss, malnutrition, rising costs of goods and services and competition for resources in the face of natural hazards, including climate change (World Food Programme 2021; Arora-Jonsson 2011). Depending on the context, women, smallholder producers, low-income households, Indigenous Peoples and minority groups can be relatively more vulnerable (World Food Programme 2021; Arora-Jonsson 2011; Lau et al. 2021).

It is widely acknowledged that climate change and its impacts are not gender neutral (Alston 2013; Reggers 2019). There is increasing evidence that climate change poses a greater risk for women in agrifood systems than for men and therefore forms a threat to gender equality (Bryan et al. 2023). On one hand, climate change affects women and men differently. In many low- or middle-income country (LMIC) contexts, women and their assets and livelihoods are more vulnerable to adverse effects of shocks and weather extremes, such as droughts and floods (Perez et al. 2015). On the other hand, socioeconomic and cultural factors, such as restricted access to resources and information, discriminatory gender norms and limited decision-making power restrict women's ability to cope with and adapt to climate change (Huyer 2016; IPCC 2019; Chanana-nag 2020).

Climate adaptation is the "process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC 2023, 2898). Adaptive capacity is defined as the ability of systems, institutions and individuals to adapt in the face of potential harm, adjust to potential damage, seize opportunities or respond to consequences (IPCC 2018; MEA 2005). Adaptive capacity can be enhanced by access to information, technology, assets and institutional and governance structures. At a systems level, an example from rice and maize production in Viet Nam's Mekong Delta shows that these systems have a high adaptive capacity due to access to resources, education and infrastructure, despite the region's exposure to multiple climate threats such as flooding, sea-level rise and saltwater intrusion (Bezner Kerr et al. 2022). There is evidence of gender differences in the adaptive capacities of individuals, some of which are linked to socioeconomic and cultural factors, such as restricted access to resources and information (Lottering, Mafongoya and Lottering 2021; Thinda, Ogundeji and Ojo 2021). Previous work, for example in Kenya, showed that women's adaptive capacity was enhanced through training and access to microcredit (Caretta 2014). A study in India observed a positive relationship between land-holding size and women farmers adopting climate-smart agricultural practices (Shukla, Chaturvedi and Tomar 2022). But even if legal entitlements and social norms are supportive of women's agency, based on case studies in Asia and Africa, Rao et al. (2019) showed that environmental stress can negatively impact women's adaptive capacity, especially those who are young, poorly educated or belong to lower castes or minority ethnicities.

To avoid widening gender gaps and to enable women to seize opportunities for enhancing climate adaptation, it is essential to understand the relationship between women's empowerment in agrifood systems and gender differences in climate-adaptive capacities, particularly in places where women are exposed to high climate change risks. This study contributes to understanding these relationships, mainly at the intrahousehold level, and explores the dimensions of women's empowerment that are more strongly related to gender-equal climate-adaptive capacities. The results of this study can help identify entry points for policies and interventions to trigger transformations needed to optimize gender equality and climate adaptation in agrifood systems affected by climate change.

We used Zambia as a case study because it has been identified as a climate–agriculture–gender inequality hotspot country (Lecoutere et al. 2023) where significant climate hazards converge with hazards affecting women because of employment in agriculture, as well as their vulnerability to systemic gender inequalities (Lecoutere et al. 2023). We focus on Luapula and North-Western provinces in Zambia as these areas have been identified as subnational climate–agriculture–gender inequality hotspot areas in Zambia. In Luapula Province, there is a relatively high climate risk, particularly for women involved in perennial crop farming such as cassava. In North-Western Province, women involved in mixed (crop and livestock) farming, as well as those farming perennial crops, vegetable, roots, tubers and cereals, leguminous crops, and oilseeds also face high climate risk (Lecoutere et al. 2023).[1] We use these areas as case studies because these are contexts where both gender equality and climate-adaptative capacities in agrifood systems are most acutely challenged by climate change. We use the Gendered Food Systems framework by Njuki et al. (2022) as the conceptual framework. The Gendered Food Systems framework (figure 1) lays out the relationship between the agrifood system and structural barriers to gender equality. The framework distinguishes structural barriers related to women's agency, their access to and control over resources, gender norms and policies and governance. The framework also identifies drivers of agrifood systems, including biophysical and environmental drivers such as climate and weather, which can be subject to gendered shocks and vulnerabilities. Recent frameworks linking climate change and gender equality in agrifood systems show that women and men have different adaptive capacities that are similarly tied to structural barriers to gender equality (Bryan et al. 2023).

[1] High climate risk faced by women in Luapula Province relates to a relatively high degree of hazards; the importance of perennial crops, mainly cassava, in which women are heavily involved; and relatively high vulnerability due to gender inequalities. High climate risk faced by women in North-Western Province relates to a moderate degree of hazards; a high degree of women's involvement in mixed farming, perennial crop, vegetable, roots, tubers and cereals, leguminous crops, and oilseeds farming; and a moderate vulnerability due to gender inequalities (for details see Lecoutere et al. 2023).

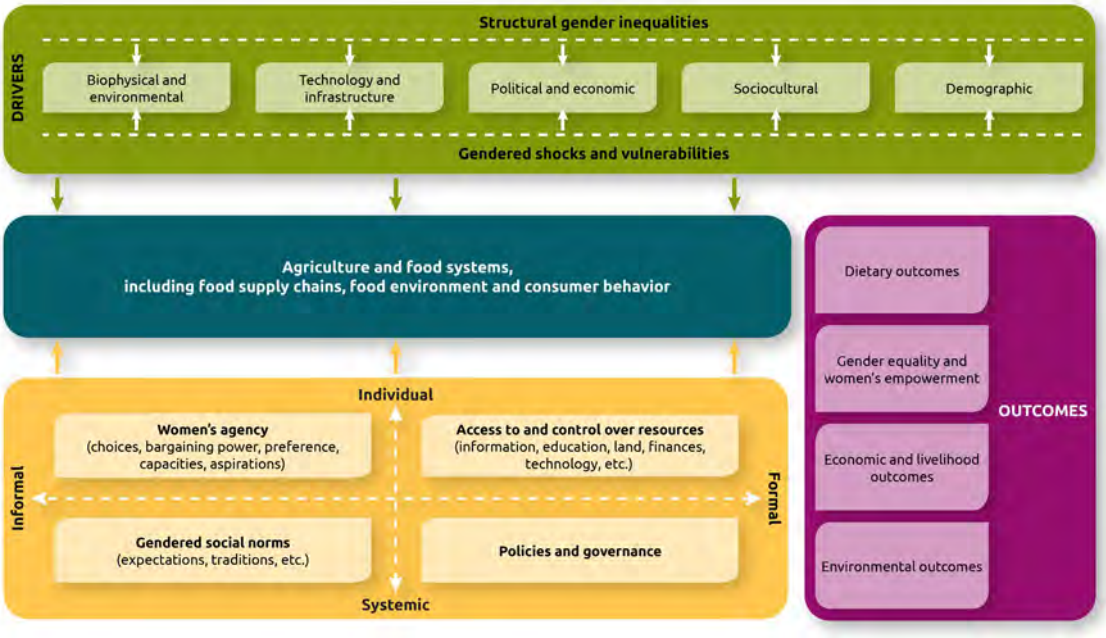

Figure 1. Gendered Food Systems framework (adapted from Njuki et al. 2022).

From the conceptual framework, we derived the following research hypotheses:

1. There is a positive correlation between women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities.
2. There is a difference in the strength of association between dimensions of women's empowerment in the household, and intrahousehold gender equality of climate-adaptive capacities.

We anticipated that intrahousehold gender equality of climate-adaptive capacities are related to the (perceived) severity of climate change. We therefore controlled for the (perceived) severity of climate change in the analysis.

In the next section, we discuss other evidence of the relationship between women's empowerment and gendered climate-adaptive capacities. We then outline the methods used and discuss the results. We conclude by making recommendations for further research, policy and practice.

2. Literature review

In this section, we discuss previous literature on the relationship between women's empowerment in the household and gender equality in climate-adaptive capacities in rural African and Asian contexts. In many cases, the relationship between gender and climate change is studied based on an interhousehold comparison of female- and male-headed households (Jost et al. 2016; Cavanagh et al. 2017; Murray et al. 2016). However, an intrahousehold gender analysis enables us to explore the gender dynamics within households that mean women are more exposed and vulnerable to climate change (Mudege et al. 2017; Twyman, Muriel, and García 2015) as well as the relationship between women's empowerment in the household and climate-adaptive capacities within households.

First, Ngigi et al. (2017) investigated the intrahousehold gender equality of adaptive capacities to climate change in rural Kenya. Their study showed that gender-specific roles, responsibilities and social norms define wives and husbands' perceptions of risk, their access to resources and their participation in social groups in a gender-differentiated way. Wives and husbands have diverging perceptions of climate risk that influence their adaptive behavior. Husbands are more likely than wives to acquire climate information and to access farm inputs through social groups. There are reasons for gender-differentiated adaptive capacities: wives' limited access to land and resources hinders their adoption of climate-smart practices in agroforestry and conservation agriculture, and consequently, the well-being outcomes of wives and husbands differ due the gendered adaptation strategies.

Second, based on a mixed-methods study conducted in Ethiopia, Mekonnen (2022) found that women have limited access to productive resources for agricultural production, with, on average, women having access to 38 percent less resources than men within a household, which makes women more vulnerable to the effects of climate change. Mekonnen also found that a 59 percent gap in ownership, and access to and decision-making power over agricultural equipment (at the disadvantage of women), which also constrains women's capacity to adapt to climate change.

Third, a comparative study of two states in India (Aryal et al. 2020) found that both women's participation in decisions relating to adopting agricultural technology and their likelihood of adopting climate-smart agriculture (CSA) are much higher in Haryana State, compared to Bihar State. The researchers infer that when there is higher participation by women in household decisions about the adoption of agricultural technology, CSA is also favored. Wealth, training and access to extension and markets also positively influences the adoption of CSA. Shahbaz et al. (2022) also found similar evidence in Pakistan. They showed that women farmers who have more decision-making power and opportunities to implement agricultural innovation are more likely to adopt more CSA practices than women farmers with weaker decision-making power fewer opportunities to implement agricultural innovation Fourth, De Pinto et al. (2020) observed how the practice of crop diversification in Bangladesh was adopted by women who were empowered. As the decision-making power of women increased, crop diversification also increased. Access to social capital through women's groups resulted in better access to information for women farmers, improved bargaining power within the household and a greater allocation of land to vegetables and fruits and less to cereals. This favors dietary diversity and crop diversity in the field (that protects against climate risks).

Fifth, Wouterse (2017) found a positive relationship between household-level empowerment[2] and the likelihood of adopting zaï pits (i.e., small water harvesting pits where seeds are planted

[2] Wouterse (2017) conceptualized empowerment as the ability to make strategic life choices. She based household-level empowerment on the Women's Empowerment in Agriculture Index (WEAI) and defined it as the average of the sum of the weighted (WEAI) adequacy scores for the primary male and female decision-maker in the household.

in holes filled with compost) based on quantitative intrahousehold gender-disaggregated data collected from women and men in 500 households in Niger. Skills and experience, as well as the perception of increasing frequency of droughts, are also positively related to the adoption of zaï pits.

Additionally, Ngigi and Muange (2022) showed the relationship between access to climate information services (CIS) and adopting CSA. Based on a study of 156 couples in rural Kenya, they demonstrated that access to CIS also differs by gender. Husbands tended to have more access to early warning systems and advisory services on adaptation than their wives. However, wives tended to have better access to weather forecasts. The authors found better access to early warning systems and advisory services resulted in both husbands and wives being more likely to make decisions to adopt CSA. However, better access to seasonal forecasts only resulted in husbands being more likely to adopt CSA. These results showed that both gender roles and different access to resources play a part in intrahousehold gender differences in adopting CSA practices.

3. Context

Zambia is one of the lowest carbon emitters in Africa and globally[3] (ClimateWatchData 2019). However, it is still exposed to climate hazards and stressors, including drought and dry spells, seasonal and flash floods, extreme temperatures and changes in season onset and rainfall (CIAT and World Bank 2017).

Weather data from the Zambia Meteorological Department shows that in the North-Western Province, long-term maximum and minimum temperatures have risen between 2000 and 2020. There are no discernible temperature trend changes in Luapula Province (Gbegbelegbe 2022). Neither province seems to have experienced statistically significant changes in total seasonal rainfall.[4] However, Luapula and North-Western provinces have had high rainfall variability during the cropping season over the last 10 years. North-Western Province had too little rain in some years, which led to droughts, and too much rain in other years, which sometimes led to floods.

Adverse economic effects of climate change impacts are felt across all sectors, but are felt more acutely in the agriculture sector, which is rain-fed. Agriculture accounts for about 20 percent of Zambia's gross domestic product and employs close to 50 percent of Zambia's economically active population (IFAD n.d.). Zambia has approximately 1.5 million smallholder farmers. It is estimated that 55 percent of the agricultural labor force in Zambia are women (ILO 2021). Women are involved in every stage of agriculture production and are lead agents of food and nutritional security, producing 80 percent of the food consumed in the country (WFP 2020). Because of their essential role, women bear the consequences of how exposed Zambia's agrifood systems are to climate hazards and stressors.

The Social Institutions and Gender Index (SIGI) 2014 ranked gender inequality in Zambia as "very high" (relatively high gender discrimination) (score of 0.45) and as "medium" based on the SIGI 2019 (score of 34.8 percent). These figures suggest an improvement in gender inequality over time.[5] The Gender Development Index 2021 suggests little difference in the female and male human development indexes (HDI). The HDI assess the social and economic development of countries using the following factors: mean years of schooling,

[3] Zambia has emitted 91 MtCO2e (ClimateWatch Data 2019).

[4] The cropping season runs from October to April.

[5] Note that SIGI 2014 and 2019 are measured differently and therefore cannot be compared.

expected years of schooling, life expectancy at birth, and gross national income (GNI) per capita. However, the female human development index decreased between 2018 and 2021, suggesting that the conditions for women in Zambia might have deteriorated (UNDP 2021). Overall, these indicators suggest although there might have been minor improvements over time, there are still gender inequalities in Zambia.

Formal legal frameworks grant equal land ownership rights to both women and men in Zambia; however, land-reform initiatives include a provision to only allocate 30 percent of newly available land to women (Kapihya and Zambia Governance Foundation 2017; UN Women 2019). Women face greater challenges in accessing and controlling land use than men. This disparity is particularly pronounced in the northern region of the country, where land allocation predominantly adheres to patrilinear structures and is primarily managed through traditional institutions, notably chiefs (Sitko and Chamberlin 2016; Kapihya and Zambia Governance Foundation 2017). Men usually receive land rights after marriage, while women tend to only receive the right to cultivation (OECD 2019). According to the Demographic and Health Survey data (2018), approximately 58 percent of women in rural Zambia do not own any land (ZSA, MoH, and ICF 2020).

Women also have limited access to credit and financial services (OECD 2019). According to the Demographic and Health Survey data (2018), only 3.2 percent of women in rural Zambia use a bank account· (ZSA, MoH, ICF 2020). An interhousehold analysis, based on the Rural Agricultural Livelihood Survey (RALS) datasets of 2012 and 2015 showed that in 2012 both male- and female-headed households had limited access to financial services, credit and social capital (Gbegbelegbe 2022). This access only slightly improved by 2015. Generally, female-headed households had less access to financial services, credit, and social capital than male-headed households in both 2012 and 2015.

The RALS data for 2012 and 2015 showed that few women in male-headed households had decision-making power over income from crop sales, and relatively few made decisions about earnings and purchases on their own (Gbegbelegbe 2022). However, the proportion of households where spouses made joint decisions on household incomes increased.

According to RALS data (2019), over two-thirds of decisions about managing fields are made by men, and men are the main decision-makers about the sales of crops and how income is used (Indaba Agricultural Policy Research Institute, 2019). However, the involvement of women (in male-headed households) tends to be higher for decisions about using income generated from crops such as groundnut, sweet potato, millet, fruits and vegetables (Indaba Agricultural Policy Research Institute 2019).

The data also suggested that women's ability to meaningfully participate in institutions, collective action, and leadership roles is constrained by prevailing gender norms in Zambia (Indaba Agricultural Policy Research Institute 2019).

At the household level, RALS data shows that the number of households that received advice on CSA practices, particularly conservation agriculture, decreased between 2012 and 2015 in both Luapula and North-Western provinces (Gbegbelegbe 2022). Consistently, female-headed households were less likely than male-headed households to have received advice on CSA practices.

According to the OECD (2019), there is a lack of support for policies and legal frameworks that facilitate women's economic empowerment in Zambia. While there is an increased focus in policies to support gender equality in creating climate-resilient agrifood systems, implementing policy in Zambia remains a challenge (Gbegbelegbe 2022).

4. Materials and methods

In this section, we present the data, indicators and methods used to examine the intersection of women's empowerment and the gender equality of climate adaptive capacities in climate hotspots in Zambia.

4.1 Study population and data

We conducted this study in Zambia because it was identified as a climate–agriculture–gender inequality hotspot country (Lecoutere et al. 2023). We focused on the Luapula and North-Western provinces because they were identified as subnational hotspots in Zambia.

We collected data in Kawambwa District in Luapula Province and Zambezi District in North-Western Province. These are rural areas where most households derive a livelihood from agrifood systems.

The collected data was combined with data collected for the AICCRA Zambia Baseline Survey 2022 (Gbegbelegbe et al. 2022). The AICCRA survey tool inquired about perceptions of climate change; adapting to climate change; access to CIS, extension services, and credit; farmers' practices and agricultural revenues; and demographic characteristics, asset holdings and living conditions of households. For the purpose of this study, the survey tool was adapted to include additional questions for measuring women's empowerment in agriculture and household food security. Intrahousehold gender-disaggregated data was collected by interviewing both the male and female co-heads of households. In both the Kawambwa and Zambezi districts, eight villages were randomly selected. The sampling frame set out to select a sample of 400 households across the 16 villages, which is representative at the village level (200 households per district). However, only 338 households were interviewed because of accessibility challenges due to the dispersed rural population and poor and weather-affected road infrastructure. Next, we excluded 139 households because they did not have both a male and female respondent. A sample size of 199 households remained and male and female co-heads were interviewed separately (117 households in Kawambwa District and 82 in Zambezi District).

Data on various aspects of women's empowerment; agrifood system outcomes; access to and knowledge and adoption of CSA and CIS; perceptions and experience of climate change; and socioeconomic and demographic household characteristics was collected (see excerpts from the survey in Annex 5). The project-level Women's Empowerment in Agriculture Index (pro-WEAI) tool informed survey questions for collecting data on women's empowerment. By using pro-WEAI, we tested the hypotheses derived from the conceptual framework that women's empowerment correlates with gender equality of climate-adaptive capacities within households, and that different dimensions of women's empowerment correlate to differing extents.

4.2 Indicators

We tested the research hypotheses by examining the correlation between indicators of women's empowerment in the household and indicators of intrahousehold gender equality of adaptive capacities. We looked at the intrahousehold gender equality of access to and knowledge and adoption of CSA practices and CIS to understand intrahousehold gender equality and capacity to adapt. We used two types of indicators of intrahousehold gender equality. The first indicator looked at access to and knowledge and adoption of CSA practices and CIS by the female co-head of the household, assuming that the higher the value of these indicators, the more gender equality that exists. The second indicator captured intrahousehold gender inequality by subtracting the value of the indicators for access, knowledge and adoption of CSA practices and CIS by the female co-head of the household from the value of the indicators of the male co-head of the same household.

We also included variables to control for perceived severity of climate change, household socioeconomic status, individual and household sociodemographic characteristics and geographic location (province) (Annex 1 lists the research hypotheses, the key indicators of interest and the control variables).

4.2.1 Indicators of intrahousehold gender equality in access to, and knowledge and adoption of CSA practices

We constructed three indicators of the female co-head's access to technical advice (TA) on CSA practices, knowledge intensity of CSA after receiving TA, and the intensity of adopting CSA practices at the time of a climate shock, based on the female co-head's responses:

Y1 = female co-head's access to TA on CSA practices
This binary variable indicates whether the respondent received technical advice with a response of 1 denoting yes, and 0 denoting no.

Y2 = female co-head's knowledge intensity of CSA after receiving TA
We calculated the knowledge intensity of CSA by dividing the sum of the number of CSA practices the female co-head of household *i* reported to know divided by the number of CSA inquired about in the survey, i.e., 19 CSA practices for crop and/or livestock[6] (for instance, if knowledge of six practices the value of the indicator would be 6/19).

Y3 = female co-head's adoption intensity of CSA at the time of a climate shock
We calculated the intensity of adopting CSA at the time of a climate shock by dividing the number of practices the female co-head reported using over the total of six possible CSA practices (i.e., intercropping, agroforestry, crop-rotation, irrigation, use improved varieties, integrated pest management).

[6] The following practices were used to construct the knowledge intensity indicator 1: Crop—soil preparation method (tillage); 2: Crop—inputs to use (seed, fertilizer/manure, etc.); 3: Crop—planting time; 4: Crop—weed management; 5: Crop—pest/insect management; 6: Crop—harvest time; 7: Crop—water conservation techniques; 8: Crop—price information—crop; 9: Crop—price information—inputs (seeds, etc.); 10: Crop—storage; 11: Crop—marketing (where to sell and when?); 12: Livestock—health management; 13: Livestock—feed management; 14: Livestock—water management; 15: Livestock—marketing; 16: Livestock—when/where to buy feed; 17: Livestock—feed price information; 18: Livestock—when/where to sell livestock; 19: Livestock—price information. Information on fish was also included in the questionnaire, but there were no responses for fishery.

We also constructed three indicators of intrahousehold gender differences for accessing TA on CSA; knowledge intensity of CSA after receiving TA; and the intensity of adopting CSA practices at the time of a climate shock by subtracting the value of the above indicators for female co-heads from the value of these indicators for male co-heads (based on male co-heads' responses) in each household *i*. The larger the (positive) value of the indicator, the greater the intrahousehold gender difference in knowledge intensity (at the disadvantage of women); the value of 0 indicates there is no intrahousehold gender difference.[7]

The resulting indicators are:

Y4 = intrahousehold gender difference in access to TA on CSA practices

Y5 = intrahousehold gender difference in knowledge intensity of CSA after receiving TA

Y6 = intrahousehold gender difference in adoption intensity of CSA practices at the time of a climate shock.

4.2.2 Indicators of intrahousehold gender equality in access to and knowledge of CIS and adopting practices after receiving CIS

We constructed three indicators of the female co-head's access to CIS, knowledge intensity of CIS and adopting practices after receiving CIS based the female co-head's responses:

Y7 = female co-head's access to CIS
This binary variable indicates whether the female co-head received CIS with a response of 1 denoting yes and 0 denoting no.

Y8 = female co-head's knowledge intensity of CIS
We calculated the knowledge intensity of CIS received by the female co-head by dividing the number of CIS the respondent reported to have received by 18, the number of CIS options inquired about in the survey. The 18 possible CIS types cover climate-related information, early warning of pests and diseases, and market prices[8] (the detailed list of CIS is in Annex 4).

Y9 = female co-head's adoption intensity of advised practices after receiving CIS
We first calculated the intensity of adopting crop-related practices after receiving CIS by dividing the number of practices the female co-head reported to have adopted by 15, the total number of practices for crops inquired about. Similarly, for intensity of adopting livestock-related practices, we divided by 8, the total number of practices for livestock inquired about.[9] We then summed these to form one indicator.

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[7] Generally, the intrahousehold gender difference is at the disadvantage of women (positive value of the indicator). The proportion of negative values for the indicators of intrahousehold gender differences in access to TA on CSA (Y5) is 6 percent; knowledge intensity of CSA (Y6) 4 percent; and adoption intensity of CSA (Y7) 20 percent.

[8] Categories: 1: Rainfall—onset of rains; 2: Rainfall—seasonal forecast (above/normal/below rains); 3: Rainfall—weekly forecast (likelihood) of rains; 4: Rainfall—daily forecast (likelihood) of rains; 5: Rainfall—cessation of rains; 6: Temperature—weekly forecast for air temperature; 7: Temperature—daily forecast for air temperature; 8: Temperature—weekly forecast for water temperature; 9: Temperature—daily forecast for water temperature; 10: Early warnings—warnings about occurrence of extremes; 11: Early warnings—warnings about dry spells; 12: Early warnings—warnings about heavy rain spells, 13: Early warnings—warnings about cold spells; 14: Early warnings—warnings about hot spells (high temperatures); 15: Pests/diseases—prevalence (number of affected fields/livestock/ponds); 16: Pests/diseases—incidence (percent affected plants/livestock/fish); 17: Pests/diseases—severity (level of damage on plant/livestock/fish); 18: Market price—crop/livestock/fish.

[9] **Crops**: 1. Do nothing; 2. Change in soil preparation (manure/compost, terracing etc.); 3. Change in planting (earlier/later/staggered planting etc.); 4. Change in irrigation application (water management); 5.Change in application of herbicide/insecticide; 6. Change in weeding; 7. Change in harvesting; 8. Change in agricultural inputs (pretreated improved seed, fertilizers, pesticides and herbicides etc.); 9. Mix long- and short-season crops; 10. Agricultural land use change; 11. Agroforestry (planting trees with crops); 12. Conservation agriculture (minimum tillage, mulch, rotation); 13. Mechanization; 14. Moved to more suitable farming environment; 15. Other (please specify); **Livestock:** 1. Do nothing; 2. Feed management changes; 3. Applied animal health vaccination/treatment; 4. Diversified livestock (new species); 5. Sold livestock; 6. Bought livestock; 7. Moved to more suitable livestock environment; 8. Other (please specify).

We also constructed three indicators of intrahousehold gender differences in access to CIS, knowledge intensity of CIS and adopting practices after receiving CIS.[10]

The resulting indicators are:

Y10 = intrahousehold gender difference in access to CIS

Y11 = intrahousehold gender difference in knowledge intensity of CIS

Y12 = intrahousehold gender difference in adoption intensity of advised practices after receiving CIS.

4.2.3 Indicators of women's empowerment in the household

The survey tool included questions for constructing the pro-WEAI.[11] The various dimensions and measures included in the pro-WEAI and in our study are presented in Table 1.

Our indicators of women's empowerment largely follow Malapit et al. (2019) and capture women's empowerment in the household. Pro-WEAI distinguishes different dimensions, including intrinsic agency (power within), instrumental agency (power to) and collective agency (power with).

Table 1. Dimensions and measures of the pro-WEAI tool included in this study

Agency	Measure in pro-WEAI	Description
Intrinsic agency	Attitudes about intimate partner violence against women	Captures how respondents feel about a husband beating his wife. We capture female co-head's perception on whether a husband is justified in hitting or beating his wife in any of the following situations; if she goes out without telling him, if she neglects the children, if she argues with him, if she refuses to have sex with him, if she burns the food. The measure can be assumed to reflect prevailing norms and attitudes toward husbands beating their wives.
	Self-efficacy	A person's confidence in their abilities to succeed in certain situations or accomplish tasks
	Autonomy in income	A measure of the internal and external motivations that influence a person's decisions regarding the use of income
Collective agency	Active member of a group	Whether the respondent is an active member of a group
Instrumental agency	Input into productive decisions	Whether a person feels they participate in decisions about the agricultural activities that they are a part of
	Ownership of land and other assets	Assess individual ownership of land and other assets
	Control over the use of income	Captures whether the respondent feels they have input into how their household spends income
	Access to and decisions on financial services	Captures whether the respondent feels they contribute to decisions on credit and whether they have access to a financial account

[10] Generally, the intrahousehold gender difference is at the disadvantage of women (positive value of the indicator). The proportion of negative values for the indicators of intrahousehold gender difference in access to CIS (Y11) is 0.5 percent; knowledge intensity of CIS (Y12) is 11 percent; and adoption intensity of advised practices on receiving CIS (Y12) is 17 percent.

[11] Pro-WEAI is rooted in (Kabeer 1999) and (Kabeer 2005) empowerment framework, which looks at empowerment as a process of change in the interrelated dimensions of resources, agency, and achievement. The framework emphasizes the importance of measuring agency and people's capacity to make strategic decisions that matter to them.

Guided by the methods for calculating pro-WEAI (Malapit et al. 2019), as a first step we determined adequacy for the female co-head of each household in each measure *i* (see Annex 2 for adequacy levels).[12] A respondent's empowerment score is the weighted average of their adequacy scores in the eight measures (all weighted 1/8).[13] In line with pro-WEAI methods, if the respondent's score is 75 percent or higher (or is adequate in 6/8 measures), then they are classified as empowered and the binary indicator of women's empowerment in agriculture within the household (X1) takes the value 1. On the contrary, if the respondent's score is below 75 percent, then they are classified as dis-empowered and the binary empowerment indicator is 0.

We also defined indicators for the different dimensions of women's empowerment to test our second hypothesis—that there is a difference in the strength of association between dimensions of women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities:

X2 = intrinsic agency
This indicator is based on the measures of self-efficacy and income autonomy. It does not include attitudes toward intimate partner violence, which is a separate indicator (X3). Women respondents are considered empowered with intrinsic agency if they achieve adequacy in self-efficacy and income autonomy.

X3 = gender norms
This indicator of gender norms is based on women respondents' attitudes toward intimate partner violence. This binary indicator is equal to 1 if the respondent believes the husband is not justified in hitting his wife in any of five different scenarios.

X4 = collective agency
This indicator is based on whether the respondent is an active member of a group, the only measure for collective agency in our study. Women respondents are considered empowered with collective agency if they achieve adequacy levels in this subindicator.

X5 = instrumental agency
This indicator is based on four measures: input into productive decisions, ownership of land and other assets, control over the use of income, and access to and decisions on financial services. Women respondents are considered empowered with instrumental agency if they achieve adequacy in three of the four measures.

4.2.4 Indicator of perceived severity of climate change

To measure the perceived severity of climate change, we constructed a variable based on five possible climate change-related challenges from the last 20 years: i) changes in temperature, ii) the onset of rainfall, iii) the amount of rainfall, iv) rainfall distribution, and v) rainfall cessation time. We relied on female co-heads' responses for this indicator.

The categorical variable takes the value of 1 for a low level of perceived climate change severity if the respondent reports negative changes in two of the five possible climate change-related challenges.[14] It takes the value of 2 for mid-level of perceived severity if negative changes are reported in three or four of the five possible challenges and takes the value of 3 of a high level of perceived severity if negative changes are reported in all five possible challenges.

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[12] A respondent is considered adequate in a measure if they attain a set threshold (the thresholds and cut-offs per measure are included in Annex 2). If the respondent falls below the threshold, they are considered inadequate in that measure (Malapit et al. 2019).

[13] We also use the female co-head's empowerment score as a continuous indicator of women's empowerment (results are included in Annex 6). The higher the empowerment score, the higher the level of empowerment for the individual.

[14] Negative changes in climate-related challenges: i) changes in temperature = increase and decrease in temperature, ii) the onset of rainfall = late onset, iii) the amount of rainfall = decreased amount, iv) rainfall distribution = worse distribution and v) rainfall cessation time = earlier or late cessation.

4.2.5 Socioeconomic status, sociodemographic characteristics and location of the household

The socioeconomic status of households is measured by land size (size of land owned, reported by the male co-head) and a wealth index that based on household asset ownership using the Equity Tool (Management for metrics 2015).[15] The indicators used in constructing the index include: whether the household has a refrigerator, electricity, a television, a sofa, a clock, a VCR/DVD, a fan, and/or a bank account; the main material of the floor and the roof of the house; and the type of fuel used for cooking.[16]

Indicators of sociodemographic characteristics include: i) the age of the male co-head; ii) the age difference between male and female co-head of the household; iii) education level of the male co-head (binary variable taking the value 1 if he attained education above primary school); and iv) household size. We included a binary variable for geographical location, which takes the value 1 if the household resides in Luapula Province.

4.3 Methods of analysis

To test the first research hypothesis—that there is a positive correlation between women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities—we used Ordinary Least Square (OLS) regression as our method of analysis. By using OLS, we examined the correlation between indicators of women's empowerment in the household and indicators of intrahousehold gender equality of climate-adaptive capacities. We controlled for women's perception of the severity of climate change, households' socioeconomic status, sociodemographic characteristics, and geographic location. We estimated the following model:

$$y_i = a + \beta_1 X_{1i} + CZ_i + dV_i + \mu_i \qquad (1)$$

Where:

y_i = indicator of intrahousehold gender equality of climate adaptive capacities for household *i*

$X1_i$ = indicator of women's empowerment of the female co-head in household *i*

Z_i = severity of climate challenges perceived by the female co-head of household *i*

V_i = vector of socioeconomic status, sociodemographic characteristics, and geographic location of the household

μ_i = error term

The coefficient of interest is β_1. If β_1 is statistically significant and has a positive value, this supports the hypothesis with a positive correlation.

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[15] A wealth index is preferred as an indicator of socioeconomic status over household income because monetary wealth indicators are likely to fluctuate over time and capture only one asset from which households derive well-being (Kakwani and Silber 2008; Ruggeri Laderchi, Saith, and Stewart 2003). Using a wealth index is also preferred for farming households because asset ownership is less sensitive to seasonal variations and is, therefore, a better representation of long-term well-being (Rakodi 1999).

[16] The index was calculated by first assigning a national wealth index score (weights) for each respondent based on their answers to each question (the weights are presented in Annex 2). For each respondent, a new variable containing the national scores for each question was created. A new variable summing the scores for all the questions was created, giving each respondent a total national score. Using the total score, each respondent was assigned a national wealth quantile. Their total score had to be greater than or equal to the lower limit of a quintile and less than the lower limit of the next quintile up. The simplified index is highly correlated with the DHS wealth index in Zambia (kappa Z 0.77) for both national samples and urban-specific samples (kappa Z 0.765) (Management for metrics 2015)

To test the second hypothesis—that there is a difference in the strength of association between different dimensions of women's empowerment in the household, and intrahousehold gender equality of climate–adaptive—we used OLS and estimated following the model:

$$y_i = a + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + CZ_i + dV_i + \mu_i \qquad (2)$$

Where:

y_i = indicator of intrahousehold gender equality of climate-adaptive capacities for household *i*

X_{2i} = indicator of intrinsic agency

X_{3i} = indicator of norms

X_{4i} = indicator of collective agency

X_{5i} = indicator of instrumental agency

Z_i= severity of climate challenges perceived by the female co-head of household *i*

V_i = vector of, socioeconomic status, sociodemographic characteristics, and geographic location of the household

μ_i = error term

The coefficients of interest are β_2, β_3, β_4, and β_5.

We also formally tested if β_2, β_3, β_4, and β_5 are statistically significantly different from one another based on a post–estimate test of (bilateral) difference of the estimated coefficients.

5. Results

In this section, we will present the descriptive statistics of the key variables followed by the results of testing the hypotheses.

5.1 Descriptive statistics of key variables

Descriptive statistics of the key variables are shown in Table 2.

Table 2. Descriptive statistics

Indicator	Label	Continuous variable	Binary variable	Mean	SD	Per-centage	SD
X1	Women's empowerment in agriculture within the household		x			27	44
X2	Intrinsic agency		x			80	40
X3	Norms		x			41	49
X4	Collective agency		x			61	49
X5	Instrumental agency		x			93	25
Y1	Female co-head's access to technical advice (TA) on CSA practices		x			50	50
Y2	Female co-head's knowledge intensity of CSA after receiving TA	x		0.03	0.04		
Y3	Female co-head's adoption intensity of CSA after receiving TA	x		0.97	1.15		
Y4	Intrahousehold gender difference in access to (TA) on CSA practices	x		0.09	0.45		
Y5	Intrahousehold gender difference in knowledge intensity of CSA after receiving TA	x		0.01	0.03		
Y6	Intrahousehold gender difference in adoption intensity of CSA after receiving TA	x		0.00	0.98		
Y7	Female co-head's access to CIS		x			96	20
Y8	Female co-head's knowledge intensity in CIS	x		0.22	0.13		
Y9	Female co-head's adoption intensity of advised practices after receiving CIS	x		0.06	0.06		
Y10	Intrahousehold gender difference in access to CIS	x		0.02	0.17		
Y11	Intrahousehold gender difference in knowledge intensity in CIS	x		0.03	0.12		
Y12	Intrahousehold gender difference in adoption intensity of advised practices after receiving CIS	x		0.01	0.06		

Indicator	Label	Categorical variable	Percentages		
			Low	Medium	High
Z	Perceived severity of climate change	x	9	38	53

Note: N=199: For the binary variables we provide the percentages and standard deviation (SD) while for the continous variables we provide the mean and SD. For the categorical variable we provide percentages per category.

5.2 The relationship between women's empowerment and intrahousehold gender equality in climate-adaptive capacities

5.2.1 The relationship between women's empowerment and access to and knowledge and adoption of CSA practices

Table 3 shows the correlation between an indicator of women's empowerment binary variable and indicators of female co-heads' access to TA on CSA, knowledge of CSA through TA, and adopting CSA after receiving TA (columns 1, 2 and 3) and indicators of intrahousehold gender differences in these (columns 4, 5, and 6).

Results in column 4 show a statistically significant negative correlation between women's empowerment and gender difference in access to TA on CSA. These results support the hypothesis of a positive relationship between women's empowerment and gender equality in climate-adaptive capacities. However, the hypothesis is neither supported nor rejected because there is no other statistically significant relationships between women's empowerment and indicators of gender equality in knowledge and adopting of CSA after receiving TA (table 3, columns 1–3 and 5–6).

Evidence suggests that, compared to households where the female co-head perceived low climate change severity, perceiving moderate or respectively high climate change severity is significantly negatively associated with intrahousehold gender difference in knowledge intensity of CSA after receiving TA (table 3, column 5).

Table 3. The relationship between a binary indicator of women's empowerment and access to and knowledge and adopting CSA after receiving TA

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co-heads'**			**Intrahousehold gender differences in**		
	Access to TA on CSA	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**	**Access to TA on CSA**	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**
Binary empowerment indicator	−0.04	−0.01	0.04	−0.13*	0.00	0.12
	(0.08)	(0.01)	(0.19)	(0.08)	(0.00)	(0.17)
Moderate climate change severity	−0.18	−0.00	0.04	0.19	−0.02***	−0.10
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
High climate change severity	−0.19	−0.01	0.02	0.07	−0.01**	0.02
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Constant	0.38**	0.04***	0.95**	0.01	0.00	0.42
	(0.16)	(0.01)	(0.39)	(0.16)	(0.01)	(0.34)
Observations	198	198	198	198	198	198
R-squared	0.24	0.09	0.09	0.06	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; moderate and high compared to low perceived climate change severity.

5.2.2 The relationship between women's empowerment and access to CIS, knowledge intensity of CIS, and adopting practices after receiving CIS

Table 4 shows the correlation between an indicator of women's empowerment binary variable and indicators of female co-heads access to CIS, knowledge intensity of CIS, and the intensity of adopting practices after receiving CIS (columns 1, 2 and 3) and indicators of intrahousehold gender difference (columns 4, 5 and 6).

There is no statistically significant relationship between women's empowerment and female co-heads' access to and knowledge of CIS, and the intensity of adopting practices after receiving CIS (table 4, columns 1–3); nor a statistically significant relationship with intrahousehold gender differences (columns 4–6). Therefore, these results do not support or reject the hypothesis of a positive relationship between women's empowerment and gender equality in climate-adaptive capacities.

Perceiving high climate change severity is significantly positively associated with the female co-heads' access to CIS and knowledge intensity of CIS (regardless of using the binary or continuous women's empowerment indicator) (table 4, columns 1 and 2).

In contrast, perceiving moderate climate change severity is associated with greater intrahousehold gender difference in access to CIS (table 5, column 4).

Table 4. The relationship between a binary indicator of women's empowerment and CIS in the face of climate change

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co-heads'**			**Intrahousehold gender difference in**		
	Access to CIS	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**	**Access to CIS**	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**
Binary empowerment indicator	−0.03	−0.01	−0.01	0.04	0.01	0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Moderate climate change severity	0.01	0.03	0.00	0.08*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)
High climate change severity	0.09*	0.10***	0.01	0.01	0.03	−0.00
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.01)
Constant	0.80***	0.16***	0.05**	0.06	−0.02	0.00
	(0.07)	(0.04)	(0.02)	(0.06)	(0.04)	(0.02)
Observations	198	198	198	198	198	198
R-squared	0.13	0.19	0.05	0.12	0.04	0.04

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Moderate and high compared to low perceived climate change severity

5.3 Differences in the strength of association between dimensions of women's empowerment and intrahousehold gender equality in climate-adaptive capacities

This section shows the results of testing the hypothesis of differences in the strength of association between dimensions of women's empowerment and intrahousehold gender equality in climate-adaptive capacities in agrifood systems. The dimensions of women's empowerment include intrinsic agency, norms (attitudes toward intimate partner violence against women), collective agency, and instrumental agency.

Table 5 presents the results of these relationships for access to and knowledge and adopting CSA practices after receiving TA. Table 6 presents the results of these relationships for access to CIS, knowledge intensity of CIS and adopting practices after receiving CIS.

Table 5 shows a statistically significant positive correlation between the female co-heads' adoption of CSA and instrumental agency (column 3); and a statistically significant negative correlation between intrahousehold gender difference in access to TA on CSA and norms.

Table 6 shows a statistically significant positive correlation between the female co-heads access to CIS and collective agency (column 1). There is also a statistically significant positive correlation between female co-heads' knowledge intensity in CIS and intrinsic agency and instrumental agency (column 2).

We tested bilateral differences between statistically significant coefficients of the indicators of women's empowerment (see Annex 8 for results). Women's instrumental agency emerges more positively associated with female co-heads' intensity of adopting CSA compared to intrinsic agency (table 5, column 3). Gender norms are more negatively associated with intrahousehold gender differences in access to TA on CSA; therefore, norms are more positively associated with gender equality (table 5, column 4).[17]

Collective agency is relatively more strongly associated with female co-head access to CIS compared to both intrinsic agency and instrumental agency (table 6, column 1). Intrinsic agency and instrumental agency are more positively associated with female co-heads' knowledge intensity of CIS compared to norms (table 6, column 2).

These results support the hypothesis that there are differences in the strength of association between the various dimensions of women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities.

[17] In the same model, intrinsic agency and collective agency coefficients are bilaterally different, but neither is statistically significant (table 9, column 4).

Table 5. The relationship between dimensions of empowerment and access to and knowledge and adoption of CSA after receiving TA

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co-heads'**			**Intrahousehold gender difference in**		
	Access to TA on CSA	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**	**Access to TA on CSA**	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**
Intrinsic agency	−0.02	−0.01	−0.19[a]	0.11[a,b]	0.00	0.05
	(0.10)	(0.01)	(0.24)	(0.09)	(0.00)	(0.21)
Norms	−0.00	0.00	0.25	−0.14*[a]	−0.00	−0.05
	(0.07)	(0.01)	(0.18)	(0.07)	(0.00)	(0.16)
Collective agency	0.04	−0.00	0.07	−0.11[b]	−0.00	−0.17
	(0.07)	(0.01)	(0.18)	(0.07)	(0.00)	(0.16)
Instrumental agency	0.07	0.01	0.66*[a]	−0.10	0.00	−0.17
	(0.14)	(0.01)	(0.34)	(0.13)	(0.01)	(0.29)
Moderate climate change severity	−0.21*	−0.01	−0.03	0.20	−0.02***	−0.03
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
High climate change severity	−0.21*	−0.02	−0.02	0.04	−0.01***	0.06
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Constant	0.33*	0.04**	0.42	0.15	0.00	0.57
	(0.19)	(0.02)	(0.48)	(0.19)	(0.01)	(0.42)
Observations	198	198	198	198	198	198
R-squared	0.24	0.09	0.12	0.08	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; moderate and high compared to low perceived climate change severity

Superscript letters a,b,... indicate bilaterally significantly different coefficients (see Annex 8 for tests of significant difference of coefficients)

Table 6. Relationship between dimensions of empowerment and CIS in the face of climate change

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co-heads'**			**Intrahousehold gender differences in**		
	Access to CIS	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**	**Access to CIS**	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**
Intrinsic agency	0.04[a]	0.04*[a]	−0.00	−0.01	−0.00	0.01
	(0.04)	(0.02)	(0.01)	(0.04)	(0.02)	(0.01)
Norms	−0.00	−0.02[a,b]	0.01	0.02	−0.01	−0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Collective agency	0.07**, [a,b]	0.00	0.00	−0.01	0.03	0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Instrumental agency	0.05[b]	0.06*[b]	0.02	0.01	0.01	−0.00
	(0.06)	(0.03)	(0.02)	(0.05)	(0.04)	(0.02)
Moderate climate change severity	0.01	0.02	0.00	0.09*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
High climate change severity	0.07	0.08**	0.01	0.02	0.03	−0.00
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
Constant	0.71***	0.10*	0.03	0.05	−0.05	−0.00
	(0.08)	(0.05)	(0.03)	(0.08)	(0.05)	(0.03)
Observations	198	198	198	198	198	198
R-squared	0.16	0.22	0.06	0.11	0.05	0.04

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; moderate and high compared to low perceived climate change severity

Superscript letters a,b,... indicate bilaterally significantly different coefficients (see Annex 8 for tests of significant difference of coefficients)

6. Discussion and recommendations

This study was conducted in Luapula and North-Western provinces in Zambia, identified as climate–agriculture–gender inequality hotspot areas by Lecoutere et al. (2023). We examined the relationship between women's empowerment in the household, and gender equality in climate-adaptive capacities.

We tested two hypotheses derived from the Gendered Food Systems framework and frameworks linking climate change and gender equality in agrifood systems (Njuki et al. 2022; Bryan et al. 2023):

i. There is a positive correlation between women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities.

ii. There is a difference in the strength of association between dimensions of women's empowerment in the household, and intrahousehold gender equality of climate-adaptive capacities.

Based on intrahousehold gender-disaggregated data collected from male and female co-heads in agricultural-based households, we used OLS regression analysis to test the hypotheses, while controlling for female respondents' perceived climate change severity and other relevant individual and household characteristics.

For our first hypothesis, we found that women's empowerment in the household is associated with more intrahousehold gender-equal access to TA on CSA practices. Our hypothesis of a positive relationship between women's empowerment and gender equality in knowledge and adopting CSA after receiving TA was neither empirically supported nor rejected; the hypothesis about a positive relationship with access to, knowledge intensity of CIS, and the intensity of adopting practices after receiving CIS was also not empirically supported nor rejected. These results suggest that, in our study sample, more gender-equal access to TA on CSA did not necessarily translate into more gender-equal knowledge and adopting CSA. Other studies have also found that women face more constraints than men for acting on access to information and extension (Ngigi and Muange 2022; Ngigi, Mueller, and Birner 2017). This implies that policies or programs that promote gender-equal access to CSA advice is insufficient to support gender-equal knowledge and practice of CSA practices. Policies and programs may need to be supplemented with hands-on training and farmer field schools that are accessible to women, and ways to enhance women's access to finance and control over household budgets or ways to reduce their time constraints.

For our second hypothesis, we found that different dimensions of women's empowerment relate differently to indicators of access, knowledge, and adopting CSA practices after receiving TA. We observed that positive norms (i.e., less support for intimate partner violence against women) are associated with a smaller intrahousehold gender differences in access to TA on CSA practices. The association with norms is significantly stronger than with intrinsic agency, which captures 'power within' (self-efficacy and autonomy in the use of income). These observations can indicate that discriminatory norms—proxied by attitudes toward intimate partner violence—constrain gender-equal access to TA on CSA practices, more than women's beliefs in their own abilities and autonomy. Alternatively, more gender-equal access may have influenced women's attitudes toward violence and discriminatory norms more than their beliefs in self-efficacy and autonomy. The results highlight an important link between gender-equal climate-adaptive capacities and more positive norms in the form of less supportive attitudes toward intimate partner violence against women.

We also found that instrumental agency, capturing 'power to' access, control and making decisions about resources and income is positively related to female co-heads' adoption

of CSA after receiving TA. This observation aligns with other studies that suggest that women's adoption of CSA may still be constrained by lack of access to resources, despite having access to and knowledge of CSA practices (Mekonnen 2022; Ngigi, Mueller and Birner 2017). Alternatively, it can point to women's strengthened access to resources when they have adopted CSA practices. This fact emphasizes the key link between gender-equal climate-adaptive capacities and women's access and control over resources. That women's instrumental agency is more positively associated with adopting CSA practices than the intrinsic agency, which could show that belief in self-efficacy and autonomy is not as important for women's adoption of CSA practices or is less likely to follow on from adopting CSA.

Similarly, access to and knowledge of CIS are differentially related to dimensions of women's empowerment. Collective agency, capturing 'power within', is positively correlated with female co-heads' access to CIS and is more strongly associated than intrinsic agency and instrumental agency. This positive relationship between membership of social groups and women's access to CIS is consistent with other studies (Ngigi, Mueller and Birner 2017).

Female co-heads' knowledge intensity of CIS is positively related with intrinsic agency and instrumental agency. These correlations are stronger than with norms. These findings could imply women's knowledge of CIS is beneficial for their access to and control over resources, as well as their belief in self-efficacy and autonomy, but has less influence on norms. Alternatively, the findings could mean that women's access to and control over resources and their belief in self-efficacy and autonomy stimulates knowledge of CIS, and norms are less important.

Generally, we observed more intrahousehold gender equality in elements that support climate-adaptive capacities when female co-heads perceive climate change as being severe. This may suggest that more gender equality in climate-adaptive supporting measures (CIS, TA on CSA) made female co-heads more aware of climate change. Alternatively, female co-heads who were more aware of severe climate change may have invested more in seeking access to, knowledge of and adopting measures that support climate-adaptive capacities. Or, if their husbands are equally aware of severe climate change, their husbands may have involved or encouraged them to access, know about, and adopt climate-adaptive measures. These findings highlight the importance of awareness by both male and female co-heads of climate change and measures to enhance climate-adaptive capacities and the importance of framing strengthened climate-adaptive capacities as a common household goal.

Our study may have some limitations. Firstly, data was collected across 16 villages, randomly selected across the two study districts. Initially, we set out to interview 400 households, a sample representative at the village level. However, we only managed to reach 338 households due to challenges in the accessibility of the study sites and the geographical dispersion of the respondents and we only included 199 households. While the sample size is smaller than planned and the representativeness is potentially compromised, we are confident that the sample still provides a relatively large and diverse set of households and rich intrahousehold gender-disaggregated data for analysis.

Secondly, testing multiple hypotheses may have increased the risk of false-positive conclusions. There is an ongoing debate about whether exploratory observational case studies need to be corrected for multiple hypotheses testing (Goeman and Solari, 2011). However, in this case, with challenges of statistical power due to a relatively small sample size, correction could result in not detecting otherwise statistically significant relationships.

Thirdly, the model for testing the second hypothesis included independent variables capturing different dimensions of women's empowerment that are correlated (intrinsic agency and gender norms measured as attitudes toward violence (see Annex 6). Arguably, this approach generates multicollinearity. The level of multicollinearity in our study was marginal (10 percent significance) and small-to-moderate levels of multicollinearity are usually not problematic. While multicollinearity may inflate the variance of the coefficients, the OLS estimates remain unbiased (Wooldrige 2013) meaning our results are valid.

We recommend future research to test the relationship between women's empowerment and intrahousehold gender equality of climate-adaptive capacities in climate-affected agrifood systems in LMIC to build robust evidence. Future studies, especially looking at various dimensions of women's empowerment independently, should seek to address the implications of multicollinearity or adopt a research design that allows for examining distinct relationships with different dimensions of empowerment.

We recommend that future studies adopt an intrahousehold lens to gender dynamics, which requires collecting gender-disaggregated intrahousehold data. Sufficiently large sample sizes are needed for appropriate statistical power. Larger sample sizes would also allow for evaluating potential challenges related to multiple hypotheses testing and for including a formal analysis of the influence of (perceived) climate change severity on the relationship between women's empowerment and gender equality of climate-adaptive capacities. More innovative approaches, such as phone interviews, could be part of the solutions for reaching both male and female respondents in large samples of households.

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Annexes

Annex 1. Research hypotheses, the key indicators of interest and the control variables

Research hypotheses, key indicators of interest and control variables

Research hypothesis	Indicators of intrahousehold gender equality of climate-adaptive capacities	Indicators of women's empowerment in the household	Control variables
There is a positive correlation between women's empowerment in the household and intrahousehold gender equality of climate-adaptive capacities in agrifood systems faced with climate change.	Y1 = Female co-head's access to technical advice (TA) on CSA practices Y2 = Female co-head's knowledge intensity of CSA after receiving TA Y3 = Female co-head's adoption intensity of CSA after receiving TA Y4 = Intrahousehold gender difference in access to TA on CSA practices Y5 = Intrahousehold gender difference in knowledge intensity of CSA after receiving TA Y6 = Intrahousehold gender difference in adoption intensity of CSA after receiving TA Y7= Female co-head's access to CIS Y8 = Female co-head's knowledge intensity in CIS Y9 = Female co-head's adoption intensity of advised practices after receiving CIS Y10= Intrahousehold gender difference in access to CIS Y11 = Intrahousehold gender difference in knowledge intensity in CIS Y12 = Intrahousehold gender difference in adoption intensity of advised practices after receiving CIS	X1 = Women's empowerment indicator	Perceived severity of climate change Socioeconomic status, sociodemographic characteristics and geographical location of the household

Research hypothesis	Indicators of intrahousehold gender equality of climate-adaptive capacities	Indicators of women's empowerment in the household	Control variables
There is a difference in the strength of association between different dimensions of women's empowerment in the household—norms, collective agency, access to and control over resources and income—and intrahousehold gender equality of climate-adaptive capacities in agrifood systems faced with climate change	Y1 Y2 Y3 Y4 Y5 Y6 Y7 Y8 Y9 Y10 Y11 Y12	X2 = Intrinsic agency (Women's self-efficacy and autonomy in income) X3 = Norms (attitudes toward gender-based violence) X4 = Collective agency X5 = Instrumental agency (Women's access to and control over resources, income, and productive decisions)	Perceived severity of climate change Socioeconomic status, sociodemographic characteristics and geographical location of the household

Annex 2. Pro-WEAI dimensions and measures

Agency	Measure in pro-WEAI	Description	Data available in this study
Intrinsic agency	Attitudes about intimate partner violence against women	Captures how respondents feel about a husband beating his wife. We capture female co-head's perception on whether a husband is justified in hitting or beating his wife in any of the following situations; if she goes out without telling him, if she neglects the children, if she argues with him, if she refuses to have sex with him, if she burns the food. The measure can be assumed to reflect prevailing norms and attitudes toward husbands beating their wives.	yes
	Self-efficacy	A person's confidence in their abilities to succeed in certain situations or accomplish tasks	yes
	Autonomy in income	A measure of the internal and external motivations that influence a person's decisions regarding the use of income	yes
	Respect among household members	Measures how the respondent feels about other members of their household and how they perceive other household members feel about them	no
Collective agency	Active member of a group	Whether the respondent is an active member of a group	yes
	Active member of an influential group	Whether the respondent is an active member of a group that they feel has influence in the community	no
Instrumental agency	Input into productive decisions	Whether a person feels that they participate in decisions about the agricultural activities that they are a part of	yes
	Ownership of land and other assets	Assess individual ownership of land and other assets	yes
	Control over the use of income	Captures whether the respondent feels that they have input into how his/her household spends income	yes
	Access to and decisions on financial services	Captures whether the respondent feels they contribute to decisions on credit and whether they have access to a financial account	yes
	Work balance	How many hours a person works in a day and includes time spent on childcare as a secondary (or simultaneous)	no
	Visiting important locations	Captures whether the respondent feels that they can visit various locations and how frequently they visit these locations	no

Pro-WEAI indicator adequacy definition

Indicator	Definition of adequacy
	Intrinsic Agency
Autonomy in income	More motivated by own values than by coercion or fear of others' disapproval: *Relative Autonomy Index*[A] score>=1 RAI score is calculated by summing responses to the three vignettes (yes=1; no=0), using the following weighting scheme: -2 for vignette 2 (external motivation), -1 for vignette 3 (introjected motivation), and +3 for vignette 4 (autonomous motivation)
Self-efficacy	"Agree" or greater on average with self-efficacy questions: *New General Self-Efficacy Scale*[B] score>=32
Attitudes about intimate partner violence against women	Believes husband is NOT justified in hitting or beating his wife in all 5 scenarios:[C] 1) She goes out without telling him 2) She neglects the children 3) She argues with him 4) She refuses to have sex with him 5) She burns the food
Respect among household members	Meets ALL of the following conditions related to another household member: 1) Respondent respects relation (MOST of the time) AND 2) Relation respects respondent (MOST of the time) AND 3) Respondent trusts relation (MOST of the time) AND 4) Respondent is comfortable disagreeing with relation (MOST of the time)
	Instrumental Agency
Input in productive decisions	Meets at least ONE of the following conditions for ALL of the agricultural activities they participate in 1) Makes related decision solely, 2) Makes the decision jointly and has at least some Input Into the decisions 3) Feels could make decision If wanted to (to at least a MEOIUM extent)
Ownership of land and other assets	Owns, either solely or jointly, at least ONE of the following: *(updated March 2020)* 1) At least TWO assets 2) Land
Access to and decisions on financial services	Meets at least ONE of the following conditions: 1) Belongs to a household that used a source of credit in the past year ANO participated in at least ONE sole or joint decision about it 2) Belongs to a household that did not use credit in the past year but could have if wanted to from at least ONE source 3) Has access, solely or jointly, to a financial account
Control over use of income	Has input in decisions related to how to use BOTH income and output from ALL of the agricultural activities they participate in AND has input in decisions related to income from ALL non-agricultural activities they participate in, unless no decision was made
Work balance	Works less than 10.5 hours per day: Workload= time spent in primary activity+ (1/2) time spent in childcare as a secondary activity
Visiting important locations	Meets at least ONE of the following conditions: 1) Visits at least TWO locations at least ONCE PER WEEK of [city, market, family/relative), or 2) Visits least ONE location at least ONCE PER MONTH of (health facility, public meeting)
	Collective Agency
Group membership	Active member of at least ONE group
Membership in influential groups	Active member of at least ONE group that can influence the community to at least a MEDIUM extent

Adapted from: Malapit,. Hazel J., Agnes R. Quisumbing, Ruth Suseela Meinzen-Dick:, Greg Seymour, Elena M. Martinez, Jessica Heckert, Deborah Rubin, Ana Vaz, and Kathryn M. Yount. Development of the project-level Women's Empowerment in Agriculture Index (pro-WEAI). IFPRI Discussion Paper No. 1796. Washington, DC: International Food Policy Research Institute.

Notes: [A] The New General Self-efficacy Scale (NGSE) is a validated scale to measure self-efficacy, or a person's capabilities and ability to reach their goals (Chen et al. 2001). [B] The Relative Autonomy Index (RAI), based on self-determination theory, is a measure of internal and external motivations that determine person's decisions (Ryan and Oeci 2000). [C] These scenarios are based on previously validated items from the Demographic and Health Surveys (Yount et al. 2014).

Annex 3. Equity tool weights

	Questions	Use these variables' names to store the national scores:	Option 1:	Option 1 national score:	Option 2:	Option 2 national score:	Option 3, if applicable:	Option 3 national score:
Q1	Does your household have… electricity?	Q1_NAT	Yes	0.116147667	No	−0.03664285181		
Q2	…a television?	Q2_NAT	Yes	0.08464404692	No	−0.04399874325		
Q3	…a refrigerator?	Q3_NAT	Yes	0.1319874793	No	−0.02913825266		
Q4	…a sofa?	Q4_NAT	Yes	0.0845585842	No	−0.0399026455		
Q5	…a clock?	Q5_NAT	Yes	0.1005824618	No	−0.0239623614		
Q6	…a fan?	Q6_NAT	Yes	0.1412569695	No	−0.02007533227		
Q7	…a VCR/DVD?	Q7_NAT	Yes	0.1009667873	No	−0.03270400305		
Q8	Does any member of this household have a bank account?	Q8_NAT	Yes	0.1016009951	No	−0.03266378801		
Q9	What is the main material of the floor?	Q9_NAT	Earth/sand/dung	−0.09571337833	Concrete cement	0.1404354717	Other	0.03060633129
Q10	What is the main material of the roof?	Q10_NAT	Thatch/palm leaf	−0.05925732113	Other	0.04770147166		
Q11	What type of fuel does your household mainly use for cooking?	Q11_NAT	Electricity	0.1485528593	Other	−0.0174442994		

Annex 4. Climate information services: type of information

Type of information
1. Onset of the rains
2. Rainfall amounts
3. Rainfall distribution daily/weekly
4. Temperature
5. Rainfall Cessation time
6. Droughts/floods (early warning)
7. Dry spell
8. Cold spell
9. Hot (high temperature) spell
10. Heavy rain spell
11. Crop pests/diseases (prevalence, incidence and severity)
12. Livestock pests and diseases
13. Fish pests and diseases
14. Crop market prices
15. Livestock markets prices
16. fish markets prices
17. input (fertilizer) prices
18. Advisory services (when to plant?, etc./ when to stock fish)

Annex 5. Excerpts of relevant sections from survey

ZAMBIA Situational analysis individual questionnaire

Date and location

Date of survey:	
Province	
District	

Demographic characteristics of farm household

How many people regularly live/sleep and eat together in this household (for past year)?

Name of household member (start with household head)	Gender (Male: 1; Female: 2)	Age	Highest educational attainment (Code A below)	Relationship with household head (Code B below)	Marital status (Code C below)

Code A:
00=None;
01=Sub–standard A; Grade 1; 01=Sub–standard B; Grade 1
02=Standard 1; Grade 2; 03=Standard 2; Grade 3
04=Standard 3; Grade 4; 05=Standard 4; Grade 5
06=Standard 5; Grade 6; 07=Standard 6; Grade 7
08=Form 1; Grade 8; 09=Form 2; Grade 9
10=Form 3; Grade 10; 11=Form 4; Grade 11
12=Form 5; Grade 12; 12=Form 6 lower
12=Form 6 upper; 15=College Student
16=Undergraduate; 17=Certificate/Diploma
18=Bachelor's Degree; 19=Master's degree & above

Perceptions of changes in climate

The questions below are for the key decision-makers on crop/livestock/fish activities in this household. Who are the key decision-makers for crop/livestock/fish activities in this household? Use roster list to answer

Would you say that rainfall/temperature has been changing (increase/decrease/same) in your community over the last 20 years? Has this affected your livelihoods (crop/livestock/fishing)? In which way?	Are you experiencing more frequent/intense/ longer droughts/floods (more/less/same) over the last 20 years? Has this affected your livelihoods (crop/livestock/fishing)? In which way?
1. Onset of the rains (earlier/late/same) 2. Rainfall amounts (increase/decrease/same) 3. Rainfall distribution (worse/same/better for plants, animals and fish) 4. Rainfall cessation time (earlier/late/same) 5. Temperature (increase/decrease/same)	1. Drought frequency (number every 10 years): increased/decreased/same 2. Drought intensity (rainfall during drought is smaller today than years ago): more/same/less rain when it rains during drought 3. Drought duration: longer/same/shorter (e.g., are droughts lasting for 2 consecutive years like 2015/16 and 2016/17) more/less/same frequent?
	1. Flood frequency: increased/decreased/same 2. Flood intensity: more/same/less rain when it rains during drought

Access to climate (weather-related and seasonal climate forecast) information services (These questions were repeated for crop production, livestock production and aquaculture)

1a. Access to CIS information

Did you have access to any climate–related information during this season (2021/22) did you have access to any forecasted knowledge on seasonal climate? _____ 1=Yes 2=No

1b. Type of information

Type of information
1. Onset of the rains
2. Rainfall amounts
3. Rainfall distribution daily/weekly
4. Temperature
5. Rainfall cessation time
6. Droughts/floods (early warning)
7. Dry spell
8. Cold spell
9. Hot (high temperature) spell
10. Heavy rain spell
11. Crop pests/diseases (prevalence, incidence and severity)
12. Livestock pests and diseases
13. Fish pests and diseases
14. Crop market prices
15. Livestock markets prices
16. fish markets prices
17. input (fertilizer) prices
18. Advisory services (when to plant etc./when to stock fish)

1c. What decisions did access to information change

What decisions did access to climate information change?	What decisions did access to climate information change?	What decisions did access to climate information change?
Crops	**Livestock**	**Aquaculture**
1. Do nothing 2. Change in soil preparation (manure/compost, terracing, etc.) 3. Change in planting (earlier/later/staggered planting.) 4. Change in irrigation application (water management) 5. Change in the application of herbicide/ insecticide 6. Change in weeding 7. Change in harvesting 8. Change in agricultural inputs (pre–treated improved seed; fertilizer; pesticides/herbicides; etc.) 9. Mix long- and short-season crops 10. Agricultural land use change 11. Agroforestry (planting trees with crops) 12. Conservation agriculture (minimum tillage, mulch, & rotation) 13. Mechanization 14. Moved to more suitable farming environment 15. Other (please specify)	1. Do nothing 2. Feed management changes 3. Applied animal health vaccination/ treatment 4. Diversified livestock (new species) 5. Sold livestock 6. Bought livestock 7. Moved to a more suitable livestock environment 8. Other (specify)	1. Do nothing 2. Feed management changes (specify) 3. Applied fish health vaccination/treatment, pond preparation 4. Fingerlings production 5. Fishpond stocking 6. Applying fertilizer 7. Harvesting 8. Selling fish 9. Buying fingerlings 10. Buying fish 11. Moved fish to a more suitable fish environment 12. Delayed stocking 13. Other (specify)

Technical advice

Did you receive any technical advice (if any) to support the decision you made in the 2021/2022 season based on the climate–related information you received? (1=Yes; 0=No)

Type of technical advice
1. Crop–soil preparation method (tillage)
2. Crop—inputs to use (seed, fertilizer/manure, etc.)
3. Crop–planting time
4. Crop–weed management
5. Crop–pest/insect management
6. Crop–harvest time
7. Crop–water conservation techniques
8. Crop–price information—crop
9. Crop–price information—inputs (seed, etc.)
10. Crop—storage
11. Crop—marketing (where to sell and where?)
12. Crop—other (specify)
13. Livestock—health management
14. Livestock—feed management
15. Livestock—water management
16. Livestock—marketing

What decisions did access to climate information change?	What decisions did access to climate Information change?	What decisions did access to climate Information change?
Crops	**Livestock**	**Aquaculture**
1. Do nothing 2. Change in soil preparation (manure/ compost, terracing, etc.) 3. Change in planting (earlier/later/staggered planting, etc.) 4. Change in irrigation application (water management) 5. Change in the application of herbicide/ insecticide 6. Change in weeding 7. Change in harvesting 8. Change in agricultural inputs (pre–treated improved seed; fertilizer; pesticides/ herbicides; etc.) 9. Mix long- and short-season crops 10. Agricultural land use change 11. Agroforestry (planting trees with crops) 12. Conservation agriculture 13. (minimum tillage, mulch, & rotation) 14. Mechanization 15. Moved to a more suitable farming environment 16. Other (please specify)	1. Do nothing 2. Feed management changes 3. Applied animal health vaccination/ treatment 4. Diversified livestock (new species) 5. Sold livestock 6. Bought livestock 7. Moved to more suitable livestock environment 8. Other (specify)	1. Do nothing 2. Feed management changes (specify) 3. Applied fish health vaccination treatment pond preparation 4. Fingerlings production 5. Fishpond stocking 6. Applying fertilizer 7. Harvesting 8. Selling fish 9. Buying fingerlings 10. Buying fish 11. Moved fish to a more suitable fish environment 12. Delayed stocking 13. Other (specify)

Extension services

1. Have you received any extension service for the 2021/2022 season (services which were not linked to climate information)? (1=Yes; 0=No)
2. Which type of service have you received (these are services which you receive regardless of whether you also received climate information services in the year)?

Shocks

	Have you experienced this shock in the current production year?	Average time taken to recover (1=within a month, 2=within the same season, 3=half a year, 4=one year, 5=more than a year, 6=did not recover)
Damage to standing crops		
Postharvest crop losses		
Drop in sales prices for agricultural produce		
Poor quality of agricultural inputs		
Increase in agricultural input prices		
Shortage of agricultural labor		
Livestock death/disease		
Theft (of crops, livestock, etc.)		
Increase in food prices (increased food expenditures)		
Illness or injury in the household		
Disease outbreak/pandemic		
Death in the household		

Living conditions of household

What is the type of housing unit? Traditional hut (uncooked mud); Improved traditional hut (plaster); Detached house; Flat/ apartment/multi–unit; Semidetached house; Servants quarters; Other (please specify)	
What is your main source of drinking water? Safe: Rainwater; Protected well; Borehole; Protected spring; Public tap; Own tap; Other tap (e.g., from nearby building); Water kiosk; Bought from other vendor; Bottled water Unsafe: Directly from river/lake/stream/dam; Unprotected well; Unprotected spring; Other (please specify)	Roof: grass Wall: wood with mud around wooden poles Soil: plain dirt Improved hut: Roof improved (tight); or iron sheet Wall: brick (burnt or unburnt) with plaster Soil: smooth and hard cow dung
What is the main source of electricity? Connected to the grid; not connected to the grid	
What is the main source of lighting? Kerosene/paraffin; electricity; Solar panel; Candle; Diesel; Open fire; Torch; None; Other (please specify)	
What is the main source of cooking energy? Collected Firewood; Purchased Firewood; Charcoal; Own Produced Charcoal; Purchased Coal Kerosene/Paraffin; Gas; Electricity; Solar; Crop/Livestock Residues; Other (please specify)	
What is your main type of toilet facility? Pit latrine without slab (just hole); concrete pit latrine with (vent) (VIPs); flushed pit latrine; improved toilet with toilet seat (mud or cement); Own flush toilet inside the household; Own flush toilet outside the household; Own pit latrine with slab; Communal pit latrine with slab; Neighbours'/another household's pit latrine with slab; Own pit latrine without slab; Communal pit latrine without slab; Pit latrine without slab; Bucket/another container; Aqua privy; None; Other (please specify)	
How many separate rooms do the members of your household occupy? (DO NOT COUNT BATHROOMS, TOILETS, STOREROOMS, OR GARAGE)	

List and value of assets in your farm household

Type of assets	Number (if no asset, put zero)	If you would sell [….], how much would you receive from the sale? (Zambian Kwacha/item) (if more than one item is reported in column 2, take the average price)	Who owns this asset? Self, spouse, family	Who makes the decision on whether to sell/ rent this asset?
Household assets				
Furniture (3/4–piece sofa set)				
Furniture (chairs)				
Furniture (table)				
Fan				
TV set				
Bed				
Mattress				
Radio or CD player				
Cell phone				
Sewing machine				
Fridge				
Freezer				
Wood stove				
Kerosene stove				
Gas cooker				
Electric stove				
Generator				
Inverter				
Farm assets				
Ox/donkey/horse cart				
Ox/donkey/horse plough				
Axe				
Hoe				
Cutlasses				
Knapsack sprayer				
Water pump				
Spade or shovel				
Wheelbarrow				
Motorized grain mill				
Fishing assets				
Transportation assets				
Bicycle				
Motorbike				
Cars and other motor vehicles				

Perception of food security

In the past two years, have you been faced with a the situation when you did not have enough food to feed the household?	
When did you experience this incident? List month(s) January…1; February…2; March…3; April….4;	2021 (June 2020 to May 2022) 2020 (June 2020 to May 2021)
What was the cause of this situation? List in order of importance (codes J)	1st reason 2nd reason 3rd reason

Codes J: Inadequate household stocks due to drought/poor rains: 1; Inadequate household food stocks due to crop pest damage: 2; Inadequate household food stocks due to small land size: 3; Inadequate household food stocks due to lack of farm inputs: 4; Food in the market was very expensive: 5; Unable to reach the market due to high transportation costs: 6; No food in the market: 7; Floods/water logging: 8; Unable to reach the market due to civil unrest/riot: 9; Conflict (militancy/insurgency:10; Other (specify): 11

Farmers' practices and revenues from agriculture (women and men plot managers)

Crop revenues

Which plots are normally used by your household? Please include the plots managed by women in this household. Size of plots (plot name; include plots managed by women)
Who owns the plot? (use names of hh; self, spouse, joint)
Who primarily decided how to use this field?
Who manages the plot (who in the household)? Use household roster: we want to capture women farmers.
What is the plot size (number/unit)?
Which crops do you normally grow on the plot?
Last year, which crop did you grow on the plot?
How much was your harvest for 2022? For cassava, how many 50 kg bags of raw cassava could the household harvest from this field if it had decided to harvest the entire field (May 2021–April 2022)?
Who primarily decides how revenue from the saleswill be used? Use a roster of household.
What is the sale price of produce in this community?

Plot management

Which plots are normally used by your household; Please include the plots managed by women in this household. (plot name; include plots managed by women)
Who owns the plot (hh member: men/women; joint)
Who primarily decided how to use this field?
Who manages the plot (who in the household)? Use household roster: we want to capture women farmers.
Who primarily decides which crops to plant on this field?
Who primarily decides which inputs to buy?
Who primarily decides when to bring crops to the market?
Who primarily markets the crop?

Autonomy in decision-making (female respondents only)

Now I am going to read you some stories about different farmers and their situations regarding different agricultural activities. This question format is different from the rest, so take your time in answering. For each, I will then ask you how much you are like or not like each of these people. We would like to know if you are completely different from them, similar to them, or somewhere in between. There are no right or wrong answers to these questions.

READ ALOUD EACH STORY, SUBSEQUENT QUESTIONS, AND RESPONSE CODES. NAMES SHOULD BE ADOPTED TO LOCAL CONTEXT AND BE MALE/FEMALE DEPENDING ON THE SEX OF THE RESPONDENT. THE ORDER OF TOPICS A–D SHOULD BE RANDOMIZED, AND WITHIN EACH TOPIC, THE ORDER OF STORIES 1–4 ARE RANDOMIZED.

Code: YES...1 NO.....0

	Are you currently like this person? (2021–2022)	Were you like this person one year ago (2020–2021)	Were you like this person two years ago (2019–2020)
"There is no alternative to how [PERSON'S NAME] uses her income. How she uses her income is determined by necessity."			
"[PERSON'S NAME] uses her income how her spouse or another person or group in her community tell her she must use it there. She does what they tell her to do."			
"[PERSON'S NAME] uses her income in the way that her family or community expect. She wants them to approve of her."			
"[PERSON'S NAME] chooses to use her income how she personally wants to and thinks is best for herself and her family. She values using her income in this way. If she changed her mind, she could act differently."			

Self-efficacy (female respondents only)

Now I'm going to ask you some questions about different feelings you might have. Please listen to each of the following statements. Think about how each statement relates to your life current and in the past, and then tell me how much you agree or disagree with the statement on a scale of 1 to 5, where 1 means you "strongly disagree" and 5 means you "strongly agree."

Codes:
STRONGLY DISAGREE……1
DISAGREE……2
NEITHER AGREE NOR DISAGREE….3
AGREE……4
STRONGLY AGREE……5

	Currently (2021–2022)	One year ago (2020–2021)	Two years ago (2019–2020)
I will/was be able to achieve most of the goals that I have set for myself.			
When facing/faced difficult tasks, I am certain that I will accomplish them.			
In general, I think/thought that I can obtain outcomes that are important to me.			
I believe/believed I can/could succeed at almost any endeavour to which I set my mind			
I will/was be able to successfully overcome many challenges.			
I am/was confident that I can perform effectively on many different tasks.			
Compared to other people, I can/could do most tasks very well.			
Even when things are tough, I can/was able to perform quite well.			

Attitude about domestic violence (asked female respondents only)

Now I would like to ask about your opinion on the following issues. Please keep in mind that I am not asking about your personal experience or whether the following scenarios have happened to you. I would only like to know whether you think the following issues are acceptable.

In your opinion (either currently or previously), is a husband justified in hitting or beating his wife in the following situations?

Code: YES…..1
NO……2
DON'T KNOW…..99

	Currently (2021–2022)	One year ago (2020–2021)	Two years ago (2019–2020)
If she goes out without telling him?			
If she neglects the children?			
If she argues with him?			
If she refuses to have sex with him?			
If she burns the food?			

Annex 6. Results using women's empowerment score

The relationship between a women's empowerment score and access to and knowledge and adoption of CSA after receiving TA

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co–head's**			**Intrahousehold gender differences in**		
	Access to TA on CSA	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**	**Access to TA on CSA**	**Knowledge intensity of CSA after receiving TA**	**Adoption intensity of CSA after receiving TA**
Empowerment score	−0.15	−0.02	0.23	−0.26	−0.00	0.10
	(0.21)	(0.02)	(0.52)	(0.21)	(0.01)	(0.45)
Moderate climate change severity	−0.18	−0.00	0.03	0.19	−0.02***	−0.08
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
High climate change severity	−0.19	−0.01	0.01	0.07	−0.01**	0.04
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Constant	0.45**	0.05***	0.85*	0.14	0.01	0.36
	(0.18)	(0.02)	(0.44)	(0.18)	(0.01)	(0.38)
Observations	198	198	198	198	198	198
R-squared	0.24	0.09	0.09	0.05	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Moderate and high as compared to low perceived climate change severity

The relationship between a women's empowerment score and CIS (access to CIS, knowledge intensity in CIS and adoption intensity of advised practices after receiving CIS) in the face of climate change

	(1)	(2)	(3)	(4)	(5)	(6)
Indicators	**Female co–head's**			**Intrahousehold gender difference in**		
	Access to CIS	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**	**Access to CIS**	**Knowledge intensity in CIS**	**Adoption intensity of advised practices after receiving CIS**
Empowerment score	−0.02	0.06	0.00	0.05	−0.06	0.00
	(0.09)	(0.05)	(0.03)	(0.08)	(0.05)	(0.03)
Moderate climate change severity	0.00	0.02	0.00	0.09*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
High climate change severity	0.09*	0.09***	0.01	0.01	0.04	−0.00
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.01)
Constant	0.82***	0.14***	0.05**	0.03	−0.00	−0.00
	(0.07)	(0.05)	(0.02)	(0.07)	(0.05)	(0.02)
Observations	198	198	198	198	198	198
R-squared	0.13	0.19	0.05	0.11	0.04	0.03

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1; Moderate and high as compared to low perceived climate change severity

Annex 7. Correlation matrix for the different empowerment subdimensions

Variables	Intrinsic agency	Collective agency	Attitudes toward violence	Instrumental agency
Intrinsic agency	1.000			
Collective agency	0.065	1.000		
	0.362			
Attitude toward violence	0.420*	0.036	1.000	
	0.000	0.611		
Instrumental agency	−0.031	0.082	−0.109	1.000
	0.663	0.248	0.125	

Annex 8. Differences in coefficients for various dimensions of empowerment across access, knowledge and adoption of CSA practices (TA) for female co-heads and gender differences

Female co-head's access to TA				
	Intrinsic agency	**Norms**	**Collective agency**	**Instrumental agency**
Intrinsic agency	0.00			
Norms	0.01	0.00		
Collective agency	0.23	0.18	0.00	
Instrumental agency	0.29	0.26	0.04	0.00
Female co-head's knowledge intensity of CSA after receiving TA				
Intrinsic agency	0.00			
Norms	0.24	0.00		
Collective agency	0.23	0.01	0.00	
Instrumental agency	1.38	0.72	0.72	0.00
Female co-head's adoption intensity of CSA after receiving TA				
Intrinsic agency	0.00			
Norms	1.57	0.00		
Collective agency	0.73	0.49	0.00	
Instrumental agency	4.29**	1.23	2.22	0.00
Intrahousehold gender differences in access to TA on CSA				
Intrinsic agency	0.00			
Norms	3.17*	0.00		
Collective agency	3.24*	0.09	0.00	
Instrumental agency	1.73	0.06	0.00	0.00
Intrahousehold gender difference in knowledge intensity of CSA after receiving TA				
Intrinsic agency	0.00			
Norms	0.32	0.00		
Collective agency	0.45	0.00	0.00	
Instrumental agency	0.15	0.97	0.86	0.00
Intrahousehold gender difference in adoption intensity of CSA after receiving TA				
Intrinsic agency	0.00			
Norms	0.10	0.00		
Collective agency	0.65	0.28	0.00	
Instrumental agency	o.38	0.15	0.00	0.00

Note: F(1, 183) *** p<0.01, ** p<0.05, * p<0.1

Differences in coefficients for various dimensions of empowerment across CIS (access to CIS, knowledge intensity in CIS and adoption intensity of advised practices after receiving CIS) in the face of climate change

Female co-head's access to CIS				
	Intrinsic agency	**Norms**	**Collective agency**	**Instrumental agency**
Intrinsic agency	0.00			
Norms	0.63	0.00		
Collective agency	4.52**	2.09	0.00	
Instrumental agency	0.02	0.87	3.30*	0.00
Female co-head's knowledge intensity in CIS				
Intrinsic agency	0			
Norms	3.45*	0		
Collective agency	2.42	0.48	00.00	
Instrumental agency	0.14	4.96**	2.61	0.00
Female co-head's adoption intensity of advised practices after receiving CIS				
Intrinsic agency	0.00			
Norms	0.33	0.00		
Collective agency	0.02	0.90	0.00	
Instrumental agency	0.70	0.15	0.95	0.00
Intrahousehold gender difference in access to CIS				
Intrinsic agency	0.00			
Norms	0.24	0.00		
Collective agency	0.13	0.06	0.00	
Instrumental agency	0.09	0.02	0.00	0.00
Intrahousehold gender differences in knowledge intensity in CIS				
Intrinsic agency	0.00			
Norms	0.07	0.00		
Collective agency	0.77	0.46	0.00	
Instrumental agency	0.05	0.27	0.86	0.00
Intrahousehold gender difference in adoption intensity of advised practices after receiving CIS				
Intrinsic agency	0.00			
Norms	1.08	0.00		
Collective agency	0.70	0.19	0.00	
Instrumental agency	0.09	0.46	0.12	0.00

Note: F(1, 183) *** p<0.01, ** p<0.05, * p<0.1

Annex 9. Full model results

Correlation between binary women's empowerment and access, knowledge and adoption of CSA after receiving TA full results

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to TA on CSA**	**Female co-head's intensity of knowledge of CSA after receiving TA**	**Female co-head's adoption intensity of CSA after receiving TA**	**Gender differences in access to TA on CSA**	**Gender differences in intensity of knowledge of CSA after receiving TA**	**Gender differences in adoption intensity of CSA after receiving TA**
Binary variable on empowerment	−0.04	−0.01	0.04	−0.13*	0.00	0.12
	(0.08)	(0.01)	(0.19)	(0.08)	(0.00)	(0.17)
Climate change severity 2 = moderate	−0.18	−0.00	0.04	0.19	−0.02***	−0.10
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Climate change severity 3 = high severity	−0.19	−0.01	0.02	0.07	−0.01**	0.02
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Land size in ha	0.06**	0.00	−0.02	−0.02	−0.00	−0.08
	(0.03)	(0.00)	(0.07)	(0.03)	(0.00)	(0.06)
Age difference between household head and spouse	0.00	0.00	−0.01	0.00	0.00	0.00
	(0.01)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)
Education of household head (binary variable 1= higher than primary)	−0.15**	−0.01*	−0.26	0.07	0.00	0.19
	(0.07)	(0.01)	(0.16)	(0.06)	(0.00)	(0.14)
Province 2 = North-Western Province	0.40***	0.00	0.60***	−0.06	−0.00	0.16
	(0.07)	(0.01)	(0.17)	(0.07)	(0.00)	(0.14)
Equity tool quantile 3	0.23***	0.02**	−0.14	−0.01	0.01	−0.07
	(0.08)	(0.01)	(0.21)	(0.08)	(0.00)	(0.18)
Equity tool quantile 4	0.19*	0.02*	−0.10	−0.04	0.01**	−0.09
	(0.10)	(0.01)	(0.25)	(0.10)	(0.00)	(0.22)
Equity tool quantile 5	−0.07	−0.00	−0.65	−0.02	0.00	0.03
	(0.16)	(0.01)	(0.41)	(0.16)	(0.01)	(0.35)
No. of household members	−0.00	−0.00*	0.01	0.00	0.00	−0.06**
	(0.01)	(0.00)	(0.03)	(0.01)	(0.00)	(0.03)
Constant	0.38**	0.04***	0.95**	0.01	0.00	0.42
	(0.16)	(0.01)	(0.39)	(0.16)	(0.01)	(0.34)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.24	0.09	0.09	0.06	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Correlation between women's empowerment score and access, knowledge and adoption of CSA after receiving TA

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to TA on CSA**	**Female co-head's intensity of knowledge of CSA after receiving TA**	**Female co-head's adoption intensity of CSA after receiving TA**	**Gender differences in access to TA on CSA**	**Gender differences in intensity of knowledge of CSA after receiving TA**	**Gender differences in adoption intensity of CSA after receiving TA**
Empowerment score	−0.15	−0.02	0.23	−0.26	−0.00	0.10
	(0.21)	(0.02)	(0.52)	(0.21)	(0.01)	(0.45)
Climate change severity 2 = moderate	−0.18	−0.00	0.03	0.19	−0.02***	−0.08
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Climate change severity 3 = high severity	−0.19	−0.01	0.01	0.07	−0.01**	0.04
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Land size in ha	0.06**	0.00	−0.02	−0.03	−0.00	−0.08
	(0.03)	(0.00)	(0.07)	(0.03)	(0.00)	(0.06)
Age difference between household head and spouse	0.00	0.00	−0.00	0.00	0.00	0.00
	(0.01)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)
Education of household head (binary variable 1 = higher than primary school)	−0.15**	−0.01*	−0.27	0.07	0.00	0.18
	(0.07)	(0.01)	(0.16)	(0.07)	(0.00)	(0.14)
Province 2 = North-Western Province	0.40***	0.00	0.60***	−0.06	−0.00	0.16
	(0.07)	(0.01)	(0.17)	(0.07)	(0.00)	(0.14)
Equity tool quantile 3	0.23***	0.02**	−0.14	−0.02	0.01	−0.05
	(0.08)	(0.01)	(0.21)	(0.08)	(0.00)	(0.18)
Equity tool quantile 4	0.19*	0.02*	−0.11	−0.04	0.01**	−0.08
	(0.10)	(0.01)	(0.25)	(0.10)	(0.00)	(0.22)
Equity tool quantile 5	−0.07	−0.00	−0.66	−0.01	0.00	0.03
	(0.16)	(0.01)	(0.41)	(0.16)	(0.01)	(0.35)
No. of household members	−0.00	−0.00*	0.01	0.00	0.00	−0.06**
	(0.01)	(0.00)	(0.03)	(0.01)	(0.00)	(0.03)
Constant	0.45**	0.05***	0.85*	0.14	0.01	0.36
	(0.18)	(0.02)	(0.44)	(0.18)	(0.01)	(0.38)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.24	0.09	0.09	0.05	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Correlation between binary women's empowerment and CIS (access to CIS, knowledge intensity in CIS and adoption intensity of advised practices after receiving CIS) in the face of climate change

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to CIS**	**Female co-head's extent of CIS received**	**Female co-head's adoption intensity of advised practices after receiving CIS crops + liv**	**Gender differences in access to CIS**	**Gender differences in the extent of CIS received**	**Gender differences in adoption intensity of advised practices after receiving CIS crops + liv**
Binary variable on empowerment (1 = empowered)	−0.03	−0.01	−0.01	0.04	0.01	0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Climate change severity 2 = moderate severity	0.01	0.03	0.00	0.08*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)
Climate change severity 3 = high severity	0.09*	0.10***	0.01	0.01	0.03	−0.00
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.01)
Land size in ha	0.01	0.01	0.00	−0.01	0.00	0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Age difference between household head and spouse	0.00	−0.00	0.00	−0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education of household head (binary variable 1 = higher than primary school)	−0.03	−0.02	−0.01	0.01	0.00	−0.01
	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Province 2 = North-Western Province	0.07**	0.01	0.02**	−0.06**	0.01	−0.00
	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Equity tool quantile 3	0.07**	0.03	0.01	−0.06*	0.01	−0.00
	(0.04)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Equity tool quantile 4	0.09**	0.10***	0.02	−0.06	0.02	0.00
	(0.04)	(0.03)	(0.01)	(0.04)	(0.03)	(0.01)
Equity tool quantile 5	−0.02	0.03	−0.00	0.06	0.06	0.00
	(0.07)	(0.04)	(0.02)	(0.06)	(0.04)	(0.02)
No. of household members	0.00	−0.01*	−0.00	0.00	−0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.80***	0.16***	0.05**	0.06	−0.02	0.00
	(0.07)	(0.04)	(0.02)	(0.06)	(0.04)	(0.02)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.13	0.19	0.05	0.12	0.04	0.04

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Correlation between women's empowerment score and CIS (access to CIS, knowledge intensity in CIS and adoption intensity of advised practices after receiving CIS) in the face of climate change

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to CIS**	**Female co-head's extent of CIS received**	**Female co-head's adoption intensity of advised practices after receiving CIS crops + liv**	**Gender differences in access to CIS**	**Gender differences in extent of CIS received**	**Gender differences in adoption intensity of advised practices after receiving CIS crops + liv**
Empowerment score (0–1)	−0.02	0.06	0.00	0.05	−0.06	0.00
	(0.09)	(0.05)	(0.03)	(0.08)	(0.05)	(0.03)
Climate change severity 2 = moderate	0.00	0.02	0.00	0.09*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
Climate change severity 3 = high severity	0.09*	0.09***	0.01	0.01	0.04	−0.00
	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.01)
Land size in ha	0.01	0.00	0.00	−0.01	0.01	0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Age difference between household head and spouse	0.00	−0.00	−0.00	−0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education of household head (binary variable 1 = higher than primary school)	−0.03	−0.02	−0.01	0.01	0.00	−0.01
	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Province 2 = North-Western Province	0.07**	0.01	0.02**	−0.06**	0.01	−0.00
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Equity tool quantile 3	0.07**	0.03	0.01	−0.05*	0.01	−0.00
	(0.04)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Equity tool quantile 4	0.08*	0.10***	0.01	−0.05	0.02	0.01
	(0.04)	(0.03)	(0.01)	(0.04)	(0.03)	(0.01)
Equity tool quantile 5	−0.02	0.02	−0.00	0.06	0.07	0.00
	(0.07)	(0.04)	(0.02)	(0.06)	(0.04)	(0.02)
No. of household members	0.00	−0.01*	−0.00	0.00	−0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.82***	0.14***	0.05**	0.03	−0.00	−0.00
	(0.07)	(0.05)	(0.02)	(0.07)	(0.05)	(0.02)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.13	0.19	0.05	0.11	0.04	0.03

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Correlation between various dimensions of empowerment and access, knowledge and adoption of CSA after receiving TA

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to TA on CSA**	**Female co-head's intensity of knowledge of CSA after receiving TA**	**Female co-head's intensity in adoption of CSA after erceiving TA**	**Gender differences in access to TA on CSA**	**Gender differences in intensity of knowledge of CSA after receiving TA**	**Gender differences in intensity in adoption of CSA after receiving TA**
Intrinsic agency	−0.02	−0.01	−0.19	0.11	0.00	0.05
	(0.10)	(0.01)	(0.24)	(0.09)	(0.00)	(0.21)
Collective agency	0.04	−0.00	0.07	−0.11	−0.00	−0.17
	(0.07)	(0.01)	(0.18)	(0.07)	(0.00)	(0.16)
Attitude toward violence	−0.00	0.00	0.25	−0.14*	−0.00	−0.05
	(0.07)	(0.01)	(0.18)	(0.07)	(0.00)	(0.16)
Instrumental agency	0.07	0.01	0.66*	−0.10	0.00	−0.17
	(0.14)	(0.01)	(0.34)	(0.13)	(0.01)	(0.29)
Climate variability 2 = moderate variability	−0.21*	−0.01	−0.03	0.20	−0.02***	−0.03
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Climate variability 3 = high variability	−0.21*	−0.02	−0.02	0.04	−0.01***	0.06
	(0.12)	(0.01)	(0.30)	(0.12)	(0.01)	(0.26)
Land size in ha	0.06**	0.00	−0.03	−0.03	−0.00	−0.07
	(0.03)	(0.00)	(0.07)	(0.03)	(0.00)	(0.06)
Age difference between household head and spouse	0.00	0.00	−0.01	0.01	0.00	0.00
	(0.01)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)
Education of household head (binary variable 1 = above primary)	−0.14**	−0.01*	−0.27	0.05	−0.00	0.16
	(0.07)	(0.01)	(0.17)	(0.07)	(0.00)	(0.15)
Province 2 = North-Western Province	0.41***	0.01	0.65***	−0.08	0.00	0.14
	(0.07)	(0.01)	(0.17)	(0.07)	(0.00)	(0.15)
Equity tool quantile 3	0.22***	0.02**	−0.09	−0.05	0.01	−0.05
	(0.08)	(0.01)	(0.21)	(0.08)	(0.00)	(0.18)
Equity tool quantile 4	0.18*	0.02*	−0.04	−0.07	0.01**	−0.04
	(0.10)	(0.01)	(0.26)	(0.10)	(0.00)	(0.22)
Equity tool quantile 5	−0.08	−0.00	−0.67	−0.02	0.00	0.06
	(0.17)	(0.02)	(0.41)	(0.16)	(0.01)	(0.36)

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Female co-head's access to TA on CSA**	**Female co-head's intensity of knowledge of CSA after receiving TA**	**Female co-head's intensity in adoption of CSA after erceiving TA**	**Gender differences in access to TA on CSA**	**Gender differences in intensity of knowledge of CSA after receiving TA**	**Gender differences in intensity in adoption of CSA after receiving TA**
No. of household members	−0.01	−0.00*	0.00	0.00	0.00	−0.06**
	(0.01)	(0.00)	(0.03)	(0.01)	(0.00)	(0.03)
Constant	0.33*	0.04**	0.42	0.15	0.00	0.57
	(0.19)	(0.02)	(0.48)	(0.19)	(0.01)	(0.42)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.24	0.09	0.12	0.08	0.09	0.07

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Correlation between various dimensions of empowerment and CIS (access to CIS, knowledge intensity in CIS and adoption intensity of advised practices after receiving CIS) in the face of climate change

Variables	Female co-head's access to CIS	Female co-head's extent of CIS received	Female co-head's adoption intensity of advised practices after receiving CIS crops + liv	Gender differences in access to CIS	Gender differences in extent of CIS received	Gender differences in adoption intensity of advised practices after receiving CIS crops + liv
Intrinsic agency	0.04	0.04*	−0.00	−0.01	−0.00	0.01
	(0.04)	(0.02)	(0.01)	(0.04)	(0.02)	(0.01)
Collective agency	0.07**	0.00	0.00	−0.01	0.03	0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Attitude toward violence	−0.00	−0.02	0.01	0.02	−0.01	−0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Instrumental agency	0.05	0.06*	0.02	0.01	0.01	−0.00
	(0.06)	(0.03)	(0.02)	(0.05)	(0.04)	(0.02)
Climate variability 2 = moderate variability	0.01	0.02	0.00	0.09*	0.04	0.01
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
Climate variability 3 = high variability	0.07	0.08**	0.01	0.02	0.03	−0.00
	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
Land size in ha	0.01	0.00	0.00	−0.01	0.00	0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Age difference between household head and spouse	0.00	−0.00	−0.00	−0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education of household head (binary variable 1 = above primary school)	−0.04	−0.02	−0.01	0.01	−0.00	−0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Province 2 = North-Western Province	0.07**	0.01	0.02*	−0.06**	0.02	−0.00
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Equity tool quantile 3	0.07*	0.02	0.01	−0.05	0.01	−0.00
	(0.04)	(0.02)	(0.01)	(0.03)	(0.02)	(0.01)
Equity tool quantile 4	0.09**	0.10***	0.02	−0.05	0.02	0.01
	(0.04)	(0.03)	(0.01)	(0.04)	(0.03)	(0.01)
Equity tool quantile 5	−0.01	0.02	−0.00	0.06	0.06	0.00
	(0.07)	(0.04)	(0.02)	(0.06)	(0.04)	(0.02)

Variables	Female co-head's access to CIS	Female co-head's extent of CIS received	Female co-head's adoption intensity of advised practices after receiving CIS crops + liv	Gender differences in access to CIS	Gender differences in extent of CIS received	Gender differences in adoption intensity of advised practices after receiving CIS crops + liv
No. of household members	0.00	−0.01*	−0.00	0.00	0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.71***	0.10*	0.03	0.05	−0.05	−0.00
	(0.08)	(0.05)	(0.03)	(0.08)	(0.05)	(0.03)
Observations	198.00	198.00	198.00	198.00	198.00	198.00
R-squared	0.16	0.22	0.06	0.11	0.05	0.04

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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