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Climate Variability and Extreme Weather Shocks in Africa: Are Female or Male Farmers More Affected?

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Abstract

African agriculture is highly sensitive to weather variability and extreme weather shocks. The question of how weather events affect participation in agricultural employment—including from a gender perspective—remains unanswered. This study aims to empirically quantify differences in how women and men adapt their participation in agricultural employment in response to climate variability and extreme weather events. Our study uses a novel individual-level database that draws mostly from Labour Force Surveys (LFS) that represents more than 80% of the total African population and covers nearly 86% of the Africa's total workforce. In order to identify shock-affected areas, we match data from that LFS with gridcell monthly time series bioclimatic variables (temperature and rainfall). We estimate two systems of equations using the seemingly unrelated regressions (SUR) estimator to account for the potential contemporaneous correlation of the error terms in each equation. Descriptive results by region show that, regardless of age and sex, agriculture dominates employment distribution. In West and Central Africa and in East and Southern Africa region the agricultural sector employs the largest share of the working population. Multivariate SUR results show that, of all weather events, heat waves and droughts have the greatest detrimental effecton the intensity of individual efforts in agriculture; the number of work hours is reduced by 40% in the case of heat waves and 14% during droughts. If farmers are women, however, the reduction in work hours due to heat wave is lessened by 40%. Given the fundamental role of women both in agricultural production and in coping with extreme weather shocks, the key priorities would lie on implementation of sustainable, climate-resilient, and gender-sensitive policies; corresponding interventions in the labor market; and gender mainstreaming in planning and promoting agriculture- and job-related programs.

1. Introduction

Agriculture in Africa supports the livelihoods of the vast majority of the African population and is the sector that absorbs the majority of the working population (James, 2014; World Bank, 2011). Data suggest that almost 224 million people aged 15 and above are directly engaged in agriculture in Africa (ILO, 2021); this corresponds to nearly half of the continent's total employed population and one-quarter of global agricultural employment.

Women play a crucial role in African agriculture. According to International Labour Organization (ILO) estimates, more than 100 million African women are directly engaged in the sector (ILO, 2021), representing 44.8% of total agricultural employment in Africa. Climate change constitutes an enormous challenge for Africa given agriculture's prominence in the economies of its countries, its importance to the livelihoods of their populations, and the sector's extreme sensitivity to climate variability and extreme weather shocks (Belloumi, 2014). An empirical approach to data can help determine the degree to which climate change and extreme weather events are currently affecting participation in agricultural employment and, by extension, agricultural livelihoods; it can also shed light on potential trends. Given the large percentage of women who are involved in agriculture on the continent, a gender perspective on understanding this question is critical.

As the scientific community continues to develop more accurate climate model simulations, analyses, and methods (IPCC, 2021a; Santer et al., 2021; Deser et al., 2020; Emori & Brown, 2005; Watterson & Dix, 2003), new alarming trends in global warming have been observed. In the past few decades, the Intergovernmental Panel on Climate Change (IPCC) has observed that the surface temperature in Africa has increased at a faster pace than the global average; it also reports that the frequency of heat waves has increased in Africa and that it is projected to increase further throughout the 21st century (IPCC, 2021b; Iturbide et al., 2020). Looking at global warming trends, it is emerging that Africa is likely to be exposed to more severe climate change conditions than other parts of the world (Weber et al., 2018). There is a consensus that agricultural yields in Africa will continue to be severely affected by changes in temperature and precipitation (Kurukulasuriya & Rosenthal, 2013) and by extreme weather events. Millions of people on the African continent, especially women whose livelihoods depend on agriculture, are expected to be disproportionately affected (Zougmoré et al., 2016) as they will potentially be prevented from engaging in agricultural employment. Under the dire scenarios projected by the IPCC (IPCC, 2021b), a vast majority of vulnerable people whose livelihoods are based on agriculture are likely to be pushed into poverty as they lack the capacity to cope with weather-related shock and climate variability (Shiferaw et al., 2014).

Indeed, to date climate change and extreme weather events represent the most pressing threat to agriculture, and immediate policy action is called for. Increasing awareness of the devastating effects of climate change on agricultural production has led to the setting up of specific policy objectives, which have been prioritized in the international policy agenda (Gupta & Tirpak, 2007). As the scientific community provides more empirical evidence on the expected negative impact of climate change on agriculture, a number of institutions at various levels have developed an array of policies and programs to combat greenhouse gas (GHG) emissions, in an effort to limit the negative consequences of climate change on agriculture (Smith & Martino, 2007; James, 2020; Ahmed et al., 2012; FAO, 2017; Meridian Institute, 2011). There has been an increasing commitment to combatting climate change; however, mainstreaming of the importance of gender to the impacts of climate change on agriculture has received little attention and has failed to be incorporated into concrete policy actions (Alston, 2014).

The existing body of literature on the relationship between gender and climate change in agriculture has focused on differential gender exposure to climate stressors; it suggests that women are more likely to be negatively affected by climate change and weather shocks than men. Women's higher vulnerability to climate stressors is primarily driven by several limiting conditions; these include lack of access to diversified livelihood strategies, which hinders women in their efforts to manage the daily risks and difficulties associated with climate variability and extreme weather events (Lal et al., 2012; Olsson et al., 2015). Although it is not surprising that women suffer more from weather-related stressors than men, the empirical literature has not yet explored the impacts of women's efforts to mitigate the negative effects of extreme weather events on agriculture. Considering women's prominent role in agriculture, this study aims to quantify differences in how women and men adapt the intensity of their participation in agricultural employment in response to extreme weather events.

The remainder of the paper is structured as follows. Section 2 provides a review of the available literature on participation in agricultural employment and climate change in Africa. In

Section 3, we present the data and methods used to estimate the effects of weather-related stressors on intensity of participation in agricultural employment. In Section 4 we show sex-disaggregated descriptive summaries of populations directly engaged in agriculture and we explore the main correlates of individual employment in agriculture as well as the effects of weather variability and shocks on employment intensity. Section 5 concludes and provides some policy implications.

2. Female Agricultural Employment and Weather Variability: A Literature Review

The two key elements on which agriculture-based livelihoods hinge are intensity of participation and returns on agricultural activity. Both elements are inevitably affected by institutional factors (e.g., governance, rule of law) and by the exogenous factors of extreme climate events and increasing variability in temperature and precipitation.

According to our review of the empirical literature, three facts emerge clearly. First, agricultural employment is irregular and is determined by the seasonal nature of agricultural activities; second, given the sensitivity of agriculture to weather, changing climate conditions are expected to reduce the intensity of participation in agricultural employment; this will negatively affect the livelihoods of agriculture-dependent populations and will thus increase their vulnerability. Third, although women have a crucial role in sustaining agriculture-dependent households, they suffer disproportionately from weather-related shocks, this is primarily due to the impediments they face in managing the risks associated with climate change.

Agricultural employment is by nature erratic and seasonal, which leads to substantial heterogeneity of livelihoods (Davis et al., 2014). Occupation multiplicity (having two or more jobs in a year) is a reality for many workers whose main employment is in agriculture; for these individuals, periods of overemployment alternate with periods of underemployment (Oya, 2015), depending on the season. This already-erratic participation in agricultural employment is further exacerbated by environmental factors such as variability in temperature and precipitation, forcing agricultural workers to diversify their livelihood strategies. Temperature and rainfall patterns are thus expected to directly affect the intensity of employment in agriculture (ILO, 2018a). Agricultural activities can be significantly affected by both extreme weather such as heat waves, droughts, and floods and by weather variability such as temperature variation in a given year or intra-annual variation in monthly precipitation; this ultimately disrupts participation in agriculture-related sectors, particularly when the capacity to adapt and cope is relatively low (Niles & Salerno, 2018).

A number of studies have empirically documented the socioeconomic costs of weather variability and extreme climatic shocks (SEI, 2009; Babatunde & Odusola, 2015; Müller et al., 2011), and have estimated the associated negative effects on crop revenues and food production (Ochieng et al., 2016). Other studies have investigated the effects of limiting environmental factors on smallholder agriculture, suggesting that in the case of weather shocks small farmers are often forced to rely on off-farm jobs (Bohle et al., 1994).

The long-term trends in Africa's temperature and precipitation patterns that have been observed by the IPCC (2021b) are expected to decrease the reliance on agriculture as a source of livelihood; it is anticipated that this will ultimately lead to cascading effects on agricultural livelihoods, rates of poverty, and the food system (Olsson et al., 2015). During the past two decades, surface temperatures recorded in African countries have been increasing faster than the global average (IPCC, 2021b), most likely due to climate change (Kotir, 2011; Kurukulasuriya & Mendelsohn, 2008). Heat waves have been observed more frequently while fewer cold extremes have been recorded. This trend in observed temperature is expected to affect the hydrological cycle, to which agriculture is extremely vulnerable as it is highly reliant on rainfed farming and is thus sensitive to precipitation patterns (Derbile et al., 2016). Increased rainfall variability and unpredictability will ultimately increase the likelihood of droughts and floods (Derbile et al., 2016). Despite the overall increases in temperature that are being observed across the continent (Figure 1), the IPCC's analysis shows some regional differences in long-term trends.

Average precipitation in North Africa has declined substantially, with increased prevalence of aridity and drought; the latter is also observed in West and Central Africa (WCA) and generally in East and Southern Africa (ESA). Some areas of ESA have experienced a decrease in snow and a decline in glacier coverage, while other regions have observed more intense precipitation that has led to flooding, in parallel to a decrease in snow and glaciers coverage (IPCC, 2021b). In many areas of the continent, drought events represent the most pressing threat to agriculture, with negative effects on both food production and food security (Shiferaw et al., 2014). Increasingly unpredictable environmental factors remain a crucial source of uncertainty for many agriculture-dependent individuals, potentially preventing them from engaging in agricultural activities (Dunne et al., 2013; Patricola & Cook, 2010). As a viable coping strategy, many individuals are only partly dependent on agriculture and rely on livelihood diversification strategies to increase their resilience to weather variability and extreme shocks.

Women's labor is a crucial factor for agricultural household livelihoods, although their role still appears to be limited to subsistence production. Although women contribute to much of the work done within the home (FAO, 2018), they are less likely to be directly engaged in productive agricultural activities than men. According to the Food and Agriculture Organization, women face "gender-specific challenges to full participation in the labour force" (FAO, 2011, p. 7). An analysis of survey data extracted from six nationally representative household surveys conducted in Africa south of the Sahara (SSA) suggests that, on average, 40% of the agricultural work force is made up of women; in Malawi, Tanzania, and Uganda it is slightly above 50%, and it is much lower in Nigeria (37%), Ethiopia (29%), and Niger (24%) (Palacios-Lopez et al., 2017). The reality is that women often combine productive and domestic activities, especially during seasons and times of year when there is a high demand for agricultural workers (Oya, 2015). This arrangement implies that due to women's much higher contribution to household-related tasks, their participation in productive agriculture and the time they devote to it may not be as high as that of men (FAO, 2018).

Despite the well-documented pivotal role of women in both agricultural production and household-related activities, it is expected that they will experience a greater impact than men from weather-related shocks. A large body of literature suggests that pre-existing gender gaps in agriculture are magnified under climate-sensitive conditions; for example, when climate-related disasters lead to declining yields and increasing food insecurity, the amount of food consumed by women tends to decline more than that of men (Lambrou & Nelson, 2013). Men are also more likely than women to migrate to shock-unaffected areas, leaving women to do extra agricultural work in their absence. To supplement and support household livelihoods, women thus assume an increased workload and greater household responsibilities (Goh, 2012). A study conducted in Tanzania has found that extreme weather events force poor women to work for wealthier women in order to collect animal fodder; this contributes further to women's already heavy workload and caretaking responsibilities (Muthoni & Wangui, 2015). In many instances, extreme weather events force women to accept jobs that expose them to hazards, illness, and work exploitation (Pouliotte et al., 2009). In some African and Asian countries, women work long hours in tea production without breaks since they are paid by quantity of production; in such circumstances they also often experience heat-related stress (Oxfam, 2009).

In general, women's higher degree of vulnerability to climate change and extreme weather events is due to a complex mix of factors; these range from gender-specific divisions of labor; lack of access to, and use of, agricultural resources such as agricultural land, inputs, and extension services; and limited capacity for adapting quickly to climate-related stressors, which is often exacerbated by pressure to conform to customary norms and roles (Jost et al., 2016; Kakota et al., 2011; Nyasimi & Huyer, 2017).

Women's well-documented pivotal role in enhancing agricultural performance and mitigating the negative effects of extreme weather events remains a key entry point for local advocacy initiatives in support of women in agriculture. Government-led interventions to address adaptation strategies have, however, failed to properly incorporate gender into planning and budgeting; this failure risks cementing or even increasing pre-existing gender inequalities (Alston, 2014).

3. Data and Methods

3.1 Data

In recent years, countries have increased their commitment to collecting systematic labor market statistics through dedicated and nationally representative Labour Force Surveys (LFSs). LFSs represent the main source of official labor statistics at the country level (ILO, 2018b) and are the best option available for characterizing a population's labor force status. LFSs collect detailed and context-specific labor market microdata, including on working conditions. Despite the increasing commitment to implementing LFSs, efforts to conduct such surveys in SSA remain disappointing overall (Oya, 2010). Compared to other regions such as the Arab region (Economic Research Forum, 2022), the European Union (Eurostat, 2021), Latin America, and Asia (Sender et al., 2005), only a few African countries have recently implemented an LFS.

For countries where LFSs are not implemented, labor market statistics can usually be drawn from other types of nationally representative household surveys. In Africa, the lack of systematically collected LFS labor market microdata is counterbalanced by data collected through household income and expenditure surveys such as the Living Standards Measurement Study (World Bank, 2022). These surveys usually include a short employment module to collect basic labor market information. Typically, information collected through household income and expenditure surveys is limited to the labor force status of the working-age population, sector of employment, number of hours worked and, in some instances, remuneration. To assess the effects of climate variability and extreme weather events on sex-specific employment in agriculture in Africa, our analysis considered data from a list of surveys that included basic information on working hours and on main sector of employment; in the end, this included 11 LFSs and 20 household income and expenditure surveys. Taken together, the surveys covered a total of 31 African countries and represented more than 80% of the total African population. They covered nearly 86% of total employed individuals in Africa over the period 2003–2019, although data collection for 24 out of the 31 surveys started in 2014. In Figure 1, Panel A shows the type of surveys used for each of the 31 countries included in the analysis, while Panel B shows the number of people employed in agriculture in each country compared to its total working-age population. All surveys except for those carried out in Chad are also representative at both rural and urban levels.

Thirty out of 31[1] sets of survey data at the lowest administrative division available are matched with gridcell time series bioclimatic variables (temperature and rainfall variability) at a spatial resolution of $\sim 1\text{km}^2$, as derived from the long-term temperature and rainfall values from WorldClim (Fick & Hijmans,

[1] Chad survey data do not contain subnational level information and was therefore excluded from the analysis of weather variability and shocks.

2017). The gridded weather data is first aggregated into the lowest administrative level of the survey in order to calculate the average value for each bioclimatic variable; it is then matched with household-level data at the lowest administrative level of the survey (regional-, district-, or village-level, depending on the country) for their use in the econometric analysis. Panels C and D of Figure 1 show average long-term temperature and precipitation at the lowest administrative levels available in the surveys.

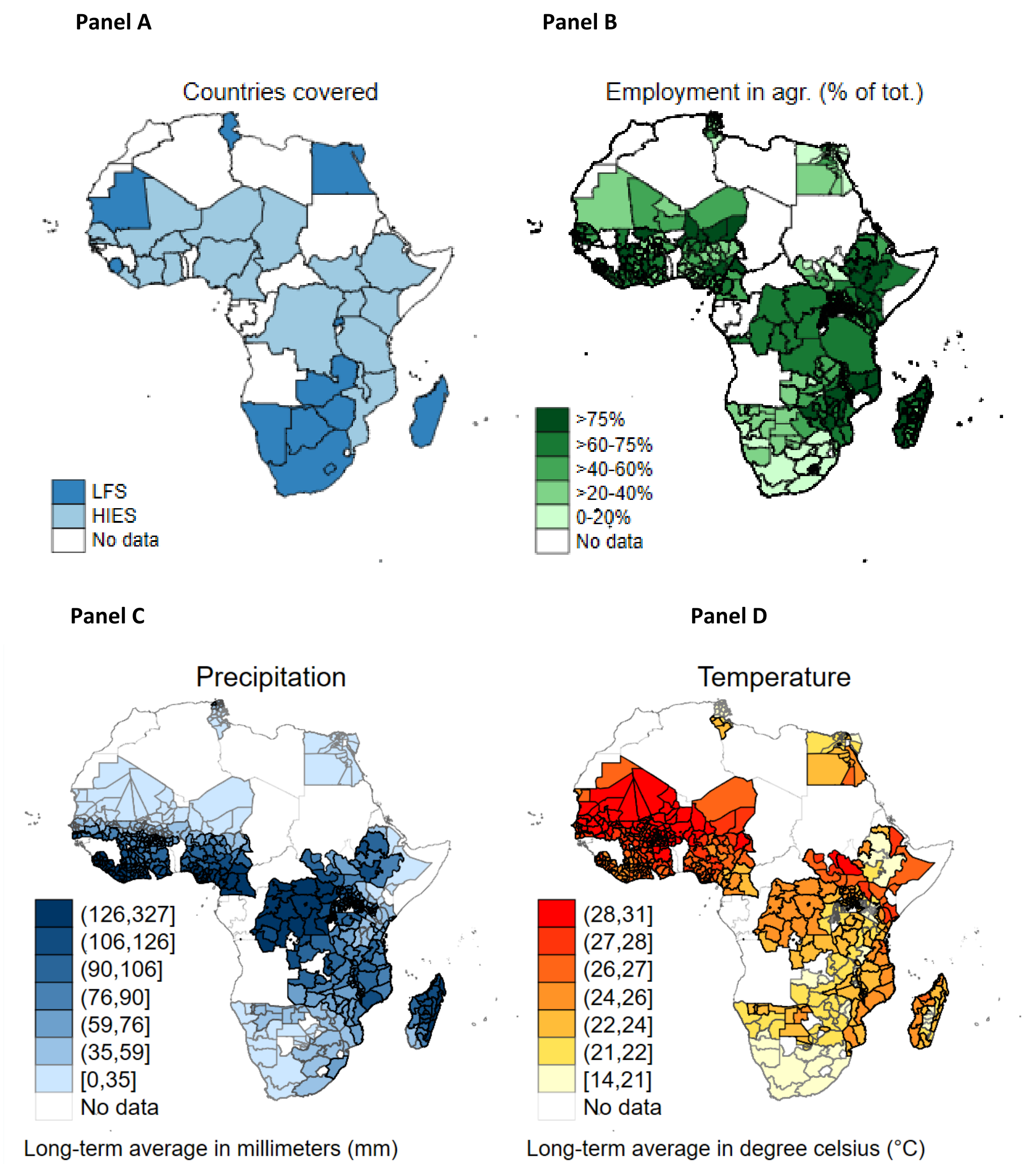

Figure 1. Countries by type of survey (Panel A); employment in agriculture as a percentage of total employment at the level of representativeness of the survey (Panel B); and average long-term mean precipitation and temperature at the lowest administrative level (Panels C and D).

Source: Authors' elaboration based on Labour Force Surveys (LFSs) and Household Income Expenditure Surveys (HIESs) (Panel A and B), and WorldClim (Fick & Hijmans, 2017) (Panel C and D).

3.2 Methods

To explore the effects of climate variability and weather shocks on intensity of participation in agricultural and non-agricultural activities at the individual level, we estimate two systems of equations using the seemingly unrelated regression (SUR) estimator to account for the potential contemporaneous correlation of the error terms in each equation (Zellner, 1962). Compared to the ordinary least squares (OLS) regressor (which does not account for potential correlation between the error terms of different equations), the SUR estimator is expected to lead to more efficient parameter estimates. The two systems of equations are estimated at the household (*h*) and individual (*p*) level, respectively, according to the following specifications:

$$Hours_{i,p,c} = X_{i,p,c}\beta' + Y_{d,c}\beta' + \left(Heat_{d,c}\beta_1\right) + \left(Drought_{d,c}\beta_2\right) + \left(Flood_{d,c}\beta_3\right) + \ n_c + \lambda_t + \varepsilon_i, \quad i = 1,2 \qquad [1]$$

$$Hours_{i,h,c} = X_{i,h,c}\beta' + +Y_{d,c}\beta' + \left(Heat_{d,c}\beta_1\right) + \left(Drought_{d,c}\beta_2\right) + (Flood_{d,c}\beta_3) + n_c + \lambda_t + \varepsilon_i, \quad i = 1,2 \qquad [2]$$

where, in Equation [1], $Hours_{i,p,c}$ expresses the log-transformed number of hours worked by an individual *p* in a typical week in sector *i* (with *i* = 1 being agriculture, and *i* = 2 non-agricultural activity); and p and c are indices for individual and country. Similarly, the dependent variable of Equation [2] captures the aggregate number of hours worked in agricultural (*i* = 1) and non-agricultural activities (*i* = 2) by household *h*, where c is the index for country. In both system of equations, location-specific (regional-, district-, or village-level, depending on the lowest administrative information available in each survey), and year fixed effects (n_c and λ_t, respectively) are also included to control for unobservable characteristics such as differences in institutions, rule of law, and idiosyncratic shocks that may have occurred in specific areas.

In the first system of equations (Equation [1]), $X_{i,p,c}$ is a matrix of individual-level demographic characteristics that include age, sex, highest level of education attained, and the rural/urban location where the individual resides. In this first system of equations, we also control for several household-level characteristics including household size and old-age dependency ratio (see Appendix 2).

In the second system of equations (Equation [2]), $X_{i,h,c}$ is a matrix of household-level covariates (Appendix 3). The independent variables in this second system of equations include: location of residence (urban or rural), household size, average age of household, average level of education attained by household members, share of household members employed, share of household members participating in agricultural and non-agricultural activities (over total household members employed), female-to-male ratio of household members engaged in agricultural and non-agricultural activities; it also includes a number of demographic variables such as old-age dependency ratio and female-to-male ratio of household members. Finally, $Y_{d,c}$ is a matrix of bioclimatic variables that enter both systems of Equations

[1] and [2], with indices d and c indicating the lowest administrative area where the household resides and the corresponding country, respectively.

The seasonal nature of agriculture leads temperature and rainfall variability to affect the intensity of participation in agriculture-related activities and this, in turn, affects agricultural income. The list of bioclimatic variables thus includes temperature and precipitation monthly average values, as well as their associated coefficients of variation (CV); this captures the intra-annual variation over the period 1981 to 2020, as obtained from ERA5 Copernicus Climate Change Service (Hersbach et al. 2018). We also include three dummy variables as proxies for weather-related extreme events, that is, heat waves ($Heat_{d,c}$), droughts ($Drought_{d,c}$), and floods ($Flood_{d,c}$). Weather shock affected areas are then identified as country-specific areas (c) at the lowest administrative level of each survey (d) where temperature and precipitation monthly specific values have been higher or lower than +2 or -2 standard deviations (SD) from the long-term monthly average during any of the six months prior to the survey interview day (as calculated from data from 1981 up until the survey year); a further specification is that the shock must have occurred during the maize cropping season, which are the months for maize planting and growing. Since our aim is to measure the effects of weather shocks on work intensity in agriculture, we refer only to the FAO maize cropping calendar to identify the months of planting and growing for each country in our sample.[2] Finally, ε_i expresses the disturbance term.

In the regressions at the individual level (Equation [1]), gendered effects of weather shocks are captured by adding three interaction terms that identify the effects of the shocks on the intensity of women's participation in agricultural and non-agricultural activities $(W_{i,p,c} * Heat_{d,c}\beta_2)$, $(W_{i,p,c} * Drought_{d,c}\beta_4)$, and $(W_{i,p,c} * Flood_{d,c}\beta_6)$, where the term $W_{i,p,c}$ is a dummy variable equal to 1 for women who engage in either agricultural or non-agricultural activities, as specified in Equation [3] below.

$$Hours_{i,p,c} = X_{i,p,c}\beta' + Y_{d,c}\beta' + (Heat_{d,c}\beta_1) + (W_{i,p,c} * Heat_{d,c}\beta_2) + (Drought_{d,c}\beta_3) + (W_{i,p,c} * Drought_{d,c}\beta_4) + (Flood_{d,c}\beta_5) + (W_{i,p,c} * Flood_{d,c}\beta_6)\, n_c + \lambda_t + \varepsilon_i, i = 1,2 \quad [3]$$

Although the set of equations has separate dependent and explanatory variables, the equations are statistically linked through cross-equation error correlation and joint distribution of error terms. To

[2] In 10 surveys, information on the month of the interview was missing; the three dummies are thus constructed for 21 out of 31 surveys. This leads to a reduction in the number of observations for some of the estimated econometric specifications (see Tables 2 and 3).

test whether the SUR models yield a gain in efficiency (as compared to separate OLS regressions), we also run the Breusch and Pagan test (Breusch & Pagan, 1980). According to the test statistics, the SUR model is recommended in cases where there is a sizable correlation between the residuals of the equations in the system; in our case, given that the *p*-value of the test is less than $\alpha = 0.05$ in both system of Equations [1] and [2], the null hypothesis of independence of the residuals vectors in the two equations is rejected and use of the SUR model is therefore justified.

4. Results

4.1 Descriptive statistics

Using LFS and Household Income Expenditure Survey (HIES) data, we attempt to shed light on sex-disaggregated employment participation in African agriculture in areas affected by extreme weather events. Table 1 presents sex-disaggregated weighted statistics on labor market participation, disaggregated by the three main African regions.

Regardless of age and sex, agriculture dominates employment distribution, with the agricultural sector absorbing the highest share of the total employed population in both WCA and ESA (52% and 60%, respectively); in contrast, only one-fourth of the total employed population of North Africa is engaged in agriculture. In ESA, the share of women participating in the labor market is considerably higher for agriculture than for non-agricultural activities (62% and 38%, respectively), while in WCA women are almost equally distributed between agricultural and non-agricultural work. Table 1 also shows strong differences between average hours worked in agricultural and non-agricultural activities. In all three regions (North, West and Central, and East and Southern Africa), in a typical week the average number of hours worked in agriculture appears to be much lower than hours spend doing non-agricultural work the difference is particularly notable in ESA where, on average, 15.6 hours fewer hours per week are spent engaged in agricultural than in non-agricultural work.

Variable	North Africa			West and Central Africa			East and Southern Africa		
	Female	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**
Age in years	27.07	26.89	26.98	23.25	22.44	22.85	24.53	23.58	24.06
Age of those employed in agriculture	32.80	40.29	38.03	35.53	36.57	36.11	33.09	31.98	32.52
Age of those employed in non-agricultural work	38.18	37.54	37.66	37.60	38.58	38.08	33.89	34.76	34.37
Employed population (percentage of total population)	0.12	0.41	0.27	0.34	0.38	0.36	0.38	0.44	0.41
Employed population with a second job	0.01	0.03	0.02	0.14	0.21	0.18	0.06	0.08	0.07
Share of employment in:									
Agriculture	0.35	0.22	0.25	0.49	0.56	0.52	0.62	0.59	0.60
Non-agricultural activities	0.65	0.78	0.75	0.51	0.44	0.48	0.38	0.41	0.40
Share of employment by sector: *									
Crops	0.33	0.20	0.23	0.41	0.52	0.47	0.56	0.43	0.49
Livestock	0.03	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.02
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Fisheries	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.01
Industry	0.09	0.32	0.27	0.12	0.13	0.13	0.06	0.16	0.11
Services	0.55	0.46	0.48	0.45	0.31	0.37	0.35	0.34	0.34
Other sectors (not specified)	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
Average weekly hours worked in:									
Agriculture	34.88	42.83	40.43	33.74	38.30	36.27	25.03	28.03	26.59
Non-agricultural activities	41.14	46.48	45.51	43.37	48.27	45.76	39.72	44.20	42.25
Average weekly hours worked, by sector: **									
Crops	35.39	42.68	40.49	34.20	38.94	36.95	25.73	28.24	26.90
Livestock	28.31	45.50	37.09	27.35	43.97	39.50	29.42	41.32	38.85
Forestry	48.00	49.79	49.72	32.62	40.71	36.79	30.42	38.50	36.39
Fisheries	.	43.91	43.91	39.48	43.72	43.27	29.69	36.60	35.49
Industry	44.46	45.65	45.57	38.13	48.18	43.63	38.83	43.45	42.23
Services	40.66	47.05	45.50	44.92	49.34	46.84	42.89	47.24	45.12
Other sectors (not specified)	16.17	42.72	28.94	44.78	50.26	48.05	40.26	47.28	44.33

Table 1. Sex-disaggregated labor market indicators in Africa.
Source: Authors' elaboration based on Labour Force Surveys and Household Income Expenditure Surveys for 31 African countries.
Note: * No information on employment participation in the subsectors of agriculture and non-agricultural activities was available for Democratic Republic of the Congo (DRC), Ethiopia, Ivory Coast, Kenya, Lesotho, Liberia, Malawi, South Sudan, Tanzania, or Zimbabwe; ** Due to missing information on employment by sector of economic activity, it was not possible to calculate weekly hours worked by subsector in DRC, Ethiopia, Ivory Coast, Kenya, Lesotho, Liberia, Malawi, South Sudan, Tanzania, or Zimbabwe; all values are statistically different for males and females at the 1% level, except those related to forestry.

The employment statistics presented in Table 1 are calculated using the one-hour criterion, that is, by accounting for all people who spent at least one hour during the reference week working for pay or profit (ICLS, 1982, 2013). Estimates of employment in agriculture, however, do not account for possible low intensity of agricultural participation.

When employment in agriculture is estimated according to all those who work at least one hour during the reference week, approximately 159 million people aged 15 and above were found to be participating in agricultural activities across the 31 analyzed countries (51% of the total employed); employment in non-agricultural activities came to 151 million (49%). In contrast, using a threshold of *at* *least* 10 hours per week to measure employment in agriculture—which is slightly more than 1.5 hours per day, assuming the six-day work week that is prevalent across most African countries—the number of people employed declines by about 15%. This simple comparison between employment statistics based on different cut-off thresholds of participation in the labor market suggests that most of the employment in agriculture is dominated by irregular and low intensity jobs, proxied here (as in Oya, 2015) by relatively low hours worked.

In our study, the underestimated and seasonal nature of employment in agriculture is combined with alarming changes in climatic conditions, specifically the above-average temperatures of the most recent 40 years (Figure 2).

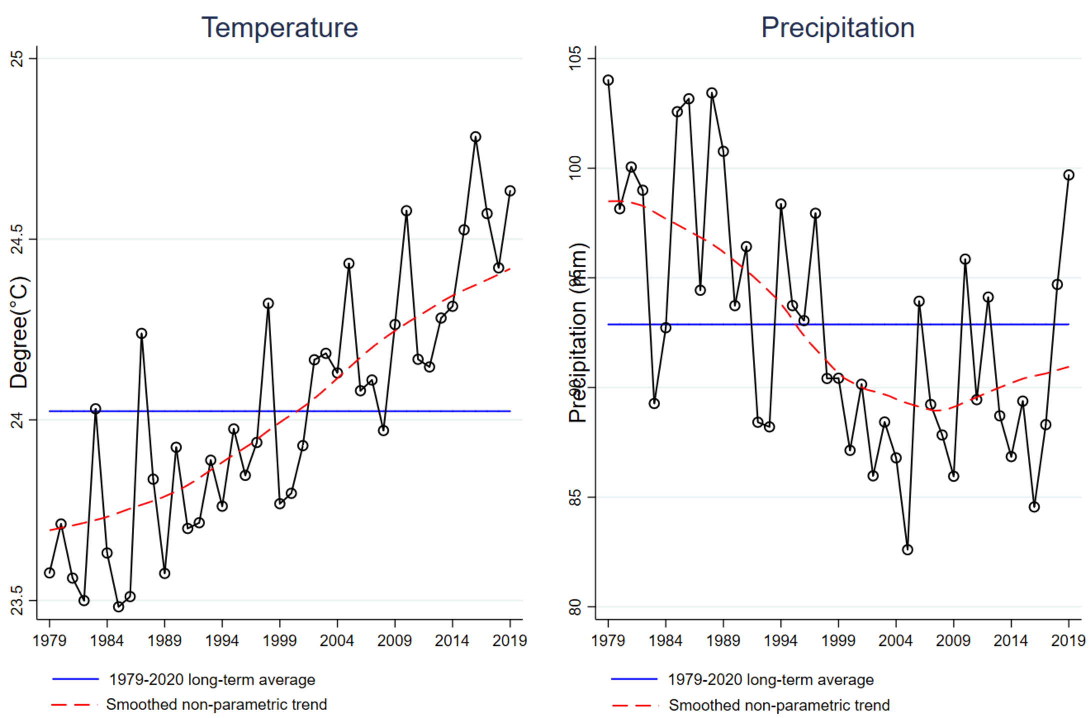

Figure 2. Long-term trends in temperature and precipitation across 30 African countries.
Source: Authors' elaboration based on data by Hersbach et al. (2018).

A closer look at the coefficients of variation (CV) in precipitation shows that among the 30 analyzed African countries, variations in precipitation patterns are particularly severe in many parts of West Africa such as Senegal, Niger, Nigeria, Gambia, Mali, and Mauritania (**Error! Reference source not found.**).

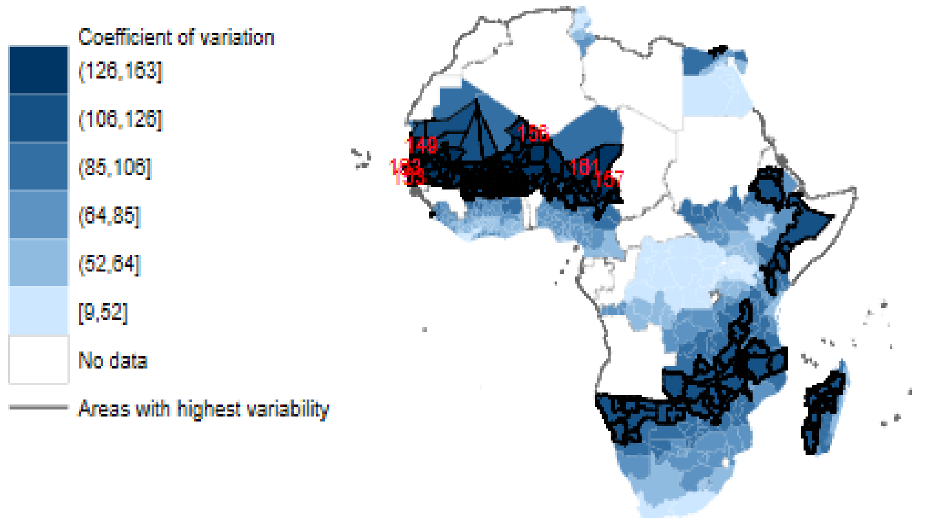

Figure 3. Coefficients of variation in precipitation.
Source: Authors' own calculation based on gridded data obtained from WorldClim (Fick & Hijmans, 2017).

We then examine differential prevalence of sex-specific agricultural employment by shock occurrence area. The data suggests that women are more likely than men to engage in agricultural employment in drought-prone areas and in areas affected by heat waves (Figure 4).[3] Comparing statistics by heat wave occurrence, for example, in WCA women represent 57% of total agricultural employment in affected areas, compared to 45% in unaffected areas; similarly, in areas of ESA affected by heat waves, women in agriculture account for 53% of the total agricultural employment, while their participation is 46.5% in areas not affected by heat waves. In areas affected by droughts (especially in WCA), women's participation in agricultural employment is higher than men's. In drought-hit areas of WCA, females represent an estimated 59% of total agricultural employment, whereas in areas not affected by drought events male participation is higher than that of women (55% and 45%, respectively). A similar pattern is also found in ESA, where women's participation in agricultural employment is higher than men's in drought-prone areas and lower in areas not affected by weather shocks.

[3] In 10 surveys, information on the month of the interview was missing; shock-affected areas were thus identified in only 21 of 31 surveys included in the analysis. Despite sample reduction, the number of countries is still sufficiently large to draw inferences at the regional level, with the only exception being North Africa for which only Tunisia is included.

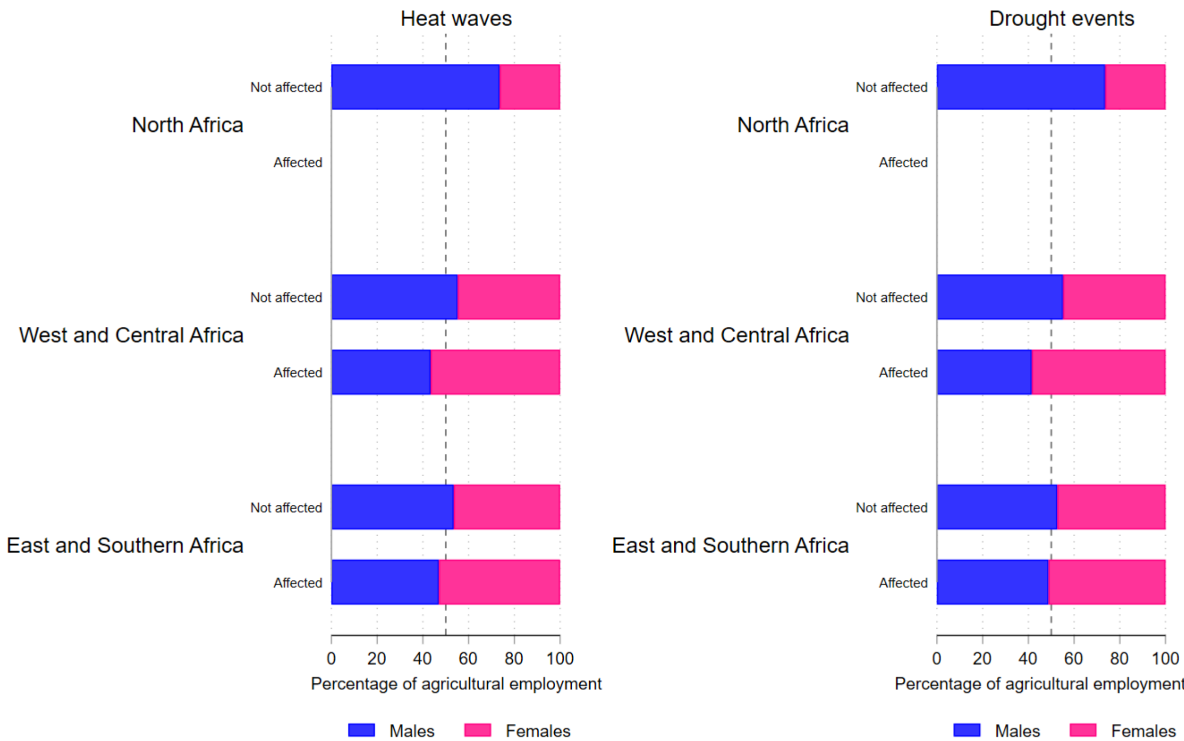

Figure 4. Sex-disaggregated employment statistics in agriculture for Africa, by shock-affected area.
Source: Authors' own computation based on data from 21 household surveys, matched with gridcell data extracted from Hersbach et al. (2018).

Figure 5 maps the average number of hours worked in agriculture at the subnational level (according to survey data from each country), overlaid with the number of heat waves, droughts, and floods that occurred during the six months prior to the interview. Simple descriptive statistics suggest that in areas affected by heat waves, individuals in agricultural employment work 5.5 fewer hours in a week than those in unaffected areas, while in drought-affected areas individuals work two hours less per week than do individuals in non-drought areas. The occurrence of floods did not yield statistically significant differences in labor intensity across regions.

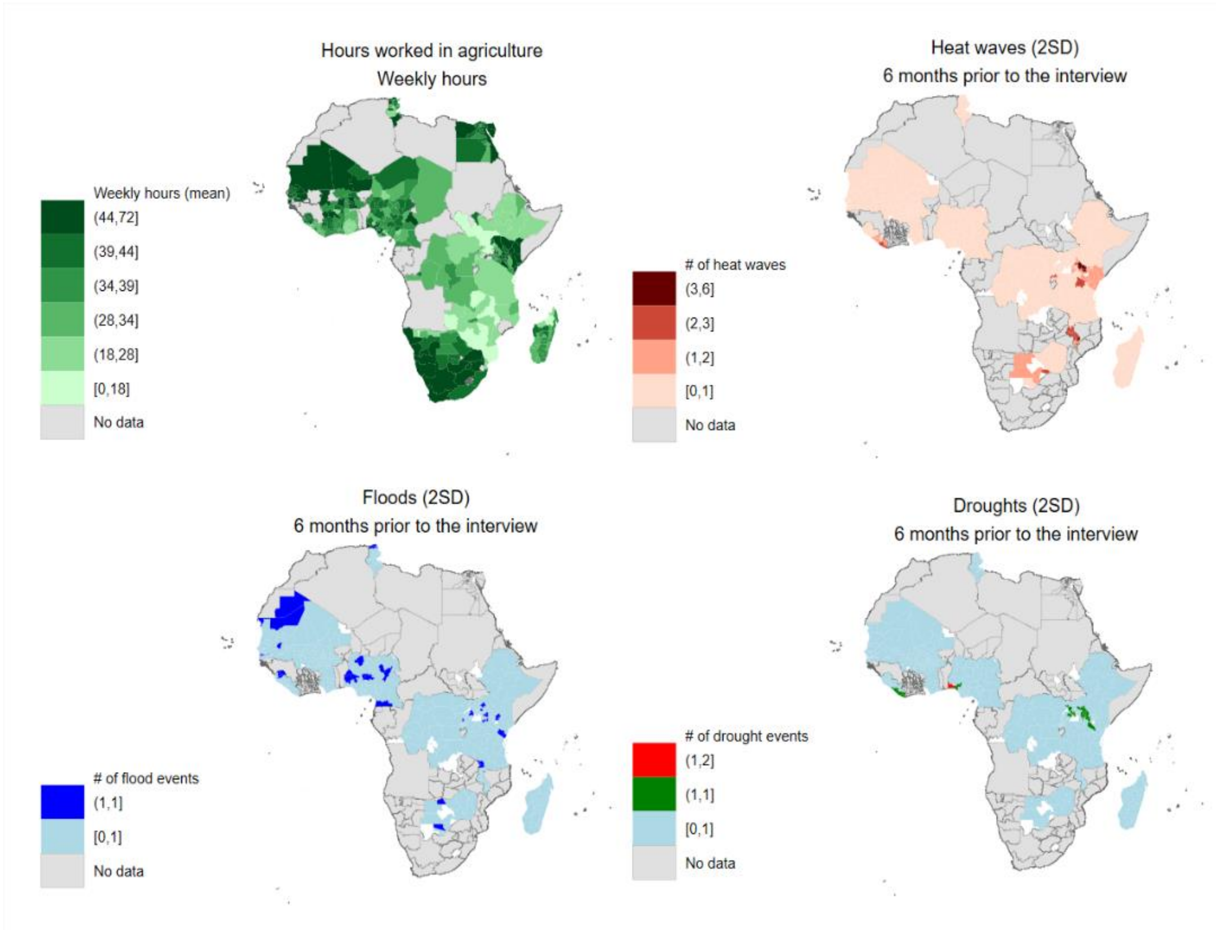

Figure 5. Average weekly hours worked in agriculture at the subnational level and number of extreme weather events in the six months prior to the interview.
Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018).
Note: SD = standard deviation.

4.2 Multivariate regressions: Main findings

We ran two regressions for each system of Equation [1] and [2], according to the use of survey sampling weights that yielded weighted or unweighted estimates.[4] For each system, the last specification (Column 3 in Tables 2 and 3) includes all countries for which information on weekly hours worked and weather shock variables are available (*n* = 21), with the parameters associated with the variables of interest shown in Figure 5. Appendix 4 shows key coefficients of interest by region. The explanatory power of the models

[4] Estimates are weighted by sampling weights to ensure national representativeness of the parameters; this allows for general inference for the 21 countries included in the specification with extreme weather shocks (Columns 3 and 6 in Tables 2 and 3), given that some surveys do not include information on the month in which the interview took place.

that is summarized by the R^2 (Tables 2 and 3) is 25% for the number of hours worked by an individual in agriculture and 62% for the total number of hours worked in agriculture by all household members.

Overall, the estimated coefficients from the multivariate regression analysis (in Tables 2 and 3) corroborate many of the findings derived from the descriptive statistics presented in Table 1. Indeed, women show a 21% lower labor intensity in agriculture and an 11% higher intensity of involvement in non-agricultural activities than their male counterparts, but with some differences by region. In North Africa, for example, the intensity of women's agricultural labor is 15% higher than men's, while the intensity of women's involvement in non-agricultural labor is 24% lower than that of men. In ESA, the estimated coefficient points to no difference between women and men in the intensity of agricultural labor, while women spend fewer hours than men in non-agricultural activities. Finally, in WCA, the intensity of women's involvement in agricultural activities is lower than that of men. These findings not only provide further evidence on the prominence of women's role in shaping agriculture-based livelihoods, but also on the central role of agriculture in reducing the gender gap, particularly in countries where cultural norms are more likely to constrain women in terms of their labor market participation.

Temperature and rainfall variability are clearly detrimental to agricultural participation at both the individual and household levels. In areas with high temperature variability, the intensity of agricultural labor (as measured by hours per week worked in the sector) decreases significantly, with North Africa being the only exception of (see Appendix 4). The estimated parameter associated with temperature variability (Table 2) suggests that a one-point increase in the CV in temperature leads to a 0.2% reduction in the number of hours an individual works in agriculture, with the effect being highest in ESA (-0.3%).

A higher temperature variability also seems to be negatively correlated at the household level with the total number of hours worked in agriculture (Table 3), where a one-point increase in the temperature's CV is expected to reduce the total number of hours worked in agriculture at the household level by 0.1%. At the household level, the effects of temperature's CV are found to be highest in ESA (-0.4%, Appendix 4).

Variables	1	2	3	4	5	6
	Agricultural activities			Non-agricultural activities		
Rural/urban location (1 = Rural households)	1.42101***	1.42370***	1.43841***	-1.64590***	-1.65096***	-1.69608***
	(0.00441)	(0.00441)	(0.00583)	(0.00453)	(0.00453)	(0.00597)
Age, log	-0.03066***	-0.03016***	-0.02533***	0.06203***	0.06174***	0.05767***
	(0.00054)	(0.00054)	(0.00067)	(0.00055)	(0.00055)	(0.00068)
Age, quadratic terms, log	0.00040***	0.00040***	0.00035***	-0.00076***	-0.00075***	-0.00070***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Females	-0.14991***	-0.15484***	-0.21023***	0.02297***	0.02927***	0.10764***
	(0.00393)	(0.00393)	(0.00542)	(0.00403)	(0.00403)	(0.00555)
Household size	0.00335***	0.00150***	0.00008	-0.00432***	-0.00352***	-0.00315***
	(0.00057)	(0.00057)	(0.00073)	(0.00058)	(0.00059)	(0.00075)
Old-age dependency ratio (household members over 64 years of age over HH members under 64 years)	-0.03726***	-0.03741***	-0.06077***	0.01940**	0.02037**	0.02926***
	(0.00785)	(0.00784)	(0.00987)	(0.00805)	(0.00805)	(0.01010)
Level of education attained (2 = At max secondary)	-0.59390***	-0.57779***	-0.61759***	0.66152***	0.64205***	0.68997***
	(0.00526)	(0.00530)	(0.00716)	(0.00540)	(0.00543)	(0.00732)
Level of education attained (3 = At max tertiary)	-0.75832***	-0.73501***	-0.77422***	0.78747***	0.75297***	0.80760***
	(0.00844)	(0.00850)	(0.01187)	(0.00865)	(0.00872)	(0.01214)
Level of education attained (4 = Not stated)	-0.12010***	-0.10841***	-0.05363***	0.26598***	0.23858***	0.19184***
	(0.00902)	(0.00907)	(0.01103)	(0.00926)	(0.00930)	(0.01129)
LT Annual Mean Temperature (degree Celsius)	-0.00660***	-0.00475***	-0.02108***	0.02488***	0.01857***	0.03504***
	(0.00095)	(0.00098)	(0.00126)	(0.00097)	(0.00100)	(0.00129)
LT Annual Precipitation (millimetres)	-0.00013***	-0.00020***	-0.00014***	0.00013***	0.00025***	0.00019***
	(0.00000)	(0.00001)	(0.00001)	(0.00000)	(0.00001)	(0.00001)
Temperature seasonality (coefficient of variation)		-0.00075***	-0.00162***		0.00078***	0.00155***
		(0.00003)	(0.00004)		(0.00003)	(0.00004)
Precipitation seasonality (coefficient of variation)		0.00091***	0.00171***		0.00076***	0.00062***
		(0.00008)	(0.00013)		(0.00009)	(0.00013)
Temperature heat shock dummy (2 SD = 1, Heat wave			-0.51671***			0.51525***
			(0.01431)			(0.01463)
Female#Temperature heat shock dummy (2 SD)			0.34170***			-0.40361***
			(0.01832)			(0.01876)
Rainfall flood shock dummy (2 SD = 1), Flood			0.19666***			-0.14354***
			(0.01572)			(0.01610)
Female#Rainfall flood shock dummy (2 SD)			-0.36843***			0.37463***
			(0.02257)			(0.02311)
Rainfall drought shock dummy (2 SD = 1), Drought			-0.15279***			0.22655***
			(0.02713)			(0.02778)
Female#Rainfall drought shock dummy (2 SD)			0.03477			-0.05226
			(0.03828)			(0.03919)
Constant	2.08937***	2.16083***	2.62716***	0.81611***	0.67891***	-0.07911**
	(0.03014)	(0.03045)	(0.03325)	(0.03092)	(0.03124)	(0.03396)
Observations	572,685	572,685	353,270	572,685	572,685	353,270
R-squared	0.30280	0.30383	0.25274	0.38427	0.38533	0.33711
Area Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES

Table 2. Weighted seemingly unrelated regressions (SURs) on hours worked in agricultural and non-agricultural activities at the individual level.
Source: author's calculation
Note: *, **, and *** indicate statistical significance at the $p < 0.1$, $p < 0.05$, and $p < 0.01$ levels. The variables "Female#" indicate the estimated coefficients associated to extreme weather shocks interacted with women's participation in agriculture.

Variables	1	2	3	4	5	6
	Agricultural activities			Non-agricultural activities		
Rural/urban location (1 = Rural households)	2.21085***	2.21311***	2.32477***	-1.72103***	-1.72915***	-1.80993***
	(0.01080)	(0.01082)	(0.01573)	(0.01064)	(0.01063)	(0.01553)
Average age in the household (HH), log	-0.01226***	-0.01156***	-0.01322***	0.02034***	0.01814***	0.01914***
	(0.00189)	(0.00189)	(0.00264)	(0.00191)	(0.00190)	(0.00268)
Average age in the HH, quadratic terms, log	0.00030***	0.00030***	0.00035***	-0.00004	-0.00005*	-0.00004
	(0.00003)	(0.00003)	(0.00004)	(0.00003)	(0.00003)	(0.00004)
Level of education attained (2 = At max secondary)	-0.57798***	-0.56088***	-0.47971***	0.61202***	0.55064***	0.55455***
	(0.01154)	(0.01164)	(0.01681)	(0.01174)	(0.01182)	(0.01725)
Level of education attained (3= At max tertiary)	-0.26063***	-0.24583***	-0.05805**	0.62503***	0.56009***	0.63922***
	(0.01894)	(0.01913)	(0.02729)	(0.01916)	(0.01931)	(0.02779)
Level of education attained (4 = Not stated	0.08623**	0.09134***	0.25510***	0.48371***	0.44480***	0.39638***
	(0.03367)	(0.03385)	(0.04466)	(0.03386)	(0.03397)	(0.04522)
Old-age dependency ratio (HH members over 64 years of age over HH members under 64 years)	0.10665***	0.09639***	0.07918***	-0.58798***	-0.55537***	-0.58603***
	(0.02012)	(0.02013)	(0.02751)	(0.02013)	(0.02009)	(0.02769)
Ratio of females/males in the HH	-0.16121***	-0.16256***	-0.19104***	-0.16368***	-0.16259***	-0.16728***
	(0.00458)	(0.00458)	(0.00644)	(0.00461)	(0.00460)	(0.00647)
Percentage of employed HH members	-0.70175***	-0.73169***	-0.98675***	-1.18621***	-1.08907***	-1.01414***
	(0.02197)	(0.02208)	(0.03187)	(0.02130)	(0.02139)	(0.03096)
Ratio of HH members in agriculture to HH members in non-agricultural activities	1.30003***	1.29933***	1.27828***			
	(0.00428)	(0.00428)	(0.00585)			
Ratio of HH members in non-agricultural activities to HH members in agriculture				2.02423***	2.01977***	1.99333***
				(0.00607)	(0.00605)	(0.00858)
Ratio of females in agriculture to males in agriculture	1.12913***	1.13144***	1.15277***			
	(0.00893)	(0.00896)	(0.01190)			
Ratio of females in non-agricultural activities to males in non-agricultural activities				0.91227***	0.93365***	1.14178***
				(0.00931)	(0.00930)	(0.01328)
LT Annual mean temperature (degrees Celsius)	-0.00770***	-0.00886***	-0.02471***	0.02259***	0.02347***	0.05139***
	(0.00225)	(0.00230)	(0.00318)	(0.00226)	(0.00231)	(0.00323)
LT Annual precipitation (millimetres)	-0.00010***	-0.00016***	-0.00014***	0.00022***	0.00046***	0.00037***
	(0.00001)	(0.00001)	(0.00002)	(0.00001)	(0.00001)	(0.00002)
Temperature seasonality (coefficient of variation)		-0.00072***	-0.00112***		0.00245***	0.00356***
		(0.00006)	(0.00011)		(0.00006)	(0.00011)
Precipitation seasonality (coefficient of variation)		0.00121***	0.00225***		-0.00280***	-0.00558***
		(0.00020)	(0.00033)		(0.00020)	(0.00033)
Temperature heat shock dummy (2 SD) (1 = heat wave)			-0.16597***			0.57250***
			(0.02845)			(0.02884)
Rainfall flood shock dummy (2 SD) (1 = flood)			-0.18354***			0.16592***
			(0.03149)			(0.03192)
Rainfall drought shock dummy (2 SD) (1 = drought)			-0.11479**			0.06023
			(0.04872)			(0.04940)
Constant	-1.79152***	-1.67866***	-0.92415***	-1.84054***	-2.26966***	-2.79129***
	(0.07406)	(0.07568)	(0.08906)	(0.07462)	(0.07603)	(0.09034)
Observations	301,259	301,259	156,182	301,259	301,259	156,182
R-squared	0.65309	0.65329	0.62359	0.63649	0.63860	0.63431
Area Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES

Table 3. Weighted seemingly unrelated regressions (SURs) on hours worked in agricultural and non-agricultural activities at the household level.

Source: author's calculation

Note: *, **, and *** indicate statistical significance at the $p < 0.1$, $p < 0.05$, and $p < 0.01$ levels.

The coefficient associated with precipitation's CV exhibits a positive sign in both household-level and individual-level regressions; this is most likely driven by the positive sign in most populated countries (such as Nigeria) when regressions are estimated using sampling weights. The precipitation's CV, however, turns to negative and statistically significant in the unweighted regression (-0.2% at the household level and -0.3% at the individual level, see Figure 6). Weighted regressions, however, suggest that in WCA, a one-point increase in the precipitation's CV is expected to reduce the total number of hours worked in agriculture by 0.5% at the household level, and by 0.1 percent at the individual level (Appendix 4).

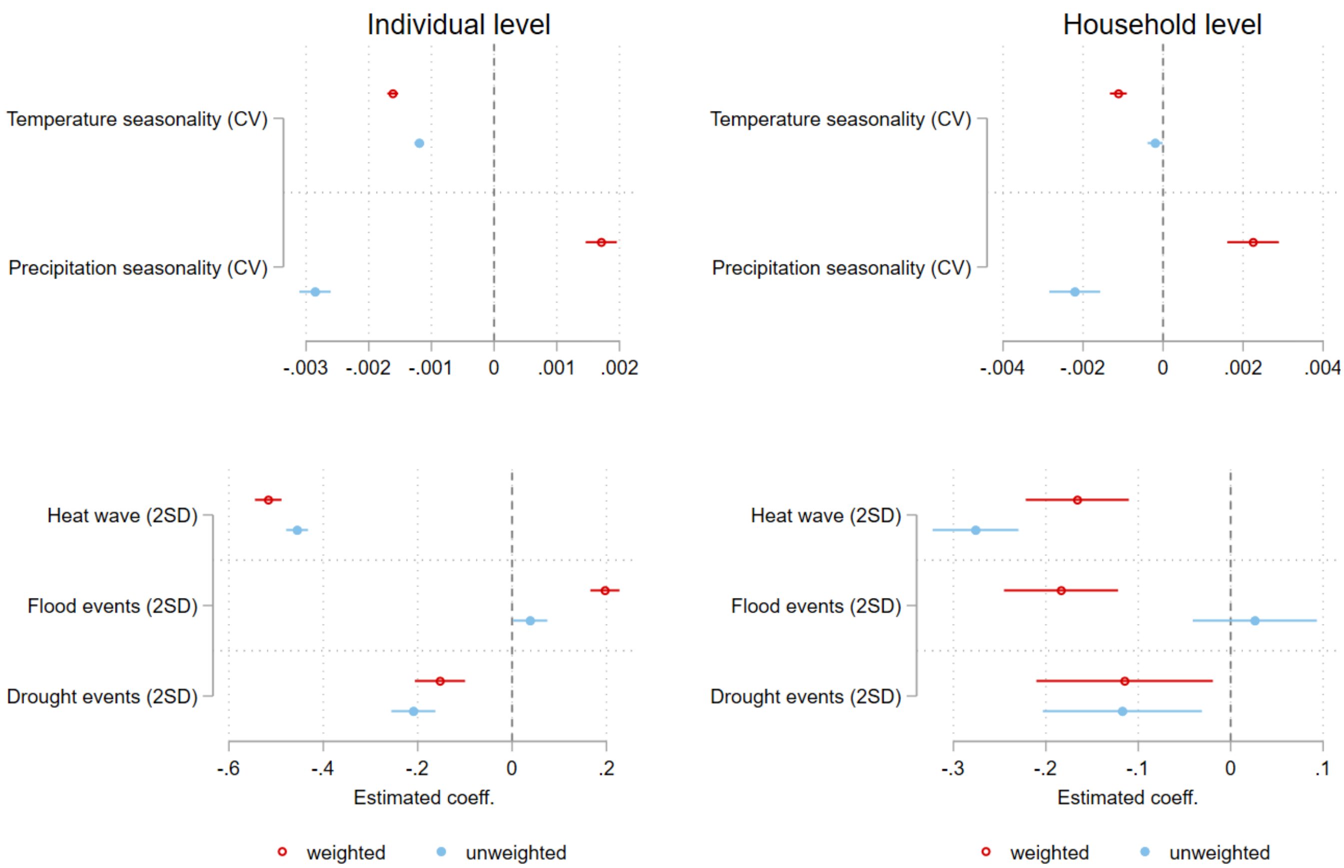

Figure 6. Estimated coefficients associated with weather variability and extreme shocks from weighted and unweighted regressions for individuals and households involved in agriculture.
Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018).
Note: CV = coefficient of variation; SD = standard deviation.

Our econometric strategy allows us to look at the effects of climatic variability and weather shocks on sex-specific labor intensity. The reference weighted model at the individual level shows that heat waves and droughts are associated with the most detrimental effects on individual effort intensity in agriculture, reducing the number of hours worked by 40% and 14% in case of a heat wave or drought event, respectively. The effects are particularly severe in West and Central Africa, showing an expected reduction in the number of hours worked by 49% and 23%, respectively (Appendix 4). Similarly, the negative impact of flood events is estimated to be more severe in East and Southern Africa, where individual effort intensity in agriculture is expected to decrease by 26% in response to a flood event. At the household level, weighted regressions suggest that experiencing a heat wave, flood, or drought event during the six months prior to the interview reduces the total number of hours worked in the household by 17%, 18%, and 11%, respectively.

We also find strong evidence of a sex-specific effect in the case of heat wave; overall, being female seems to mitigate the negative impact of heat waves on farmers' work intensity in agriculture by 40% (Figure 6). The estimated coefficients robustly the importance of being female as a factor in mitigating the negative effects of heat waves on farming activities in both WCA and ESA.

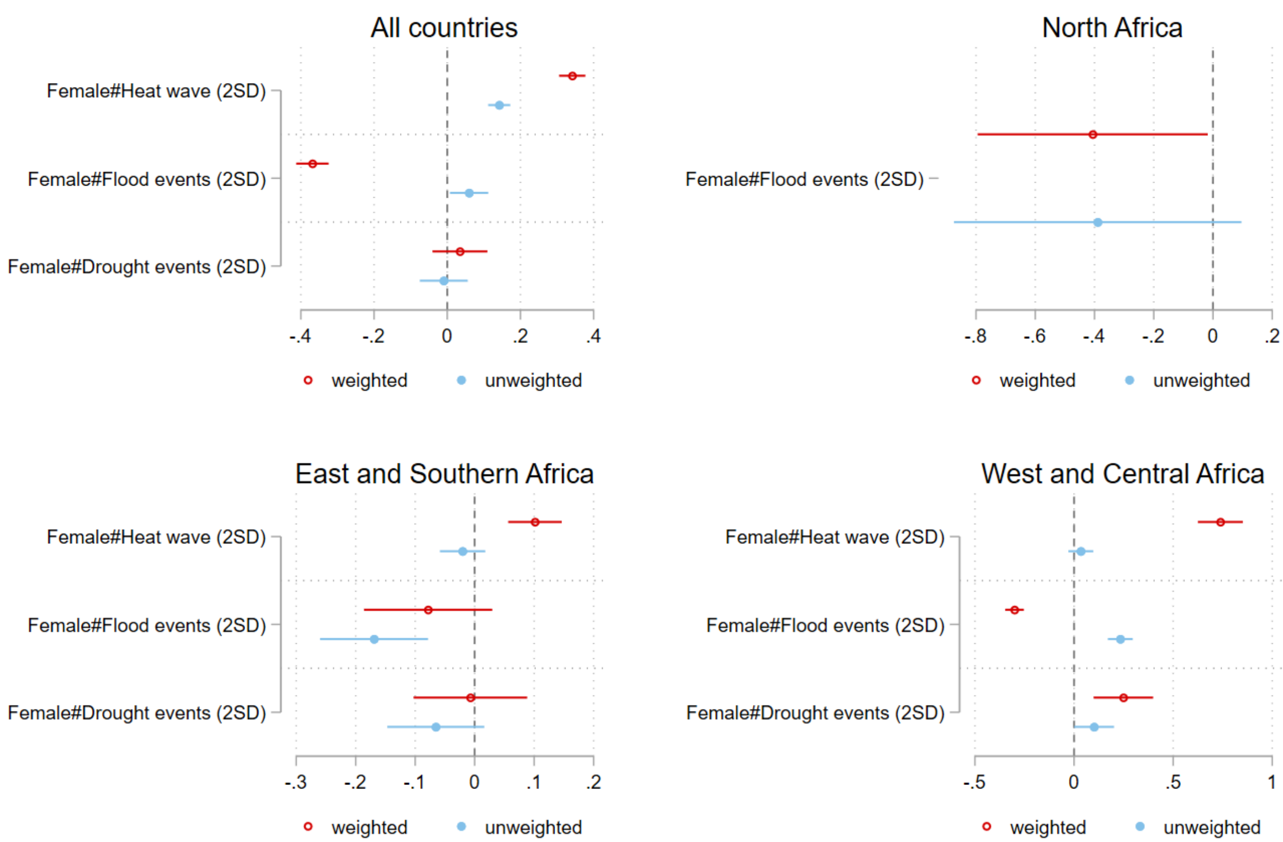

Figure 7. Estimated coefficients associated with the interaction between sex of the farmer and shocks on labor intensity in agriculture.
Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018).
Note: SD = standard deviation. The variables "Female#" in Figure 7 indicate the estimated coefficients associated to extreme weather shocks interacted with women in agriculture.

5. Conclusions and Policy Implications

Our study is based on a large database of recent nationally representative Labor Force Survey data for 31 countries in Africa, allowing comparison of descriptive statistics as well as inference for almost 80% of the African population. Our dataset includes various individual as well as household-level labor-related measures that are used to compare labour market participation and intensity; these are matched with various bioclimatic dimensions to explore the effects of natural environment on agricultural labor participation and intensity.

Individual-level statistics suggest that agriculture is the dominant sector in both WCA and ESA, and that participation in the labor market in the 31 African countries is higher among men than women. Sex- and sector-disaggregated statistics nevertheless highlight that in ESA women's participation in the labor market is considerably higher in agriculture than in non-agricultural activities (62% and 38%, respectively), while in WCA women are almost equally distributed between the two sectors (49% and 51%, respectively). In North Africa, in contrast, only about one-third of the total women employed are engaged in agriculture (35%) but their participation is higher than that of men.

Both heat waves and droughts are associated with the most detrimental effects on individual effort intensity in agriculture; they reduce the number of hours worked by 40% and 14%, respectively, in the case of a heat wave or drought event. The effects are particularly severe in West and Central Africa, where there is an expected reduction in the number of hours worked by 49% (West) and 23% (Central). We also find strong evidence of a sex-specific effect in the case of heat wave; overall, being female farmer seems to be a factor that mitigates the negative impact of heat waves on farmers' work intensity in agriculture by 40%, highlighting the importance of female participation in farming in mitigating the negative effects of heat waves on farming activities.

Institutional factors and exogenous factors such as climatic variability and weather shocks are expected to affect intensity of agricultural participation and its anticipated returns, calling for policy action. Our econometric analysis shows that precipitation and temperature variability is probably one of the most limiting factors of full participation in agricultural activities. Increasingly unpredictable environmental factors are a crucial source of uncertainty that limits and hampers the capability of smallholder farmers to invest in often unprofitable and low-return agricultural activities. As a viable coping strategy, many households are only partly dependent on agriculture and rely on livelihood diversification strategies to increase their resilience to weather variability and extreme shocks.

Under these conditions, government-led policy and interventions need to be designed to limit the negative effects of increasing climate variability and extreme weather events that affect participation in crop, livestock, forestry, and fisheries production. Given the fundamental role of women both in agricultural production and in coping with extreme weather shocks, sustainable, climate-resilient, and gender-sensitive policies and interventions remain a key priority alongside the need to incorporate gender intothe planning and budgeting of agriculture-related programs.

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Appendix 1: Sample size of individuals (*i*) and households (*h*) for each country

Country	Subregion	World Bank income group	Survey name	Type of survey	Year	Sample	
						i	h
Botswana	Southern Africa	Upper-middle income	Labour Force Survey	LFS	2006	30,237	9,138
Burkina Faso	Western Africa	Low income	Enquête Multisectorielle Continue 2014	HIES	2014	77,037	10,411
Cameroon	Central Africa	Lower-middle income	Fourth Cameroon Household Survey: ECAM4	HIES	2014	46,560	10,303
Chad	Central Africa	Low income	Enquête Harmonisee sur les Conditions de Vie des Menage	HIES	2019	41,077	7,493
Congo, Democratic Republic of the	Central Africa	Low income	Enquête Nationale du Type 1-2-3 Auprès des Ménages	HIES	2011	111,679	21,413
Côte d'Ivoire	Western Africa	Lower-middle income	Enquête sur le Niveau de Vie des Ménages	HIES	2008	59,699	12,479
Egypt	Northern Africa	Lower-middle income	Labour Force Survey	LFS	2017	335,396	82,902
Ethiopia	Eastern Africa	Low income	Ethiopian Socioeconomic Survey	HIES	2016	23,390	4,950
Gambia	Western Africa	Low income	Integrated Household Survey on Consumption Expenditure and Poverty Level Assessment	HIES	2016	105,794	13,281
Ghana	Western Africa	Lower-middle income	Living Standard Survey with Household Module	HIES	2014	72,372	16,772
Kenya	Eastern Africa	Lower-middle income	Integrated Household Budget Survey	HIES	2015	92,789	21,767
Lesotho	Southern Africa	Lower-middle income	Household Budget Survey	HIES	2003	27,678	5,988
Liberia	Western Africa	Low income	Household Income and Expenditure Survey	HIES	2016	36,300	8,350
Madagascar	Eastern Africa	Low income	Enquête Nationale sur l'Emploi et le Secteur Informel	LFS	2015	15,641	4,152
Malawi	Eastern Africa	Low income	Malawi Fourth Integrated Household Survey	HIES	2016	53,884	12,447
Mali	Western Africa	Low income	Enquête Modulaire et Permanente Auprès des Ménages 2018	HIES	2018	46,931	6,656
Mauritania	Western Africa	Lower-middle income	Enquête Nationale de Référence sur l'Emploi et le Secteur Informel	LFS	2017	47,085	7,978
Mozambique	Eastern Africa	Low income	Inquerito Sobre Orcamento Familiar	HIES	2015	130,222	32,828
Namibia	Southern Africa	Upper-middle income	Labour Force Survey	LFS	2018	40,993	9,728
Niger	Western Africa	Low income	Enquête Nationale sur les Conditions de Vie des Ménages	HIES	2014	22,671	3,617
Nigeria	Western Africa	Lower-middle income	General Household Survey–Panel	HIES	2013	27,244	4,536
Rwanda	Eastern Africa	Low income	Rwanda Labour Force Survey	LFS	2017	77,761	11,811
Senegal	Western Africa	Lower-middle income	Enquête de Suivi de la Pauvrete au Senegal	HIES	2011	168,203	17,891
Sierra Leone	Western Africa	Low income	Labour Force Survey	LFS	2014	25,641	4,199
South Africa	Southern Africa	Upper-middle income	Quarterly Labour Force Survey	LFS	2017	276,876	84,887
South Sudan	Eastern Africa	Low income	High Frequency Survey	HIES	2016	55,565	9,335
Tanzania, United Republic of	Eastern Africa	Low income	Tanzania National Panel Survey	HIES	2013	20,556	3,924
Tunisia	Northern Africa	Lower-middle income	Tunisia Labour Market Panel Survey	LFS	2014	16,346	4,508
Uganda	Eastern Africa	Low income	Uganda National Panel Survey	HIES	2016	15,819	3,305
Zambia	Eastern Africa	Lower-middle income	Quarterly Labour Force Survey	LFS	2018	49,551	9,826
Zimbabwe	Eastern Africa	Lower-middle income	Labour Force and Child Labour Survey	LFS	2019	39,126	9,441

Appendix 2: Dependent and independent variables of individual-level models

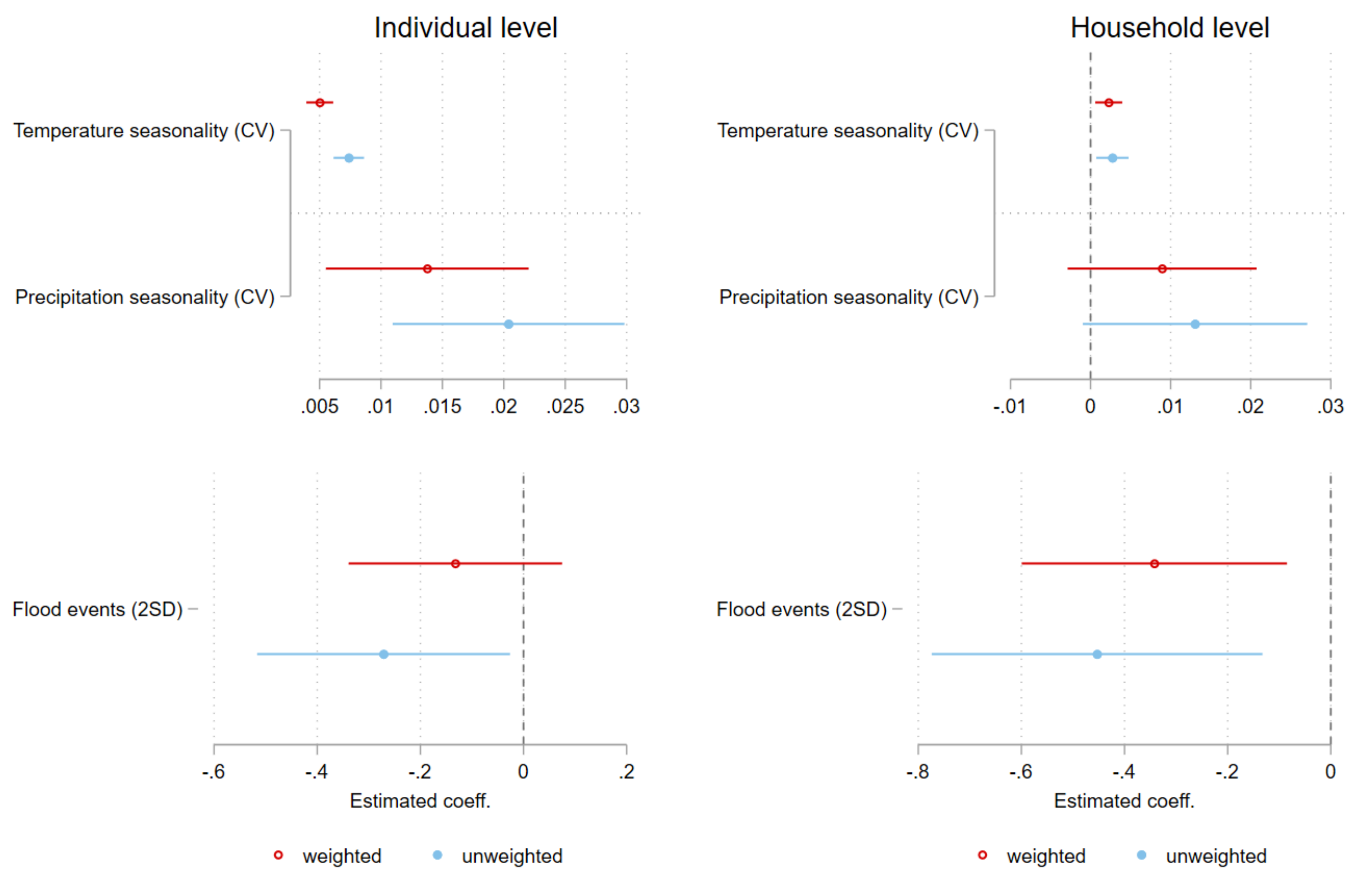
	N	Mean	SD	Min.	Max.
Dependent variables					
Weekly hours worked in agriculture (log)	640,875	1.525	1.761	0	5.118
Weekly hours worked in non-agricultural activities (log)	640,875	2.051	1.890	0	5.124
Independent variables					
Dummy for individual living in rural (1) and urban (0) areas	640,875	0.538	0.499	0	1
Age of the individual	640,875	35.92	15.16	0	120
Age of the individual quadratic term	640,875	1,520	1,220	0	14,400
Sex of the individual: females (0) males (1)	640,875	0.431	0.495	0	1
Level of education attained in the household: At max primary (1), secondary (2), tertiary (3), not stated	580,253	1.423	0.670	1	4
Household (HH) size	640,875	6.470	4.868	1	82
HH members aged 64 or more over HH members less than 64 years	633,951	0.0782	0.237	0	12
Long-term average of temperature over the last 20 years	640,875	23.22	3.699	13.27	30.17
Long-term average of precipitation over the last 20 years	640,875	864.4	626.3	0.446	3,724
Coefficient of variation in temperature	640,875	267.5	175.3	23.25	798.5
Coefficient of variation in precipitation	640,875	88.16	34.59	11.81	163.4
Individuals experiencing temperature values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the interview	364,329	0.161	0.367	0	1
Females interacted with temperature heat shock values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	364,329	0.0763	0.265	0	1
Individuals experiencing precipitation values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the interview	364,329	0.0423	0.201	0	1
Females interacted with rainfall flood shock values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	364,329	0.0199	0.140	0	1
Individuals experiencing precipitation values lower than -2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the interview	364,329	0.0278	0.165	0	1
Females interacted with rainfall drought shock values lower than -2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	364,329	0.0134	0.115	0	1
Country subnational area fixed effects	640,875	327.4	191.4	1	663
Year fixed effects	640,875	2015	2.708	2006	2020

Appendix 3: Dependent and independent variables for the household-level model

	N	Mean	SD	Min.	Max.
Dependent variables					
Weekly hours worked in agriculture (log)	338,419	-1.078	4.239	-4.605	7.636
Weekly hours worked in non-agricultural activities (log)	338,419	1.383	4.001	-4.605	6.936
Independent variables					
Dummy for individual living in rural (1) and urban (0) areas	338,419	0.502	0.500	0	1
Average age in the household (HH)	338,419	27.26	12	5.4	99
Average age in the HH, quadratic term	338,419	887.7	893	29.16	9801
Average level of education attained in the HH: At max primary (1), secondary (2), tertiary (3), not stated	306,110	1.706	0.642	1	4
Household members aged 64 years / household members aged less than 64 y.o.	332,975	0.0738	0.243	0	12
Ratio of female HH members to male HH members	338,419	1.223	1.078	0	14
Percentage of employed HH members	338,419	0.486	0.285	0	1
Ratio of HH members working in agriculture to household members working in non-agricultural activities	338,419	0.844	1.479	0	37
Ratio of HH members working in non-agricultural activities to HH members working in agriculture	338,419	1.041	1.057	0	21
Ratio of female HH members in agriculture to male HH members in agriculture	338,419	0.335	0.641	0	14
Ratio of female HH members in non-agricultural activities to male HH members in non-agricultural activities	338,419	0.402	0.633	0	14
Long-term average of temperature over the last 20 years	338,419	22.50	3.681	13.27	30.17
Long-term average of precipitation over the last 20 years	338,419	808.7	638.4	0.446	3,724
Coefficient of variation in temperature	338,419	297.6	185.8	23.25	798.5
Coefficient of variation in precipitation	338,419	83.39	32.14	11.81	163.4
HHs experiencing temperature values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	164,171	0.196	0.397	0	1
HHs experiencing precipitation values higher than +2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	164,171	0.0465	0.211	0	1
HHs experiencing precipitation values lower than -2 standard deviation (SD) from the long-term monthly average, at least once during the six months prior to the date of the interview	164,171	0.0297	0.170	0	1
Country subnational area fixed effects	338,419	337.5	200.5	1	664
Year fixed effects	338,419	2015	2.699	2006	2020

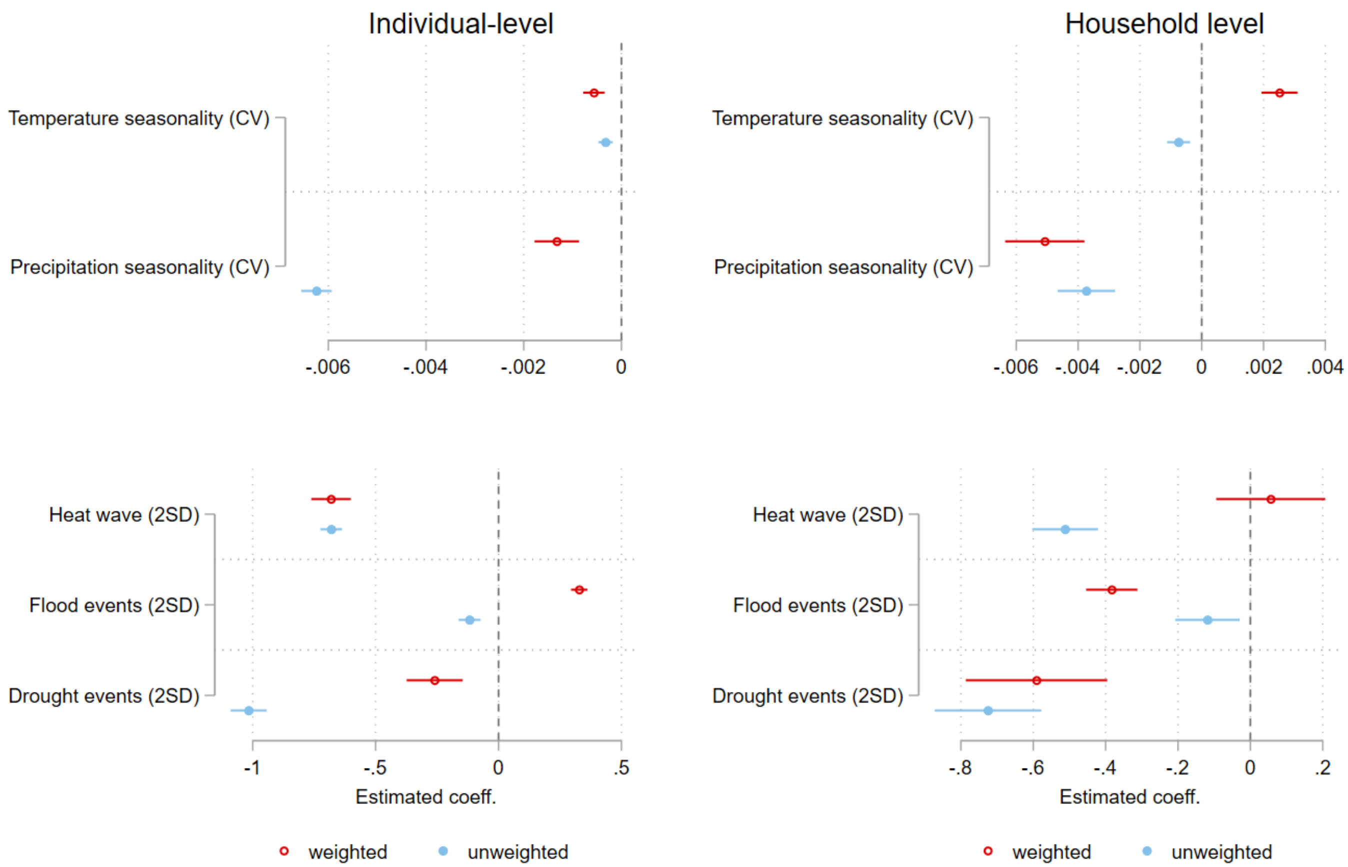
Appendix 4: Individual- and household-level estimated coefficients for weather variability and weather shocks

North Africa



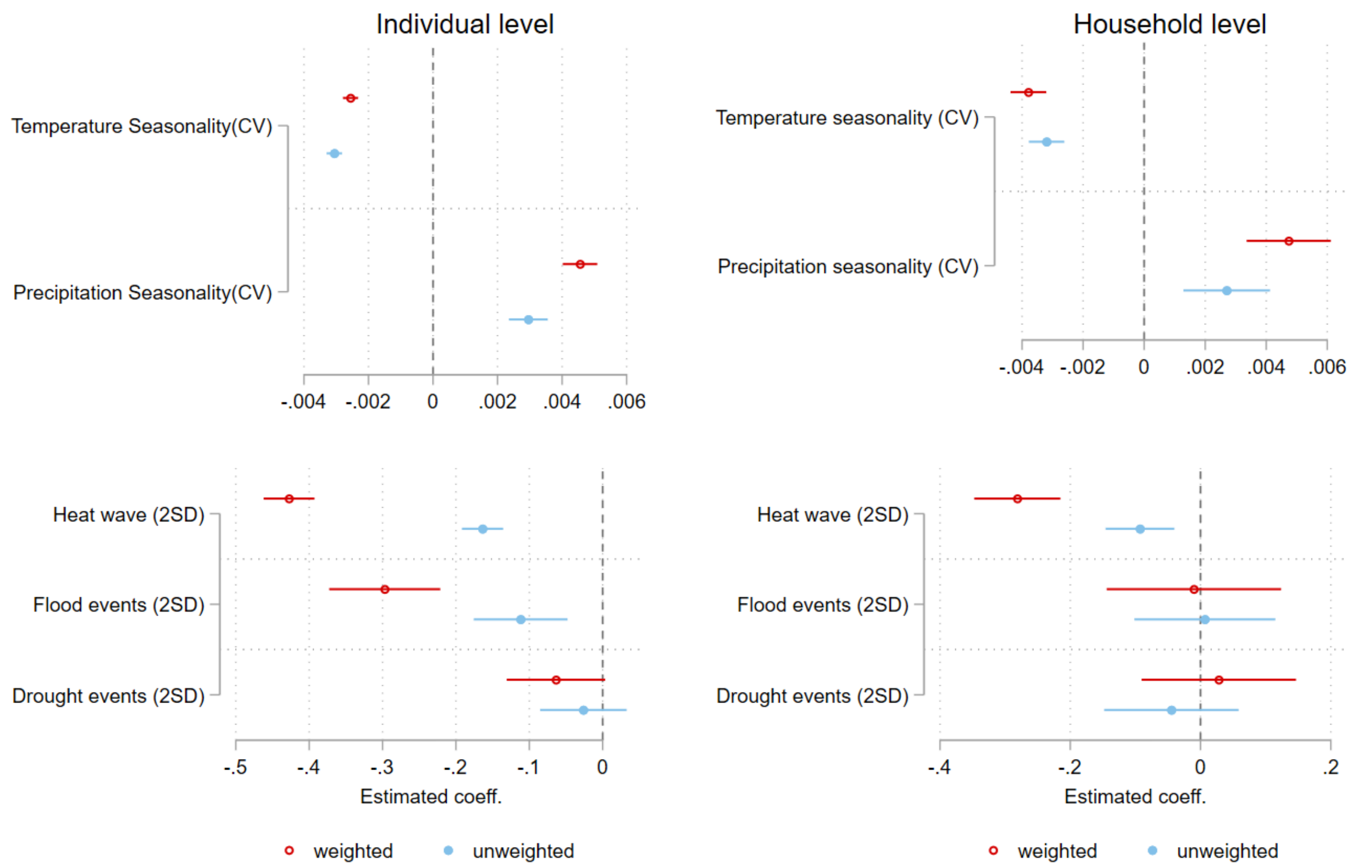
Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018).
Note: SD = standard deviation and CV = coefficient of variation. The variables "Female#" indicate the estimated coefficients associated to extreme weather shocks interacted with women's participation in agriculture.

West and Central Africa



Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018). **Note:** SD = standard deviation and CV = coefficient of variation. The variables "Female#" indicate the estimated coefficients associated to extreme weather shocks interacted with women's participation in agriculture.

East and Southern Africa



Source: Authors' own calculations based on 30 household surveys. Heat waves, droughts, and flood events are identified based on data by Hersbach et al. (2018). **Note:** SD = standard deviation and CV = coefficient of variation. The variables "Female#" indicate the estimated coefficients associated to extreme weather shocks interacted with women's participation in agriculture.