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IFPRI Discussion Paper 02115

April 2022

Weather Variability and Extreme Shocks in Africa

Are Female or Male Farmers more Affected?

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Abstract

African agriculture is extremely sensitive to weather variability and extreme weather shocks. Understanding how weather events affect the intensity of participation in agricultural employment, including from a gender perspective, remains an unanswered empirical question. To this end, the ultimate objective of this study is to empirically quantify how women and men differentially adapt their intensity of participation in agricultural employment under weather variability and extreme climatic events. Our study takes advantage of a novel individual-level database mostly drawn on Labor Force Surveys (LFS) representing more than 80% of the total African population and covering nearly 86% of the total employed in Africa, matched with gridcell monthly time series bioclimatic variables (temperature and rainfall) to identify shock-affected areas. We estimate two systems of equations through the Seemingly Unrelated Regression (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 the employment distribution, absorbing a relatively higher share of the total employed population in both West-Central and East and Southern Africa. Multivariate SUR results show that both heat waves and droughts are associated 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. However, the reduction of hours worked due to heat wave is lessened by 40% if farmers are women. Given the fundamental role of women both in agriculture production and in coping with extreme weather shocks, sustainable, climate-resilient, and gender-sensitive policies and interventions on the labor market remain a key priority alongside gender mainstreaming in planning and promoting agriculture- and job-related programmes.

Acknowledgements

We would like to thank Shuang Zhou for spatial data processing and analysis. This work received funding support by USAID under the Gender, Climate Change and Nutrition Integration Initiative (GCAN), as part of the US Government's Feed the Future. The opinions expressed herein belong to the authors, and do not necessarily reflect those of FAO, USAID, GCAN, IFPRI, or CGIAR. All errors are our own responsibility.

1. Introduction

Agriculture in Africa has been traditionally seen as an important employment provider, supporting agriculture-based livelihoods of the vast majority of the African population, (James, 2014; World Bank, 2011) and absorbing the largest share of the employed population. Data suggest that almost 224 million people aged 15 and above are directly engaged in agriculture in Africa (ILO, 2021), corresponding to nearly half of the total employed population in the continent and absorbing ¼ of global agricultural employment.

Women play a crucial role in African agriculture, with an estimated more than 100 million women directly engaged in the sector, according to the ILO (ILO, 2021), representing 44.8 % of total agriculture employment in Africa. Despite the largely documented prominent role of agriculture in Africa in supporting the livelihoods of millions of people, the alarming changing climatic conditions remains the most important challenges in African agriculture, extremely sensitive to weather variability and extreme weather shocks (Belloumi, 2014). Understanding how climate change and extreme weather events affect the intensity of participation in agricultural employment and, in turn, agricultural livelihoods, including from a gender perspective, remains largely an empirical question.

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, while heat waves in Africa have occurred more frequently, and are projected to increase throughout the 21st century (IPCC, 2021b; Iturbide et al., 2020). Looking at past trends in global warming, the emerging finding is that the African continent will be exposed to changing climatic conditions more severely than the rest of world (Weber et al., 2018). There is a consensus that, under the current and future scenarios, agricultural yields in Africa will continue to be severely affected by changing temperature and precipitation (Kurukulasuriya & Rosenthal, 2013), as well as extreme weather events. Weather variability and extreme shocks are expected to disproportionally affect millions of people, especially women, who depend on agriculture-based livelihoods in Africa (Zougmoré et al., 2016), by preventing them from engaging in agricultural employment. Under the dire scenarios projected by the IPCC (IPCC, 2021b), a vast majority of vulnerable people who depend upon agriculture-based livelihoods are expected to be pushed into poverty, as long as they lack the capacity to cope weather-related shock and variability (Shiferaw et al., 2014).

Indeed, to date climate change and extreme weather events represent the most pressing threat to agriculture, which call for immediate policy actions. Increasing awareness of the devastating effects of climate change on agricultural production has led to the set-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 negative impact of climate change on agriculture, several institutions at various levels have developed an array of policies and programs to combat greenhouse gas (GHG) emissions, so as to limit the negative consequences of climate change on agriculture (Smith & Martino, 2007, EPRS, 2020, Ahmed et al., 2012; FAO, 2017; Meridian Institute, 2011). Despite increasing commitment to fighting climate change, gender mainstreaming of climate change in agriculture has received poor attention and failed to be incorporated into concrete policy actions (Alston, 2014).

The exiting body of literature on the relationship between gender and climate change in agriculture has focused on gender exposure to climate stressors, suggesting that women are more likely to be negatively affected by weather shocks than men. Women's higher vulnerability to climate stressors is mainly driven by several limiting conditions, including lack of access to diversified livelihood strategies that prevent women from managing the daily risks associated with climate variability and extreme weather events (Lal et al., 2012, Olsson et al., 2015). Although women are expected to suffer disproportionally from weather-related stressors compared to men, the empirical literature has not yet explored the potential effects of women in mitigating the negative effects of extreme weather events on agricultural activities. Considering the prominent role of women in agriculture, the ultimate objective of this study is to empirically quantify how women and men adapt their intensity of participation in agricultural employment under extreme weather events.

The remainder of this 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 population 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. Finally, section 5 concludes and provides some policy implications.

2. Female agricultural employment and weather variability: a literature review

Agriculture-based livelihoods hinge on two key elements: *i)* intensity of participation and *ii)* its corresponding return. Both institutional and exogenous factors -such as extreme climate events and increasing variability in temperature and precipitation- are expected to affect intensity of agricultural participation and anticipated returns.

According to the review of the empirical literature, three stylized facts emerge. First, agricultural employment is dominated by an irregular pattern driven by the intrinsic weather seasonality heavily affecting agricultural activities. Second, being the agricultural sector extremely sensitive to weather variability and extreme weather shocks, the alarming changing climate conditions are expected to reduce the intensity of participation in agricultural employment, while exposing the population dependent upon agriculture at high risk of vulnerability, ultimately triggering negative effects on agriculture-based livelihoods. Third, although women have a crucial role in sustaining agricultural household livelihoods, they suffer disproportionally from weather-related shocks, mainly due to barriers that hamper their capabilities to manage risks associated with climate change.

Agricultural employment is characterized by an erratic and seasonal pattern by nature, leading to substantial heterogeneity of livelihoods (Davis et al., 2014). Occupation multiplicity[1] is often a pervasive reality for several workers who are mainly engaged in agriculture, alternating periods of over-employment with periods of under-employment (Oya, 2015), according to the agricultural season. Limiting environmental factors (*e. g.*, temperature and precipitation variability) exacerbate the already erratic participation in agricultural employment, forcing agricultural workers to diversify their livelihood strategies. In this context, the degree of intensity of employment in agriculture is expected to be directly influenced by temperature and rainfall

[1] Occupation multiplicity occurs when an individual combines two or more jobs over the year.

patterns (ILO, 2018a). Both extreme weather -*e. g.*, heat waves, droughts and floods- and weather variability -*e. g.*, the temperature variation over a given year or the intra-annual variation in monthly precipitation- can significantly affect agricultural activities, ultimately disrupting participation in agriculture-related sectors, particularly when adaptive capacity to cope with extreme weather shocks is relatively low (Niles & Salerno, 2018).

Variability in rainfall and temperature, including extreme weather events, is one of the most critical challenges in African agriculture, extremely sensitive to weather variability (Belloumi, 2014) given the strong exposure of the continent to climate and the heavy reliance on agriculture. A number of studies (Stockholm Environment Institute, 2009; Babatunde & Odusola, 2015; Müller et al., 2011) have empirically documented the socio-economic costs of weather variability and extreme climatic shocks, and 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 small farmers are often forced to rely on off-farm jobs in case of shocks (Bohle et al., 1994).

The long-run trend in temperature and precipitation observed by the IPCC (2021b) in Africa is expected to decrease dependency on agriculture in the continent. ultimately leading to cascading effects on agricultural livelihoods, poverty, and the food system (Olsson et al., 2015). During the past two decades, the overall climate scenario in Africa has suggested that surface temperature recorded in African countries has been alarming, increasing at faster rates than the global average (IPCC, 2021b), most likely reflecting the effects of global climate change (Kotir, 2011; Kurukulasuriya & Mendelsohn, 2008). Heat waves have been observed more frequently, while cold extremes less frequently. The worrying trend in the observed temperature is expected to affect the hydrological cycle exposing agriculture to increasing vulnerability largely due to the sector's high reliance on rainfed farming and to the sensitivity of agricultural production to precipitation patterns (Derbile et al., 2016). The observed changes in the hydrological cycle in the continent are projected to increase rainfall variability, while unpredictable rainfall patterns will ultimately increase the likelihood of extreme climate events, such as droughts and floods (Derbile et al., 2016). Despite an increasing trend in temperature observed across the continent (shown in section 3 below), the analysis conducted by the IPCC shows some differences in the long-term trend across regions.

Average precipitation in North Africa (NA) has declined substantially, with increase in aridity and droughts, the latter also observed in West-Central (WCA) and in East and Southern Africa (ESA). By contrast, in ESA the observed intensification in precipitation has led to flooding, in parallel to a decrease in snow and glaciers coverage (IPCC, 2021b). Drought events represent the most pressing threat to agriculture in many areas in the continent, producing negative effects both on food production and food security (Shiferaw et al., 2014). The increasingly unpredictable environmental factors remain a crucial source of uncertainty for many agriculture-dependents, 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 unfortunately 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. According to FAO (FAO, 2011), women face "gender-specific challenges to full participation in the labour force". An analysis of survey data extracted from six nationally representative household surveys conducted in SSA suggests that women's participation in productive crop activities is 40% on average, slightly above 50% in Malawi, Tanzania, and Uganda, but 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 at times when productive activities in agriculture are very demanding (Oya, 2015). This arrangement implies that women's participation in productive agriculture may not be as high as that of men, and the time devoted to agricultural activities can be lower compared to men's, due to their much higher contribution to household-related tasks (FAO, 2018).

Despite the largely documented pivotal role of women in both productive and in household-related agricultural activities, women are expected to suffer disproportionally from weather-related shocks compared to men. A large body of literature suggests that pre-existing gender gaps in agriculture is magnified under climate-sensitive contexts. For example, when climate-related disasters lead to declining yields and increasing food insecurity, women tend to consume less food than men (Lambrou & Nelson, 2013). Men are also more likely than women to migrate to shockunaffected areas, while women are forced to carry out extra tasks in agriculture during men's absence, and are exposed to increasing workload and household responsibilities to supplement and support household livelihoods (Goh, 2012). A study conducted in Tanzania has found that extreme weather events force poor women to be hired by wealthier women in order to collect animal fodder, hence adding extra workload to the already existing women's tasks and caretaking responsibilities (Muthoni & Wangui, 2015). In many instances, extreme weather events force women to accept jobs exposing them to hazards, illnesses, and work exploitation (Pouliotte et al., 2014). In some African and Asian countries, women work long hours per day in tea production without taking rest break since they are paid by quantity of production, while being exposed to the consequences of 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, ranging from gender-specific division of labour, lack of access to and use of agricultural resources, *i.e.* agricultural land, inputs, extension services, as well as limited capacity to prompt adaptation to climate-related stressors, often resulting from customary norms and roles (Jost et al., 2016; Kakota et al., 2011; Nyasimi & Huyer, 2017).

While the largely documented pivotal role of women in enhancing agricultural performance and mitigating the negative effects of extreme weather events remains a key entry points for local advocacy initiatives in support of women in agriculture, government-led interventions to address adaptation strategies have failed to properly incorporate gender mainstreaming in planning and budgeting, with the risk of 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 collect systematic labour market statistics through dedicated nationally representative Labour Force Surveys (LFS). LFS represent the main source of official labour statistics at the country level (ILO, 2018b) and the best option available to characterize population's labour force status. LFS collect detailed and context-specific labour market microdata, including on working conditions. Despite the increasing commitment to implement LFS, efforts to conduct LFS in SSA remain overall disappointing (Oya, 2010).

Compared to other regions, such as the Arab Region[2], the EU[3], and Latin America and Asia (Sender et al., 2005), only a handful of African countries has recently implemented an LFS.

For countries where LFS are not implemented, labour market statistics can be usually drawn from other types of nationally representative household surveys. In Africa, the lack of systematically collected labour market microdata from LFS is balanced by data collected through household income and expenditure surveys, such as the Living Standards Measurement Study[4]. These surveys usually include a short employment module to collect basic labour market information. Typically, information collected through household income and expenditure surveys is limited to the labour force status of working-age population, sector of employment, number of hours worked, and, in some instances, remuneration paid. To assess the effects of climate variability and extreme weather events on sex-specific employment in agriculture in Africa, the final list of surveys with basic information on working hours and main sector of employment considered in our analysis includes 11 LFS and 20 household income and expenditure surveys; overall they cover a total of 31 African countries. These surveys represent more than 80% of the total African population and cover nearly 86% of the total employed in Africa over the period 2003-2019, although most surveys (24 out of 31) have been collected starting 2014. Panel *a* of Figure 1 shows the type of surveys used for each of the 31 countries included in the analysis, while Panel *b* shows the country's share of employment over total working-age population. All surveys -except for Chad- are also representative at both rural and urban level.

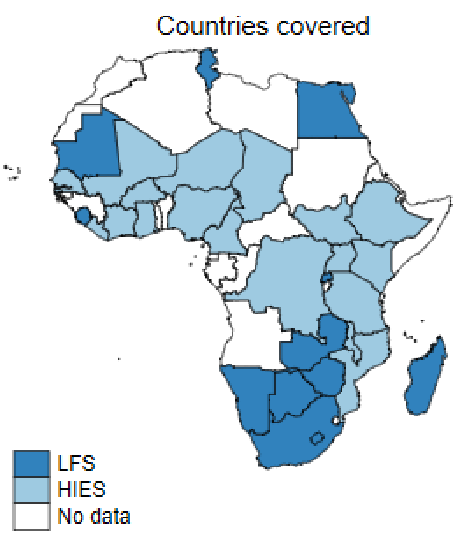
We match 30 out of 31[5] survey data at the lowest administrative division available in the survey with gridcell time series bioclimatic variables (temperature and rainfall variability) at a spatial resolution of $\sim 1Km^2$, derived from the long-term temperature and rainfall values from WorldClim (Fick & Hijmans, 2017). The gridded weather data are first aggregated into the lowest administrative level of the survey to calculate the average value for each bioclimatic variable and then matched with household-level data at the lowest administrative level of the survey -region, district, or village, depending on the country- for their use in the econometric analysis.

[2] http://www.erfdataportal.com/index.php/catalog
[3] https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey
[4] https://www.worldbank.org/en/programs/lsms
[5] Chad survey data do not contain sub-national level information and was therefore excluded from the analysis of weather variability and shocks.

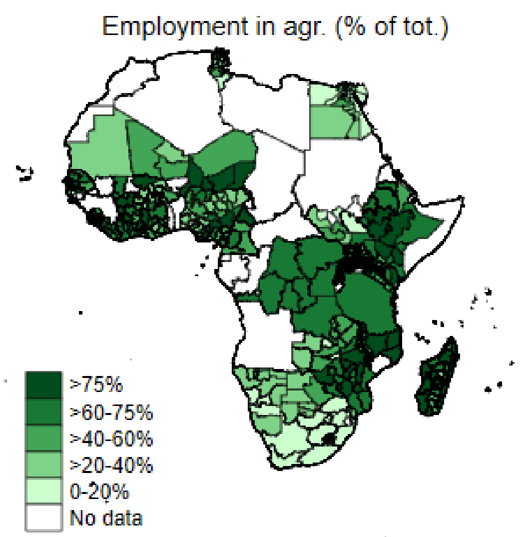
Panels C and D of Figure 1 below show average long-term temperature and precipitation at the lowest administrative levels available in the surveys.

Figure 1. Countries by type of survey (Panel A); share of employment in agriculture at the level of representativeness of the survey (% of total employment) (Panel B); average long-term mean precipitation and temperature at lowest administrative level (Panel C and D). Source: Authors' elaboration based on LFS and HIES (Panel A and B), as well as WorldClim (Fick & Hijmans, 2017) (Panel C and D).

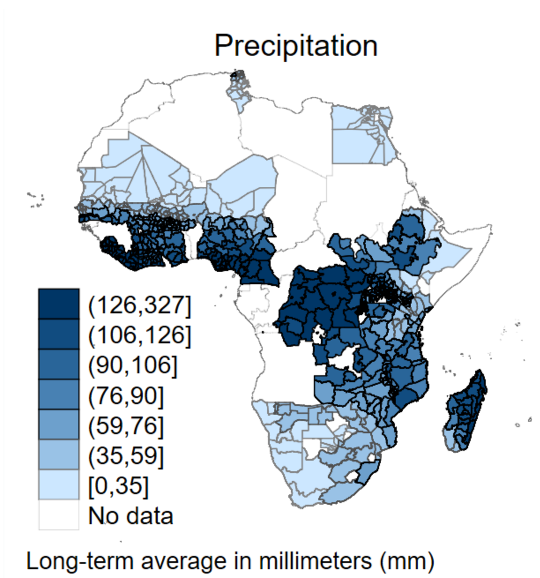
Panel A



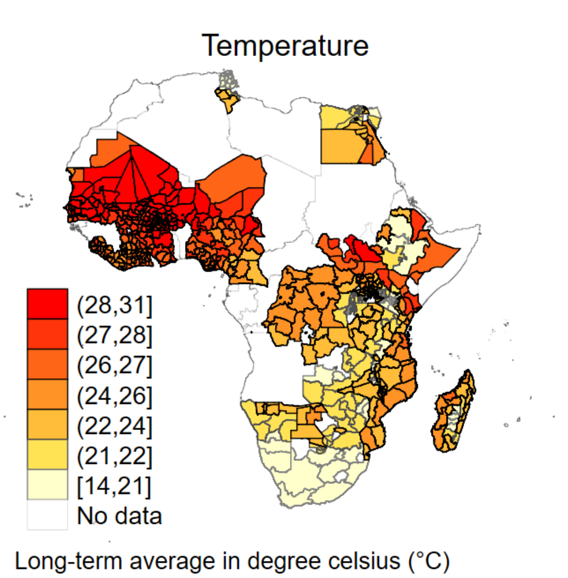
Panel B



Panel C



Panel D



3.2 Methods

To explore the effects of weather variability and climatic shocks on intensity of participation in agricultural and non-agriculture at the individual level we estimate two systems of equations. The equations are estimated through the Seemingly Unrelated Regression (SUR) estimator to account for the potential contemporaneous correlation of the error terms in each equation (Zellner, 1962). Compared to OLS regressor --that 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:

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

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

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 $i=1$ agriculture*,* and $i=2$ non-agriculture); and p, c are indices for individual and country. Similarly, the dependent variable of Equation [2] captures the aggregate number of hours worked in agriculture (i=1) and non-agriculture ($i=2$) by the household h, where c is the index for country. In both system of equations, location-specific (region, district, or village 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]), $\boldsymbol{X}_{i,p,c}$ is a matrix of individual-level demographic characteristics, including age, sex, the highest level of education attained, and the rural/urban location where the individual resides. In the first system of equation, we also control for several household-level characteristics including household size, old-age dependency ratio (Appendix 2).

In the second system of equations (Equation [2]), $\boldsymbol{X}_{i,h,c}$ is a matrix of household-level covariates (Appendix 3). The independent variables in the second systems of equations include: area of residence (urban or rural), household size, average age of the household, average level of education attained by household members, share of employed household members, share of household members participating in agriculture and in non-agriculture (over total household members employed), ratio female-to-male in agriculture and in non-agriculture, as well as a number of demographic variables (*e.g.*, old dependency ratio and ratio female-to-male household members). Finally, $\boldsymbol{Y}_{d,c}$ is a matrix of bioclimatic variables that enter both equations of models [1] and [2], with indices d, c indicating the lowest administrative area where the household resides and the corresponding country, respectively.

Since the seasonal nature of agriculture leads temperature and rainfall variability to affect the intensity of participation in agriculture-related activities and, in turn, agriculture income, the list of bioclimatic variables includes temperature and precipitation monthly average values, as well as their associated coefficients of variation (CV) capturing the intra-annual variation over the period 1981 to 2020 obtained from ERA5 Copernicus Climate Change Service (Hersbach et al. 2018).

We also include three dummy variables proxying weather-related extreme events -*i.e.*, heat waves ($Heat_{d,c}$), drought ($Drought_{d,c}$), and flood ($Flood_{d,c}$) shocks. Shock-affected areas are then identified as country-specific areas (c) -at the lowest administrative level of each survey (d)- with temperature and precipitation monthly specific values higher (lower) than +2 or -2 standard deviations (SD) from the long-term monthly average -computed from 1981 up until the survey year- during any of the six months prior to the survey interview day, if the shock has occurred during the maize cropping season -*i.e.*, the months for maize planting and growing-. Since our aim is to measure the effects of weather shocks on work intensity in agriculture, we only refer to the FAO maize cropping calendar to identify the months of planting and growing season for each country in our sample.[6] Finally, ε_i expresses the disturbance term.

In the regressions at the individual-level [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 agriculture and non-agriculture $\left(W_{i,p,c} * Heat_{d,c}\beta_2\right)$, $\left(W_{i,p,c} * Drought_{d,c}\beta_4\right)$ and $\left(W_{i,p,c} * Flood_{d,c}\beta_6\right)$, where the term $W_{i,p,c}$ is a dummy variable equals to 1 for women who engage in either agriculture or non-agriculture agriculture activities, as specified in equation [3] below.

[6] Due to missing information on the month of the interview in 10 surveys, the three dummies are constructed for 21 out of 31 surveys, thus leading to a reduction in the number of observations for some of the estimated econometric specifications (see Table 2 and 3).

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

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 test whether the SUR models yield a gain in efficiency -as opposed 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 case of 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 α=0.05 in both model [1] and [2], the null hypothesis of independence of the residuals vectors in the two equations is rejected and, therefore, use of the SUR model is justified.

4 Results

4.1 Descriptive statistics

Using LFS and household income and expenditure survey 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 labour market participation, disaggregated by the three main African regions.

Regardless of age and sex, agriculture dominates the employment distribution, absorbing a relatively higher share of the total employed population in both WCA and ESA (52 and 60 per cent, respectively); conversely, only one-fourth of the total employed population in North Africa is engaged in agriculture. In East and Southern Africa, the share of women participating in the labour market is considerably higher in agriculture than in non-agriculture (62% and 38%, respectively), while in WCA women are almost equally distributed between agriculture and non-agriculture. Table 1 also shows strongly significant differences between average hours worked in agriculture and non-agriculture. In a typical week, the average number of hours worked in agriculture appears to be much lower than in non-agriculture in all three regions, and particularly in ESA where, on average, hours worked in agriculture are 15.6 lower than those worked in non-agriculture.

Table 1. Sex-disaggregated labour market indicators in Africa. *Source*: authors' elaboration based on LFS and HIES for 31 African countries

Variable	North			West-Central			East-Southern		
	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 the employed in agriculture	32.80	40.29	38.03	35.53	36.57	36.11	33.09	31.98	32.52
Age of the employed in non-agriculture	38.18	37.54	37.66	37.60	38.58	38.08	33.89	34.76	34.37
Employed population (% 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-agriculture	0.65	0.78	0.75	0.51	0.44	0.48	0.38	0.41	0.40
Employment sectoral share[7]:									
Crop	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-agriculture	41.14	46.48	45.51	43.37	48.27	45.76	39.72	44.20	42.25
Average weekly hours worked in sectors[8]									
Crop	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

Note: all values are statistically different by male and female at the 1% level, except those related to Forestry.

Employment statistics presented in Table 1 below are computed using the one-hour criterion, i.e. by accounting for all people who, during the reference week, work at least one hour in exchange for pay or profit (ICLS, 2013, 1982). However, estimates of employment in agriculture do not account for the potential low intensity in 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 agriculture activities across the 31 analyzed countries, whereas employment in non-agriculture corresponds to less than half of total estimated employment (49 per cent), or 151 million. On the contrary, using a threshold of *at least* ten hours per week (hence, just slightly

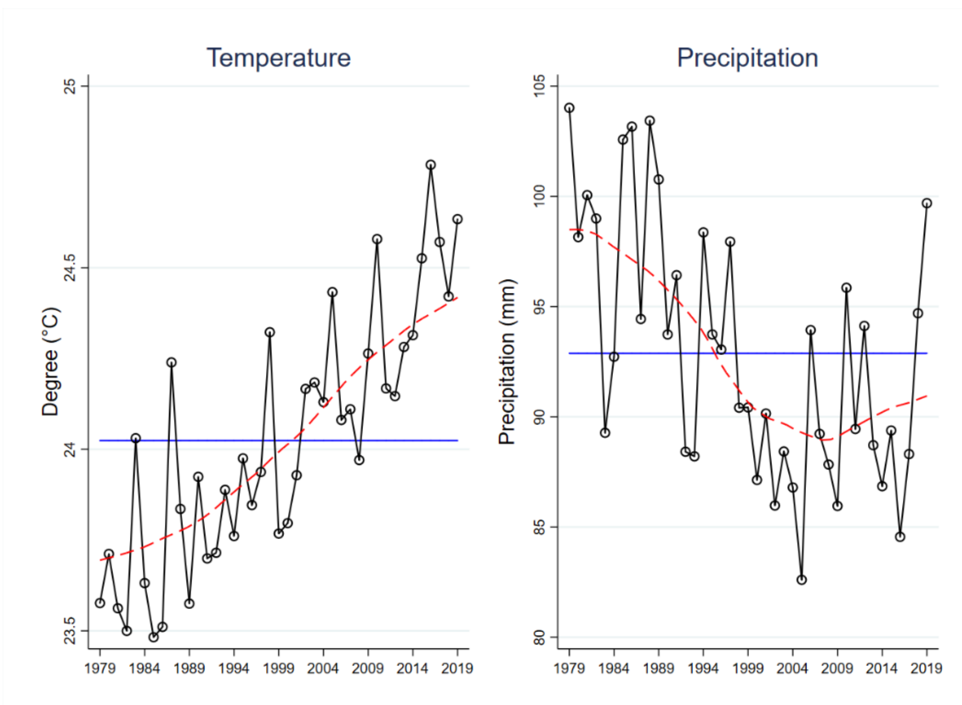
[7] Congo DRC, Ethiopia, Ivory Coast, Kenya, Lesotho, Liberia, Malawi, South Sudan, Tanzania and Zimbabwe do not contain information on employment participation in sub-sectors of both agriculture and non-agriculture.

[8] Due to missing information on employment by sector of economic activity, it was not possible to calculate weekly hours worked by sub-sector in Congo DRC, Ethiopia, Ivory Coast, Kenya, Lesotho, Liberia, Malawi, South Sudan, Tanzania, and Zimbabwe.

more than 1.5 hours per day assuming the traditional six working days across most African countries) to measure employment in agriculture, the number of people employed reduces by about 15 per cent. The simple comparison between employment statistics based on different cut-off thresholds of participation in the labour market suggests that most of the employment in agriculture is dominated by irregular and low intensity jobs, proxied here by relatively low hours worked (as also done in Oya, 2015).

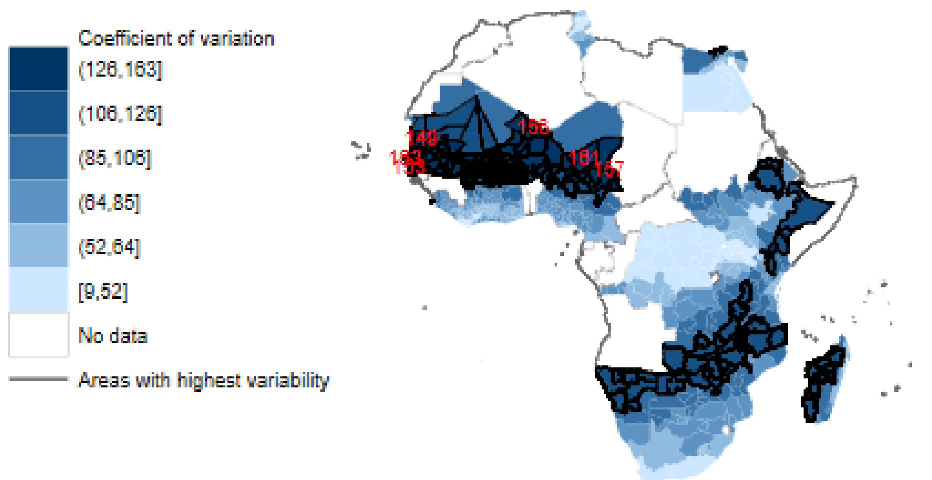
In our study, the underestimated and seasonal nature of employment in agriculture is combined by the alarming changing climatic conditions that have been occurring over the last four decades in the continent, as witnessed by the average annual temperature recorded in the African countries analyzed, with many years showing an annual temperature above the average of the last 40 years (Figure 2).

Figure 2. Long-time trends in temperature and precipitation across 30 African countries. *Source*: authors' elaboration based on data by Hersbach et al., 2018.



Unpredictable rainfall patterns in Africa have contributed to a higher likelihood of extreme climate events, such as heat waves, droughts, and floods (Derbile et al., 2016). A closer look at data shows that among the 30[9] analyzed African countries precipitation's CV is particularly severe in many parts of West Africa e.g., Senegal, Niger, Nigeria, Gambia, Mali, and Mauritania (Figure 3).

Figure 3 Coefficient of variation in precipitation. Source: 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. Data suggest that women are more likely than men to engage in agriculture employment in drought-prone areas, as well as in areas affected by heat waves (Figure 4)[10]. For example, comparing statistics by heat wave occurrence, in WCA women represent 57% of total agriculture employment in areas affected, down to 45% in areas not affected; similarly, in heat waves-affected areas of East and Southern Africa, women in agriculture account for 53% of total agricultural employment, while their participation is lower relatively to men in areas not affected by heat waves (46.5 %). Women's participation in agricultural employment is higher than men's in areas affected by droughts, especially in WCA. In drought-hit areas of WCA, females represent an estimated 59% of total agricultural employment, whereas male participation is higher relatively to women in areas not affected by drought events (55% and 45%, respectively). A similar pattern is also found in ESA where women's participation in agriculture employment is higher in drought-prone areas and lower in areas not affected by shocks.

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9 Chad survey data do not contain sub-national level information and was therefore excluded from the analysis of weather variability and shocks.

10 Due to missing information on the month of the interview in 10 surveys, shock-affected areas were identified only in 21 out of 31 surveys included in the analysis. Despite sample reduction, the number of countries is still sufficiently large to draw inference at the regional level, with the only exception of North Africa for which only Tunisia is included.

Figure 4. Sex-disaggregated employment statistics in agriculture by shock-affected area. *Source*: own computation based on 21 household survey data matched with gridcell data extracted from Hersbach et al., 2018.

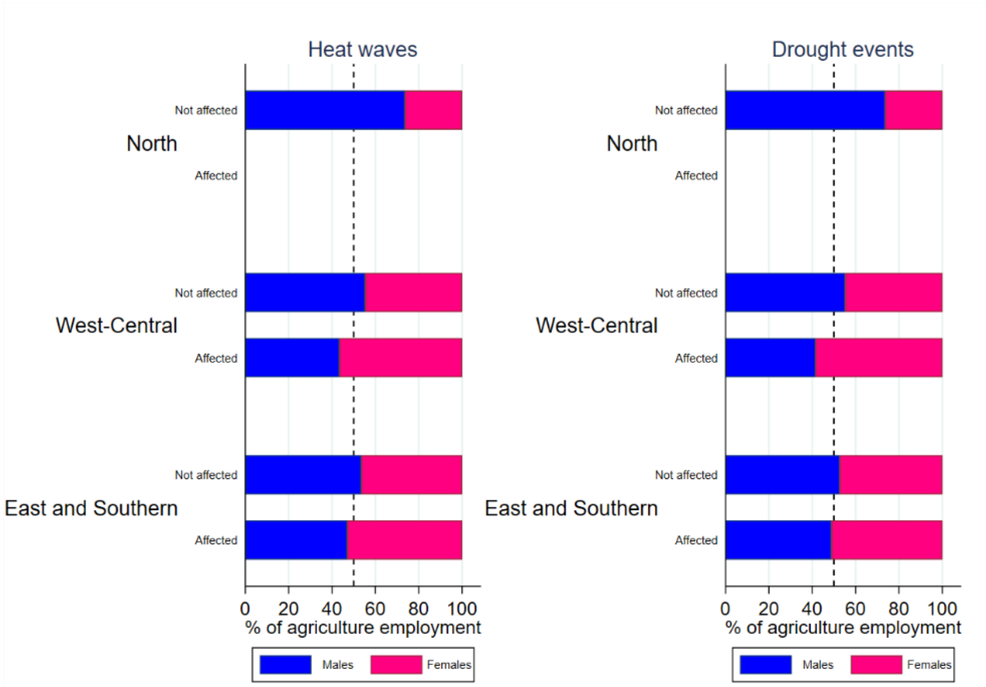
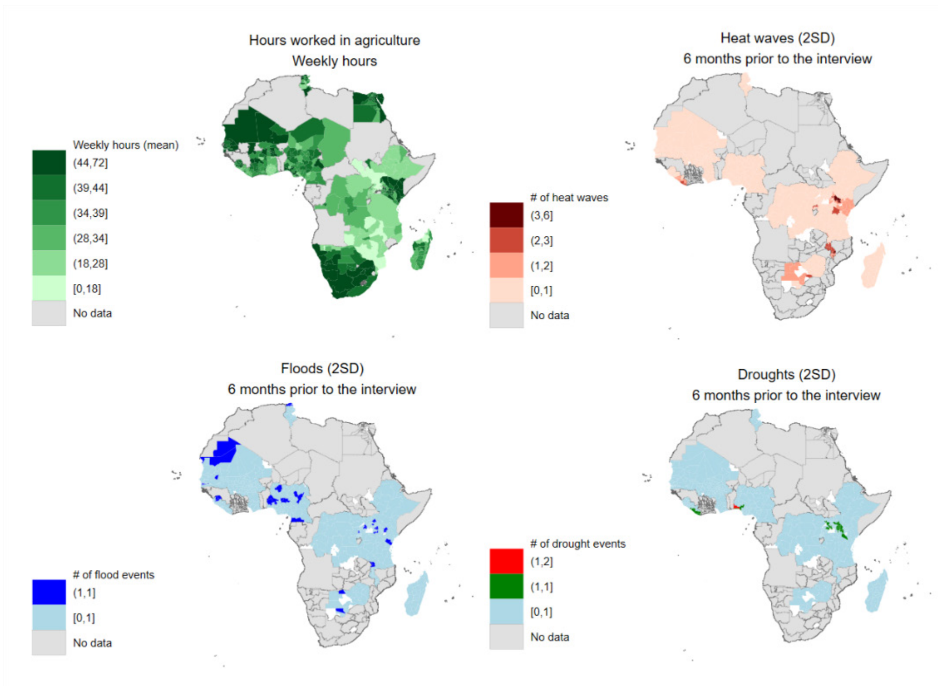


Figure 5 maps the average number of hours worked in agriculture at the sub-national level -statistically representative of the survey in each country- overlaid with the number of heat waves, drought, and flood events occurred during the six months prior to the interview. Simple descriptive statistics suggest that in areas affected by heat waves individuals in agriculture work in a week 5.5 fewer hours than those in areas not affected, while in drought-prone areas a individuals work two fewer hours compared to individual in non-drought-prone areas. No statistically significant differences in labour intensity across regions were detected due to floods.

Figure 5. Average weekly hours worked in agriculture at the sub-national level and number of extreme weather events in the six months prior to the date of interview. *Source*: own calculations based on 30 household surveys. Heat waves, drought, and flood events are identified based on data by Hersbach et al., 2018.



4.2 Multivariate regressions: main findings

We run two regressions for each system of Equation [1] and [2], according to the use of survey sampling weights -yielding weighted or unweighted estimates-.[11] For each system, the last specification (column 3 in Table 2 and 3) includes all countries for which information on weekly hours worked as well as weather shock variables are available (n=21), with the parameters associated to the variables of interest shown in Figure 5. Appendix 4 shows key coefficients of interest by region. The explanatory power of the models summarized by the R^2 (Table 2 and 3) is 25% for the number of hours worked by an individual in agriculture, while 62% for the total number of hours worked in agriculture by all household members.

Overall, the estimated coefficients from the multivariate regression analysis (in Table 2 and 3) corroborate many of the findings derived from the descriptive statistics presented in Table 1. Indeed, women show a 21% lower labour intensity in agriculture and an 11% higher in non-

[11] Estimates are weighted by sampling weights to ensure national representativeness of the parameters, thus allowing general inference for the 21 countries included in the specification with extreme weather shocks (columns 3 and 6 in Table 2 and 3), given some surveys do not include information on the interview time.

agriculture than their male counterpart, but with some difference by region. For example, in North Africa, the intensity of women's agricultural labour is 15 percent higher compared to men's, while women's intensity of non-agricultural labour is lower relatively to men (-24%). In East and Southern Africa, the estimated coefficient points to no difference in the intensity of agricultural labour between women and men, while women work fewer hours than men in the non-agricultural sector. Finally, in Western and Central Africa women's labour intensity in agricultural activities is lower compared to men. These findings not only provide further evidence on the prominent role of women 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 labour market participation.

The effects of temperature and rainfall variability are confirmed to be detrimental to agricultural participation, at both the individual- and household-level. Moreover, in areas with high temperature variability the intensity of agricultural labour -measured in terms of weekly hours worked in the sector- decreases remarkably, with the only exception of North Africa (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 reduction in the number of hours worked in agriculture by an individual by 0.2 %, with the effect being highest in East and Southern Africa (-0.3%).

A higher temperature variability also seems to be negatively correlated with the total number of hours worked in agriculture at the household level (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 percentage points. At the household level, the effects of temperature's CV are found to be highest in East and Southern Africa (-0.4%, Appendix 4).

Table 2. Weighted seemingly unrelated regressions on hours worked in agriculture and non-agriculture at the individual level

VARIABLES	1	2	3	4	5	6
		Agriculture			Non-Agriculture	
Rural/urban location = 1, Rural HHs	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 dep. ratio (HH members 64+y.o. over HH members <=64y.o.)	-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 most 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 most 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 cel), mean	-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 (mm), mean	-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 FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

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

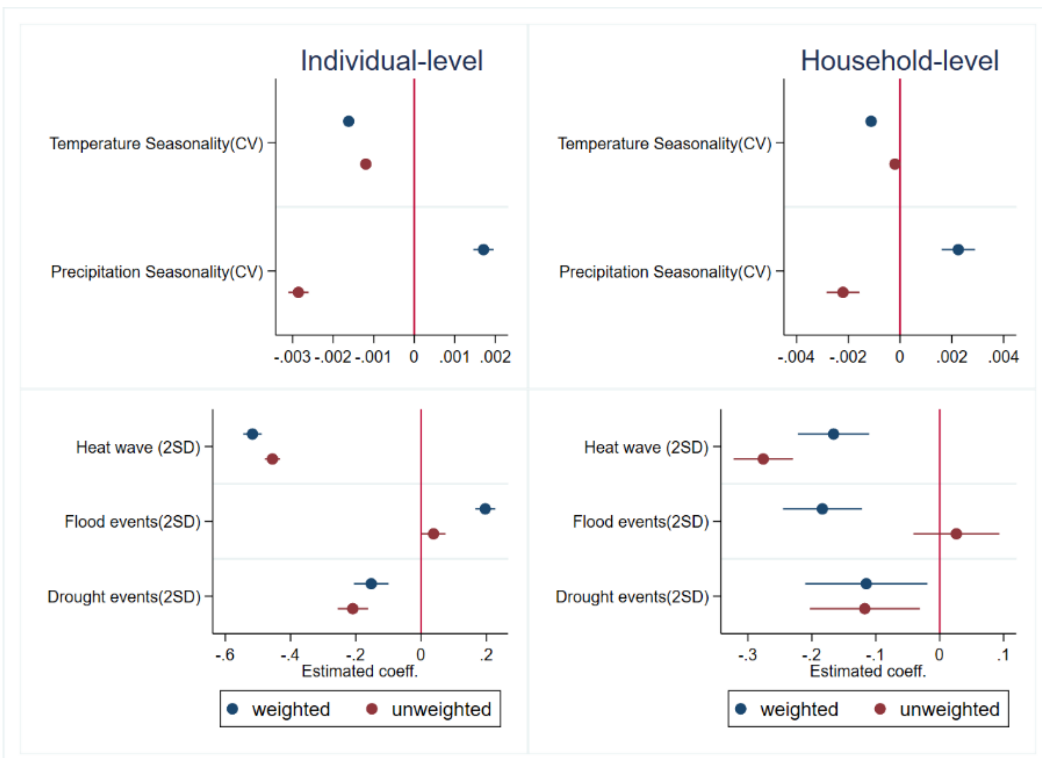
Table 3. Weighted seemingly unrelated regressions on total number of weekly hours worked in agriculture and non-agriculture at the household level

VARIABLES	1	2	3	4	5	6
		Agriculture			Non-Agriculture	
Rural/urban location = 1, Rural HHs	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 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 most 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 most 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 dep. ratio (HH members 64+y.o. over HH members <=64y.o.)	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 HH females/males	-0.16121***	-0.16256***	-0.19104***	-0.16368***	-0.16259***	-0.16728***
	(0.00458)	(0.00458)	(0.00644)	(0.00461)	(0.00460)	(0.00647)
% 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 HH members in agr/HH members in non-agr	1.30003***	1.29933***	1.27828***			
	(0.00428)	(0.00428)	(0.00585)			
Ratio HH members in non-agr/HH members in agr				2.02423***	2.01977***	1.99333***
				(0.00607)	(0.00605)	(0.00858)
Ratio females/males in agr.	1.12913***	1.13144***	1.15277***			
	(0.00893)	(0.00896)	(0.01190)			
Ratio females/males in non-agr				0.91227***	0.93365***	1.14178***
				(0.00931)	(0.00930)	(0.01328)
LT Annual Mean Temperature (degree cel), mean	-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 (mm), mean	-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 FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

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

The coefficient associated with precipitation's CV exhibits a positive sign in both the household-level and the individual-level regressions, most likely driven by the positive sign in most populated countries (e.g., Nigeria) when regressions are estimated using sampling weights. However, the precipitation's CV turns to be negative and statistically significant in the unweighted regression (-0.2% at the household level and -0.3% at the individual level (Figure 6 below). Yet, weighted regressions suggest that in West and Central Africa, a one-point increase in the precipitation's CV is expected to reduce the total number of hours worked in agriculture by 0.5 percent at the household level, and by 0.1 percent at the individual level (Appendix 4).

Figure 6. Estimated coefficients associated to weather variability and extreme shocks from weighted and unweighted regressions for individuals and households involved in agriculture.

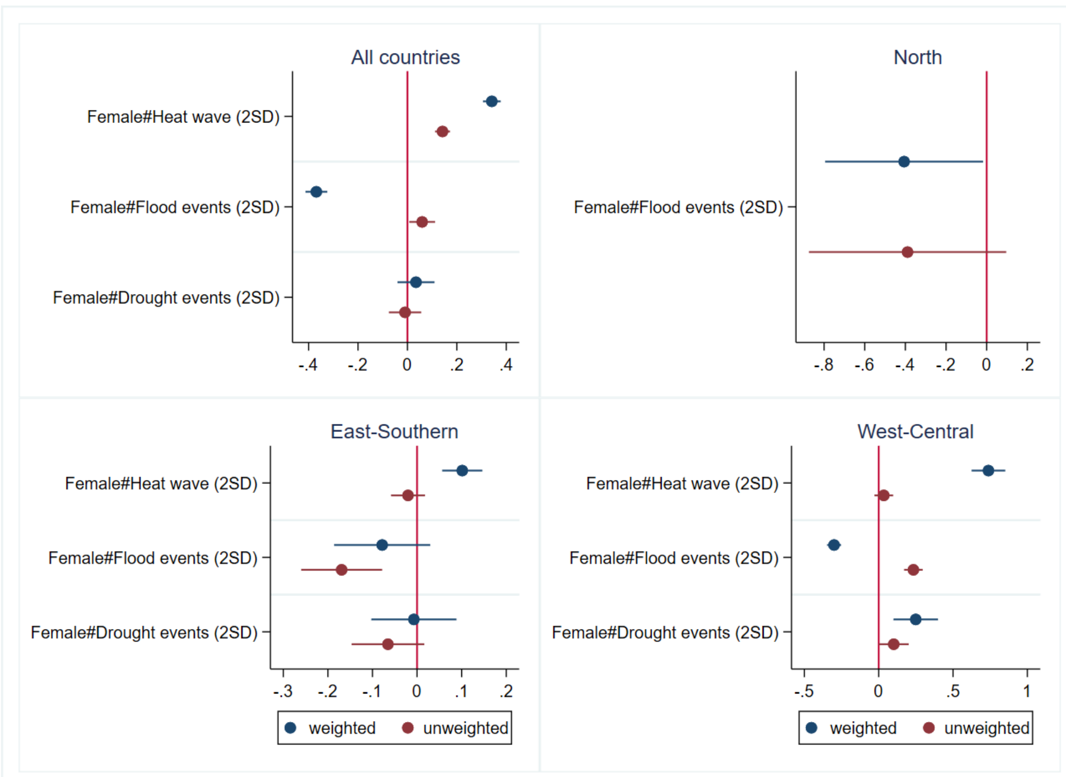


Our econometric strategy allows to look at the effects of climatic and weather shocks on sex-specific labour intensity. The reference weighted model at the individual level shows that both heat waves and droughts are associated the most detrimental effects on individual effort intensity in agriculture, 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, given 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%, due to a flood event. At the household level, weighted regressions suggest that experiencing a heat wave, flood, or drought event during at least one of 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 case of a heat wave: overall, being a female farmer seems to mitigate the negative impact of heat waves on work intensity in agriculture by 40%, (Figure 6). The estimated coefficients robustly support the importance of female farming in mitigating the negative effects of heat waves in both WCA and ESA.

Figure 7. Estimated coefficients associated to the interaction between sex of the farmer and shocks on labour intensity in agriculture.



5. Conclusions and policy implications

Our study is based on a large database of recent nationally representative labour 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 labour-related measures used to compare labour market participation and intensity, matched with various bioclimatic dimensions to explore the effects of natural environment on agricultural labour participation and intensity.

Individual-level statistics suggest that agriculture is the dominant sector in both West-Central Africa and East and Southern Africa, although participation in the labour market in the 31 African countries is higher among men than women. Nonetheless, sex- and sector-disaggregated statistics highlight that in East and Southern Africa women's participation in the labour market is considerably higher in agriculture than in non-agriculture (62% and 38%, respectively), while in West-Central Africa women are almost equally distributed between the two sectors (49% and 51% respectively). In North Africa, instead, only about one-third of total women employed are engaged in agriculture (35%) but their participation is higher than men's.

Both heat waves and droughts are associated 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, given an expected reduction in the number of hours worked by 49 and 23%. We also find strong evidence of a sex-specific effect in case of a heat wave: overall, being a female farmer seems to mitigate the negative impact of heat waves on work intensity in agriculture by 40%, highlighting the importance of female farming in mitigating the negative effects of heat waves.

Institutional and exogenous factors -such as climatic shocks- are expected to affect intensity of agricultural participation and expected return, calling for policy action. Our econometric analysis shows that precipitation and temperature variability is probably one of the most limiting factors for full participation in agricultural activities. The 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-returns 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, supporting government-led policy and interventions need to be designed to limit the negative effects of increasing weather variability, as well as extreme weather events affecting participation in crops, livestock, forestry, and fisheries production. Given the fundamental role of women both in agriculture production and in coping with extreme weather shocks, sustainable, climate-resilient, and gender-sensitive policies and interventions remain a key priority alongside gender mainstreaming in planning and budgeting agriculture-related programmes.

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

Country	Sub-Region	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	Enquete Nationale du type 1-2-3 aupres des menages	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 menages et	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	Enquete 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 the individual-level models

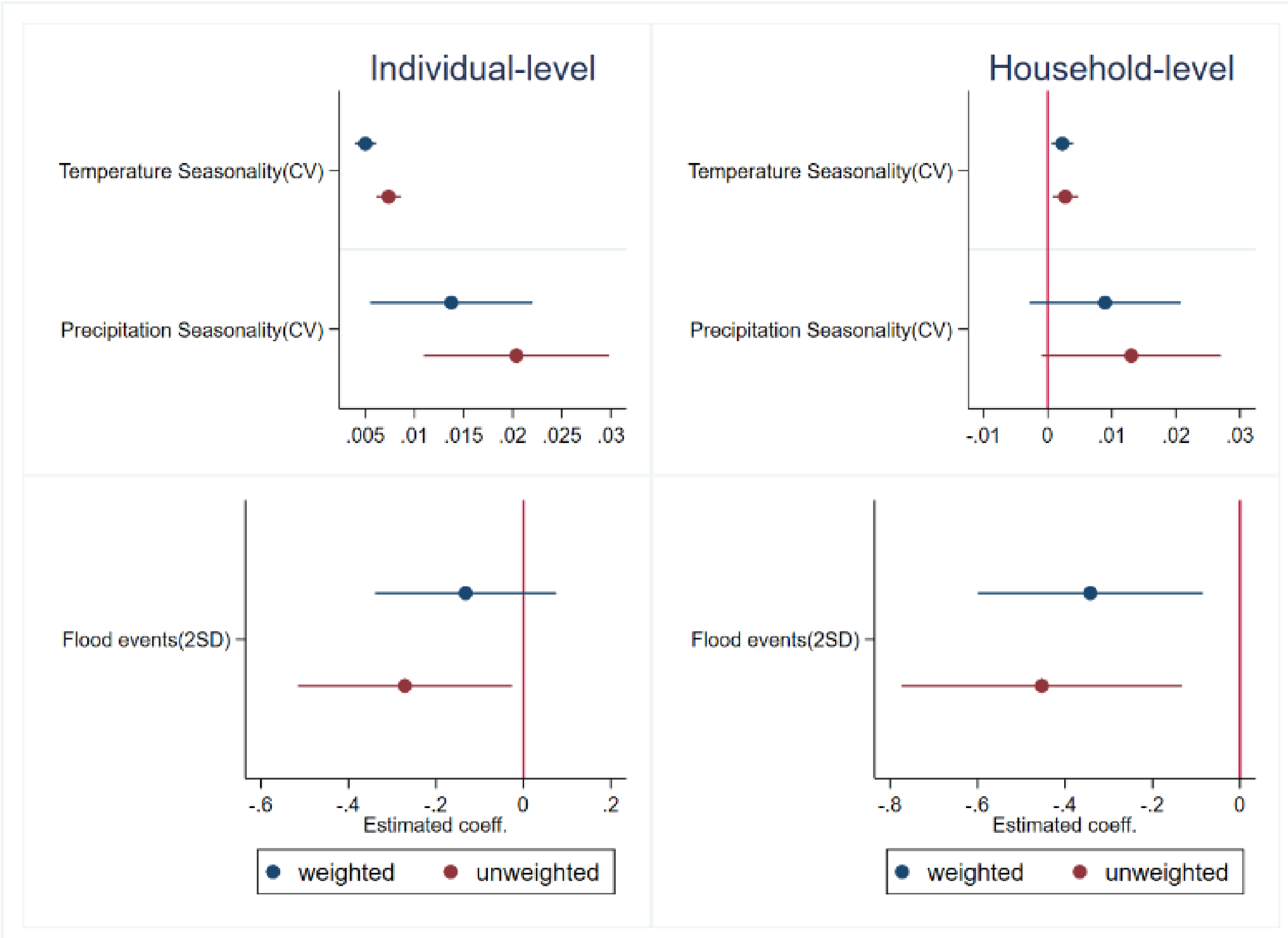
	N	Mean	SD	Min.	Max.
Dependent variables					
Weekly hours worked in agriculture (log)	640,875	1.525	1.761	0	5.118
Weekly hours worked in non-agriculture (log)	640,875	2.051	1.890	0	5.124
Independent variables					
Dummy for individual living in Rural (1) and urban (0) areas	640,875	0.538	0.499	0	1
Age 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 HH: At most primary (1), secondary (2), tertiary (3), not stated	580,253	1.423	0.670	1	4
Household size	640,875	6.470	4.868	1	82
Household members aged 64+ / household members aged less than 64 y.o.	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
Individual 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
Individual 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
Individual 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 sub-national 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

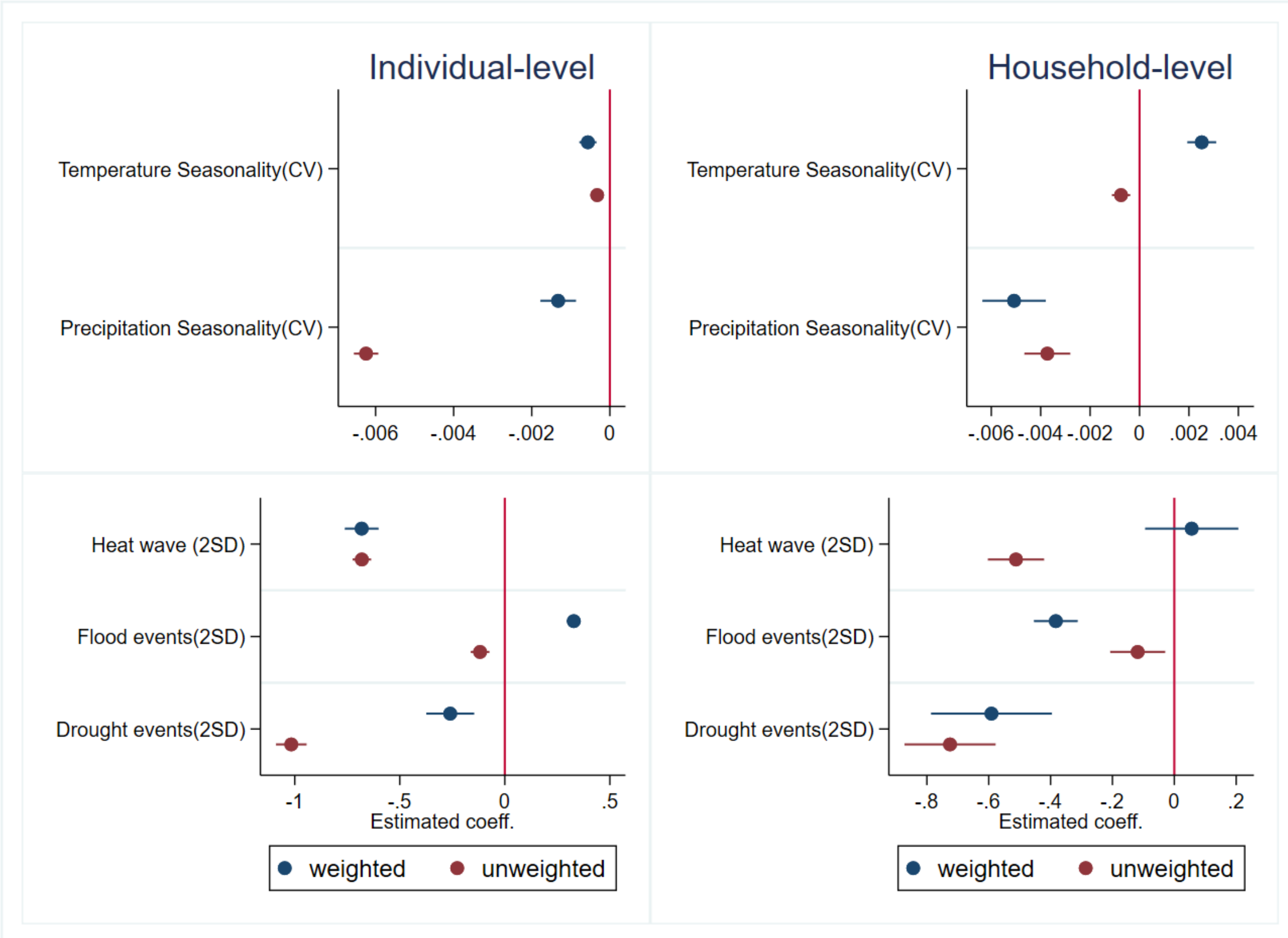
	N	Mean	SD	Min.	Max.
Dependent variables					
Weekly hours worked in agriculture (log)	338,419	-1.078	4.239	-4.605	7.636
Weekly hours worked in non-agriculture (log)	338,419	1.383	4.001	-4.605	6.936
Independent variables					
Dummy for individual living in Rural (1) and urban (0) areas	338,419	0.502	0.500	0	1
Average age in the 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 most primary (1), secondary (2), tertiary (3), not stated	306,110	1.706	0.642	1	4
Household members aged 64+ / household members aged less than 64 y.o.	332,975	0.0738	0.243	0	12
Ratio female household members/male household members	338,419	1.223	1.078	0	14
% of employed household members	338,419	0.486	0.285	0	1
Ratio household members working in agriculture/household members working in non-agriculture	338,419	0.844	1.479	0	37
Ratio household members working in non-agriculture/household members working in agriculture	338,419	1.041	1.057	0	21
Ratio female household members in agriculture/ male household members in agriculture	338,419	0.335	0.641	0	14
Ratio female household members in non-agriculture/ male household members in non-agriculture	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
Household 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
Household 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
Household 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 sub-national 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

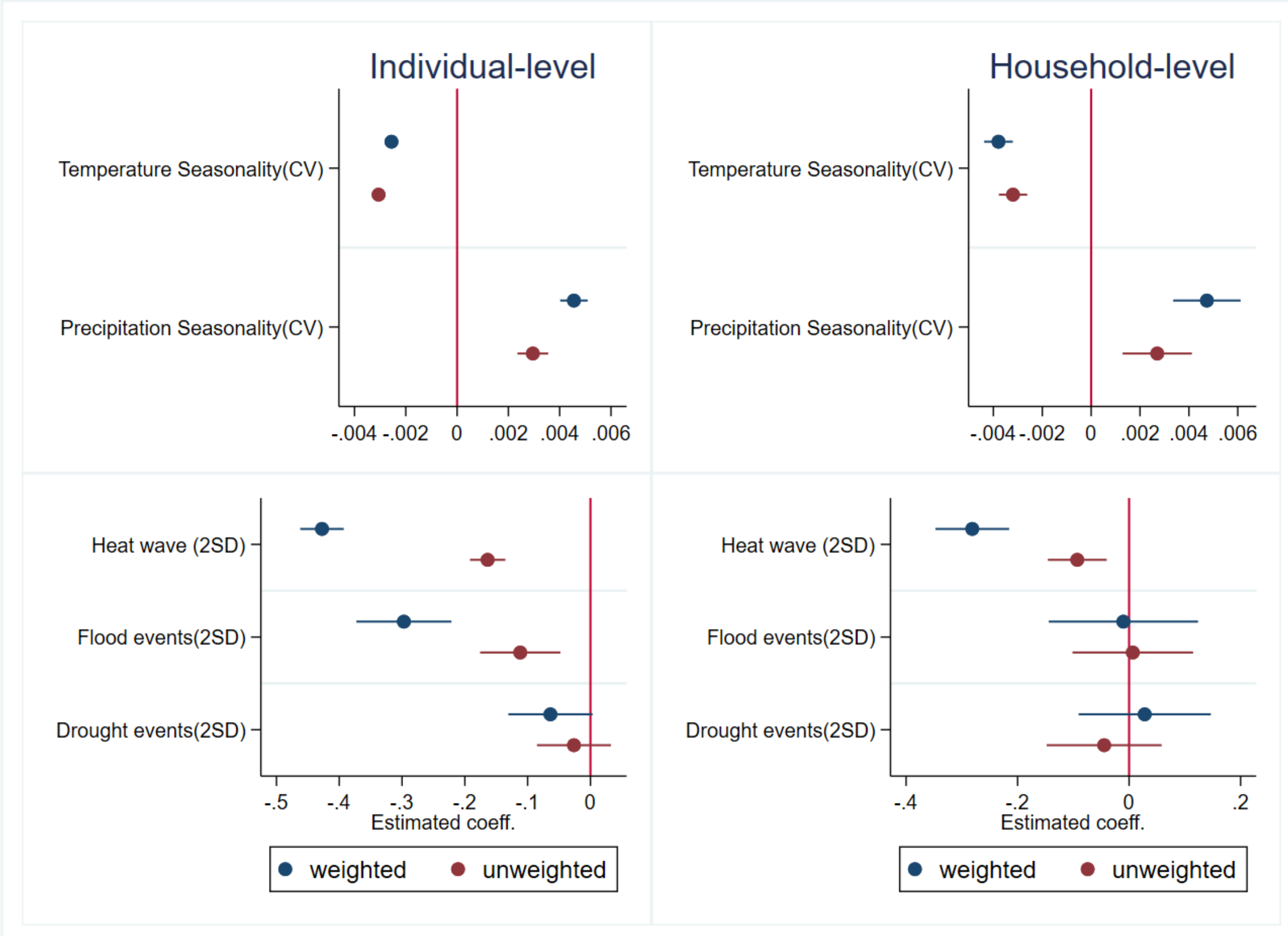
North Africa



West-Central Africa



East and Southern Africa



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