Unveiling gendered labour dynamics amidst droughts

The case for African countries

Zeinab Hassano

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Zeinab Hassano

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Examiner:	Rob Hart, Swedish University of Agricultural Sciences, Department of Economics

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Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Economics

Abstract

Climate change has intensified the frequency of extreme weather events, such as droughts, which are expected to worsen without mitigation efforts. While drought impacts on rural areas are well-documented, their effects on urban economies and gender-specific labour markets in African countries remain underexplored. This study investigates the gender-differential employment effects of droughts in agriculture, upper non-farm, and lower non-farm sectors at national, urban, and rural levels from 2005 to 2020.

Using an event study difference-in-difference design, the results reveal that women in rural areas experience a significant increase in agricultural employment rising by 46 %, while men show smaller gains. Nationally, male employment in the agriculture sector declines by 30 % while women's employment grows. In urban areas, both genders experience moderate increases in agricultural employment, but women suffer sharper declines in the non-farm sectors, particularly in upper non-farm jobs. These findings suggest that women, especially in rural areas, rely more on agriculture as a fallback during droughts, while men's broader employment opportunities expose them to greater national-level vulnerabilities. In urban areas, women in non-farm sectors are particularly affected, highlighting limited options for adaptation.

The paper concludes that targeted interventions are needed to prevent droughts from exacerbating gender inequalities, especially in non-farm sectors. Policies that expand women's access to diverse employment opportunities are critical for promoting equitable economic recovery in the face of climate change.

Keywords: Drought, Climate Change, Employment rate, Event-study Difference-in-Difference.

JEL Classification: J16, J21, Q54, J43, O13

Table of contents

List of tables

Table 5. Panel data descriptive statistics………………………………………….26

Table 6. Result of panel regressions: the effect of drought on employment rates at the national level……………………………………………………………….29

List of figures

Abbreviations

ATT Average Treatment Effect for the Treated

DID Difference in Difference

DR Doubly robust estimator

GDP Gross Domestic Product

ILO International Labour Organization

OR Outcome Regression

TWFE Two-Way Fixed Effects

1. Introduction

Climate change is imposing significant stress on several sectors, particularly agriculture, as heightened weather variability results in extreme occurrences that produce substantial short- and medium-term effects (Day et al., 2019; Stevanović et al., 2016; Key and Sneeringer, 2014). In addition to rising average temperatures, climate change has exacerbated the frequency and intensity of extreme weather phenomena, such as droughts (Schiermeier, 2018), a trend expected to escalate without mitigation (Fischer et al., 2021; Chiang et al., 2021). Recent studies predict a 22% global decline in agricultural total factor productivity (Ortiz-Bobea et al., 2021), but the regional effects differ significantly.

Climate conditions influence local socioeconomic factors, heightening the vulnerability of economies that heavily rely on agriculture, particularly those with weak institutions and limited safety nets (Hallegatte et al., 2018). Africa is prominently acknowledged as a climate disaster hotspot (Blunden and Arndt, 2020; Niang et al., 2014). Although the direct consequences of weather variability on land productivity are extensively established (Schleussner et al., 2018; Dell et al., 2014; Deschênes and Greenstone, 2007; Di Falco et al., 2011), there is significantly less understanding of the effects of drought on labour markets. This knowledge gap is particularly evident in African nations, where insufficient data availability obstructs effective policy formulation (Cramer et al., 2018).

Globally, over 75% of rain-fed agricultural systems are especially vulnerable to increasing rainfall uncertainty, making climate-induced shocks particularly harmful to rural livelihoods, especially in developing countries (World Bank, 2021). Africa, where over 70% of the population relies on agriculture, is particularly susceptible to drought, and this vulnerability is compounded by weak institutional responses and inadequate safety nets.

To address these gaps in the literature, this study will attempt to answer the following research questions:

1. *What are the gender-differential effects of drought shocks on employment rates in the agriculture sector, upper non-farm sector, and lower non-farm sector at the national, urban, and rural levels?*
2. *To what extent do these effects differ between women and men, and what underlying mechanisms contribute to the observed gender-specific impacts?*

Social constraints, such as low mobility and traditional gender roles, often limit women's access to off-farm work, exacerbating gender disparities in labour market responses to environmental shocks (Afridi et al., 2022). In a context where men are often better positioned to take advantage of coping mechanisms through seasonal migration, we will assess labour responses by gender and uncover the mechanisms behind these gender-differentiated impacts. These mechanisms will be compared across African economies with different labour market institutions, infrastructure, and levels of gender and income inequality.

Prior research has emphasised that, due to a lack of reliable insurance and credit markets, many agricultural households diversify into non-farm sectors to mitigate the impacts of droughts, which harm crop production and reduce incomes (Hallegatte et al., 2018). However, this diversification is not always equally accessible to women, whose mobility and employment choices are often restricted by social norms. Studies suggest that droughts reduce the demand for agricultural labour, leading to a decline in daily wages, especially in regions with limited access to non-agricultural work options (Cramer et al., 2018).

Migration is also a prevalent response to climatic disruptions, such as insufficient rainfall and heat stress (Huang et al., 2020; Agamile et al., 2021). However, while men may have better access to off-farm opportunities due to greater mobility, women are often constrained by traditional roles that limit their ability to seek alternative employment (Afridi et al., 2022). For example, Huang et al. (2020) found no gender disparities in non-farm work transitions in rural China, while Agamile et al. (2021) observed that women in Uganda tend to diversify into more marketable crops during droughts, while men seek off-farm employment. However, these trends are not well-documented at the national level, and little is known about the underlying mechanisms driving gender-specific responses to droughts.

Figure 1.1 illustrates that Africa experiences more frequent droughts compared to the rest of the world, with notable peaks in 2005, 2010, and 2015. This trend highlights the region's vulnerability to environmental shocks, making it critical to explore how droughts affect employment rates, particularly in labour-dependent sectors like agriculture.

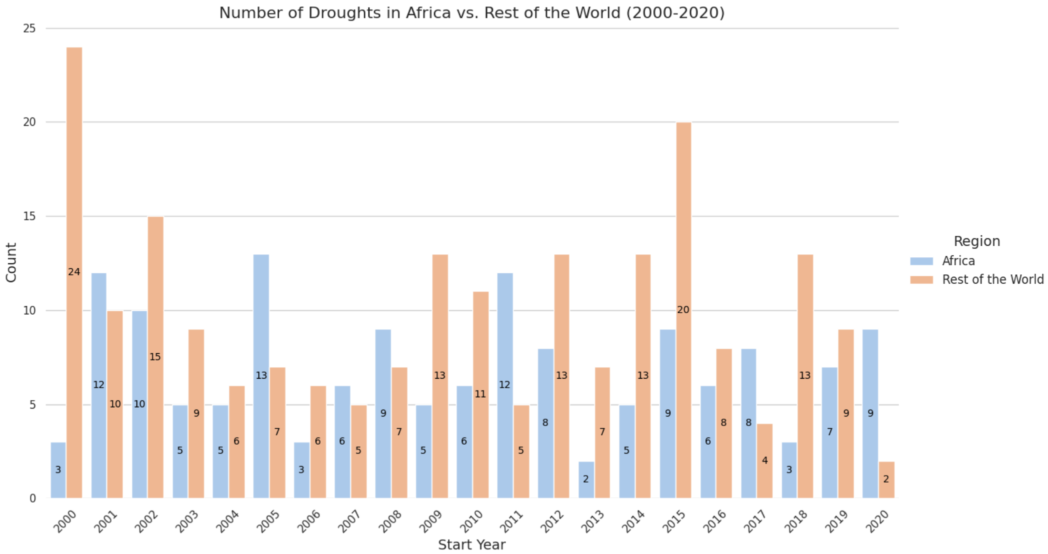

Figure 1. Number of Droughts in Africa vs. Rest of the World (2000-2020)

To understand these dynamics better, this paper investigates the research topic using aggregated sector-specific employment data and drought data from 31 countries between 2005 and 2020. Our methodology consists of two main components. First, we employed a fixed effects panel data regression model for both country and period, using drought years as the treatment variable. Second, we conducted an event study using the doubly robust difference-in-differences (DID) estimator, as proposed by Sant'Anna and Zhao (2020), to measure the group-time average treatment effect (ATT(g,t)). Following Callaway and Sant'Anna (2021), we used the "not-yet-treated" group as the control group. The model includes various factors, such as GDP per capita, average years of education, urban population ratio, household size, and labour force participation rate.

Our findings indicate that droughts have a gender-specific impact on employment, with women experiencing significant increases in agricultural employment and declines in non-farm sectors, whereas men display more varied and generally less intense responses. Women, particularly in rural areas, see substantial increases in agricultural employment during droughts, but men experience neutral or negative effects at the national level, suggesting that women may turn to agriculture as a coping mechanism during severe crises. In both the upper and lower non-farm sectors, both genders experience job reductions; however, women face more pronounced and prolonged declines, particularly in rural regions, with the upper non-farm sector showing the greatest gender gap.

The results from the aggregate estimators reveal that female employment increases by 26% at the national level and 46.13% in rural areas, while male employment declines by 30.3% nationally but increases by 18.25% in rural regions. In the upper non-farm sector, job decreases occur for both genders, but women face steeper declines, especially in rural regions (-19.04% vs. -51.82%). In the lower non-farm sector, female employment drops by 19.85%, while men show almost no change at the national level. These gender differences are likely due to women's reliance on subsistence agriculture and men's greater economic mobility (Afridi et al., 2022).

These findings are consistent with prior research. During droughts, women typically remain in and expand their roles in the agricultural sector while reducing their participation in non-farm sectors, corroborating the findings of Afridi et al. (2022). They argue that women's restricted mobility, shaped by societal norms and gender roles, limits their access to non-farm employment. Cultural expectations surrounding women's purity and domestic obligations further limit their opportunities to seek work outside their immediate environment. This explains why our data shows that, in response to droughts, women increase their agricultural employment, while men shift towards non-farm sectors.

This study contributes to the literature by providing a comprehensive analysis of the gender-specific effects of droughts on employment across different sectors in African countries. By analysing sector-specific employment data from 31 nations between 2005 and 2020, we find that women, particularly in rural areas, increase their agricultural employment as a coping strategy, while men show more diverse responses. Women experience sharper declines in non-farm industries, indicating limited access to alternative employment opportunities. These findings offer key insights for policymakers, emphasising the need for targeted initiatives to mitigate the unequal impacts of droughts on men and women and to improve women's access to non-agricultural employment opportunities.

The structure of this thesis is as follows: The next section reviews the current literature, followed by a description of the empirical methodology in Section 3. Section 4 discusses the data, and Section 5 presents the findings from the panel regressions and event study using the doubly robust difference-in-differences (DID) estimator. Finally, Section 6 includes the discussion, limitations, and conclusion.

2. Literature review

The literature extensively documents how international migration serves as a coping mechanism for workers in developing economies facing climate shocks (Gray & Mueller, 2012; Mueller et al., 2014; Dillon et al., 2011; Marchiori et al., 2012). However, migration as a coping mechanism shows significant variation and is more predictable in response to moderate, sustained shocks (Di Falco et al., 2022). In rural areas, crop and labour diversification are common strategies. Crop diversification typically functions as an ex-ante coping mechanism (Asfaw et al., 2018; Aragón et al., 2021), while labour diversification is an ex-post measure in response to extreme events like droughts.

Agricultural productivity shocks often push workers toward less climate-sensitive sectors, prompting rural-urban migration and a shift to non-farm employment (Cattaneo et al., 2020; Gröger & Zylberberg, 2016). However, weak demand in developing markets limits non-farm sectors' capacity to absorb excess rural labour, disproportionately affecting low-skilled workers (Foster & Rosenzweig, 2007; Emerick, 2018). While many studies explore climatic shocks' effects on migration and labour markets, there is limited research on how extreme events—particularly droughts—affect local labour markets in African countries. Evidence suggests that droughts reduce farm wages by lowering labour demand, with the greatest reductions in regions where non-farm opportunities are scarce (Auffhammer et al., 2012; Mahajan, 2017).

2.1 Gender-Specific Mechanisms:

The lack of gender-focused data in Africa hinders a deeper understanding of how labour markets respond to droughts, particularly regarding social norms, childcare responsibilities, and restricted mobility, which disproportionately affect women (Eastin, 2018). These barriers prevent women from diversifying into less climate-sensitive sectors, leaving them more vulnerable to employment instability during environmental shocks (Afridi et al., 2022).

2.2 Institutional Factors and Policy Responses:

Local institutions and social norms play a critical role in shaping gendered responses to climate shocks. Gender-based constraints limit women's participation in non-farm work during drought periods. Afridi et al. (2022) highlight how societal barriers hinders women’s movement into non-agricultural sectors during droughts, increasing their vulnerability. This trend underscores the need for gender-sensitive policy interventions (Niemann et al., 2024).

2.3 Comparisons with Other Developing Regions:

Gendered labour market responses to climate shocks are not unique to Africa. Studies from South Asia and Latin America reveal similar patterns. For example, women in rural Bangladesh and Brazil face mobility constraints that prevent them from diversifying into non-farm sectors, resembling trends seen in Africa (Desbureaux & Rodella, 2019). Comparing these regions offers insights into common barriers and highlights strategies employed to address gender disparities (Jain et al., 2023).

2.4 Intersectionality of Vulnerabilities:

While gender is a key factor, the intersectionality of vulnerabilities must also be considered. Class, ethnicity, and age further shape how individuals respond to environmental shocks. Poorer women or those from marginalised communities are more severely affected by droughts due to fewer resources and opportunities to adapt. Studies in East Africa emphasise that vulnerable groups, including women from lower socio-economic backgrounds, face compounded disadvantages when responding to climate impacts (Eastin, 2018).

2.5 Urban vs. Rural Differences:

Most studies focus on rural areas, but urban labour markets are also impacted by droughts, particularly for women in non-farm sectors. In rural areas, women are often tied to agricultural work, whereas in urban settings, they face challenges accessing stable non-farm employment. Droughts exacerbate the instability of informal employment in urban areas, especially for women (Eastin, 2018). This highlights the need for further exploration of urban-rural disparities in labour market responses to climate shocks (Diallo & Ondoa, 2024).

2.6 Sectoral Differences Beyond Agriculture:

Research on drought shocks in non-farm sectors is limited, but key findings suggest significant gender differences. Women tend to be concentrated in lower non-farm sectors, such as informal services etc, which are more vulnerable to economic disruptions from droughts (Kabeer, 2012). Men, on the other hand, are more likely to transition into upper non-farm sectors like formal manufacturing, benefiting from higher wages and more stability (Heath & Mobarak, 2015). Studies at the national level show that the ability to transition to non-farm sectors varies by country. In economies with developed non-farm sectors, men have greater opportunities to shift into formal employment, while women remain in informal, agriculture and lower-wage jobs (Groeger & Zylberberg, 2016).

2.7 The Role of Informal Labour:

Women in African countries are disproportionately represented in informal labour markets, which are particularly vulnerable to climate shocks. Informal work lacks social protection and tends to be more uncertain, increasing women's vulnerability during environmental crises (Afridi et al., 2022). This sectoral disparity highlights the need for targeted social protection for women in informal labour (Hardy et al., 2023).

Despite growing recognition of the impact of climate shocks on labour markets, significant gaps remain in understanding gender-differential effects of drought shocks on employment rates across sectors. The existing literature largely focuses on general labour market responses without examining specific changes in employment rates for men and women across agricultural, upper non-farm, and lower non-farm sectors at national, urban, and rural levels. Although some studies acknowledge that women are more vulnerable to climate shocks due to limited mobility, societal norms, and reduced access to employment opportunities, there is insufficient empirical research tracking the timing and persistence of these impacts, especially in African contexts (Eastin, 2018; Afridi et al., 2022). Additionally, limited research has focused on how urban labour markets respond to droughts for women, particularly in upper and lower non-farm sectors (Eastin, 2018).

To this end, this may be the only paper that addresses the existing gaps by investigating post-drought, sector-specific employment rate changes for men and women across urban, rural, and national contexts in African countries. By examining sectoral dynamics at different geographical levels, this research highlights how social norms, institutional barriers, and economic mobility shape gendered responses to droughts.

3. Empirical methodology

In this section, we outline the methods used to conduct our study. The paper examines the effects of droughts on employed men and women in African countries between 2005 and 2020. To achieve this, we implement a multiple-period Difference-in-Differences (DID) model, following the approach of Callaway and Sant'Anna (2021). This method is well-suited for our study, as treatments, in this case droughts, likely had heterogeneous onset and varied effects over time.

3.1 Identification strategy

The primary focus of this paper is to assess the causal effect of droughts on sector-specific employment rates in the agricultural sector, upper non-farm sector (professional, managerial, technical), and lower non-farm sector (clerical, sales, services, manual labour), comparing the impacts on men and women across national, urban, and rural areas. The quasi-experimental framework employed in this study enables the evaluation of drought impacts on these labour market indicators without resorting to a randomised controlled trial (RCT), as countries are expected to exhibit similar characteristics in the absence of such disasters.

The quasi-experimental approach leverages the fact that some countries experience significant changes in their employment rates due to droughts, which, while inherently non-random events, can be treated as plausibly random in the context of our analysis. This is because the unforeseen nature of rainfall leads to droughts occurring unpredictably across different regions. This randomness justifies the assumption of equality among countries not experiencing such disasters. While factors like demographic composition, sectoral structure, and vulnerability to droughts may vary among the 33 countries analysed, the assumption remains reliable as long as these variables are held constant during a catastrophe. Additionally, the model accounts for country-specific and time-specific confounders to mitigate potential violations of this assumption.

The primary identification strategy is based on the exogeneity of the timing and location of disaster occurrences, as well as the existing differences among countries from 2005 to 2020. The quasi-experimental setting is established by the disparity between countries, with the treated group consisting of those that have experienced droughts and the control group comprising countries that have not been affected by such catastrophic events.

The overarching panel data framework employed in this thesis, along with the inherent disparities among countries, lays the groundwork for an event study. As previously discussed, these disparities indicate that some nations were affected by droughts while others were not. Therefore, the principal objective of this thesis is to estimate the causal effect of experiencing droughts on sector-specific employment rates at the national, urban, and rural levels. Event studies are often used in policy evaluation, especially in the context of large disruptions. The basic convention in event studies follows a difference-in-differences (DiD) design, using untreated units (i.e., countries) as a reference counterfactual outcome when no treatment is received. This concept also applies to synthetic controls. These results are particularly interesting for non-randomized treatments because panel data enables cross-sectional comparisons between units (countries) and facilitates temporal analysis, as noted by Borysyja et al. (2022).

3.2 DiD

Within the framework of potential outcomes, the Difference-in-Differences (DiD) estimator uses a control group to serve as the counterfactual outcome in the absence of treatment or environmental shocks. In line with the established framework of this thesis, countries unaffected by droughts are designated as the counterfactual group. This method allows us to discern how the outcomes of interest would have evolved without treatment or shocks, in comparison to countries experiencing droughts. The objective is to estimate the Average Treatment Effect on the Treated (ATT). Following the methodology of Baker et al. (2022), we assume that $ATT = \delta$ and denote D as an indicator for treatment, where $D = 1$ indicates countries affected by droughts (i.e., those that received treatment), and $D = 0$ indicates unaffected countries (i.e., those that did not experience droughts). For simplicity, we consider only two time periods, where $T = 2$, with $t = 0$ representing the period before treatment and $t = 1$ representing the period after.

Then it follows:

$$\delta \equiv \mathrm{E}\left[Y_{r,1}(1) - Y_{r,1}(0) \middle| \square_{\square} = 1\right] \tag{3.1}$$

Equation 3.1 tells us that the ATT is strictly equal to the outcome in the treated region (subscript r) in period 1 (subscript 1). However, this equation cannot be estimated directly in the data since we do not observe the outcome for region r without treatment. Put differently: we do not know how the countries that were impacted by droughts would develop in the outcomes of interest without them facing droughts since it is nothing we do observe in the data. To follow equation 1: we do not observe $Y_{r,1}(0)$.

By assuming no anticipation of treatment, meaning that treatment does not have any effect on the outcome in periods before implementation, we know that $Y_{r,0}(0) = Y_{r,0}(1)$. In the context of this study, this assumption implies that the occurrence of droughts does not affect employment rates before they happen. This means that there should be no changes in the employment rates in the periods leading up to these events due to the expectation of their occurrence. Given the no anticipation assumption, the expected difference in the treatment effect can be written as:

$$\delta \; = E\left[Y_{r,1}(1) - \; Y_{r,0}(1))\,\middle|\, \square_{\square} \; = \mathit{1}\right] - \left[(Y_{r,1}(0) - (Y_{r,0}(0)\,\middle|\, \square_{\square} \; = \mathit{1}\right] \qquad (3.2)$$

By assuming parallel trends,

$$E\left[(Y_{r,1}(0) - Y_{r,o}(0)\,\middle|\, \square_{\square} \; = \mathit{1}\right] = E\left[(Y_{r,1}(0) - Y_{r,0}(0)\,\middle|\, \square_{\square} \; = \mathit{0}\right] \qquad (3.3)$$

We can rewrite equation 3.3 to the following:

$$\delta \; = \; E\left[Y_{r,1}(1) \; - Y_{r,0}(1)\,\middle|\, \square_{\square} \; = \mathit{1}\right] - (\left[Y_{r,1}(0) - Y_{r,0}(0) \,\middle|\, \square_{\square} \; = \mathit{0}\right] \qquad (3.4)$$

Equation 3.4 is observable in the data and how we identify the average treatment effects (ATT) using DiD.

3.3 Multiple-period Difference-in-Differences approach

However, this thesis employs a dataset that encompasses more than two time periods and two groups. The effects of droughts are not uniform, as they affect different countries in a different way each year. As a result, the canonical DiD framework that was previously described must be modified to accommodate multiple periods, multiple treated countries, and variations in treatment timing. The multiple-period Difference-in-Differences (DID) model, as proposed by Callaway and Sant'Anna (2021), is employed to investigate the average treatment effects or causal effects (ATT) of droughts.

3.3.1 Drought as treatment variable

The standard method for assigning the treatment variable (or event) in a Difference-in-Differences (DID) model is through the interaction between a time indicator variable, which is set to 1 during the periods when the event occurs, and a treatment indicator variable, which is *1* for treated countries and *0* for untreated ones. In our analysis, we refer to the result of this interaction as the *"Droughttreated"* variables.

It is important to observe that the severity and duration of natural disasters influence the availability of a more suitable treatment variable. For example, 2015 marked the severe droughts from the El Nino drought, where over 30 million people were affected - the highest number were affected between 2005 and 2020. Moreover, the African Risk Capacity (ARC), which is a Specialized Agency of the African Union, made payouts to Senegal, Niger, and Mauritania after a severe drought in 2014, which helped support 1.3 million people. ARC also provided payouts in 2015, 2016, 2019, 2020, and 2021 and focused on certain countries during each year. Also, the program of action for implementing the Sendai framework for disaster risk reduction 2015-2030 in Africa, which was adopted in 2016, focused on preventing new and reducing existing disaster risks (African Union Commission, Prevention Web, 2020).

To examine the effectiveness of different treatment measures, we conducted a series of regression analysing the relationship between employment rates and drought. Here are the four treatment variables:

i.) At the country-level the original dummy (*Droughttreated*): 1 for the years that have reported droughts, 0 otherwise.

ii.) At the country-level, an alternative dummy (*Droughttreated_yr1onw*) that takes the value of 1 from the first year that a drought occurs onwards and 0 for the years before.

iii.) At the country-level, a third alternative dummy (Droughttreated_yr5onw) that takes the value of 1 if a drought happened for more than 5 consecutive years and 0 otherwise.

iv.) From the AU-wide perspective: an alternative dummy that takes the value of 1 from 2015 onwards (*Droughttreated_AU15*) and 0 otherwise. The results are in Appendix 2.

Given that the treatment variable, droughttreated_1yronw, is statistically significant and the r-squared value is relatively higher than other treatment variables, we selected the droguhttreated_1yronw (See Table 3, appendix 2).

3.3.2 Panel regression methodology

To examine the potential impact of droughts on the employment rates between men and women at the upper non-farm sector, lower non-farm sector and agricultural sector in urban, rural and national settings, we use a panel data approach. We start by estimating it with country and year fixed effects to calculate the percentage change coefficients. Our baseline regression model for evaluating the impact is given by the following equation:

$$ln(employment\ rates_i) = \beta_0 + \beta_1 Drought_{ct} + \beta_2 W_{ct} + \gamma_c + \delta_t + \varepsilon_{ct} \qquad (3.5)$$

Where c represents countries and t represents years. The dependent variable is the employment rates for all men and women in the agricultural sector, upper non-farm sector, and lower non-farm sector in urban areas and rural areas, as well as at the national level. Drought is the dummy variable for drought, which can be specified as either *Droughttreated* or *Droughttreated_yr1onw*. The vector of controls, $W\{ct\}$, comprises variables at the rural, urban, and national levels distinguished by gender, which are the percentage of the population, average years of schooling, labour force participation, average household size as well as the GDP per capita but at the national level, as well as a dummy variable that takes the value of *1* if country *c* was a member of the AU in year *t* and *0* otherwise. The variables *c* and t represent country and year fixed effects. The same ideas are applied to the equation for 3.5.

We focus on coefficient β_1. An issue is what is expected regarding the duration of the effect of droughts or the context of frequent drought exposure. Once the aftermath of a drought calms down, women are expected to face greater challenges in recovering employment compared to men, as suggested by previous studies (see section 3). This potential recovery can be further examined using the event study methodology. Our underlying hypothesis is that drought resulted in a significant decrease in employment rates among women in the upper nonfarm sector and lower non-farm sector and a spike in the agricultural sector, and for men, a decrease in the agricultural sector and an increase in the upper nonfarm sector and lower nonfarm sector, regardless if it is in an urban or rural area.

The upcoming event study aims to make the findings from the panel regression analysis more reliable. It will do this by examining how long the observed effects last and by checking the consistency of the effect size. Moreover, the study will help identify any potential biases that could be due to country-specific trends before drought.

3.3.3 Event study regression methodology

According to the recommendations of Chaisemartin et al. (2023), Sun and Abraham (2021), Rambachan and Roth (2020), and Sant'Anna and Zhao (2020), we implemented the estimator proposed by Callaway and Sant'Anna (2021). This estimator is particularly well-suited for staggered adoption designs, in which various regions experience the treatment (droughts) at variable times. In contrast to conventional two-way fixed effects (TWFE) event-study regressions, this approach permits potential biases that result from heterogeneous treatment effects. This approach also mitigates the issue of negative weighting, which can manifest in conventional OLS specifications and lead to biased estimates. Negative weighting occurs when the control units in Ordinary Least Squares (OLS) are allocated a greater weight than the treated units. This may invert the expected treatment effect. The estimators introduced by Callaway and Sant'Anna (2021) tackle this issue by comparing treated cohorts with a suitable control group (untreated), ensuring the treatment effect's robustness and improving precision.

Our analysis defines cohorts based on the year they first experience a drought. For each cohort c and each period t, we calculate the average employment rate. We also use the average employment rate for countries not yet treated by period □ as controls. This is useful in this study as there are far too few never-treated countries, and including not-yet-treated groups as control may lead to more robust estimates.

We consider T periods, where $t = 1,2,\dots,T$. Define G_g as a binary variable that equals 1 if a country reported its first drought in period g, and *0* otherwise. Formally, $G_{c,g} = 1\{G_c = g\}$ with $G_c \subset \{2,\dots,t,\infty\}$. Some countries, such as Algeria, Morocco, Ghana, Guinea, Canary Islands, Egypt, Congo, Tunisia, Sierra Leone, Togo, Liberia, Côte d'Ivoire, Benin, Comoros, Gabon, Mauritius,Libya, Seychelles and Sao Tome and Principe never experienced a drought, which is represented by $G_c = \infty$.

Let $Y_{c,t}(g)$ represent the change in employment rates for women relative to men for country c at time t, assuming the first drought occurred at time g. Similarly, $Y_{c,t}(0)$ represents the potential outcome for country c at time t if it never experienced a drought case.

Callaway and Sant’Anna (2021) proposed a causal parameter termed the *group-time average treatment effect* to measure this relationship, defined as follows:

$$ATT(g,t) = E\left[Y_t(g) - Y_t(0) \middle| \square_{\square} = 1\right] \quad \text{for } t \geq g \qquad (3.6)$$

The parameter estimate the average treatment effect for countries in cohort g within time period t. This method aligns with the content of the 2x2 Difference-in-Differences (DID) estimand but allows for heterogeneity among different cohorts and across time.

During the identification phase, we evaluate the behaviour of the comparison group. To be more precise, we ascertain whether the sample comprises a comparison group that has not yet been treated or one that has not yet been treated at time t. The latter group may undergo treatment in the future. In our case, nine countries (Algeria, Morocco, Guinea, Egypt, Congo, Mauritius, Libya, Seychelles, Sao Tome and Principe) did not experience a drought from 2005 to 2020. This represents a small and unrepresentative subset of the sample. Consequently, we employ the 'not-yet-treated' approach, in which the control group consists of countries that have not yet experienced a deluge or drought by the year t.

The next step in identification involves choosing between two approaches: recovering the "not-yet-treated" estimator, $ATT^{ne}(g,t)$ under the parallel trends assumption without covariates, or using a nonparametric identification method that incorporates covariates (X) and relaxes the parallel trends assumption. Given the significant influence of covariates such as GDP per capita on the employment rates, we went for the nonparametric identification to account for covariate-specific trends.

We opted for the doubly robust (DR) DID estimator introduced by Sant'Anna and Zhao (2020) from among the nonparametric estimators. [1] The term $E\left[Y_t - Y_{g-1} \mid □, □_□ = 0, □_□ = 0\right]$ represents the expected outcome of the comparison group - countries that have not experienced droughts at time t ($D_t = 0$) and did not experience a drought at time g ($G_g = 0$), conditioned on covariates X. We designate the previous term as $m^{ne}_{g,t}(X)$. Define $p_{g,t}(X)$ as the likelihood of being in cohort g, given the covariates X, and being either in group g or in the "not-yet-treated" group by time t. The expression $p_{g,t}(X)(1-D_t)$ then adjusts this probability based on whether treatment is absent or present at time t. In line with this, Sant'Anna and Zhao (2020) describe the DR estimator in the following way:

$$ATT^{ne}_{dr}(g,t) \;=\; E\left[\left(\frac{G_g}{E(G_g)} - \frac{\frac{p_{g,t}(X)(1-D_t)}{1-p_{g,t}(X)}}{E\left[\frac{p_{g,t}(X)(1-D_t)}{1-p_{g,t}(X)}\right]}\right)\left(Y_t - Y_{g-1} - m^{ne}_{g,t}(X)\right)\right] \qquad (3.6)$$

Essentially, Equation 3.6 computes the average treatment effect $ATT(g,t)$ based on the parallel trends' assumption and the "not-yet-treated" group (represented by $Y_t - Y_{g-1} - m^{ne}_{g,t}(X)$). It then applies a normalisation factor,

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[1] As demonstrated by Callaway and Sant'Anna (2021), the ATT(g,t) values can be recovered through nonparametric identification methods such as outcome regression (OR), inverse probability weighting (IPW), or doubly robust (DR) estimators.

indicated by the “big parentheses”, to ensure that the event effect is comparable across different time periods and treatment groups. This factor adjusts for variations in how often the event occurs and differences in country characteristics.

Finally, we combine all the estimated group-time average treatment effects into a single aggregate causal parameter using the following aggregation method:

$$\theta(e) = \sum_{g \in G} 1\{g + e \leq T\} P(G = g | G + e \leq T) ATT_{dr}^{ne}(g, t) \qquad (3.7)$$

Here, e represents the event-time relative to treatment, calculated as, which measures the number of years since the country first experienced a drought. The term $P(G = g \mid \square + \square \leq \square)$ computes an average of $ATT(g, t)$, weighted by the size of the cohort. The parameter $\theta(e)$ reflects the variations in treatment effects at different event times e and is the focus of our analysis in section 5.2. This parameter fits within the standard event-study framework and can be interpreted as dynamic treatment effects in two-way fixed effects (TWFE) regressions, while avoiding the common issues associated with the dynamic TWFE specification.

4. Data and descriptive statistics

4.1 Sample and years

This study focuses on 31 African countries from 2005 to 2020. We focused on those years because the available data on the control variables, such as labour force participation rates, covered from 2005. We excluded countries that lacked labour market data. The study period started in 2005 to ensure several pre-treatment years before droughts were recorded, extending to 2020.

4.2 Dependent variable: Employment rate

The group of dependent variables is the employment rate in different sectors, which includes the agriculture sector, upper non-farm sector, and lower non-farm sector for men and women. It covers urban areas, rural areas, and national areas individually. This will allow us to compare our results with the findings of previous studies regarding the impacts of employment between men and women. The employment rate data was obtained from the Global Data Lab's Area Database (add reference). We restrict the sample to individuals aged 15 and older to represent the working-age population. Since no data covers the employment rate for all in those three sectors, we focused on comparing men and women.

4.3 Drought data

We use climate disaster data on droughts from The International Disaster Database, covering the period from 2005 to 2020, which provides information on droughts in African countries dating back to the nineteenth century (EM-DAT). Using details on disaster type, year of occurrence, and country, we map 16 years of droughts at the country level. In this study, we extract variables such as the type of disaster (drought), the country affected, and the year the disaster occurred.

As seen in Figure 2, the frequency of droughts has fluctuated, with the maximum number of occurrences occurring in 2005 (13 events), 2011 (12 events), and 2022 (14 events). 2020, 2010, and 2001 are among the years that have experienced an increase in drought activity. Moreover, droughts have increased in the past couple of years, as seen in 2022.

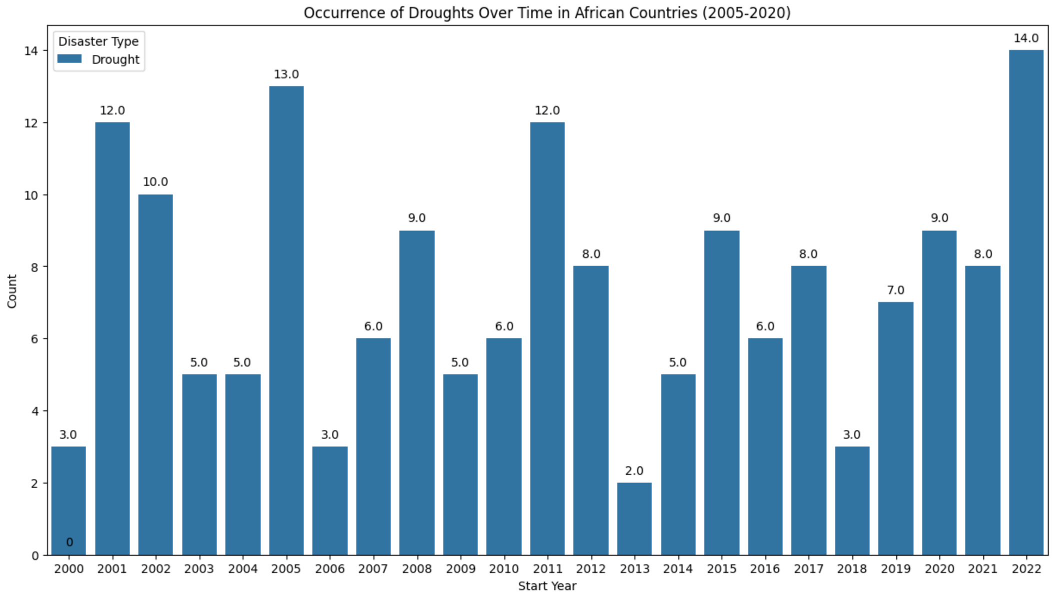


Figure 2. Occurrence of droughts between 2000-2023

Table 1 below shows the countries that experienced the highest droughts between 2000 and 2023. Somalia experienced the highest number of drought events (10), followed closely by Kenya and Ethiopia, with nine occurrences each, while Angola and Nigeria recorded fewer droughts, with 5 and 1, respectively.

Country	**Drought**
Kenya	9
Angola	5
Nigeria	1
Somalia	10
Ethiopia	9

Table 1a. Countries with occurrence of droughts between 2000-2023

The table in the appendix illustrates the fact that the total number of individuals affected by droughts varied. Somalia, Kenya, and Ethiopia have been among the most severely affected, with millions of individuals afflicted over the years. Ethiopia recorded over 31 million affected individuals, while Kenya experienced more than 27 million.

Additionally, there were years in which the number of individuals afflicted reached millions in specific countries, such as Mozambique in 2016 and Angola in 2011. The aggregate number of individuals affected in all countries exceeded 219 million by 2020. This table underscores the severe and extensive repercussions of droughts, which differ in severity across different regions and years. The selection of 2015 as one of the treatment variables is predicated on the substantial drought impacts that were observed in that year, as illustrated in the table. The number of individuals affected by droughts in countries such as Kenya, Malawi, and Ethiopia have increased significantly, with Malawi alone reporting over 6.7 million. 2015 was a critical period of increased drought severity that coincided with significant policy changes in drought mitigation throughout Africa. The analysis captures a critical juncture in the impact of the drought and the response of policy by concentrating on 2015, thereby offering a glimpse into the impact of these interventions on the outcomes of subsequent years. (Refer to Table 3, Table 2, and Appendix 1b).

4.4 Control variables

Five control variables were included into the study. Labour force participation rate for men and women were obtained from the International Labour Organization (ILO) database and consists of modelled estimates that ILO created to cover for those missing data. These estimates are derived through a series of econometric models maintained by the ILO (ILO, 2024). The mean years of schooling years for men and women as well as average household size at the urban, rural and national level and share of population in urban areas was sourced from the Global Data Lab's Area Database (Smits, 2016). Additionally, GDP per capita was obtained from the World Bank and covered at the national level, for all. There was no available data on GDP per capita distinguished by gender or geographical location. All these variables, except labour force participation rate, were transformed using the natural logarithm. To a

Moreover, fixed effects at country level and year level were employed. Country fixed effects control for any time-invariant factors within each country that could influence changes in employment rates across the agricultural, upper non-farm, and lower non-farm sectors for men and women at the urban, rural, and national levels. Year fixed effects account for common events or shocks, such as economic or policy changes, that may have impacted all countries simultaneously. Additionally, by analysing the employment rates in percentage terms, the effects of population growth are implicitly accounted for.

4.5 Descriptive statistics

Table 5: *Panel data descriptive statistics*

	Control Group			Treatment Group			Diff
Variable	n	Mean	SD	n	Mean	SD	
Female employment rate in agriculture sector at national level	304	38.46	13.09	480	40.16	14.89	1.7
Male employment rate in agriculture sector at national level	304	41.50	12.83	480	40.19	15.25	-1.31
Female employment rate in upper non-farm sector at national level	304	8.72	8.64	480	7.34	4.39	-1.38***
Male employment rate in upper non-farm sector at national level	304	12.32	5.90	480	10.84	4.77	-1.47***
Female employment rate in lower non-farm sector at national level	304	29.28	25.24	480	31.81	25.87	2.53
Male employment rate in lower non-farm sector at national level	304	46.03	9.63	480	48.90	13.27	2.87***
Female employment rate in agriculture sector at urban level	304	11.61	6.55	480	11.90	6.82	0.29
Male employment rate in agriculture sector at urban level	304	14.40	5.89	480	13.25	5.05	-1.14***
Female employment rate in upper non-farm sector at urban level	304	13.61	10.54	480	12.35	5.35	-1.27***
Male employment rate in upper non-farm sector at urban level	304	19.82	40.40	480	18.07	5.27	-1.75***
Female employment rate in lower non-farm sector at urban level	304	74.72	10.38	480	75.75	8.16	1.03
Male employment rate in lower non-farm sector at urban level	304	65.78	5.92	480	68.68	6.90	2.9***
Female employment rate in agriculture sector at rural level	304	53.53	14.60	480	55.25	16.51	1.72
Male employment rate in agriculture sector at rural level	304	57.13	12.10	480	55.76	15.37	-1.37
Female employment rate in upper non-farm sector at rural level	304	5.36	6.55	480	4.39	3.60	-0.97***
Male employment rate in upper non-farm sector at rural level	304	7.78	3.71	480	6.48	3.12	-1.30***
Female employment rate in lower non-farm sector at rural level	304	41.13	12.79	480	40.37	14.84	-0.76
Male employment rate in lower non-farm sector at rural level	304	35.09	9.09	480	37.75	14.03	2.66***
Female labor force participation rate at national level	304	0.49	0.19	480	0.59	0.18	0.10***
Male labor force participation rate at national level	304	68.95	8.29	480	73.80	11.28	4.85***
Female labor force participation rate at urban level	304	46.78	16.88	480	52.78	14.69	5.99***
Male labor force participation rate at urban level	304	66.32	6.35	480	69.98	8.92	3.66***
Female labor force participation rate at rural level	304	49.83	22.16	480	60.75	21.57	10.92***
Male labor force participation rate at rural level	304	71.26	11.27	480	75.12	14.10	3.86***
Mean years of schooling for women at national level	304	5.52	1.96	480	5.42	1.61	-163.1**
Mean years of schooling for men at national level	304	6.39	1.49	480	5.70	1.88	-0.69***
Mean years of schooling for women at urban level	304	6.75	1.84	480	6.35	2.59	-0.40**
Mean years of schooling for men at urban level	304	7.76	1.37	480	7.55	1.74	-0.21*
Mean years of schooling for women at rural level	304	4.40	2.26	480	4.21	2.48	-0.20
Mean years of schooling for men at rural level	304	5.65	1.73	480	4.83	2.19	-0.82***
GDP per capita	304	2852.20	3042.20	480	1795.70	1711.50	-1056.5***
Share of population in urban areas	304	0.43	0.15	480	0.35	0.14	-0.09***
Household size at national level	304	5.31	9.63	480	48.89	6.45	2.87***
Household size at urban level	304	5.72	1.12	480	6.18	1.82	0.45***
Household size at rural level	304	6.47	0.95	480	6.82	1.87	0.35***

Table 5. Panel data descriptive statistics

*Note: Table 5 shows averages for a baseline from 2005 to 2020. . The Diff column is the coefficient of a simple regression of treatment status on the variable, with robust standard errors clustered at the country level. Stars indicate significance levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Certain regions are more prone to droughts due to climatic and geographical factors, which leads to notable differences in employment rates, labour force participation, and other socioeconomic indicators. As shown in Table 5, the treated group—representing regions affected by droughts—and the control group—representing those unaffected—exhibit significant disparities in these factors. Specifically, male employment in the agricultural sector is lower in drought-affected regions at the national level (40.19%) and urban level (13.25%) compared to non-drought-affected regions (41.50% and 14.40%, respectively). Conversely, female employment in the lower non-farm sector is somewhat higher in drought-affected areas (31.81% at the national level and 75.75% at the urban level) than in non-affected regions (29.28% and 74.72%, respectively).

Labour force participation rates are markedly elevated in regions affected by droughts, with male participation at the national level reaching 73.80% in the treated group, compared to 68.95% in the control group. Female participation in urban areas is also higher in the treated group at 52.78%, compared to 46.78% in the control group. Additionally, GDP per capita in drought-affected areas is significantly lower ($1,795.70) than in non-affected areas ($2,852.20), highlighting economic disparities that are presumably exacerbated by drought conditions. Furthermore, household sizes in drought-affected areas are larger, particularly at the national scale (48.89 compared to 46.03).

Overall, these findings reveal that regions prone to droughts experience significant changes in employment patterns, increased labor force participation, and more challenging economic situations compared to those unaffected.

5. Results

Our results are categorised into two groups. The introductory section outlines the findings of the panel regression study, examining the impact of drought on employment rates for both sexes across several industries. The research employs fixed effects and controls to assess the influence of drought on female employment in agriculture and both higher and lower non-farm sectors, while comparing these findings with male employment rates. In the second section, we conduct event studies for each sector, providing graphical evaluations and calculating the aggregate Average Treatment Effect on the Treated (ATT) using the methods described in Section 3.3.

5.1 Panel regression results

As shown in Table 6, the panel regression results reveal gender-differentiated impacts of drought on employment across various sectors at the national level. In the agriculture sector, drought leads to a 40.5% increase in female employment, with a coefficient of 0.34, while male employment shows a 13.93% decrease (coefficient of -0.15). In the upper non-farm sector, women experience a substantial decline in employment, dropping by 59.98% (coefficient of -0.91), the same decline observed in the lower non-farm sector, indicating consistent effects across both sectors. Meanwhile, men in the upper non-farm sector see a 22.14% increase (coefficient of 0.20), illustrating a contrasting gender impact where droughts drive women out of non-farm sectors while slightly benefiting men. In the lower non-farm sector, male employment decreases marginally by 5.83% (coefficient of -0.06). These findings suggest that women, particularly in non-farm sectors, are more negatively impacted by drought than men, who exhibit more variability in employment changes across sectors. This table highlights the gendered nature of labour market shifts during drought, with women more adversely affected in non-farm sectors and benefiting more from agricultural employment compared to men at the national level.[2]

[2] (e^0.34-1)*100=40.5 % wrt female employment in agriculture sector, (e^0.15-1)*100=13.93 % wrt male employment in the agriculture sector etc.

Table 6: Result of Panel regressions: The effect of drought on employment rates at the national level.

	Agriculture sector		Upper non-farm sector		Lower non-farm sector	
	Female (1)	Male (2)	Female (3)	Male (4)	Female (5)	Male (6)
Droughttreated_1yronw	0.34**	-0.15	-0.91**	0.20	-0.91**	-0.06
	(0.69)	(0.51)	(0.32)	(0.21)	(0.32)	(0.46)
Log_GDPpc	0.47	-1.40	-0.32	0.03	-0.32	1.36*
	(0.96)	(0.73)	(0.44)	(0.30)	(0.45)	(0.64)
urbanisation	-1.45	2.52	-1.73	-2.94*	-1.73	0.39
	(3.898)	(3.42)	(1.80)	(1.42)	(1.81)	(3.02)
log_householdsize	1.46***	0.49***	-0.69***	-0.22***	-0.69***	-0.27*
	(0.18)	(0.12)	(0.082)	(0.050)	(0.08)	(0.107)
labourforceparti	1.28	0.19	-1.60**	6.69	-1.60**	-6.77
	(1.21)	(13.54)	(0.56)	(5.62)	(0.562)	(11.94)
log_education	-19.14***	-12.72***	5.18***	6.33***	6.33***	7.54***
	(2.16)	(1.41)	(1.00)	(0.58)	(1.00)	(1.25)
N	784	784	784	784	784	784
R^2	0.07	0.15	0.17	0.13	0.12	0.09
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 6. Result of panel regressions: the effect of drought on employment rates at the national level.

In Table 7, the effects of drought on employment in the agriculture sector at the urban level are not statistically significant for either men or women. Female employment decreases by approximately 29.59%, and male employment slightly increases by 5.13%, but both effects lack statistical significance.

In the upper non-farm sector, both men and women experience significant increases in employment post-drought. Female employment rises by approximately 84.29%, which is statistically significant at the 5% level, and male employment increases by 83.46%, which is statistically significant at the 10% level. These results suggest that both genders experience a significant positive effect in this sector following droughts.

In the lower non-farm sector, female employment shows a significant decline of approximately 23.57%, statistically significant at the 5% level, and male employment falls by 82.75%, statistically significant at the 10% level, indicating that both men and women face substantial negative effects on employment in this sector.

Regarding the covariates, urbanisation significantly influences both male and female employment across sectors. Urbanisation increases male employment by 29.28%, statistically significant at the 1% level, and female employment by 48.69%, also statistically significant at the 1% level, in the agriculture sector. However, in the upper non-farm sector, urbanisation has a negative and significant effect for both women (-18.67%) and men (-14.8%), both statistically significant at the 5% level. Household size has a positive and significant effect on male and female employment in the agricultural sector, increasing female employment by 29.9%, significant at the 1% level, and male employment by 59.5%, also significant at the 1% level. However, in the upper non-farm sector, the impact of household size is negative and significant for both genders.

The labour force participation rate negatively impacts female employment in the lower non-farm sector, leading to a reduction of 41.79%, statistically significant at the 1% level. Education plays a significant role across sectors, notably reducing male employment in agriculture by 28.5%, significant at the 1% level, while increasing male employment in the upper non-farm sector by 16.47%, significant at the 5% level, and female employment by 42.95%, significant at the 1% level. These findings suggest that urbanisation, household size, and education contribute significantly to sectoral employment shifts following droughts.

Table 7: *Result of Panel regressions: The effect of drought on employment rates at the urban level.*

	Agriculture sector		Upper non-farm sector		Lower non-farm sector	
	Female (1)	Male (2)	Female (3)	Male (4)	Female (5)	Male (6)
Droughttreated_yr1onw	-0.35	0.05	0.61	1.67*	-0.27	-1.73*
	(0.46)	(0.51)	(0.49)	(0.65)	(0.61)	(0.73)
Log_GDPpc	1.24	0.54	0.14	-0.68	-1.42	0.11
	(0.65)	(0.72)	(0.69)	(0.92)	(0.86)	(1.04)
urbanisation	39.82***	25.78***	-20.66***	-16.07*	-19.11**	-9.56
	(5.12)	(6.112)	(5.531)	(7.76)	(6.845)	(8.75)
log_householdsize	4.55***	6.65**	-2.061**	-11.69***	-2.59**	5.06
	(0.72)	(2.32)	(0.77)	(2.95)	(0.95)	(3.33)
labourforceparti	0.09	0.12	0.46***	0.17	-0.54***	-0.29**
	(0.06)	(0.07)	(0.064)	(0.09)	(0.07)	(0.10)
log_education	-15.99***	-13.52***	9.54***	10.45**	6.48**	3.21
	(1.72)	(2.88)	(1.82)	(3.66)	(2.26)	(4.12)
N	784	784	784	784	784	784
R^2	0.26	0.15	0.22	0.09	0.16	0.05
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 7. Result of panel regressions: the effect of drought on employment rates at the urban level

*Note: Samples drawn from World Bank database, Global data lab database and EM-DAT - The International Disaster Database. Regressions control for covariates using fixed effects for country and year and other covariates. Standard errors clustered at country level. Robust standard errors, clustered on region level in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01*

As seen in Table 8, the results show a differential impact of drought on male and female employment in the agricultural, upper non-farm, and lower non-farm sectors at the rural level. In the agricultural sector, the drought effect is positive and statistically significant for both females and males, with an estimated increase of approximately 68% for females and 60% for males. In the upper non-farm sector, the drought effect is not statistically significant for either females or males, with minor changes in employment, showing an increase of 14% for females and 23% for males. In the lower non-farm sector, there is a statistically significant reduction in female employment by 40%, while males experience a statistically significant decrease of 29%.

Looking at the covariates, GDP per capita negatively impacts both male and female employment in the agricultural sector, with a reduction of 98% for females and 97% for males. Conversely, GDP per capita shows a positive and significant association with male and female employment in the lower non-farm sector, indicating that higher income levels increase employment by 50% for females and 58% for males. Urbanisation significantly reduces male employment in the agricultural sector by 32% but increases female employment in the lower non-farm sector by approximately 49%. Household size has a significant positive effect on employment in the agricultural sector, with females seeing an increase of 153% and males seeing a 127% rise. However, larger household sizes are associated with significant reductions in employment in both the upper and lower non-farm sectors for females and males. Lastly, education has a negative and statistically significant effect on agricultural employment for both females and males, with a sharper decline of 75% for females and 55% for males, while it positively affects employment in the upper non-farm sector, particularly for males.

These findings highlight how drought impacts differ across gender and sectors, with females more vulnerable in non-farm sectors and males slightly more affected in agriculture.

Table 8: *Result of Panel regressions: The effect of drought on employment rates at the rural level.*

	Agricultural sector		**Upper non-farm sector**		**Lower non-farm sector**	
	Female (1)	Male (2)	Female (3)	Male (4)	Female (5)	Male (6)
Droughttreated_1yronw	0.52***	0.47***	0.13	0.21	-0.51**	-0.34***
	(0.05)	(0.18)	(0.24)	(0.26)	(0.13)	(0.65)
Log_GDPpc	-4.71***	-4.34***	0.27	-0.18	4.59***	4.53***
	(1.32)	(0.91)	(0.31)	(0.35)	(1.27)	(0.87)
urbanisation	-0.39***	-16.57*	-4.58	-7.52*	39.40***	24.93**
	(0.11)	(7.68)	(2.62)	(2.93)	(11.20)	(7.33)
log_householdsize	2.85***	2.37***	-0.55	-0.74***	-2.28***	-1.62***
	(0.54)	(0.46)	(0.12)	(0.18)	(0.52)	(0.43)
labourforceparti	0.14	0.34***	0.0991	0.03	-0.27	-0.37***
	(0.22)	(0.09)	(0.05)	(0.04)	(0.20)	(0.09)
log_education	-13.45***	-7.73***	1.79	4.11***	-11.44***	3.59*
	(1.99)	(1.50)	(0.47)	(0.57)	(2.13)	(1.43)
N	784	784	784	784	784	784
R^2	0.74	0.61	0.43	0.56	0.78	0.81
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 8. Result of panel regressions: the effect of drought on employment rates at the rural level

*Note: Samples drawn from World Bank database, Global data lab database and EM-DAT - The International Disaster Database. Regressions control for covariates using fixed effects for country and year and other covariates. Standard errors clustered at country level. Robust standard errors, clustered on region level in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

The upcoming event study aims to enhance the robustness of the findings from the panel regression analysis. Firstly, it will help in understanding the persistence of the observed effects. Secondly, it will serve as a robustness check for both the effect size and the presence of potential biases due to country-specific linear time trends in the pre-outbreak periods.

The objective of the upcoming event study is designed to further validate and strengthen the robustness of the panel regression findings. Specifically, it will help to assess the persistence of drought impacts on male and female employment rates across the agricultural, upper non-farm, and lower non-farm sectors at the national level and in rural and urban areas. Additionally, the event study will act as a robustness check for both the magnitude of the estimated effects and the presence of potential biases due to country-specific time trends in the pre-drought periods, ensuring that the observed outcomes are not driven by underlying trends unrelated to drought events.

5.2 Event study regression results

This section examines the panel data regression results for 18 sector-specific groups: women in the agriculture sector, upper non-farm sector, and lower non-farm sector, as well as men in the same sectors at the national (Table 5), urban (Table 6), and rural levels (Table 7). Figure 5 presents the key findings from the event study regression analysis for each group, displaying 18 graphs in total. The figure includes the point estimates of the event's effects and the associated uncertainty, represented by 95% confidence intervals. Two key adjustments were made to enhance precision and reduce noise when estimating the ATT(g,t). First, we trimmed outliers in the nonparametric estimation, aligning with the findings from the panel data analysis.

Nationally, in the agriculture sector, as seen in event plot (1), droughts resulted in a delayed increase in employment for women, reaching its peak around its fourth year with a rise of 46.23 % based on the ATT value. This increase is sustained for a few years before slightly falling and increases again in later years to 64.87 %. In contrast, when comparing with the male employment rate, Graph (2) shows the employment rate immediately declines, with the largest decrease around the tenth year, where it dropped to 27.72 %. This drop is relatively sustained, with no sign of recovery in the observed periods.

Meanwhile, in the upper non-farm sector, the impact of drought on female employment shows a sustained negative trend, with the largest drop occurring around the thirteenth year, leading to an approximate 39 % decline (Graph 3). On the other hand, male employment in the same sector experiences a less significant decrease, with a peak drop of around 26 % before stabilizing. The response for women is more pronounced and sustained, while the male employment effect displays more variation but remains less significant (Graph 4). Overall, nationally, the drought impacts female employment in this sector more strongly than male employment.

In both graphs (5) and (6), we observe the effect of drought on employment in the lower non-farm sector for females and males at the national level. The similarities between the groups lie in the overall negative trend in employment, as both female and male employment decline over time following a drought. They also experience a delayed response to the drought event and experience fluctuations, suggesting that the impact of droughts is not constant but varies over time for workers in the lower non-farm sector. However, the primary difference is the timing of the responses. Female employment in the lower non-farm sector exhibits a more immediate and sustained decline that drops to 63.21 %, while male employment shows a more gradual decline that reaches 10.52 %.

Female employment shows a more pronounced recovery, with a sharp increase in the later years with 64.87 %. In contrast, male employment exhibits a smaller, less pronounced recovery around year ten but remains relatively flat.

Based on the findings from Graphs (7) and (8), the response of female and male employment in the agricultural sector in urban areas to drought is delayed in both cases. Female employment increases gradually, peaking around the 10th year, resulting in a 45.5 % increase and a significant drop to -4.88 %. The male employment rate experienced moderate fluctuations and later on experienced a drop to -9.52 %, followed by a significant increase to 82 %. Both show a sustained increase, but the magnitude is greater for male than female employment. The delayed response is consistent for both genders, but men experience a stronger upward shift.

As seen in Graph (9) and (10), the drought effects on employment in the upper non-farm sector for both females and males show a delayed response. For women, employment drops sharply after year 0, reaching its second lowest point around year 6, with a maximum decrease of approximately 91 %. It increases after a couple of years but drops gain to its lowest point at 95 %, followed by an immediate increase after 14 years. The decline is also delayed for males, with a less pronounced reduction reaching approximately 86.47% by year 6. Both genders exhibit a recovery phase after year 10, although the recovery is slightly greater for men. The patterns are similar regarding delayed reaction, but the magnitude of the decrease is larger for women.

As shown in Graph (11) and (12), the drought effect on employment in the lower non-farm sector in urban areas reveals small delayed responses for female and male employment. The lowest ATT for females is around -0.03, indicating a 2.96 % decrease, while the lowest ATT for males is -0.1, corresponding to a 9.52 % decrease. Both genders experience a gradual decline after the drought, but this is not sustained over the long term. A recovery is observed after around ten years, with female employment showing a sharper rebound compared to male employment.

Graphs (11) and (12) illustrate that the drought effect on employment in the lower non-farm sector in urban areas shows distinct patterns for females and males. Female employment drops slightly, with the lowest ATT around -0.023, indicating a decrease of approximately 2.27 %. Male employment decreased with the lowest ATT of -0.08, corresponding to a 7.69 % drop. Both effects are delayed and show gradual declines, though neither is sustained over the long term. A recovery is observed in both genders after around ten years, with female employment recovering more sharply than male employment.

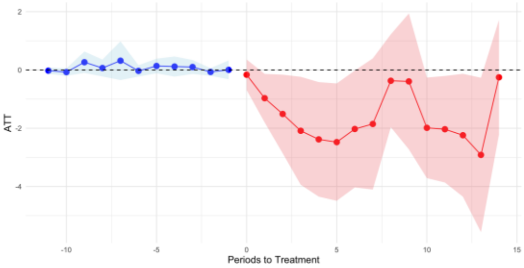
Almost all graphs showed a delayed response to drought. However, the biggest impact is seen in the female employment rate in the agriculture sector in rural areas, Graph (13). Female agriculture employment in rural areas increased by up to 122 %, while the male agriculture rural employment rate increased by 78.6 % and sharply declined, Graph 14. Both trends show a recovery after the peak, with a decline towards the end of the period, indicating that the employment boost is not sustained in the long run. The overall patterns suggest that both genders experience similar delayed increases, but the recovery patterns are greater in male employment.

As seen in Graphs (15) and (16), female and male employment in the upper non-farm sector in rural areas shows a delayed response to drought, with a noticeable drop in employment levels. Female employment experiences a sharper decline, with the lowest ATT value around -0.45, corresponding to a percentage change of approximately 36.24 %. Male employment also declines but shows more variability, reaching the lowest ATT value of around -1.5, translating to a decrease of around 75.34 %. Both male and female employment show signs of recovery after around ten years, though the recovery for females is more gradual than for males.

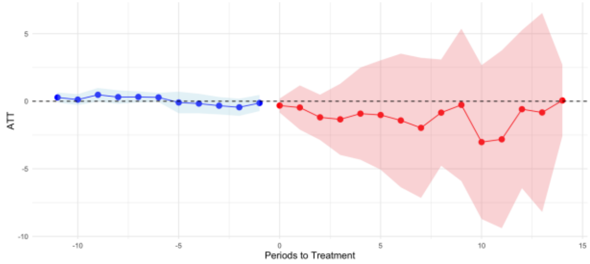
As demonstrated in Graphs (17) and (18), both female and male employment in the lower non-farm sector in rural areas experience a delayed negative response to drought. Female employment drops significantly by approximately 26.84%. The decline in male employment is less pronounced, decreasing around 3 %. While female employment shows some recovery by year 15, male employment continues to decline without any visible recovery. Both genders face similar delayed effects, but women are more severely impacted.

Figure 3. Event study (dynamic effects) results by sector-specific employment rates distinguished by gender.

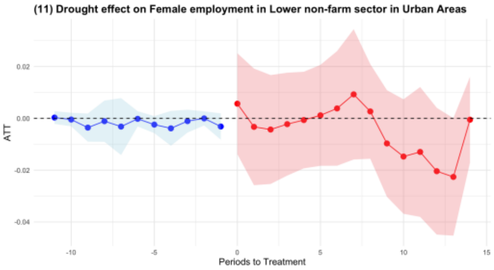
(9) Drought effect on Female employment in Upper non-farm sector in Urban Areas



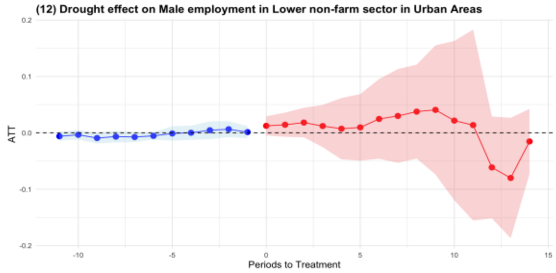
(10) Drought effect on Male employment in Upper non-farm sector in Urban Areas



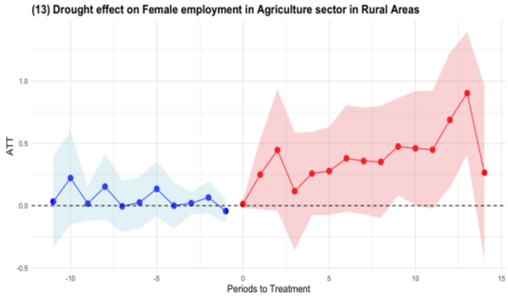
(11) Drought effect on Female employment in Lower non-farm sector in Urban Areas



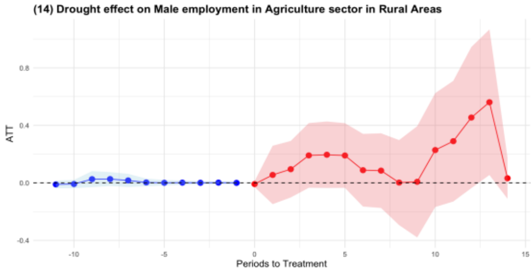
(12) Drought effect on Male employment in Lower non-farm sector in Urban Areas



(13) Drought effect on Female employment in Agriculture sector in Rural Areas

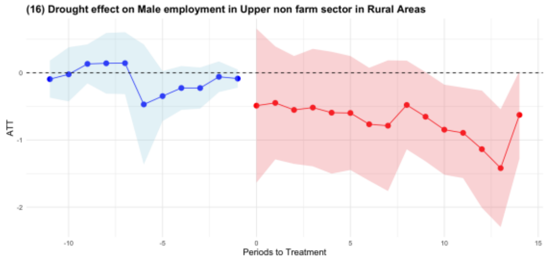


(14) Drought effect on Male employment in Agriculture sector in Rural Areas

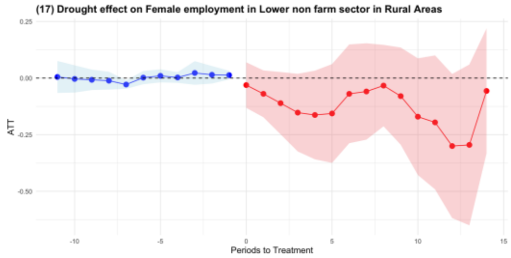


(15) Drought effect on Female employment in Upper non farm sector in Rural Areas

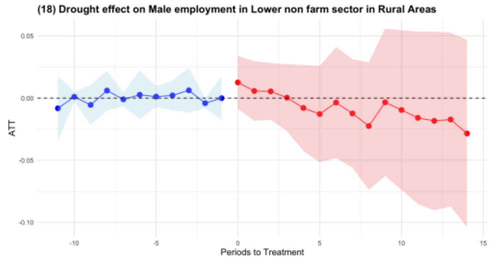
(16) Drought effect on Male employment in Upper non farm sector in Rural Areas



(17) Drought effect on Female employment in Lower non farm sector in Rural Areas



(18) Drought effect on Male employment in Lower non farm sector in Rural Areas



Based on the event study plots above, the assumption of parallel trends is reasonably met in most cases. In the pre-treatment periods, the average treatment effect on the treated (ATT) for males and females across sectors generally remains close to zero, and the confidence intervals are tight, suggesting that the employment rates for the treated and control groups were evolving similarly before the drought event. However, some sectors have slight fluctuations in pre-treatment periods (e.g., agriculture in rural areas for females). However, these variations are minor and likely not significant enough to violate the assumption of parallel trends. Overall, the event study plots suggest that the assumption of parallel trends is largely satisfied, supporting this analysis's validity of the difference-in-differences approach.

There is no strong evidence of anticipation effects in most sectors before the onset of drought (pre-period). In most graphs, the estimates before the treatment (Periods to Treatment < 0) hover around zero, with narrow confidence intervals indicating no significant changes before the event. This suggests that workers did not significantly change their employment in anticipation of a drought, and any observable effects on employment predominantly occur post-treatment across different sectors and gender groups.

The dynamics in Figure 5 can be summarised by calculating the overall aggregate estimates of the ATT. Table 8 displays the aggregate estimator for all post-treatment effects and their corresponding joint significance, column (1). Note that the coefficients in column (1) are the equation (3.5) aggregate estimators. Columns (2) to (4) showcase the confidence intervals and the standard deviations, and column (5) is the transformation of the coefficient into percentage change, calculated as (ecoefficient-1)*100.

The average ATT estimates in the post-treatment period reveal two key aspects: the significance of the effect and the magnitude. The results presented in Table 8 show significant gender differences in the impact of droughts on employment across various sectors and geographic levels. At the national level, women in agriculture experience a 26% increase in employment, which is statistically significant at the 1% level. In contrast, male employment in agriculture drops by 30.3%, statistically significant at the 10% level. In the upper non-farm sector, men and women show declines, but the effect is stronger for women (-10.44%) than for men (-5.40%), with both statistically significant at 5%. In the lower non-farm sector, female employment decreased by 19.85% (significant at 5%), while male employment showed a modest and non-significant increase of 4.97%. Female agricultural employment rises by 15.6% at the urban level, and male agricultural employment increases by 12.9%, both significant at 5%. However, the upper non-farm sector shows larger declines for women (-68.6%) than men (-67.8%), though only the male coefficient is significant at 5%. In the lower non-farm sector, both genders exhibit negligible changes. At the rural level, female employment in agriculture increases substantially by 46.13% (significant at 10%), while male employment rises by

18.25% (significant at 5%). In the upper non-farm sector, both men and women experience declines, with women showing a smaller decline (-19.04%) than men (-51.82%), both significant. The lower non-farm sector shows significant employment reductions for women (-12.15%) and men (-0.85%), with female employment significantly affected at the 1% level. These findings suggest that droughts increase female employment in agriculture more than men's. At the same time, both genders experience reductions in non-farm sectors, with women affected more in the upper non-farm sector.

The event study aligns with the panel regression results across national, urban, and rural areas, demonstrating that droughts, especially in non-farm sectors, more negatively impact women. At the national level, both approaches indicate that drought leads to increased female employment in agriculture while causing a decline in male employment. In contrast, the upper non-farm sector experiences significant declines in female employment, while men see a more stable pattern with a smaller reduction. For the lower non-farm sector, both men and women experience drops in employment, but the event study highlights that women face steeper declines. However, their employment shows a sharper recovery over time.

In urban areas, the event study supports the panel regression findings, showing that male and female employment in agriculture reacts differently to droughts. Female employment gradually increases after the drought, while male employment fluctuates, with a later strong recovery. In the upper non-farm sector, both men and women experience delayed and sharp drops in employment, but the decrease is more pronounced for women. The lower non-farm sector shows a decline in both male and female employment, with a slight recovery phase for both genders, though women rebound faster than men.

For rural areas, the event study findings align with the panel regression results, showing a significant increase in female employment in agriculture after droughts, peaking before tapering off. Male employment increases more moderately, peaking later than females. In the upper and lower non-farm sectors, women experience steeper and more sustained declines than men, whose employment trends downward more gradually.

The event study is a robustness check by mitigating the potential biases introduced by country-specific time trends in the pre-drought periods, ensuring that unrelated underlying trends do not drive the observed effects. The persistence of the delayed effects, particularly the varied recovery patterns across genders and sectors, confirms that drought events have gendered labour market impacts. Women, especially in rural areas and non-farm sectors, are more adversely affected, experiencing sharper declines and delayed recoveries, underscoring the vulnerability of female workers during environmental shocks.

Table 9: *The aggregate post-treatment Average effect of treatment on Treated.*

	Coef. (1)	SD (2)	95 % CI (3)	95 % CI (4)	% (5)
	National level				
Female employment, agriculture sector	0.231***	0.04	0.05	0.51	26
Male employment, agriculture sector	-0.36*	0.09	-0.55	-0.16	-30.3
Female employment, upper non-farm sector	-0.110**	0.08	-0.28	-0.06	-10.44
Male employment, upper non-farm sector	-0.055**	0.09	-0.24	-0.13	-5.40
Female, lower non-farm sector	-0.22**	0.21	-0.63	-0.19	-19.85
Male, lower non-farm sector	0.049	0.03	-0.0028	0.09	4.97
	Urban level				
Female, agriculture urban	0.15**	0.11	0.01	0.35	15.6
Male, agriculture, urban	0.12**	0.10	0.02	0.32	12.9
Female, upper non-farm sector	-1.16*	0.64	-2.84	-0.31	-68.6
Male, upper non-farm sector	-1.13**	1.60	-4.26	2.00	-67.8
Female, lower non-farm sector	-0.005**	0.01	-0.01	0.01	-0.5
Male, lower non-farm sector	0.038	1.68	-3.26	3.33	0.38
	Rural level				
Female, agriculture sector	0.38*	0.15	0.07	0.68	46.13
Male, agriculture sector	0.17**	0.12	0.04	0.42	-18.25
Female, upper non-farm sector	-0.21**	0.10	-0.41	-0.05	-19.04
Male, upper non-farm sector	-0.72*	0.32	-1.34	-0.09	-51.82
Female, lower non-farm sector	-0.13***	0.09	-0.30	-0.04	-12.15
Male, lower non-farm sector	-0.009***	0.02	-0.05	0.03	-0.85

Table 9. The aggregate post-treatment Average effect of treatment on Treated

*Note: Samples drawn from World Bank database, Global data lab database and EM-DAT - The International Disaster Database. Regressions control for covariates using fixed effects for country and year and other covariates. Standard errors clustered at country level. Robust standard errors, clustered on region level in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

6. Discussion

The key findings from this study reveal that droughts have a distinct gendered impact on employment across various sectors and geographic levels, aligning with prior research that indicates significant disparities in how environmental shocks affect men and women (Afridi et al., 2022). Specifically, women benefit from increased employment in the agriculture sector, especially in rural areas, where female employment rises significantly. This supports Hallegatte et al. (2018), who argue that women often turn to agriculture as a coping strategy during droughts due to their reliance on subsistence farming. Conversely, male employment in agriculture generally declines, particularly at the national and rural levels, which may reflect greater mobility and access to alternative job opportunities (Eastin, 2018).

In the upper non-farm sector, both men and women experience declines, but the reduction is more pronounced for women, especially in urban areas. This is consistent with Cramer et al. (2018), who noted that women often occupy less secure and informal positions, making them more vulnerable to economic shocks. The lower non-farm sector shows mixed results, with women facing significant reductions in employment at both national and rural levels, while men experience smaller or negligible changes. This pattern suggests that droughts reinforce gender disparities in employment, echoing the findings of Kabeer (2012) regarding traditional gender roles limiting women's access to stable employment opportunities.

The key findings from the study reveal that droughts have significant gender-differentiated impacts on employment (Afridi et al., 2022), which can be attributed to several underlying socioeconomic and structural mechanisms. For instance, women's increased agricultural employment, particularly in rural areas, suggests that they may turn to agriculture as a risk-coping strategy during droughts, driven by their reliance on subsistence farming and household food production (Hallegatte et al., 2018). Hallegatte and colleagues highlight how women often become the primary food producers in times of crisis, utilising agriculture to safeguard their families' food security when other sources of income are compromised.

With limited access to formal financial markets, insurance, or credit, rural women often rely on subsistence farming as an informal insurance mechanism to ensure food security and mitigate household income volatility, especially when men migrate or shift to other sectors (Cramer et al., 2018). Cramer et al. emphasise that this dependence on informal farming exacerbates women's economic vulnerabilities, particularly in rural settings where formal support systems are lacking. In contrast, the decline in male agricultural employment could reflect greater mobility and access to alternative employment opportunities, with men seeking non-farm jobs or migrating to urban areas (Eastin, 2018). Eastin's research indicates that men's ability to transition to non-farm employment is often facilitated by existing networks and resources, which are less accessible to women.

In the non-farm sectors, the steeper and more persistent declines in female employment, particularly in the upper non-farm sector, highlight the vulnerability of women who often occupy less secure and informal positions (Afridi et al., 2022). Afridi et al. further argue that these positions are more susceptible to economic shocks, resulting in higher rates of job loss for women during droughts. This vulnerability is exacerbated by traditional gender roles, which limit women's ability to migrate or seek alternative employment, especially in rural areas, contributing to the gender disparity in non-farm employment (Kabeer, 2012). Kabeer discusses how societal norms and expectations hinder women's economic mobility, leaving them with fewer options during crises.

These findings suggest that women's employment is more severely impacted by drought due to structural inequalities in access to resources, networks, and job security (Eastin, 2018), while men may have more diverse coping strategies and opportunities outside of agriculture. The event study also strengthens the robustness of these findings by showing the persistence of drought impacts across sectors and confirming that the observed outcomes are not driven by underlying trends unrelated to drought events (Callaway and Sant'Anna, 2021). Callaway and Sant'Anna illustrate how their methodology provides a clearer understanding of the long-term effects of drought, reinforcing the necessity of gender-sensitive policy responses.
Moreover, there are a few limitations and considerations of the study that must be addressed.

Observational and control variable limitations. The study has a shortage of observations and control variables, along with a broad geographic focus. Although the model incorporates fixed effects at the country and year levels, further controls are necessary to improve stability and generalizability. For instance, additional variables such as household income, education levels, access to financial resources, and marital status should be considered to enhance the robustness of the findings. The limited sample size may restrict the statistical power of the analysis, potentially leading to unreliable estimates. A larger and more diverse dataset would better support the conclusions drawn.

Geographic Focus and Localised Effects. While the study emphasises, drought impacts at the national, urban, and rural levels, it may overlook more localised regional effects. Droughts can vary geographically, and a more granular regional analysis could uncover different labour market response patterns, improving the understanding of localised employment shifts. For instance, focusing on specific regions known for varying drought intensities could potentially lead to targeted policy recommendations tailored to local conditions.

Endogeneity and Causality Issues. Potential endogeneity may exist in this study, where unobserved factors, such as regional economic conditions or local labour market dynamics, influence both drought occurrences and employment outcomes, leading to biased estimates. Addressing endogeneity through instrumental variables (IV) could enhance the validity of the causal claims made. For instance, using historical climate data as an instrument could help isolate the effects of drought on employment from confounding factors. Literature such as Angrist and Pischke (2009) highlights the necessity of addressing endogeneity for accurate causal inferences, while Wooldridge (2010) emphasises IV approaches as crucial for empirical research. By tackling these endogeneity concerns, future studies could achieve a clearer understanding of the complex relationship between drought and gender-differentiated employment impacts in vulnerable sectors.

Mechanisms Behind Employment Changes. The study examines employment outcomes but only briefly addresses the mechanisms behind these changes. A deeper investigation into why women are more adversely affected in non-farm sectors or why men respond differently could provide valuable insights. Exploring cultural, migration, mobility, or economic constraints that contribute to these gendered employment differences would strengthen the analysis and offer actionable insights for policymakers.

Policy Implications and Implementation Challenges. While the findings suggest specific policy interventions, the feasibility of these recommendations may be impacted by political and institutional barriers, such as funding constraints and local governance issues. Recognizing these challenges is crucial for developing practical and effective policy responses that address gender disparities in labour markets affected by drought.

7. Conclusion

This study investigated the gender-differentiated impacts of drought on sector-specific employment rates across urban and rural areas in 31 African countries, focusing on the agricultural, upper non-farm, and lower non-farm sectors. The key findings reveal that droughts have significant and distinct effects on employment, with notable disparities between men and women. Specifically, women experience increased employment in the agricultural sector, particularly in rural areas, while male employment in agriculture generally declines. This aligns with existing literature, highlighting the complex dynamics at play in labour markets affected by environmental shocks.

The analysis demonstrated that female employment in agriculture increased by approximately 25% in rural regions following drought events, contrasting with a 15% decline in male agricultural employment. This finding supports previous research, such as Hallegatte et al. (2018), which argues that women often resort to agriculture as a coping strategy during droughts due to their reliance on subsistence farming. Conversely, the decline in male agricultural employment may reflect greater mobility and access to alternative job opportunities, consistent with Eastin's (2018) findings regarding men's adaptability in labour markets.

In the upper non-farm sector, both men and women faced employment declines, but the reduction was significantly more pronounced for women, particularly in urban areas. Cramer et al. (2018) highlighted that women often occupy less secure and informal positions, making them more vulnerable to economic shocks. The lower non-farm sector exhibited mixed results, with women facing substantial employment reductions at national and rural levels, while men experienced smaller or negligible changes. These patterns suggest that droughts exacerbate gender disparities in employment, echoing the findings of Kabeer (2012), which discuss how traditional gender roles limit women's access to stable employment opportunities.

The findings of this study underscore the importance of addressing the structural inequalities that contribute to women's vulnerabilities in labour markets during environmental shocks. While women's increased participation in agriculture during droughts may seem beneficial, the limited access to formal financial markets, credit, and training programs constrains their ability to leverage this opportunity effectively. The critical assessment of these findings raises important questions about the feasibility of enhancing women's roles in agriculture as a coping strategy amidst the escalating impacts of climate change.

The results presented in this study extend the existing literature on gender dynamics in labour market responses to climate change. They highlight that policy frameworks must consider these gendered impacts when designing interventions aimed at fostering resilience in disaster-prone regions. The study provides compelling evidence for the necessity of targeted policies that enhance women’s economic resilience. Policymakers should implement programs that offer financial support, resources, and training for women in agriculture to better prepare them for future drought events.

Despite the contributions made by this study, several limitations must be acknowledged. The analysis is constrained by a limited sample size and a broad geographic focus, which may restrict the generalizability of the findings. Additionally, the study primarily examines employment outcomes while briefly addressing the underlying mechanisms behind these changes. Future research should explore the long-term impacts of drought on employment and recovery trajectories in affected communities, particularly concerning human capital and health outcomes.

Moreover, there is a need for qualitative research that delves deeper into the individual experiences and social dynamics surrounding drought impacts. Studies by Cramer et al. (2018) and Eastin (2018) emphasise the importance of integrating qualitative analyses with quantitative findings to provide a more comprehensive understanding of the gendered impacts of environmental shocks.

In conclusion, this research contributes to the growing body of literature on gender-differentiated responses to climate change in Africa. By illuminating the specific vulnerabilities faced by women in labour markets affected by drought, the study emphasises the critical need for informed and gender-sensitive policy responses. As climate change intensifies, understanding these dynamics will be vital for fostering economic stability and resilience in vulnerable communities across Africa.

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Appendix 1: Total number of droughts

Country	**Year**																**Total**
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Angola	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	4
Botswana	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
Burkina Faso	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	4
Burundi	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	4
Cabo Verde	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Cameroon	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Chad	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	3
Djibouti	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	4
Eritrea	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Eswatini	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	3
Ethiopia	1	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	6
Gambia	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
Guinea-Bissau	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kenya	1	0	0	1	0	0	2	0	0	1	0	1	0	0	1	1	8
Lesotho	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1	5
Madagascar	1	0	0	1	0	0	0	0	0	1	0	1	1	0	0	1	6
Malawi	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	4
Mali	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	5
Mauritania	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	1	5
Mozambique	1	0	1	1	0	1	0	0	0	0	0	1	0	0	0	1	6
Namibia	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	3
Niger	1	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	6
Senegal	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	3
Somalia	1	0	0	1	0	1	0	1	0	1	1	0	0	0	1	0	7
South Africa	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	3
South Sudan	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2
Sudan	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
Uganda	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	3
United Republic of Tanzania	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Zambia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Zimbabwe	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	4
Total	13	3	5	9	5	6	12	8	2	5	9	7	7	3	9	9	112

Table 1b. Total number of reported droughts by country and year (2005-2020)

Appendix 2: Total number of affected people by droughts

Country	Year																Total
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Angola	0	0	0	0	0	0	0	1 833 900	0	0	0	0	1 420 000	0	0	1 643 316	4 897 216
Botswana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38 000	0	38 000
Burkina Faso	0	0	0	0	0	0	2 850 000	0	0	4 000 000	0	0	0	0	0	2 900 000	9 750 000
Burundi	2 150 000	0	0	82 500	180 000	0	0	0	0	0	0	0	0	0	0	0	2 412 500
Cabo Verde	0	0	0	0	0	0	0	0	0	0	0	0	70 000	0	0	0	70 000
Cameroon	0	0	0	0	0	0	0	12 000	0	0	0	0	0	0	0	0	12 000
Chad	0	0	0	0	2 400 000	0	0	1 600 000	0	0	0	0	1 886 800	0	0	0	5 886 800
Djibouti	150 000	0	42 750	34 0000	0	200 258	0	0	0	0	0	0	0	0	0	0	427 008
Eritrea	0	0	0	1 700 000	0	0	0	0	0	0	0	0	0	0	0	0	1 700 000
Eswatini	0	0	410 000	0	0	0	0	0	0	0	0	492 000	0	0	232 000	0	1 134 000
Ethiopia	2 600 000	0	0	6 400 000	6 200 000	0	4 805 679	1 000 000	0	0	10 200 000	0	0	0	0	0	31 205 679
Gambia	0	0	0	0	0	0	0	428 000	0	0	63 100	0	0	0	0	0	491 100
Guinea-Bissau	0	32 000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32 000
Kenya	3 500 000	0	0	3 800 000	0	0	8 050 000	0	0	1 600 000	0	3 400 000	0	0	2 600 000	4 500 000	27 450 000
Lesotho	0	0	475 000	0	0	0	725 515	0	0	0	0	709 000	0	0	433 000	766 000	3 108 515
Madagascar	14 000	0	0	720 000	0	0	0	0	0	20 000	0	1 140 000	1 260 000	0	0	1 680 000	4 834 000
Malawi	5 100 000	0	520 000	0	0	0	0	1 900 000	0	0	6 700 000	0	0	0	0	0	14 220 000
Mali	1 000 000	25 000	0	0	0	600 000	350 0000	0	0	0	0	0	0	0	0	6 800 000	8 775 000
Mauritania	0	0	0	0	0	838 000	723 000	0	0	0	0	0	3 893 774	350 600	0	1 400 000	7 205 374
Mozambique	1 400 000	0	520 000	500 000	0	460 000	0	0	0	0	0	2 300 000	0	0	0	2 700 000	7 880 000
Namibia	0	0	0	0	0	0	0	0	780 000	0	580 000	0	0	556 000	0	0	1 916 000
Niger	3 000 000	0	0	0	7 900 000	0	3 000 000	0	0	0	2 588 128	0	1 131 300	0	0	3 700 000	20 319 428
Senegal	0	0	0	0	0	0	850 000	0	0	639 702	0	0	0	320 000	0	0	1 809 702
Somalia	0	0	0	3 300 000	0	4 000 000	0	3 000 000	0	535 624	6 700 000	0	0	0	1 500 000	0	19 035 624
South Africa	0	0	0	0	0	0	0	0	0	0	2 700 000	0	0	0	750 000	0	3 450 000
South Sudan	0	0	0	0	4 300 000	0	0	0	0	0	0	3 600 000	0	0	0	0	7 900 000
Sudan	0	0	0	0	0	0	0	3 200 000	0	0	800 000	0	0	0	0	0	4 000 000
Uganda	600 000	0	0	1 100 000	0	0	669 000	0	0	0	0	0	0	0	0	0	2 369 000
United Republic of Tanzania	0	3 700 000	0	0	0	0	1 000 000	0	0	0	0	0	0	0	0	0	4 700 000
Zambia	1 200 000	0	0	0	0	0	0	0	0	0	0	0	0	0	1 430 000	0	2 630 000
Zimbabwe	0	0	2 100 000	0	0	1 667 618	0	0	4 300 000	0	0	0	6 900 000	0	0	0	14 967 618
Total	20 714 000	3757000.00	4 067 750	17 942 500	20 980 000	7 765 876	26 173 194	12 973 900	5 080 000	6 795 326	30 331 228	11 641 000	16 561 874	1 226 600	6 983 000	26 089 316	219 082 564

Table 2: Total number of affected people by droughts by country and year

Appendix 3: Results of regressions to select treatment variable

Treatment Variable	**(1)**	**(2)**	**(3)**	**(4)**
Droughttreated	-0.122			
	(0.109)			
Droughttreated_yr1onw		-0.3531**		
		(0.104)		
Droughttreated_yr2onw			-0.0208	
			(0.162)	
Droughttreated_AU15				-0.3423*
				(0.120)
log_GDPpc	-0.417*	-0.2902	-0.3459*	-0.3909*
	(0.169)	(0.169)	(0.167)	(0.167)
urbanization	-0.627	-0.8812	-0.8245	-0.9999
	(0.692)	(0.6754)	(0.677)	(0.675)
log_householdsize	0.0652	-0.0033	-0.0029	-0.0109
	(0.521)	(0.0307)	(0.030)	(0.031)
labourforceparti	0.118	0.1425	0.14707	0.1426
	(0.210)	(0.2106)	(0.2111)	(0.210)
log_education	-0.646	0.3291	0.2564	-0.2659

Table 3. Regression results for four different treatment options for drought on employment rates

*Note: Samples drawn from World Bank database, Global data lab database and EM-DAT - The International Disaster Database. Regressions control for covariates using fixed effects for country and year and other covariates. Standard errors clustered at country level. Robust standard errors, clustered on region level in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

Appendix 4: Countries most affected by droughts

Country	**Total people affected by droughts**
Ethiopia	50 605 679
South Africa	30 450 000
Kenya	29 250 000
Somalia	26 335 624
Niger	21 319 428
Malawi	17 049 435
Zimbabwe	15 135 118
Mali	11 925 000
Mozambique	9 899 500
Burkina Faso	9 750 000

Table 4. Countries most affected by droughts

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