Temperature and Precipitation Extremes and Labor Supply in Central Africa

Vladimir Hlasny
UN ESCWA
Yasmine Abdelfattah
University of Prince Edward Island, Cairo Campus & Cairo University

18-Dec, 2024

Motivation

- Africa is one of the world's regions most vulnerable to climate change. This calls for a deeper understanding of the consequences, risks and mitigation measures.

- Prior literature has examined the impacts of extreme weather events in different parts of Africa on demography, migration, production and agriculture, and labor supply.

- We hope to contribute up-to-date evidence by assessing the effects of extreme temperatures, precipitation & humidity on working hours, of less or more exposed workers, across 4 Central African countries with multiple rounds of High Frequency Phone Surveys for 2020–2023.

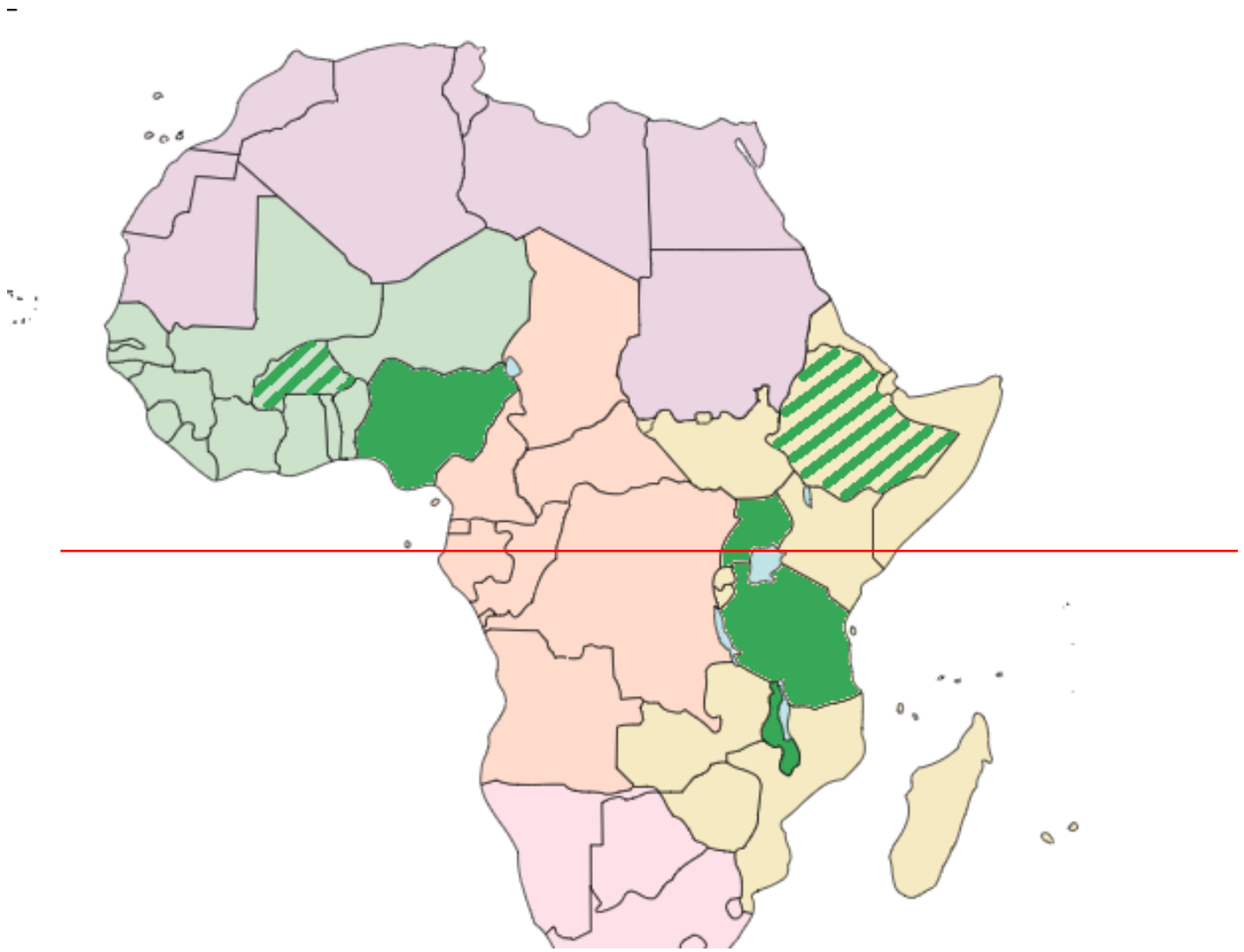
Research Questions

- How does climate change as measured by extreme values of temperature, precipitation and humidity impact labor supply in Central Africa?

- Which manifestation of extreme weather exerts the most serious impacts, and are there safe or threshold levels with respect to the impacts? Do they interact?

- Do these impacts differ between genders, and between occupations with high versus low exposure to weather?

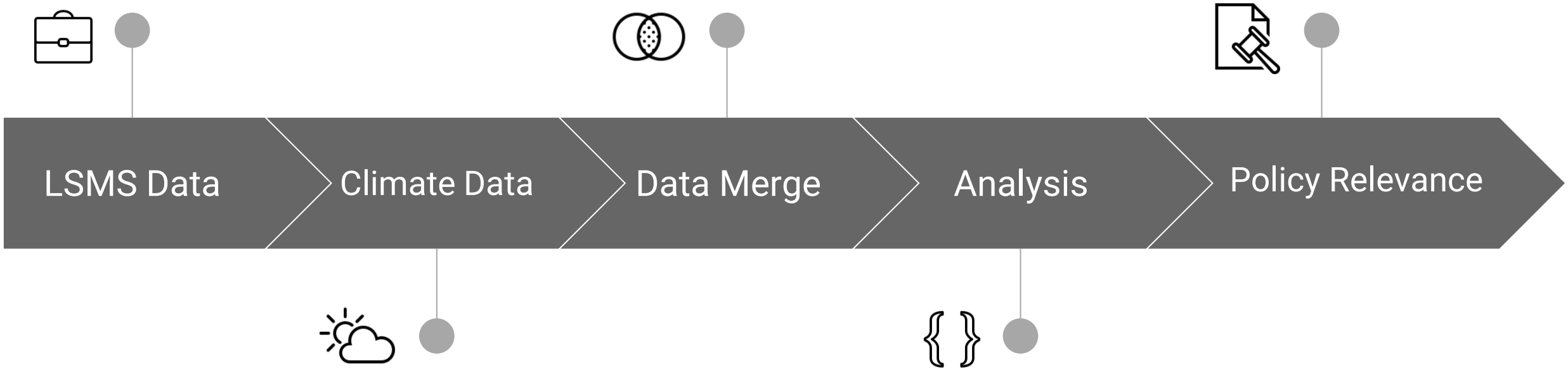
Data used



Labor supply in Malawi, Nigeria, Tanzania & Uganda

Forming a consolidated dataset that includes both labour and climate variables

Drawing conclusions and policy implications



Satellite climate variables

Using generalized linear models (GLMs) to estimate climate variables' effects on labor supply

Examining Climatic Variations and Labor Supply: Data Sources & Integration

1. Socioeconomic Data: Living Standards Measurement Study (LSMS)

Scope: Harmonized household- and individual-level data.

Countries & Rounds:

- **Malawi:** 2022-2023 (Rounds 13, 14, 18)
- **Nigeria:** 2020-2023 (Rounds 2-20)
- **Tanzania:** 2021-2023 (Rounds 2-8)
- **Uganda:** 2000-2023 (Rounds 2-14)

Key Features:

- Covers demographics, education, employment, welfare.
- **Geographical Identifiers:** Regions (Adm 1), Districts (Adm 2), Localities (Adm 3).
- Enables linkage to external datasets for **spatial-temporal analysis**.

- Longitudinal survey data from the 2020–2023 LSMS High Frequency Phone Surveys, screening hours worked in the past week in one's main job.
  - MWI: 3,394 respondents with >0 hours from 31 districts (215 sub-districts) over 13 weeks.
  - NGA: 23,043 respondents from 37 districts (390 sub-districts) over 48 weeks.
  - TZA: 8,834 respondents from 30 districts (2,226 sub-districts) over 27 weeks.
  - UGA: 9,483 respondents from 119 districts (183 sub-districts) over 36 weeks.

- Globally gridded weather & climate datasets:
  - NASA Prediction of Worldwide Energy Resource (POWER) Project, funded through the NASA Applied Sciences Program for relative humidity.
  - Daily data from closest weather stations mappable using Global Administrative Areas (GADM) shapefiles based on Humanitarian Data Exchange.

Examining Climatic Variations and Labor Supply: Data Sources & Integration (Cont'd)

2. Climate Data: NASA POWER Database

Resolution: Daily meteorological data (0.5° x 0.5° latitude/longitude).

Metrics: Maximum temperatures, precipitation, relative humidity.

Integration Process:

- Aggregated into weekly averages (7-day moving windows) during survey weeks.
- Matched to LSMS regions using precise spatial coordinates.

Temporal Coverage: 2020–2023 (2024 forthcoming).

Examining Climatic Variations and Labor Supply: Data Sources & Integration (Cont'd)

3. Geographical Boundaries:

GADM Shapefiles Source: Humanitarian Data Exchange (HDX).

Application:

- Defines administrative regions.
- Facilitates spatial mapping and merging LSMS survey areas with climate data.
- Enhances analysis granularity while aligning with LSMS frameworks.

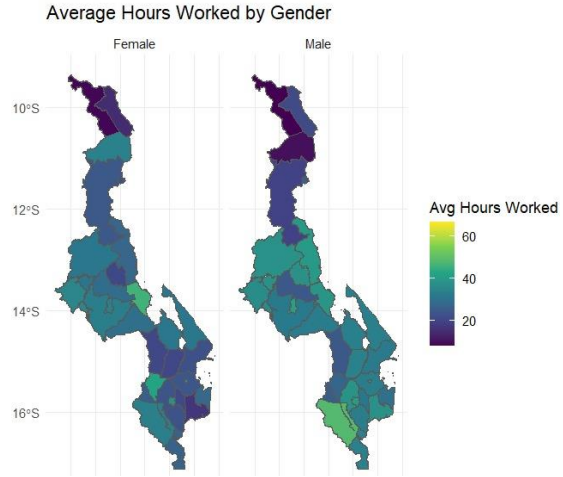
Integrated Dataset:

- Enables a **localized analysis of climate–socioeconomic intersections**, providing insights into labor supply dynamics under varying climatic conditions.

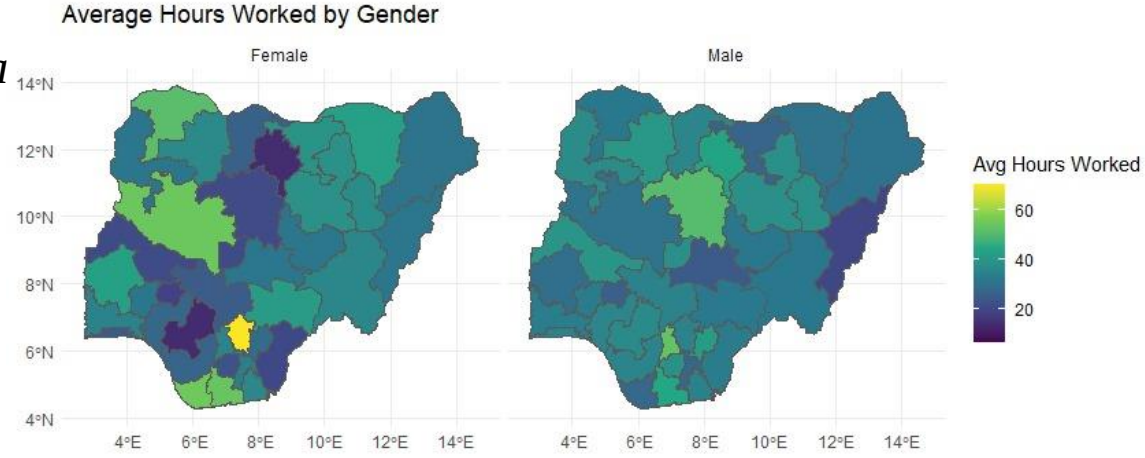
Weekly hours worked in current job by national district, by gender

Men typically work longer hours than women, Tanzanians longer than Malawians

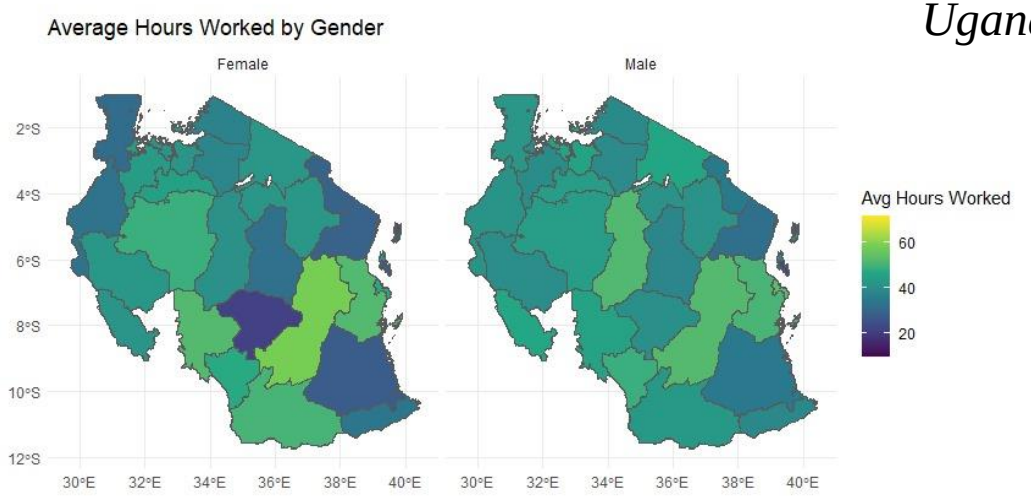
Malawi



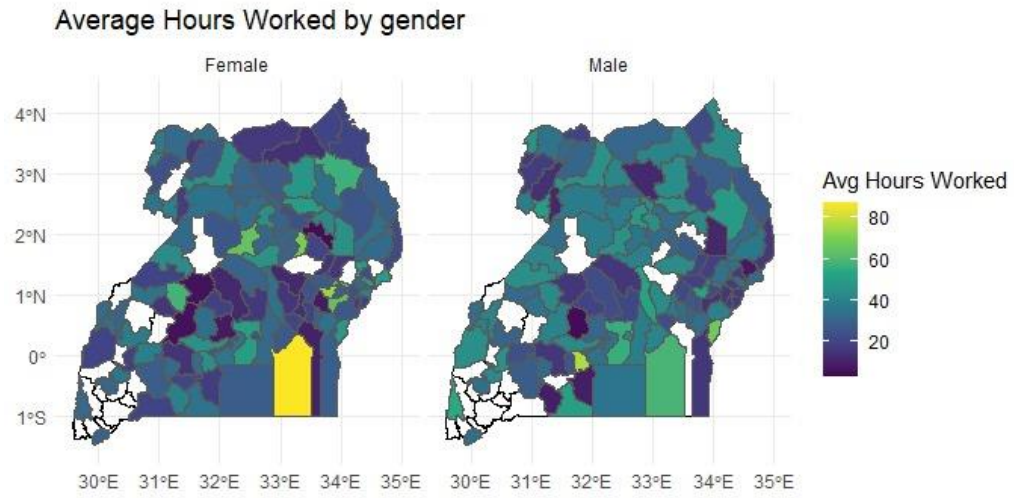
Nigeria



Tanzania



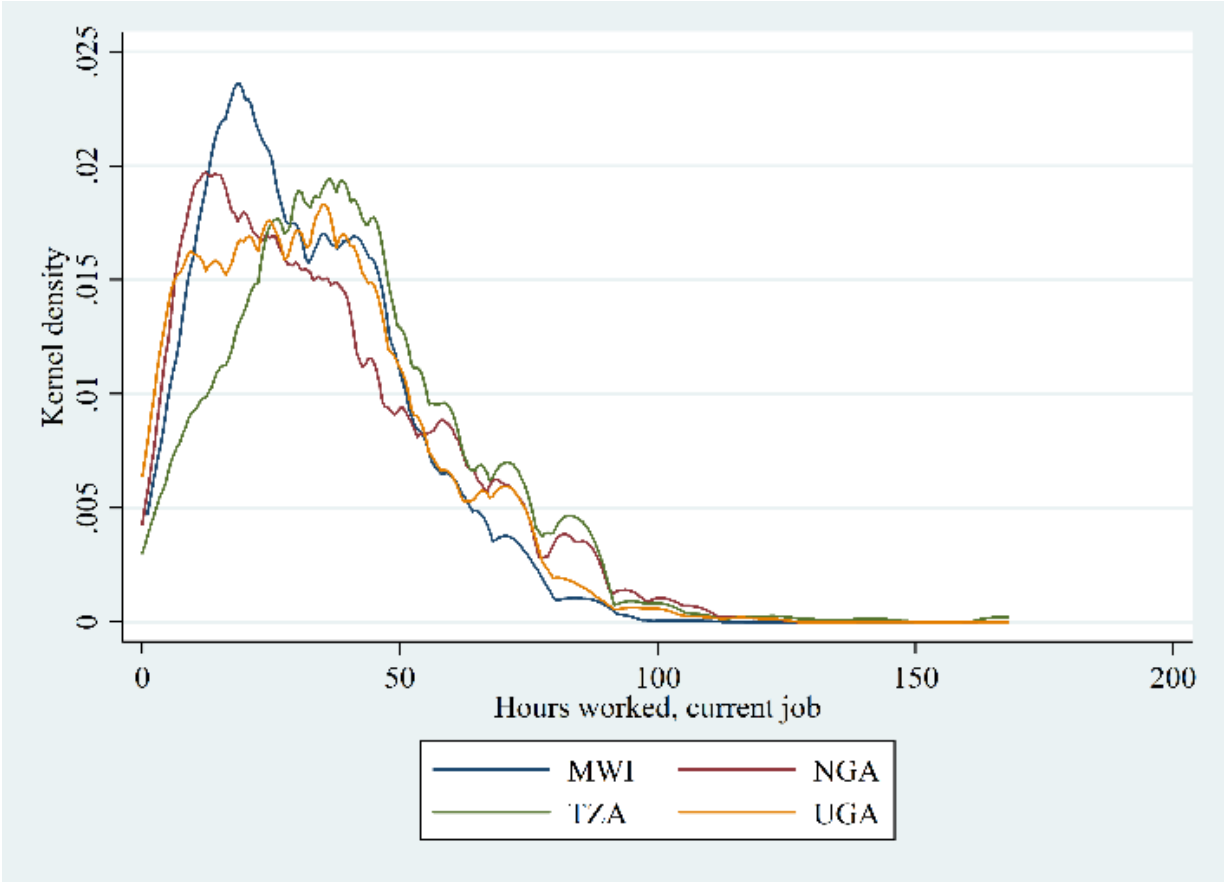
Uganda



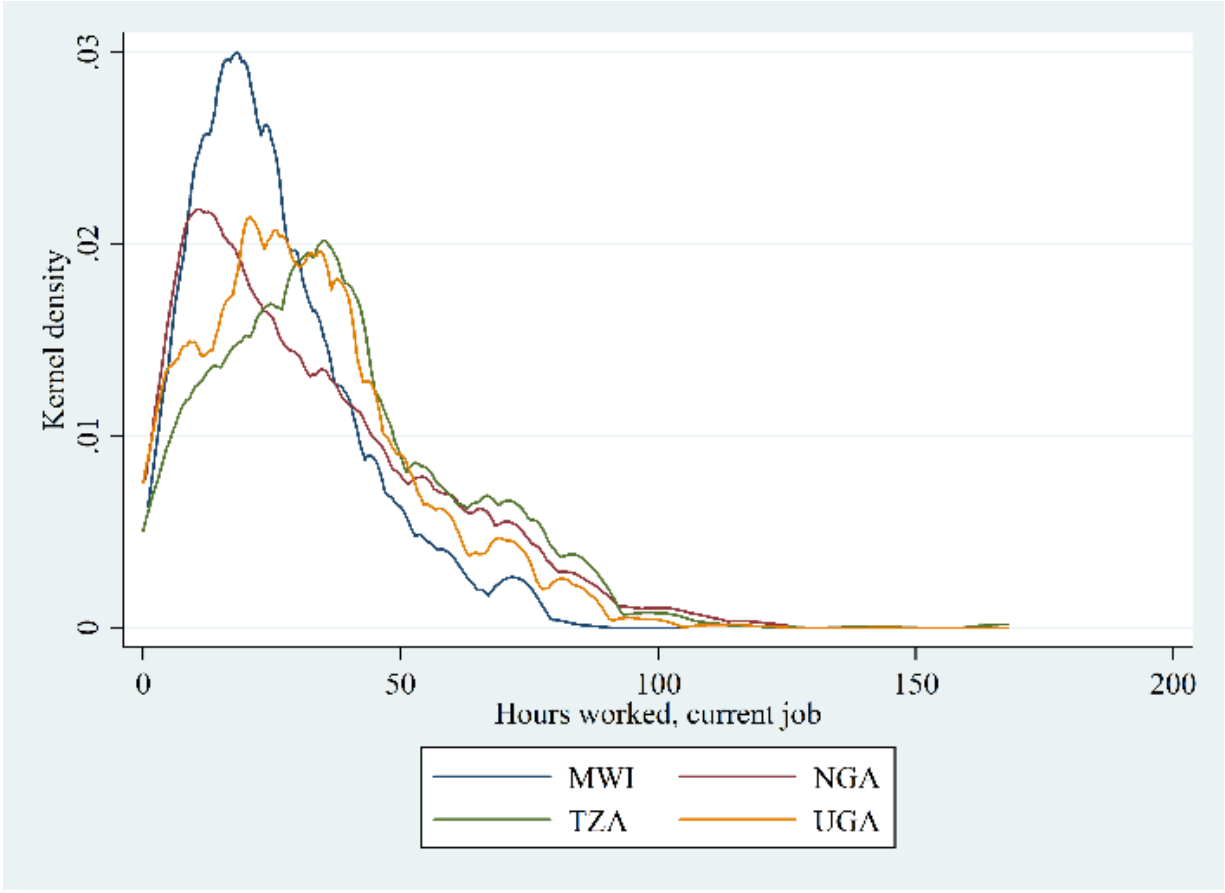
Source: Authors' analysis based on 2020–2023 HFPS for Malawi (rounds 13,14,18), Nigeria (rounds 2–20), Tanzania (rounds 2–8), and Uganda (rounds 2–14). National panel sampling weights are used. GADM shapefiles based on Humanitarian Data Exchange (2024).

Weekly hours worked in current job, by gender

Men



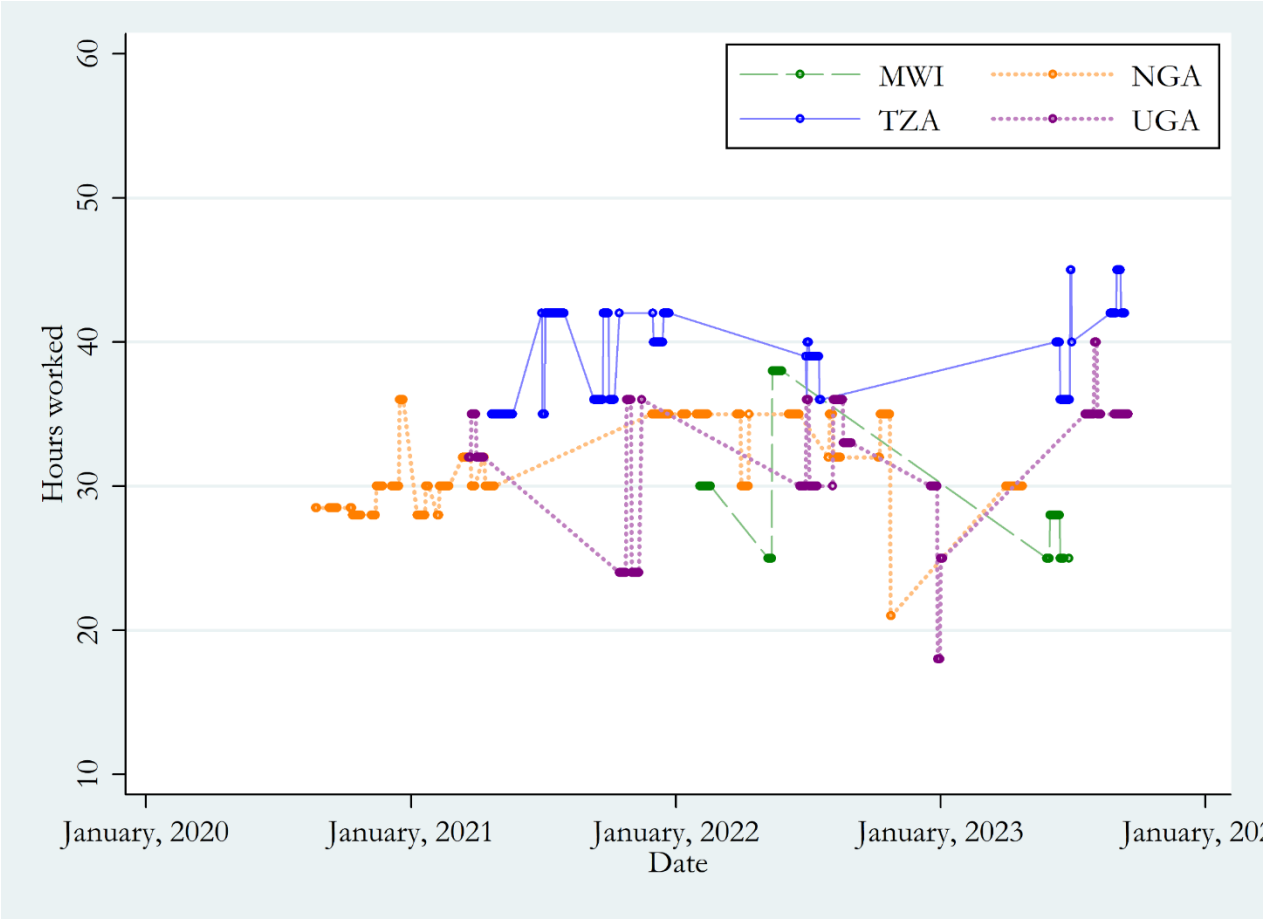
Women



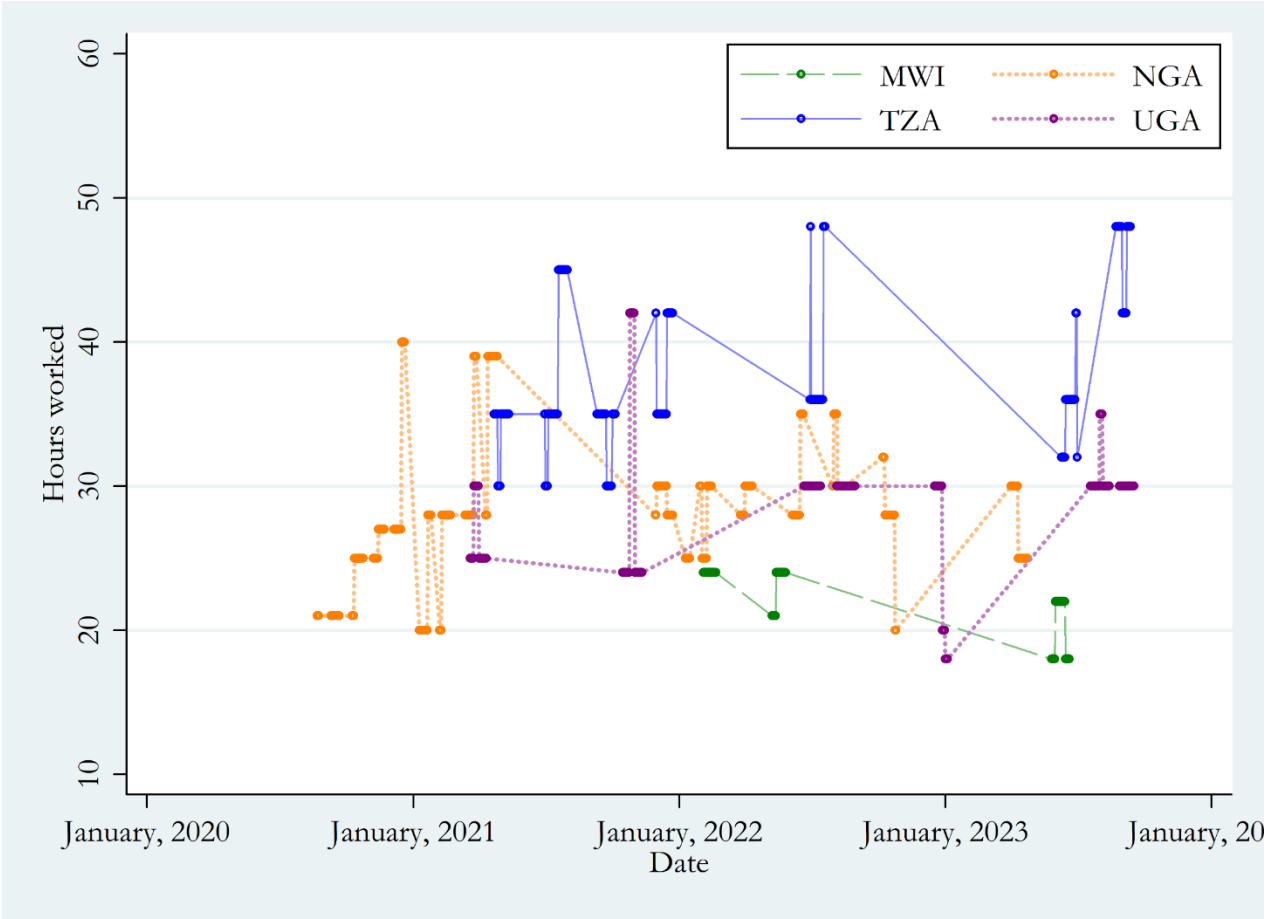
Source: Authors' analysis based on 2020–2023 HFPS for Malawi (rounds 13,14,18), Nigeria (rounds 2–20), Tanzania (rounds 2–8), and Uganda (rounds 2–14). National panel sampling weights are used.

Weekly hours worked in current job, biweekly median by gender (if hours > 0)

Men

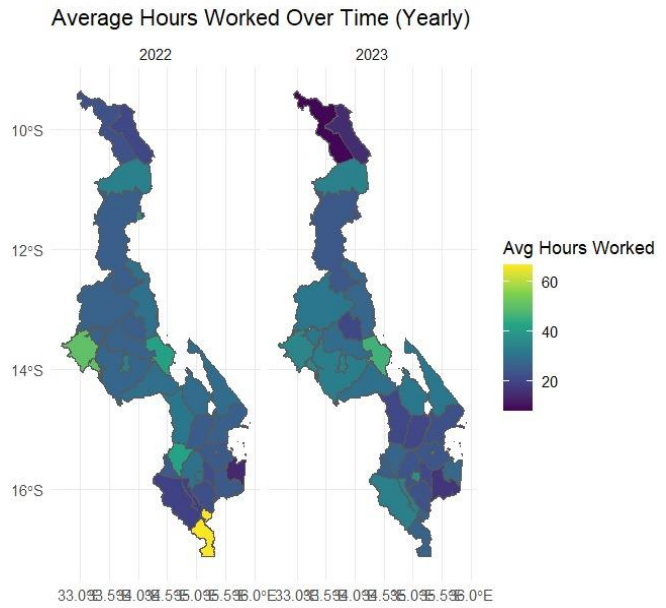


Women

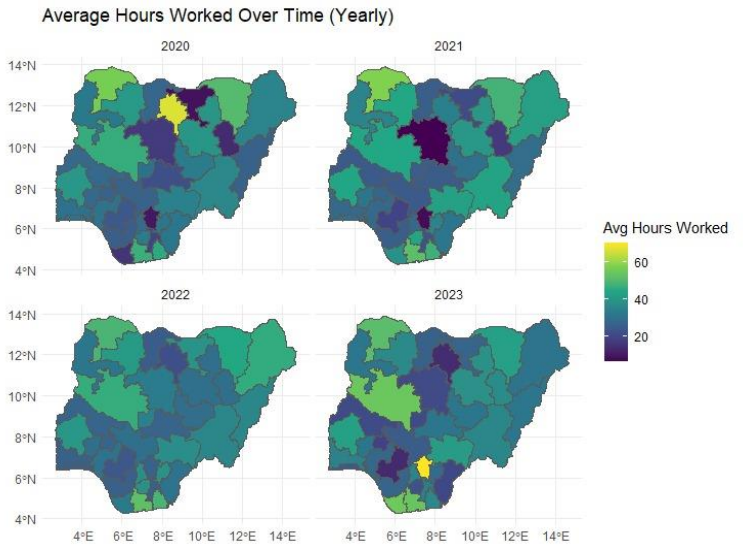


Weekly hours worked vary by year … perhaps according to the dry/wet seasons surveyed

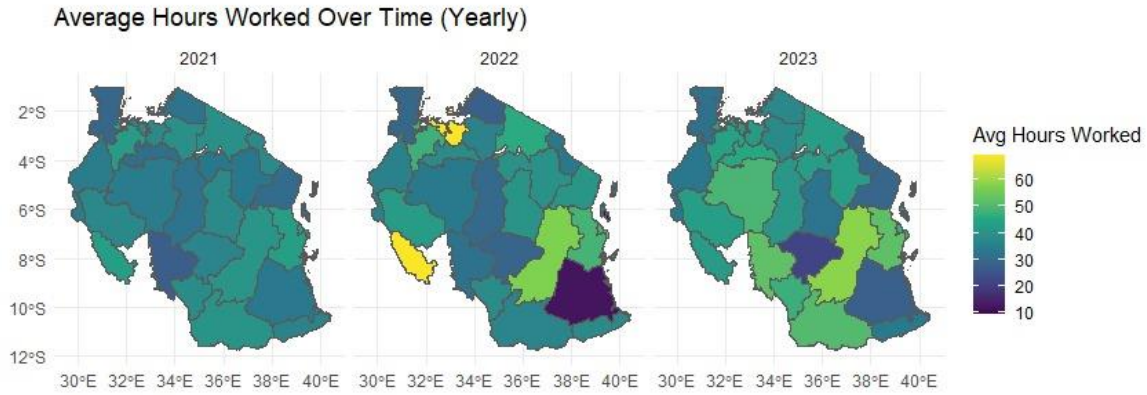
Malawi



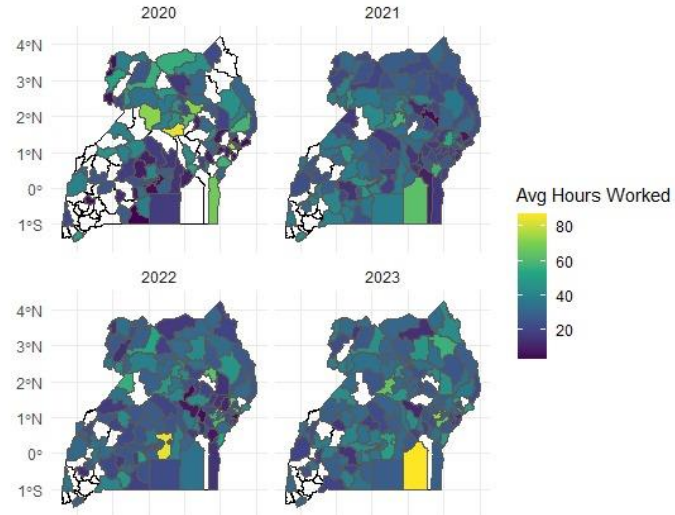
Nigeria



Tanzania



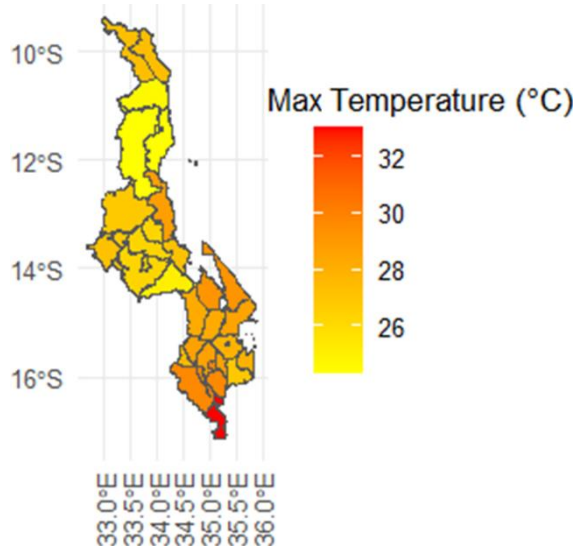
Uganda



Source: Authors' analysis based on 2020–2023 HFPS for Malawi (rounds 13,14,18), Nigeria (rounds 2–20), Tanzania (rounds 2–8), and Uganda (rounds 2–14). National panel sampling weights are used. GADM shapefiles based on Humanitarian Data Exchange (2024).

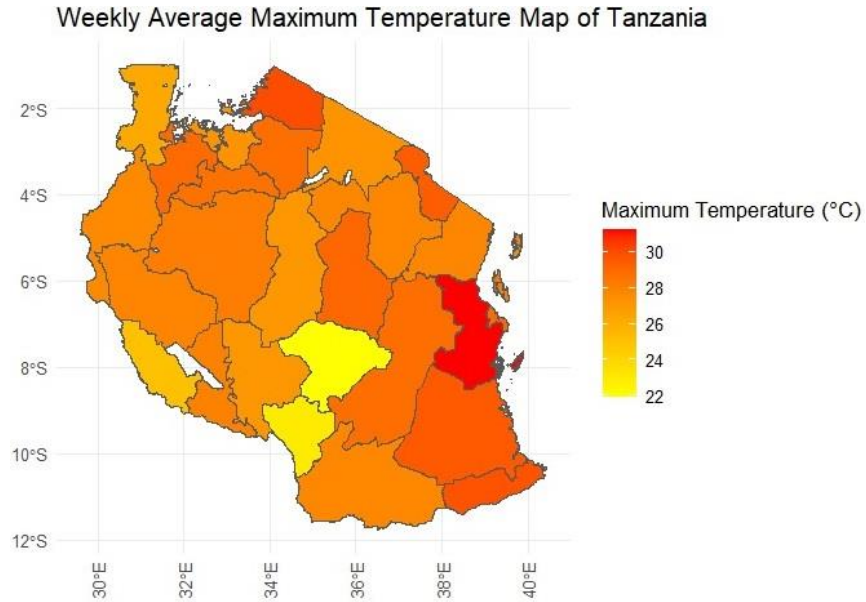
Weekly average of daily maximum temperature by national district

Malawi

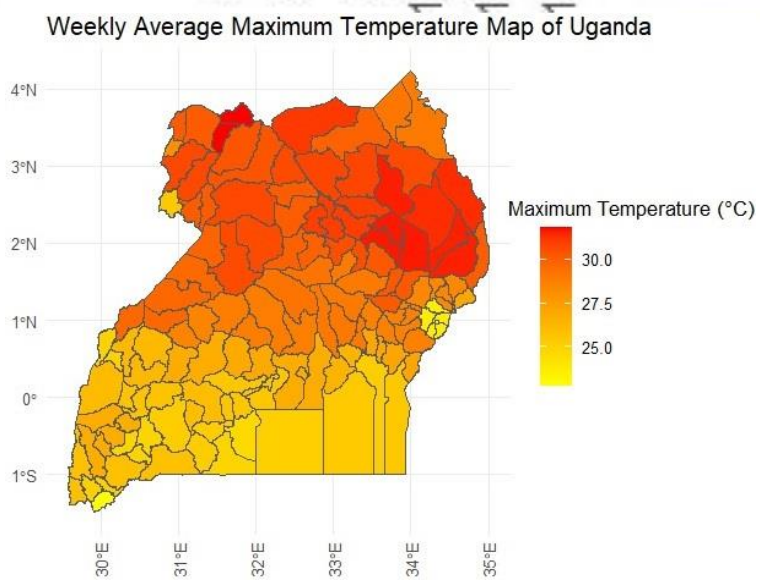


Nigeria

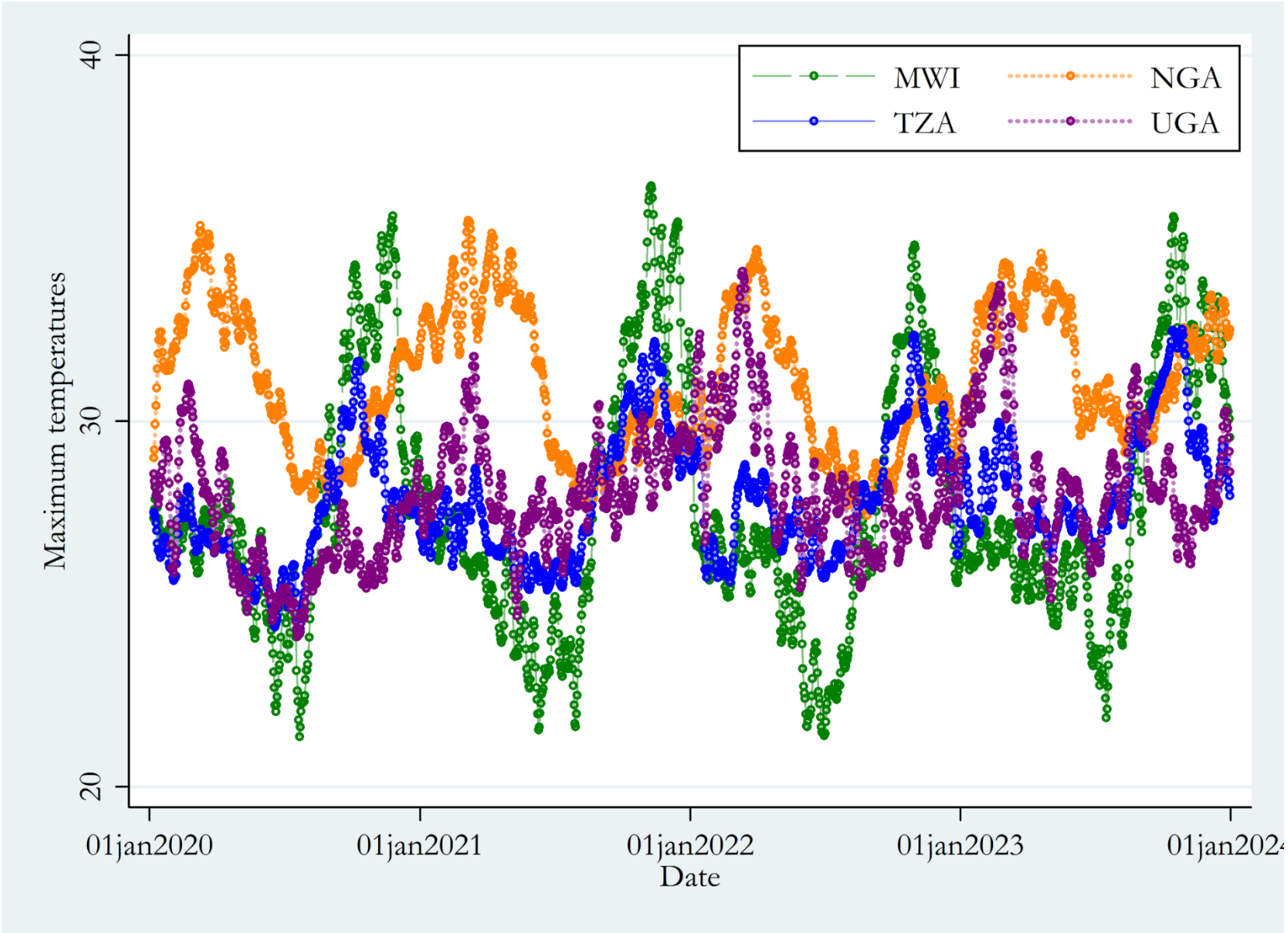
Tanzania



Uganda

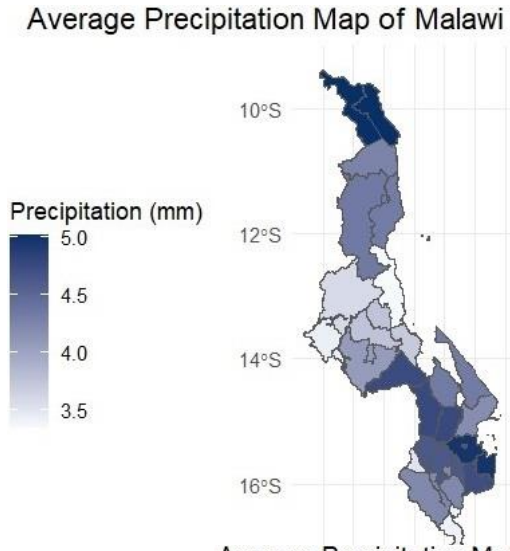


Source: Authors' analysis using NASA POWER. GADM shapefiles based on Humanitarian Data Exchange (2024).

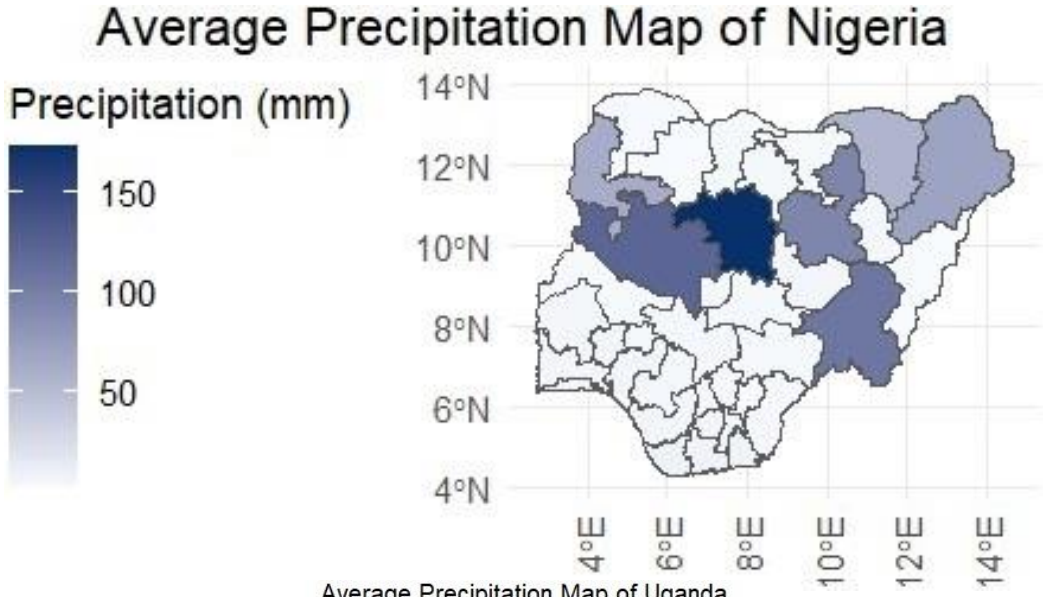

MWI
NGA
TZA
UGA
Maximum temperatures
40
30
20
01jan2020
01jan2021
01jan2022
01jan2023
01jan2024
Date

Weekly precipitation by national district

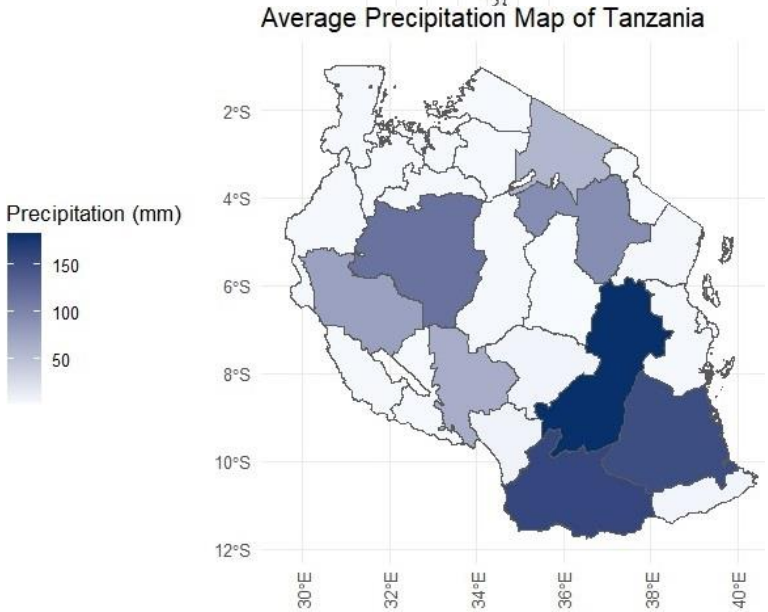
Malawi



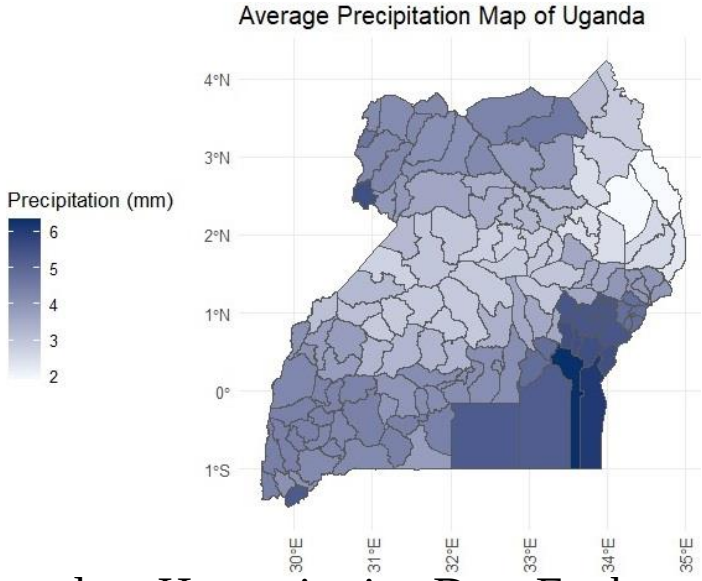
Nigeria



Tanzania



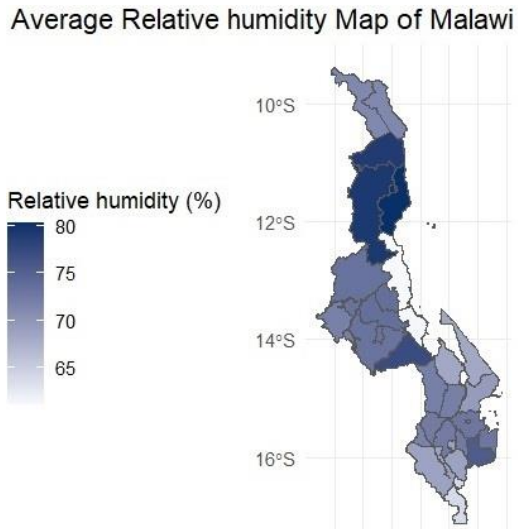
Uganda



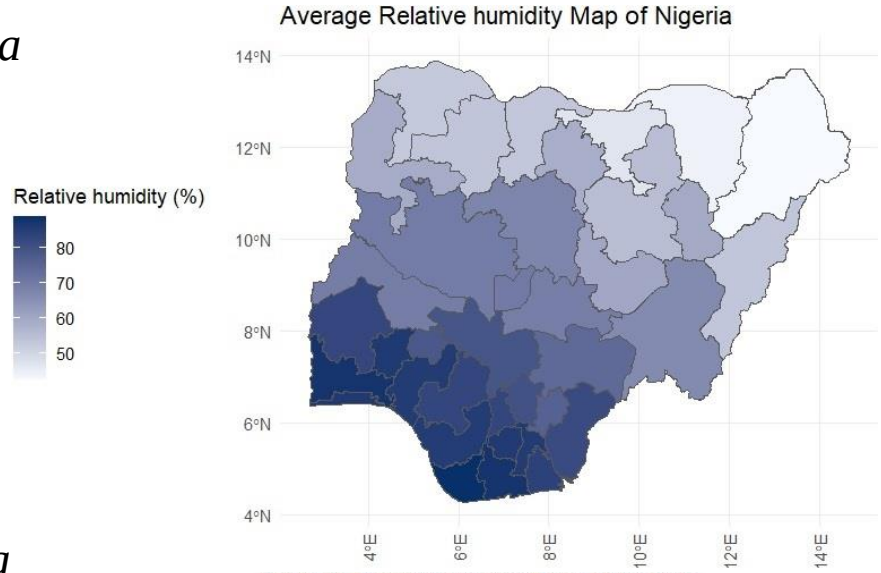
Source: Authors' analysis using NASA POWER. GADM shapefiles based on Humanitarian Data Exchange (2024).

Weekly relative humidity by national district

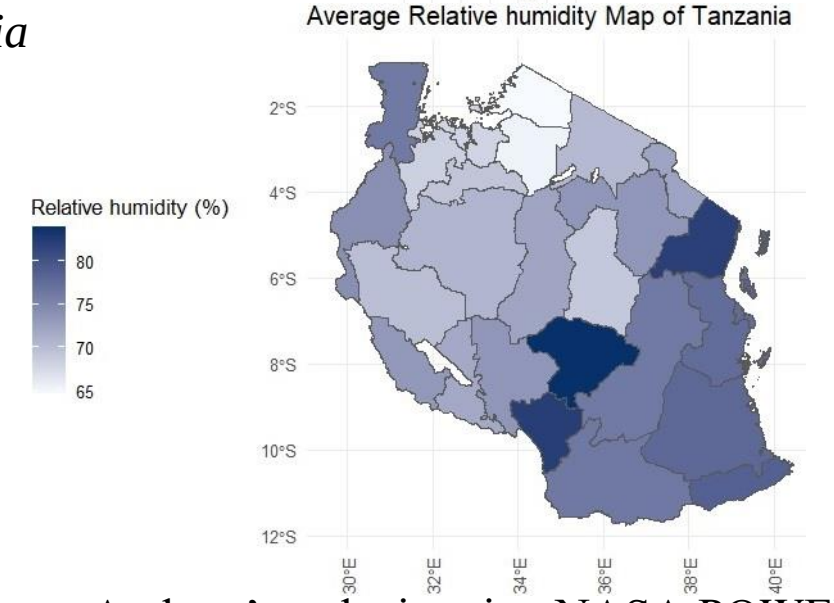
Malawi



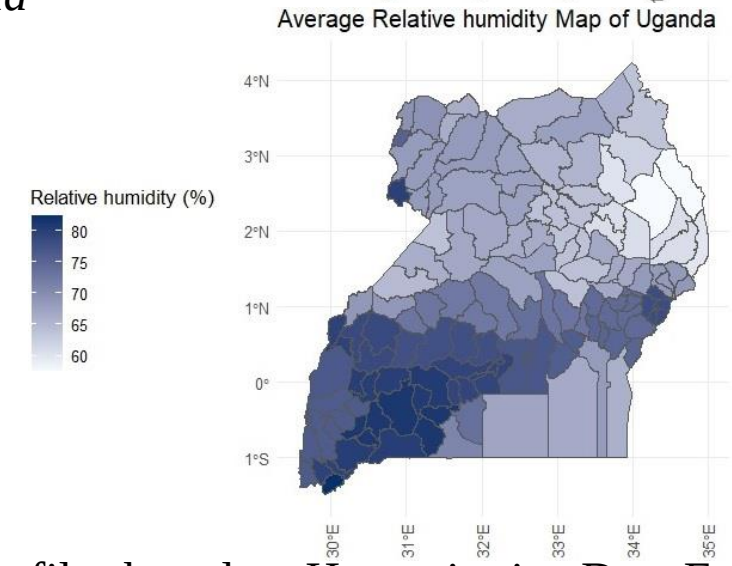
Nigeria



Tanzania



Uganda



Source: Authors' analysis using NASA POWER. GADM shapefiles based on Humanitarian Data Exchange (2024).

	Malawi (dry season)	Malawi (wet season)	Nigeria (dry season)	Nigeria (wet season)	Tanzania (dry season)	Tanzania (wet season)	Uganda (dry season)	Uganda (wet season)
Men								
Lab force part	88.33%	86.87%	90.68%	88.71%	81.72%	99.89%	100.00%	80.92%
Employed	74.11%	77.58%	77.45%	73.99%	63.38%	81.80%	85.06%	73.26%
Hours worked	32.38	31.95	36.47	35.17	42.51	39.23	34.69	35.81
Max temper.	25.63C	28.69C	31.95C	30.60C	27.77C	28.00C	27.88C	28.02C
Precipitation	2.05	57.07	22.45	220.36	107.97	297.77	17.55	33.49
Relat humidity	70.93	76.20	59.12	78.82	69.71	77.79	69.32	73.44
Women								
Lab force part	86.65%	87.02%	82.01%	84.39%	81.73%	99.88%	100.00%	83.95%
Employed	63.61%	69.77%	59.51%	61.45%	53.76%	64.88%	75.84%	69.60%
Hours worked	26.21	26.33	33.07	32.20	39.37	37.28	33.87	33.86
Max temper.	25.63C	28.69C	31.95C	30.60C	27.77C	28.00C	27.88C	28.02C
Precipitation	2.05	57.07	22.45	220.36	107.97	297.77	17.55	33.49
Relat humidity	70.93	76.20	59.12	78.82	69.71	77.79	69.32	73.44

Research Framework

- We utilize the conventional econometric framework from prior studies (Zivin & Neidell 2014; Shayegh et al. 2020; Abou-Ali et al. 2022) as follows:

$$y_{ist} = \beta_0 + \beta_1 wther_{st} + \beta_2 wther_{st}^2 + \delta X_{its} + \alpha_1 t + \alpha_2 t^2 + \rho_s + \epsilon_{ist}$$

  - y_{ist} is the respondent i's labor supply in location s during week t.
  - Weather indicators are (1) average of the maximum weekly temperature faced by respondents in week *t* in location *s*; (2) average precipitation faced by respondents in week *t* in location *s;* (3) average humidity faced by respondents in week *t* in location *s*.
  - X_{its} is a vector of individual/district-level characteristics which are controlled for including exposed sector, potential work experience, experience squared, employment type, gender, HHD size, HHD size squared, rainy season.
  - t, t^2, ρ_s are time trend, trend squared, and district fixed effects, respectively.
  - Exposed sector is interacted with extreme weather indicators

From prior evidence, sectors exposed to extreme weather events are:

- Agriculture, hunting, fishing
- Mining, manufacturing
- Electricity, gas, water supply
- Construction
- Transport, driving, post, travel agencies.

Estimators

- Alternative dependent variables are employment status, and hours worked in the past week.
- Because these are limited dependent variables, we use the corresponding estimators:
  - logit for employment status
  - tobit (treating hours worked as continuous but left-censored) or negative binomial regression for hours worked (treating hours as an over-dispersed count variable).
- A within-estimator with individual-level random or fixed effects is used to offset autocorrelation & latent heterogeneity across workers.
- Standard errors are heteroskedasticity robust or jackknife estimates.

Malawi, Men

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.127	-4.368*	-0.127*	-0.097***	-4.437***	-0.283***
	(0.188)	(2.246)	(0.071)	(0.000)	(0.025)	(0.001)
Max tempertr. Squared	0.013	0.236*	0.006	0.004***	0.213***	0.014***
	(0.010)	(0.135)	(0.004)	(0.000)	(0.002)	(0.000)
Avg precipitation	-0.005	0.029	0.001	-0.001***	0.024***	-0.000
	(0.021)	(0.081)	(0.002)	(0.000)	(0.001)	(0.000)
Avg precipitat squared	-0.000	-0.000	-0.000	0.000***	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.085	0.591	0.015	0.043***	0.810***	0.066***
	(0.116)	(1.056)	(0.029)	(0.000)	(0.015)	(0.001)
Relat humidity squared	-0.000	-0.009	-0.000	-0.000***	-0.012***	-0.001***
	(0.001)	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	-0.184	-8.688	-0.268	0.268***	-18.651***	-1.761***
	(2.682)	(23.888)	(0.627)	(0.004)	(0.270)	(0.011)
Vulnerable x temperature	0.033	-0.042	0.008	-0.065***	0.024**	0.050***
	(0.121)	(0.853)	(0.024)	(0.000)	(0.010)	(0.000)
Vulnerable x precipitation	0.013	0.013	0.000	-0.000***	-0.008***	-0.002***
	(0.011)	(0.035)	(0.001)	(0.000)	(0.000)	(0.000)
Vulnerable x humidity	-0.013	0.000	-0.001	-0.000***	0.136***	0.018***
	(0.032)	(0.293)	(0.008)	(0.000)	(0.003)	(0.000)

Malawi, Women

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.113	0.051	-0.028	-0.097***	0.978***	0.158***
	(0.166)	(2.611)	(0.102)	(0.000)	(0.032)	(0.002)
Max tempertr. Squared	0.016	0.113	0.005	0.004***	0.073***	-0.008***
	(0.010)	(0.171)	(0.007)	(0.000)	(0.002)	(0.000)
Avg precipitation	0.022*	-0.098	-0.003	-0.001***	-0.112***	-0.006***
	(0.013)	(0.094)	(0.003)	(0.000)	(0.001)	(0.000)
Avg precipitat squared	-0.000**	0.000	0.000	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.330***	0.396	0.019	0.043***	0.442***	0.153***
	(0.124)	(1.694)	(0.055)	(0.000)	(0.021)	(0.002)
Relat humidity squared	-0.002**	-0.002	-0.000	-0.000***	-0.001***	-0.001***
	(0.001)	(0.013)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	5.982**	28.344	0.864	0.268***	30.539***	1.787***
	(2.626)	(28.221)	(0.944)	(0.004)	(0.337)	(0.022)
Vulnerable x temperature	-0.157	-0.763	-0.018	-0.065***	-0.813***	0.002**
	(0.114)	(1.038)	(0.035)	(0.000)	(0.012)	(0.001)
Vulnerable x precipitation	0.009	0.058	0.002	-0.000***	0.065***	0.008***
	(0.007)	(0.045)	(0.001)	(0.000)	(0.001)	(0.000)
Vulnerable x humidity	-0.079***	-0.462	-0.016	-0.000***	-0.504***	-0.032***
	(0.030)	(0.343)	(0.011)	(0.000)	(0.004)	(0.000)

Nigeria, Men

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.114	0.116	-0.014	-0.097***	0.024***	0.037***
	(0.095)	(0.788)	(0.030)	(0.000)	(0.003)	(0.000)
Max tempertr. Squared	0.004	-0.032	-0.001	0.004***	-0.014***	-0.001***
	(0.003)	(0.029)	(0.001)	(0.000)	(0.000)	(0.000)
Avg precipitation	-0.001***	0.001	0.000	-0.001***	-0.002***	-0.000***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	0.000**	-0.000	-0.000	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.049***	-0.091	-0.002	0.043***	-0.078***	-0.001***
	(0.010)	(0.087)	(0.003)	(0.000)	(0.000)	(0.000)
Relat humidity squared	-0.000***	0.001	0.000	-0.000***	0.002***	0.000***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	-0.131	-2.411	0.054	0.268***	-1.674***	-0.063***
	(0.695)	(6.019)	(0.198)	(0.004)	(0.025)	(0.001)
Vulnerable x temperature	-0.046	-0.264	-0.012	-0.065***	-0.248***	-0.003***
	(0.036)	(0.303)	(0.010)	(0.000)	(0.001)	(0.000)
Vulnerable x precipitation	0.000**	-0.001	-0.000	-0.000***	-0.001***	-0.000***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable x humidity	0.000	-0.049	-0.003*	-0.000***	-0.028***	-0.001***
	(0.005)	(0.046)	(0.001)	(0.000)	(0.000)	(0.000)

Nigeria, Women

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.184	-1.001	-0.049	-0.097***	0.709***	0.055***
	(0.131)	(1.293)	(0.048)	(0.000)	(0.006)	(0.000)
Max tempertr. Squared	0.008*	0.014	0.001	0.004***	-0.034***	-0.002***
	(0.005)	(0.047)	(0.002)	(0.000)	(0.000)	(0.000)
Avg precipitation	0.000	0.005	0.000	-0.001***	-0.001***	0.000***
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	-0.000	-0.000	-0.000	0.000***	0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.037**	-0.068	0.001	0.043***	-0.160***	-0.002***
	(0.015)	(0.164)	(0.005)	(0.000)	(0.001)	(0.000)
Relat humidity squared	-0.000*	-0.000	-0.000	-0.000***	0.002***	0.000***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	0.241	-10.078	0.175	0.268***	-16.007***	-0.633***
	(0.943)	(9.675)	(0.374)	(0.004)	(0.050)	(0.002)
Vulnerable x temperature	-0.016	-0.351	-0.033*	-0.065***	0.206***	0.017***
	(0.048)	(0.449)	(0.018)	(0.000)	(0.002)	(0.000)
Vulnerable x precipitation	0.000	0.000	-0.000	-0.000***	0.001***	-0.000***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable x humidity	-0.000	0.055	-0.003	-0.000***	0.107***	0.002***
	(0.007)	(0.078)	(0.003)	(0.000)	(0.000)	(0.000)

Tanzania, Men

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.222	-8.816***	-0.327***	0.021***	-9.426***	-0.438***
	(0.845)	(1.132)	(0.045)	(0.001)	(0.010)	(0.000)
Max tempertr. Squared	-0.007	-0.091**	-0.006***	-0.002***	-0.093***	-0.001***
	(0.036)	(0.043)	(0.002)	(0.000)	(0.000)	(0.000)
Avg precipitation	0.001	-0.002	-0.000	0.001***	-0.002***	-0.000***
	(0.002)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	0.000	0.000	0.000	-0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	-0.155	-1.725***	-0.071***	0.030***	-1.860***	-0.071***
	(0.301)	(0.228)	(0.008)	(0.000)	(0.002)	(0.000)
Relat humidity squared	0.001	-0.032***	-0.001***	-0.001***	-0.033***	-0.001***
	(0.004)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	1.109	-16.184**	-0.436*		-15.278***	0.018***
	(2.586)	(7.795)	(0.253)		(0.073)	(0.002)
Vulnerable x temperature	-0.071	0.278	0.007		0.306***	-0.005***
	(0.121)	(0.449)	(0.015)		(0.004)	(0.000)
Vulnerable x precipitation	-0.001	-0.004	-0.000		-0.004***	-0.000***
	(0.000)	(0.003)	(0.000)		(0.000)	(0.000)
Vulnerable x humidity	-0.015	0.168	0.004		0.149***	-0.001***
	(0.042)	(0.119)	(0.004)		(0.001)	(0.000)

Tanzania, Women

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	2.674*	-9.045***	-0.376***	-0.018***	-9.589***	-0.493***
	(1.426)	(1.435)	(0.055)	(0.001)	(0.016)	(0.001)
Max tempertr. Squared	-0.100	-0.010	-0.003	-0.001***	-0.005***	0.003***
	(0.067)	(0.055)	(0.002)	(0.000)	(0.001)	(0.000)
Avg precipitation	-0.007**	-0.009	-0.000**	0.001***	-0.009***	-0.000***
	(0.003)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	0.000**	0.000	0.000	-0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	-1.810**	-0.891**	-0.045***	0.014***	-1.144***	-0.067***
	(0.727)	(0.384)	(0.015)	(0.000)	(0.003)	(0.000)
Relat humidity squared	0.026***	-0.035***	-0.002***	-0.000***	-0.034***	-0.001***
	(0.009)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	-2.613	-10.351	-0.087		-7.154***	0.328***
	(3.743)	(10.686)	(0.341)		(0.104)	(0.004)
Vulnerable x temperature	0.072	-0.182	-0.010		-0.237***	-0.023***
	(0.154)	(0.603)	(0.019)		(0.006)	(0.000)
Vulnerable x precipitation	0.000	-0.001	0.000		-0.001***	0.000***
	(0.001)	(0.003)	(0.000)		(0.000)	(0.000)
Vulnerable x humidity	0.041	0.020	-0.004		-0.022***	-0.007***
	(0.061)	(0.163)	(0.006)		(0.002)	(0.000)

Uganda, Men

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.008	-3.857***	-0.384***	0.026***	-4.548***	-0.138***
	(0.159)	(1.322)	(0.090)	(0.002)	(0.013)	(0.001)
Max tempertr. Squared	0.007	0.271***	0.020***	0.006***	0.299***	0.010***
	(0.007)	(0.067)	(0.005)	(0.000)	(0.001)	(0.000)
Avg precipitation	0.010	0.140***	0.007***	0.005***	0.143***	0.001***
	(0.007)	(0.050)	(0.002)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.135***	5.063***	0.316***	0.084***	5.262***	0.227***
	(0.045)	(0.490)	(0.032)	(0.001)	(0.005)	(0.000)
Relat humidity squared	-0.001**	-0.054***	-0.004***	-0.000***	-0.056***	-0.002***
	(0.001)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	0.509	7.543	0.256	-0.101***	7.743***	1.114***
	(1.965)	(18.802)	(1.121)	(0.026)	(0.175)	(0.008)
Vulnerable x temperature	-0.039	-1.014	-0.018	0.031***	-0.919***	-0.056***
	(0.102)	(0.880)	(0.054)	(0.001)	(0.008)	(0.000)
Vulnerable x precipitation	0.003	-0.018	0.001	-0.003***	-0.018***	0.001***
	(0.004)	(0.035)	(0.001)	(0.000)	(0.000)	(0.000)
Vulnerable x humidity	0.004	-0.081	-0.011	0.010***	-0.100***	-0.011***
	(0.026)	(0.261)	(0.015)	(0.000)	(0.002)	(0.000)

Uganda, Women

	Logit (Employed)	Tobit (Hours)	Neg binomial (Hours)	Logit (Employed), FE	Tobit (Hours), RE	Neg binomial (Hours), FE
Max temperature	-0.040	-3.903***	-0.228***	0.026***	-4.789***	-0.293***
	(0.182)	(1.436)	(0.079)	(0.002)	(0.014)	(0.001)
Max tempertr. Squared	0.004	0.126*	0.007*	0.006***	0.158***	0.014***
	(0.009)	(0.073)	(0.004)	(0.000)	(0.001)	(0.000)
Avg precipitation	0.007	-0.005	0.002	0.005***	-0.009***	-0.001***
	(0.006)	(0.037)	(0.002)	(0.000)	(0.000)	(0.000)
Avg precipitat squared	-0.000	-0.000	-0.000	-0.000***	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relat humidity	0.079	4.010***	0.233***	0.084***	4.225***	0.239***
	(0.054)	(0.497)	(0.030)	(0.001)	(0.005)	(0.000)
Relat humidity squared	-0.001	-0.040***	-0.002***	-0.000***	-0.043***	-0.002***
	(0.001)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)
Vulnerable sector	-0.985	-9.757	-0.272	-0.101***	-8.508***	0.559***
	(2.176)	(19.488)	(1.036)	(0.026)	(0.179)	(0.009)
Vulnerable x temperature	0.091	1.621*	0.076	0.031***	1.513***	0.030***
	(0.112)	(0.909)	(0.048)	(0.001)	(0.008)	(0.000)
Vulnerable x precipitation	-0.004	0.032	0.001	-0.003***	0.033***	0.001***
	(0.003)	(0.021)	(0.001)	(0.000)	(0.000)	(0.000)
Vulnerable x humidity	0.015	-0.217	-0.017	0.010***	-0.245***	-0.017***
	(0.028)	(0.271)	(0.015)	(0.000)	(0.002)	(0.000)

Results summary

In Malawi,

- Extreme heat clearly affects men's labor supply adversely (at a diminishing rate), but has an unclear effect on women.
- Precipitation affects labor supply of both genders negatively, but weakly.
- Relative humidity appears to affect it positively for both genders (at a diminishing rate).
- Sectors *a priori* identified as vulnerable might be affected more adversely – but evidence is not conclusive. There are level and slope differences between genders.

In Nigeria,

- the estimated effects are weaker and less significant or clear.
- There is weak evidence that men in vulnerable sectors are affected worse than in other sectors.

In Tanzania,

- Extreme heat affects both men's and women's labor supply adversely (at a diminishing rate).
- Precipitation affects labor supply of both genders negatively, but very weakly.
- Relative humidity appears to affect it negatively for both genders (at a diminishing rate).
- Sectors *a priori* identified as vulnerable might be affected more adversely – but evidence is not conclusive, particularly for men.

In Uganda,

- Extreme heat affects both men's and women's labor supply adversely (at a diminishing rate).
- Precipitation and humidity appear to affect it positively, especially among men.
- There is weak evidence that men in vulnerable sectors are affected worse than in other sectors.

Policy Implications

- Given that most of the strategically important activities in the region are considered to be “high-risk” with relatively more exposure to extreme weather, our study emphasizes the importance of predicting the relationship between changes in climate conditions and labor supply & productivity.

- This calls for serious attention and immediate action from policy makers towards the pressing issues of climate change since this could ultimately have a negative impact on the regional economies.

Future Work

- Given the currently weak results, we will focus on getting the relationship right. Could the responses be nonlinear or step functions?
- Given the potential effect of COVID-19 lockdowns on labor supply, and potential interactions between weather extremes and COVID-19 eruptions, the nexus between the three will be explored.
- We hope to get extreme weather data at a more granular level, at sub-district or respondent location.
- For completeness, we may supplement this work with analysis of ‘employment status’ in Burkina Faso and Ethiopia.