National Policies and Strategies for Food, Land and Water Systems Transformation

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Climate Change, Income Sources, Crop Mix, and Input Use Decisions: Evidence from Nigeria

Mulubrhan Amare
IFPRI
(With Bedru Balana)

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Motivation

- This study aims to;
  - quantify the **impacts of climate change** on agricultural productivity, income shares, crop mix, and input use decisions.
  - shed light on the **pathways that mediate agricultural productivity**, focusing on farmers' crop mix and input use decisions.
- Using long-term temporal variabilities in precipitation and temperature variables to measure climate change,
- Exploring the nonlinear effects of changes in precipitation and temperature on outcome variables and
- Examining the long-term combined effects of precipitation and temperature on outcome variables of our interest.

Background of the Study

- Climate change poses serious challenges for farming households, affecting their food production, planning capacity, and livelihood outcomes like food security and household income
- Crop mix and input use decisions are important considerations in response to climatic factors among smallholders in SSA
- Climate-related information on the magnitude, timing, and distribution of precipitation and temperature changes can have a significant effect on the farmers' crop mix decisions and their adoption of sustainable agricultural practices

The Nigerian Context

- Adverse climatic changes exacerbate the challenges in the agriculture sector, which is already performing well below its potential.
- In 2011, as a policy response to the effects of climate change, the country produced the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN)
- According to the BNRCC report, in the absence of adaptation measures, climate change could reduce GDP by 6 and 30 percent by 2050.
- Nigerian agriculture is highly vulnerable to changes in climate factors, especially in terms of production losses, income losses, and household food insecurity.

Data Sources and Description

- Combines survey panel data with long-term satellite-based spatial data on temperature and precipitation.
- Restricted the data to farm households that planted croplands and for which data on temperature and precipitation at the household level are available.
- Balanced panel of **2129 farm households** for three waves of panel data and a **total of 6387 samples** in all three waves
- The temperature data was extracted from NASA MERRA-2 (Modern-Era Retrospective Analysis for Research and Application)
- Monthly precipitation data over a 30-year period at a spatial resolution of 0.05° x 0.05° (~ 5 km x 5 km) was extracted from the Climate Hazards 276 Group InfraRed Precipitation Station (CHIRPS) archives.
- Satellite-based long-term precipitation data was used instead of gauge measurements

Definition of Climate Change Variables

- Climate changes – using crop calendar
- Growing degree days (GDD): calculated using the cumulative exposure to temperatures between a lower bound (the standard base temperature of 8°C) up to an upper threshold of 32°C. We converted daily temperatures into growing degree days (GDD) using the following formula:

$$GDD = \begin{cases} 0 & if \quad T \leq 8C \\ T - 8 & if \quad 8C < T \leq 32C \\ 24 & if \quad T > 32C \end{cases}$$

- Focused on the deviation of temperature from the norm

$$\Delta \mathrm{GDD}_{it} = \ln(\mathrm{GDD}_{it}) - \ln(\overline{\mathrm{GDD}}_i)$$

- Degree days defined above 32°C (GDD>32) as harmful degree days (HDD).

$$\Delta \mathrm{HDD}_{it} = \ln(\mathrm{HDD}_{it}) - \ln(\overline{\mathrm{HDD}}_i)$$

- Precipitation fluctuations: the deviation of a given year's precipitation during the growing season from the historical averages

$$\Delta \mathrm{R}_{it} = \ln(\mathrm{R}_{it}) - \ln(\overline{\mathrm{R}}_i)$$

Definition of outcome variables

- Agricultural productivity (real net crop income per hectare)
- Crop mix (the share of area planted in major crops to total land area cultivated)
- Income share: (1) crop income; (2) income from livestock; (3) nonfarm self-employment; (4) wages; (5) and other sources)
- Input use (fertilizer, purchased seeds, and pesticides used in production)

Methodology: Estimation Strategy

- Estimate the effect of farmers' crop mix decisions and income share from different sources using :

$$SL_{itk} = \gamma_1 \Delta GDD_{it} + \gamma_2 \Delta HDD_{it} + \gamma_3 \Delta R_{it} + \gamma_4 \Delta R_{it}^{\ 2} + \gamma_5 X_{it} + \eta_{it} + \mu_i + \varepsilon_{itk}$$

- Factors affecting the intensity of a specific crop area planted could also affect the intensity of an area planted with other crop types, as well as cross-equation error terms. Thus, a seemingly unrelated regression (SUR) model is used
- Investigated the effect of climate changes on input use using:

$$Z_{it} = \underline{\beta}_1 \Delta GDD_{it} + \beta_2 \Delta HDD_{it} + \beta_3 \Delta RD_{it} + \beta_4 \Delta RD_{it}^{\ 2} + \beta_5 X_{it} + \eta_{it} + \mu_i + \varepsilon_{it}$$

- Input use, such as area planted, fertilizer application, purchased seed, and pesticide use

Results and Discussions

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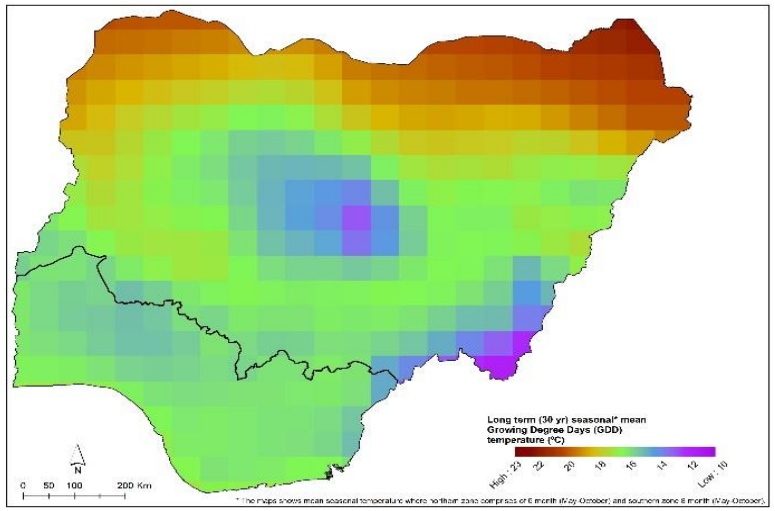
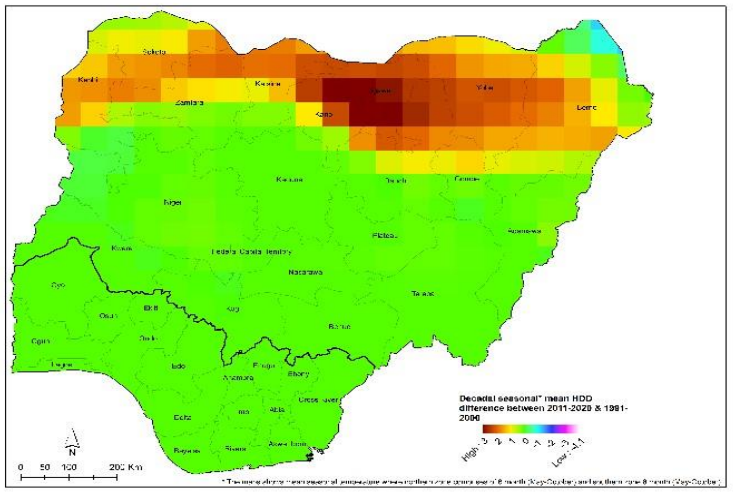
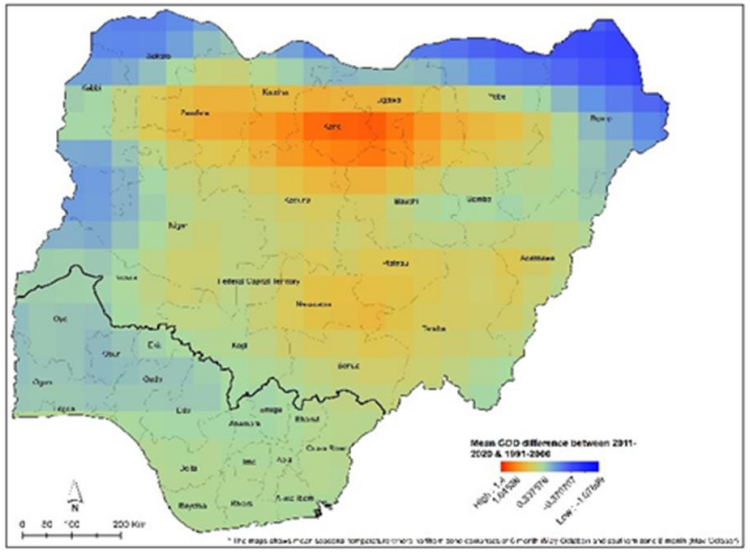
- Spatial Distribution of GDDS and HDDS

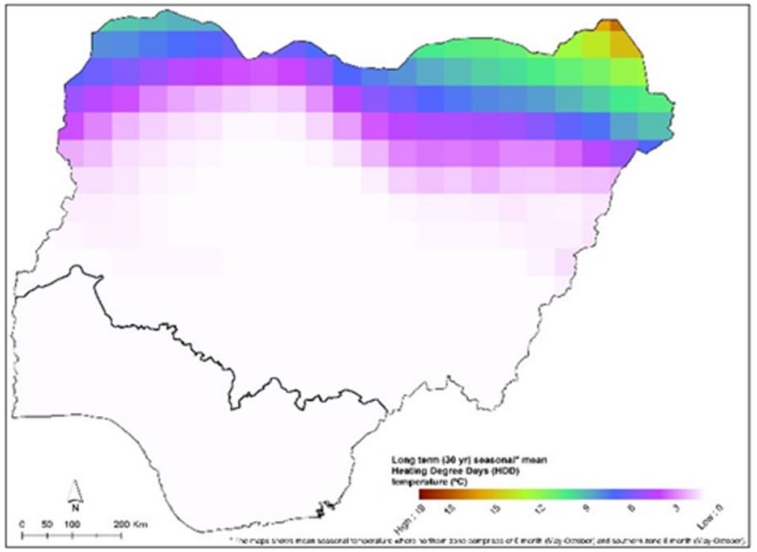
- The distributions of differences in GDDs and HDDs over time

- The north–south differences in GDDs and HDDs in the country. Over the period of three decades (1985–2016), **northern Nigeria generally experienced significant climatic fluctuations**









Results and Discussions

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Summary statistics

Variable	Mean	Std. Dev.
Agricultural productivity and input use		
Agricultural productivity (Output per ha $US PPP)	3425.95	4756.65
Area planted (ha)	0.91	1.27
Fertilizer use (yes=1)	0.45	0.50
Purchased seed (yes=1)	0.32	0.47
Purchased pesticide (yes=1)	0.43	0.50
Income share		
Income shares of crop (%)	57.09	38.88
Income shares of livestock (%)	4.10	14.19
Income shares of self-employment (%)	26.91	34.37
Income shares of wage employment (%)	6.70	21.35
Other sources of income (%)	5.20	-8.79
Crop mix		
Area shares of cereals	36.03	41.48
Area shares of legumes	12.10	20.94
Area shares of tubers	32.79	42.27
Area shares of trees	4.75	12.42
Other crops	14.33	17.12

Results and Discussions

Effect of Climate Changes on Agricultural Productivity

	Agricultural Productivity	
	(1)	(2)
ΔHDD	-0.391***	-0.348***
	(0.092)	(0.088)
ΔGDD	6.196***	6.360***
	(1.421)	(1.434)
ΔP	-0.087***	-0.082***
	(0.002)	(0.003)
ΔP sqr	-2.120	-2.273
	(1.582)	(1.601)
Controls	No	Yes
HH FEs	Yes	Yes
Year FEs	Yes	Yes
N	6387	6387

- **15%** (one standard deviation) **increase** in change in harmful degree days leads to a **decrease** in agricultural productivity by **5.22%** on average
- This may indicate that, within the context of this study, **temperature variability** plays a stronger role in influencing **agricultural production and productivity**.

Results and Discussions

The Effect of Climate Changes on Income Sources

	Income share from crops		Income share from livestock		Income share from self-employment		Income share from wage employment	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ΔHDD	-2.033*	-3.437**	1.506**	1.248**	-0.346	-0.536	2.034**	1.901**
	(1.451)	(1.426)	(0.589)	(0.582)	(1.398)	(1.433)	(0.812)	(0.836)
ΔGDD	55.671***	-53.545***	4.580	6.705***	-21.690**	-28.419***	21.315***	24.539**
	(11.984)	(13.295)	(2.680)	(2.133)	(8.019)	(9.353)	(5.527)	(11.794)
ΔP	11.306*	-20.458***	4.618*	6.434**	3.832*	4.134**	4.326	1.889
	(6.785)	(6.606)	(2.531)	(2.541)	(2.105)	(2.153)	(3.085)	(3.187)
ΔP sqr	-17.640	-22.524***	13.716**	12.327**	33.861**	30.206**	9.004	7.172
	(8.185)	(7.143)	(5.035)	(5.597)	(14.814)	(14.204)	(6.304)	(6.011)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
HH FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6387	6387	6387	6387	6387	6387	6387	6387

- ΔHDD
  - **decreases** the income share from crops and nonfarm self-employment
  - **increases** the income share from livestock and non-agricultural wage income

Results and Discussions

Effect of Climate Changes on Farmers' Crop Mix Decisions

	Area shares of cereals		Area shares of legumes		Area shares of Tubers		Area shares of trees	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔHDD	-21.211***	-7.715***	5.356***	2.179**	3.345**	2.432**	-1.897***	-1.914***
	(1.957)	(1.655)	(0.879)	(0.886)	(1.318)	(1.144)	(0.488)	(0.512)
ΔGDD	15.405	230.757***	-80.570***	-133.391***	119.660***	93.839***	91.836***	83.763***
	(25.593)	(24.101)	(11.379)	(12.938)	(20.851)	(22.225)	(6.335)	(7.571)
ΔP	-86.464***	-109.713***	-29.328***	-35.591***	154.717***	120.602***	19.917***	18.610***
	(7.623)	(7.085)	(3.753)	(3.827)	(6.351)	(6.295)	(2.200)	(2.279)
ΔP sqr	-87.479***	-35.054	-12.229	-16.446	241.783***	119.077***	42.235***	37.197***
	(32.844)	(32.238)	(16.329)	(17.443)	(27.476)	(28.311)	(9.591)	(10.418)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
HH FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6387	6387	6387	6387	6387	6387	6387	6387

- Farmers respond to extreme heat by making **changes in crop choices**, switching from cereals and tree crops to legumes and tubers.
- Precipitation change **decreases** the land share of **cereals and legumes**, while it **increases** the land share of **tubers and tree crops**.

Results and Discussions

The Effect of Climate Changes on Input Use Decisions

	Area planted		Fertilizer use		Purchased seed		Pesticide Use	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔHDD	0.096***	0.078***	-0.050**	-0.021**	-0.135***	-0.122***	0.104***	0.087**
	(0.033)	(0.030)	(0.021)	(0.010)	(0.031)	(0.024)	(0.036)	(0.036)
ΔGDD	-2.710***	-2.154***	-3.543***	-2.514***	0.640	0.591**	-2.758***	-2.278***
	(0.468)	(0.480)	(0.575)	(0.542)	(0.517)	(0.299)	(0.508)	(0.496)
ΔP	-0.515***	-0.408***	-0.778***	-0.604***	0.184*	0.174**	-0.360**	-0.275**
	(0.136)	(0.137)	(0.158)	(0.151)	(0.101)	(0.083)	(0.142)	(0.138)
ΔP sqr	-1.140**	-1.012**	-1.104*	-0.961	0.279	0.250	-0.585	-0.531
	(0.512)	(0.513)	(0.630)	(0.621)	(0.555)	(0.384)	(0.673)	(0.645)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
HH FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

- **Positive** and statistically significant effect of HDD on area planted
- Change in HDD has a **negative** and significant effect on fertilizer use.

Results and Discussions

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The Effect of Climate Changes on Agricultural Productivity by Wealth Indicators

	Asset poor	Asset non-poor	TLU poor	TLU non-poor
ΔHDD	-0.358***	-0.281***	-0.202	-0.358***
	(0.110)	(0.105)	(0.145)	(0.093)
ΔGDD	6.591***	6.105***	8.784***	5.823***
	(2.035)	(1.656)	(2.147)	(1.528)
ΔP	-0.434**	-0.213	-0.397**	-0.340**
	(0.213)	(0.434)	(0.201)	(0.179)
ΔP sqr	-3.621	-1.151	-4.886*	0.069
	(2.752)	(1.654)	(2.496)	(1.859)
Controls	Yes	Yes	Yes	Yes
HH FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
N	2129	4258	2129	4258

- ΔHDD and precipitation has a **negative** effect on agricultural productivity for both poor and non-poor households, but it has a stronger impact for the poor households.

Conclusions

- Climatic factors have negative impacts on agricultural productivity
- Changes in crop mix and agricultural input use are potential adaptation methods in response to climatic factors.
- The income shares from livestock and nonfarm activities increase with increases in climate shocks
- Climate change has heterogeneous effects on poor compared with relatively non-poor households, measured in terms of differences in endowments of productive assets and livestock holdings

Implications

- Targeted interventions that promote climate-resilient agricultural practices
- Policy interventions that enhance access to agricultural inputs are warranted in order to ensure crop diversification is a viable coping strategy for climate anomalies
- Development of the livestock sector and micro/small enterprises as a potential strategy for mitigating the impacts of climate change on farming communities.
- Pro-poor interventions to reduce the inequality of access to livelihood capital such as land and other productive assets.

Thank You!

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