Effects of Weather on Maize Yield in Kenya

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Outline

Introduction

Data

Methods

My Suggestion

Introduction

- SSRP project, related to ForPAc project
- Extreme weather → disasters (maybe name some years of drought in Kenya??)
    - Early warning systems have been developed
- Goals: Improve early warning systems in Kenya
- Shifting the disaster management from reactive to protective
- Two predominant rainfall regimes in Kenya:
    1. Arid and semi-arid (ASAL): bi-modal
        - Short rains: March to May
        - Long rains: October to December
    2. non-ASAL: uni-modal
        - March to August
- Perhaps a map of ASAL and non-ASAL

Approach

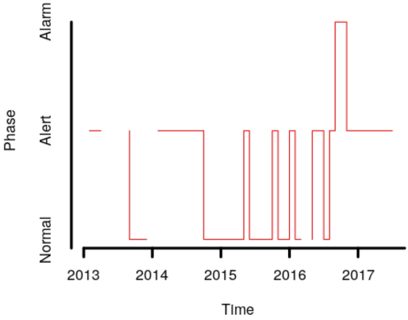
- Various approaches considered including:
  - Relating NDMA Early warning phase classification to weather
  - Relating markets and food prices to weather
  - Relating maize yields to weather to weather
  - Computable general equilibrium (CGE) models

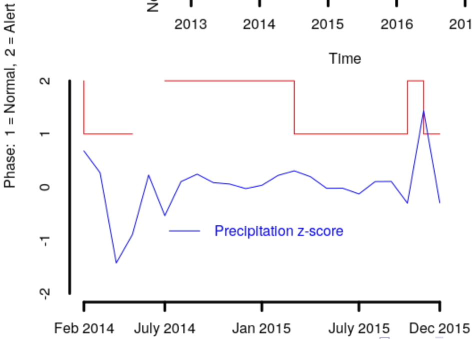
NDMA Early Warning Phase Classification

Example: Kitui county

Normal* → *Alert* → *Alarm

- Bulletins for ASAL counties
- Online since 2013
  - But in pdf format
- For county and month





Approach

- Narrowing the research question:
  - Relationship of maize yield and weather in Kenya
    - What is it about weather that causes drought related disasters?
    - Which particular characteristics of weather are the most 'responsible' for drought related disasters?

Sample:

- Panel of 47 counties of Kenya, 1981 – 2017

Data

- Maize yields
  - source: Famine Early Warning Systems Network (FEWS NET)
  - County level, yearly, tonnes per hectare
- Weather:
  - Daily, 0.25° resolution gridded data
  - Precipitation
    - source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
  - Temperature
    - source: Berkeley Earth
  - Aggregation needed to conform with the yield data

$$\begin{array}{lcl} 0.25^\circ \text{ grid} & \rightarrow & \text{county level} \\ \text{daily} & \rightarrow & \text{yearly} \end{array}$$

add how averaged over seasons ASAL and non ASAL

Precipitation and temperature measures

- Measures typically considered:
    - Total precipitation over rainy seasons
    - Average temperature during rainy seasons
- Less commonly used measures considered:
    - Maximum daily precipitation (floods)
    - Maximum daily temperature
    - Coefficients of variation: precipitation and temperature
    - Maximum length of dry spell during rainy seasons
    - Number of dry spells during rainy seasons
    - Number of heatwave days
    - Cumulative precipitation on days when precip. $> 90th$ percentile

Linear mixed effects models

- Panel: County $\times$ Year
- Slopes allowed to vary over counties

$$
\begin{aligned}
log(y_{1t}) &= \sum_{m=1}^{p} \beta^m x_{1t}^m + \sum_{n=1}^{q} b_1^n z_{1t}^n + \epsilon_{1t} \\
log(y_{2t}) &= \sum_{m=1}^{p} \beta^m x_{2t}^m + \qquad \sum_{n=1}^{q} b_2^n z_{2t}^n + \epsilon_{2t} \\
&\vdots \\
log(y_{47t}) &= \sum_{m=1}^{p} \beta^m x_{47t}^m + \qquad\qquad \sum_{n=1}^{q} b_{47}^n z_{47t}^n + \epsilon_{47t}
\end{aligned}
$$

y_{it} = Maize yield t/hectares, county i in year t

β = Vector of effects of other covariates

$X_{i,t}$ = Matrix of values of other covariates in county i in year t

$\epsilon_{i,t}$ = Error term

Linear mixed effects models

- Panel: County $\times$ Year
- Slopes allowed to vary over counties

$$log(y_{it}) = \sum_{m=1}^{p} \beta^m x_{it}^m + \sum_{n=1}^{q} b_i^n z_{it}^n + \epsilon_{it} \qquad i = 1, ..., 47 \quad \text{counties}$$

y_{it}	$=$	Maize yield t/hectares, county i in year t
α_i	$=$	Fixed effects), county i
δ	$=$	Effect of drought on economy
$X_{i,t}$	$=$	Matrix of values of other covariates in county i in year t
$\epsilon_{i,t}$	$=$	Error term

ideas

- Plot of dependency of precip or some measure and yields..
- Maybe also general description of the mixed effects models as I have in the draft
- Look at the document on google docs 'Yield and climate' to see if I can use something

Effects of droughts on economy

Computable General Equilibrium (CGE)

- ?
  - 5 agro-ecological zones,46 production activities (incl. 35 zone specific agricultural production sectors), 22 commodity groups, 15 primary factors of production

Fixed (inputs)	Determined by model (outputs)
Capital stock	Domestic price of each commodity
Land (by region)	Land allocated across crops
Supply of labor per skill type	Real wages
Foreign capital inflow	Real exchange rate
Trade balance	

- The simulation use a 'balanced' macro closure in which aggregate **investment, government demand, and consumption are fixed shares of total absorption**
- Intermediate inputs into production are determined as fixed shares of the quantity of output

Effects of droughts on economy

Computable General Equilibrium (CGE) Models

- **?**
  - Exploring range of scenarios for food price increase in 2030
    - 1. Baseline 2. Climate change 3. Climate change with adaptation 4. Adaptation only in sub-Saharan Africa
  - Global coverage, set of individual country models, linked through international trade
  - Climate change (incl. drought) modelled as changes in factor productivity (usually negative)

My suggestion - panel estimation

My interest: **Effects of drought on economy in Kenya**

- **Response variable**
  - Volumes of production (crop specific, total)
  - Profit per acre (**?**)
    - (Value of agricultural products - prod. expanses)/acres (crops, pasture, grazing)
- **Units of analysis**
  - Counties in Kenya $\times$ year
- **Explanatory variable of interest**
  - Dummy variable (0/1) drought occurred in a particular county and year or not
  - Several varieties - various specifications of drought:

My idea - panel estimation

$$Y_{i,t} = \alpha_i + \gamma_t + \delta D'_{i,t} + \beta \boldsymbol{X_{i,t}} + \epsilon_{i,t}$$

$$\begin{aligned}
Y_{i,t} &= \text{Response variable (food production/price), county } i \text{ in year } t \\
\alpha_i &= \text{Fixed effects, county } i \\
\delta &= \text{Effect of drought on economy} \\
D_{i,t} &= \text{Indicator variable} \\
&\quad\; D = 1 \text{ if drought in county } i \text{ in year } t,\ D = 0 \text{ otherwise} \\
\beta &= \text{Vector of effects of other covariates} \\
X_{i,t} &= \text{Matrix of values of other covariates in county } i \text{ in year } t \\
\epsilon_{i,t} &= \text{Error term} \\
\gamma_t &= \text{Year specific indicator?}
\end{aligned}$$

Thank you for attention

Precipitation and temperature measures considered I

- Total precipitation over the rainy season
- Coefficient of variation of the precipitation during the rainy season
- Maximum length of dry spell during the rainy season (in number of days)
- Number of dry spells during the rainy season: a dry spell defined as 4 consecutive days without rain or more[1]
- Number of dry spells during the rainy season: a dry spell defined as 10 consecutive days without rain or more[1]
- Number of dry spells during the rainy season: a dry spell defined as 20 consecutive days without rain or more[1]

[1] Threshold for a dry day was considered 1mm.

Precipitation and temperature measures considered I

- Average temperature during the rainy season
- Standard deviation of temperature during the rainy season
- Cumulative degree days during the rainy season (excluding the days when maximum temperature above 30°C or below 10°C
- Number of heatwave days during the rainy season when max. temperature $> 35°$C
- Maximum daily precipitation - to control for possible floods
- Sum of precipitation amount on days where precipitation is above 90^{th} percentile of precip. of the whole period[2]
- Sum of precipitation amount on days where precipitation is above 95^{th} percentile of precip. of the whole period[3]

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[2] 90^{th} percentile was calculated for the subsample of wet days, that is the days where precipitation is above or equal to 1mm.

[3] 95^{th} percentile was calculated for the subsample of wet days, that is the days where precipitation is above or equal to 1mm.

Precipitation and temperature measures considered I

- Sum of precipitation amount on days where precipitation is above 99^{th} percentile of precip. of the whole period[4]
- Number of days where precipitation is above 90^{th} percentile of precip. of the whole period[2]
- Number of days where precipitation is above 95^{th} percentile of precip. of the whole period[3]
- Number of days where precipitation is above 99^{th} percentile of precip. of the whole period[4]

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[2] 90^{th} percentile was calculated for the subsample of wet days, that is the days where precipitation is above or equal to 1mm.

[3] 95^{th} percentile was calculated for the subsample of wet days, that is the days where precipitation is above or equal to 1mm.

[4] 99^{th} percentile was calculated for the subsample of wet days, that is the days where precipitation is above or equal to 1mm.