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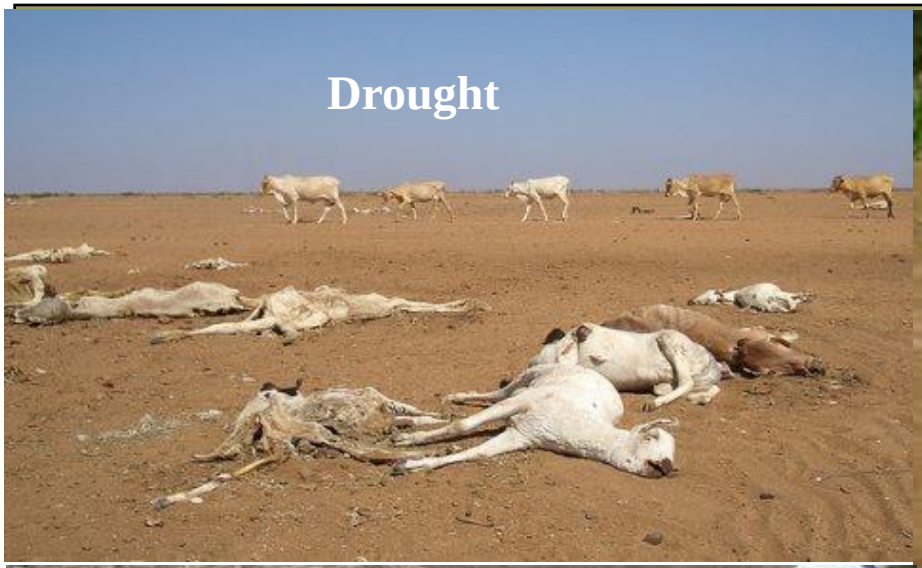
TEGEMEO INSTITUTE OF AGRICULTURAL POLICY AND DEVELOPMENT

Effects of climate variability and change on agricultural production and household welfare in Kenya


Drought


Flooded rural villages-loss of livelihood


Stressed water resources


Deforestation


Land degradation
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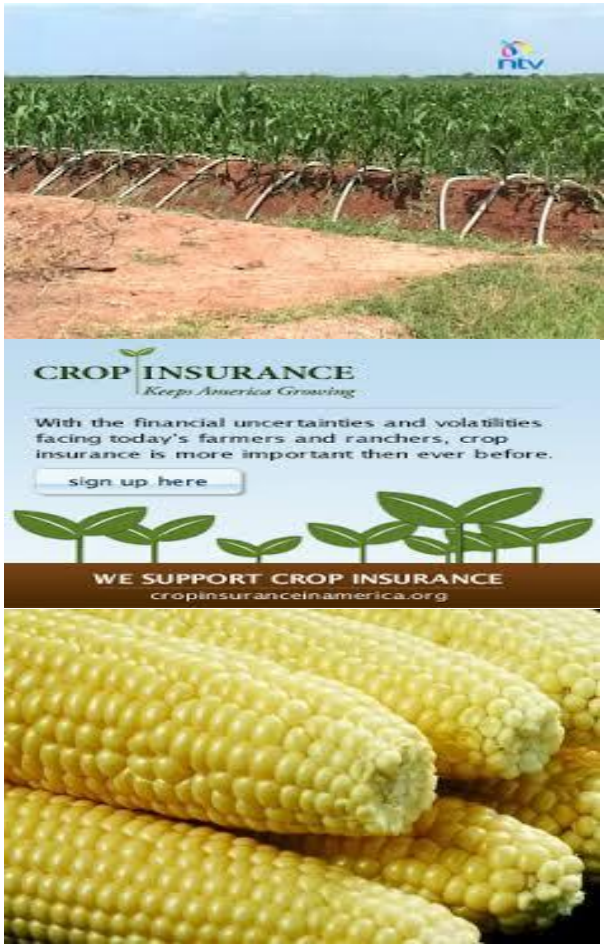
Recognised in SDGs

- Hinder achievement:
  - Zero hunger and food security
  - No poverty
  - Protecting and restoring ecosystems
- Building resilience and adaptation capacity is emphasized.
- Smallholder livelihoods:
  - Farm yields
  - Input use

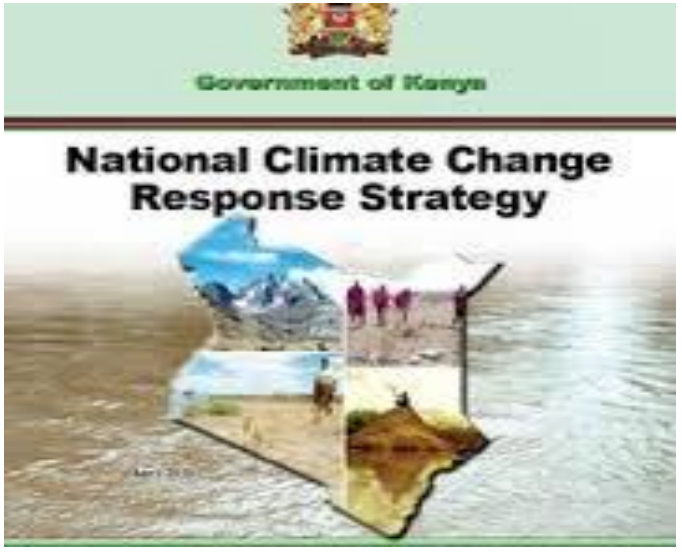
Strategies

- **Drought resistant varieties**
- **Irrigation and water harvesting**
- **Crop insurance**
- **Early warning and monitoring systems for DRR**
- Construction of dykes
- Human migration
- Changing planting dates
- Diversifying in and out of agriculture
- Reliance on safety nets and social networks
- Social protection, etc.



Government response

- National Climate Change Response Strategy (2010)
- Climate Change Action Plan (2013-2017).
- Galana Kulalu Irrigation scheme
- Climate Smart Agriculture(CSA) program, 2015



Objectives

- To establish the effect of climate variability and change on agricultural production and household welfare in Kenya
  - What is the effect of climatic variability and change on agricultural production? *J. Ochieng, L. Kirimi, M. Mathenge*
  - What is the effect of various weather shocks on household welfare in rural Kenya? *A. Wineman, J. Ochieng, N. M. Mason, and L. Kirimi*

Outline:

Each paper is organized as follows:

- Research questions
- Data
- Results
- Conclusions
- Policy recommendations

Effect of climatic variability and change on agricultural production

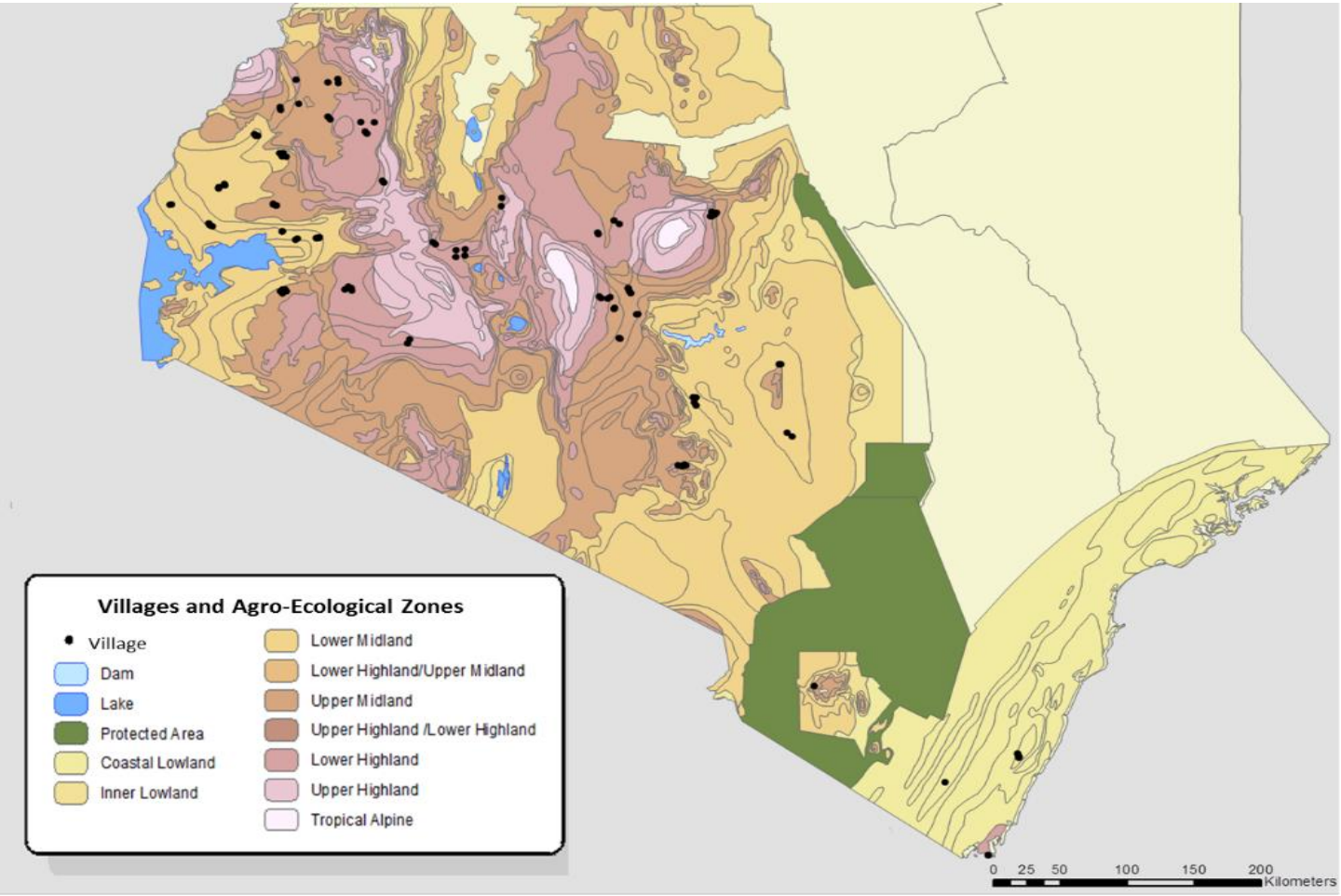
- Research questions:
  - What is the effect of climate variability and change on smallholder crop production?
  - What is the effect of future changes in climate on smallholder crop production (by 2020, 2030, 2040)?

- Results are disaggregated:
  - All crops
  - Maize
  - Tea

Data

- Four waves of the Tegemeo Agricultural Policy Research and Analysis (TAPRA) Rural Household survey, 2000-2010.
- Balanced panel of 1,243 households.
- Rainfall and temperature for the data collection year from Kenya Meteorological Services (KMS)-5-day period
- Rainfall and temperature for 30 years (1980-2010) from KMS.

TAPRA survey villages



Variables used

Climate data	Agricultural Production Variables
Short term (Data collection year-2000-2010)	
Rainfall (Mean Monthly –Total yearly/12 - mm)	Crop income (gross income in Ksh at nominal prices)
Mean temperature (in degrees Celsius)	Maize income (gross income in Ksh)
Long term (moving average for 1980-2010)	Tea income (gross income in Ksh)
Long term Rainfall (in mm)	Other socio-economic variables (age, assets, off-farm incomes etc.) included as controls
Long term Temperature (degrees Celsius)	
Notes: Crop income include incomes from all the crops grown by smallholders	

- Production function: estimated by household fixed effect model

Predicting effect of climate change

- Simulations based on elasticities.
- Average elasticities of climate variables on crop, maize and tea revenues are evaluated at mean
- Predicted climate change values compared with 1980-2010 base average
- All other factors are held constant.

Results

Variables	Crop revenue	Tea Revenue	Maize revenue
Rainfall	0.007***	-0.0223***	0.0043***
Long term rainfall	0.033	-0.1277	0.0905
Mean temperatures	-0.5740***	1.0372**	0.0411
Long term mean temperature	-8.2395***	8.8997*	-9.800***
Rainfall*temperature	-0.0055	0.0008	-0.0060
Household FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Notes: *** p<0.01, ** p<0.05, * p<0.1			

Predicting effect of climate change by 2020, 2030 and 2040

- Projections from KMS data indicate that annual rainfall will increase by 11.2%, 26.3% and 29.8% in 2020, 2030 and 2040, respectively (KMS data).

- Temperature is likely to increase by 1°C in 2020 & 2°C & 2.5°C in 2030 and 2040, respectively (CIAT, 2011, Belloumi, 2014).

Predicted effect of climate change on agricultural production

Year	Increase level (%/ °C)	Climate variable	Rainfall and temperature increase effect (in %) Crop revenue	Maize revenue	Tea revenue
2020	11%	Rainfall	0.8	0.6	-2.5
	1°C	Temperature	-14.2	1.1	2.3
2030	26%	Rainfall	0.9	1.2	-5.5
	2°C	Temperature	-14.8	2.2	2.4
2040	30%	Rainfall	1.0	1.9	-8.8
	2.5°C	Temperature	-15.2	3.3	2.5

Net Effect by 2040 in % (increase in rainfall and temperature by 30% and 2.5^{0}C respectively)

Crop income	Maize income	Tea income
-14.2	**+5.2**	**-6.4**

Conclusions

- Climate change has the potential to significantly affect small-scale farmers' livelihoods.
- Temperature has a negative effect on crop and maize revenues, but a positive one on tea, while rainfall has a negative effect on tea incomes.
- Tea production is very sensitive to stable rainfall and temperature, and any excess would negatively affect production patterns.
- Compared with today, the future effect of climate change show that agriculture will be adversely affected by 2020, 2030 and 2040, but much effect will be felt in the Kenyan tea sector.

Conclusions

- Rise in temperatures significantly reduces agricultural incomes (up to 15% if temperature rises by 2.5°C in 2040).
- A 30% increase in rainfall by 2040 would increase crop incomes including maize income by 1-2%, and reduce those from tea by 9%.
- Temperature effect on crop production is much higher than rainfall, confirming past findings in Kenya (Kabubo-Mariara and Karanja, 2007).

Policy recommendations

- Rethinking about the likely harmful effect of climate change and integrate it into agriculture and environment policy formulation processes in Kenya.

- Consolidate and implementing policies particularly those focusing on climate change to prevent destruction of natural environment and enhance uptake of strategies such as crop and livestock insurance.

- Crop production will be adversely affected if nothing is done. Need to investment in adaptation strategies at national, county and at farm level especially in tea growing regions to build farmers' resilience

“Climate change brings not only bad news but also a lot of potential. The winners will be those who are prepared for change and know how to adapt.”- CIAT 2011

Thank you

Let it rain:

Weather extremes and household welfare in rural Kenya

Ayala Wineman[1], Justus Ochieng[2], Nicole M. Mason[1], and Lilian Kirimi[2]

[1]Department of Agricultural, Food, and Resource Economics, Michigan State University;
[2]Tegemeo Institute of Agricultural Policy and Development, Egerton University

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Research questions:

1. What are the impacts of various weather shocks on household welfare in rural Kenya?
2. Do the impacts differ across the population?
3. Through which channels do weather shocks affect household welfare?
4. Which characteristics help to offset the negative effects of low rainfall?

Data:

- 3 waves of the Tegemeo Agricultural Policy Research and Analysis (TAPRA) Rural Household survey, 2000-2007
- **Historical rainfall data** (5-day periods; 5 km^2 resolution)
- **Historical temperature and wind speed data** (daily; 50 km^2 resolution)

Key variables:

WELFARE

- Net household (HH) **income** per adult equivalent per day
- HH is **poor**
- Poverty gap
- Poverty severity
- **Calories available** per adult equivalent per day
- HH is 'energy deficient'

EXTREME WEATHER

(*main growing season*)

- **High rainfall**: Cumulative millimeter pentads above 75 mm
- **Low rainfall**: Cumulative millimeter pentads below 15 mm
- **Heat**: Cumulative degree days above 32 °C (daytime)
- **High winds**: Cumulative wind speed days above 5 m/s

Methods:

- Household fixed effects regressions
- Fluctuations in observed weather = exogenous
- 1,264 households, 3 panel waves (2003/04, 06/07, 09/10)

Results (Effects of weather shocks):

	Income per day	HH is poor	Calories per day
High rainfall	-6.5	+0.02	**+260.8**
Low rainfall	**-25.6**	**+0.08**	-208.1
Heat	+1.7	**-0.03**	+100.0
Wind	+9.7	-0.02	-6.0

Coefficients from household fixed effects regressions
Green = statistically significant at 10% level or lower

Results (mechanisms of weather shock impacts):

Income per day

	Crop production	Livestock	Off-farm
High rainfall	-7.5	+0.6	+0.4
Low rainfall	**-17.3**	+1.4	-9.7
Heat	+1.2	+0.9	-0.4
Wind	**+9.6**	+1.4	-1.3

Calories per day

	Field crops	Vegetables / fruits	Livestock products	Purchased
High rainfall	+155.6	**+95.2**	+20.0	-22.3
Low rainfall	**-507.0**	-13.1	**-48.1**	**+362.7**
Heat	+3.2	**+98.5**	+6.8	-5.3
Wind	**+276.6**	**-95.1**	-1.0	**24**

Green = statistically significant

Results (by agro-ecological region):

	Income per day	Calories per day
High rainfall	-4.3	**+259.1**
Low rainfall	**-29.1**	-323.1
Heat	+2.1	**+157.9**
Wind	+0.1	**+617.6**
Highlands * High rainfall	**-88.5**	+153.0
Highlands * Low rainfall	+46.7	+558.7
Lowlands * High rainfall	**+60.1**	+1,167.8
Lowlands * Low rainfall	+59.3	+2,610.0
Lowlands * Heat	+0.1	-246.0
Lowlands * Wind	-9.4	**-1,868.2**

Green = statistically significant

Results (mitigating factors):

	Dependent variable = income per day (transformed)	
High rainfall	-0.05	+0.01
Low rainfall	**-0.48**	-0.06
Heat	**+0.05**	**+0.15**
Wind	+0.07	-0.40
Credit availability (lagged)	-0.43	
Credit * Low rainfall	**0.39**	
HH belongs to savings group		**-0.38**
Savings group * Low rainfall		**+0.23**

Green = statistically significant

Conclusions & policy implications:

- Periods of rainfall deficit ↓ income but not calorie availability.

  → Households are (to some extent) able to **smooth consumption with a 'pivot' to the food market**.

- Low rainfall ↓ income from both on- and off-farm sources, particularly in the midlands.

  → **The non-farm economy does not serve as a 'perfect' safety net** for income.

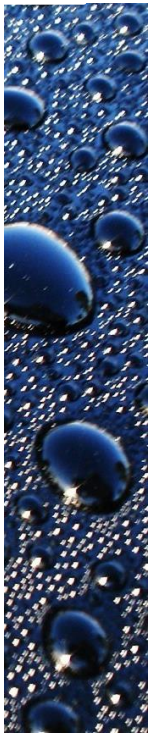
- The effect of each type of weather shock **differs by agro-ecological region**.
  - High rainfall ↓ income in the highlands, and high winds ↓ calorie availability in the lowlands.

Conclusions & policy implications (cont'd):

- Among the factors that offset the negative effects of low rainfall on income, **access to financial services is an important coping mechanism**.

  → Credit provision and savings devices have great potential to improve household resilience to weather shocks.

- An analysis of the welfare effects of weather shocks benefits from a **comprehensive approach**:
  - Different types of weather shocks,
  - Multiple aspects of welfare, and
  - a consideration of heterogeneity in the population.



Thanks!