The Impact of Climate Change on Smallholder Food Production in the Tropics

Paul Wagstaff, Senior Agriculture Advisor, Self Help Africa
Self Help Africa

- International development organisation dedicated to the vision of an economically thriving and resilient rural Africa.
- Offices in Dublin, Belfast, London, Shrewsbury, New York
- Currently working in Burkina Faso, Ethiopia, Eritrea, Kenya, Malawi, Togo, Uganda and Zambia.
- Part of the Gorta Group: Self Help Africa, TruTrade, Partner Africa
Rainy Seasons in the Tropics
The Sahel: Climate Change or cycles of rainfall variability?

Rainfall data from Darfur.
There appears to be cycles of rainfall variability
Temperature effects on crop production

Maize
Reduced availability of water for crops

Maize

Agro-ecological zone and temperature regime (medium = 15 °C - 25 °C; high = > 25 °C)

- Semi-arid, high temperatures
- Sub-humid, high temperatures
- Semi-arid, medium temperatures
- Humid, high temperatures / Sub-humid, medium temperatures
- Humid, medium temperatures

Water requirements:

- Initial (15-25 days): 1.17 - 1.56
- Crop development (25-40 days): 1.95 - 2.34
- Mid-season (20-40 days): 2.07 - 2.76
- Late season (20-35 days): 3.45 - 4.14
- Ripening (10 days): 4.15 - 4.98

mm/day
Growing Period, Magburaka, Sierra Leone

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Reduction in soil fertility

- Increase in temperature will reduce soil moisture.
- Increase the rate of decomposition of organic material and oxidation of nutrients. Negative feedback loop.
- Reduce the numbers of beneficial soil organisms.
Increased incidence of disease & pest attacks

- Increase in temperature linked to proliferation of pests: faster metabolism + reproduction. Fall Armyworm 1-2 month life cycle.
- Increased rainfall will favour fungal disease
- Changes to vector behaviour: aphids, white fly.
**Impacts on Livestock Production**

**Heat stress**: balance between heat dissipation and heat production.

Most livestock species thrive at “comfort zones” between 10 and 30° C. (25 °C for Friesian-Holsteins).

Above 30 ° animals reduce their feed intake by 3 to 5% for each degree of temperature rise.

There are important differences in how different livestock breeds respond to increased temperatures.

Traditional cattle breeds crossed with Friesian Holsteins. Increase in milk production but the cross-bred animals need large quantities of water and are vulnerable to heat stress.
Impacts on Fodder Production

- Changes in quantity and quality of feed and fodder, species composition of grasslands and digestibility and nutritional quality of forage.

- Elevated carbon dioxide levels, combined with increases in temperature, precipitation and nitrogen deposition, will result in increased primary productivity in pastures, with changes in species distribution and litter composition.
Distribution of vector-borne livestock diseases.

- These changes occur as a result of shifts in the geographical ranges of ticks, mosquitoes, flies, ...
- **Ticks**: East Coast Fever/ corridor disease (*Theileria parva*), babesiosis (redwater), anaplasmosis (rickettsia bacteria)
- **Mosquitoes**: Rift Valley Fever (virus).
- **Tsetse Fly**: trypanosomiasis (protozoa).
- **Gastrointestinal nematodes (GINs)** in goats (Test and Selective Treatment, QUB).
- **African Swine Fever** in Europe. More juvenile boar surviving mild winters in Europe, boar populations soaring.
Climate Change: increases in productivity

- Higher concentrations of atmospheric CO$_2$ will benefit many crops (CO$_2$ fertilisation).
- Potatoes: increased CO$_2$ increases the number and weight of tubers.
- Longer growing seasons in higher latitudes and altitudes (Ethiopia).
- Reduced frost risks allowing winter cropping in temperate areas (Nepal, Afghanistan, DPRK).
Climate Change and Human Nutrition

• Reduction in dietary diversity. “Higher long-term temperatures were found to cause a significant drop in overall child nutrition. Conversely, a year that sees higher-than-average levels of rainfall could lead to an increase in child nutrition in the following year”.

• Changes in crop nutrient levels
• C₄ plants concentrate CO₂ internally, so increased atmospheric levels have limited effects on C₄ plants.
• C₃ plants, except legumes, cannot extract enough N from the soil to maintain C:N ratios with higher photosynthesis rates.
  • > CO₂ = increase in photosynthesis and carbohydrates in cereals.
  • = increased demand for Phosphorus.
• > CO₂ = decrease in Zn, Fe and proteins in C₃ grains and legumes*.

Meredith T Niles et al 2021 Environ. Res. Lett. 16 015010
Climate Smart Agriculture

FAO definition of CSA:

1. Sustainably increasing agricultural productivity and incomes;
2. Adapting and building resilience to climate change;
3. Reducing and/or removing greenhouse gases emissions, where possible.

Details in the FAO CSA Sourcebook
Examples of Climate Smart Agriculture

- Agroforestry
- Conservation Agriculture
- System for Rice Intensification
- Drought Tolerant crops/ varieties
- Quick Maturing/ drought avoiding varieties
- Flood tolerant crops/ varieties
- Salt Tolerant crops/ varieties
- Soil and water conservation/ revegetation of degraded areas:
  - Rainwater harvesting
  - High Efficiency Irrigation
  - Farmer / herder Managed Natural Regeneration
  - Dryland/ drought tolerant Agro-forestry systems
- Soil fertility management
- Seed priming & Transplanting
- Coastal Protection
- Pastoralism
- Livestock breed conservation/ Livestock Diversity
- Rangeland Management
- Early Warning Systems
- Fuel Efficient stoves
- Power generation
- Biofuels
- Insurance
Agroforestry: *Faidherbia albida*

**Reverse phrenology:** produces leaves in the dry season and sheds them in the rainy season

**Nitrogen fixation: Zambia:** maize yields were 3 tons ha⁻¹ under *F. albida* canopies and only 2 tons ha⁻¹ outside the canopies. GART (2008)

**Senegal:** yield of pearl millet was 2.5 times higher under the canopy of *F. albida* than outside the canopy (Charreau and Vidal, 1965).
Water Management

- World demand for freshwater will soon exceed supply.
- Agriculture is the largest user of freshwater.
- "More crop per drop"
- How can we do this?
High Efficiency Irrigation

Drip irrigation

Simple pumps
High Efficiency Irrigation: Pakistan

Rain guns to irrigate wheat and chickpeas on edge of Thar Desert, South Punjab.

Lining canals to reduce water loss.
Road run-off water harvesting ponds, Burundi

Irrigation channel

Fanya juu terracing
Soil and Water Conservation. Conservation Agriculture, Dokryon Farm North Korea

Upper field under CA
Gully beginning to recover

Lower field, traditional agriculture
Stones visible in gully bed
Measuring reduction in soil erosion under CA, DPRK

- Maize under traditional agriculture: soil loss = 8.7 tonnes/ha/year
- Maize intercropped with Red Clover: 8 tonnes/ha/year
- Maize under Conservation Agriculture: 7.7 tonnes/ha/year
Crop and Variety Diversity

- By growing a range of crops farmers can hedge against climate risks, + increase dietary diversity + soil fertility.
- South Sudan: sorghum (*sorghum bicolor*) varieties: *cham*, early maturing, harvested in August; *alep cham*, second early; *unangjan*, maincrop; *maboior*, late maturing harvested in December
- Liberia: farmers plant 5-7 varieties of rice
- fields are scattered to take advantage of different soil types, seasonal opportunities and to spread risks.
- … But farmers with very small landholdings struggle to produce enough carbohydrate and are unable to allocate land for other crops.
Livestock Diversity

• Some traditional breeds are already adapted to projected climate changes. Karakul sheep, Red Maasai sheep
• Cross-breeding risks, market pressures.
• Changes to herd structure: cows → camels, goats → sheep
• Not without risks: Kenya now the World’s 3rd camel producer – MERS risks?
Conservation Agriculture

• Avoid disturbing the soil (minimum mechanical soil disturbance): rippers, direct seeders, jab planters, zai holes.
• Keep the soil covered: mulch, cover crops
• Rotate the crops:
  • Malawi: maize → groundnuts/ peanuts (cash/ nutrition/ nitrogen) → soya (cash, tobacco substitute/ nitrogen).
  • Zambia: maize → groundnuts / Bambara nuts / cowpeas (cash/ nutrition/ nitrogen) → sunflower (cash)
  • Zimbabwe: maize → cowpeas → sorghum
Ox-drawn Direct Seeders

Fitareli Planter, Brazil

Magoye Planter & Ripper, Zambia

Knapik, Brazil
Jab Planters

Fitarelli, Brazil

Li Seeders
By hand

Planting Basins / Zaï Holes, Zimbabwe
Continuous Soil Cover

Mulched CA plots, Zambia, 2015
Perennial Pigeon Pea

Cover Crops

Velvet Bean / Mucuna

CA plot, Tz. Maize, grass mulch + lablab as a green cover crop. Lablab is too aggressive for the maize.
Maize yields in Malawi, 2010/11-2012/13

Maize yields in Zambia, 2010/11, 2012-13
## Impact of CA on Women’s workload in Malawi

### Conventional Labour Requirements

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[Image ofographs and tables showing conventional and CA labour requirements for various agricultural activities.]