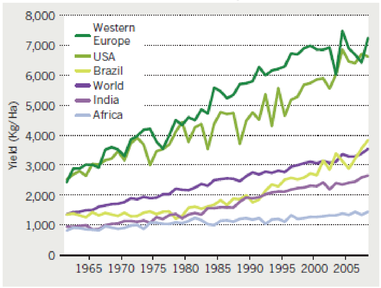
Effects of a Biofuels Market on Ethiopian Maize Production

Patrick R. Campbell | Thayer School of Engineering at Dartmouth College | Hanover, NH USA

THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

BACKGROUND

-Africa has historically lagged behind other regions in agricultural advances, with yields of up to 5x less than certain developed areas.

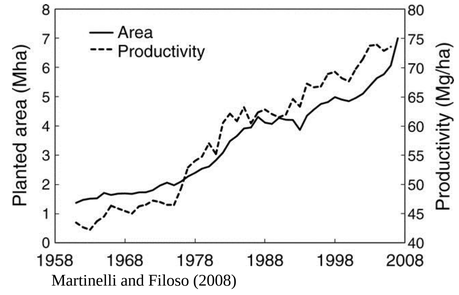


Lynd and Woods (2011)

-African farmers face a “double penalty” of both lower prices for crops and higher transportation costs than other countries, leading to lower profits.

-Africa lacks many innovations that protect farmers from large commodity price fluctuations, such as crop insurance or futures pricing.

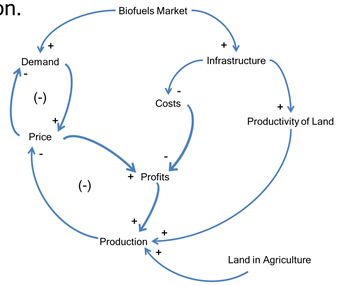
-The development of a biofuels market based on sugar cane in Brazil has led to increased yields and agricultural development.



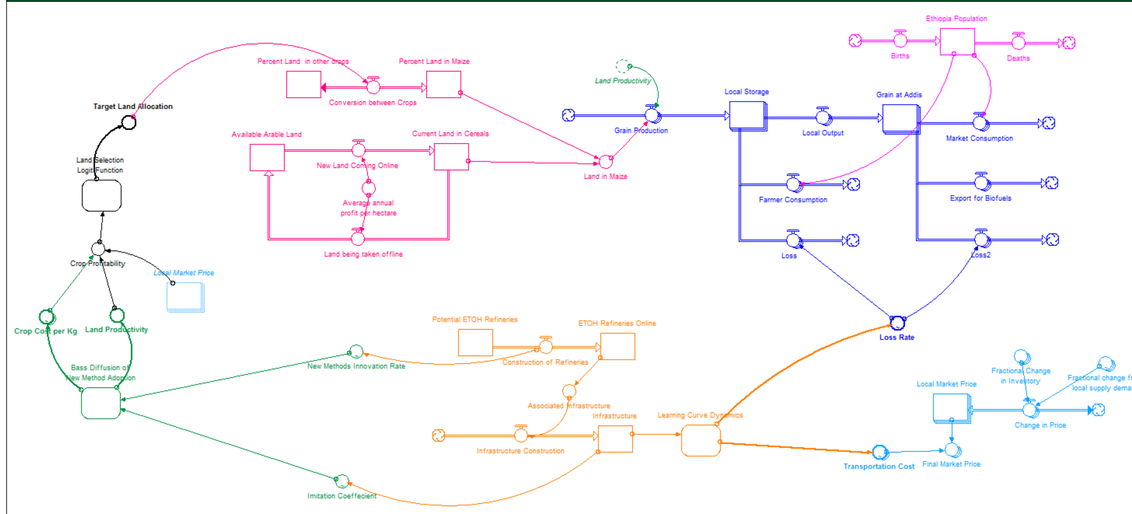
Martinelli and Filoso (2008)

HYPOTHESIS

The introduction of a corn ethanol market to Ethiopia will spur agricultural stability, increased profits, and increased yields through promoting consistent demand, infrastructure development, and agricultural advances. Note this model does not allow imports of grain, creating a semi-closed model boundary to illustrate the difficulty of achieving independent food security without intervention.



THE MODEL



Farmer Choice Logic: A logit function based on profits per hectare was used to determine how land should be allocated.

Land Allocation: Land in cereals was divided into maize and other crops. More land was brought into the system if average profit per hectare was high.

Crop Supply Chain: Crops were first sent to a local depot, then to Addis Ababa, the capital of Ethiopia and its main commercial hub.

Population Dynamics: Current Ethiopian birth and death rates used to project continuous population growth.

Pricing Structure: Pricing was based on flows and inventory at Addis, as farmers typically keep 80% of their yields for personal consumption. Prices were initially set at their 2012 values

Biofuels Development: Main effects of the construction of corn ethanol plants were increased maize demand, decreased loss rates and transportation costs, and increased productivity of land via education of new methods.

Agricultural Practices: A Bass diffusion model was used to drive the adoption of new practices, which resulted in an approximately 60% increase in land productivity.

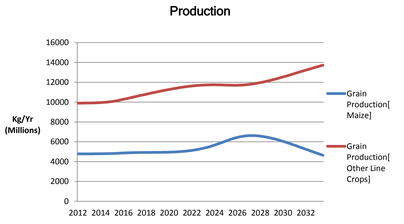
RESULTS

1. No Biofuels Development

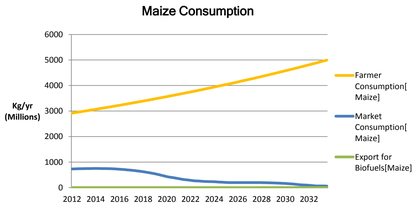
Without a biofuels market, demand and prices rise dramatically due to rapid population growth increasing demand (a). Production of grain remains relatively steady, with total productivity increasing slightly as more land is brought into growth (b). Farmer consumption of maize is largely unrestricted, but we see market supply decrease due to both low supply and high prices, and eventually plummets to near zero once maize prices reach 8 times that of the initial price (c).

a.

b.



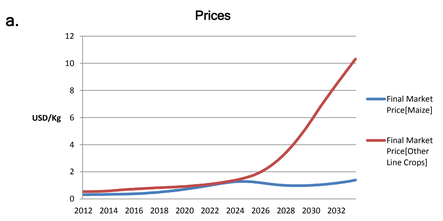
c.



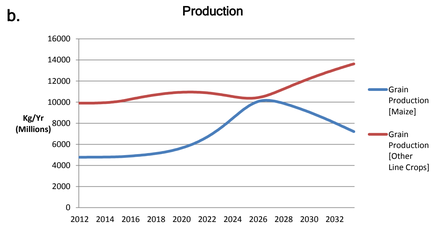
2. Biofuels Development

With the introduction of a biofuels market, we see smaller price increases compared to the base case in Maize, but eventually higher prices in other line crops (a). Maize production initially spikes during development of the new demand, followed by a crash when the growth of demand stagnates (b). We see continued market consumption of maize as well, due to lower prices and sufficient supply (c).

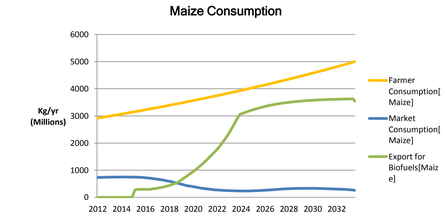
a.



b.



c.

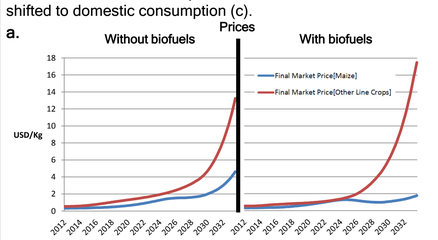


Conditions for biofuels development:
Max Construction Rate: 1 Implementation Start Year: 2015 Plant Limit: 10

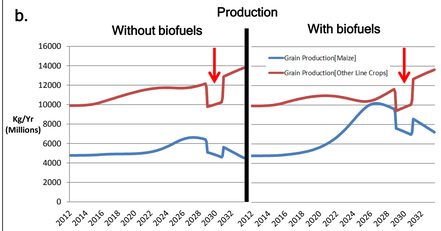
3. Impact of Biofuels Development on Drought Resilience

In this scenario, we see the impact of a simulated drought in 2029 and 2030 on the system, indicated by the red arrows (b). A biofuels market results in more stable maize prices, but increased prices of other crops over time (a). Most noteworthy is that market consumption of maize remains higher with the biofuels market during and following the drought compared to the base case without biofuels, as the surplus maize used for biofuels can be shifted to domestic consumption (c).

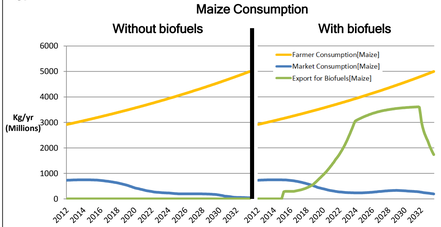
a.



b.



c.



Conditions for biofuels development with drought:
Max Construction Rate: 1 Implementation Start Year: 2015 Plant Limit: 10
Drought represented by a 20% decrease in all grain production during 2029 and 2030

CONCLUSIONS

1. **Increasing demand due to a rapidly growing population lead to increased food insecurity.** Given the increasing demand in many developing countries resulting from rapid population growth, production of key grains will need to increase to prevent runaway price increases. Given business as usual, Ethiopia will be unable to achieve food independence without dramatic price increases and dietary restrictions.

2. **A biofuels market can spur increased maize demand and production, leading to greater production capacity and more stable maize prices.** Through simultaneously increasing grain supply and demand, a biofuels market for maize allows for increased production capacity without dramatic price decreases. It is noteworthy, however, that while the increased supply and demand brought about by a biofuels market can provide somewhat of a buffer, the population growth remains the primary demand driver over the long term for all crops.

3. **The production capacity resulting from a biofuels market can partially insulate against catastrophe.** In the event of a drought or other catastrophe that results in decreased yields, the capacity increases facilitated by a biofuels market can provide short term protection against reduced market consumption through shifting the surplus maize used for biofuels to market consumption. However, long term decreases in consumption would likely still occur due to the rapid increase in prices following a drought and the continual population growth. Farmer consumption is not affected by the drought in either case.

ACKNOWLEDGEMENTS

Major thanks to Professor Steve Peterson for his guidance, inspiration, mentorship and support throughout this project. Also thanks to Mark Laser, Lee Lynd, Chad Piersma and Jeremy Woods for their expertise and insights, and to the Dartmouth College President’s Fund for their generous financial support.

SOURCES

1. Berhane, Guush. Foodgrain Consumption and Calorie Intake Patterns in Ethiopia. Working paper no. 23. Addis Ababa: International Food Policy Research Institute, 2011. Print.
2. Demeke M., 2012. Analysis of incentives and disincentives for maize in Ethiopia. Technical notes series. MAFAP, FAO, Rome.
3. “Ethiopia Commodity Exchange.” Ethiopia Commodity Exchange. Ethiopia Commodity Exchange, 2009. Web. 9 Mar. 2015.
4. Lynd, Lee R., and Jeremy Woods. “Perspective: A New Hope for Africa.” Nature 474.7352 (2011): 520-21. Web.
5. Lynd, Lee R. et al. “Bioenergy and African Transformation.” Biotechnology for Biofuels 8.18 (n.d.): n. pag. Web. 3 Mar. 2015.
6. “Maize Prices | Food Security Portal.” Maize Prices | Food Security Portal. IFPRI, 2012. Web. 09 Mar. 2015.
7. Martinelli, Luiz A., and Solange Filoso. “Expansion Of Sugarcane Ethanol Production In Brazil: Environmental And Social Challenges.” Ecological Applications 18.4 (2008): 885-98. Web.
8. Rashid, Shahidur, Kindie Getnet, and Solomon Lemma. Maize Value Chain Potential in Ethiopia Constraints and Opportunities for Enhancing the System. Working paper. Washington, DC: International Food Policy Research Institute, 2010. Print.
9. Tefera, Abu. Ethiopia Grain and Feed Annual. Rep. no. ET-1301. N.p.: Global Agricultural Information Network, 2013. Print.
10. Thurow, Roger, and Scott Kilman. Enough: Why the World's Poorest Starve in an Age of Plenty. New York: PublicAffairs, 2009. Print.
11. World Bank Database (http://data.worldbank.org/)