Crop Modeling for Integrated Bioeconomic Impact Assessments

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Technology Platform

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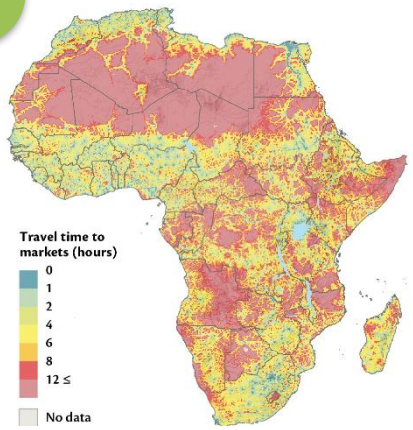

Data System

Spatial database of harmonized baseline indicators on high-resolution grids

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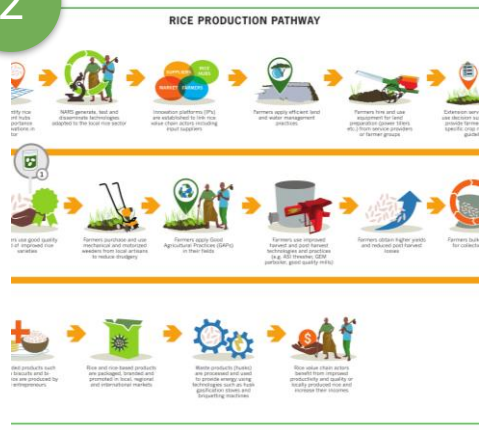

Impact Pathway

Identifying effective entry points of intervention and M&E

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Farming Systems Modeling

Assessing biophysical impacts of investments on **productivity**, **environment**, and **GHG emissions**

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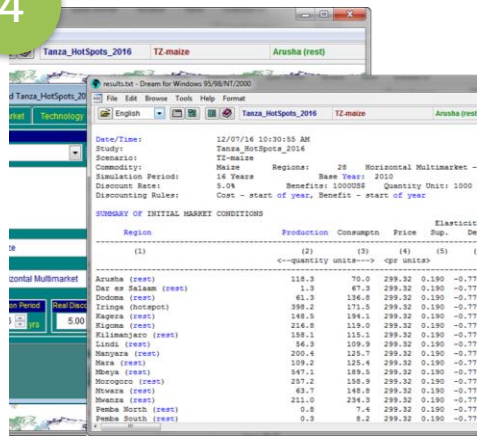


Bioeconomic Modeling

Assessing technology impacts on the economy of households, country, and region

Maize in **Tanzania**

Can maize farmers profit from investments on improved seeds and inorganic fertilizer?

Legumes in **Malawi**

Can farmers profit from rotating maize with legume crops?

Weather Risk in **Sub-Saharan Africa**

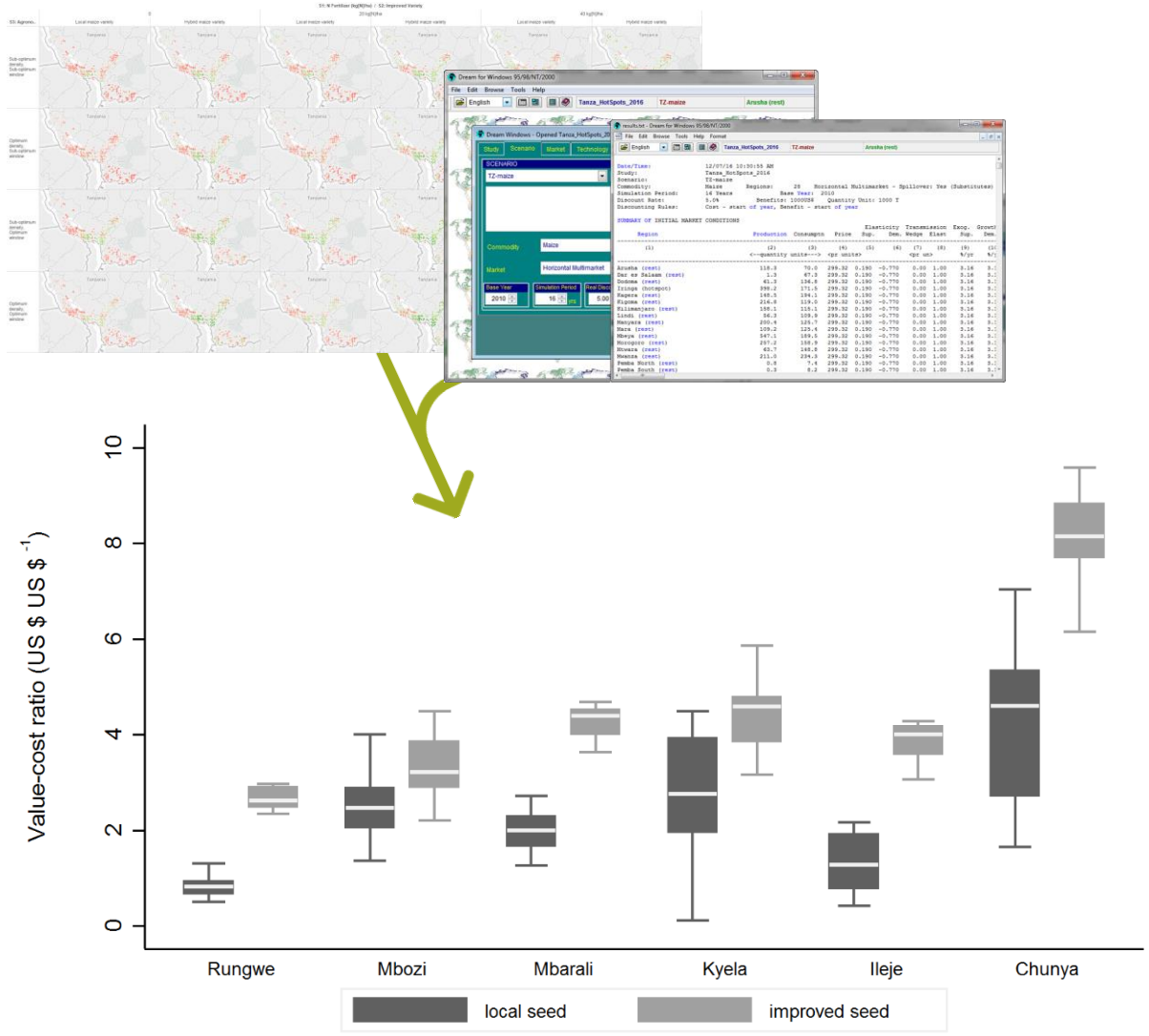
How does weather risk change the yield benefits of fertilizer and improved maize varieties?

Maize in Southern Tanzania

Case Study #1

Can maize farmers profit from investments on improved seeds and inorganic fertilizer?

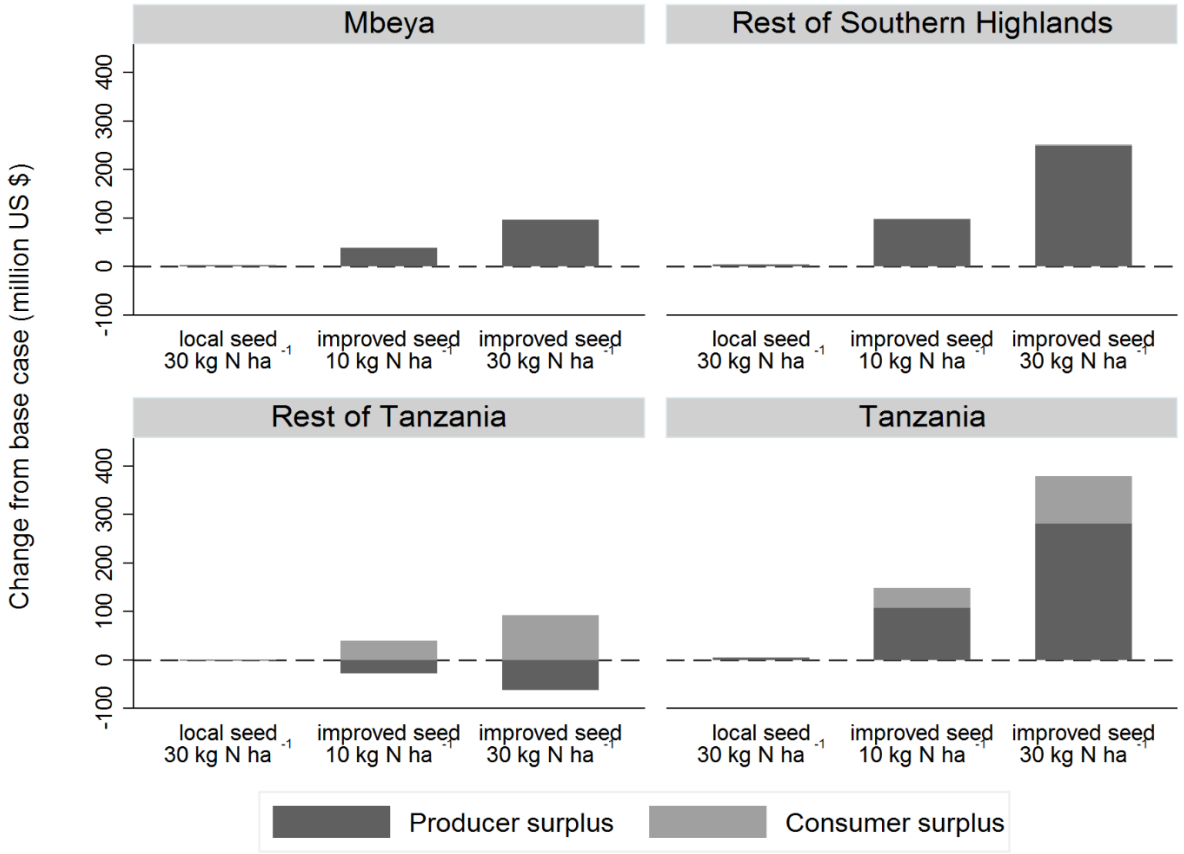
- Combined crop simulation modeling with household data on costs and prices to investigate field-scale profitability.
- Scaled up the household-level results to the regional and national level using an economic surplus model.



Maize in Southern Tanzania

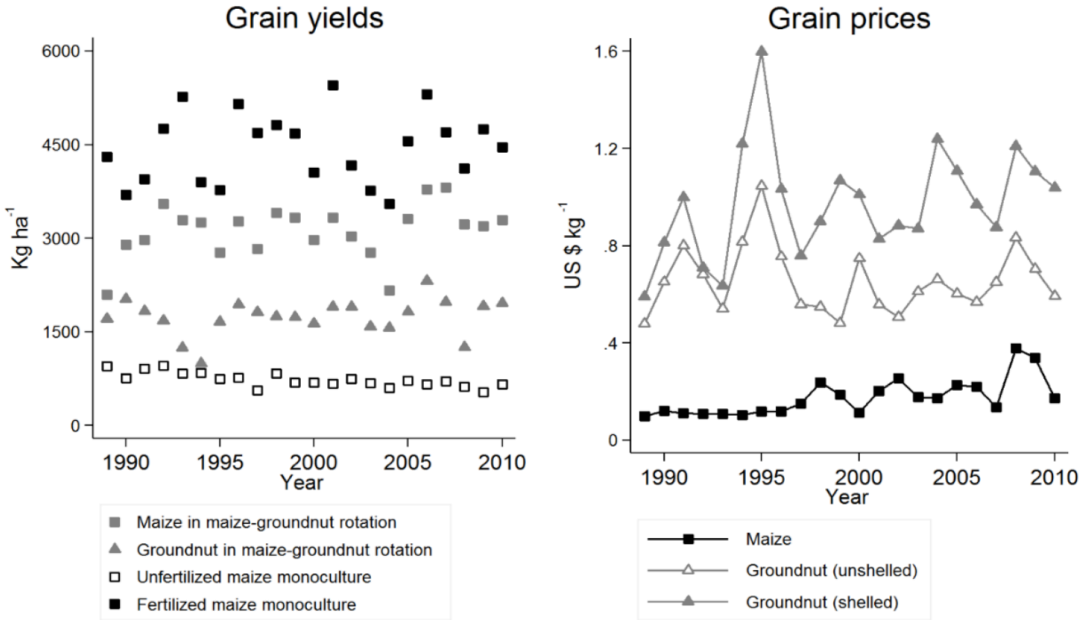
Can maize farmers profit from investments on improved seeds and inorganic fertilizer?

- Use of improved seeds and fertilizer increased yields and profits without negative effect on yield or profit stability.
- Economic benefits to farmers and consumers both increased with the uptake of seed and fertilizer, despite negative effects on prices.



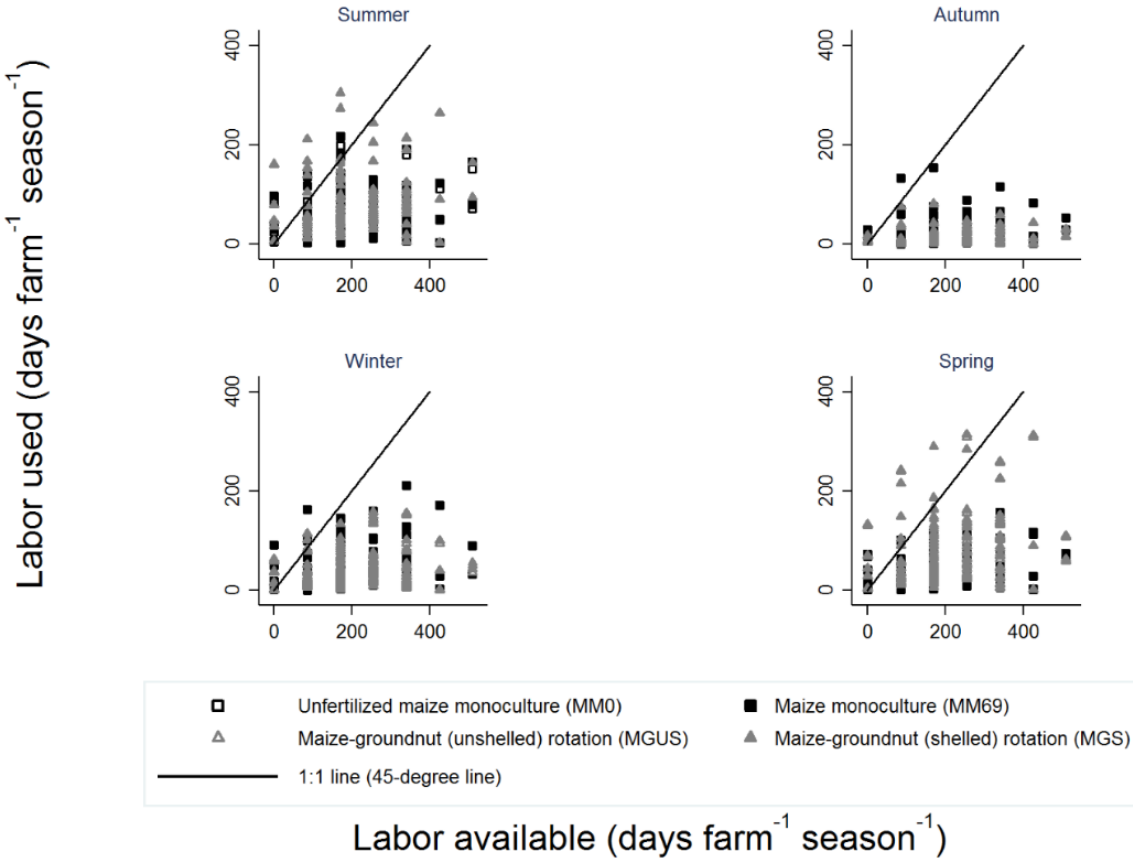
Can farmers profit by rotating maize with legumes?

- Combined crop modelling and an agricultural household survey with an economic analysis.
- Explored the economic, risk, and labor implications of using different legume and fertilizer practices in maize-based cropping systems in central Malawi.



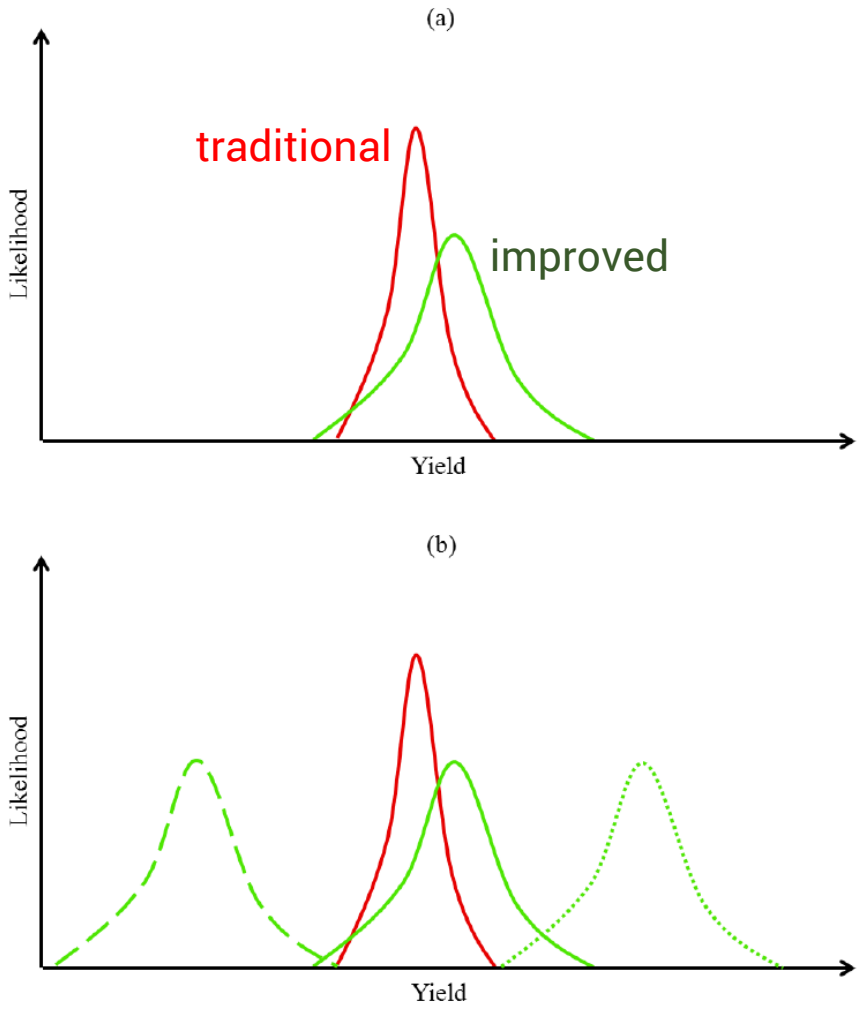
Can farmers profit by rotating maize with legumes?

- The maize-groundnut rotation increased risk-adjusted profits.
- The maize-groundnut rotation had 54% lower caloric yield and used more labor than the maize monoculture, augmenting the increased chance of labor shortages for farm households.



How does weather risk change the yield benefits of fertilizer and improved maize varieties?

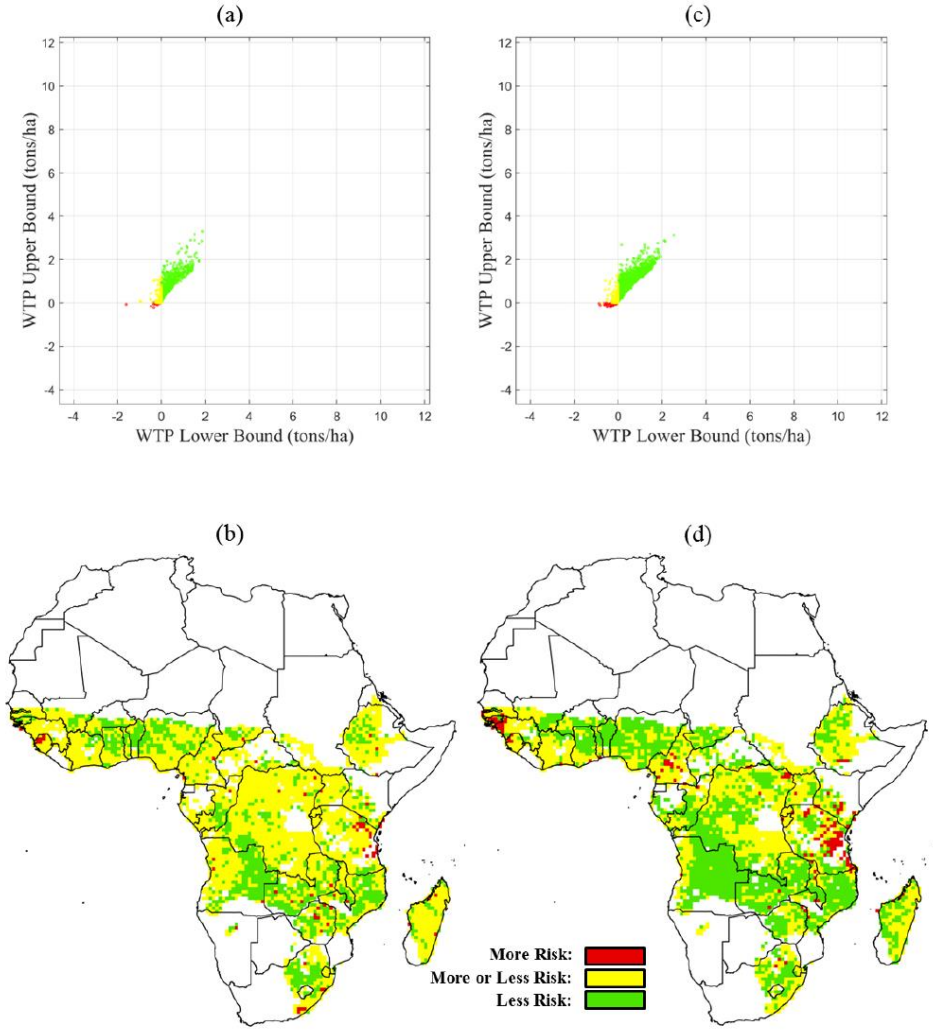
- Combined crop modeling with the willingness to pay bounds analysis to provides a practical strategy for dealing with farmer's risk tolerances.
- Comprehensive continental-scale analysis using a grid-based crop modeling framework to account for spatio-temporal heterogeneity.



How does weather risk change the yield benefits of fertilizer and improved maize varieties?

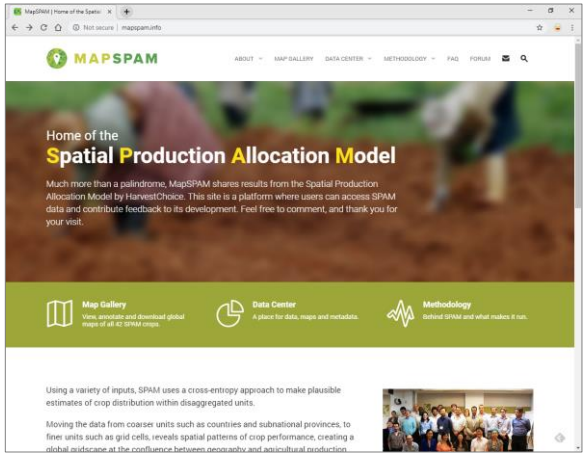
- While the benefits of fertilizer increase over time without improved seeds, the benefits of improved seeds decrease overtime without fertilizer. Introducing improved seeds first would help raising farmer adoption of both fertilizer and improved seeds.

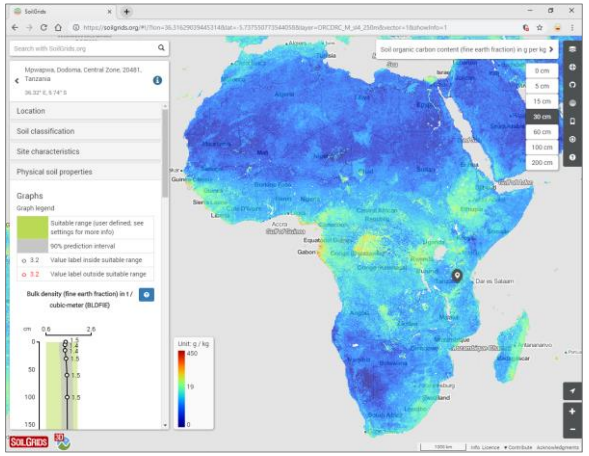
Figure 2: Traditional Variety With versus Without 40 kg/ha of Nitrogen Fertilizer in Year 1 (Panels (a) and (b)) and 10 Years After Adoption (Panels (c) and (d))

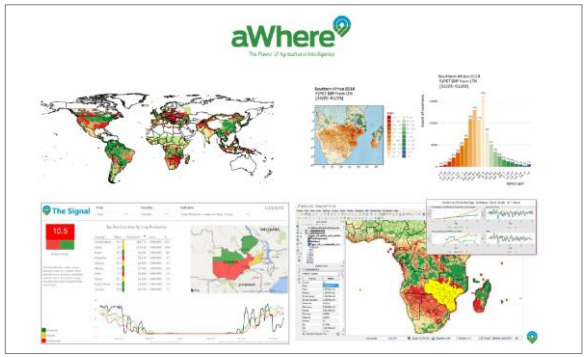


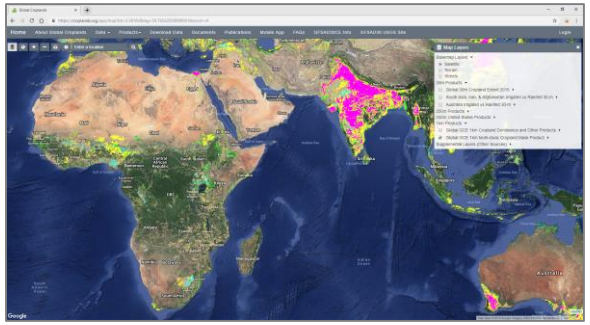
Better Data

- **Crop geography** (2010)
- **Daily weather** (since 2008)
- **CMIP6 monthly mean climate** (2030/2050/2080)
- **Soil properties** (250m/1 km)









New Model

DSSAT v4.7 (2017)

- Temperature responses updated for high temperature response.
- ET functions and effect of CO_2 has been improved.
- Updated the hourly energy balance routines, which have a finer grained simulation of water uptake and plant stress due to water deficit.
- Includes growth stage-controlled irrigation routines and allows deficit irrigation regimes.
- GHG emissions (CO_2, N_2O) now predicted. Working on methane.

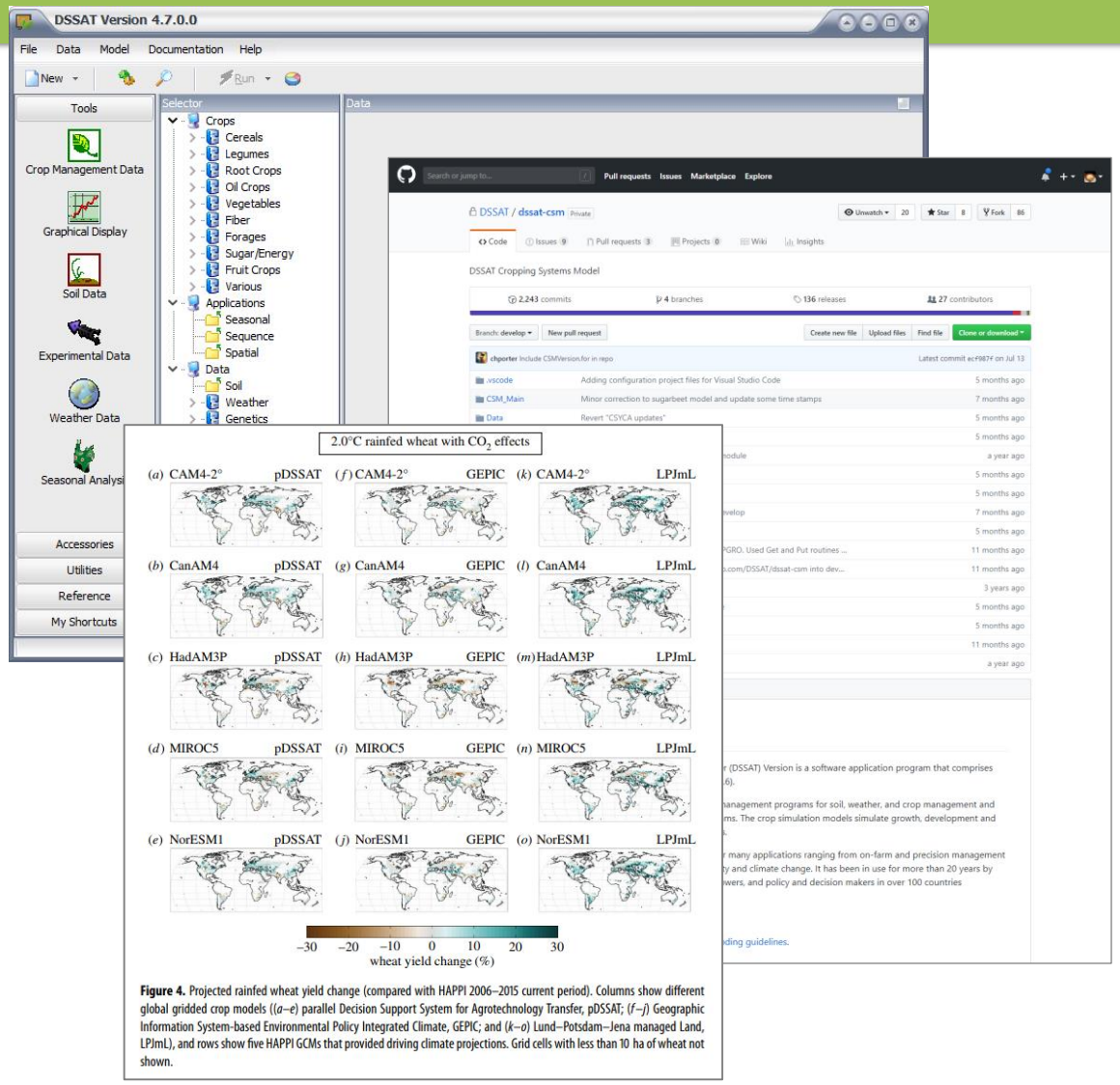
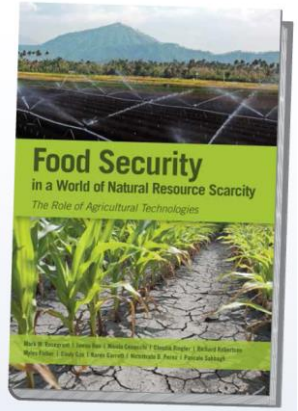
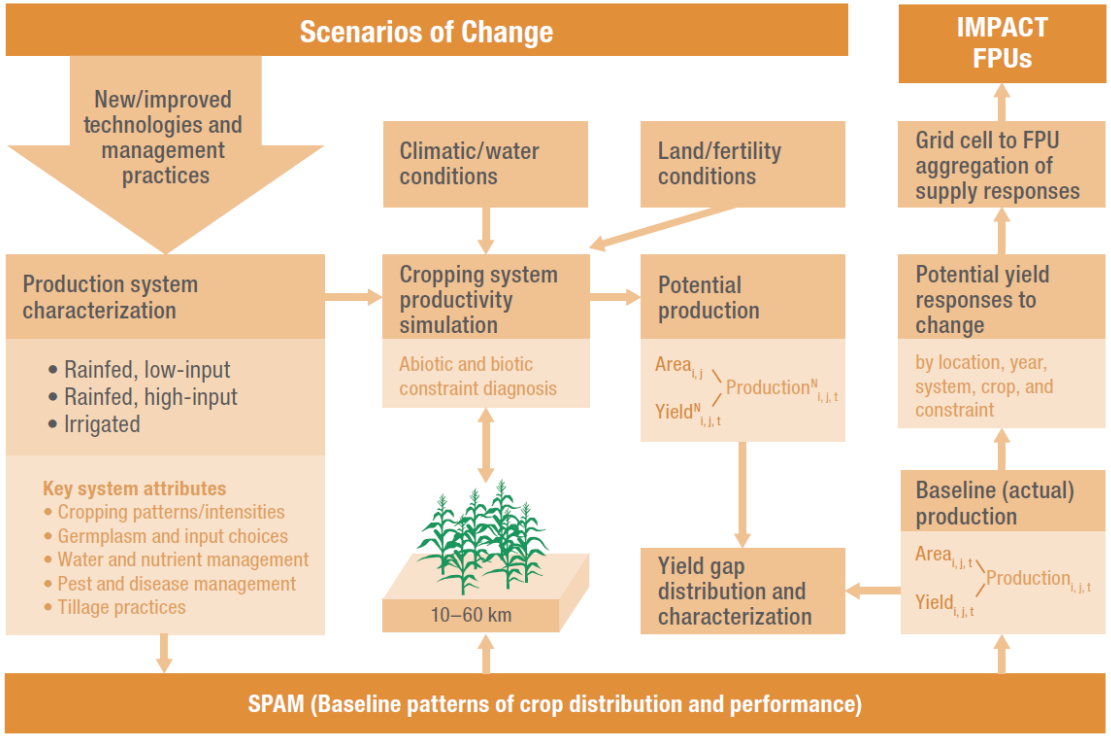


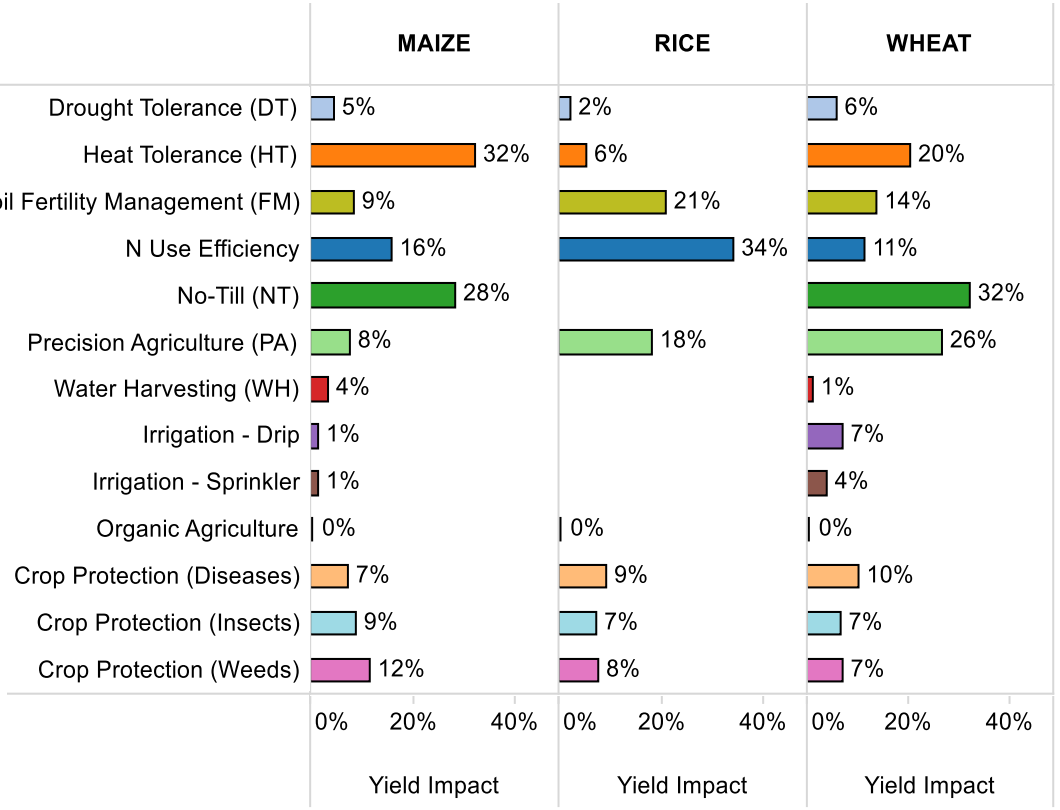
Figure 4. Projected rainfed wheat yield change (compared with HAPPI 2006–2015 current period). Columns show different global gridded crop models ((*a*–*e*) parallel Decision Support System for Agrotechnology Transfer, pDSSAT; (*f*–*j*) Geographic Information System-based Environmental Policy Integrated Climate, GEPIC; and (*k*–*o*) Lund–Potsdam–Jena managed Land, LPJmL), and rows show five HAPPI GCMs that provided driving climate projections. Grid cells with less than 10 ha of wheat not shown.

Technology Potential Assessments

Case Study #4



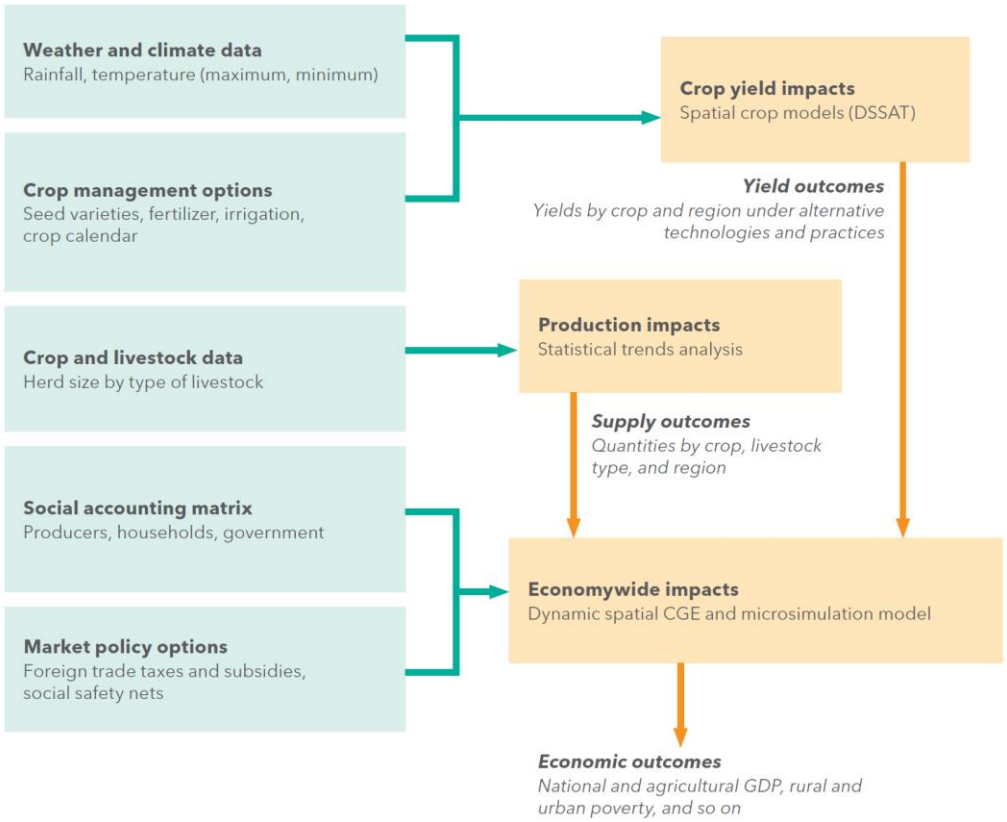




Simulation of Risk Management Policy Options

Case Study #5

FIGURE 6 INTEGRATED ANALYTICAL FRAMEWORK

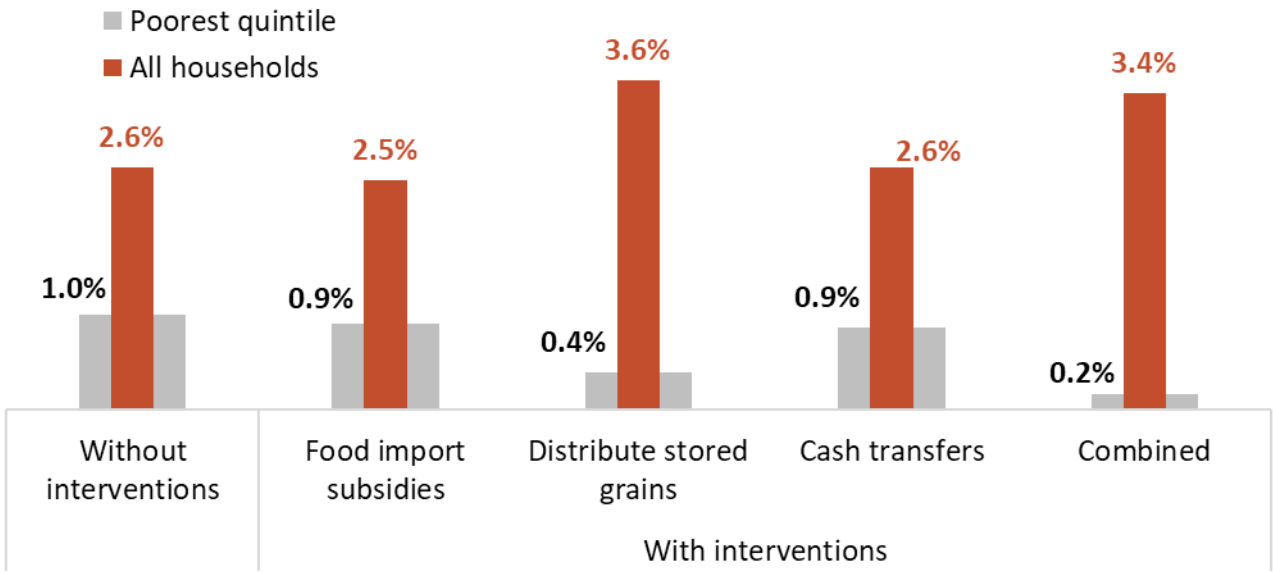


Source: Authors.

Note: CGE = computable general equilibrium; DSSAT = Decision Support System for Agrotechnology Transfer; GDP = gross domestic product.

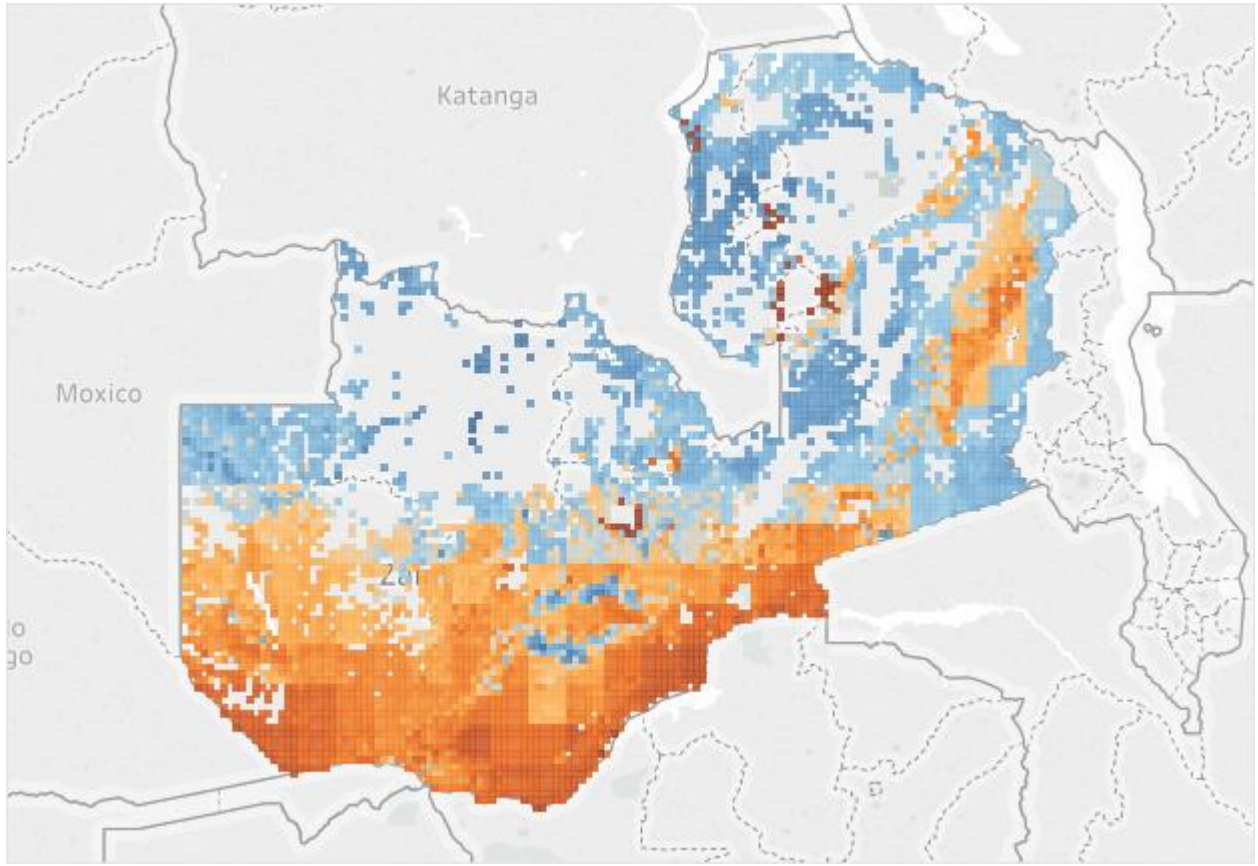
Household consumption losses during strong El Niño events in Ethiopia

(percentage reductions)



More Sophistications

- Modeling to understand considerably more complexity in changes in yields at the pixel-level.
- Capability to understand possible unintended consequences (e.g., export ban in Zambia increased poverty of net sellers)



Simulated yield differences between baseline and El Niño in 2015/16 in Zambia

Learn More

Case Studies

1. Komarek, Adam M., Jawoo Koo, Ulrike Wood-Sichra, and Liangzhi You. "Spatially-explicit effects of seed and fertilizer intensification for maize in Tanzania." Land use policy 78 (2018): 158-165.
2. Komarek, Adam M., Jawoo Koo, Beliyou Haile, Siwa Msangi, and Carlo Azzarri. "Trade-offs and synergies between yield, labor, profit, and risk in Malawian maize-based cropping systems." Agronomy for Sustainable Development 38, no. 3 (2018): 32.
3. Hurley, Terrance, Jawoo Koo, and Kindie Tesfaye. "Weather risk: how does it change the yield benefits of nitrogen fertilizer and improved maize varieties in sub-Saharan Africa?." Agricultural Economics 49, no. 6 (2018): 711-723.
4. Rosegrant, Mark W.; Koo, Jawoo; Cenacchi, Nicola; Ringler, Claudia; Robertson, Richard D.; Fisher, Myles; Cox, Cindy M.; Garrett, Karen; Perez, Nicostrato D.; and Sabbagh, Pascale. 2014. Food security in a world of natural resource scarcity: The role of agricultural technologies. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/9780896298477
5. Koo, Jawoo, ed.; Thurlow, James, ed.; ElDidi, Hagar, ed.; Ringler, Claudia, ed.; De Pinto, Alessandro, ed. 2019. Building resilience to climate shocks in Ethiopia. Washington, DC: International Food Policy Research Institute (IFPRI) and United Nations Development Programme (UNDP). https://doi.org/10.2499/9780896293595