How Geospatial Data & Tools Improve Agricultural Investment Decisions

HarvestChoice
About HC
Data Framework
SPAM 2005
Socio-economic Data
Price Modeling
Recent Studies

IFPRI Update
Foresight with IMPACT
Global Futures

Legend
Travel time to cities (2010)
Hour
< 4
4 - 8
8 - 12
12 - 24
> 24

JAWOO KOO j.koo@cgiar.org
SUPPORTING ASSESSMENTS OF STRATEGIC INVESTMENT CHOICES IN AGRICULTURAL TECHNOLOGY DEVELOPMENT AND ADOPTION SINCE 2006

JAWOO KOO
crop modeling, data analytics

CARLO AZZARRI
micro-economics, poverty, nutrition

LIANG YOU
SPAM, DREAM, econometrics

BELiyOU HAILE
M&E, micro-economics

APURBA SHEE
M&E, data modeling

ELODIE VALETTE
geo-diffusion of tech. innovation

CINDY COX
technical writer, technology evaluation

CLEO ROBERTS
farming systems characterization

MARIa COMANESCU
web development, programming

MELANIE BACOU
microeconomics, CRP mapping

QUEENIE GONG
crop production statistics data

HO-Young Kwon
crop and soil process modeling

ULRIKE WOOD-SICHTHRA
data management, SPAM, DREAM

ZHE GUO
GIS coordinator, market access

IVY ROMERO
administrative coordinator

Geospatial Data & Tools for Better Investment Decisions

4th GYGA Workshop | September 24, 2015
FIVE GUIDING QUESTIONS

1. Where are the poor, and what are their welfare status?
2. On what farming systems do the poor most depend?
3. What are the constraints affecting the productivity and market integration of those farming systems?
4. What present or prospective investments in technologies and practices might best address those constraints?
5. What will be the benefits of investment on productivity, income, and the reduction of poverty and hunger?
AGRICULTURAL INVESTMENT ASSESSMENT, SPATIALLY

Invest?

What's out there, where?

Priority?

Potential impact?

Any risks?

DEcision Score Card

Priority

Potential Impact

Risk

Geospatial Data & Tools for Better Investment Decisions

4th GYGA Workshop | September 24, 2015
Decision-makers will need to choose investment options accounting for tradeoffs.

Need for multi-objective, spatially-explicit data and tools that can help prioritizing and rationalizing the choices.
WHERE
Baseline & Targeting

WHAT
Technology Options & Inventory
+ Integrated Impact Assessments

HOW
Simulation & Scenario Analysis Tools (Plus, M&E)
HarvestChoice CELL5M (700+ 10 km spatial layers)
Drawing on a variety of inputs, SPAM uses an entropy-based, data-fusion approach to “plausibly” assess cropping system distribution and performance at a “meso-gridded” scale of 5-minute globally or 30-seconds at country level (if data available).

**CHALLENGES:**
- Different sources → contradictory information
- All raster data not at same scale
- Sub-national data complete, at least level1, better level2
- Conform national crops → FAO/SPAM crops
- Consistencies between layers — constraints met
  - ag_land → 2020
  - ff → crop
  - other
  - ag_crops

Cropping intensities & production systems shares consistent with data and model
- Validation of results

**OPPORTUNITIES:**
- Move out of IFPRI enclosure, put results and model in the cloud
- Include data at larger scale — 100x1 km → 1x1 km
- Always use most recent data — statistics, ag_land, irrigation, distribution, administrative units
- Provide and use national/sub-national prices
- Change crop list — expand/reduce (suitability?)
- Proprietary suitability conditions (modify model)
- Reproducibility of results
- Teaching tool for GIS, modelling, GAMs
- Validation ‘easier’ at large scale, reduced area

**VALIDATION:**
- Validation process by other CGIAR centers (e.g. IFPRI, CIAT, ICRISAT, CIP, CYMMIT). Each focuses on the mandate crops.
- Crop map view ‘parties’ by local experts and agronomists
- Crowd-sourcing on a dedicated website (mapSPAM.info)

**COLLABORATORS:**
- IFPRI
- HarvestChoice
- International Institute for Applied Systems Analysis
Socio-economic data harmonization

- Nationally-representative HH surveys from 26 countries (includes all GYGA countries!)
- 71 variables (socio-demographic, land size, livestock, dwelling condition, assets, access to infrastructure)

What correlates with poverty?

Geospatial Data & Tools for Better Investment Decisions

HarvestChoice

Better Choices, Better Lives
SOCIO-ECONOMIC DATA
HARMONIZATION: COUNTRY SNAPSHOTS

Presenting harmonized socio-economic data (e.g., overview of agricultural characteristics, such as production, sales, household and farm structure, livestock, inputs, management practices, and farm assets) in a standardized format across six countries (Malawi, Uganda, Tanzania, Ghana, Ethiopia, and Nigeria) using cross-country databases of nationally-representative household surveys and agricultural censuses.

Being developed as non-technical products serving the scope of providing basic socio-demographic and agricultural statistics.

Geospatial Data & Tools for Better Investment Decisions
4th GYGA Workshop | September 24, 2015
Farmgate Fertilizer Price:

\[ P_{\text{fert, farm}} = P_{\text{fert, port}} + \text{Build-up costs} \]

(Handling + “Barriers” + Transport Costs)
Price Modeling

Assessing Farm-Gate Prices: Output Surpluses to Local Markets

Farmgate Fertilizer Price:
\[ P_{fert, \text{farm}} = P_{fert, \text{port}} + \text{Build-up costs} \]
\[ \text{(Handling + “Barriers” + Transport Costs)} \]

Farmgate Maize Price
\[ P_{maize, \text{farm}} = P_{maize, \text{market}} - \text{Transport Costs} \]
Reduce landed cost of urea

Reduce transport costs

Streamlined customs/border regulations

Baseline

20% change

50% change
PRICE + CROP MODELING

ASSESSING PROFITABILITY OF FERTILIZER APPLICATIONS

Geospatial Data & Tools for Better Investment Decisions

4th GYGA Workshop | September 24, 2015
1. Agro-climatic suitability

2. Yield responses to fertilizer

3. Modeling of farm-gate prices

4. Profitability analysis

Transport cost from port to farm-gate

Wheat farming enterprise data

Transport cost from capital to farm-gate

International wheat and fertilizer prices

Mean Yield (kg/ha)

High : 8000

Low : 1

no fertilizer

recommended rate of fertilizer

quick sensitivity analysis tool in Excel

net economic return and potential production

Net economic return (US$/Ha)

Incremental net economic return (%)

T0 T1 T2 T0 to T1 T0 to T2 T1 to T2

Country

Angola -186.60 -98.75 -22.11 55.82 88.37 74.22
Barbadi 755.11 1096.98 1562.42 45.66 98.91 24.20
Ethiopia 59.42 172.60 353.87 191.51 292.27 34.56
Kenya 741.03 796.46 1160.50 31.77 56.61 18.85
Mozambique 151.46 230.31 327.92 48.32 65.94 44.03
Mauritius -46.94 37.53 39.20 162.10 183.51 34.46
Rwanda 1135.30 1377.55 1566.96 21.77 38.51 13.75
Tanzania 376.60 554.67 608.47 46.35 72.74 16.71
DCR 376.67 247.33 405.53 183.21 164.65 30.82
Uganda 636.30 903.64 1103.94 41.35 72.68 22.17
Zambia 67.72 310.20 449.48 358.06 563.73 44.90
Zimbabwe -25.72 236.49 400.16 1019.48 1655.83 69.21
Percent Change in World Price of Maize

http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128022
RISK ASSESSMENT

Yield/Profit or Some Other Measure of Desirable Outcomes

Likelihood

Distribution Without Intervention

Distribution With Intervention

This is certainly worse!

This is certainly better!

But at what point between these two extremes will the distribution with/without intervention just be preferred?
RISK ASSESSMENT
Maize, [Unimproved, No fertilizer] → [Improved, 40 kg[N]/ha]
Subnational crop production statistics indicate the average maize yield in Songea is 1.5 t/ha. Using agricultural census data on the percentage of maize growing farmers using fertilizer and improved seeds, spatially distributed using the market accessibility at grid-level (10x10 km2) as a proxy, the average yield was disaggregated into three levels using simulation model.
### SIMULATED MAIZE YIELD RESPONSES IN SONGEA

Aggregated over time, area-weighted average across the maize growing areas in Songea. Red bars indicate average yields simulated as less than 3 t/ha. By combining three strategies, average yield can reach up to 3.7 t/ha in Songea.

<table>
<thead>
<tr>
<th>S1: N Fertilizer (kg[N]/ha)</th>
<th>S2: Improved Variety</th>
<th>S3: Agronomy (Planting Density &amp; Planting Window)</th>
<th>Yield (kg/ha, Current maize area only)</th>
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<tr>
<td>0</td>
<td>Local</td>
<td>Sub-optimum Density, Sub-optimum window</td>
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<tr>
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<td>Optimum Density, Sub-optimum window</td>
<td>0.5K</td>
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<td></td>
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<td>Optimum Density, Optimum window</td>
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<td>Optimum Density, Sub-optimum window</td>
<td>1.0K</td>
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<td>Sub-optimum Density, Optimum window</td>
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<tr>
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<td>Optimum Density, Optimum window</td>
<td>3.1K</td>
</tr>
<tr>
<td>40</td>
<td>Local</td>
<td>Sub-optimum Density, Sub-optimum window</td>
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<td>Optimum Density, Optimum window</td>
<td>3.7K</td>
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</tbody>
</table>
SIMULATED MAIZE YIELD RESPONSES ACROSS SOUTHERN HIGHLAND

Aggregated over time, area-weighted average across current maize growing areas in Southern Highlands.
Increasingly available gridded soil data

✓ NOT readily available for crop simulation models!
Developing DSSAT-compatible gridded soil database

- : from SoilGrids 1km
- : Derived using pedo-transfer functions (Saxton & Rawls, 2006) and SoilGrids 1km data (soil texture and organic carbon)
- : Estimated based on the available water storage capacity (AWC, mm/m) using HWSD’s classification and the HarvestChoice’s HC27

All other information : from Harvest Choice’s HC27(HC.SOL)
Strategic foresight:
Long-term projections from IFPRI, GFSF and AgMIP

Keith Wiebe, IFPRI and GFSF
ISPC, Rome, 16 September 2015
Modeling climate impacts on agriculture: biophysical and economic effects

Climate
- General circulation models (GCMs)

Δ Temp
Δ Precip

Biophysical
- Global gridded crop models (GGCMs)

Δ Yield (biophys)

Economic
- Global economic models

Δ Area
Δ Yield
Δ Cons.
Δ Trade
Socioeconomic and climate drivers

Shared Socioeconomic Pathways (SSPs)

Representative Concentration Pathways (RCPs)

IMPACT baseline results

• Yields – climate effects by commodity and region
• Prices – comparing socioeconomic and climate effects
• Total demand – comparing commodities
• Per-capita food demand – by commodity and region
• Net trade – by region
• Food security – by region
Projections to 2050 w/o climate change

Baseline increases in global yields, area, production, consumption, exports, imports and prices of coarse grains, rice, wheat, oilseeds and sugar in 2050 (% change relative to 2005 values)

Source: Wiebe et al. (Environmental Research Letters, 2015)
Climate change impacts in 2050

Climate change impacts on global yields, area, production, consumption, exports, imports and prices of coarse grains, rice, wheat, oilseeds and sugar in 2050 (% change relative to 2050 baseline values)

Source: Wiebe et al. (Environmental Research Letters, 2015)
Climate change impacts and trade

Impacts of climate change and trade policy on yields, area, production, exports and prices of five commodities, (% deviation from baseline values in 2050 without climate change)

Source: Wiebe et al. (Environmental Research Letters, 2015)
Yield effects of climate change, by region (SSP2)

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Yield effects of climate change, by region (SSP2)

Cereals

Maize

Rice

Wheat

WLD = World; EAP = East Asia and Pacific; EUR = Europe; FSU = Former Soviet Union; LAC = Latin America and Caribbean; MEN = Middle East and North Africa; NAM = North America; SAS = South Asia; SSA = Sub-Saharan Africa;

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Yield effects of climate change, by region (SSP2)

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Total global demand: aggregated commodities (SSP2, NoCC)

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Total global demand: maize, rice, wheat (SSP2, NoCC)

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Per-capita food demand (SSP2, NoCC)

Cereals

Roots & tubers

Oilseeds

Pulses

Fruits & veg

Meat

WLD = World; EAP = East Asia and Pacific; EUR = Europe; FSU = Former Soviet Union; LAC = Latin America and Caribbean; MEN = Middle East and North Africa; NAM = North America; SAS = South Asia; SSA = Sub-Saharan Africa;

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Net trade (SSP2, RCP8.5)

Cereals

DVG = Developing Countries; EAP = East Asia and Pacific; SAS = South Asia; FSU = Former Soviet Union; MEN = Middle East and North Africa; SSA = Sub-Saharan Africa; LAC = Latin America and Caribbean

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Population at risk of hunger (SSP2, RCP8.5)

EAP = East Asia and Pacific; SAS = South Asia; FSU = Former Soviet Union;
MEN = Middle East and North Africa; SSA = Sub-Saharan Africa; LAC = Latin America and Caribbean

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Malnourished children (SSP2, RCP8.5)

EAP = East Asia and Pacific; SAS = South Asia; FSU = Former Soviet Union;
MEN = Middle East and North Africa; SSA = Sub-Saharan Africa; LAC = Latin America and Caribbean

Source: IFPRI, IMPACT version 3.2, 8 September 2015
Quantitative foresight modeling to inform prioritization

Keith Wiebe, IFPRI and GFSF
ISPC, Rome, 15 September 2015
Objectives

1. Improved system of integrated biophysical and economic modeling tools
2. Stronger community of practice for scenario analysis and ex ante impact assessment
3. Improved assessments of alternative global futures
4. To inform research, investment and policy decisions in the CGIAR and its partners
Key points

• Not one center alone, but all 15 CGIAR centers (and other partners)
• Not just individual technologies, but broader scenarios
• Not model results alone, but as one input among several to inform decision making by others
• Not one-time results, but building capacity and a framework to continue assessing options over time
Modeling climate impacts on agriculture: biophysical and economic effects

Climate
- General circulation models (GCMs)
  - Δ Temp
  - Δ Precip

Biophysical
- Global gridded crop models (GGCMs)
  - Δ Yield (biophys)

Economic
- Global economic models
  - Δ Area
  - Δ Yield
  - Δ Cons.
  - Δ Trade
1. Improved modeling tools

- Complete recoding of IMPACT version 3
- Disaggregation geographically and by commodity
- Improved water & crop models
- New data management system
- Modular framework
- Training
2. Stronger community of practice

• All 15 CGIAR centers now participate in GFSF
  • Bioversity, CIAT, CIMMYT, CIP, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, ILRI, IRRI, IWMI, WorldFish; AfricaRice and CIFOR are joining

• Collaboration with other global economic modeling groups through AgMIP
  • PIK, GTAP, Wageningen, IIASA, UFL, FAO, OECD, EC/JRC, USDA/ERS, …
3. Improved assessments

- Role of agricultural technologies
- Africa regional reports
- Analyses by CGIAR centers
- CCAFS regional studies
- AgMIP global economic assessments
## Promising CGIAR technologies

<table>
<thead>
<tr>
<th>Crop</th>
<th>Center</th>
<th>Trait</th>
<th>Countries (Region)</th>
<th>Final Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>CIMMYT</td>
<td>Drought tolerance</td>
<td>Angola, Benin, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Uganda, United Republic of Tanzania, Zambia, Zimbabwe (M1)</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat tolerance</td>
<td>Bangladesh, India, Nepal, Pakistan (M2)</td>
<td>30%</td>
</tr>
<tr>
<td>Wheat</td>
<td>CIMMYT</td>
<td>Drought tolerance</td>
<td>Iran, Turkey (W1)</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat tolerance</td>
<td>India, Pakistan (W2)</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drought and heat tolerance</td>
<td>Argentina, South Africa (W3)</td>
<td>30%</td>
</tr>
<tr>
<td>Potato</td>
<td>CIP</td>
<td>Drought tolerance</td>
<td>Bangladesh, China, Kyrgyzstan, India, Nepal, Pakistan, Tajikistan, Uzbekistan (P1)</td>
<td>4-40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat tolerance</td>
<td></td>
<td>4-40%</td>
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<tr>
<td></td>
<td></td>
<td>Drought and heat tolerance</td>
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<td>4-40%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>ICRISAT</td>
<td>Drought tolerance</td>
<td>Burkina Faso, Eritrea, Ethiopia, India, Mali, Nigeria, Sudan, United Republic of Tanzania (S1)</td>
<td>20-80%</td>
</tr>
<tr>
<td>Groundnut</td>
<td>ICRISAT</td>
<td>Drought tolerance</td>
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<td>40-60%</td>
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<tr>
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<td>Heat tolerance</td>
<td></td>
<td>40-60%</td>
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<td>Drought and heat tolerance</td>
<td></td>
<td>40-60%</td>
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<tr>
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<td>high yielding</td>
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<tr>
<td>Cassava</td>
<td>CIAT</td>
<td>Mealybug control methods</td>
<td>China, India, Indonesia, Lao People’s Democratic Republic, Myanmar, Thailand (C1)</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Islam et al. (draft)
4. Informing decision making

- National partners
- Regional organizations
- International organizations and donors
- CGIAR
  - Centers
  - CRPs
  - System?
Model improvements under way

- Livestock and fish
- Nutrition and health
- Variability
- Poverty
- Land use
- Environmental impacts