CGIAR Climate Change Adaptation work as it relates to GYGA

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With input from: Alex B. Heinemann, Sylvain Delerce, Daniel Jimenez, David Arango, T. Rosenstock and A. Jarvis
Outline

• What is CCAFS? Where does it work? How does it work?
• Environmental and drought stress characterisation for prioritising breeding strategies and management
• Data-driven agronomy for adapting Colombian rice production systems to climate variability
• Preliminary results on stochastic frontier analysis of technical efficiency
What is CCAFS? Where does it work? How does it work?
Over-arching objectives

1. To identify and test pro-poor adaptation and mitigation technologies, practices, and policies for food systems, adaptive capacity and rural livelihoods

2. To provide diagnosis and analysis that will ensure cost effective investments, the inclusion of agriculture in climate change policies, and the inclusion of climate issues in agricultural policies, from the sub-national to the global level
CCAFS Theory of Change

Working with partners to collect the evidence and to change opinions and worldviews
1. CSA Alliance, World Bank, IFAD, Climate Finance Orgs, Ministries
2. World Vision, National Meteorological Agencies, Disaster Risk Agencies, Insurance Agencies
3. IIASA, FAO, Global Research Alliance for Agricultural GHGs
4. Food security and climate adaptation agencies, GFAR, CFS

Enhanced local adaptation planning processes
- Early warning and response integrated in national agencies
- Mechanisms and incentives established for low emissions development
- Improved policy framework for managing food security; prioritisation tools used

Working with partners to make it happen
1&3: CSA Alliance, World Bank, IFAD, Green Climate Fund, PROLINNOVA, climate finance orgs, ministries
2: World Vision, National Meteorological Agencies, Disaster Risk Agencies, Insurance Agencies

Key
- Flagship 1: Climate-smart agricultural practices
- Flagship 2: Climate-information services and climate-informed safety nets
- Flagship 3: Low emissions development
- Flagship 4: Policies and institutions for climate resilient food systems
FP 1: Climate-smart practices

FP 2: Climate information services and climate-informed safety nets

FP 3: Low emissions development

FP 4: Policies and institutions for a resilient food system

20 million farmers have transformed their agricultural practices to be climate-smart

Build the resilience of 10 million farmers to climate-related risk

20% reduction of GHG emissions while enhancing food security in at least seven countries

25 countries will have enabling agricultural, climate change and food security policies, with a 50% increase in investments

By 2025
Climate smart villages: Key agricultural activities for managing risks

**CLIMATE SMART VILLAGE / FARM**

**Weather smart**
- Seasonal weather forecasts
- ICT based agro-advisories
- Index based insurance
- Climate analogues

**Water smart**
- Aquifer recharge
- Rainwater harvesting
- Community management of water
- Laser leveling
- On-farm water management

**Carbon smart**
- Agroforestry
- Conservation tillage
- Land use systems
- Livestock management

**Nitrogen smart**
- Site specific nutrient management
- Precision fertilizers
- Catch cropping / legumes

**Energy smart**
- Biofuels
- Fuel efficient engines
- Residue management
- Minimum tillage

**Knowledge smart**
- Farmer-farmer learning
- Farmer networks on adaptation technologies
- Seed and fodder banks
- Market info
- Off-farm risk management-kitchen garden
Based on household data, you can differentiate the relative importance of various activities to food availability and target household and farming system specific interventions.

Lushoto, Tanzania

- Food crop production intensification, opening of market options
- Problem alleviation through more production, off-farm opportunities
- Market options, further production intensification, diversification, Crop-livestock integration
- Enormous within site variation in FA
- Accompanied by a complete shift in farm orientation
- Different types of best-bet interventions for different groups of farmers

Van Wijk et al., in prep
Ritzema et al., in prep
Frelat et al., in prep
Some key questions

• Can GYGA approaches help identifying potential system interventions that sustainably increase productivity, in cereal-based systems?

• How can GYGA scaling up methods help prioritising interventions at national and regional levels?

• What does [sustainable] intensification mean at a regional level, in prescribed shared socio-economic pathways (SSPs)? (cf. Martin)
Environmental and drought stress characterisation for prioritising breeding strategies and management
Environmental and drought stress characterisation for prioritising breeding strategies

RESEARCH PAPER

Variation and impact of drought-stress patterns across upland rice target population of environments in Brazil

Alexandre Bryan Heinemann¹, Camilo Barrios-Perez², Julian Ramirez-Villegas²,³,⁴, David Arango-Londoño², Osana Bonilla-Findji²,³, João Carlos Medeiros¹ and Andy Jarvis²,³

- Develop a method to classify environments
- Identify drought stress patterns in each environment
- Provide information for targeting breeding
Field experiments (PHE & GRO)

Oryza2000 crop model

Calibrated model

Field experiments (EVAL)

Fully evaluated model

Environment groupings

Drought stress pattern

Breeding and management recommendations
Methods: soils and weather

Cultivar:
BRS Primavera (check cultivar);

Simulations:
8 Sowing dates (November to December;
51 weather stations (30 years);
7 soils (by texture);
Environment groups

Frequency of occurrence (%)

Yield (kg ha$^{-1}$)

Harvest Year

Probability of Exceedance (%)

Frequency of occurrence (%)

Environments

LFE
FE
HFE
Environment group occurrence varies by planting date and soil textural class.
Stress patterns in each environment group

Stress Index (ETa/ETp)

Days After Emergence

Yield (kg/ha)

Stress Patterns
Key messages

• Stress-free conditions occur 14 % overall (current strategy)
• Additional impact in 42 % area could be achieved if focus extends to reproductive stress
• Soil texture / PASW has a large impact on environment occurrence
• Early planting reduces the occurrence of least favorable environments.
Further work:

- How do the groups and stresses vary with climate change?

2041-2065

- We know there is yield gap (e.g. median Ya in HFE=2,700 kg ha⁻¹, median Yp=3,200 kg ha⁻¹). How can we determine its causes?
Data-driven agronomy in Colombian rice production systems
Towards a data-driven agronomy

- Imported technology
- Broadly adapted technology
- Regional adapted agronomy
- Big Data Methods + Data-driven Agronomy

Years

Yield (t/ha)

19XX

2015
Towards a climate site-specific management system

Delerce et al. (in prep.)
• Leveraging farm-level databases designed for various purposes

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Years of data available for the study</th>
<th>In Saldaña (lowland irrigated)</th>
<th>In Villavicencio (rainfed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Harvest monitoring</td>
<td>2007 to 2014</td>
<td>945</td>
<td>269</td>
</tr>
<tr>
<td>(b) National Rice Survey</td>
<td>2007 to 2012</td>
<td>95</td>
<td>28</td>
</tr>
<tr>
<td>(c) Sowing date experiments</td>
<td>2012 to 2013</td>
<td>200</td>
<td>79</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1240</strong></td>
<td><strong>376</strong></td>
<td></td>
</tr>
</tbody>
</table>

• And national [public] weather datasets
• Using machine-learning methods to
  – To develop understanding of cropping system response to climate
  – Assess climatic (Yw, Yp) potential yield and develop recommendations (varieties)
• Conditional Inference Forests (CIF) models explain ~30% farm-level yield variability

<table>
<thead>
<tr>
<th>Model</th>
<th>Observations</th>
<th>Runs</th>
<th>Average R-squared</th>
<th>R-squared standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saldaña – F733</td>
<td>254</td>
<td>100</td>
<td>29.6%</td>
<td>8.28</td>
</tr>
<tr>
<td>Saldaña – F60</td>
<td>150</td>
<td>100</td>
<td>41.9%</td>
<td>8.71</td>
</tr>
<tr>
<td>Saldaña – Lagunas</td>
<td>187</td>
<td>100</td>
<td>4.5%</td>
<td>3.47</td>
</tr>
<tr>
<td>Villavicencio – F174</td>
<td>134</td>
<td>100</td>
<td>28.7%</td>
<td>10.9</td>
</tr>
</tbody>
</table>

**ARTICLE**

Climate variation explains a third of global crop yield variability

Deepak K. Ray¹, James S. Gerber¹, Graham K. MacDonald¹ & Paul C. West¹
Lowland irrigated (Saldaña) – F733

Rainfed – F174

For rice: based on Peng et al. (2004) PNAS

Ramirez-Villegas et al. (2015) JXB
• Spatio-temporal climate pattern grouping using daily data (dynamic time warping, DTW)

Delerce et al. (in prep.)
• Identifying a ‘best-performing’ variety was not always possible, but could be done in most cases

• Variety-specific recommendations available from growers association

Delerce et al. (in prep.)
Conclusion and future work

• Farm-level data in conjunction with weather data allowed producing tailored recommendations for raising productivity

• Future work includes the combined use of these models with seasonal weather forecasts to provide management recommendations.
Preliminary results on stochastic frontier analysis of technical efficiency
Estimating technical efficiency through stochastic frontier models

Arango, Ramirez-Villegas et al. (in prep.)
Data and methodology

- Farm level data from survey:
  - yield,
  - farm size
  - N and P app. rates
  - number of fertiliser applications
  - man hours
  - machine hours
- Weather data
- 771 farms (509 irr. lowland, 262 rainfed)
• Modelled frontier (potential) yield rainfed rice:
  – 0.18 % per 1 % increase in N
  – 0.08 % per 1 % increase in seed quantity
  – -0.1 % per 1 % increase in man labour hours (these are used mostly in harvest)
  – Variety: 0.01 - 0.27 % per switch
• Modelled frontier (potential) yield rainfed rice:
  – 0.04 % per 1 % increase in P
  – 0.07 % per 1 % increase num. fert. applications
  – -0.12 % per 1 % change in distance to market
  – Variety: 0.02 – 0.10 % per switch
  – Highly environment-specific