Transitioning Cereal Systems to Adapt to Climate Change

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Global challenges and opportunities for adaptation of cereal systems in sub-Saharan Africa

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Utilizing crop models as integrating platforms

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Content

- Why use models?
- Key questions
- Hierarchy of scale
- What extension wants to know
- Knowledge gaps & integrating what?
- Framework & user interactions

Why use models?

- Understanding processes, patterns
- Identifying knowledge gaps
- Converting data into knowledge (using tools)

Models (or tools) should enable:

- **An actionable decision to be made by someone**
- **Out-scaling of knowledge & technology**

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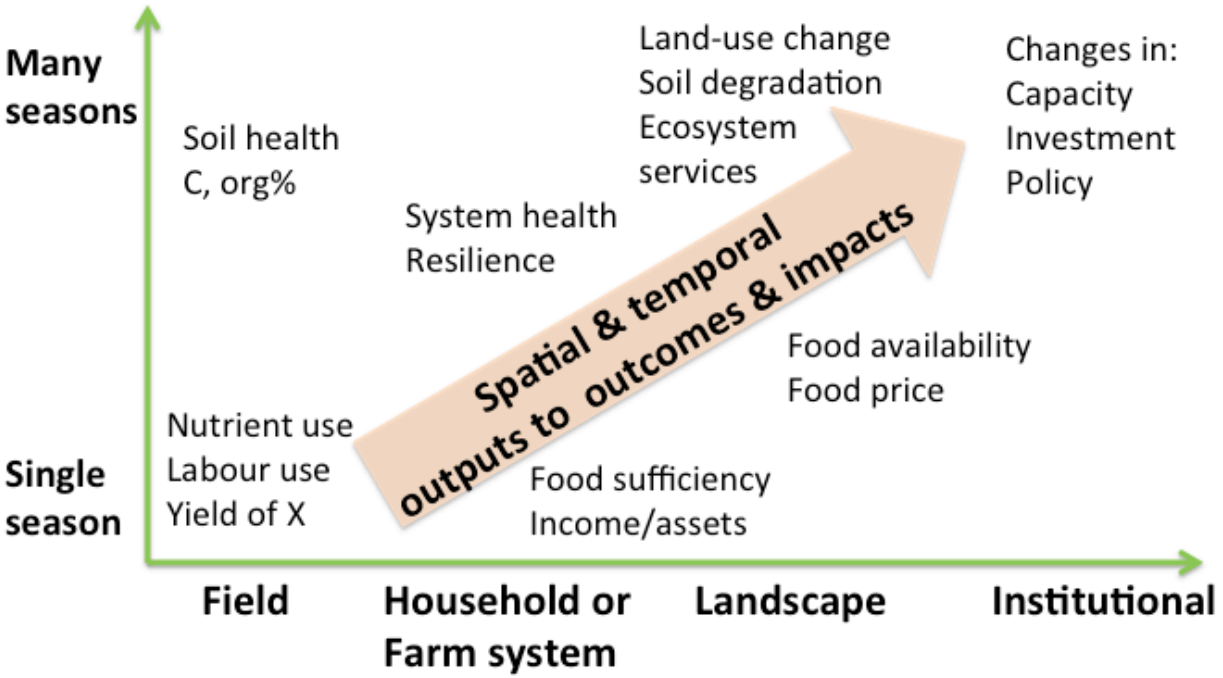
Key questions

- Who is the user?
- What question(s) do they want answering?
- At what scale?
- What is the product?
- What is the process (with users)?

- What are the gaps?

Hierarchy of scale & time

- Molecular
- Biochemical
- Cellular
- Organ
- Plant
- Community
- Pixel
- Landscape



+ temporal & spatial indicators

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Agronomy matters: what extension wants to know (my bias)

At scale (100,000s farmers) in maize-based systems in Kenya & Rwanda:

- 12-26% gain with organic matter (composted maize stover)
- 7-26% gain with timing fertilizer by growth stage cf plant ht
- 2-40% gain with lime microdose in planting hole
- 11-15% gain topdressing with urea cf CAN
- Marginal – choice of variety

Can crop (cropping system) models (help to) answer these (& many more) questions?

How will this knowledge be shared?

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Crop management/adaptation wish list

- Land/soil management (contours, *in-/ex-situ* water mgt)
- Pre-rain land preparation (1° & 2° tillage)
- Variety selection (adaptation, quality traits)
- Planting (timing, arrangement, density, depth)
- Cropping system (sole, intercrop, relay, cover crops, rotation…)
- Nutrient mgt (rate, time, method, type)
  - Organic, basal, top-dress, acidity
- Weed mgt
- Pests & diseases (identification & treatment)
- Post-harvest mgt

Knowledge gaps; integrating what?

White et al. 2011 Methodologies for simulating impacts of climate change on crop production

Challenges:

- $[CO_2]$
- Soil properties
- Temperature extremes (heat)
- Uncertainty/risk
- Genes

Today:

- ?
- Higher resolution data: but phosphorus, micro-nutrients
- More models include high temperature responses
- Climate & crop model ensembles
- Genotype specific parameters & gene networks

Pests (& diseases)

Dynamics, epidemiology & interactions with the crop rarely studied

Ecology	Altitude	Observed 2013	Predicted 2055
Highland tropical	>1600	0	8.3
Moist transition	1300-1600	11.1	12.4
Dry mid-altitude	1000-1300	11.1	17.9
Lowland tropical	<1000	22.7	28.1

Impact climate change on stem borer damage (% yield loss) in maize in Kenya Source: Mwalusepo et al. 2015

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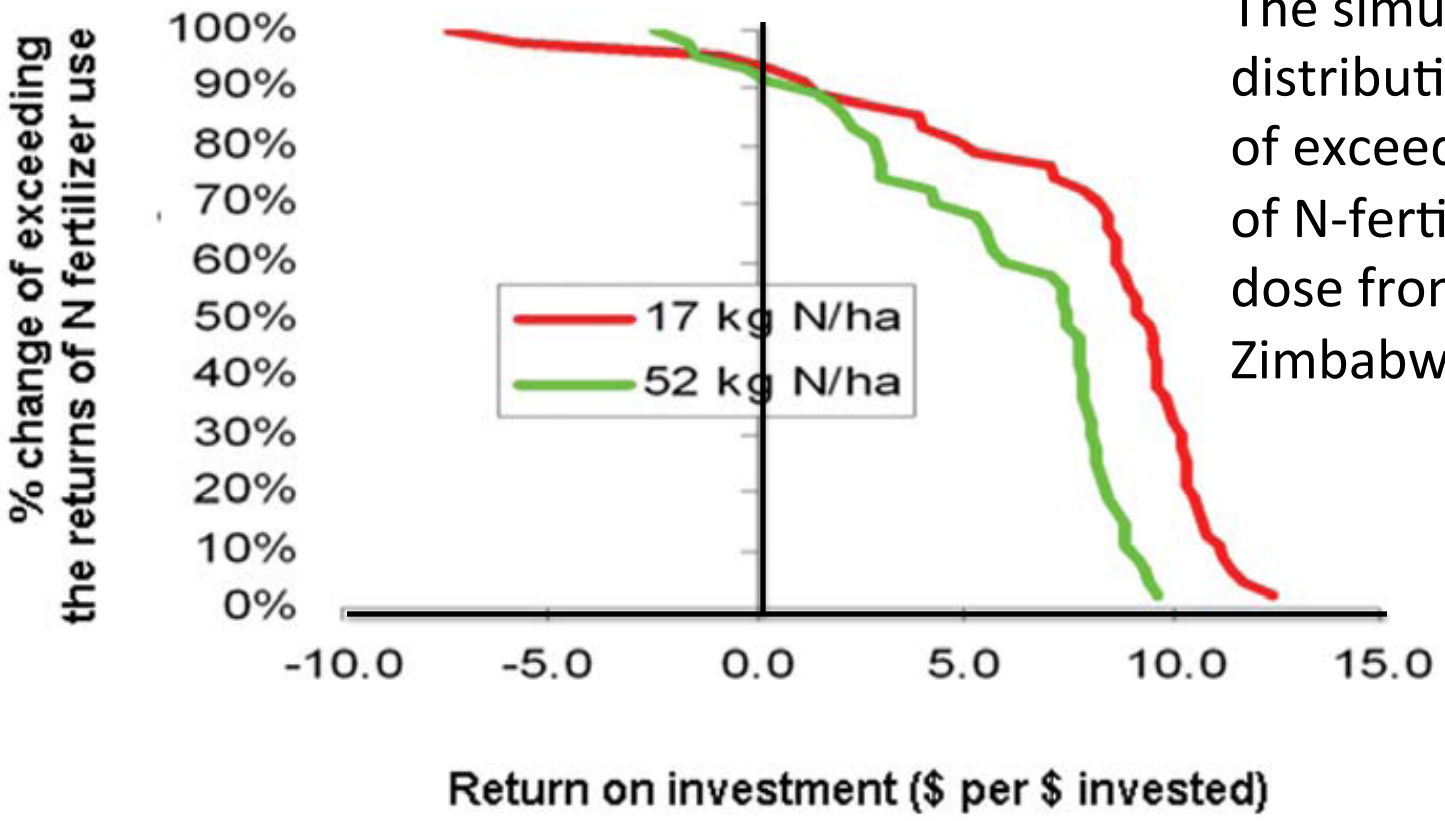
Farmers need information on productivity, profitability & risk



The simulated distribution of % chance of exceeding the returns of N-fertilizer micro-dose from Masvingo, Zimbabwe

Economists model '**downside risk**'. Menale et al. Agric. Econ. 2015

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Gender-relevant outputs

Women

- High dependence natural resources
- Control less land, tenure less secure, land poorer quality
- Less likely to use inputs
- Less access to extension
- *Different preferences for varieties*

Parameter (all %)	Ethiopia	Bangladesh
Female share of population	50.2	49.4
Agricultural share of economically active women	73.5	57.4
Share of rural households that are female headed	20.1	n/a

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Quality & nutrition outputs

Parameter (all %)	Ethiopia	Bangladesh
Share of underweight children in rural households	49	40

- Crop/livestock systems are very important & provide human & livestock food, feed & fodder
- Nutrition/quality a major development agenda
  - Zinc, iron
  - Pro-vitamins
  - Protein
  - Dietary diversification

Climate change impacts on quality?

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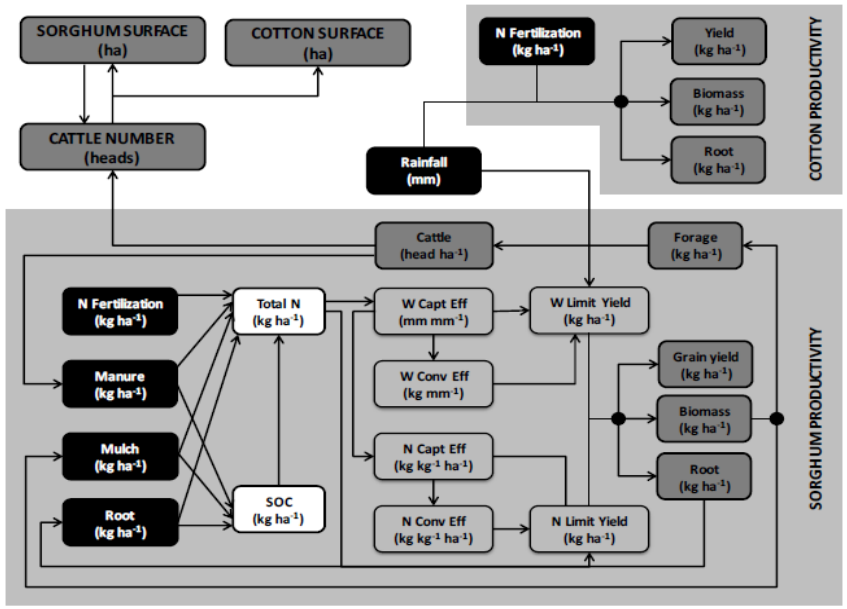
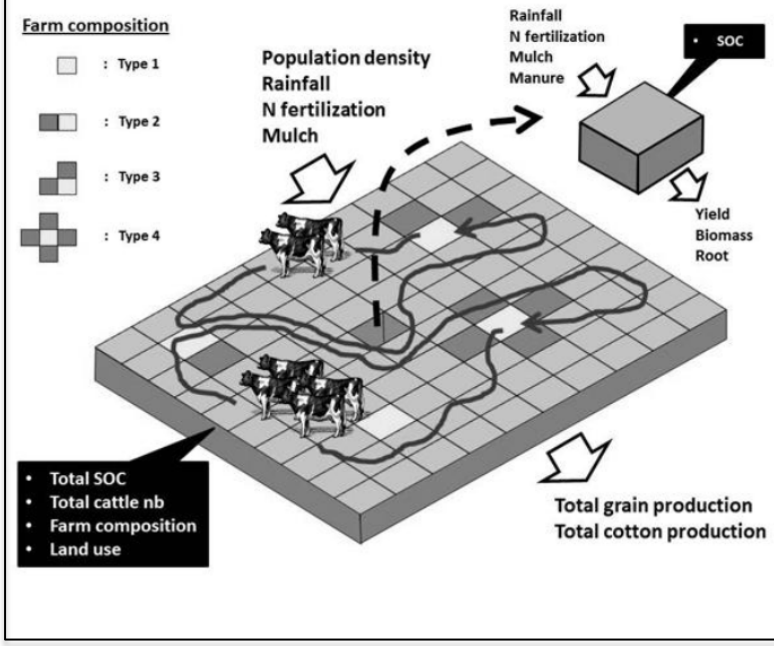
Integrating crop models into trade-off & scaling model frameworks

CLIF – Crop-Livestock Interaction at Farm-scale model



SABLE – Simplified Agent-Based Land-use Explorations model



APSIM model output; decisions for agent-based model from PRA & surveys. Baudron et al. various

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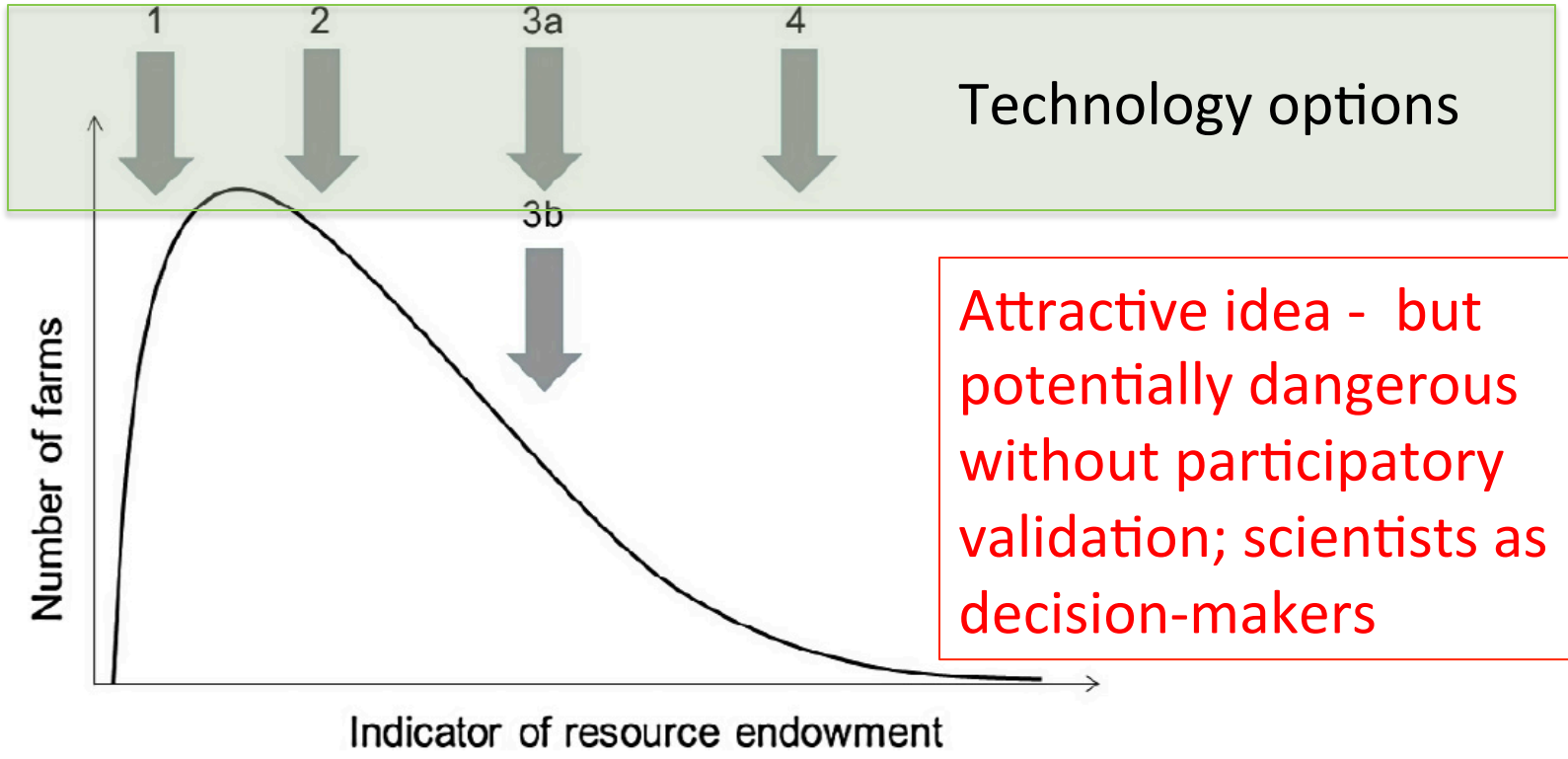
Options by context; models & decision-support tools to target technology



Attractive idea - but potentially dangerous without participatory validation; scientists as decision-makers

Source: van Wijk 2014

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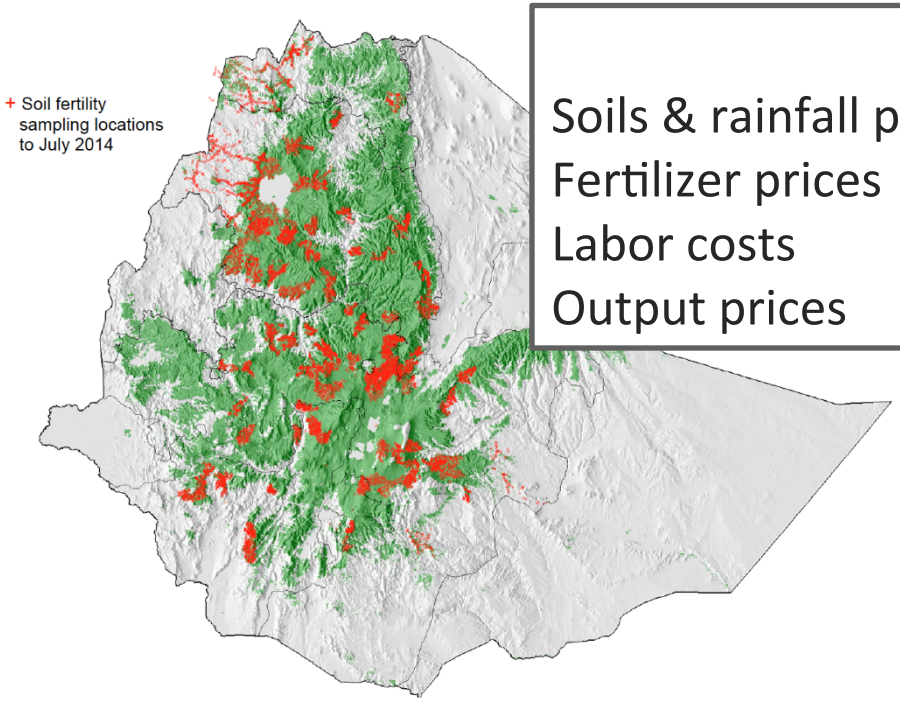
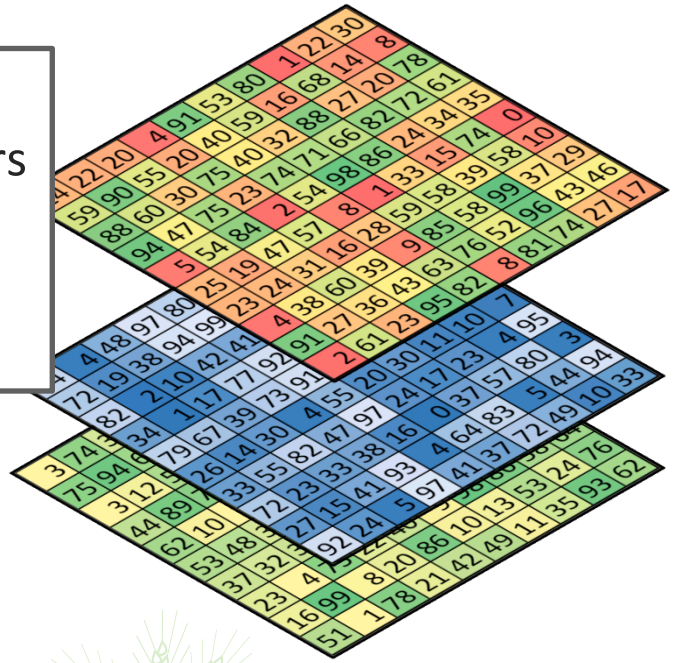
Geospatial ex-ante modeling frameworks

- Spatial resolution is improving all the time (e.g. 250m for soils; <10km climate)
- But many decisions will be made at coarser resolution (e.g. variety adaptation; fertilizer blend/type)



Soils & rainfall parameters
Fertilizer prices
Labor costs
Output prices



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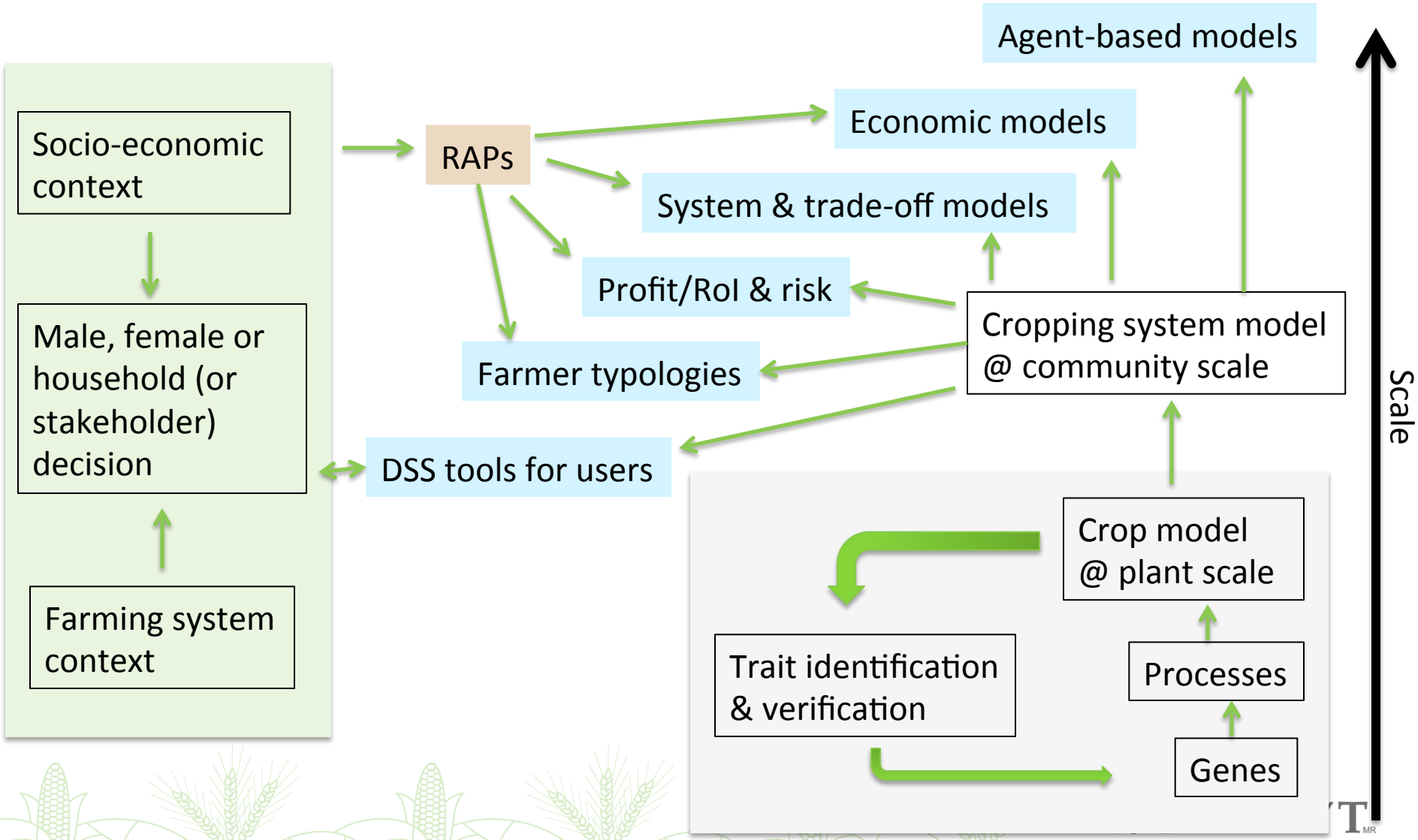
Interaction with users

- RAPs & interactive processes with stakeholders (e.g. CCAFS, AgMIP)
- Participatory crop modelling (APSIM group, especially climate variability & change)
- Co-development of decision-support tools (e.g. nutrient & irrigation management)

See: Webber et al. What role can crop models play in supporting climate change adaptation decisions to enhance food security in sub-Saharan Africa? Ag Sys 2014

Crop model integration platform or framework



Models & applications for intermediate users or translators

Outcome

Output target

Process research

Enabling & analysis tools

Technology generation

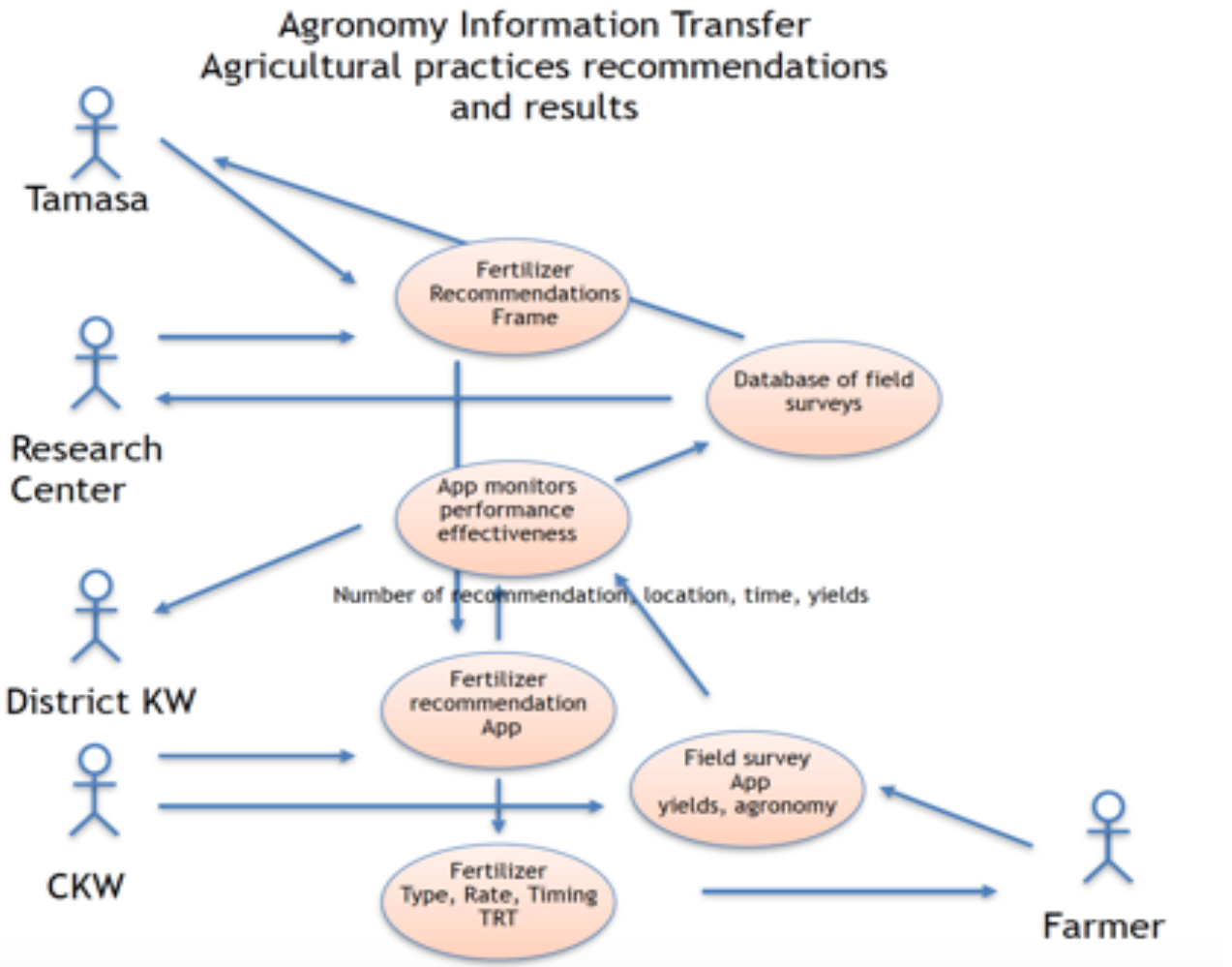
End users

Intermediate users & translators

Modeling

Analysis & synthesis

Data



CKW - community knowledge worker

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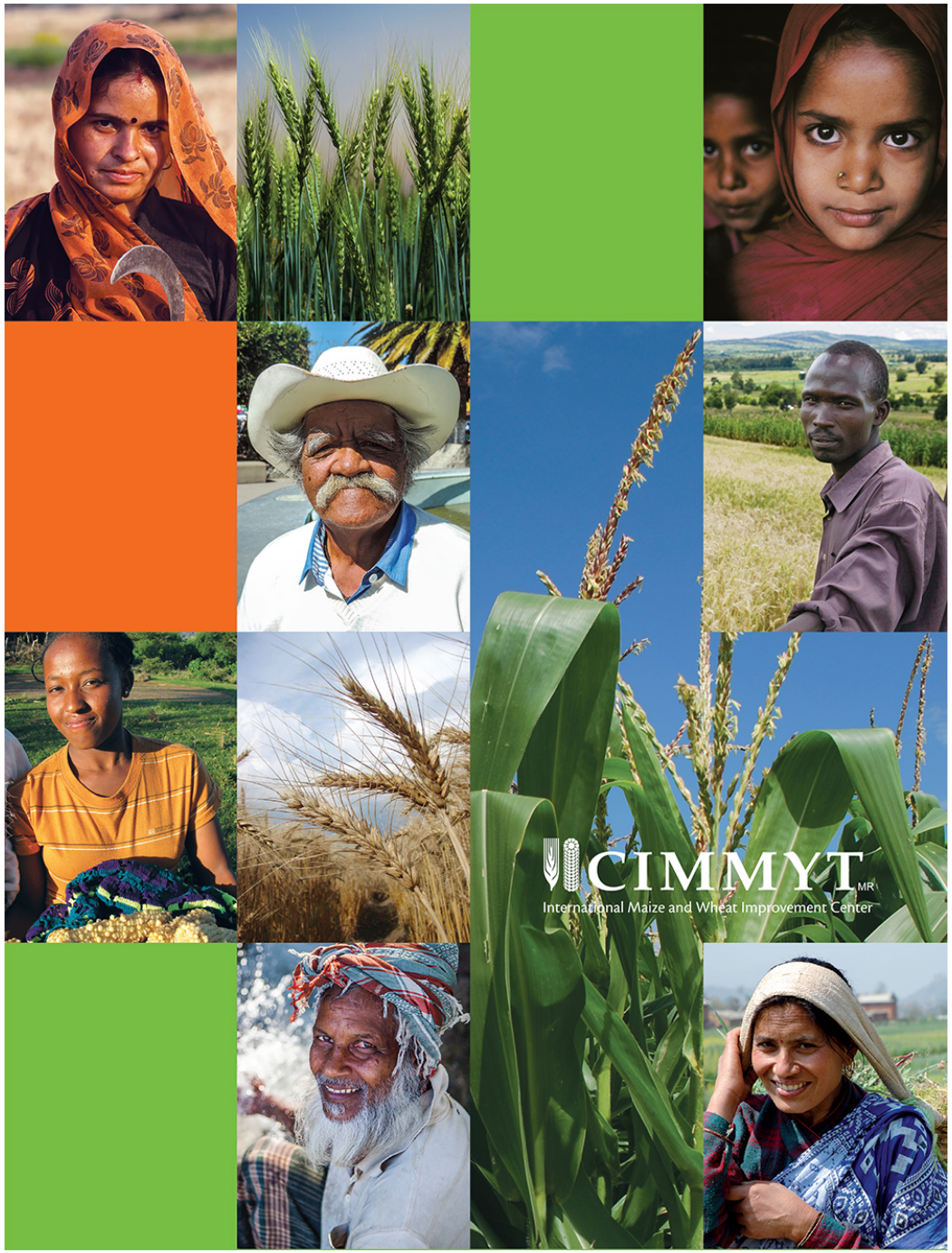

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Thank you!

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Washington State University

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