Symposium ISTRC

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Ex ante assessment of climate change adaptation strategies in resource-poor countries: study cases from East Africa

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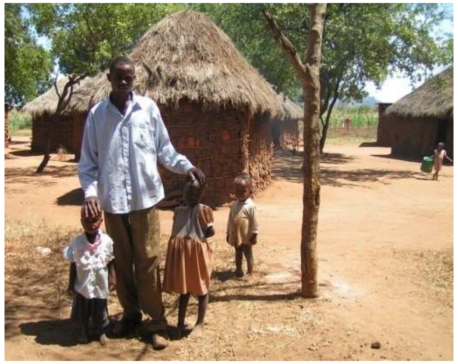
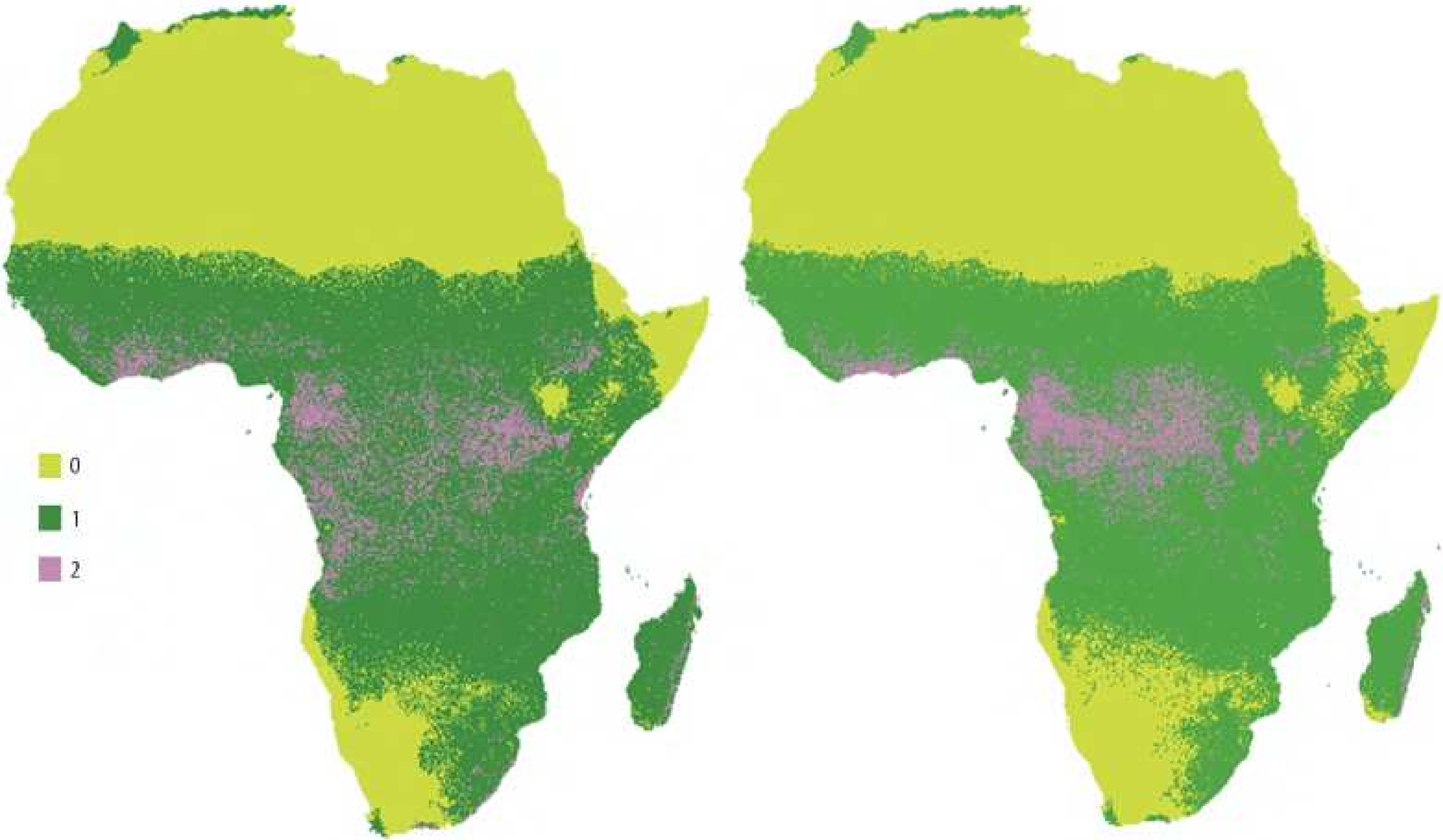
Climate change and adaptation in SSA

IPCC Fourth Assessment Report (2007):

- CC predicted to have most negative impact on poorest people in SSA
- Impacts inevitable for next 30 years, regardless of global mitigation efforts
- Crop yields may fall by 10-20% by 2050, more severe in some areas
- CC will aggravate existing challenges to food security, economic development, health,…
- Adaptation strategies absolutely necessary to mitigate CC impacts


Number of growing seasons

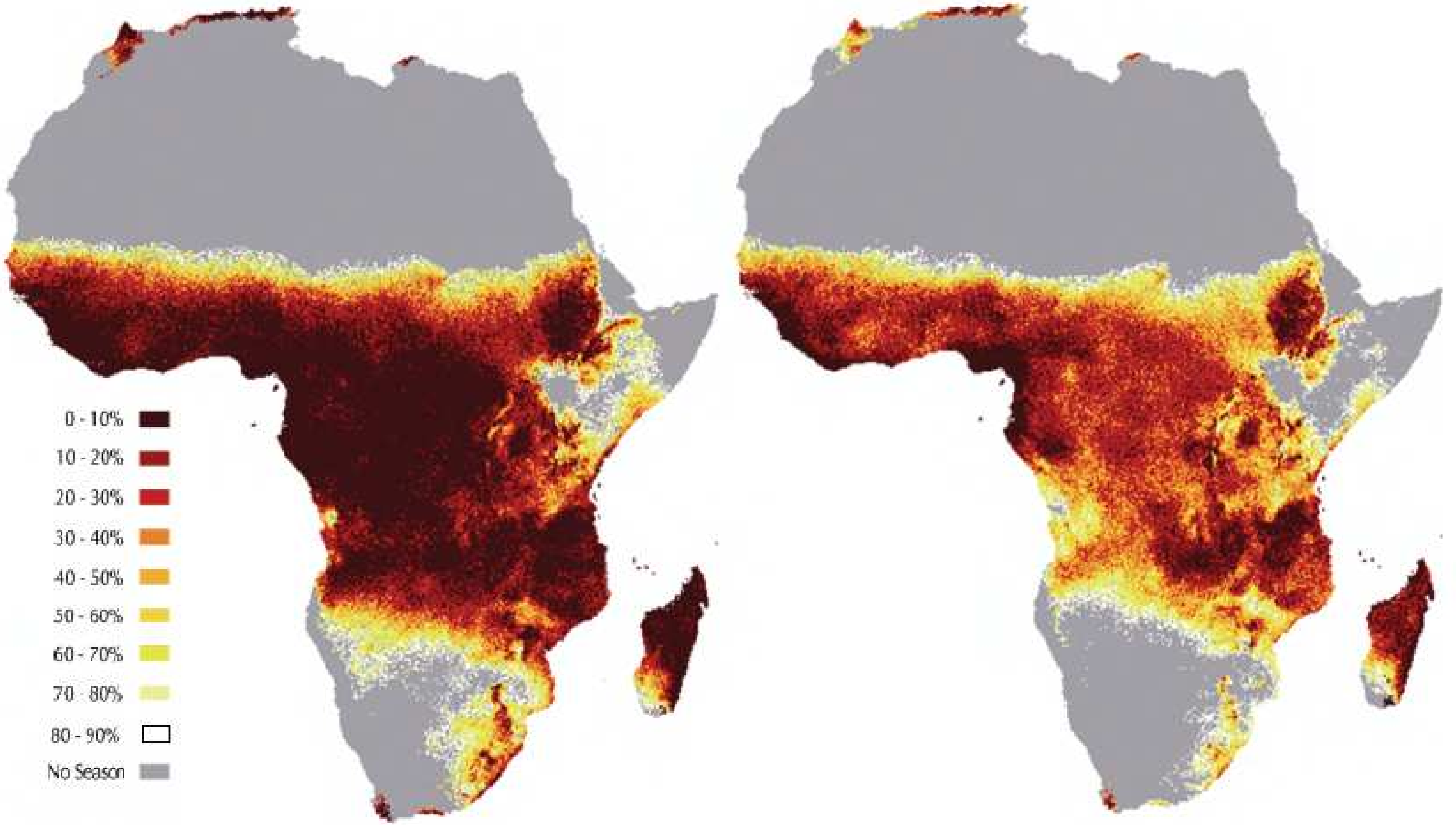


Current conditions

2050 (HadCM3, A1)

Source: Thornton et al., 2006

Percentage of failed seasons



Current conditions

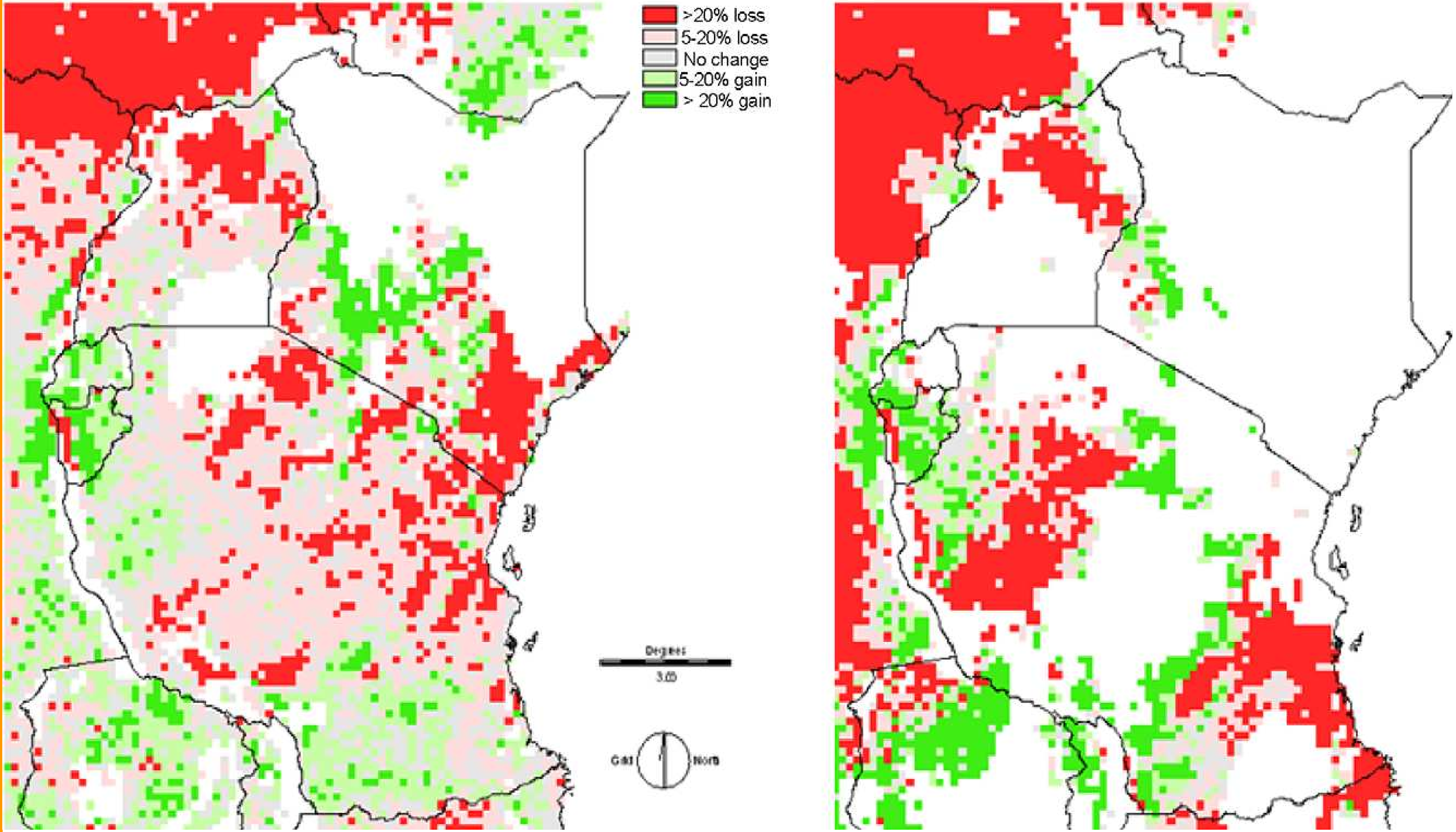
2050 (HadCM3, A1)

Source: Thornton et al., 2006

Climate change and adaptation in SSA

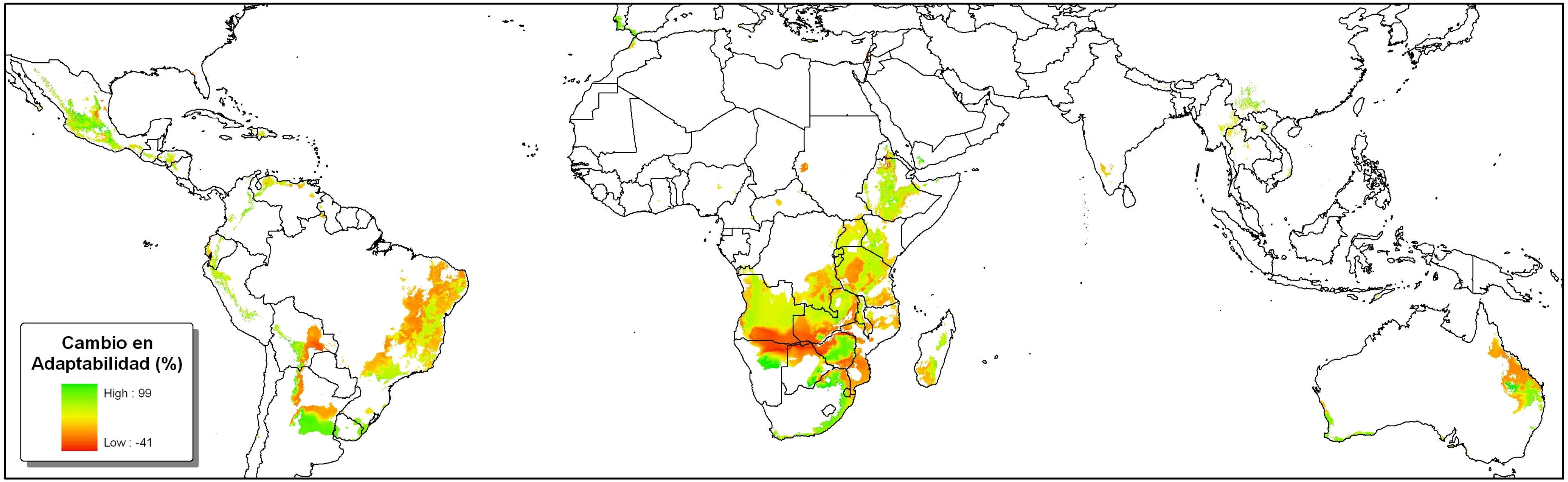
- Current research:
  - Downscaled GCM or RCM projections
    - Uncertain and highly variable (esp. rainfall, from 2050,…)
    - Different scenarios (~ world economy, emissions,…)
    - Feedback with land cover
  - Crop and livestock models: simulate effects on future productivity
    - Usually potential productivity (- management, diseases,…)
    - Often not parameterized for local varieties and conditions or no model at all (e.g. fruits, fodder crops,…)
    - No ‘mixed system’ models (intercropping, crop-livestock interactions)
  - Adaptation strategies:
    - Single crop, aggregated results, ‘representative farm’….
    - Hiding large variability and too general for locally specific adaptation strategies in semi-subsistence smallholder systems in SSA
    - Data intensive (high resolution bio-physical, socio-economic)

- **Maize and beans yield by 2050** **(Thornton et al., 2009)**
  - **DSSAT crop models**
  - **HadCM3 model, A1 scenario**

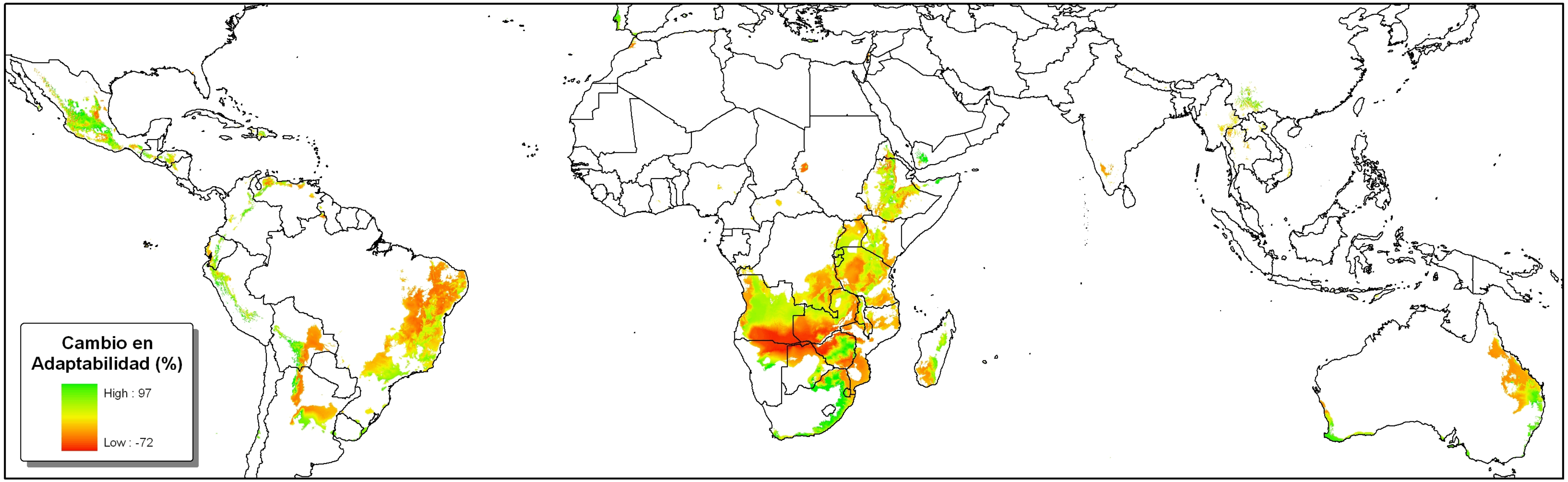


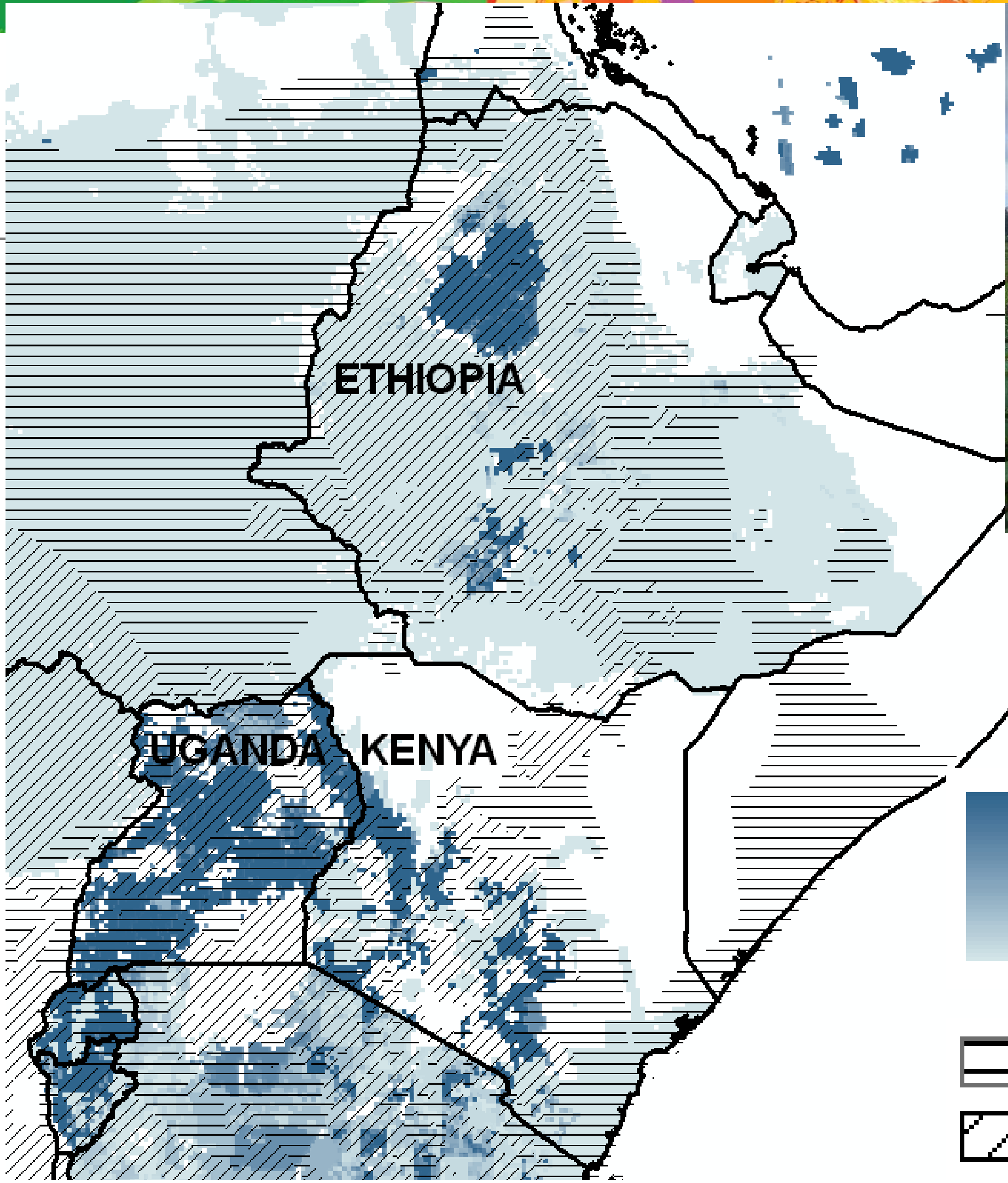
- **Changes in potato and sweet potato suitability by 2050** **(Jarvis et al., 2009)**
  - **ECOCROP model**
  - **Average of 18 GCMs, scenario**

Change in suitability 2020



Change in suitability 2050



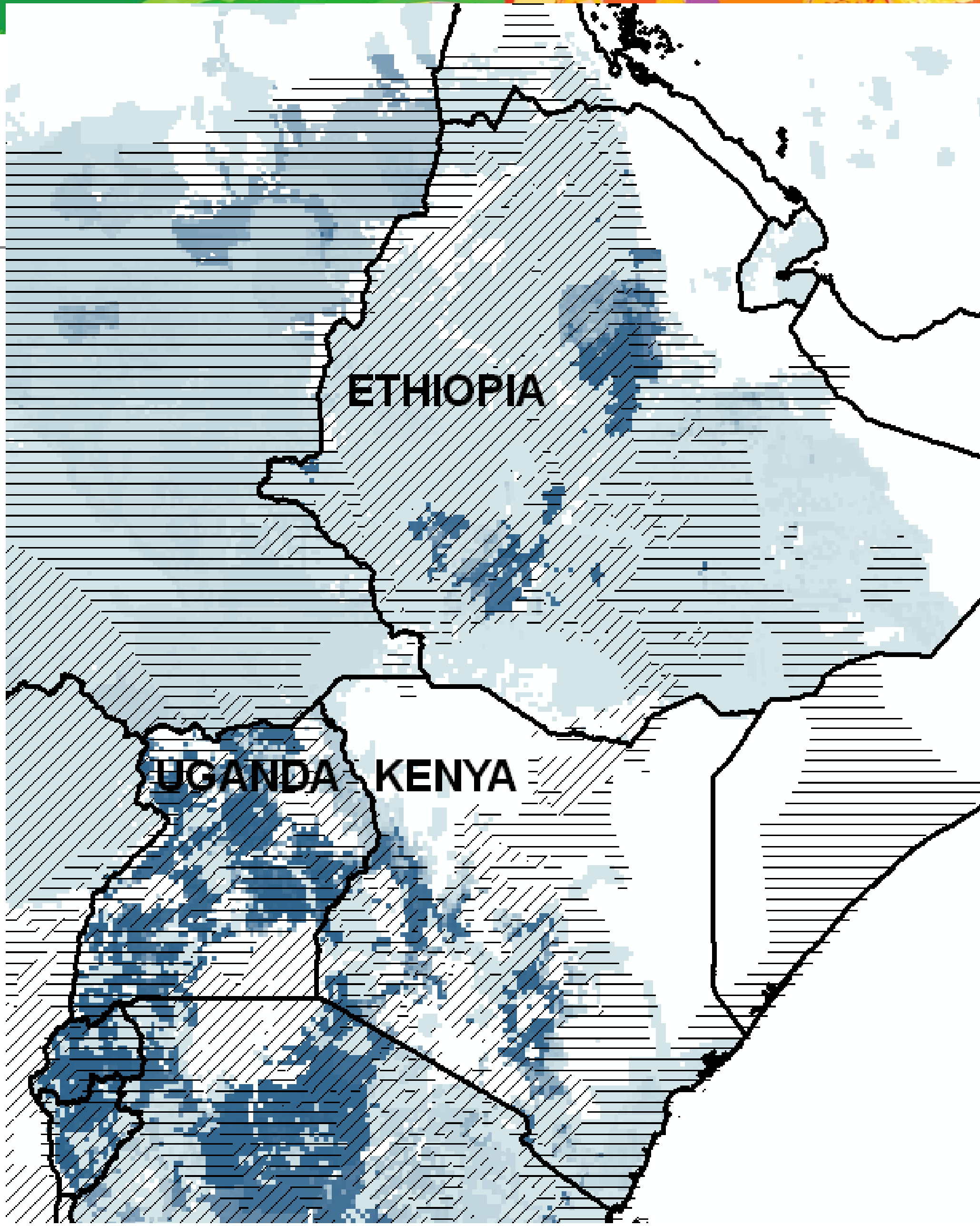


Potatoes

High
importance
Low

>20 % loss in LGP

5-20 % loss in LGP



Sweet Potatoes

Climate change and adaptation in SSA

In summary:

- **Adaptation strategies in smallholder agriculture context:**
  - **Need to disaggregate to agricultural system / household level!**
  - **Bio-physical & socio-economic aspects**
    - **Complex, data demanding, time consuming,…**
    - **Problem of ‘quantification’ of adaptation strategies**
  - **Development of simple, reliable enough methods to *ex ante* assess adaptation strategies (technologies, policies)**
    - **Capture key components of system and variability (sensitivity analysis)**
    - **Realize but minimize uncertainties and assumptions**
    - **Data / model scarcity: analogue approaches, empirical equations,…pragmatic tools!**

Research methodology:

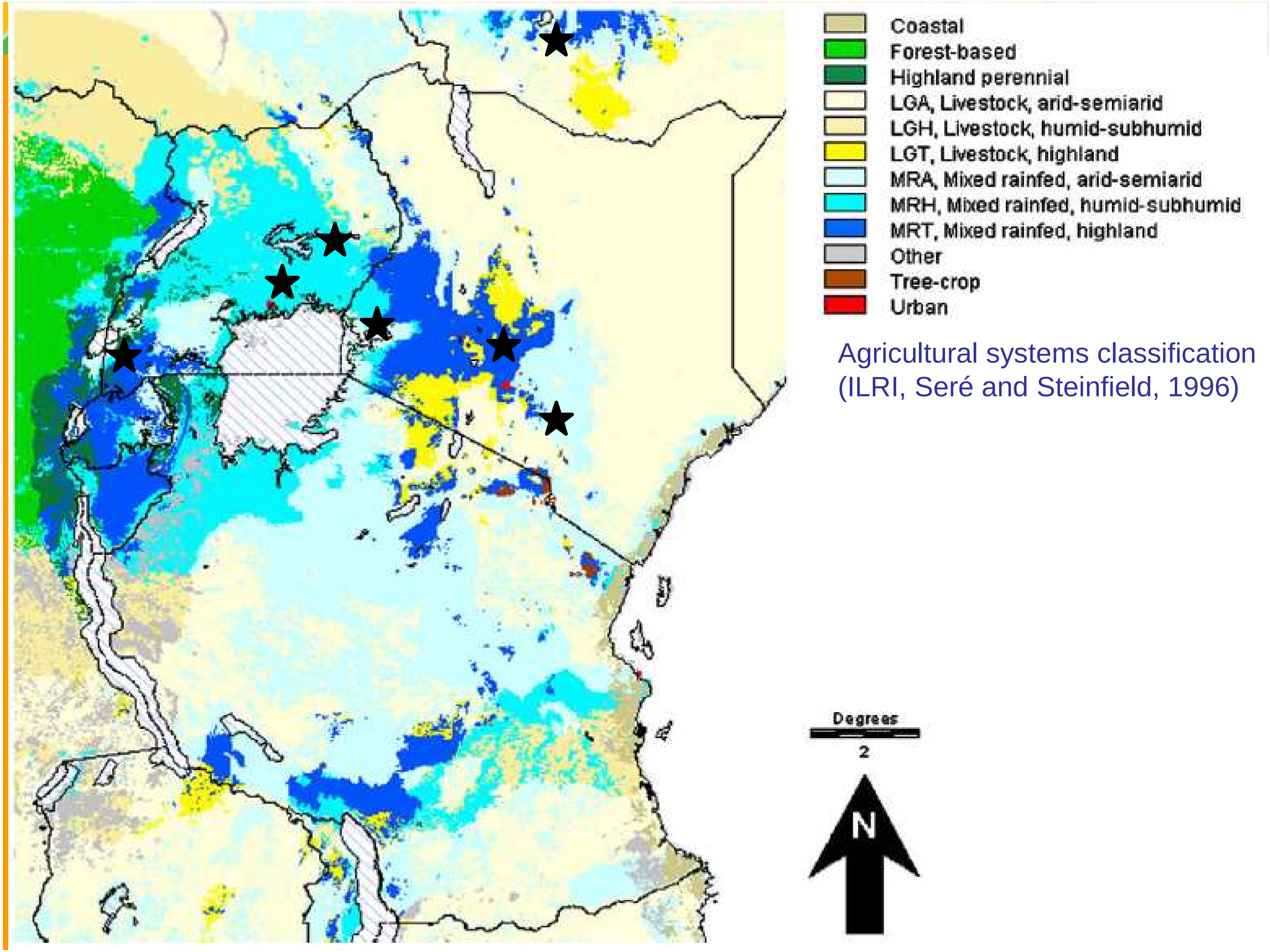
Tradeoff Analysis (TOA) framework

- Assessing environmental and economic feasibility of alternative technologies and policies

- Linking stakeholders with research teams (‘reality check’)

- Using (semi-)quantitative impact assessment tools and models

- Using site specific (often readily available) data to capture **variation** in farm population (land and resource allocation, productivity, off farm income,….) at the **agricultural system level**
↔ ‘representative farm’ approaches



Agricultural systems classification (ILRI, Seré and Steinfield, 1996)

Tradeoff Analysis methodology for climate change impact assessment

TOA TRADEOFF ANALYSIS

farmers, extension workers, local community leaders

- Public stakeholders
- Policy makers
- Scientists

Identify indicators and scenarios

poverty rates
soil productivity
nutritional status

dual-purpose sweet potato, drought tolerant potato
improved livestock management

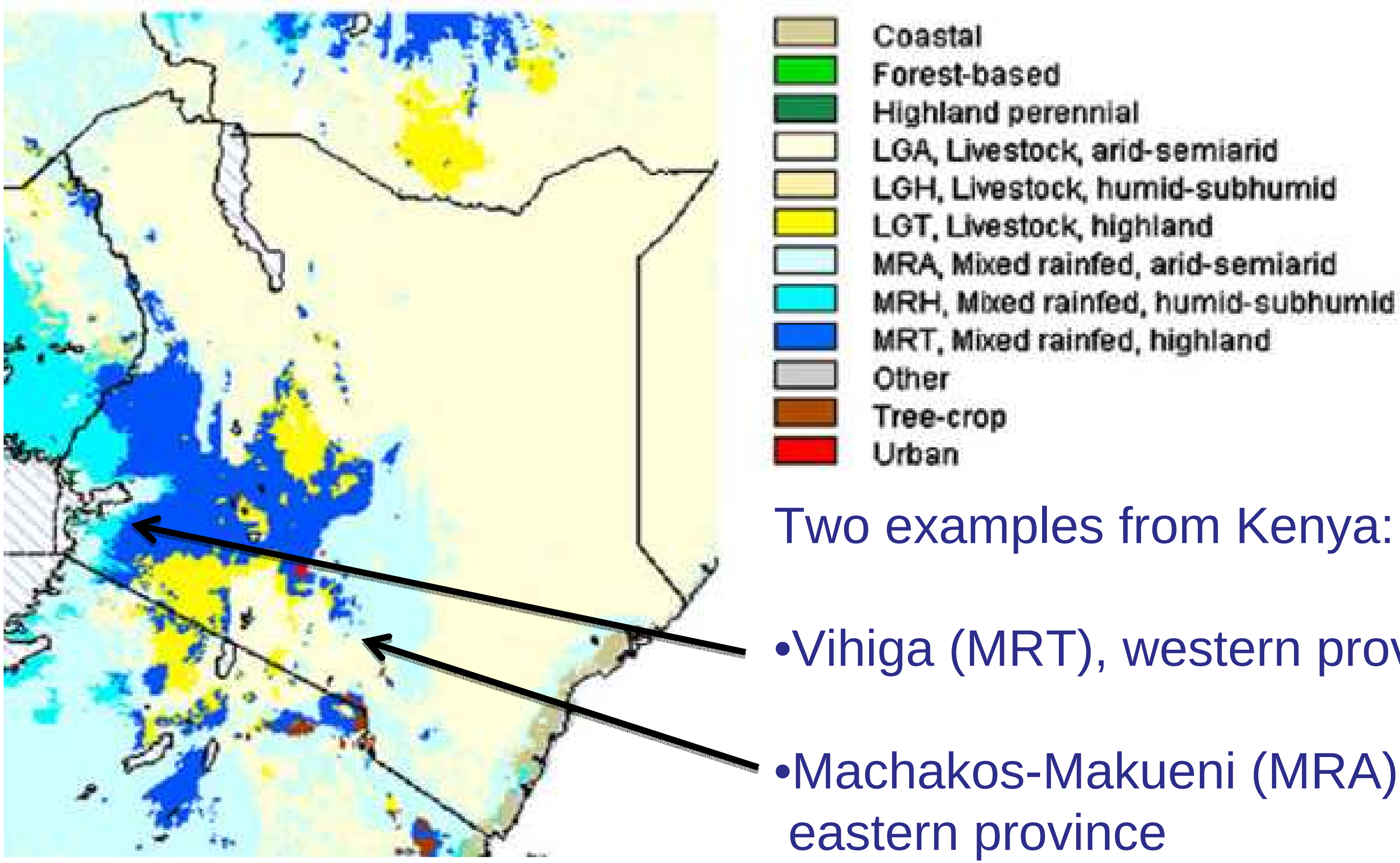
investment in transportation infrastructure
Payment for environmental services (C seq.)

Coordinated Disciplinary Research

- Downscale GCM and RCM output
- Prepare crop and livestock models
- Prepare economic data and models
- Prepare environmental data and models
- Set up scenarios for simulation
- Implement analysis using TOA software

Evaluate results with stakeholders

Application



Two examples from Kenya:

- Vihiga (MRT), western province
- Machakos-Makueni (MRA), eastern province

Study area: Vihiga, western Kenya

Alt. (m)	Prec. (mm)	Temp.(℃)	Main crops
1300-1500	1800-2000	14-32	maize, beans, sweet potato, Napier

- Mixed crop-livestock system, semi-subsistence
- Depleted soils, small farms
- One of the poorest districts in Kenya (60% on <$1/day)

Number of farms	119
Number of cropping seasons*	207
Number of farms having livestock	112
Total cultivated area (ha/season/farm)	0.35 (0.31)
Tropical Livestock Units** (TLU/farm)	1.69 (1.18)
Milk production (liter/day)	2.7 (2.8)
Lactation length (days)	261 (23)

Cropping system	Maize-Beans	Napier Grass	Mixed
% of farms growing crop	80.9	56.3	61.3
Number of cropping seasons***	154	112	110
Area (ha/season/farm)	0.24 (0.21)	0.15 (0.18)	0.17 (0.16)
Crop yield (kg/ha)	1512 (1269)	33321 (22945)	4265 (2818)
Net returns (KSh/ha)	13428 (16902)	21197 (23280)	26188 (21042)

* Total of observed cropping seasons in data set. 89 farms have two cropping seasons, 29 have one.
** 1 TLU = 250 kg of body weight.
*** Total number of cropping seasons where crop is observed.

Study area: Machakos, Eastern province

Alt. (m)	Prec. (mm)	Temp.(℃)	Main crops
400-2100	500-1300	15-25	maize, beans, veg., cassava

- Mixed crop-livestock system, semi-subsistence
- Depleted soils, small farms
- Terraces, small scale irrigation for vegetables

Tradeoff Analysis methodology for climate change impact assessment

1. Characterization of the current agricultural system
2. Simulation of effects of climate change on current system
3. Simulation of adaptation strategies

(e.g. Introduction improved varieties, payment for environmental services,...)

Towards reduced complexity modeling (‘Minimum Data’ approach):

- Data on land use allocation (crop area, yield, livestock,…) and net returns
- Experimental (on farm) yield data for DP SP
- Livestock feed characteristics (DM, energy, crude protein, harvest index)
- Empirical data on effect of feed quality on milk production
- Climate change projections
- Estimated effects of CC on crop yields (crop models, analogue approaches)

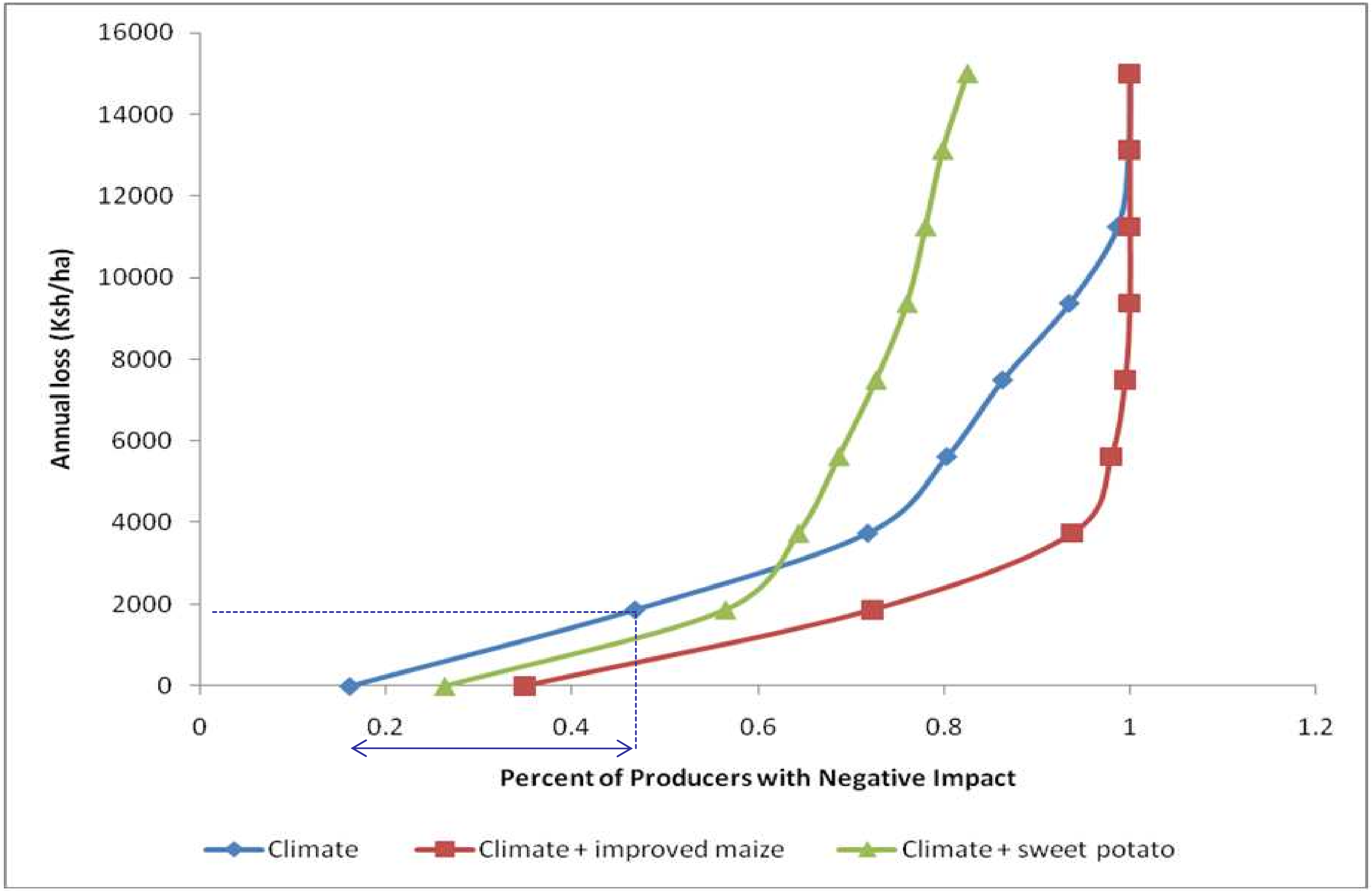
- **CC: Production changes per agricultural system** (Thornton et al., 2009)
  - **DSSAT crop models for maize and beans**
  - **Mean of four combinations of HadCM3 and ECHam4 GCMs, A1 and B1**
  - **Observed analogue productivity data for other crops (/sensitivity analysis)**
  - **Assumed no direct effect of CC on livestock productivity**

	National Production		MRT		MRH		MRA	
	2030	2050	2030	2050	2030	2050	2030	2050
Maize								
Burundi	9.1	9.1	14.4	18.1	−1.8	−8.8	–	–
Kenya	15.0	17.8	33.3	46.5	−4.6	−9.8	−1.1	−8.4
Rwanda	10.8	14.9	13.4	18.8	5.4	3.6	1.1	2.7
Tanzania	−3.1	−8.1	7.5	8.7	−1.6	−6.4	−5.1	−11.1
Uganda	−2.2	−8.6	4.9	3.1	−4.6	−12.9	−1.1	−6.3
Beans								
Burundi	21.8	23.7	29.0	35.9	5.2	−4.2	–	–
Kenya	14.2	16.7	18.2	23.6	0.3	−6.8	–	–
Rwanda	14.6	16.4	16.9	19.7	0.1	−4.7	–	–
Tanzania	6.7	−0.6	35.7	57.4	4.0	−5.0	4.5	−5.7
Uganda	−1.5	−18.1	11.0	4.0	−3.7	−20.8	5.7	−13.1

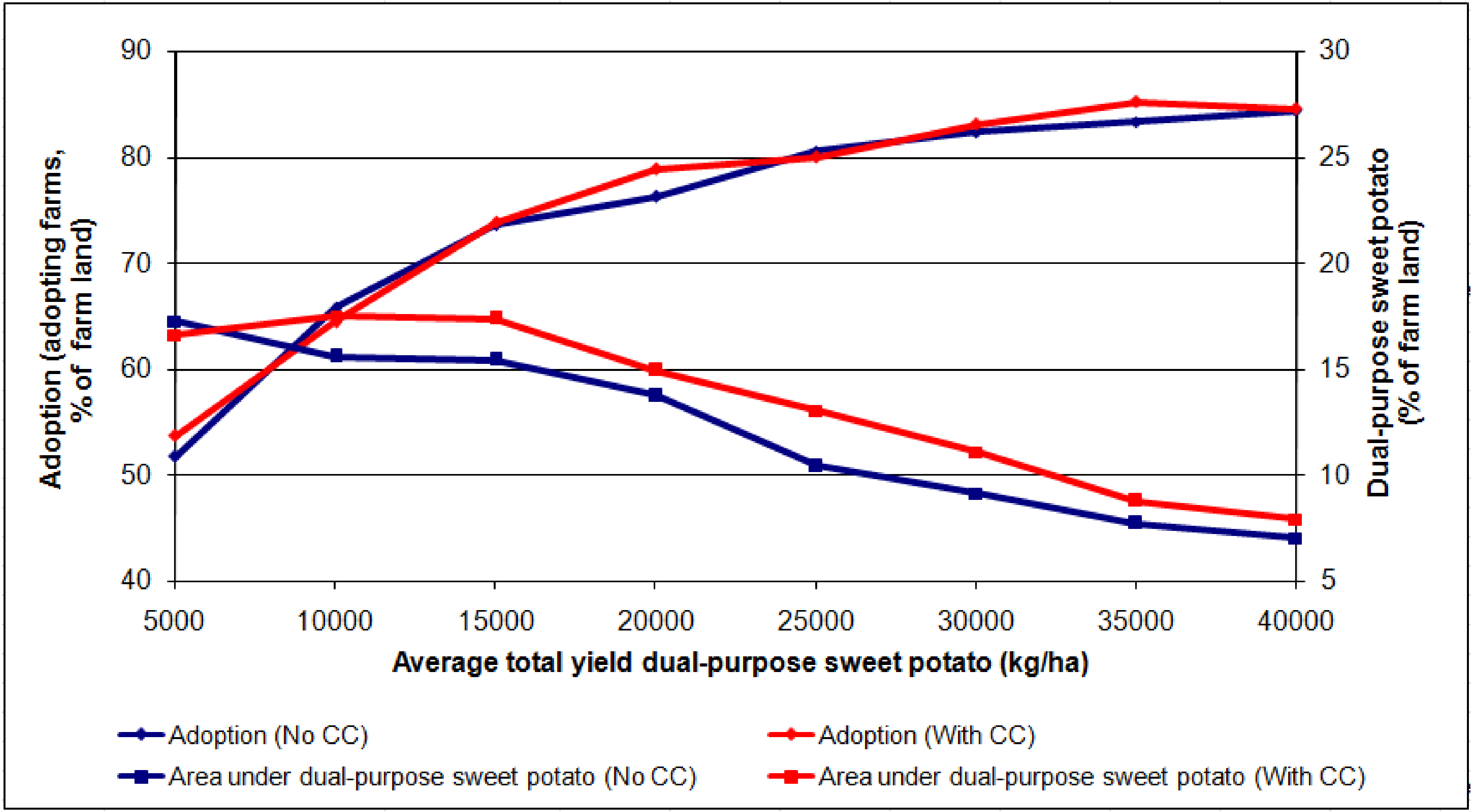
MRT, mixed rainfed temperate/tropical highland.
MRH, mixed rainfed humid–subhumid.
MRA, mixed rainfed arid–semiarid.

- **Adaptation strategies tested:**
  - **Machakos: - drought tolerant maize variety**
    - introduction of sweet potato
  - **Vihiga: - introduction of dual-purpose sweet potato**

Machakos: - drought tolerant maize - introduction sweet potato



Vihiga: - dual-purpose sweet potato



Conclusions

- Serious implications from CC in SSA, but not negative everywhere…
- Lots of issues and uncertainties in CC projections and methodologies to assess site-specific adaptation
- Need for simple, reliable enough methods to *ex ante* assess adaptation strategies at agricultural system / household level
- Minimum Data TOA approach proposed for rapid integrative analysis of adaptation options (being aware of limitations!)
- Two contrasting examples for different agricultural systems Kenya:
- Adverse effects of CC only partially offset by proposed adaptation strategies
- Some regions are predicted to benefit from CC
- Ongoing work to cover other agricultural systems in the region (potato and sweet potato areas in Kenya, Uganda, Ethiopia)

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