Impact of projected climate change scenario on production of maize:
Case study of Bloemfontein & Thaba Nchu districts

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20-23 November, 2012
**SANCID Symposium,**
Drakensberg, South Africa

Agricultural Model Inter-comparison and Improvement Project (AgMIP)

- To improve the characterization of the of **risk of hunger and regional food security under climate change and to enhance adaptation** capacity of developing and developed countries-**IPCC**

- Institutional human capacity building in climate change impact assessment

Southern Africa

*in development
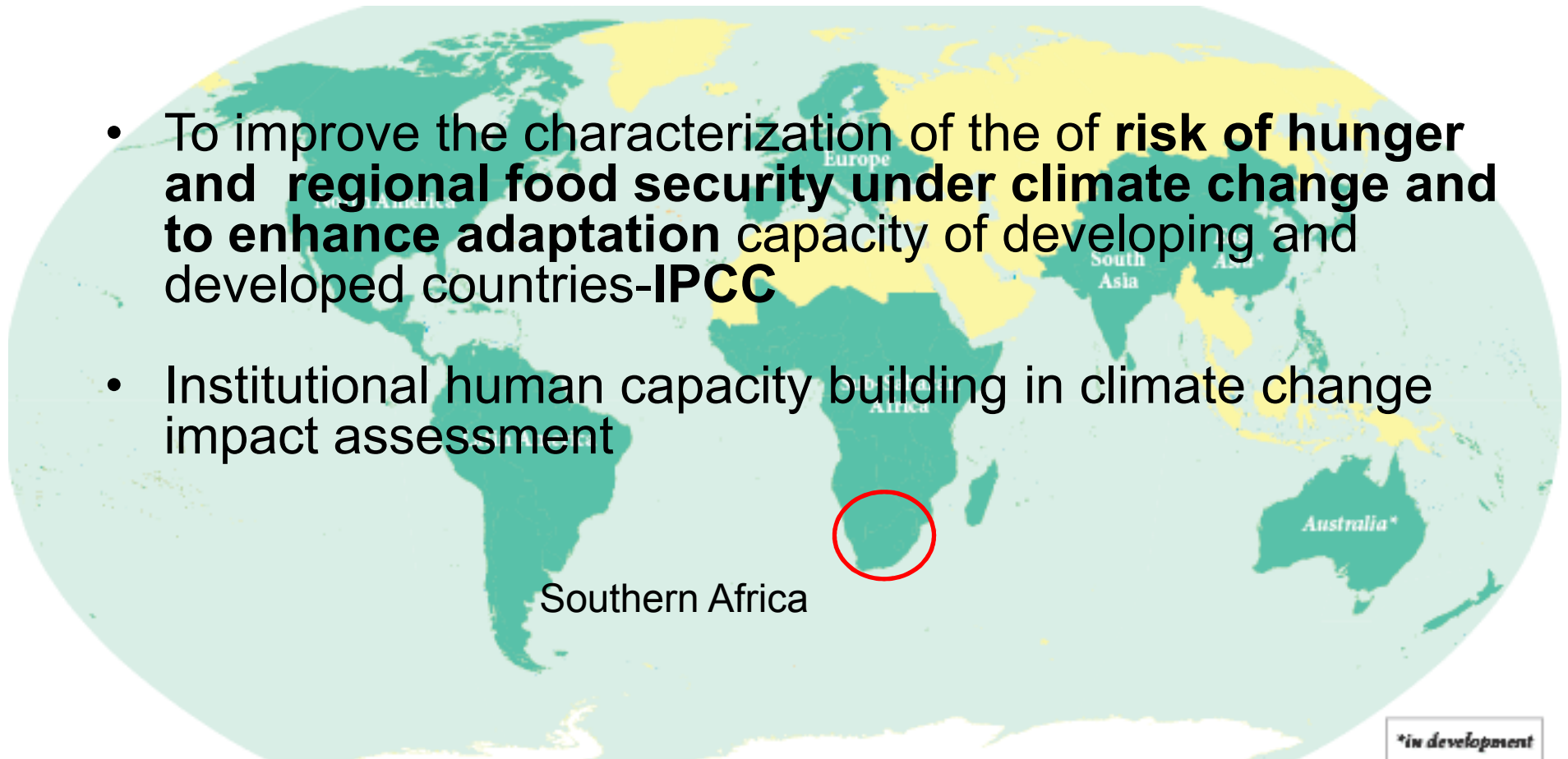
International effort linking the climate, crop and economic modeling communities to produce the next generation of climate impact projections for the agriculture sector

Background

- In the last three decades several biophysical (GCMs and crop models) and economic simulation models have been developed and used to assess the impacts of climate change (CC)

- Weakness on CC impact assessment:
  - **limited model inter-comparison** and **multi-model assessment** (Rosenzwieg et al 2012)
  - methods used to date on impact of CC and adaptation are not **well suited** to assess **socio-economic impacts** of CC and adaptation potential (Antle, 2012)
    - fail to represent heterogeneity and technological detail essential to analysis of adaptation

Sothern Africa Agricultural Model Inter-comparison and Improvement Project (SAMIIP)
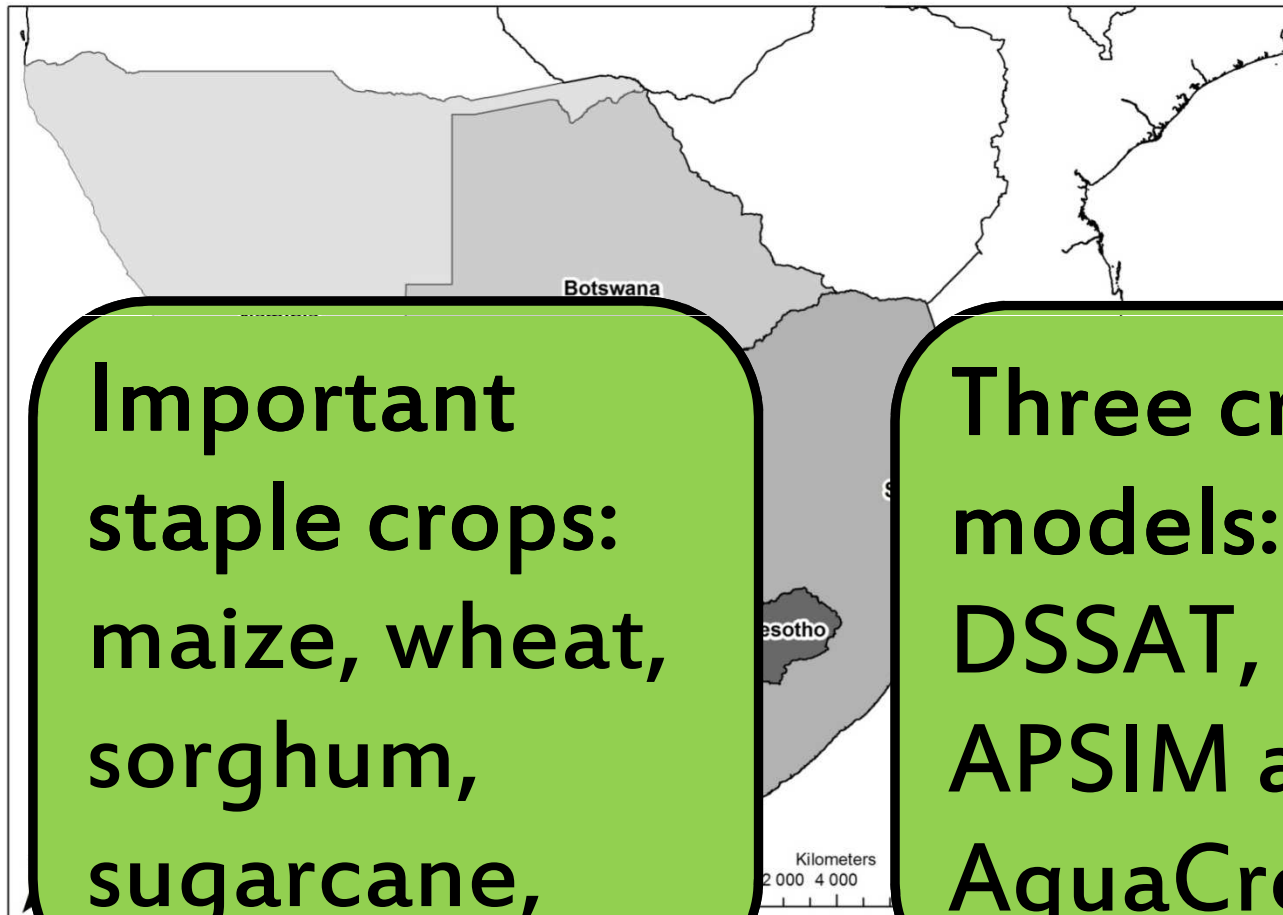
Important staple crops: maize, wheat, sorghum, sugarcane, sweetpotatoe

Three crop models: DSSAT, APSIM and AquaCrop,19 GCMs
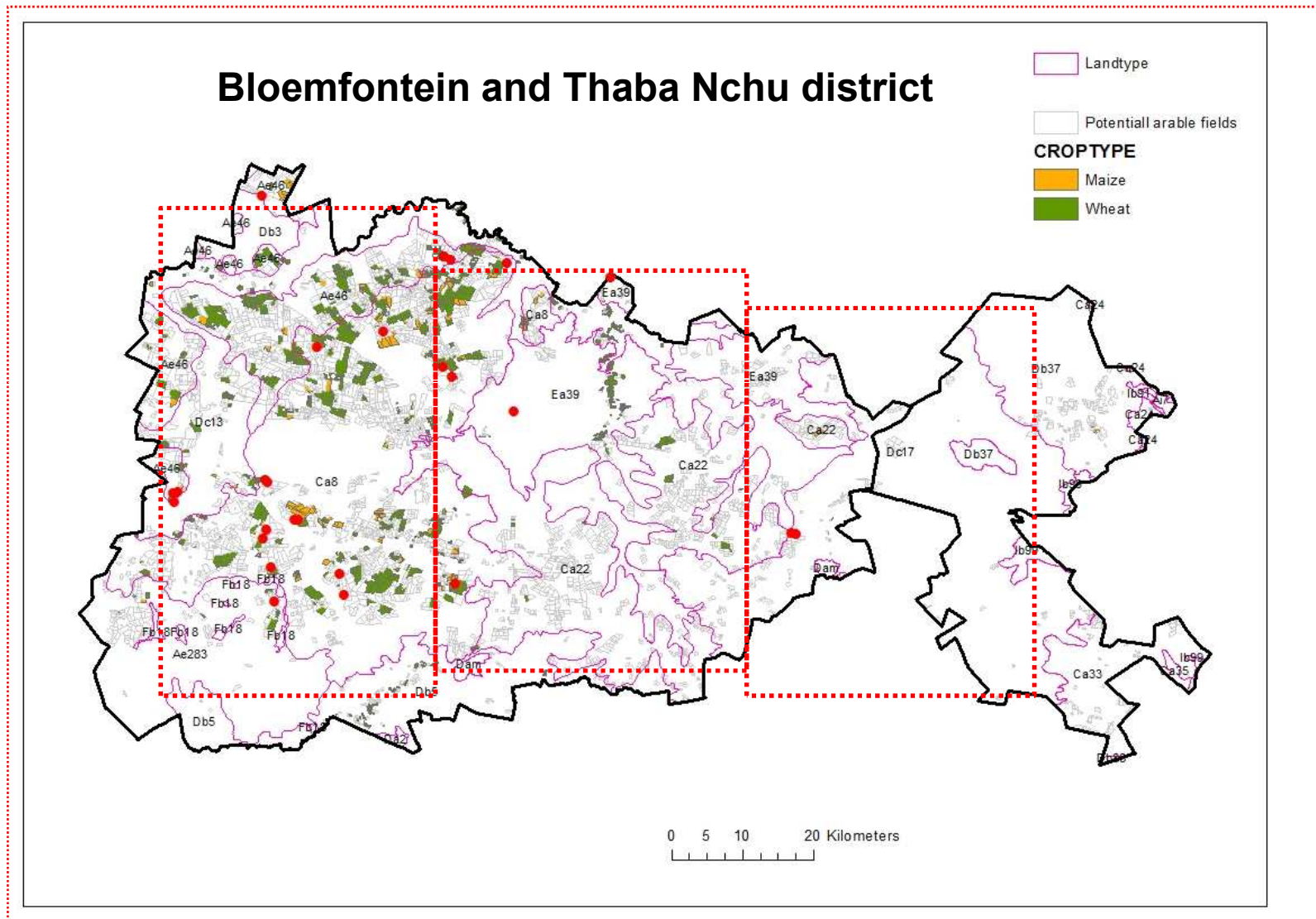
"Fast track / Proof of concept"

Objectives

- To compare historical and future maize production (**mean yield** and **distribution/variability)** simulated using **DSSAT** crop model for a selected region using past and future climate data

- To characterise **uncertainties** (risks) of **future maize production** in a selected region using Trade-Off Analysis for Multidimensional Impact Assessment (**TOA-MD**) economics model
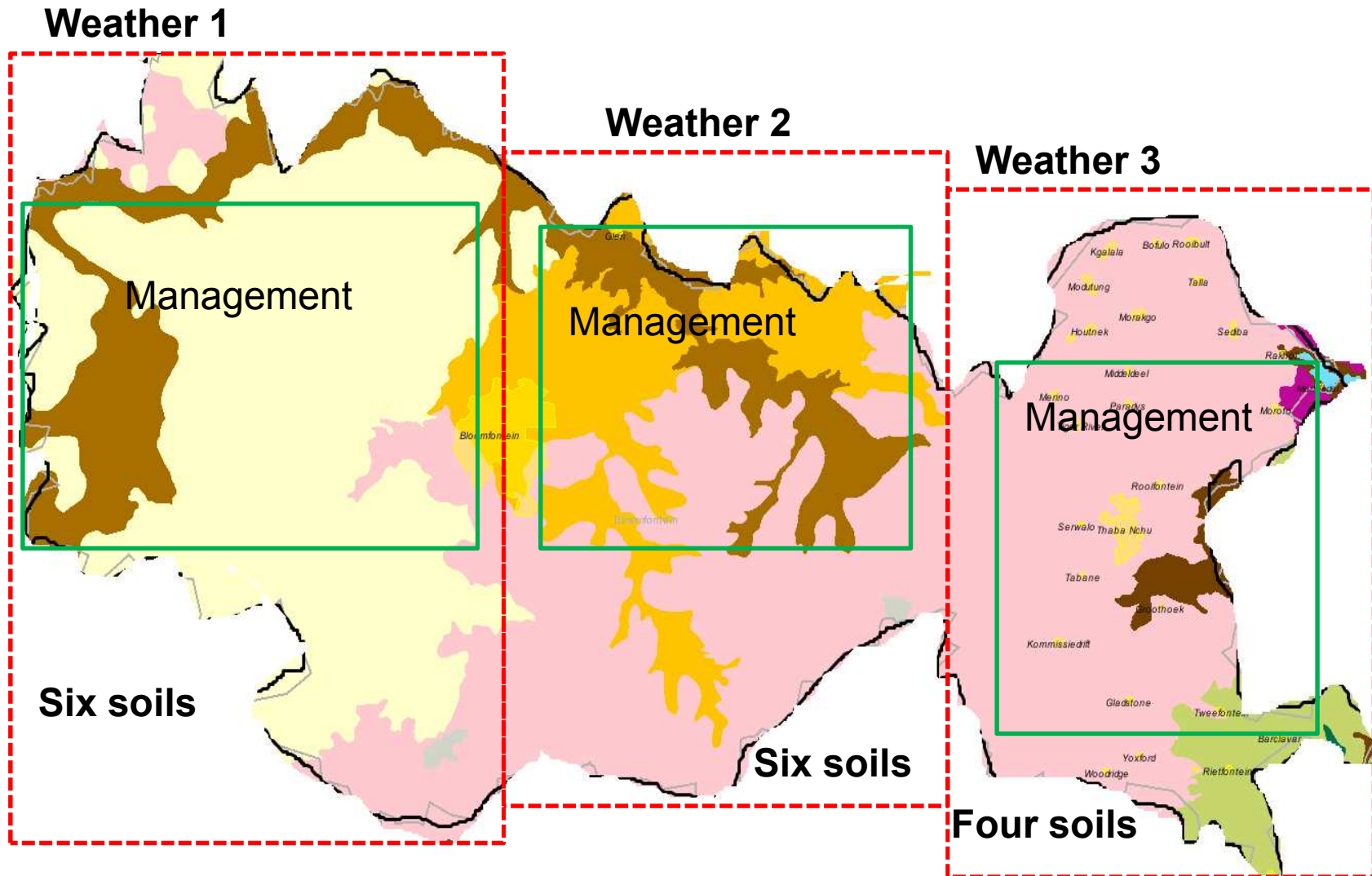
Methodology

- Bloemfontein & Thaba Nchu district was identified for this study-considering Free State the largest maize production in South Africa

- The district was subdivided into homogenous climate zones (HCZs), soil and management attributes

- Each zone was described for its soil and management

Methodology (cont)

Bloemfontein and Thaba Nchu district

Landtype

Potentiall arable fields

CROPTYPE

Maize

Wheat

0 5 10   20 Kilometers

Methodology (cont)

Methodology (cont)

Management practices

Planting date	Planting density (plants ha^{-1})	Nitrogen fertilization (kg ha^{-1})	Soil
15 Nov	10,000	0	Bainsvlei
01 Dec	15,000	40	Hutton
15 Dec	20,000	80	Bonheim
01 Jan		120	Swartland
			Valsrivier
			Arcadia

- 3 weather x 6 soil x 4 Planting D x 3 Planting density x 4 Nitrogen = 486 treatment combination

Methodology (cont)

- DSSAT was calibrated for the local condition using observed data for small scale and large scale farmers

- Past crop productivity and yield variability:
  - simulated for each HCZ as single site using historical weather data (1980-2009) [**Baseline**]

- Future crop productivity and yield variability
  - simulated using projected future weather data (2030-2059) to establish [**Future**]
  - MaxT= +3° C, MinT= +3° C, Rain= *0.85 and CO_2= 571 ppm

- Mean yield for the region was adjusted
  - using slope of observed and simulated district yield (2003 -2008)

Methodology (cont)

- Yield was simulated over different weather, soils and management for multiple years to provide
  - distribution of yield- that the economist needs to know the "winners and losers"
- TOA-MD model (Antle J and Valdivia R, 2010) was used to simulate impact climate change on economics of farmers
- **TOA-MD** is a unique simulation tool for **multi-dimensional impact assessment-** based on a statistical description of a heterogeneous farm population
  - simulates impacts of changes in:
    - technology and socio-economic conditions
    - environmental conditions such as climate
    - policy interventions such as Payments for Ecosystem Services

Methodology (cont)

- TOA-MD can be used to simulate many possible experiments
  - Climate change without adaptation
    – System 1: base climate, base technology
    – System 2a: changed climate base technology
  - Climate change with adaptation
    – System 1: base climate, base technology
    – System 2b: changed climate, adapted technology
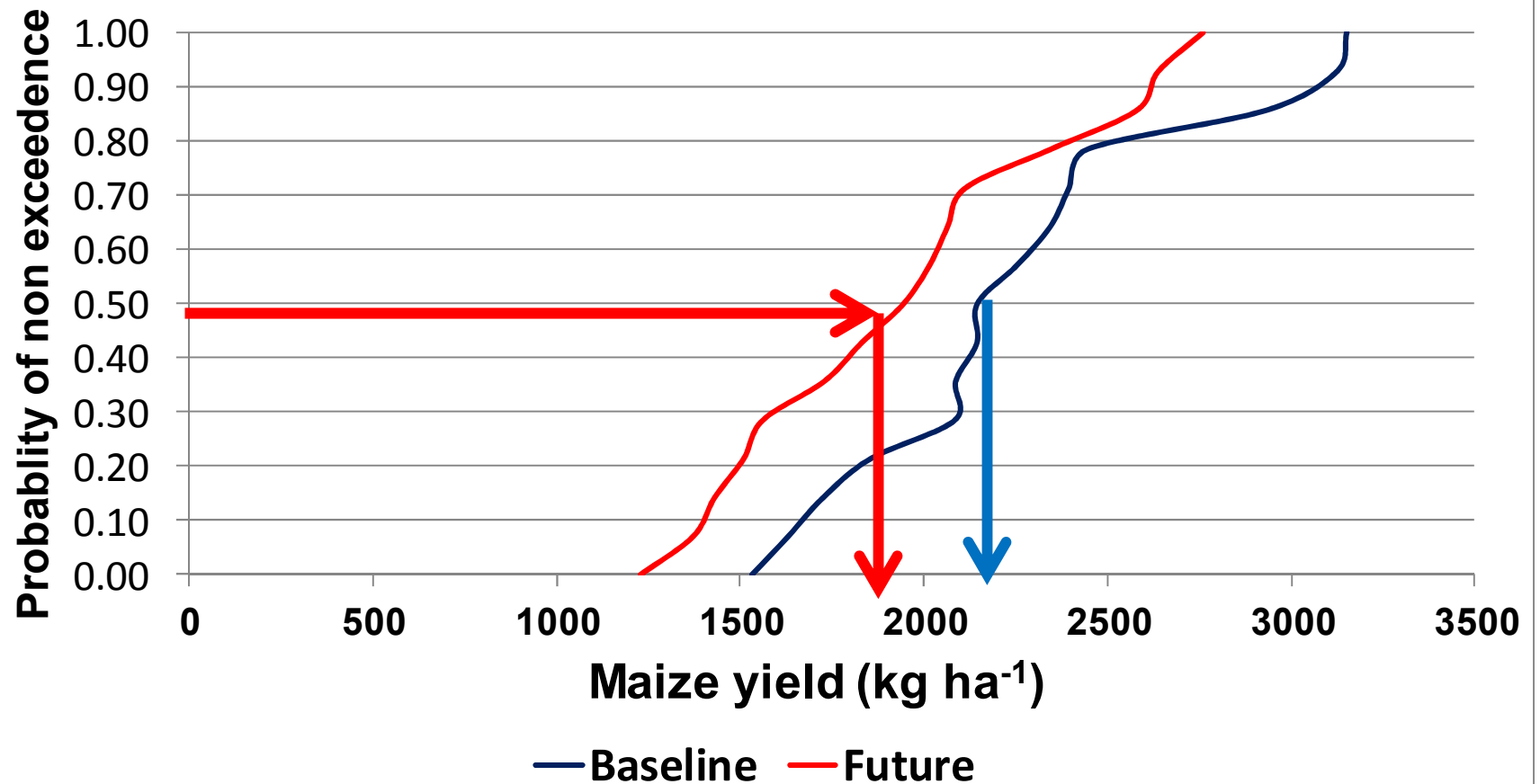- Antle (2010) provides an overview of the methodology

Preliminary results

Maize yield for 30 years baseline (1980-2009) and future (2030-2060)
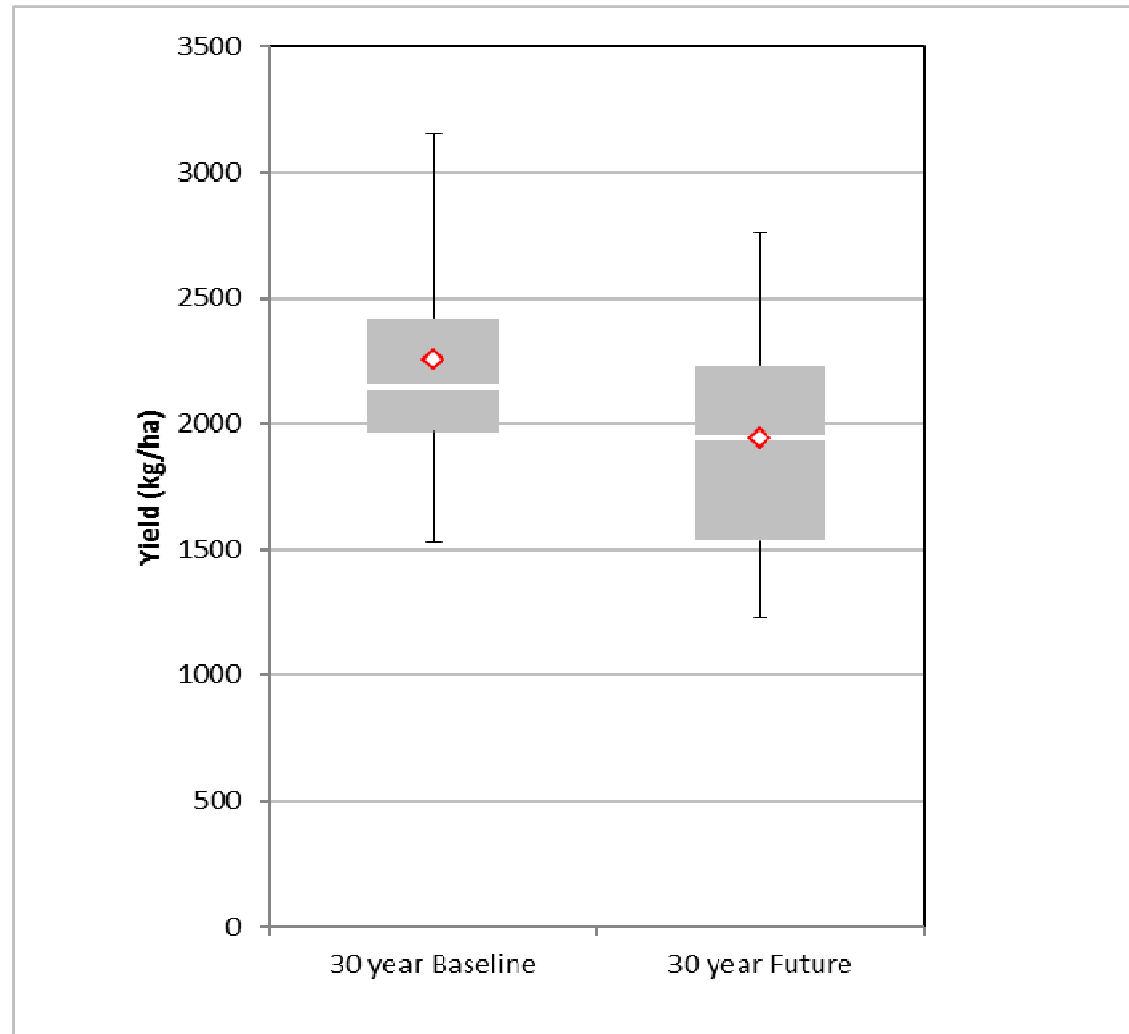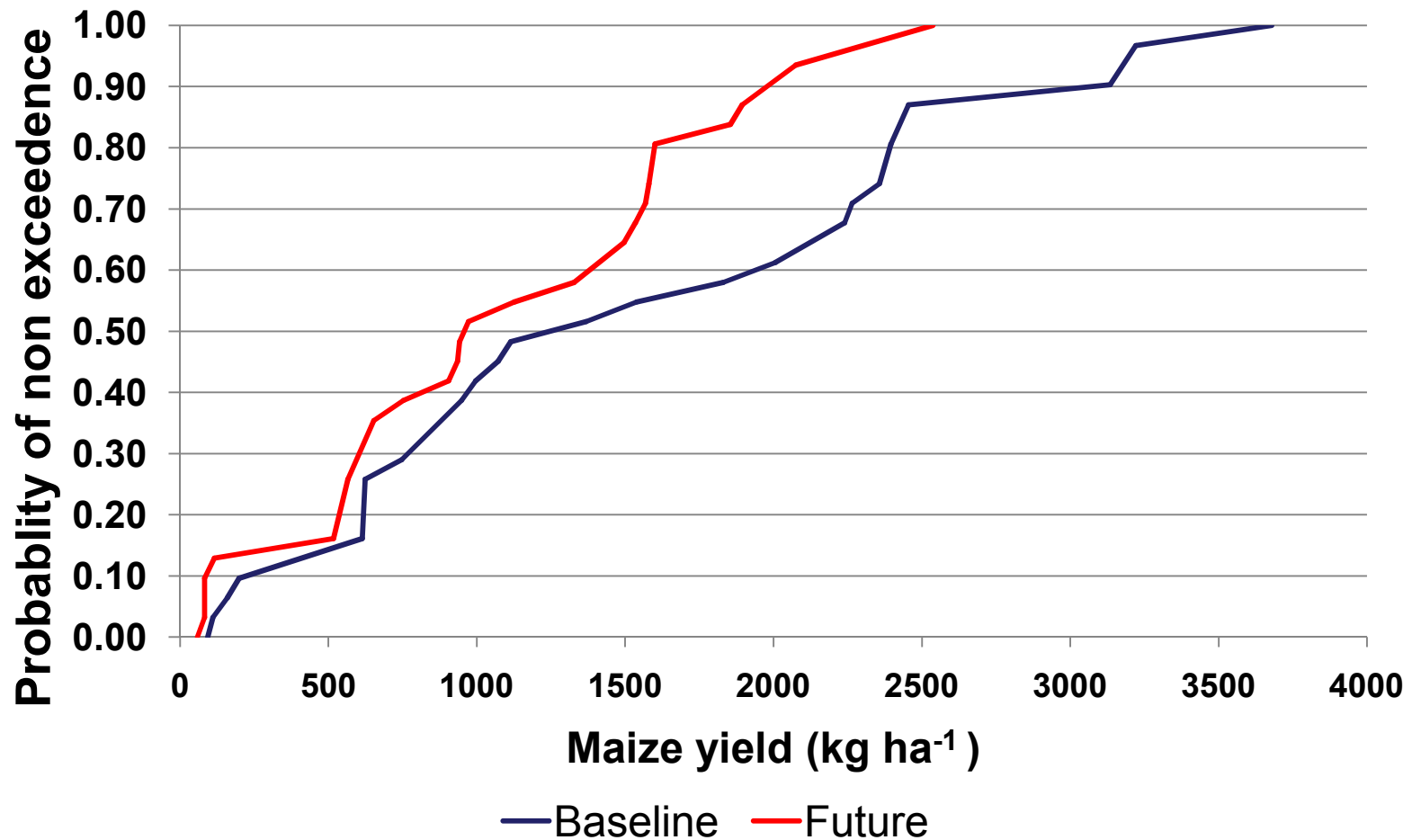
Results (cont.)

30 years baseline and future average yields for commercial farmers
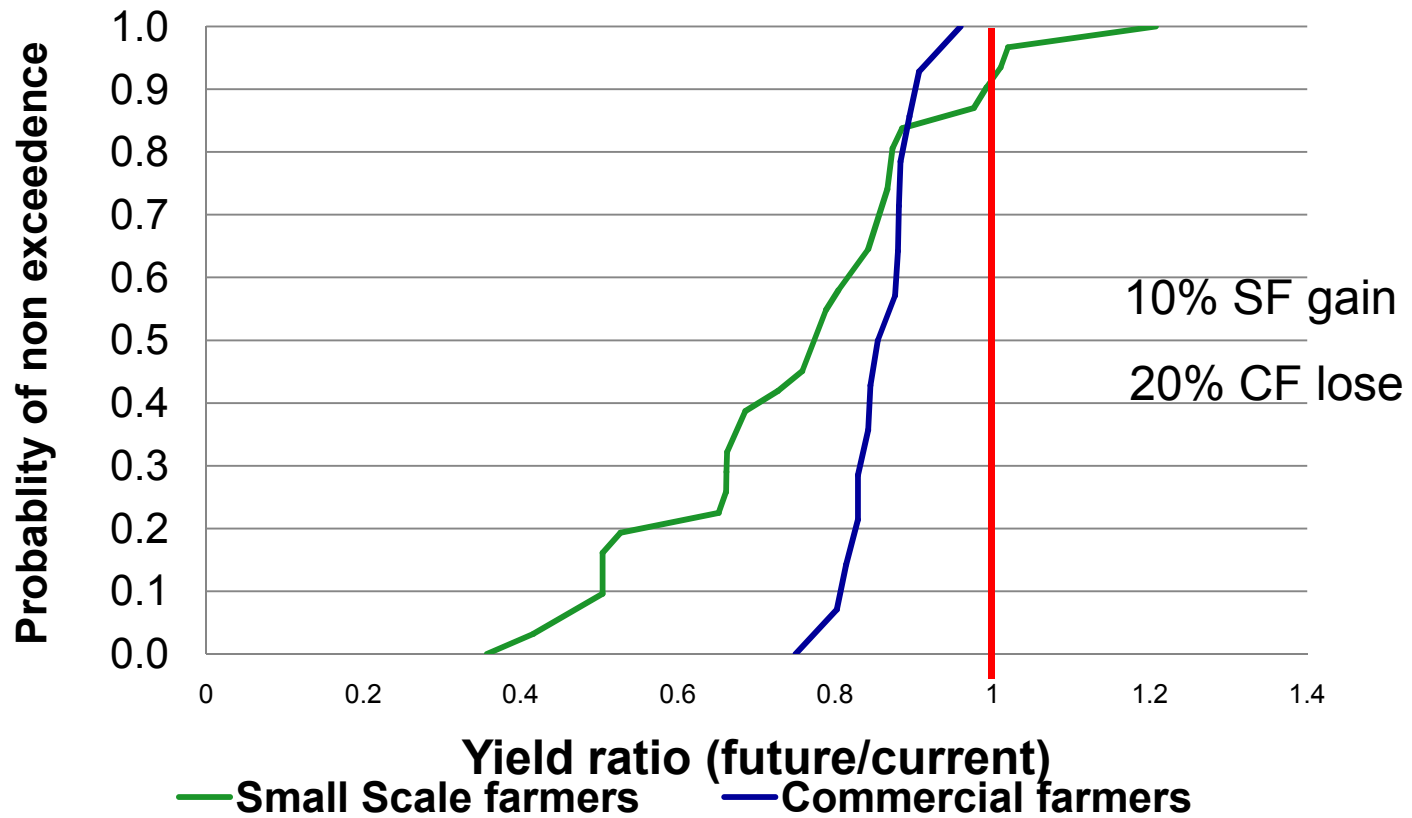
Results (cont.)

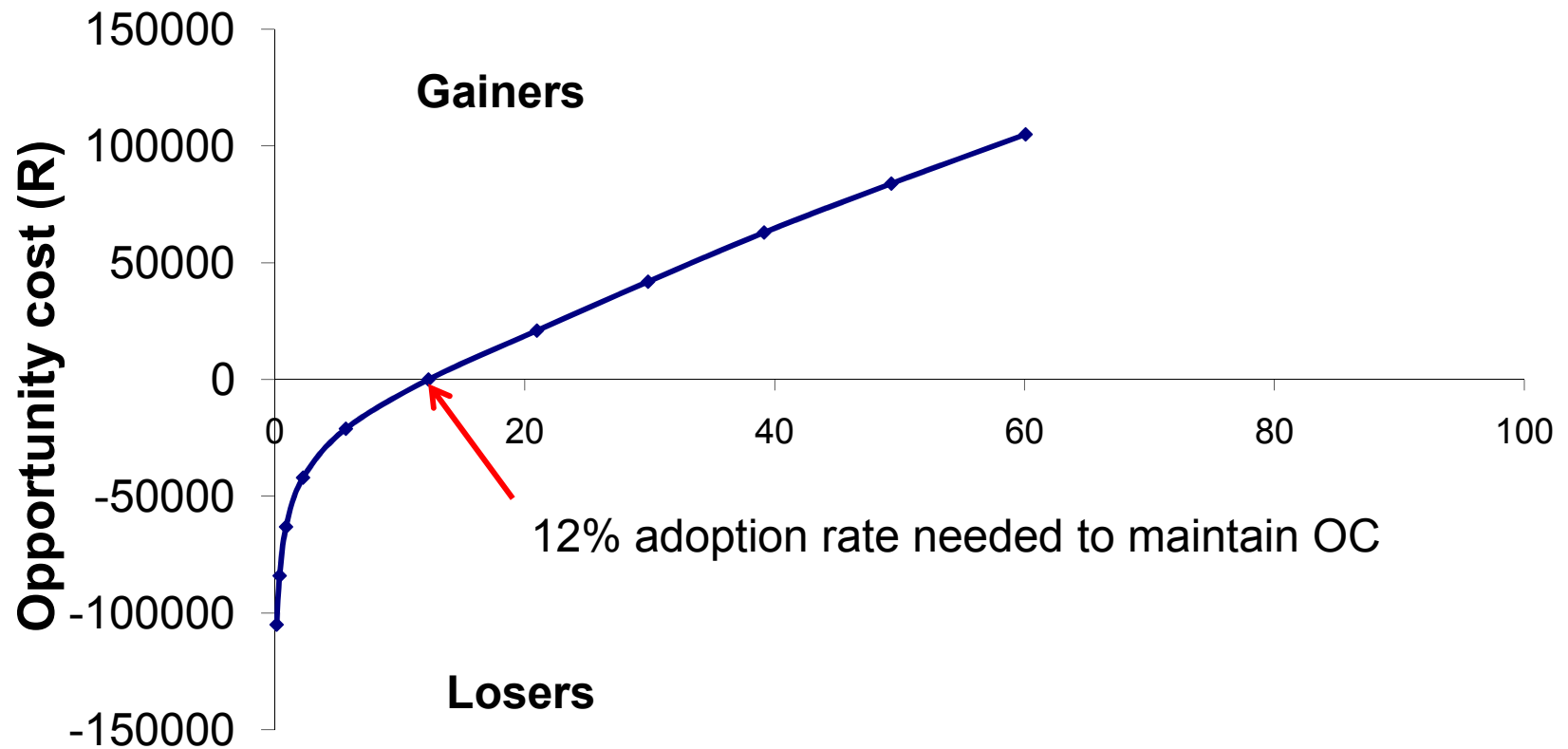30 years baseline and future yields for small scale farmers

Results (cont.)

Ratio between future and current climate for small scale and commercial farmers

10% SF gain
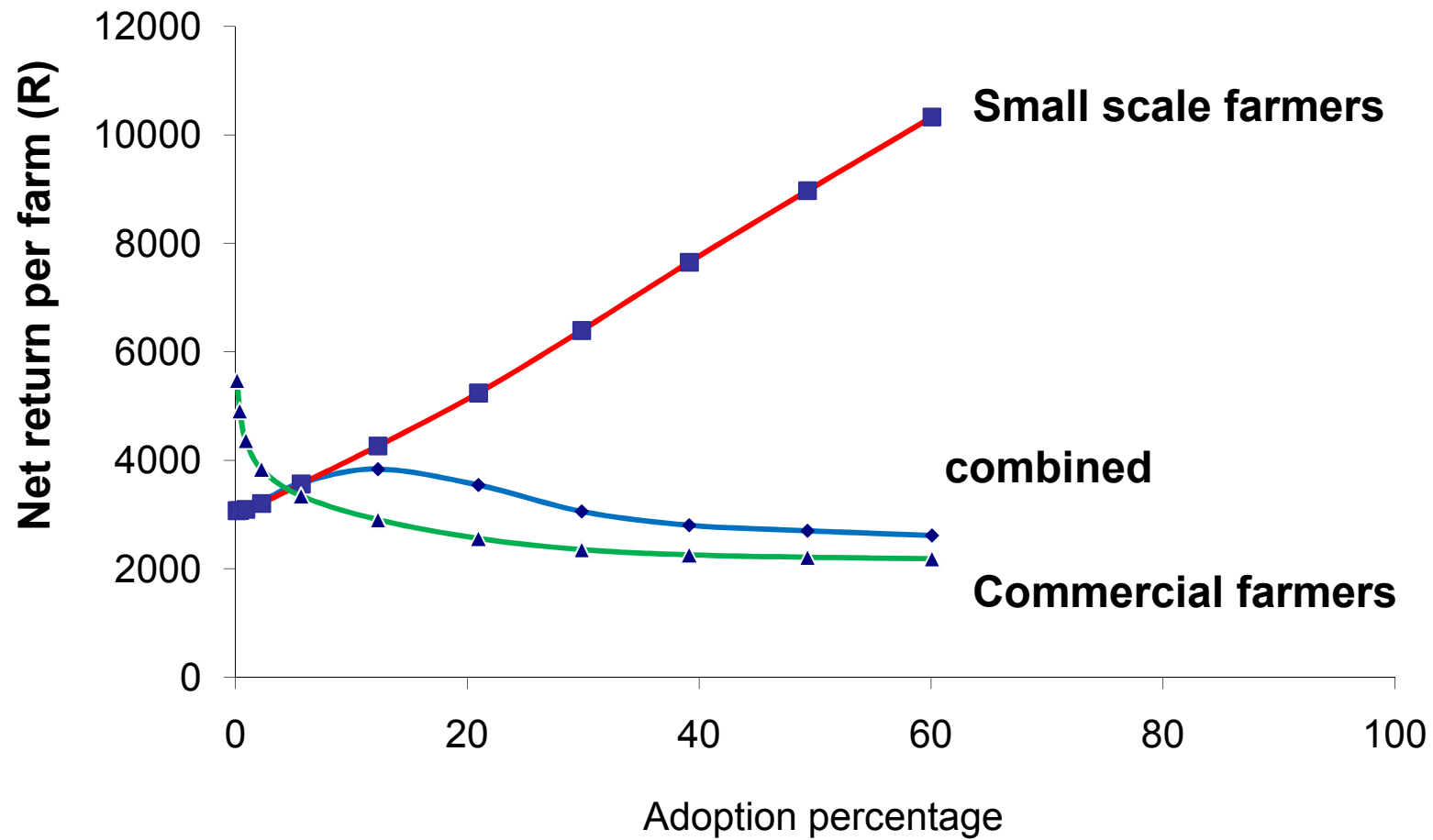
20% CF lose

Results (cont.)

Technology adoption rate vs Opportunity cost (R)

ADOPT_A: Adoption rate in overall farmers (%)

Results (cont.)

Net return per farm (R) vs adoption(%)

Conclusion

- Linking crop and economic models- is a new approach to assess impact of climate change
- Progress has been made during the fast track in South Africa in developing methodology for CC impact assessment
- Commercial farmers will have 20% less yield
- Small scale farmers will suffer up to 60% reduction in yield, but still 10% will get better yield than the past
- Results obtained from the fast track is preliminary and still needs to be refined

Acknowledgement

Thank you