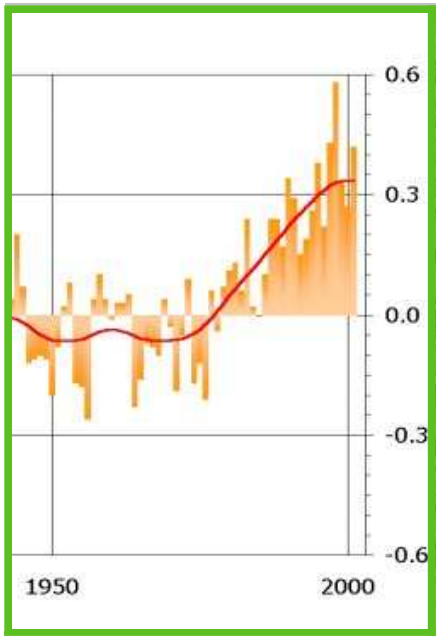




Sustainable agriculture and climate change: threats, challenges and innovation

Greg Masters, Julie Flood and Lindsey Norgrove

www.cabi.org
KNOWLEDGE FOR LIFE

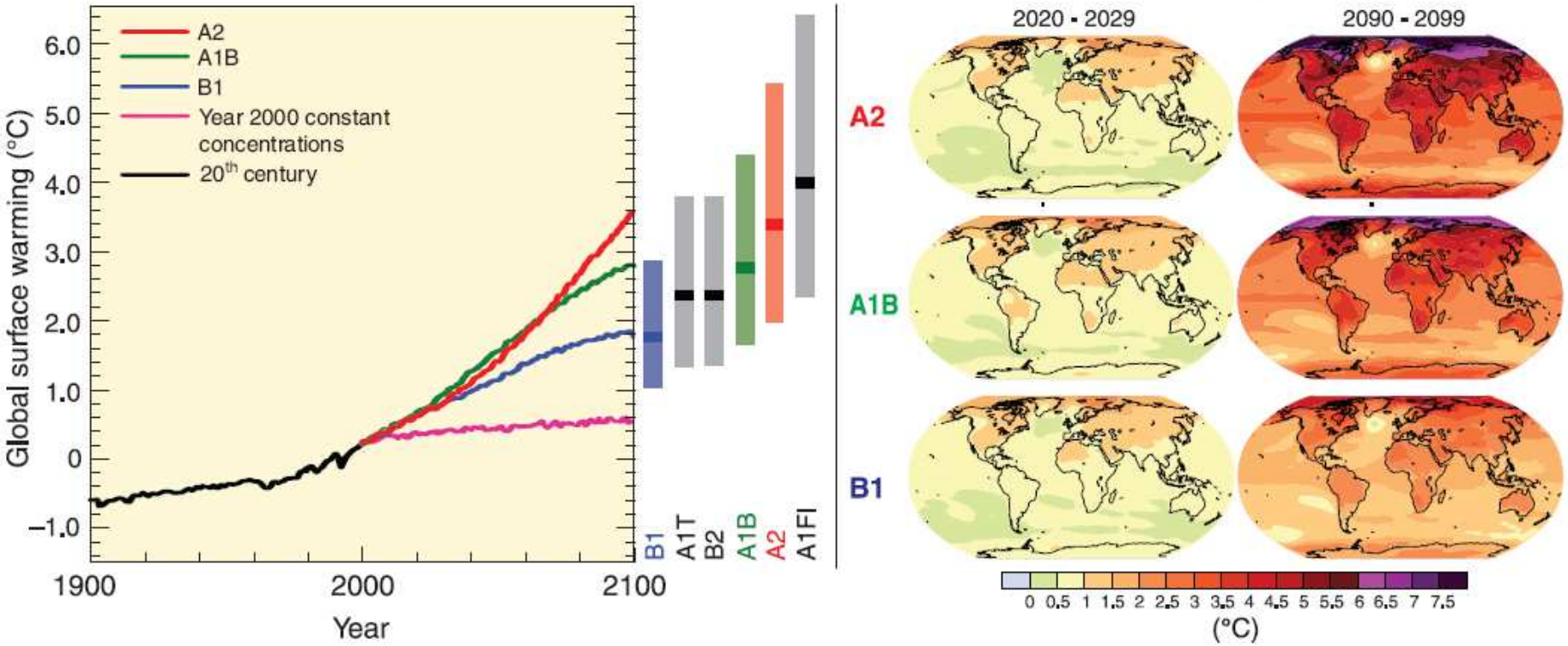
Issues and Focus

- Climate change will alter all parameters surrounding sustainable agriculture – for example crop growth, yield, management, disease and pest complexes
- Challenges are in crop management, pest and disease control.
- Focus on tackling food security by reducing losses – this needs innovation in the face of climate change
- Innovations include joined up thinking in IPM (integrated pest management) including the use of biocontrol and biopesticides

Structure

- The threat of climate change impacts
- Crop management - challenges and innovation
- Pests and diseases – challenges and innovation
- Examples: Siam Weed; Banana; Cacao
- Summary

Atmosphere-Ocean General Circulation Model projections of surface warming



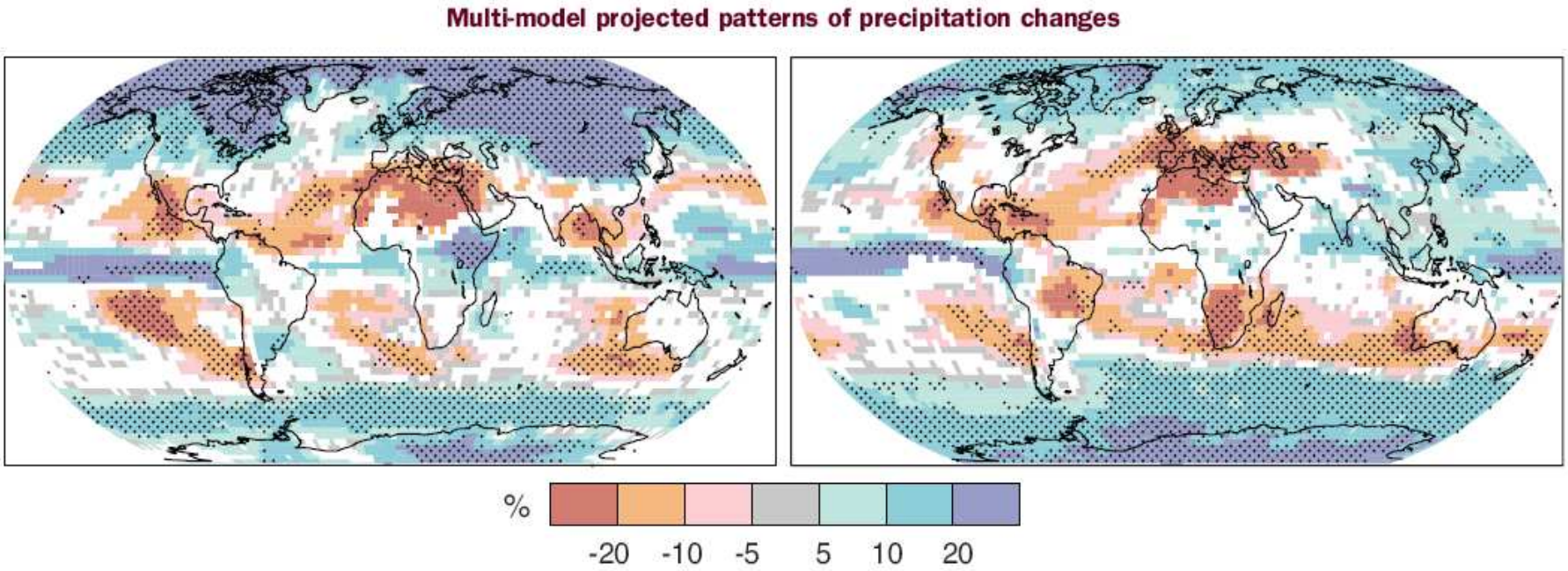


Figure 3.3. *Relative changes in precipitation (in percent) for the period 2090-2099, relative to 1980-1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {WGI Figure 10.9, SPM}*

More extreme weather events

Credit: Earthsci.org

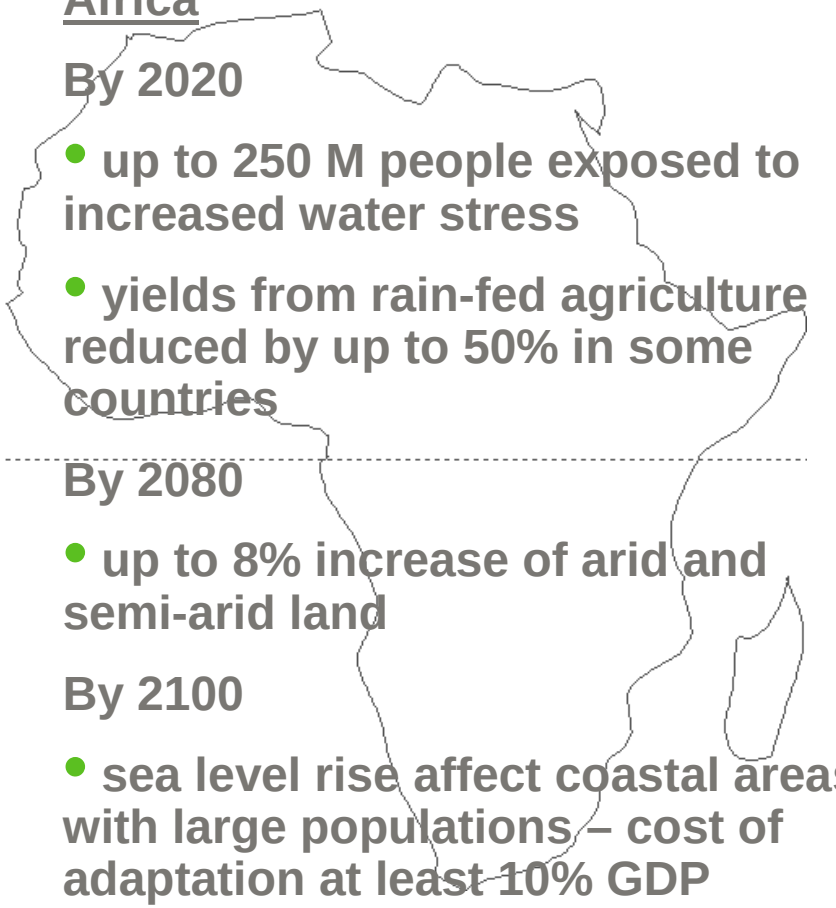
credit:The Age.com.au

- Increasing destructiveness of tropical cyclones over the past 30 yrs (Emanuel 2005).
- Major impact on crops:

  20 March 2006: *Cyclone Larry* (category 5) hit Innisfail, Queensland, devastating 90% of the banana crop

  22 August 2007: *Hurricane Dean*, hit Martinique, in the Caribbean, destroying more than 600 million AUD of bananas

Regional impacts of climate change



Africa

By 2020

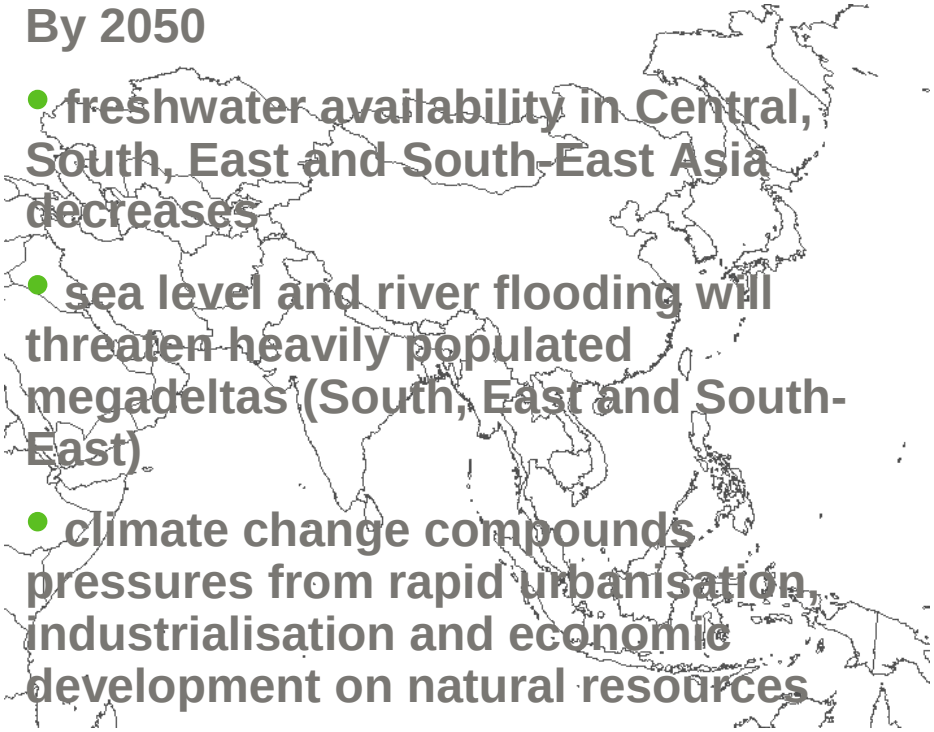
- up to 250 M people exposed to increased water stress
- yields from rain-fed agriculture reduced by up to 50% in some countries

By 2080

- up to 8% increase of arid and semi-arid land

By 2100

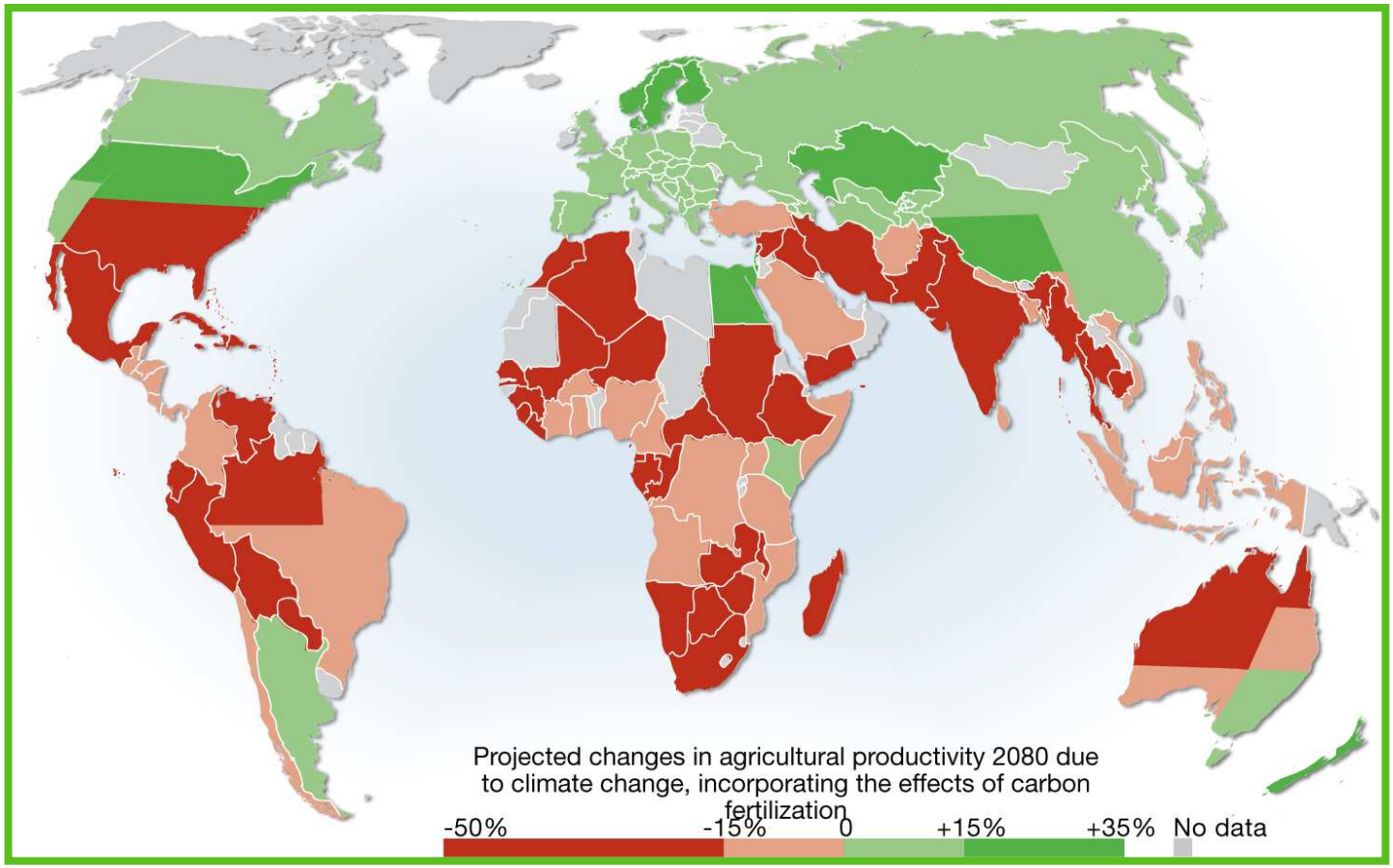
- sea level rise affect coastal areas with large populations – cost of adaptation at least 10% GDP



Asia

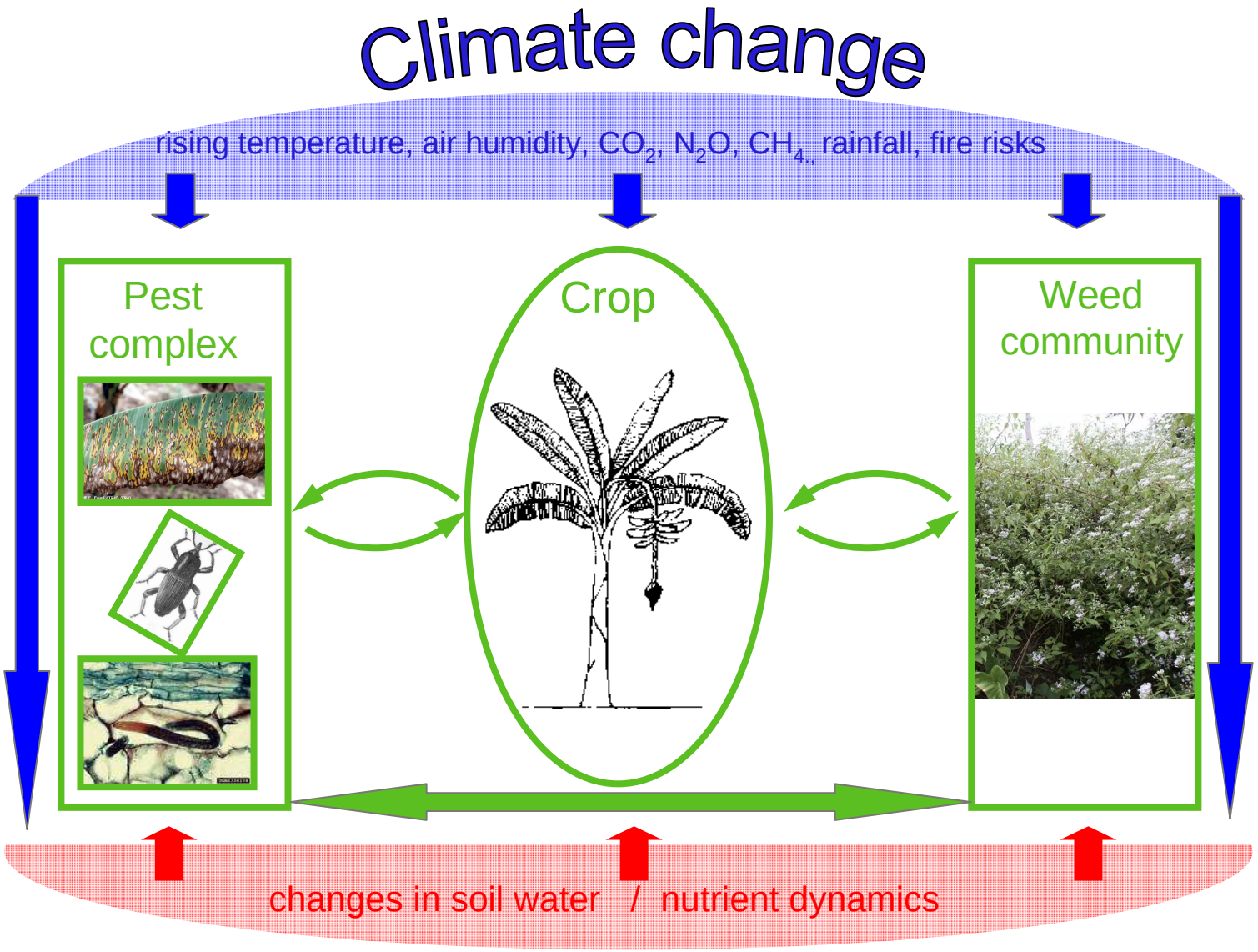
By 2050

- freshwater availability in Central, South, East and South-East Asia decreases
- sea level and river flooding will threaten heavily populated megadeltas (South, East and South-East)
- climate change compounds pressures from rapid urbanisation, industrialisation and economic development on natural resources

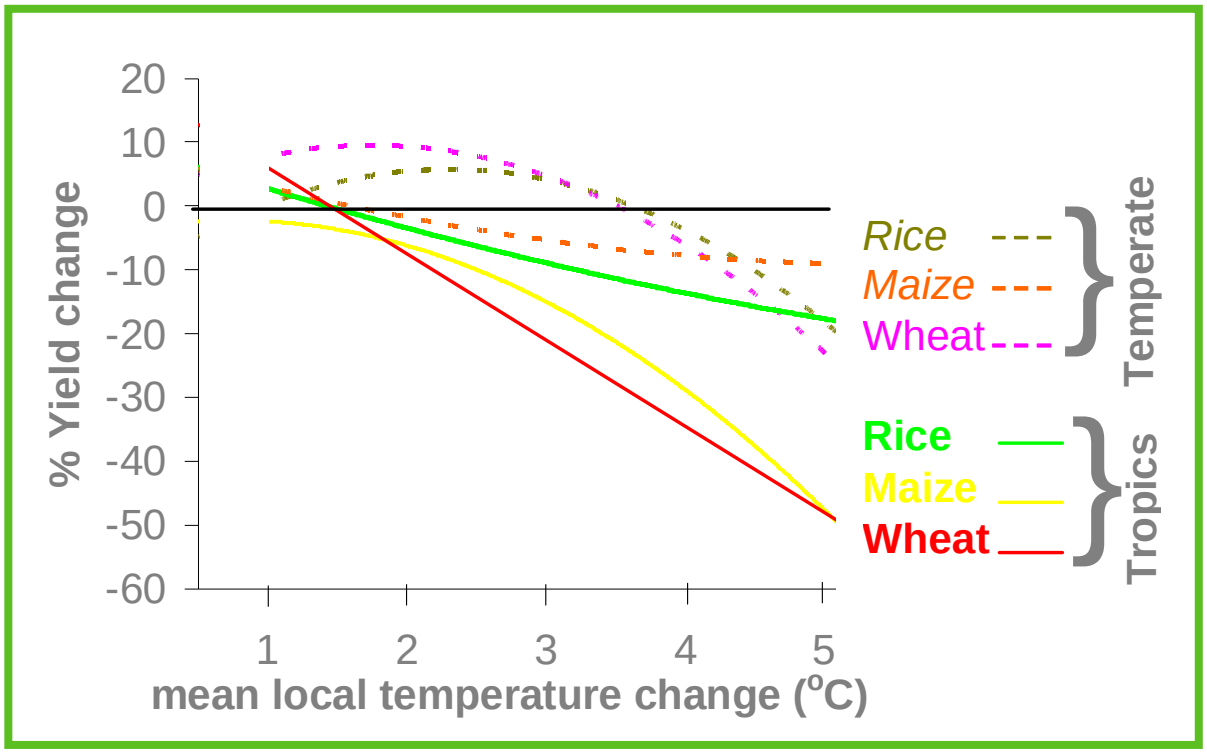


Projected changes in global agricultural productivity by 2080 due to climate change. Red = a decrease in productivity; Green = an increase in productivity. LDCs/ tropics expected to suffer the most.

Systematic Impacts



Effect of higher temperatures on crop yields



adapted from IPCC (2007) by Norgrove, summarising 69 studies. No adaptation.

< 3 °C increase higher yields in temperate zones

> 3 °C increase lower yields in temperate zones

Any increase lower yields in tropics

Altered distribution of pests



- Changed pest/ crop /soil dynamics
- Ranges of some pests may expand to higher altitudes & latitudes
- More extreme climatic disturbances will create opportunities for pest colonisation and establishment

credit: Yonghachea

credits: Norgrove

Predicted expansion of Siam weed range

- *Chromolaena odorata* (Siam weed) is a serious weed from S. America, invasive throughout the tropics
- CLIMEX™ *(Sutherst et al 2007)* uses IPCC models plus precipitation, vapour pressure, & temperature data to predict climate change surfaces for global weeds, including Siam weed
- In West Africa, the range of Siam weed is predicted to expand east to Central Africa and beyond (*Kriticos 2007*)
- Biocontrol is contentious as many farmers perceive Siam weed positively as it outcompetes the more difficult-to-manage *Imperata* grass

Pest and Disease Interactions

- Siam weed is an attractant for the African grasshopper *Zonocerus variegatus (Le Gall 2003)*
- Increases in *Zonocerus* populations correlated with and attributed to increasing cover of Siam weed
- *Zonocerus* defoliates banana, cassava and other food crops
- *Zonocerus* can transmit bacterial blight *(Zandianakou-Tachin et al 2007),* a serious disease of cassava, a main staple in the region

Z. variegatus on Siam weed credit: Cock

Z. variegatus credit: Cock

Z. variegatus on cassava (*Manihot esculenta)*

Management options: Green Muscle®

- Green Muscle is an environmentally-friendly mycoinsecticide of *Metarhizium anisopliae* var. *acridum*
- Developed by the collaborative LUBILOSA project comprising CABI, IITA, GTZ & CILSS/ AGRHYMET
- Can be used to control *Z. variegatus, Schistocercia gregaria,* the desert locust and other hoppers
- Commercialised by Biological Control Products SA (Pty) Ltd, South Africa and SenBio, Senegal

Desert locust infected with Green Muscle ®


Banana-plantain (Central Africa)

- Most important food cash crop staple
- Cultivated in '*esep*' long fallow fields intercropped with mélon (*Cucumeropsis mannii*), tannia, macabo; after a fallow >10 y.
- Without fertilizer, pesticides or herbicides
- Weeding twice per year with machete

Pest pressures of banana-plantain

2. Black Sigatoka *Mycosphaerella fijiensis*

3. Weevils.

Cosmopolites sordidus

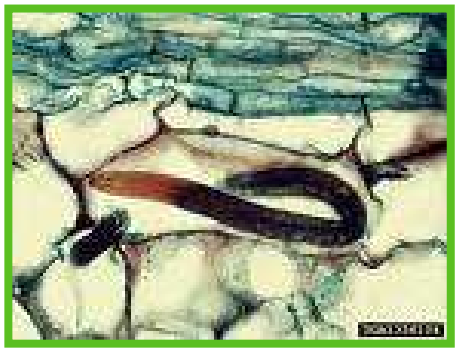
1. Root nematodes

Radopholus similis

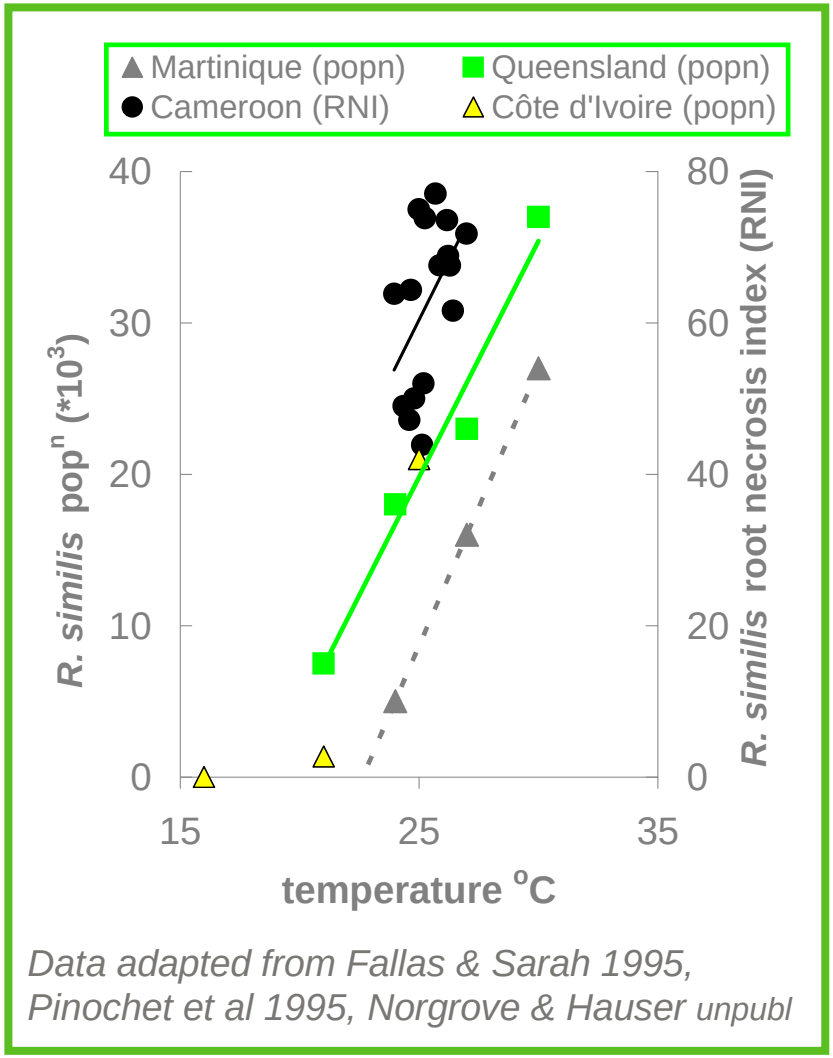
Meloidogyne spp.

Pratylenchus goodeyi (at altitude)

(Helicotylenchus multicinctus)



More damage by nematodes at higher temperatures



Data adapted from Fallas & Sarah 1995, Pinochet et al 1995, Norgrove & Hauser unpubl

Temperature effects on *R. similis* populations and root necrosis index.

- Higher temperatures lead to higher reproductive rates, more root necrosis and yield losses
- *R. similis* is absent at the cooler high altitudes & latitudes. But is this changing?
- *R. similis* might replace the less damaging highland species, *Pratylenchus goodeyi* at higher altitude

Promoting better management

Global Plant Clinic:

- Establishes rural plant clinics
- Trains local “plant doctors”
- Promotes IPM to farmers

Methods to reduce damage from nematodes:

- Using clean planting material,
- Immersion in hot water to kill nematodes,
- Removal of roots and outer infected tissue from culture plantlets or carefully pared suckers
- Removing all plant parts from old fields, using crop rotation or leaving land fallow for at least 3 years

Smallholder cacao and pest pressure

- Cocoa, of S. American origin, is grown throughout the humid Tropics
- World production ~ 3.5 million tonnes p.a.
- More than 70% of world production is from the coastal zone of West/Central Africa where it is grown by smallholder farmers
- In Africa, blackpod (*Phytophthora palmivora* and *P. megakarya)* are major biotic constraints; similarly frosty pod (*Moniliophthora roreri*) and witches' broom (*Moniliophthora perniciosa)* in Latin America
- Global yield loss to blackpod alone ~ 0.5 million tonnes p.a.

Higher humidity in cacao growing areas?

- Predicted higher temperature, humidity or rainfall in some parts of the humid tropics will exacerbate yield losses to fungal diseases
- Yet, above 26℃, *P. megakarya* growth is sub-optimal (*Brasier & Griffin 1979*) so aggressiveness might reduce as climate change advances
- Farmers use mainly copper-based contact fungicides but this strategy will become less effective if rainfall increases, as the product will be washed off

P. megakarya infection of cherelle

cocoa grown under forest shade

Novel biocontrol agents in cacao

- Promote more effective control methods to farmers, including rational fungicide use, improved sprayers and spraying techniques (*Bateman 2004*)

- Novel control methods. *Trichoderma* endophytes are plant symbionts. They can protect their hosts from diseases through various mechanisms: competitive exclusion, antibiosis, induced resistance and mycoparasitism; can be applied as inoculation of seeds (grow with plant)

- *Trichoderma* spp. that exhibit these properties and colonise cocoa tissue are being collected, isolated & screened for potential as biocontrol agents (*Holmes et al 2004*, *Bailey et al 2008*)

Summary

- Climate change will reduce crop yields both directly and by new interactions between crops, pests and diseases.

- Developing countries in the tropics are likely to be hit hardest.

- Adaptation strategies are needed:
  - **Training and capacity building at local level**
  - **Community-based early warning and risk management**
  - **Early control of pest outbreaks**

Further work

- Climate change impacts are case-specific. Need to be understood by referring to existing data or conducting new fundamental research
- Need new methods such as biocontrol agents to compensate for reduced efficacy of contact fungicides under greater precipitation (cacao)
- Greater pest problems require more stringent cultural control methods or use of tolerant varieties (bananas)

Thanks

Colleagues:

- Dave Moore
- Rob Reeder
- Emma Thompson
- John Bridge
- Keith Holmes
- Trevor Nicholls

Thank you for your attention!