Impact of Climate Change on Crop production

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Acknowledgment
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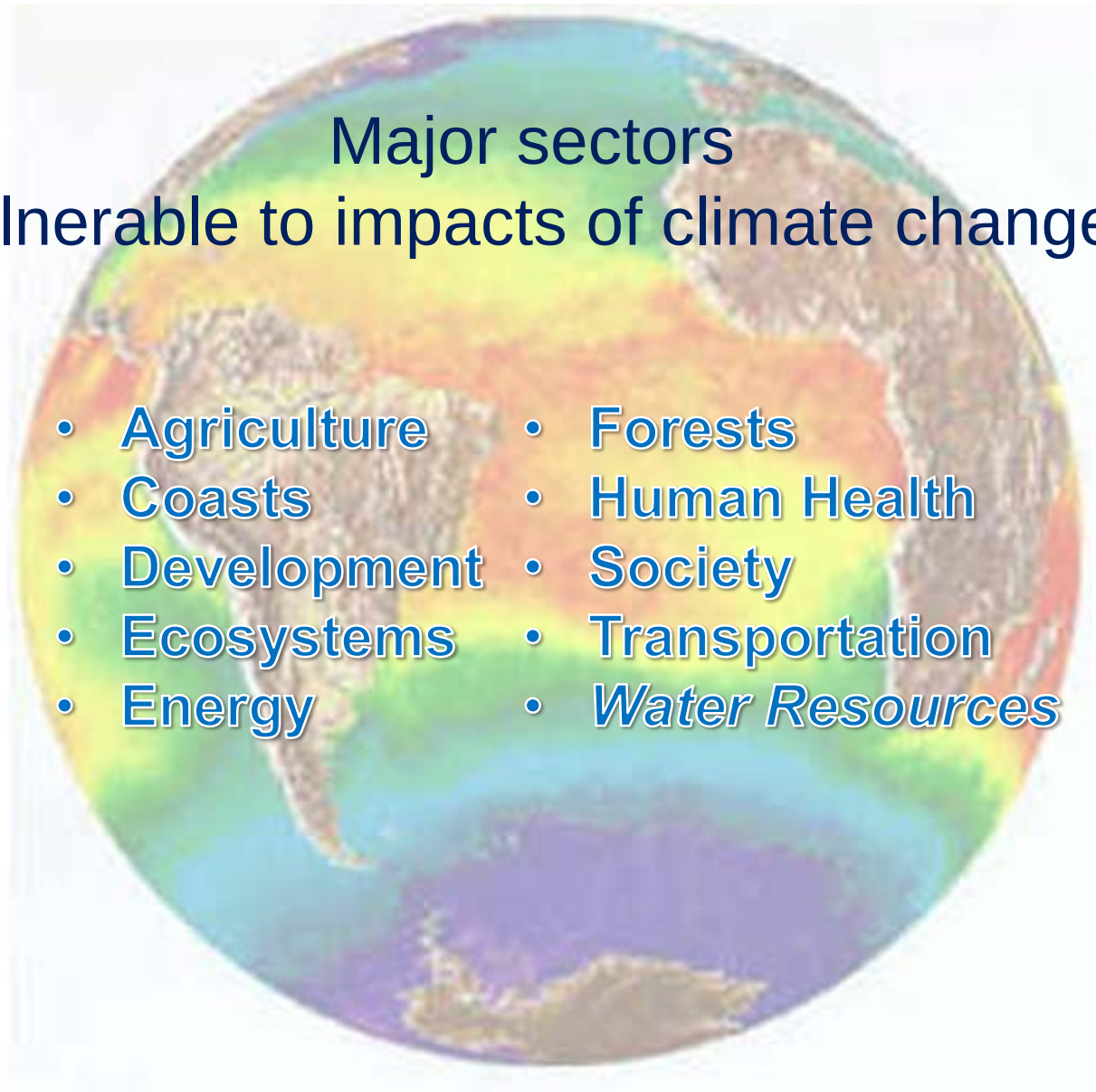
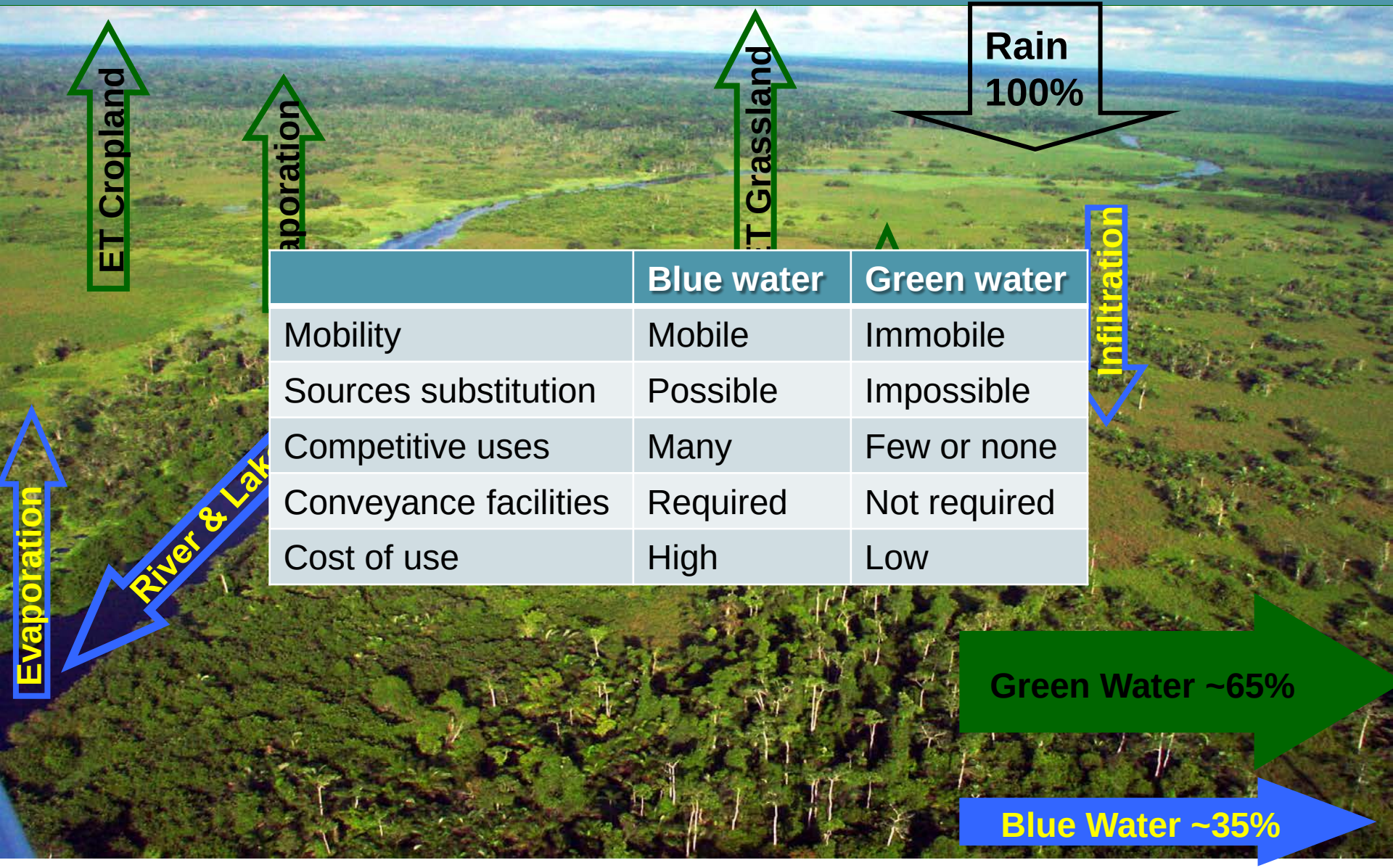
Impact of climate change



Major sectors
vulnerable to impacts of climate change:

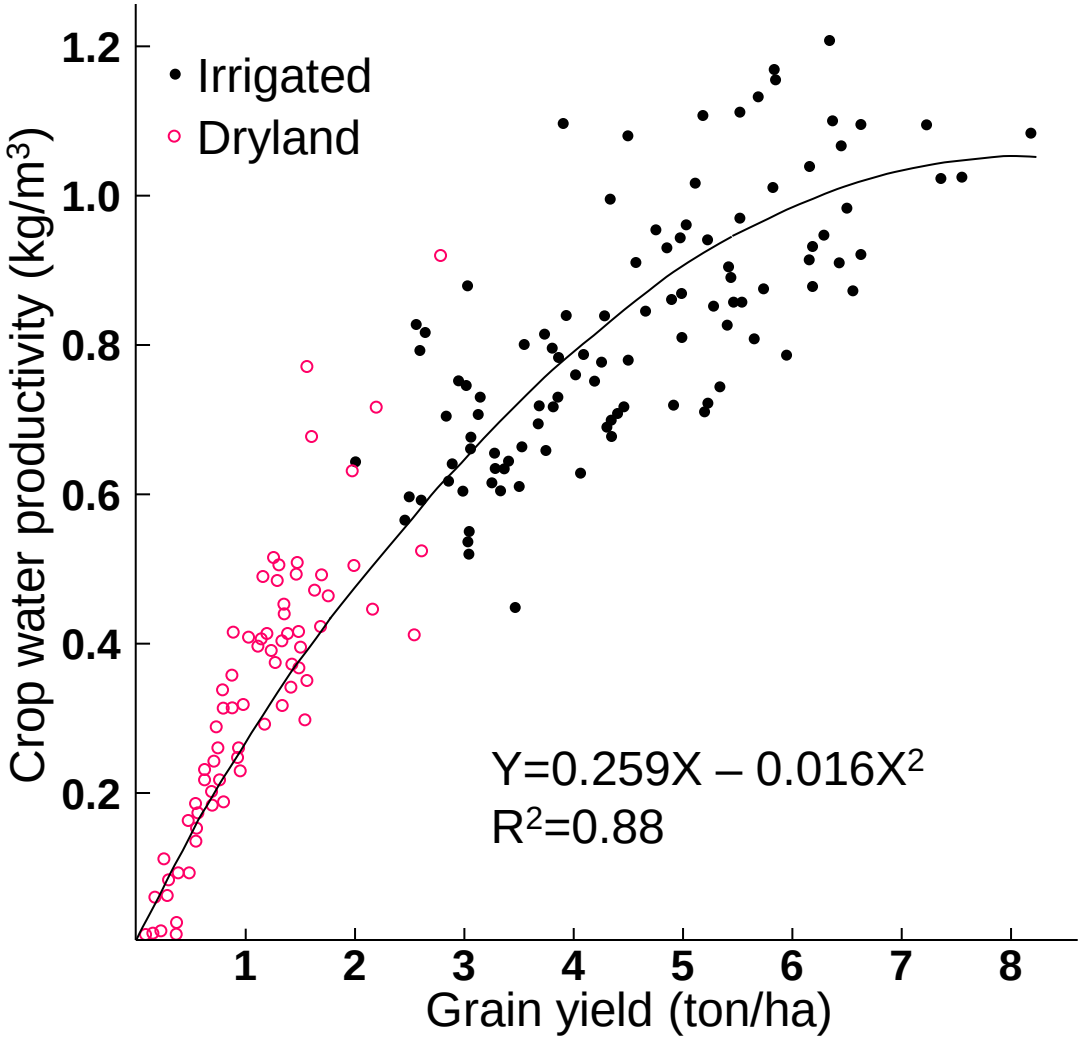
- Agriculture
- Coasts
- Development
- Ecosystems
- Energy
- Forests
- Human Health
- Society
- Transportation
- *Water Resources*

Blue and green water



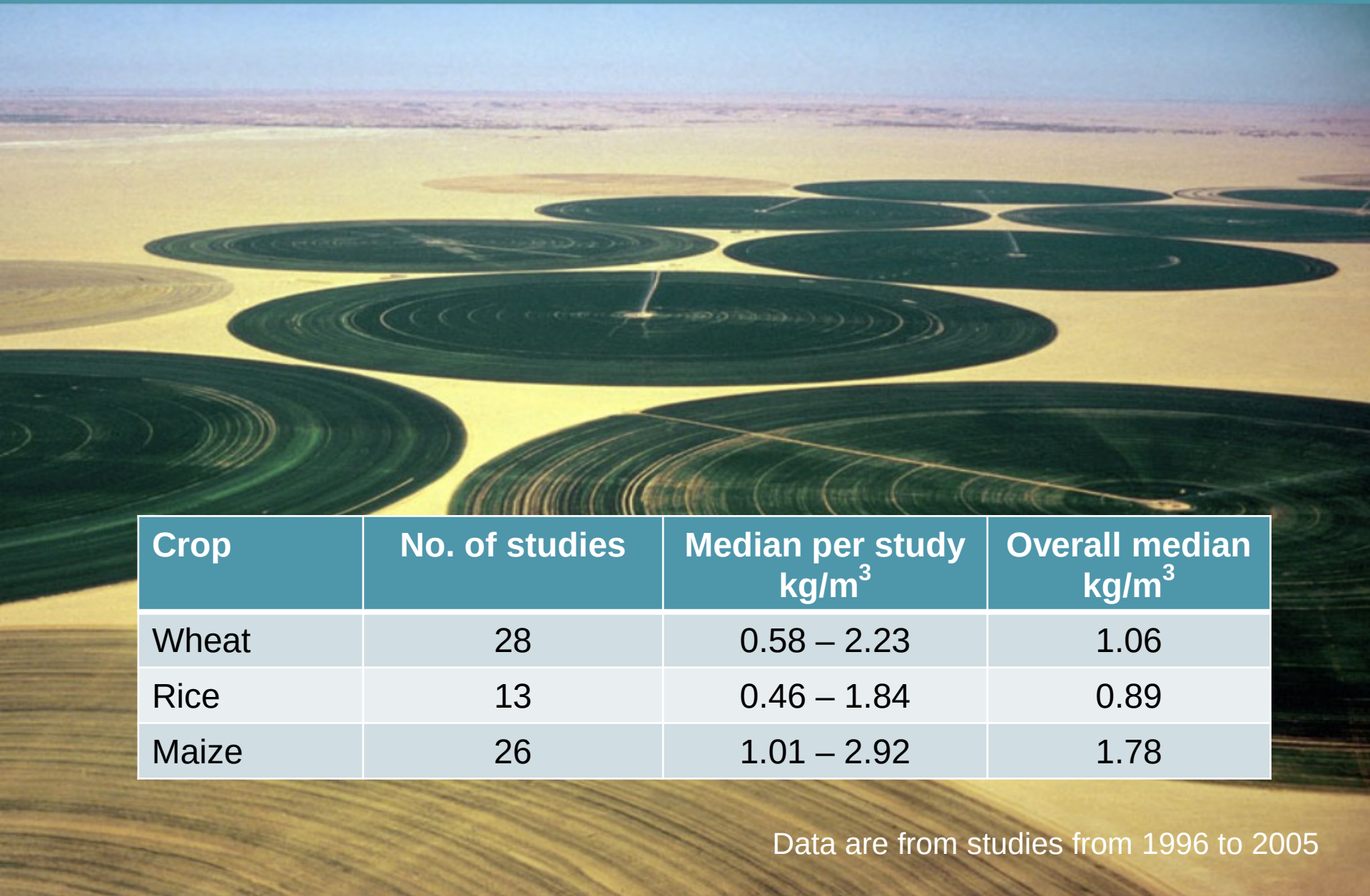
	Blue water	Green water
Mobility	Mobile	Immobile
Sources substitution	Possible	Impossible
Competitive uses	Many	Few or none
Conveyance facilities	Required	Not required
Cost of use	High	Low

Relationship of crop water productivity (cwp) to grain yield



From: Musick *et al.* 1994

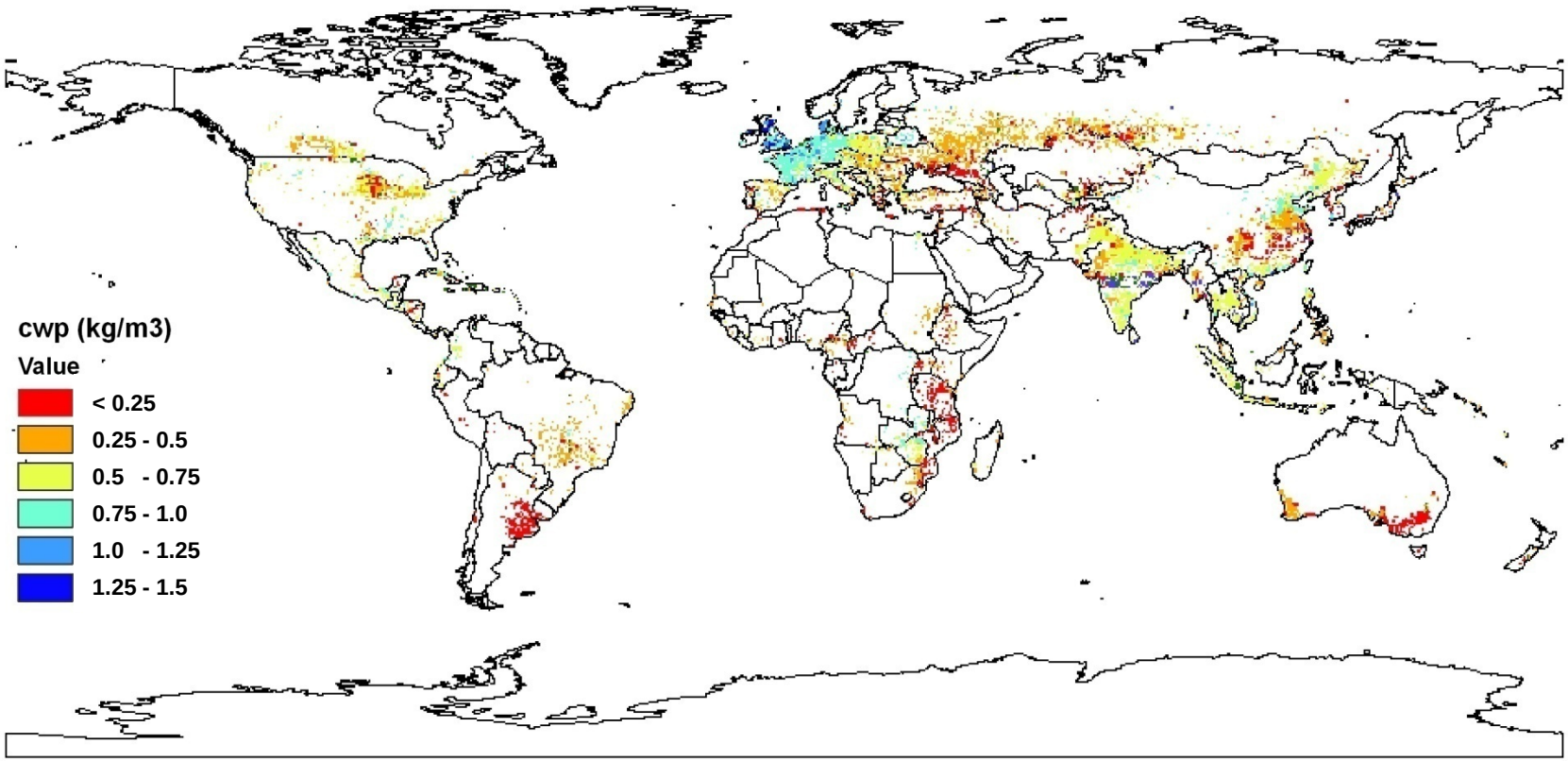
Irrigated crop water productivity



Crop	No. of studies	Median per study kg/m^3	Overall median kg/m^3
Wheat	28	0.58 – 2.23	1.06
Rice	13	0.46 – 1.84	0.89
Maize	26	1.01 – 2.92	1.78

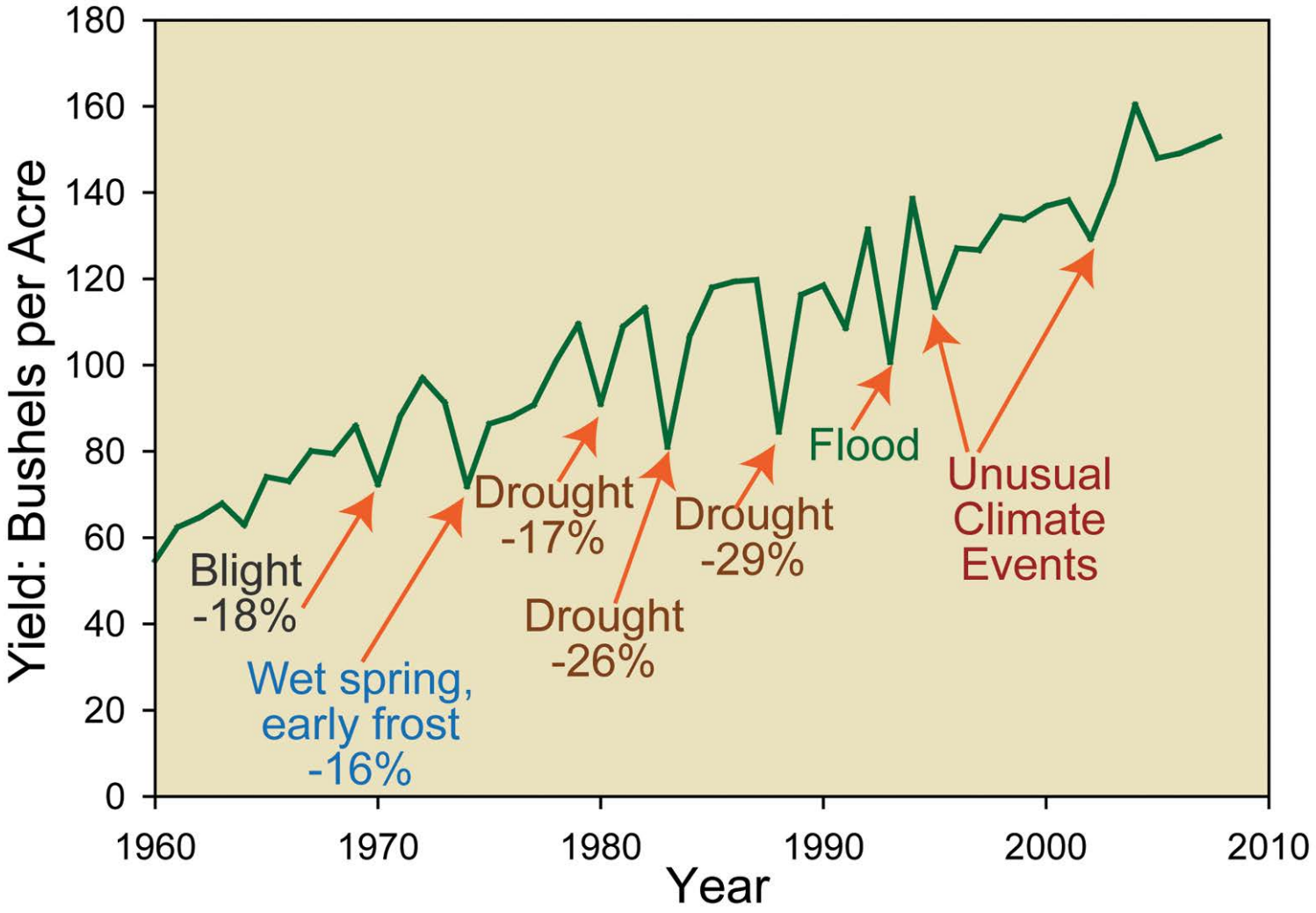
Data are from studies from 1996 to 2005

Crop water productivity of wheat (2000)



From Liu *et al*. 2007

Impact of climate on agricultural production



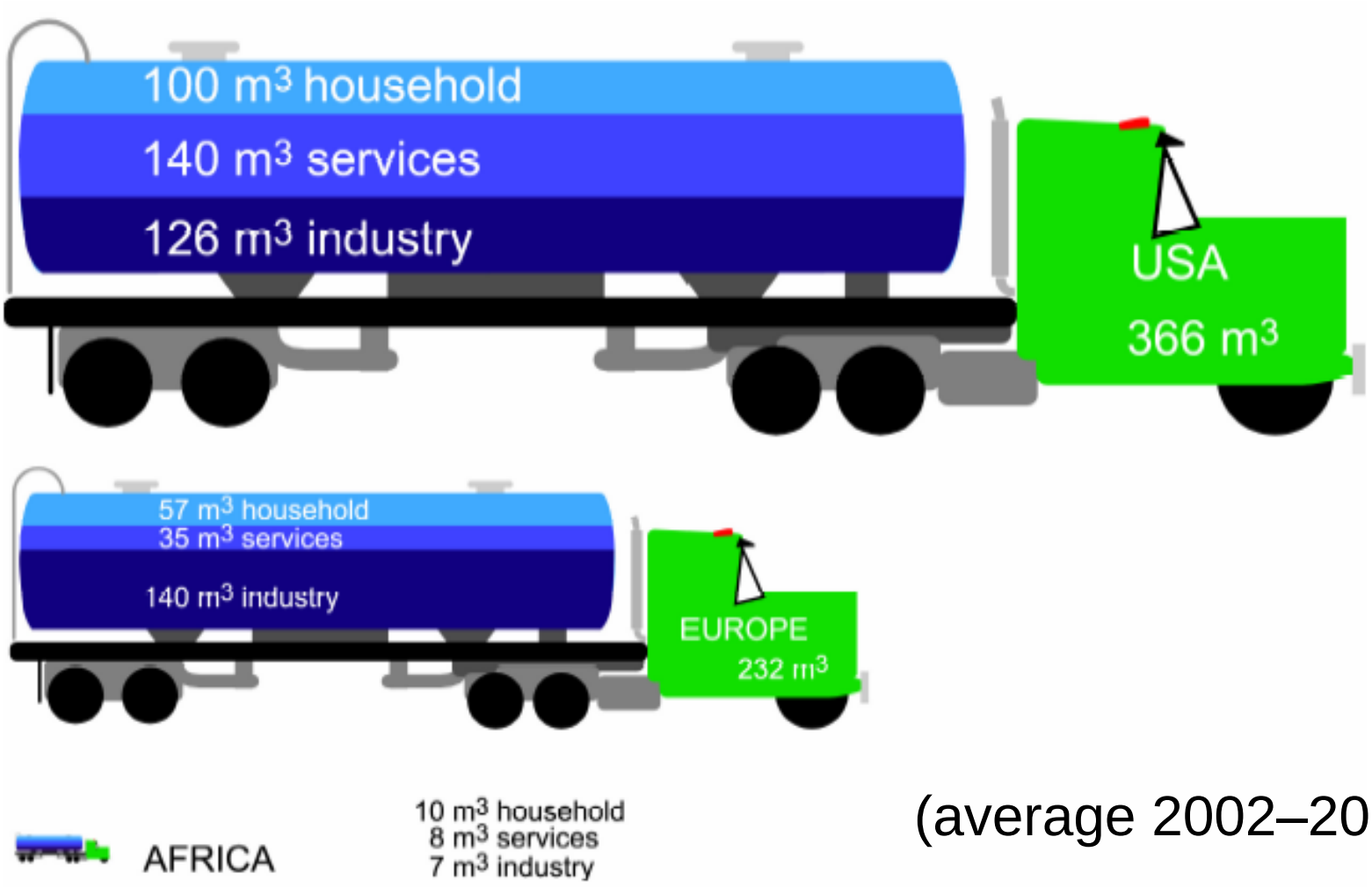
USGCRP 2009

Annual water requirement per person

Sufficient	**> 1700 m^3**
Water stress	**1000 - 1700 m^3**
Scarcity	**500 - 1000 m^3**
Extreme scarcity	**< 500 m^3**

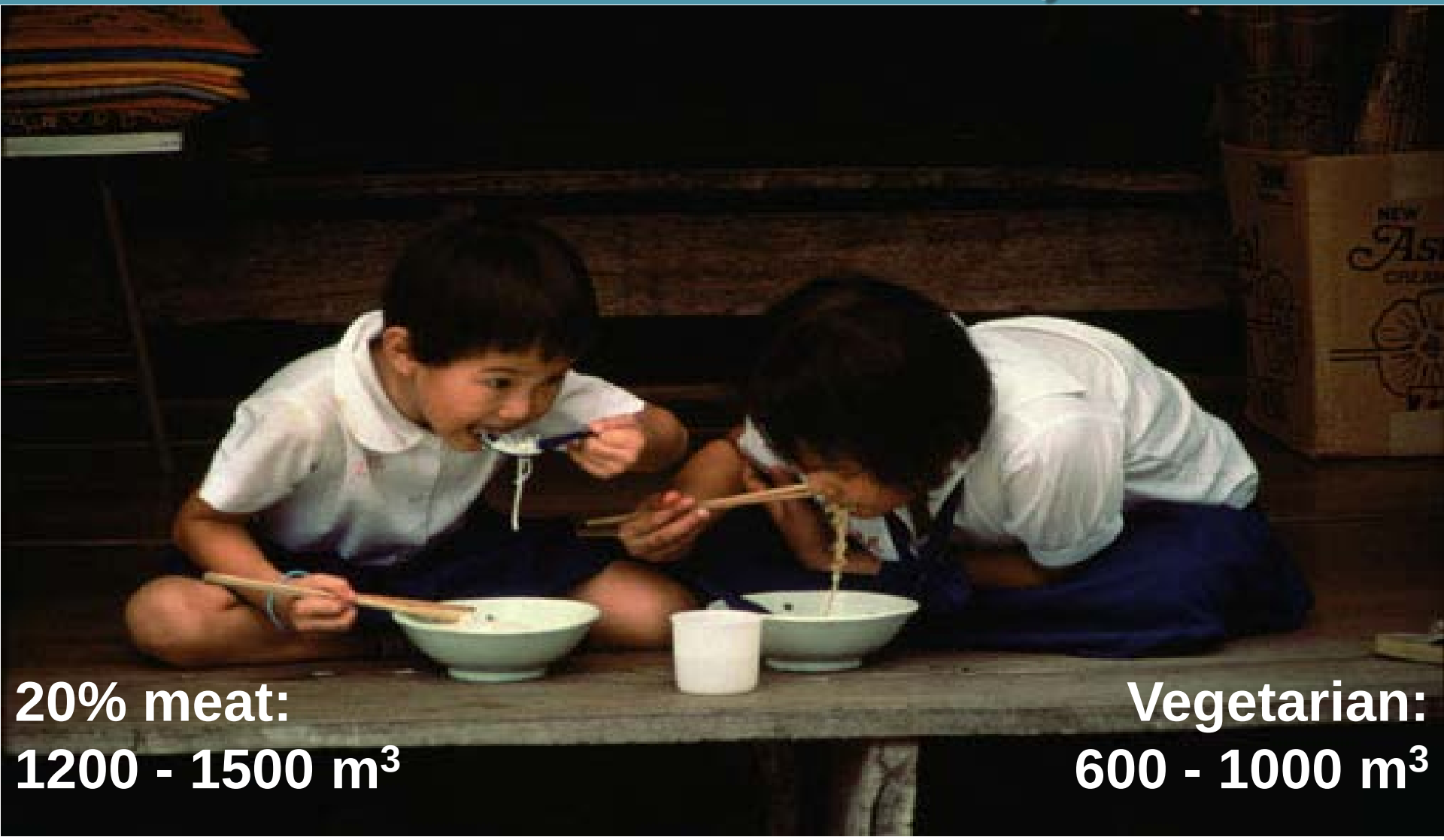
From Falkenmark & Widstrand, 1992

Annual water requirement per capita for household, services, industrial activities

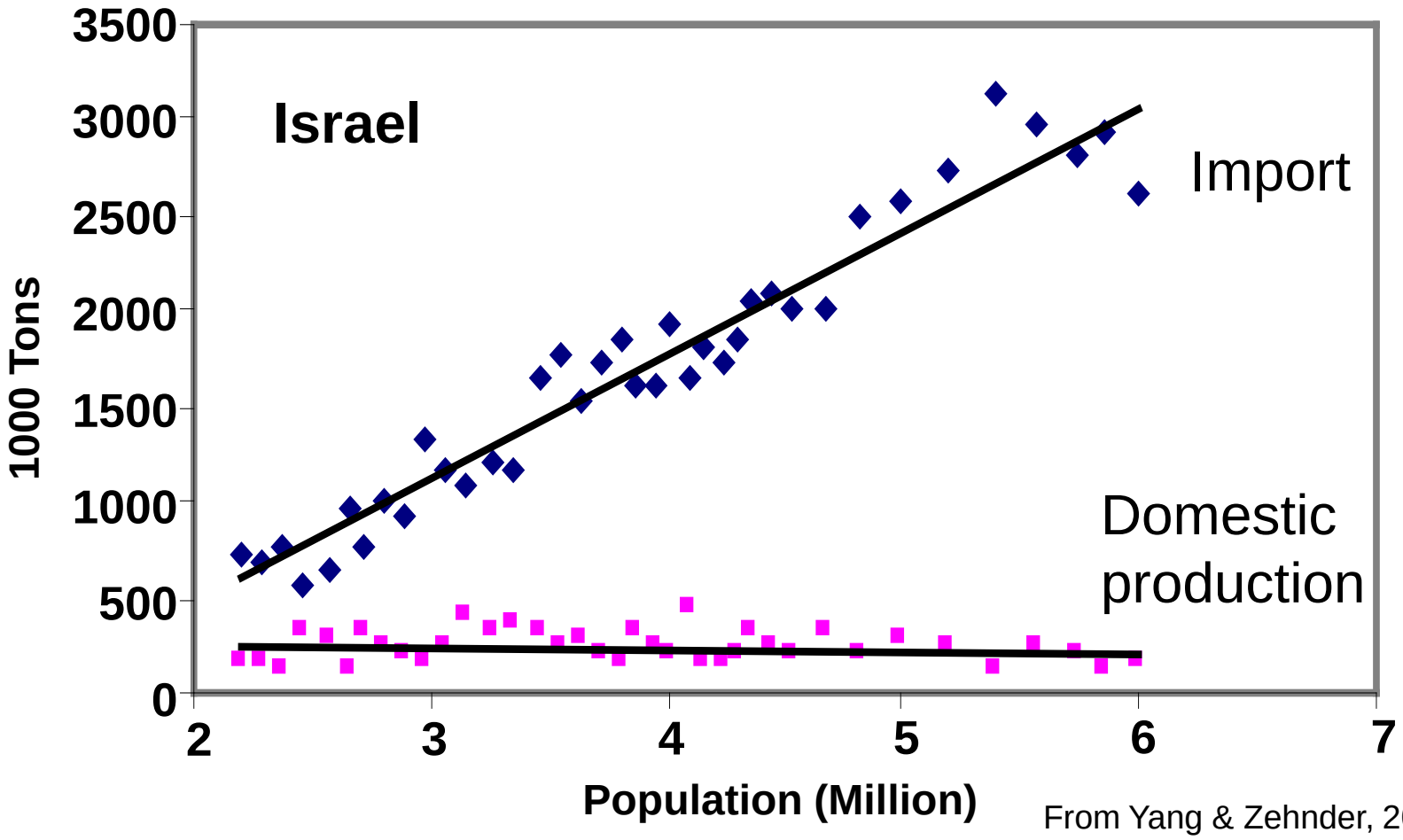


(average 2002–2011)

Annual per capita water needs for food to cover 2500 kcal a day

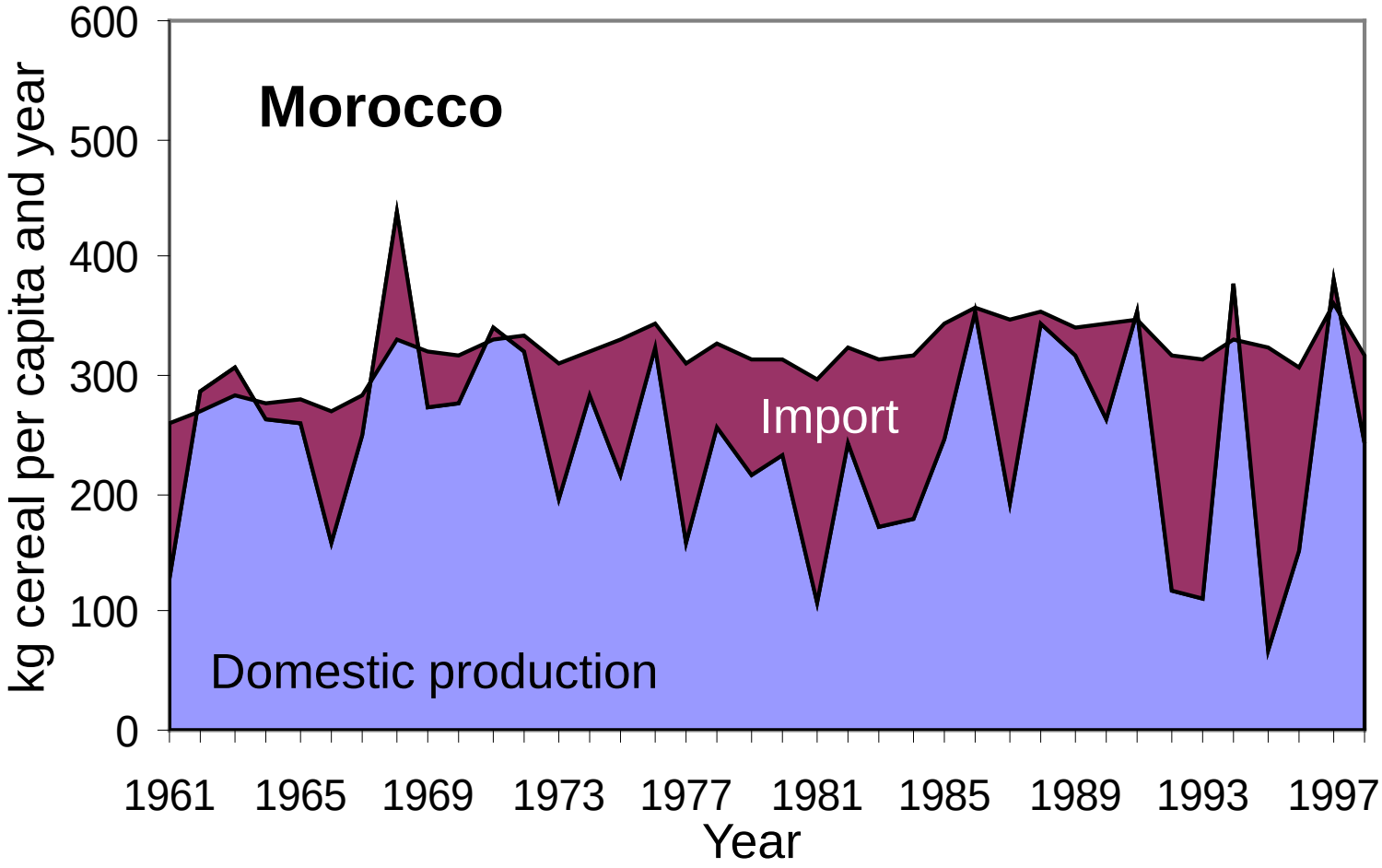


Population, cereal import, and domestic production (1961–1998)



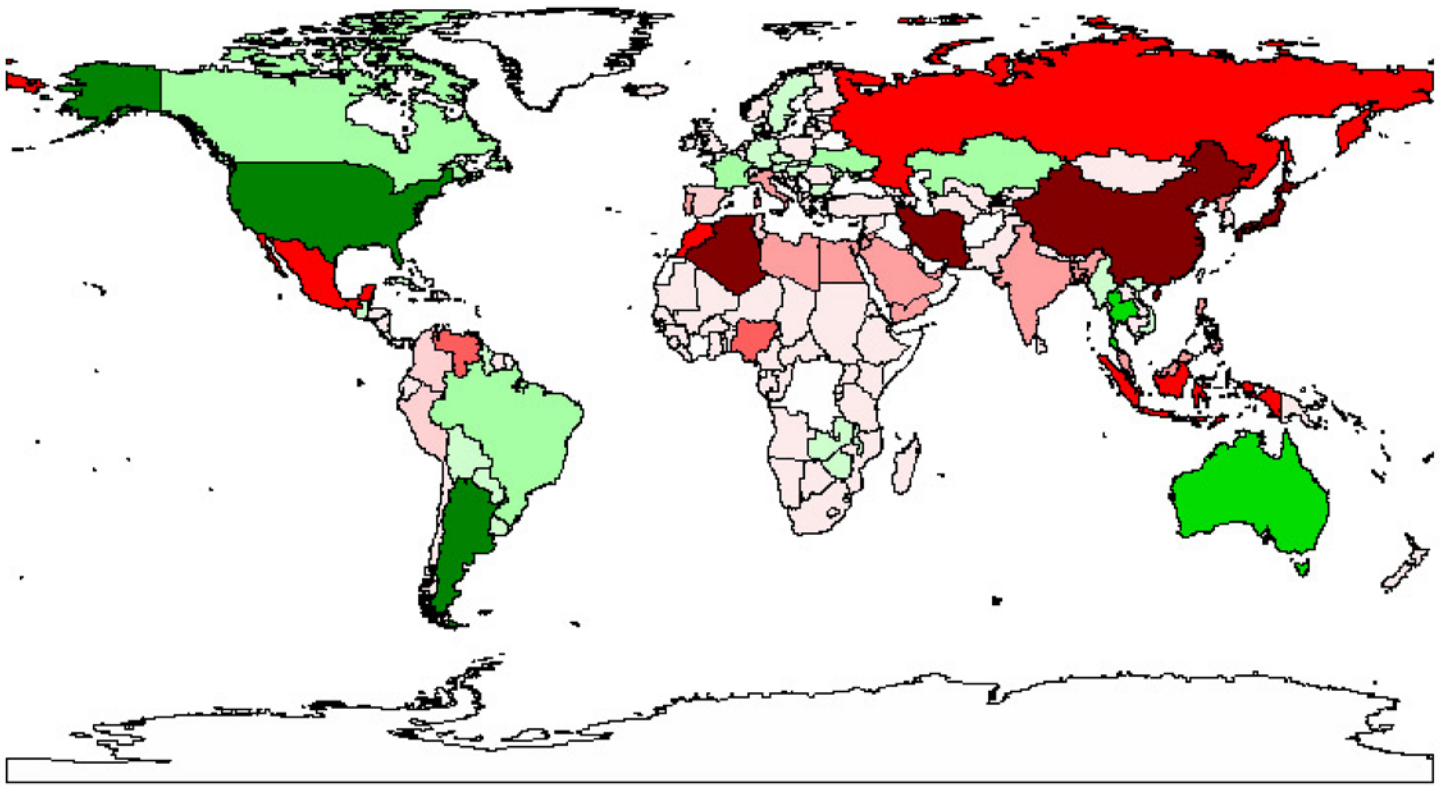
From Yang & Zehnder, 2002

Changes and sources of per capita cereal supply, 1961–1998 (kg/capita)



Data from Yang & Zehnder, 2002

Net virtual water trade by country (average over the period 2000–2006)

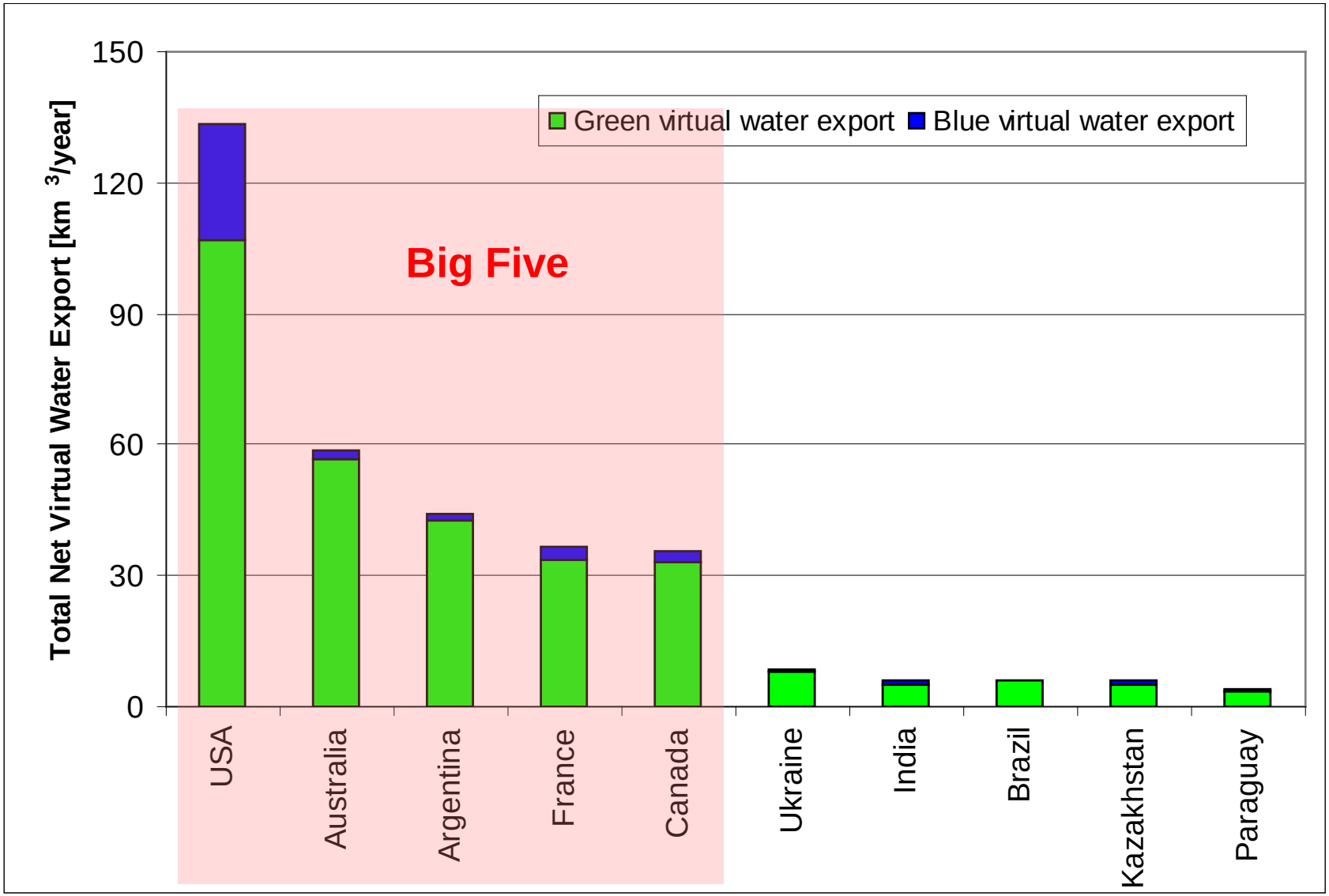


Unit: cubic km

no data	-15 - 0	15 - 20
-100 - -50	0 - 5	20 - 30
-50 - -25	5 - 10	30 - 60
-25 - -15	10 - 15	

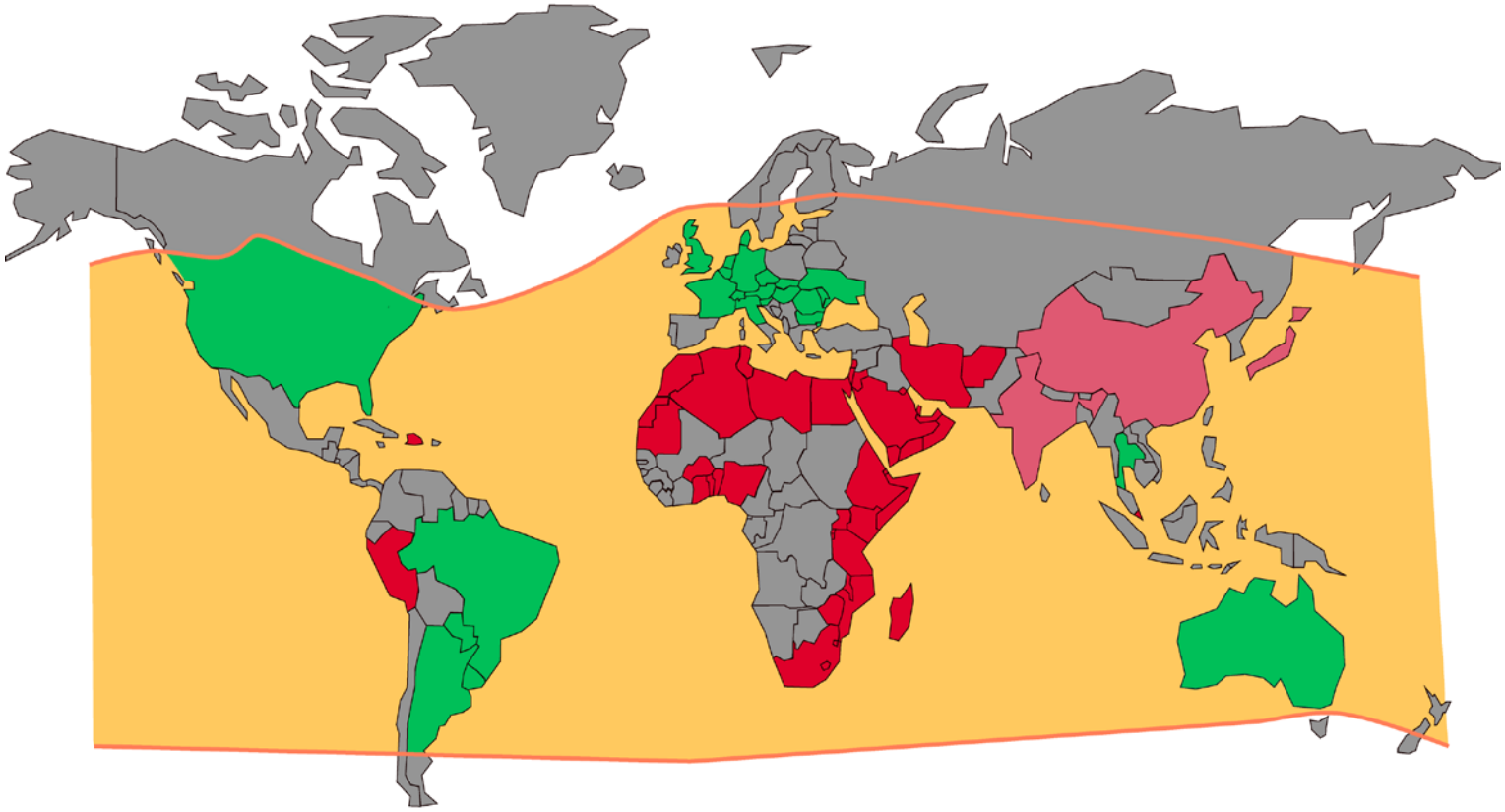
From Yang *et al.* 2007

Virtual water export



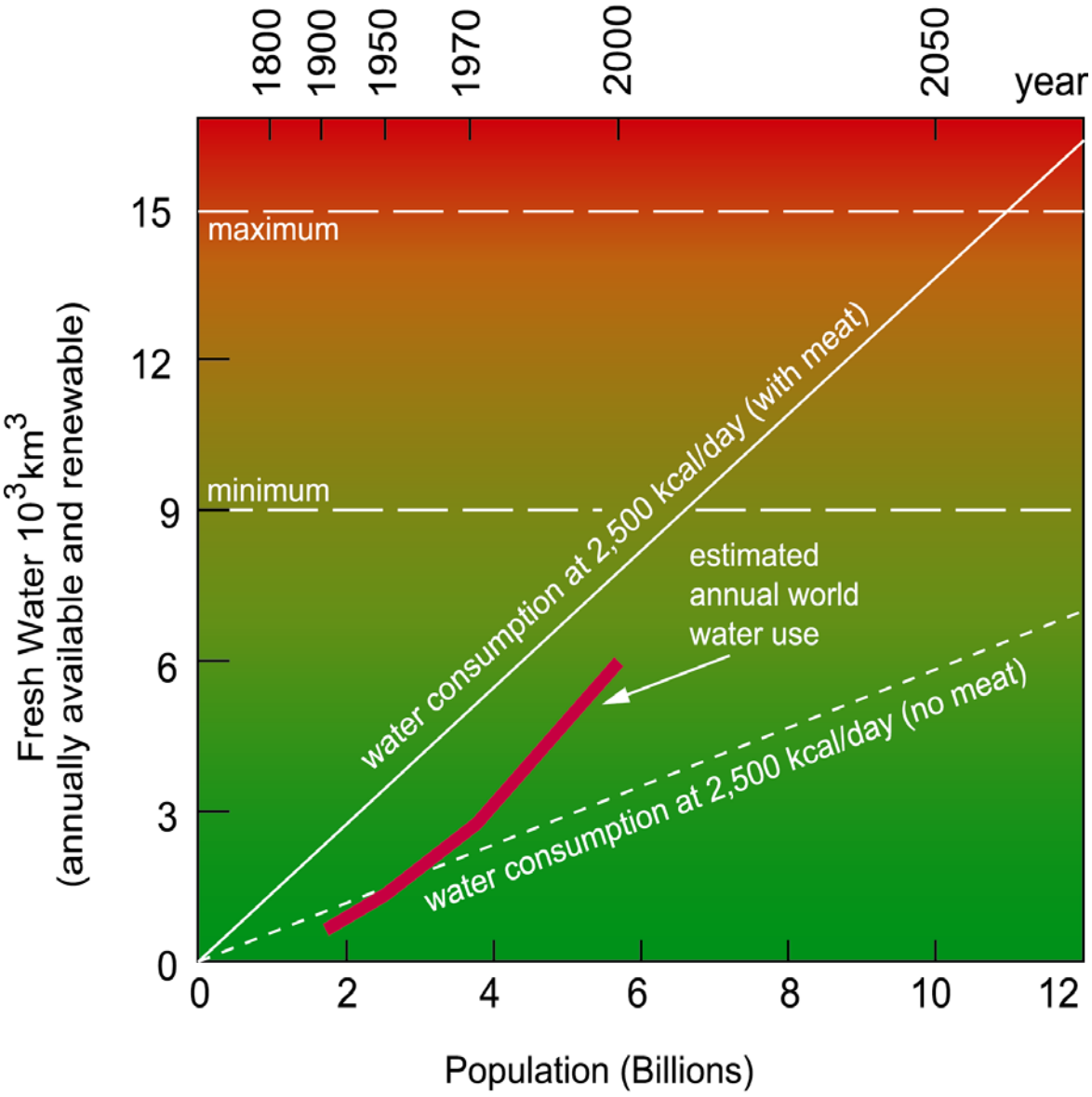
From Liu *et al.* 2009

Situation 2030



From Zehnder, 2002

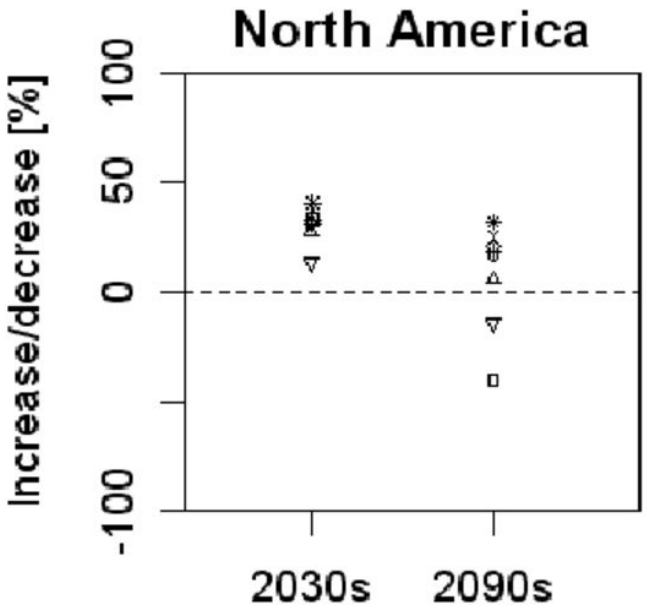
Projection of water availability



From Zehnder, 1999

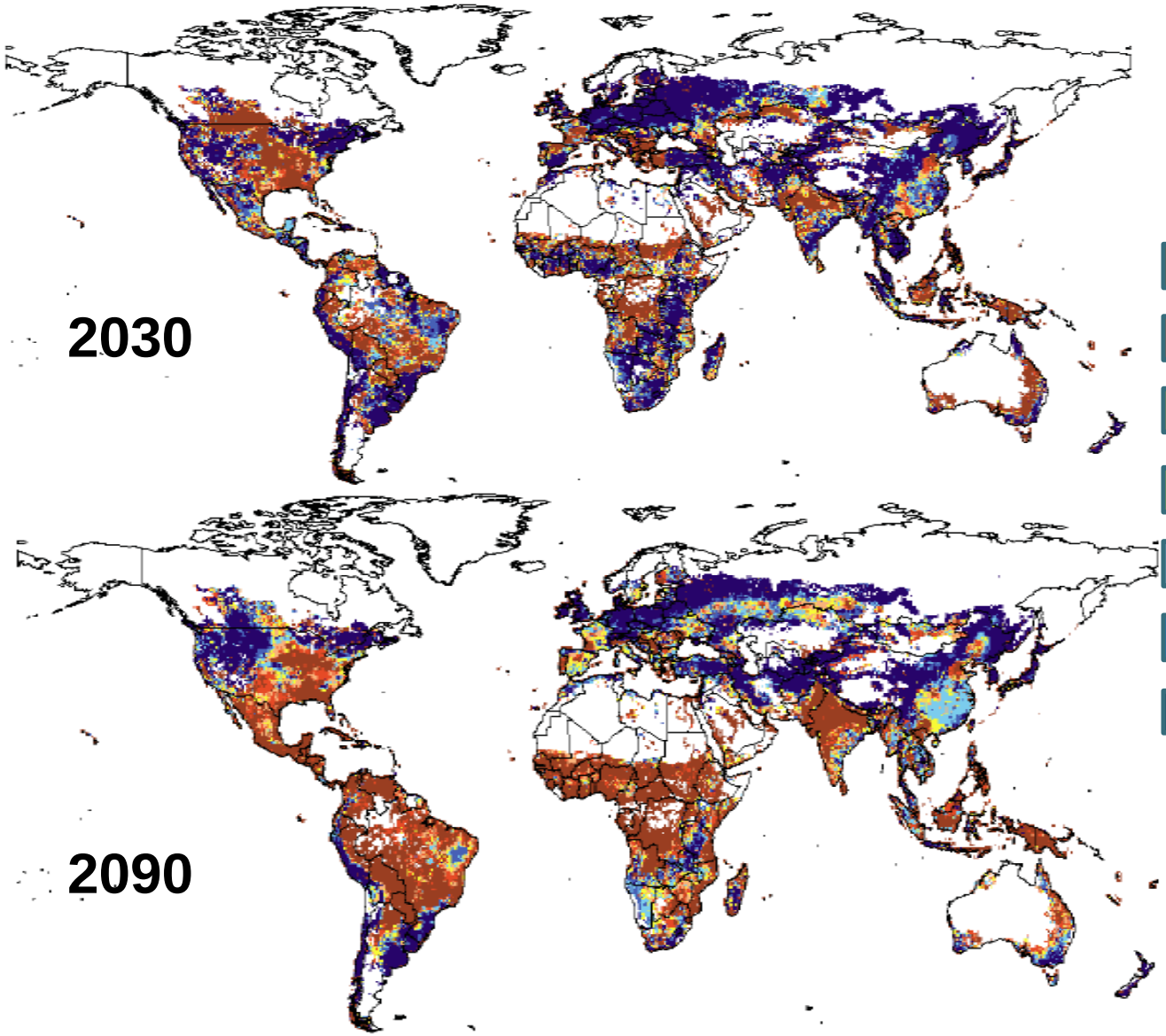
Future? – models used and interpretation

Models used
HadCM3 (Hadley Centre Coupled Model, version 3), UK
CGCM2 (Coupled Global Climate Model version 2), Canada
CSIRO2 (Commonwealth Scientific and Industrial Research Organization), Australia
Parallel Climate Model couples three models, USA
Scenarios
A1FI - emphasis on fossil-fuels (Fossil Intensive).
B2 – local environmental sustainable



Increase with high confidence	7 scenarios
Increase with medium confidence	6 scenarios
Increase with low confidence	5 scenarios
Decrease with low confidence	5 scenarios
Decrease with medium confidence	6 scenarios
Decrease with high confidence	7 scenarios
Increase/decrease mixed	All others

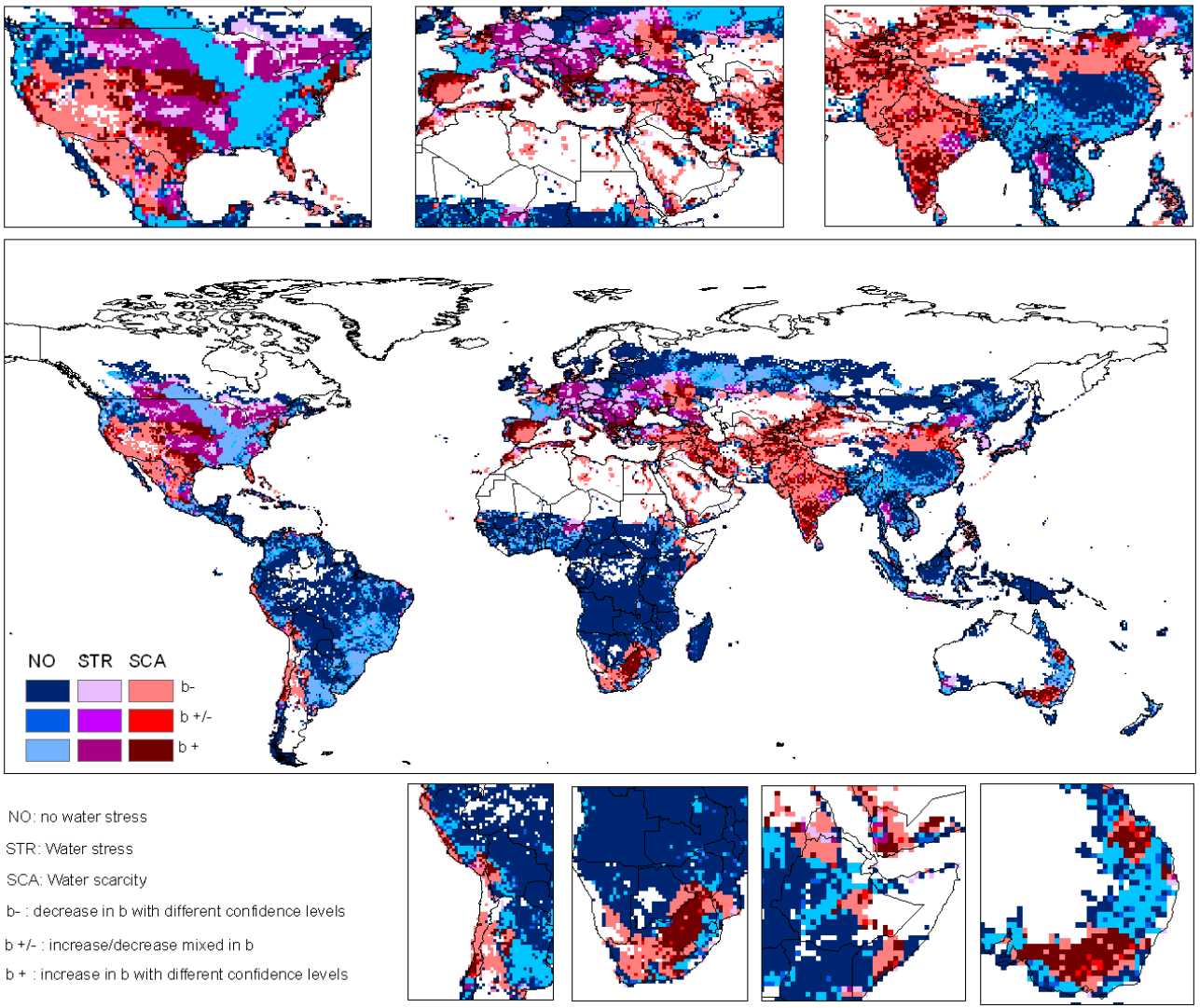
Impact of climate change on crop production (wheat, maize & rice)



- Decrease with high confidence
- Decrease with medium confidence
- Decrease with low confidence
- Increase/Decrease mix
- Increase with low confidence
- Increase with medium confidence
- Increase with high confidence

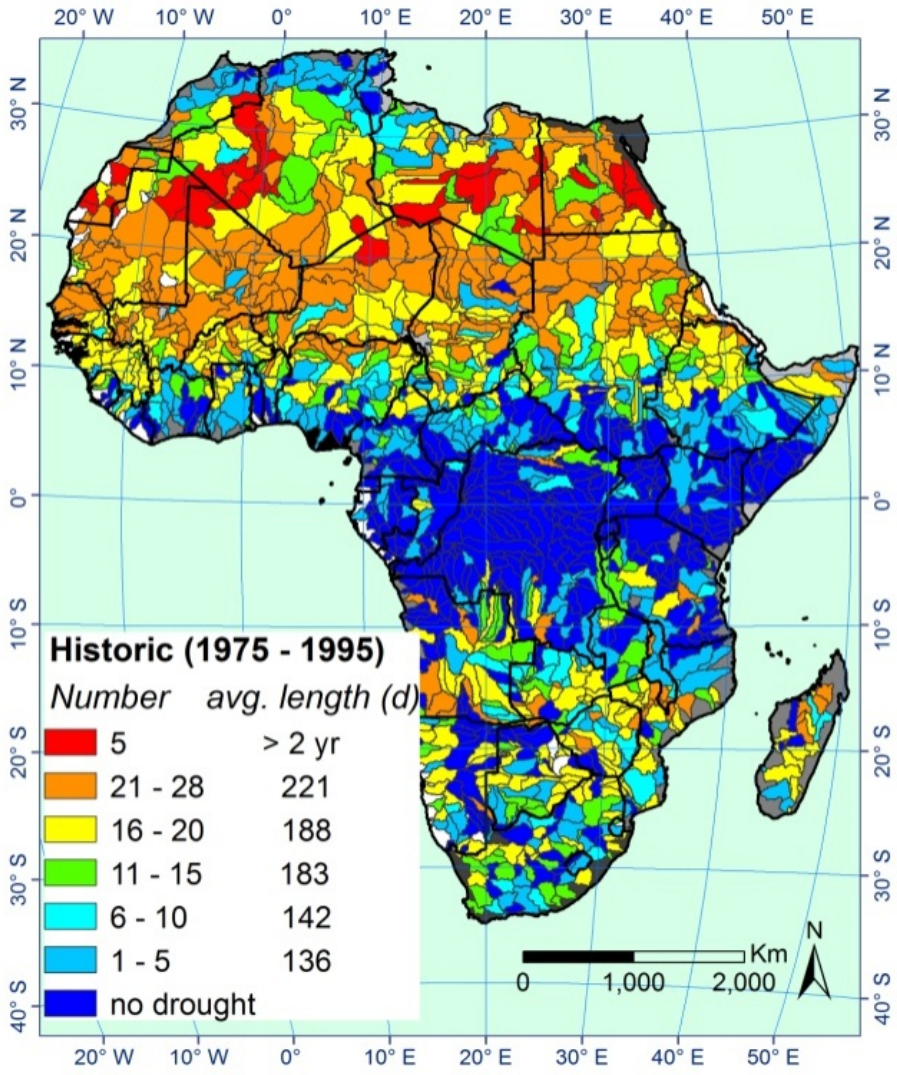
Liu *et al*. 2013

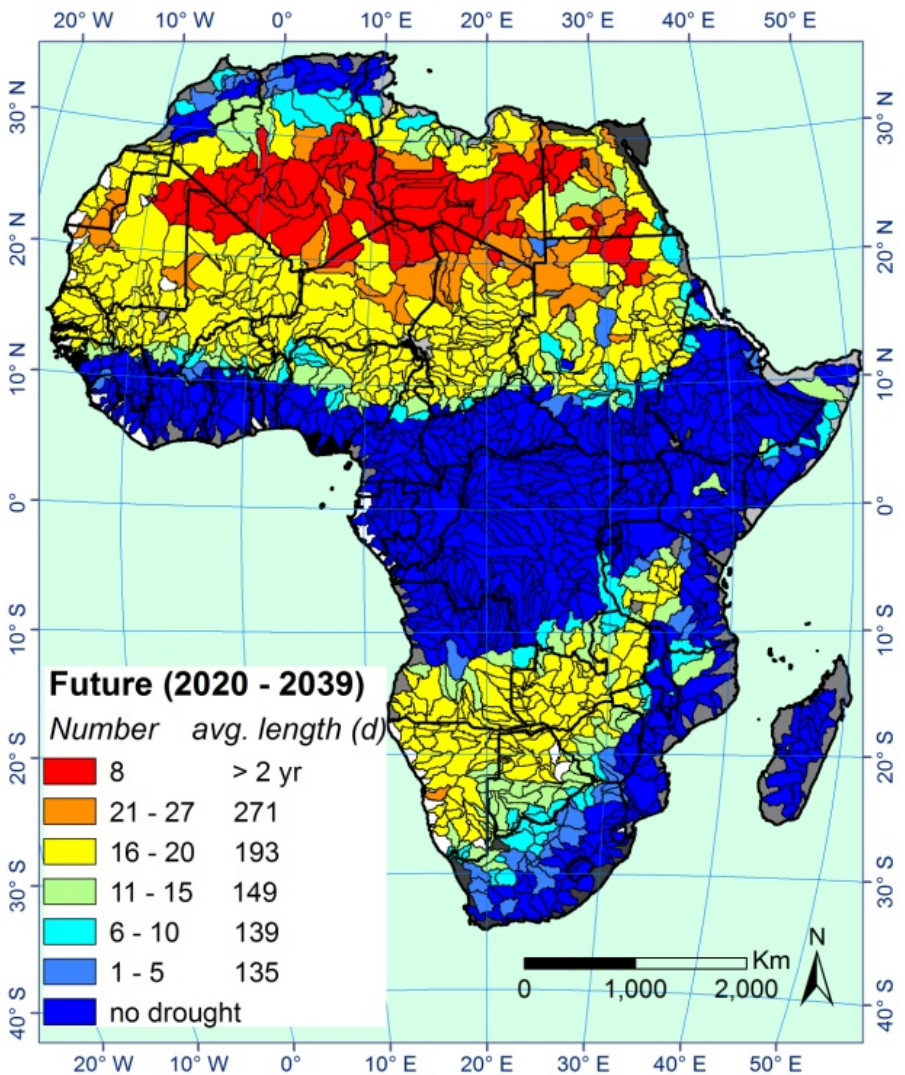
Climate change induced trend in blue water availability in 2030



Liu *et al*. 2013

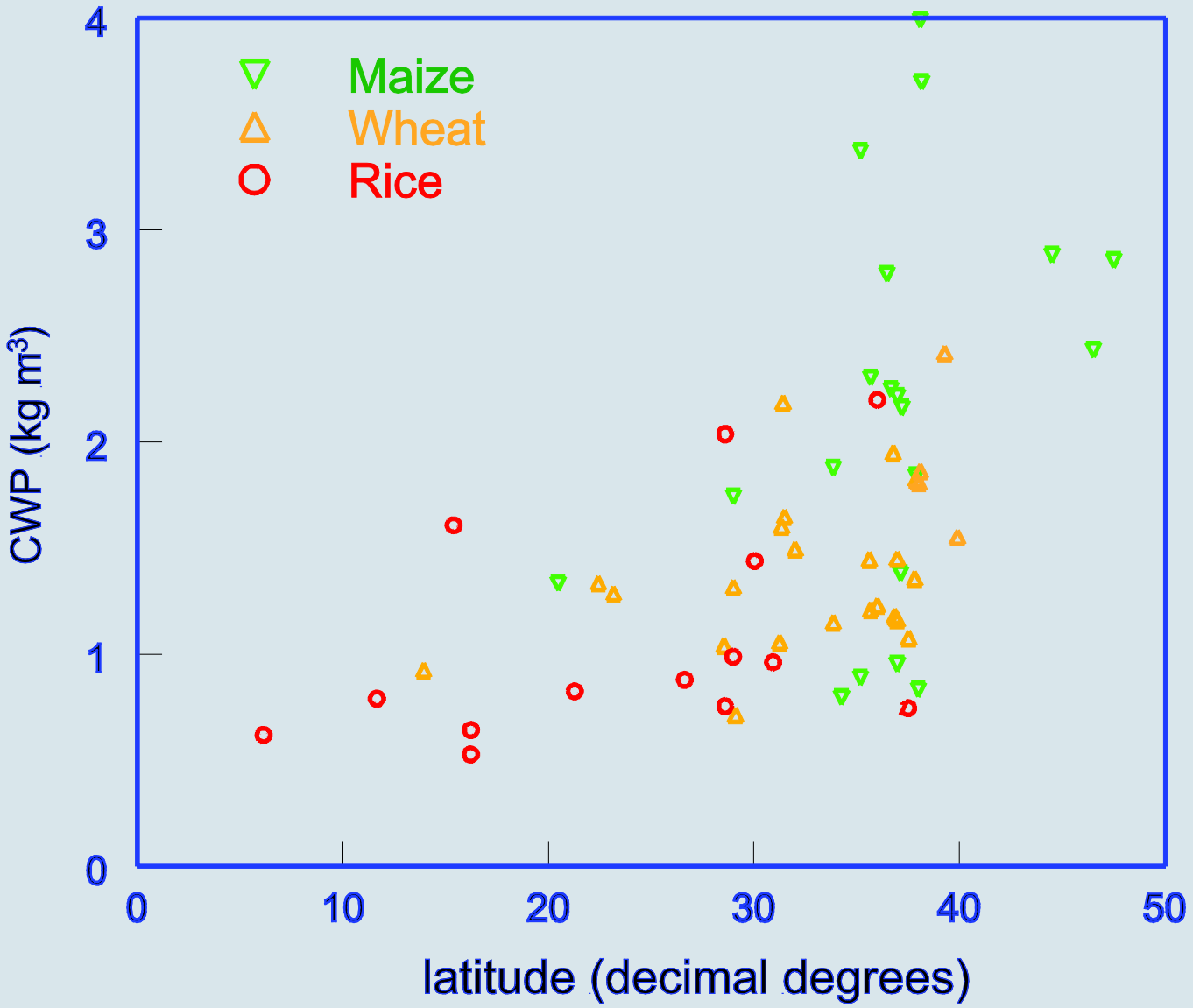
Frequencies of droughts





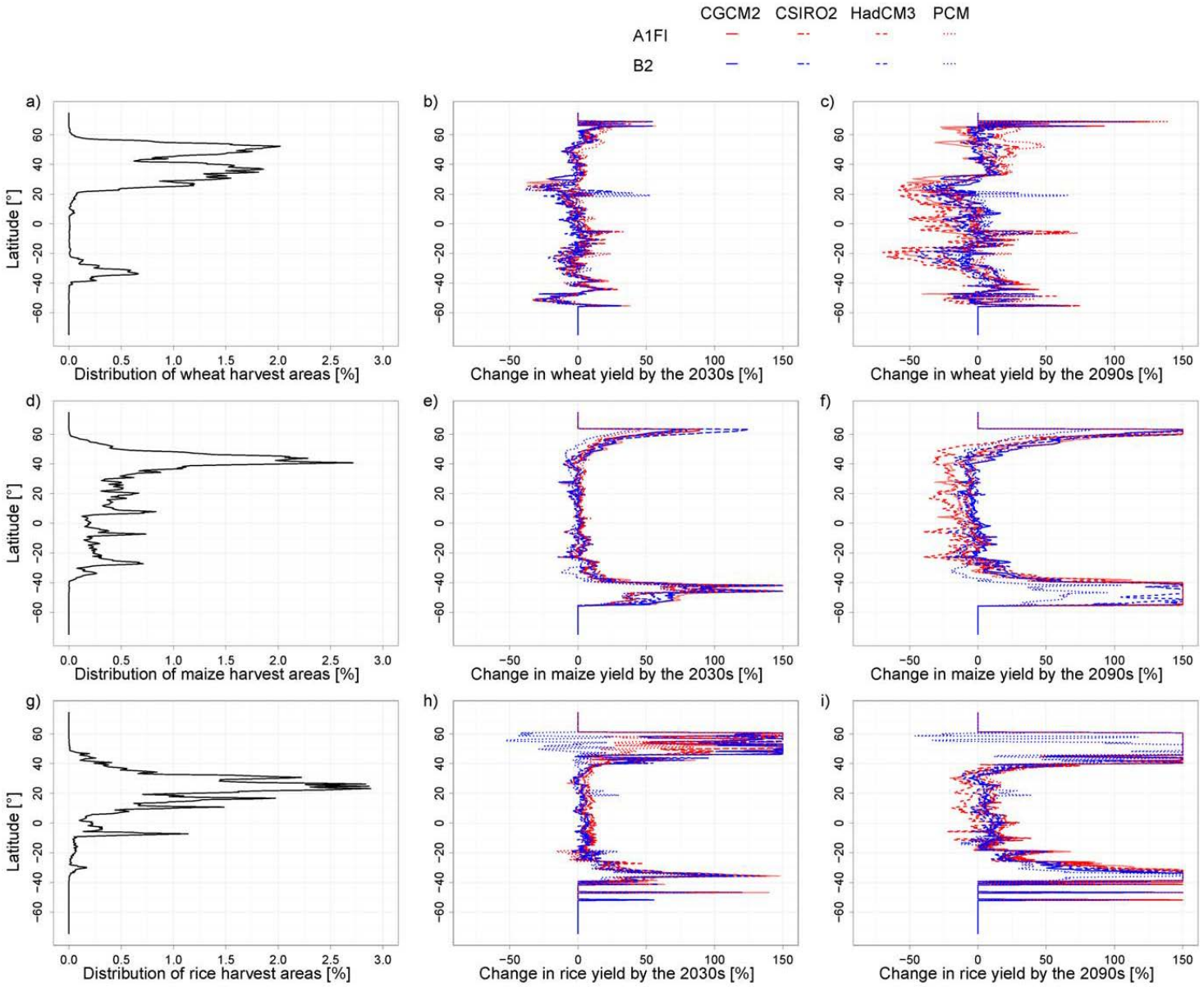
Faramarzi *et al*. 2013

Latitude dependent irrigated crop water productivity



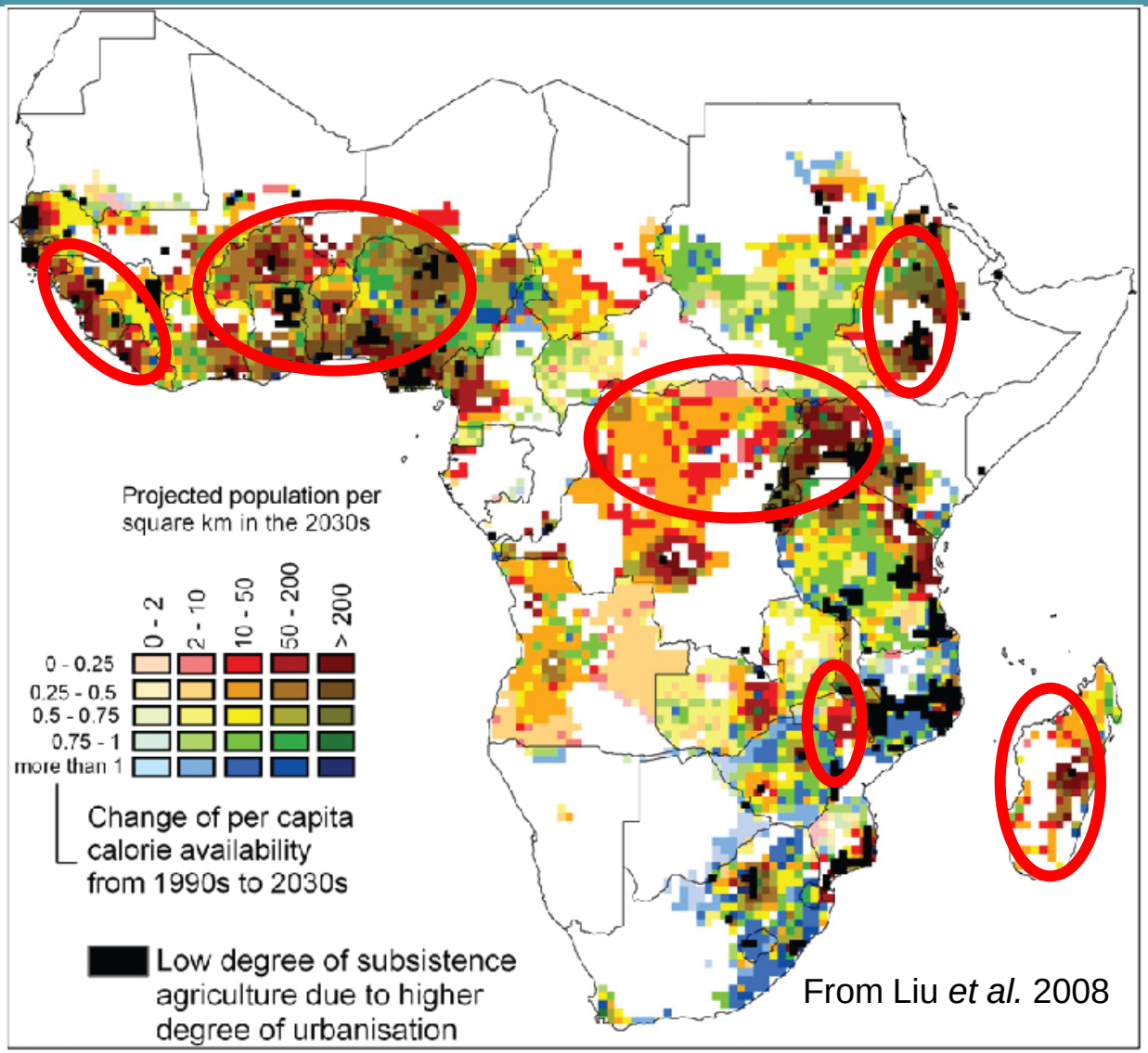
Adopted from Zwart & Bastiaansen, 2004

Change in crop yield



Liu *et al.*, 2013

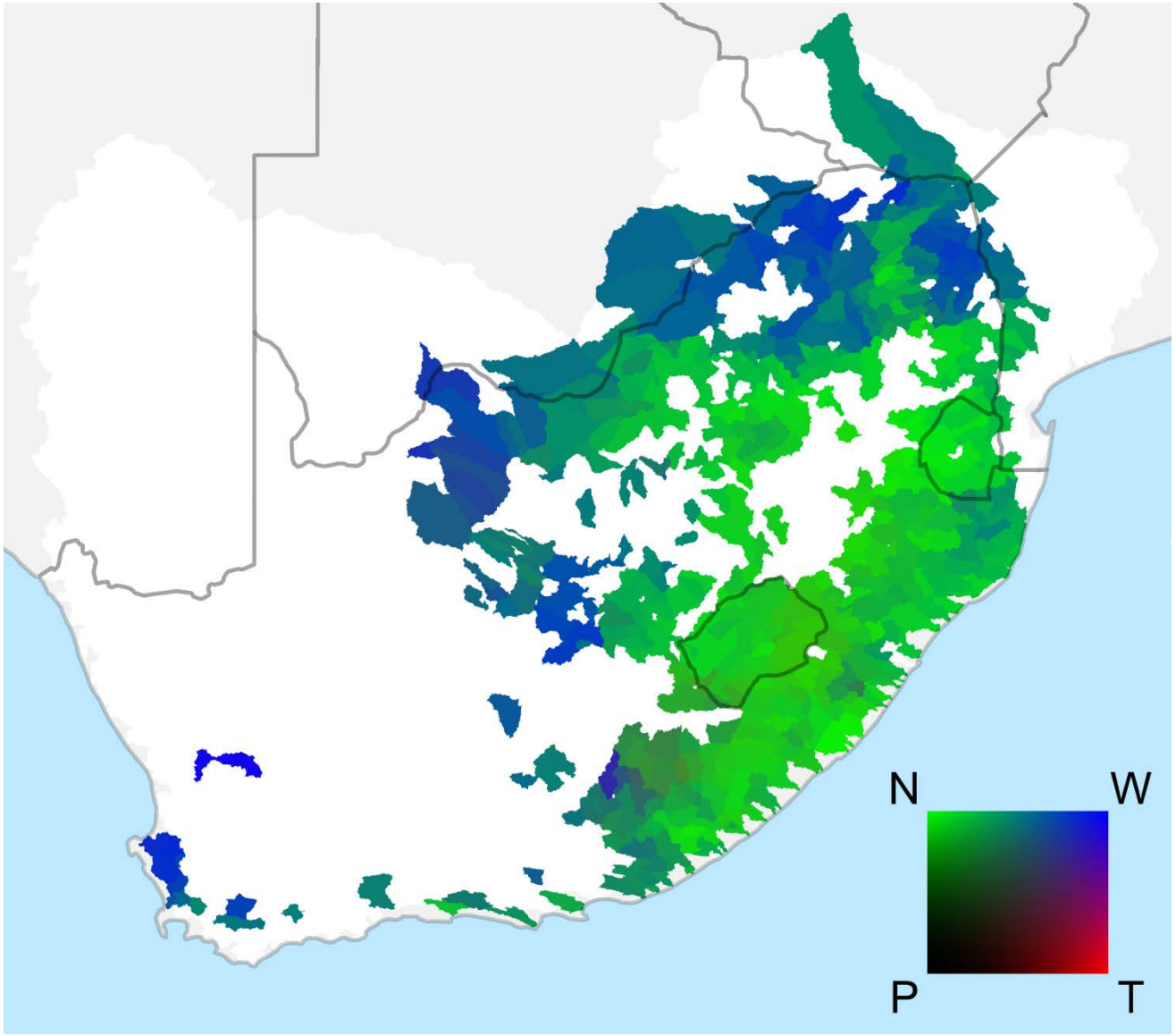
Food security in 2030



Example:
Sub Saharan Africa

Areas ⬭ with high food insecurity

Limiting factors for crop yields



% of stress

100 0

0 100

N W

Andersson *et al.* 2013

Challenges & Conclusions

- Climate change may have globally less of a negative effect on water availability & food production but we need to feed 2 billion humans more.
- Flood and draughts will influence increasingly local food and water security.
- Economic and political dependence in the water and virtual water (food) sector is growing.
- Virtual water must become an integral part of future water management decisions.
- Geopolitical efforts are needed to allow the principle of national food self-sufficiency to be abandoned.
- Only if these challenges are met governments can take the most optimal economic and ecological decisions for the use of the available water in their countries.