Transitioning Cereal Systems to Adapt to Climate Change

November 13-14, 2015

Funded through Award #2011-68002-30191 from USDA National Institute of Food and Agriculture

Adaptation to drought under climate change: A global perspective

Stefan Siebert
Senior Scientist
University of Bonn

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Adaptation to drought under climate change: A global perspective

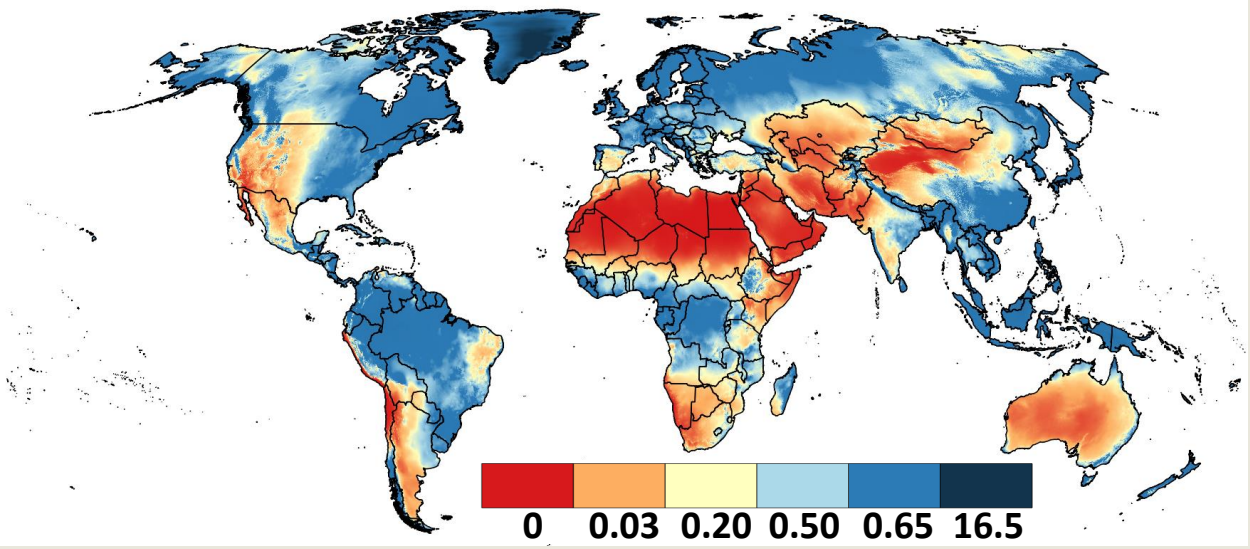
- **Introduction**
- **Adaptation to drought by**
  - **Land use conversion**
  - **Irrigation**
  - **Trade**
  - **Crop and cultivar choice**
  - **Adjusted crop phenology**
  - **Increased water use efficiency**

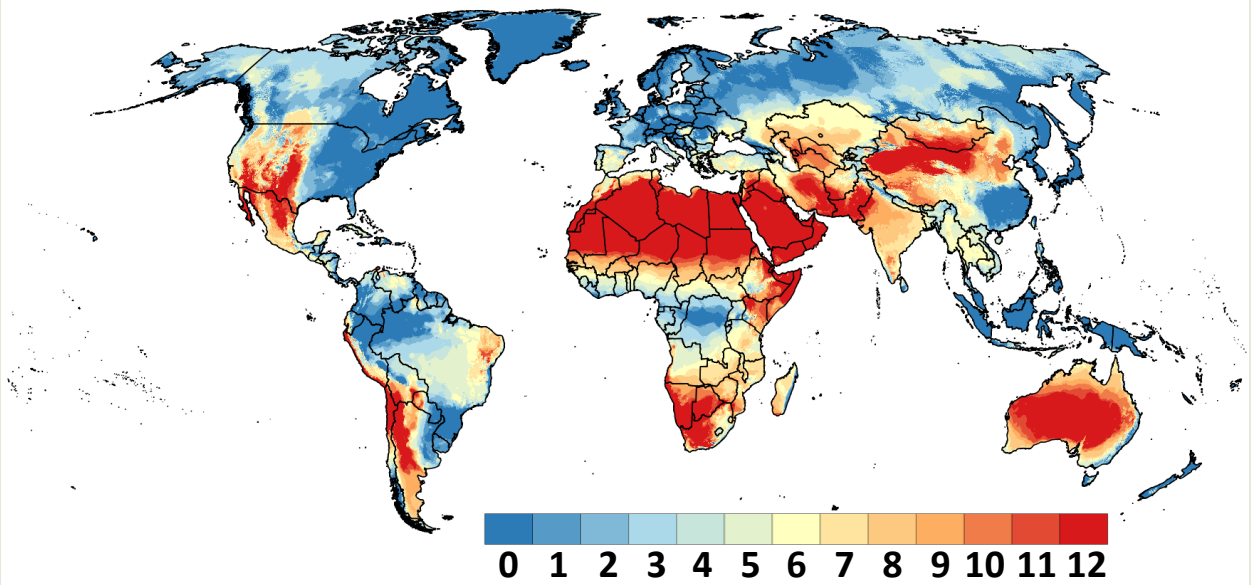
Freshwater is a renewable resource!

Spatiotemporal patterns matter!

Annual P / PET
(aridity index)

0.00 – 0.03	hyper-arid
0.03 – 0.20	arid
0.20 – 0.50	semi-arid
0.50 – 0.65	dry sub-humid
> 0.65	humid



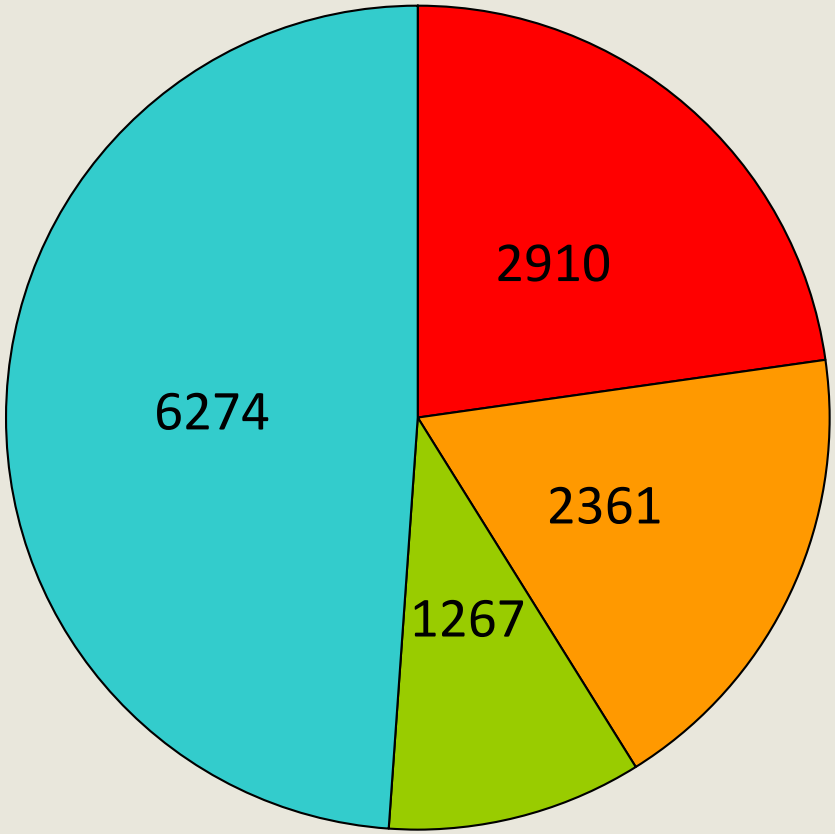


Number of months with P < 0.5 PET

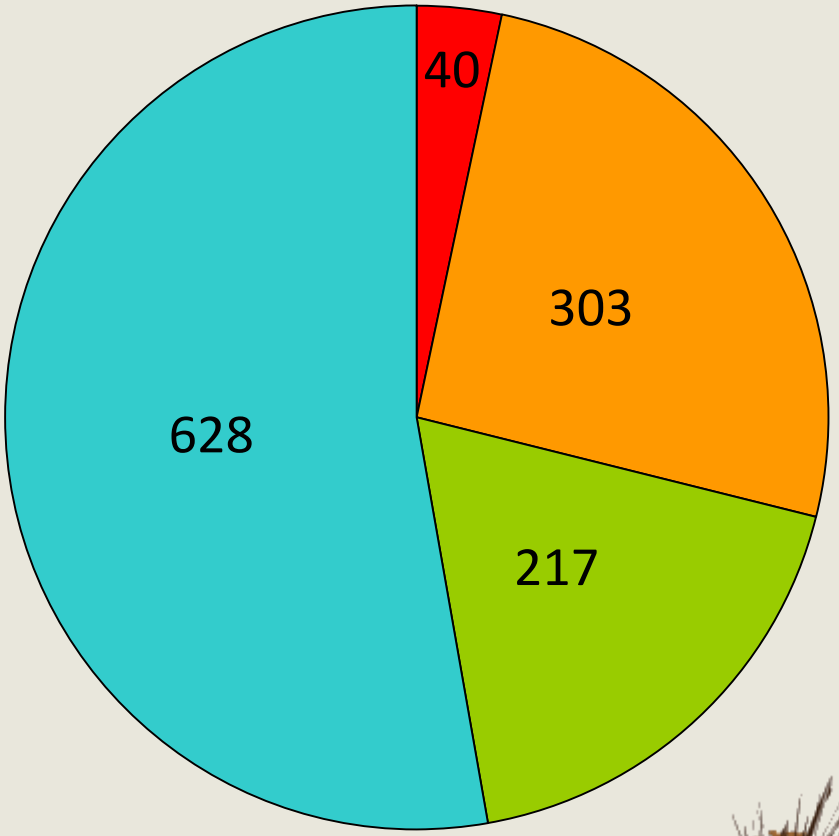
Data sources:
WorldClim,
Global Aridity and PET Database

Little rainfed cropping on arid land!

Total land area
(Million ha)



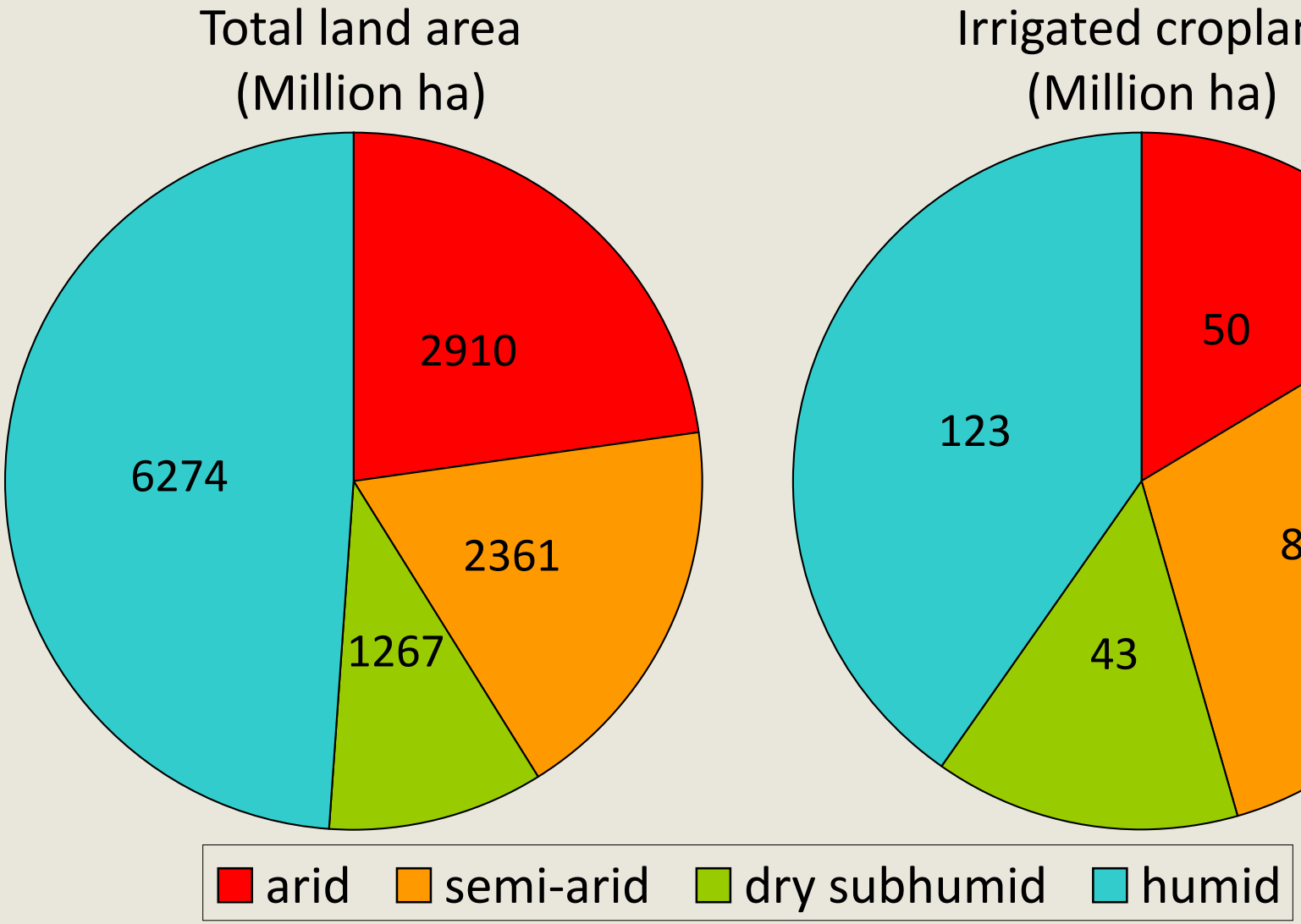
Rainfed cropland
(Million ha)



arid | semi-arid | dry subhumid | humid

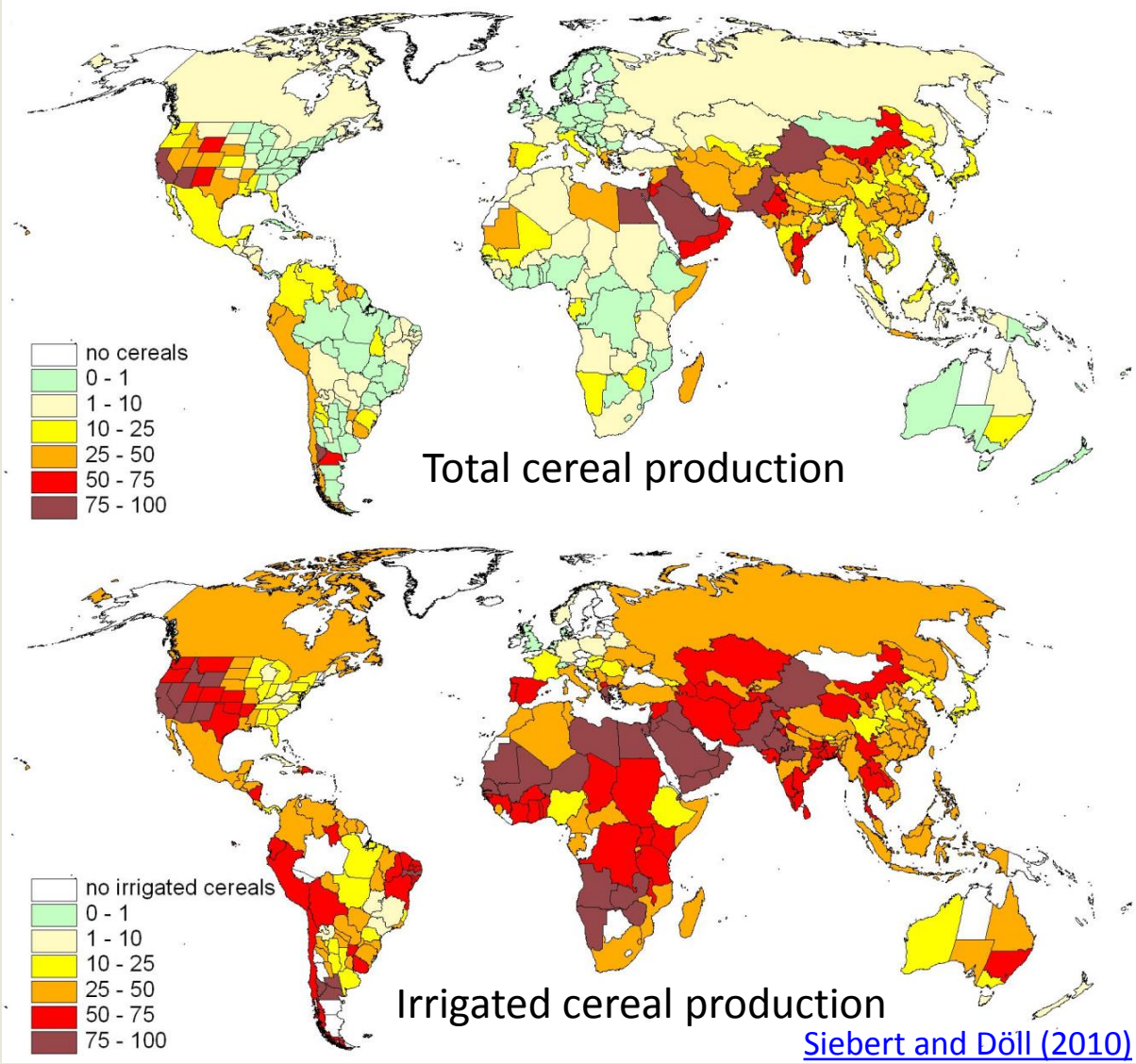
Data sources: Ramankutty et al. 2015, Siebert et al., 2015

More irrigated crops on arid land!



Data sources: Ramankutty et al. 2015, Siebert et al., 2015

Higher crop productivity by irrigation!

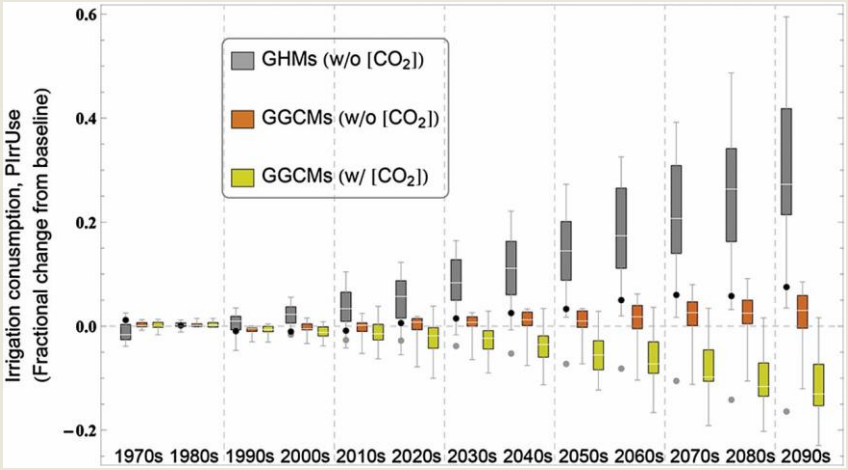


Siebert and Döll (2010)

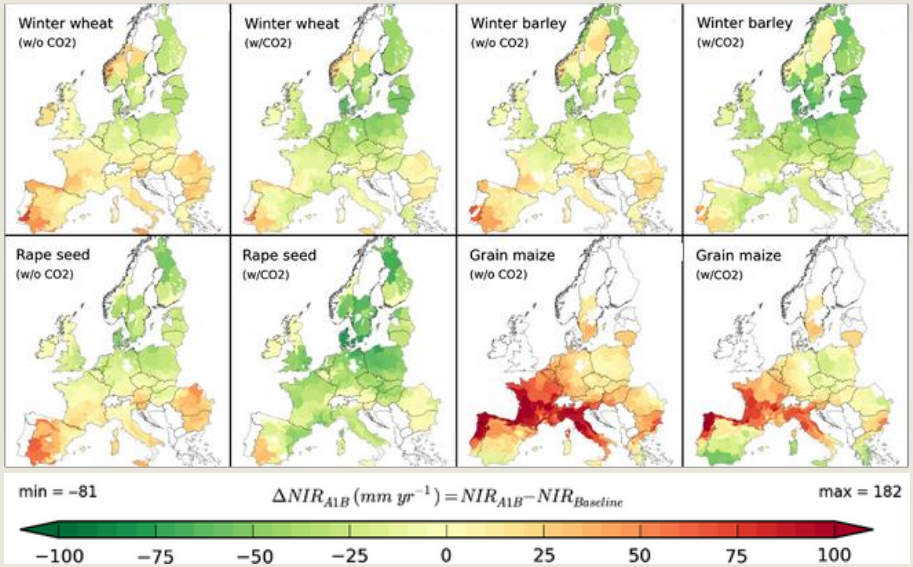
Production loss in cereal production (~ year 2000) when not using irrigation

In arid regions yields are more than doubled when using irrigation

Will irrigation water requirement increase under climate change?



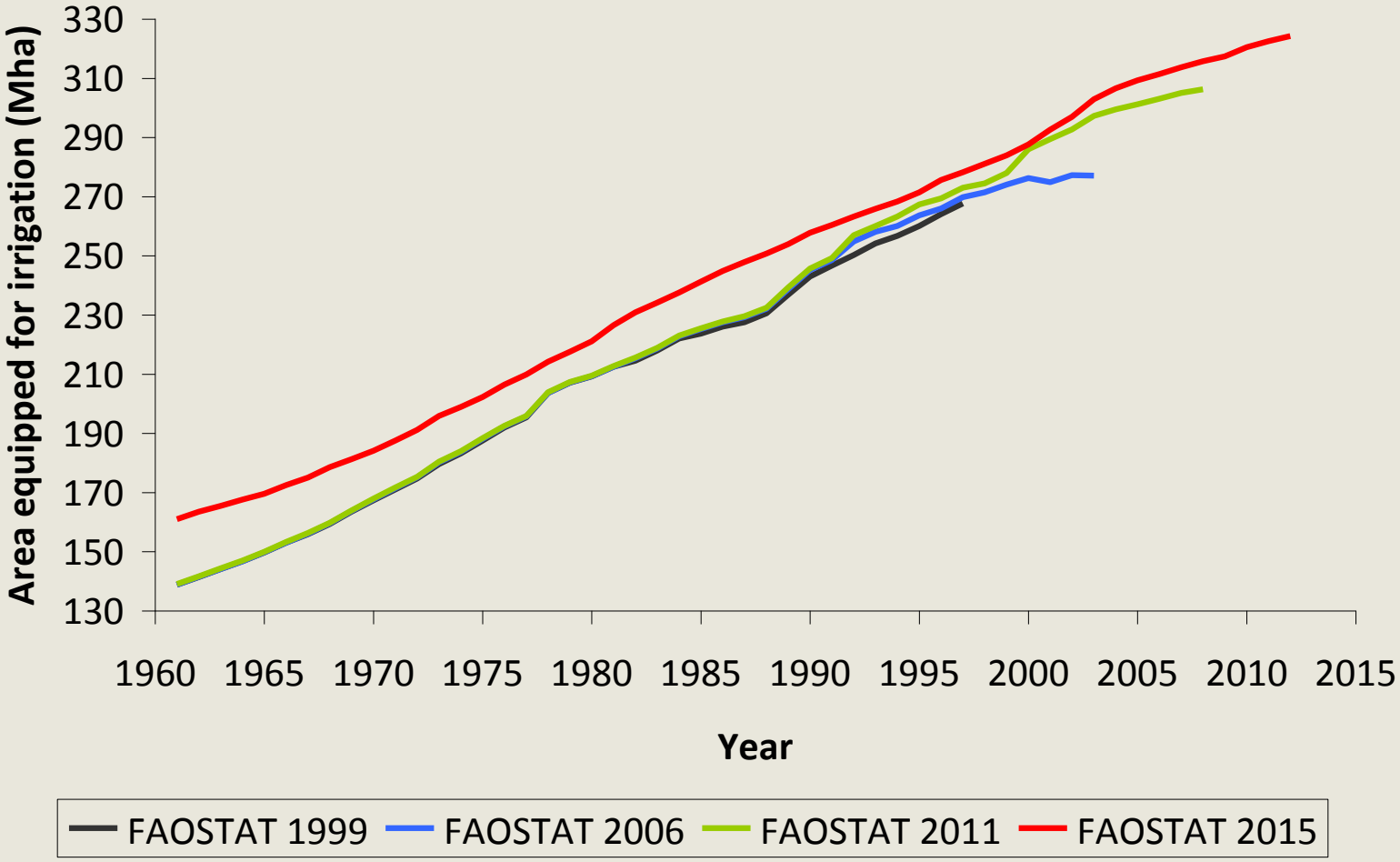
Elliot et al., 2014



Zhao et al., 2015

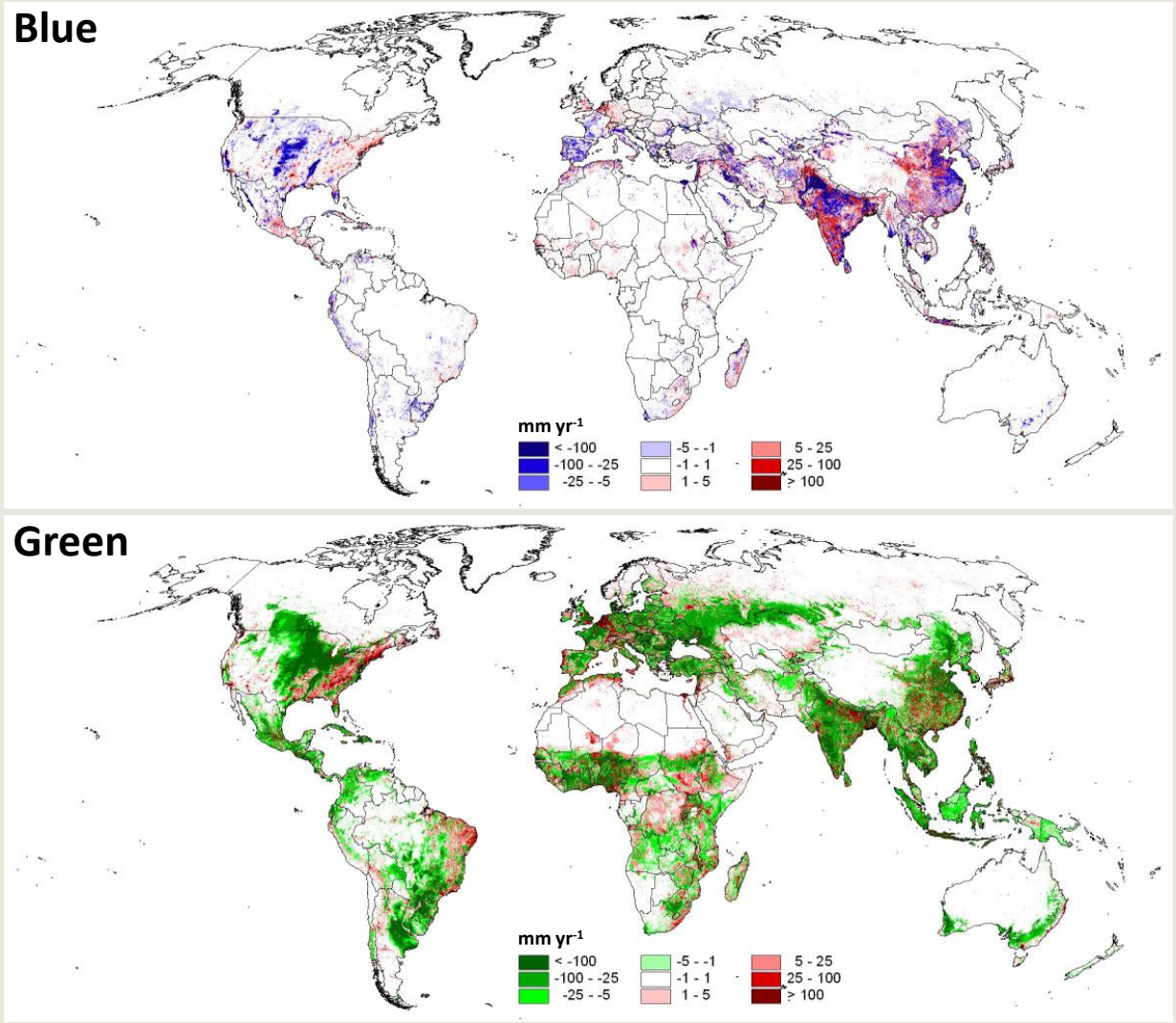
When accounting for the effect of increasing CO_2 on crop growth and transpiration, **irrigation requirements will decline** (at least for C_3-crops).

Is the increase in irrigated land becoming smaller?



No! The slow down often shown for most recent years likely because of time lag in the availability of census statistics!

Saving water by trade?



Hoff et al., 2014

Net balances of blue and green virtual water flows caused by trade of 21 major crop commodities:

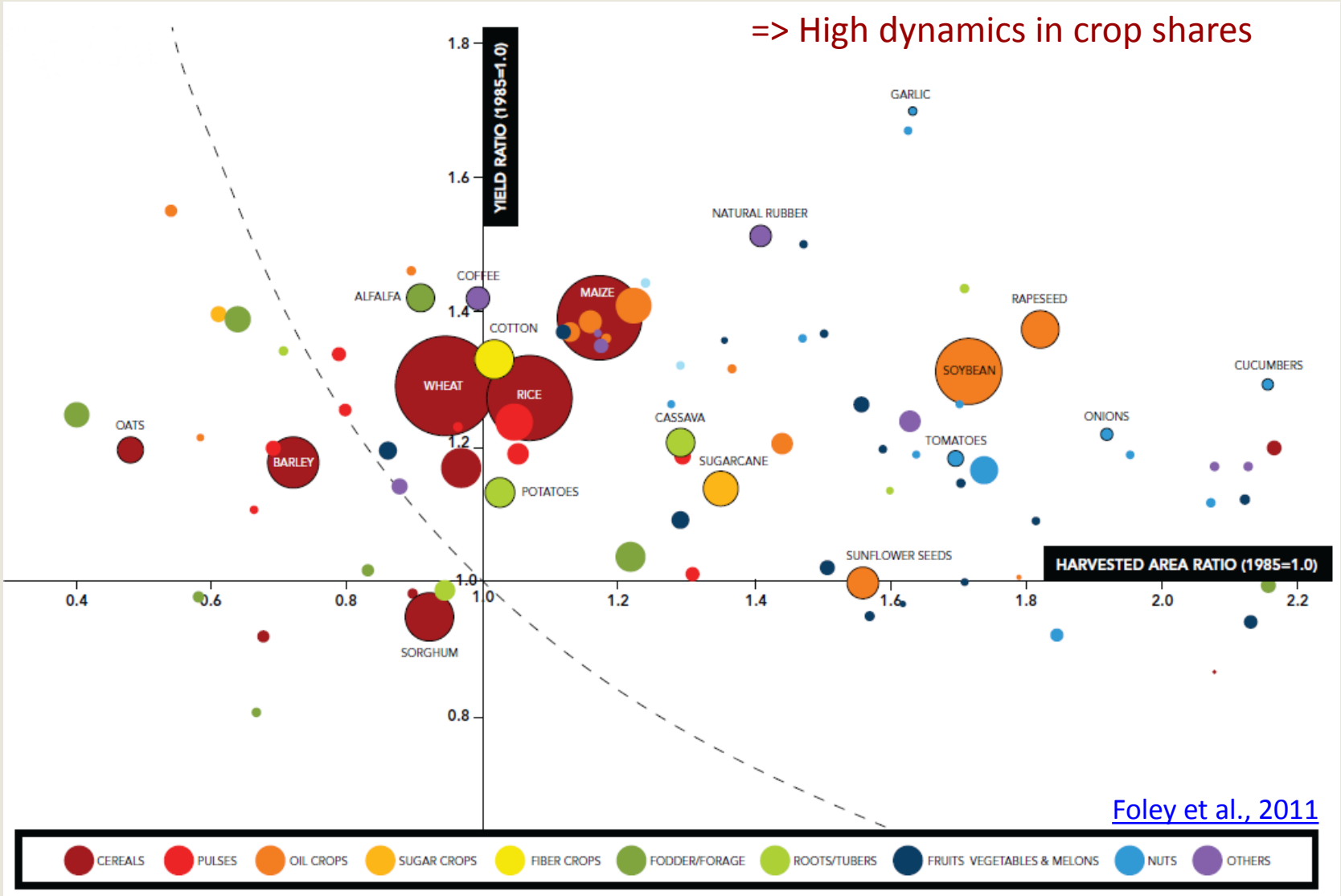
Hyper arid regions (AI<0.03):
Inflow of blue water: 5 km^3 yr^{-1}
Inflow of green water: 17 km^3 yr^{-1}

Arid regions (0.03<AI<0.2):
Outflow of blue water: 48 km^3 yr^{-1}
Inflow of green water: 54 km^3 yr^{-1}

Semi-arid regions (0.2<AI<0.5):
Outflow of blue water: 34 km^3 yr^{-1}
Outflow of green water: 130 km^3 yr^{-1}

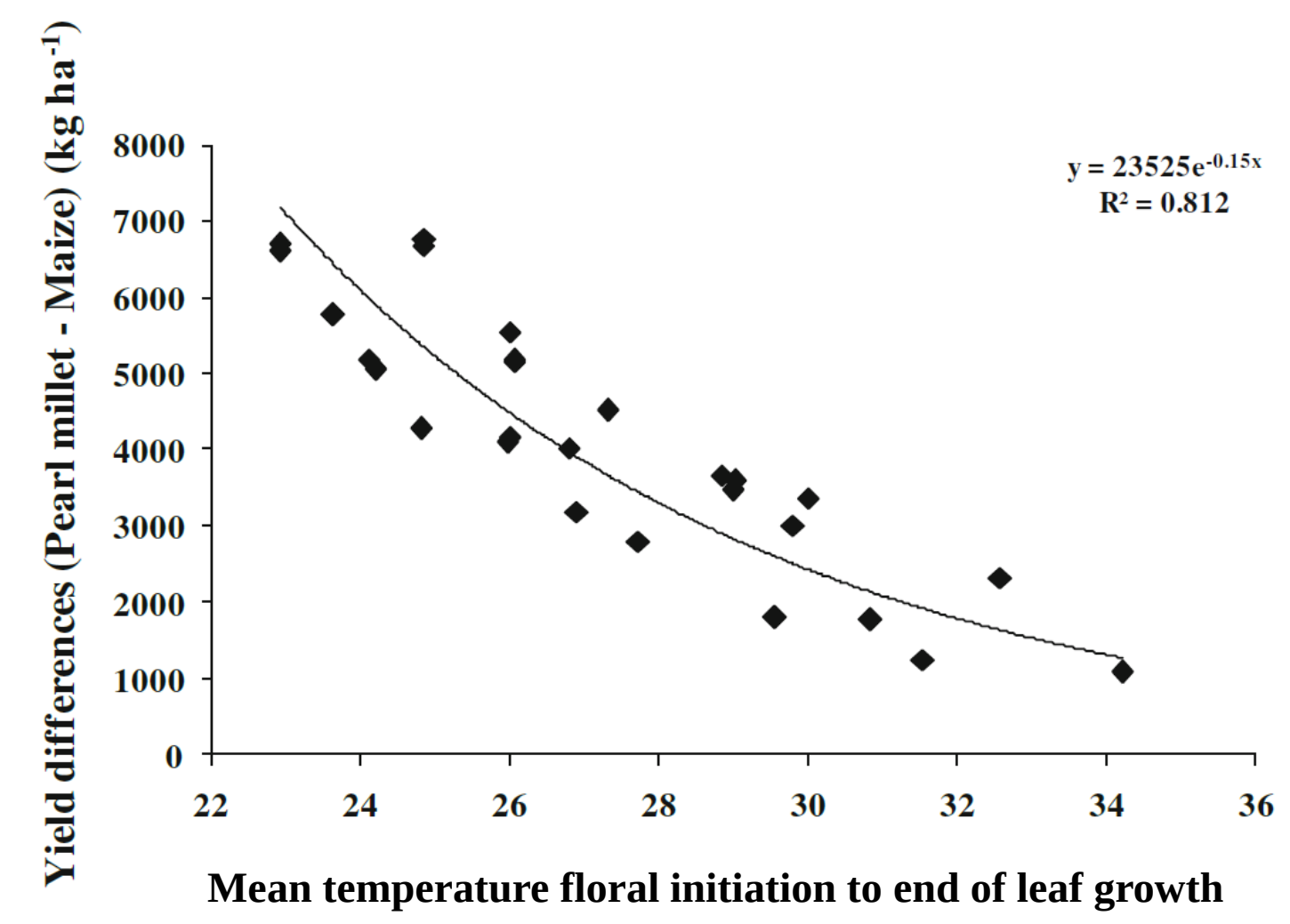
Adaptation by crop substitution?

=> High dynamics in crop shares



Foley et al., 2011

Pearl millet versus maize (both irrigated) under climate change in Iran



Eyshi Rezaei et al., 2015

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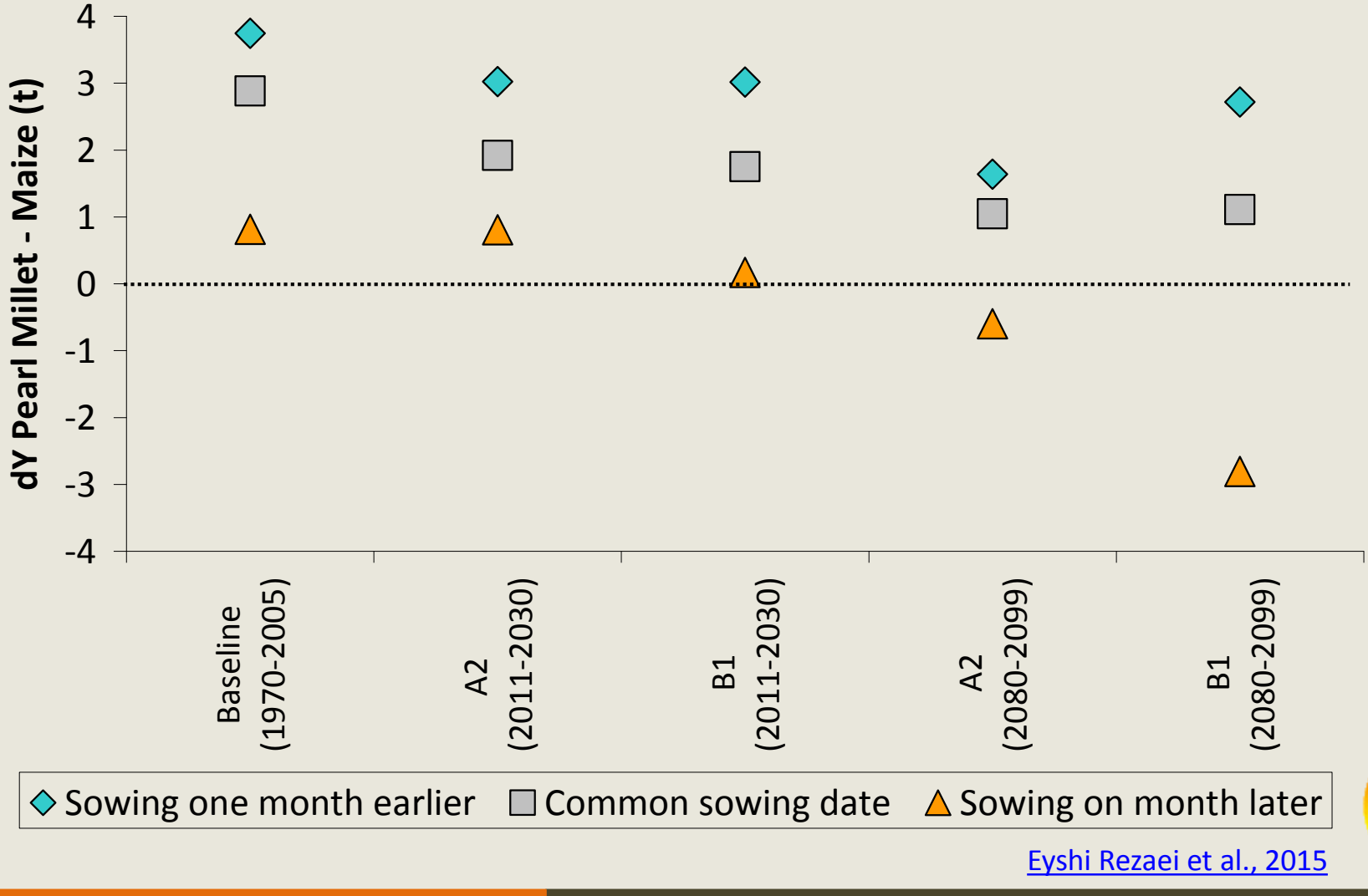
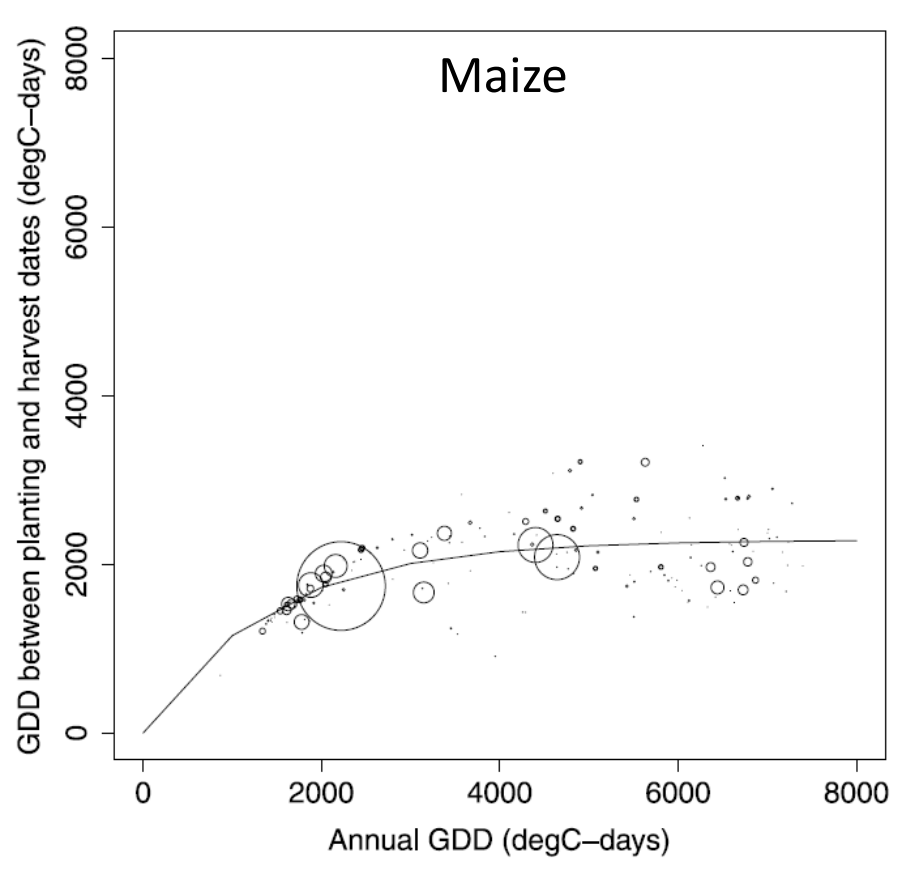
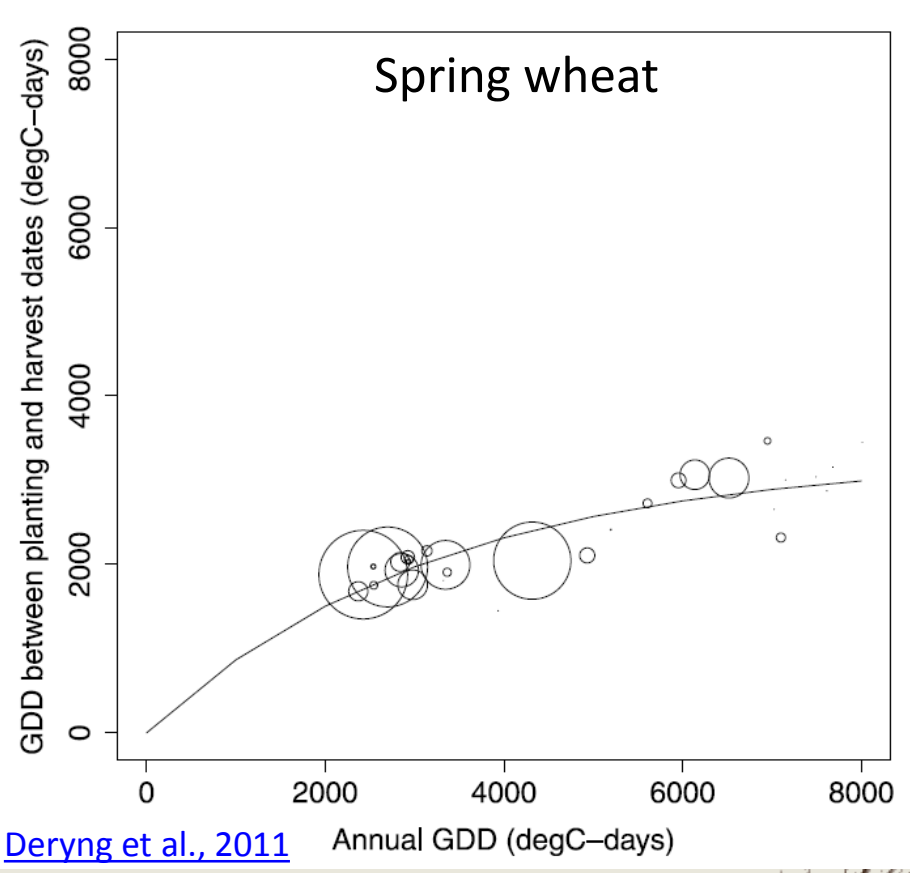


Eyshi Rezaei et al., 2015

Cultivar selection





Deryng et al., 2011

Different thermal time requirements of cultivars offer another option for adjusting crop phenology to seasonality of climate

Conclusion

=> Big change in technology, management, crops, cultivars, trade flows and consumer behavior can be expected

=> Looking for innovations by changing these factors may be similar important as improving present local production systems

Climate is not changing by tomorrow, long-term change needs to be considered

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Thank you to our sponsors:

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Thank you!

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