Adaptation to drought under climate change: A global perspective

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Transitioning Cereal Systems to Adapt to Climate Change
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- 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!

Introduction
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

Data sources:
WorldClim, Global Aridity and PET Database
Little rainfed cropping on arid land!

Total land area (Million ha)
- Arid: 2910
- Semi-arid: 2361
- Dry subhumid: 1267
- Humid: 6274

Rainfed cropland (Million ha)
- Arid: 40
- Semi-arid: 303
- Dry subhumid: 217
- Humid: 628

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

Adaptation: changing cropland use
More irrigated crops on arid land!

Total land area (Million ha)
- Arid: 6274
- Semi-arid: 2910
- Dry subhumid: 2361
- Humid: 1267

Irrigated cropland (Million ha)
- Arid: 50
- Semi-arid: 123
- Dry subhumid: 43
- Humid: 89

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

Adaptation: changing cropland use
Higher crop productivity by irrigation!

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

In arid regions yields are more than doubled when using irrigation

Adaptation: irrigation

Siebert and Döll (2010)
Will irrigation water requirement increase under climate change?

When accounting for the effect of increasing CO$_2$ on crop growth and transpiration, irrigation requirements will decline (at least for C$_3$-crops).

Adaptation: irrigation
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!
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 km³ yr⁻¹
- Inflow of green water: 17 km³ yr⁻¹

**Arid regions (0.03<AI<0.2):**
- Outflow of blue water: 48 km³ yr⁻¹
- Inflow of green water: 54 km³ yr⁻¹

**Semi-arid regions (0.2<AI<0.5):**
- Outflow of blue water: 34 km³ yr⁻¹
- Outflow of green water: 130 km³ yr⁻¹

Hoff et al., 2014
Adaptation by crop substitution?

Adaptation: crop + cultivar choice

Foley et al., 2011

=> High dynamics in crop shares
Pearl millet versus maize (both irrigated) under climate change in Iran

Adaptation: crop choice

Eyshi Rezaei et al., 2015
Pearl millet versus maize (both irrigated) under climate change in Iran

Adaptation: modified sowing date

Eyshi Rezaei et al., 2015
Cultivar selection

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

Adaptation: **cultivar choice**
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

Adaptation: **modified sowing date**
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