

Crop Water Productivity and “Water Gaps”

Quantifying the Benefits of Increasing Crop
per Drop in Global Agriculture

Kate A Brauman, Ph.D.

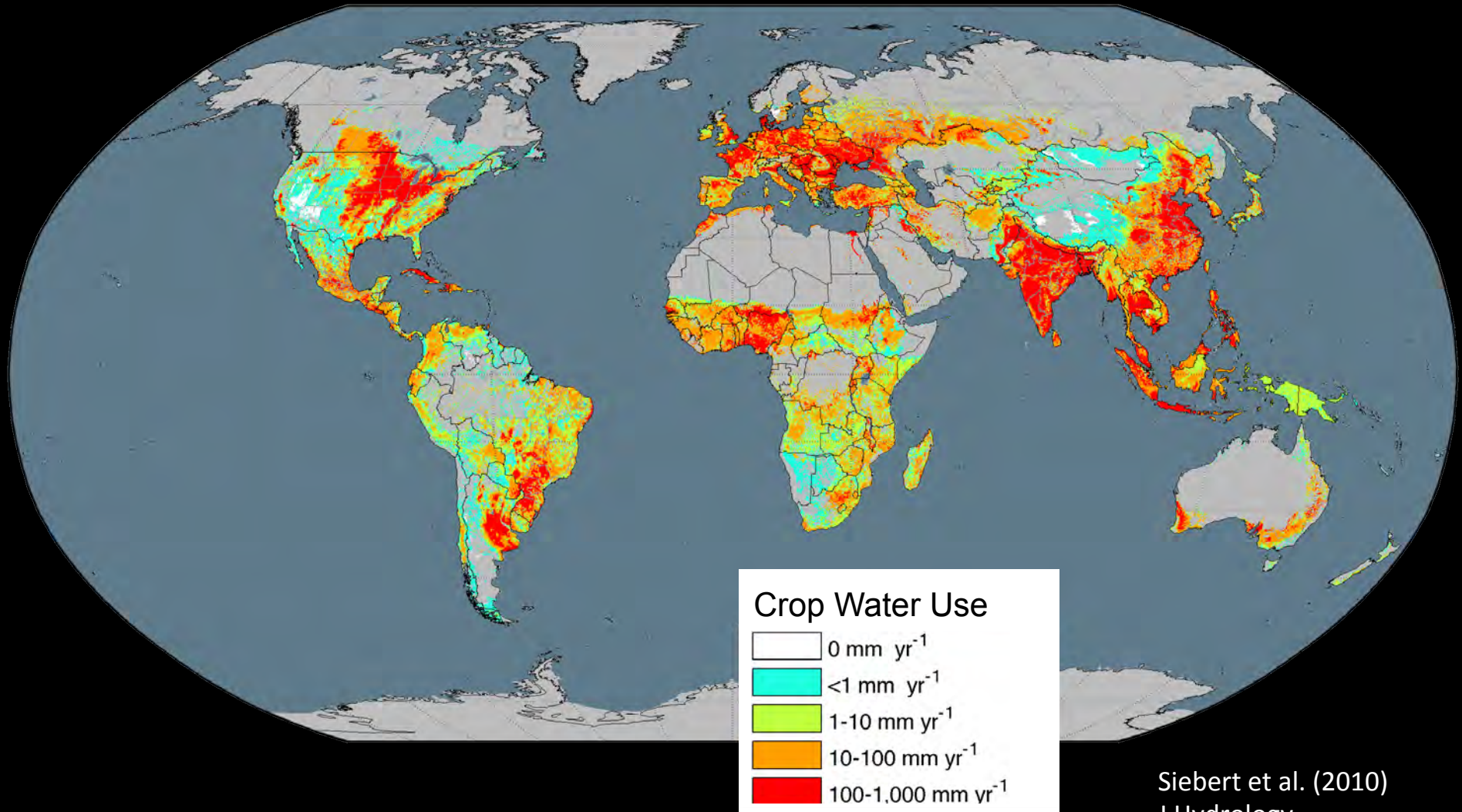
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UNIVERSITY OF MINNESOTA
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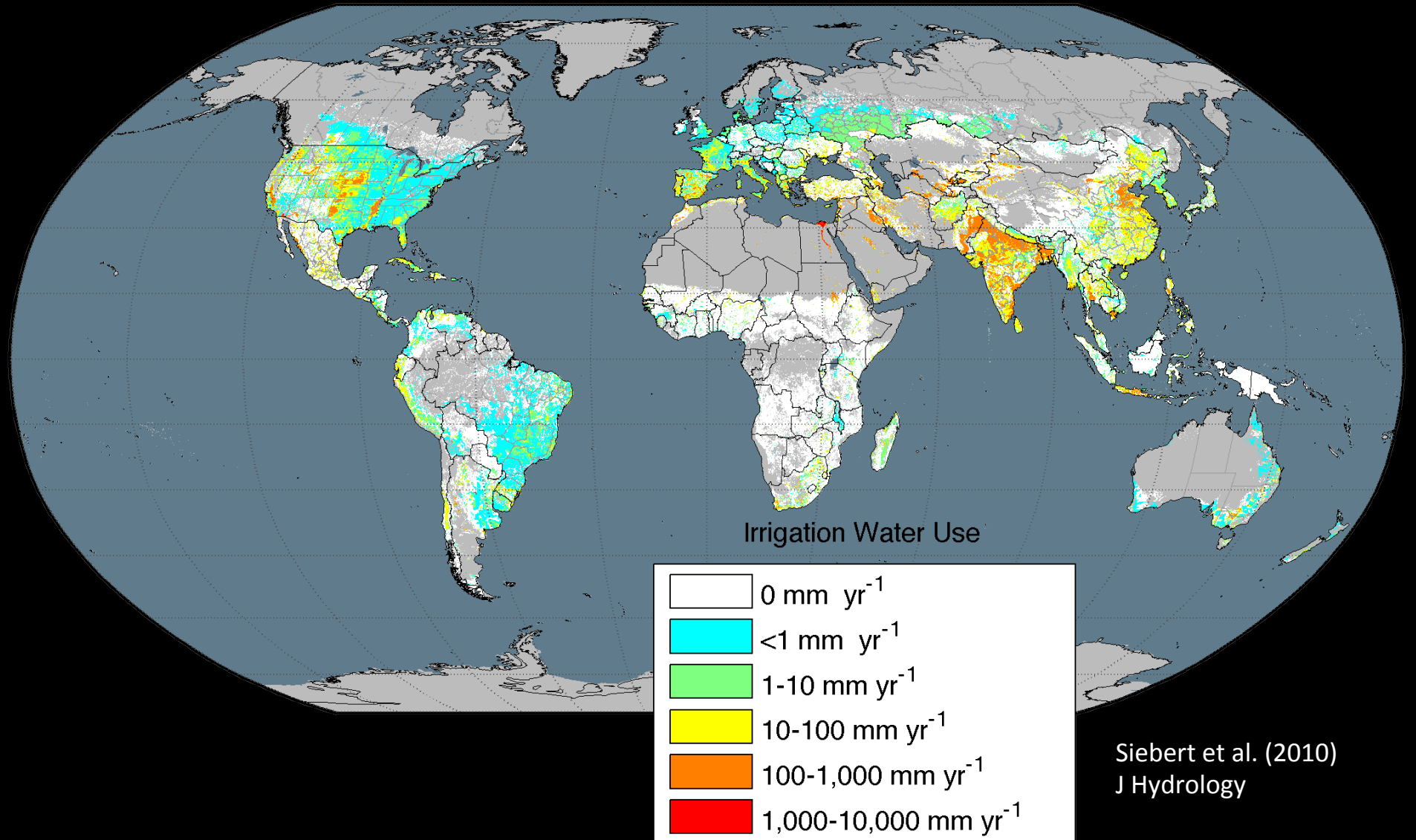
Agriculture needs water



Water Consumption by Crops Varies Globally (rain + irrigation water)

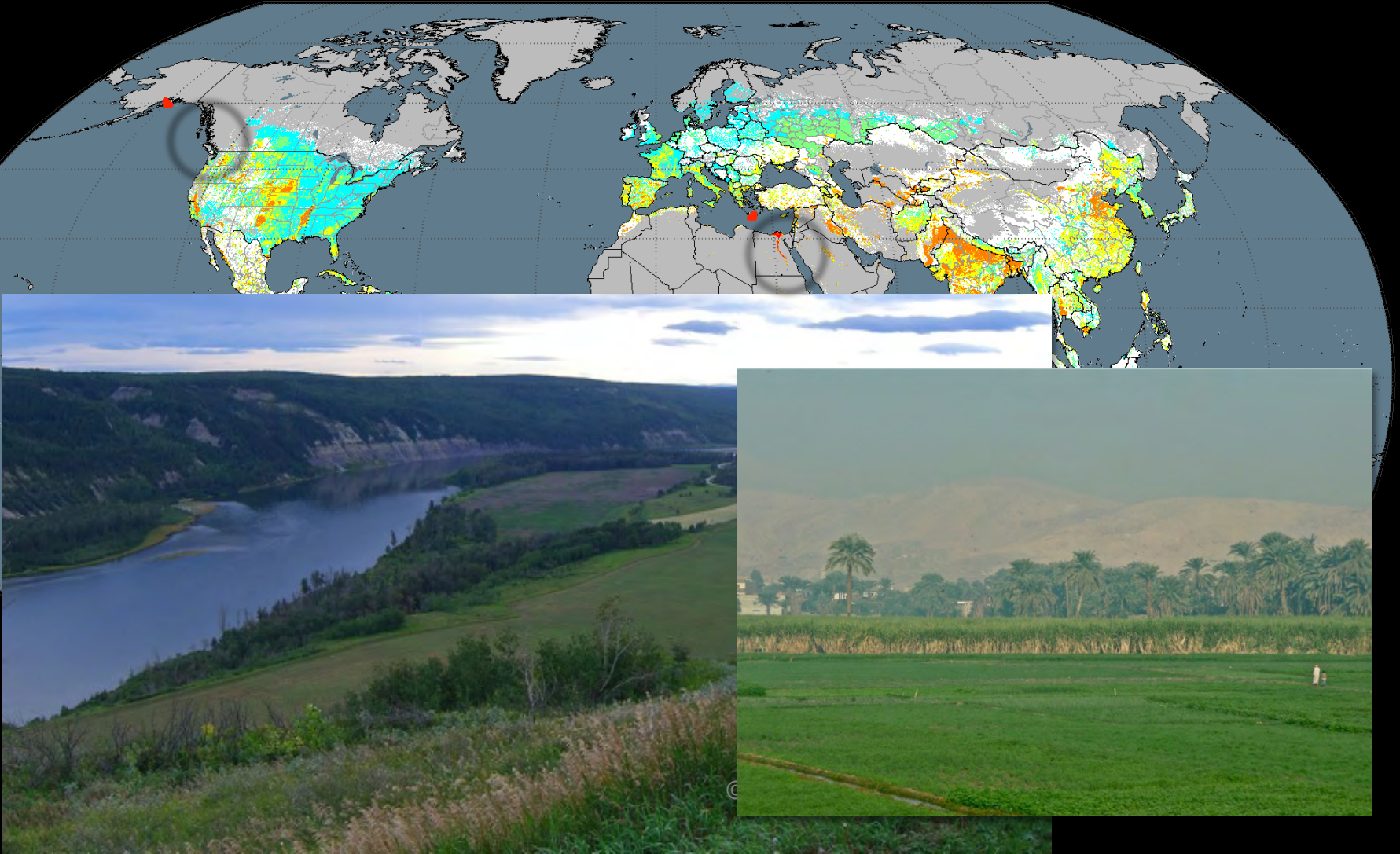


Irrigation Consumption by Crops Varies Globally



Irrigation Consumption by Crops Varies Globally

Irrigation Water Use





Minnesota



Kansas

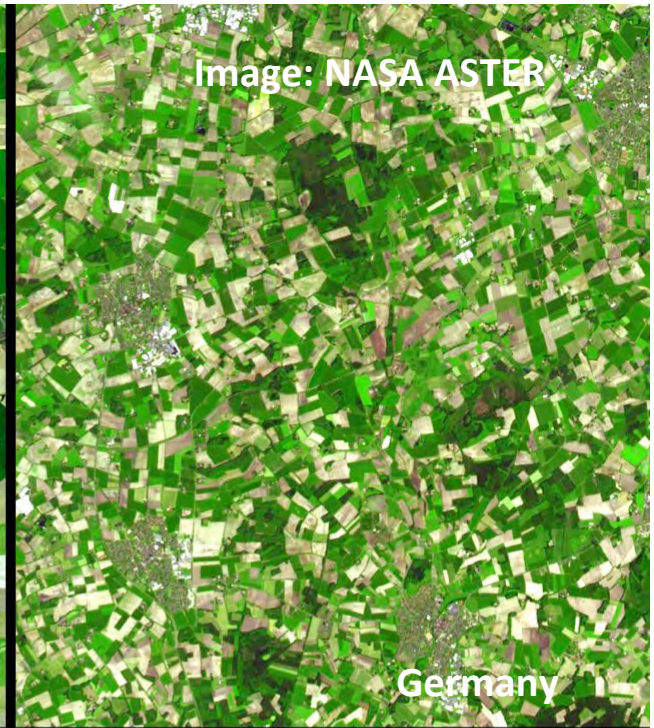
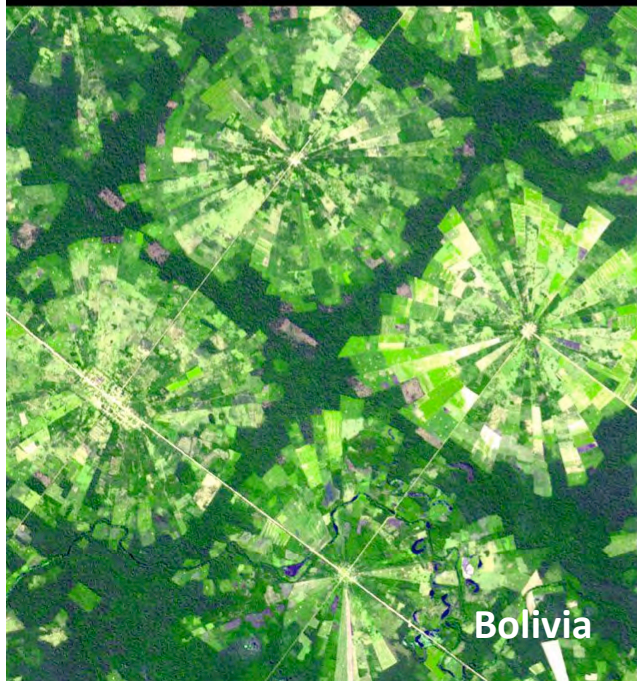
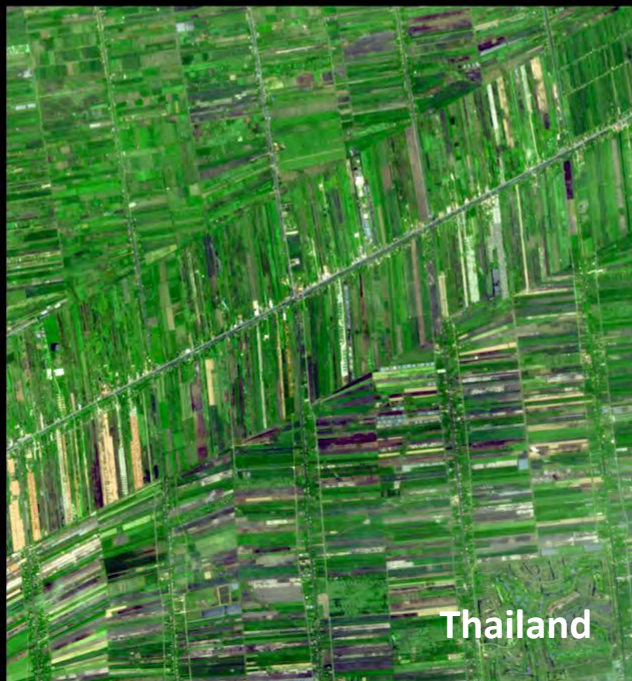


Image: NASA ASTER

Germany



Bolivia



Thailand



Brazil



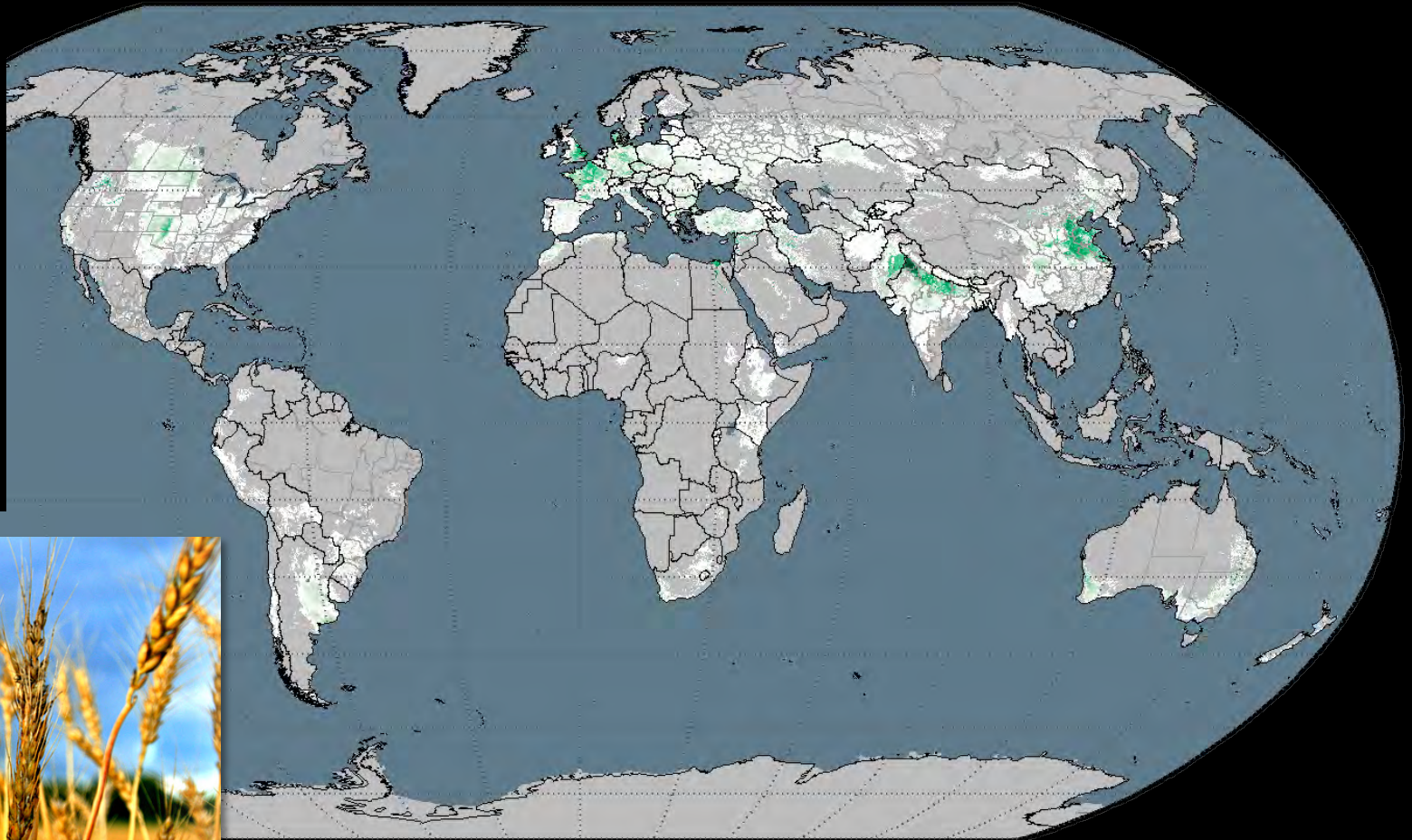
Image: NASA ASTER

- Management and climate affect crop water productivity

Production Data

Wheat
(circa 2000)

- Global Landscapes Initiative
- EarthStat.org
- 177 FAO crops
- 5' spatial resolution (~8,000 ha)
- Yield and cultivated area
- Historical data to 1960 for 5+ crops



Monfreda (2008) GBC

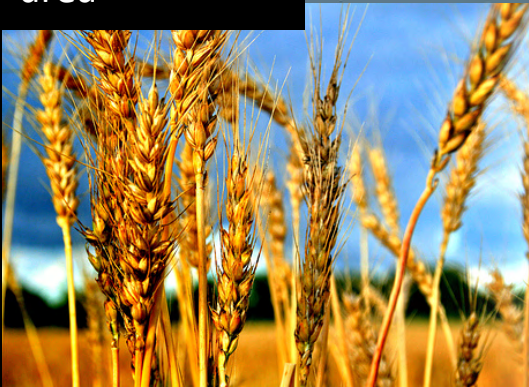
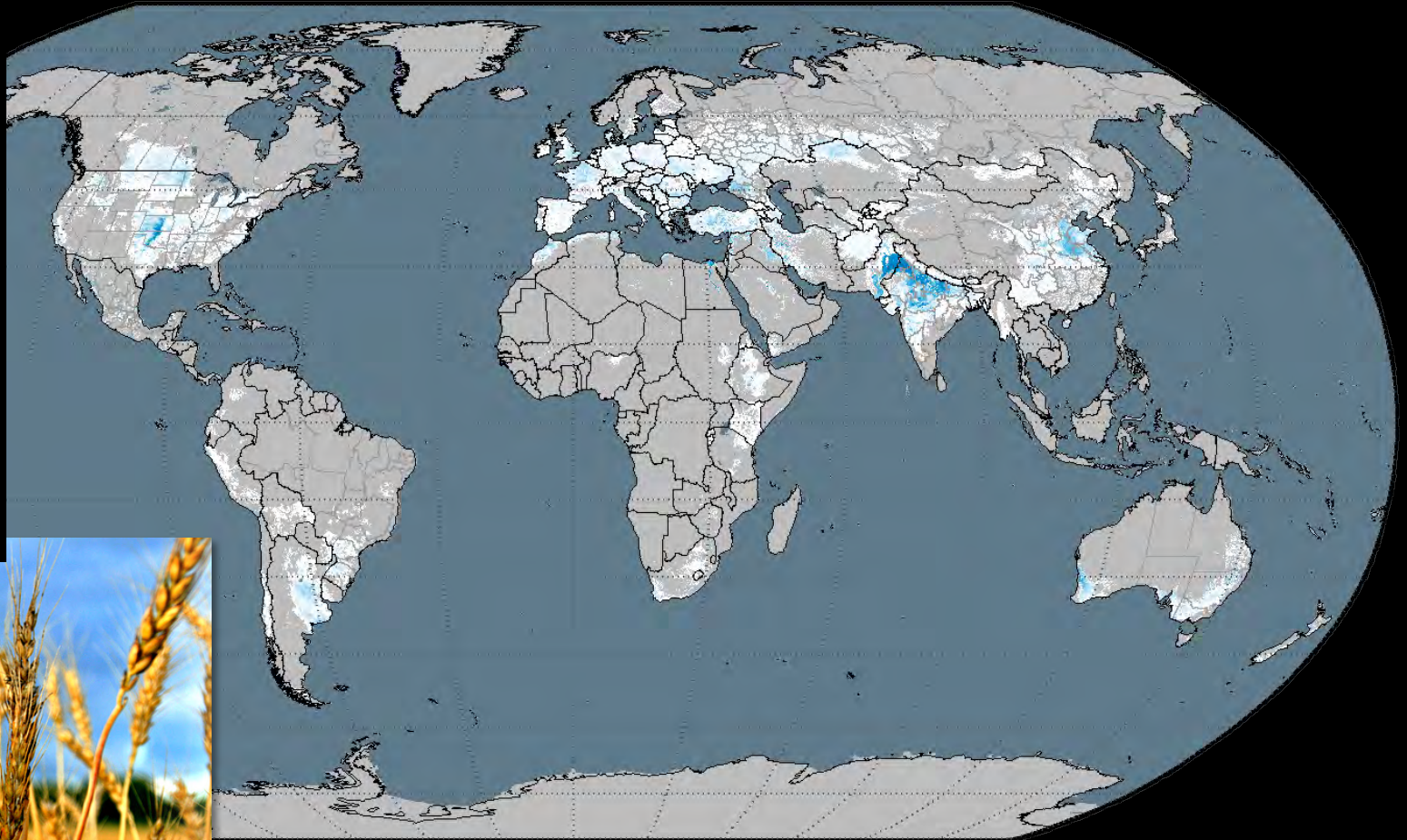
Wheat Production (tons/yr)



- Crop Science Bonn
- 16 FAO crops + 10 groups
- 5' spatial resolution (~8,000 ha)
- Rain and irrigation water consumption
- Rainfed and irrigated yields and cropland area

Water Use Data

Wheat
(circa 2000)

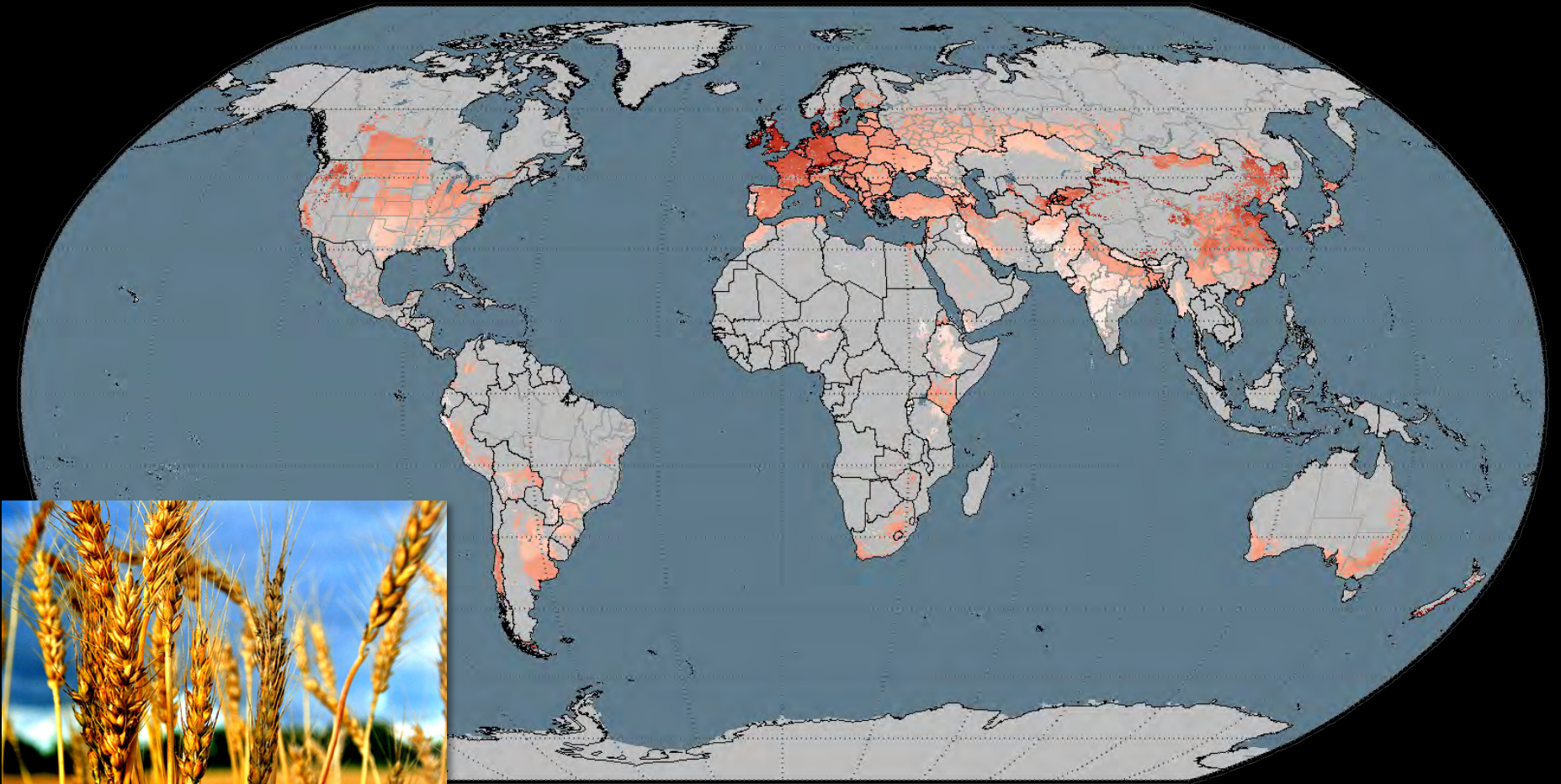


Siebert (2010) J Hydrology

Wheat Water Consumption (m^3/yr)



“Crop Per Drop” Varies Globally



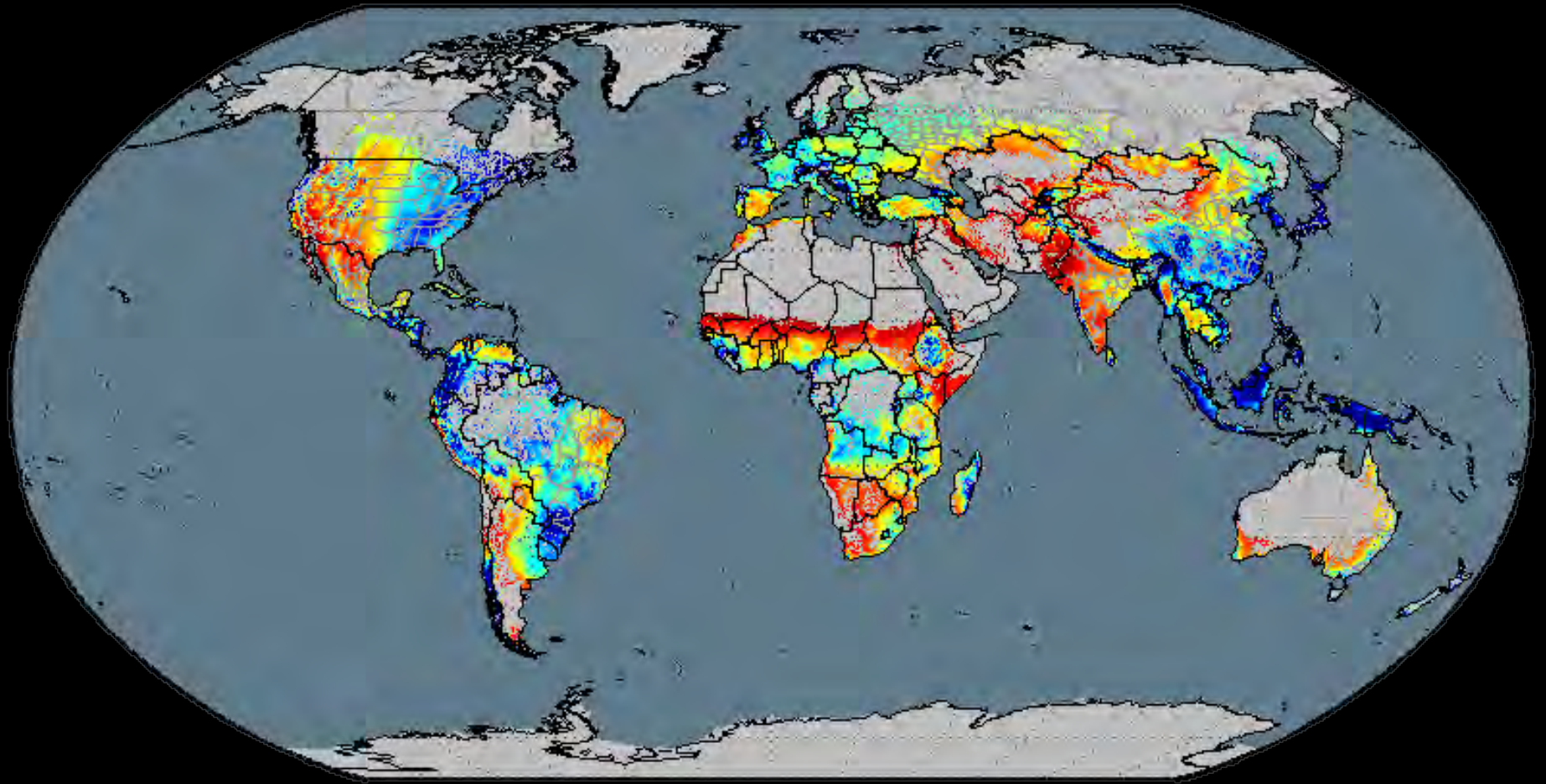
Brauman et al. (2013) ERL

Wheat Water Productivity (kcal/liter)



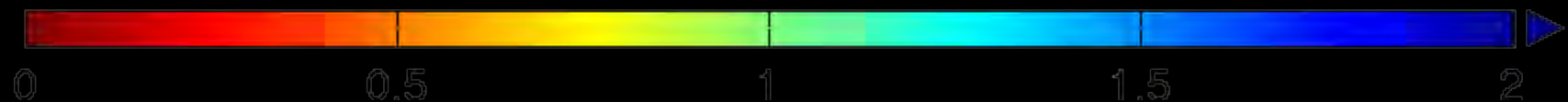
Climate Distribution

20 evenly spaced climate zones: P/PET

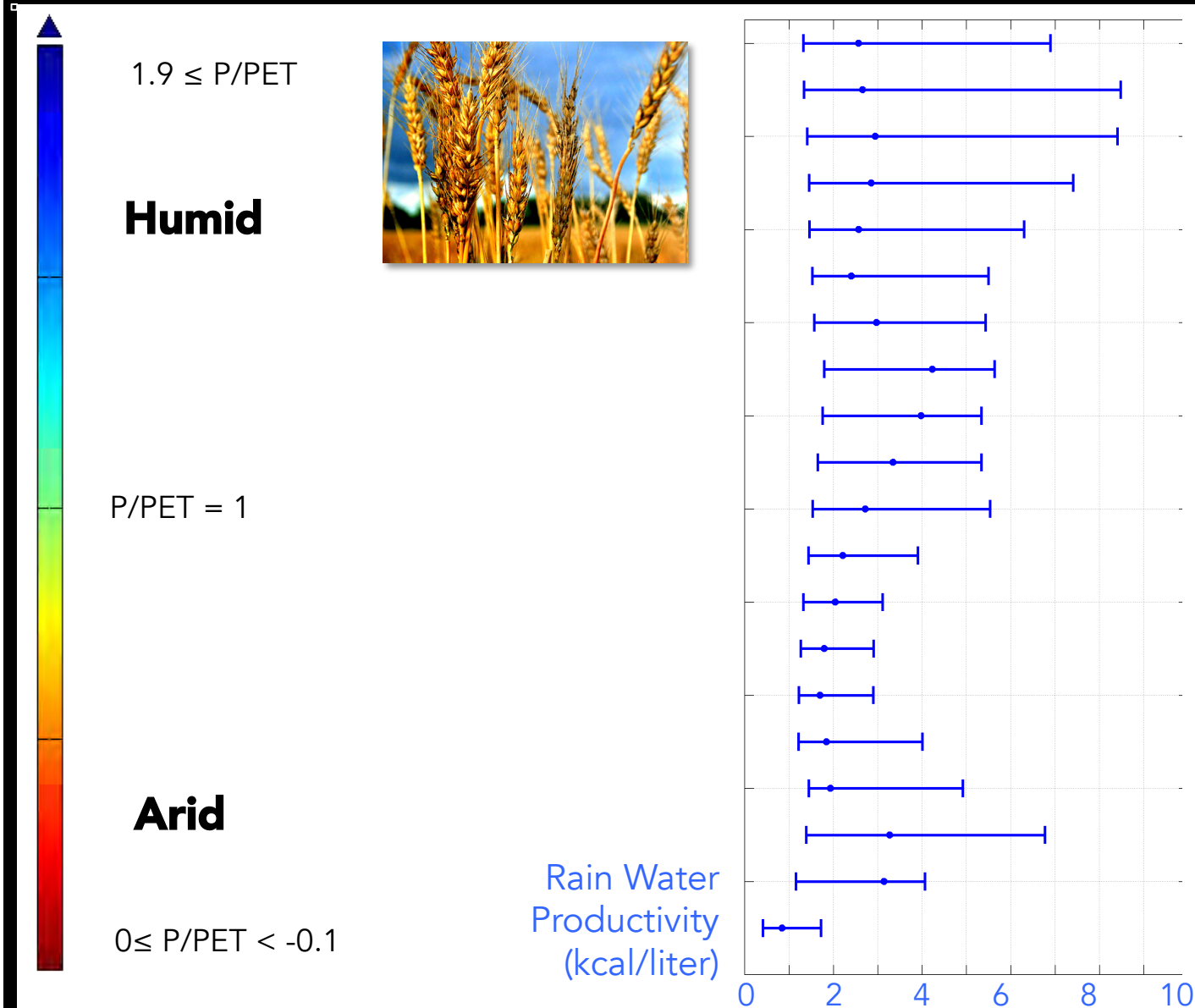


Brauman et al. (2013) ERL

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Range of Wheat Water Productivity



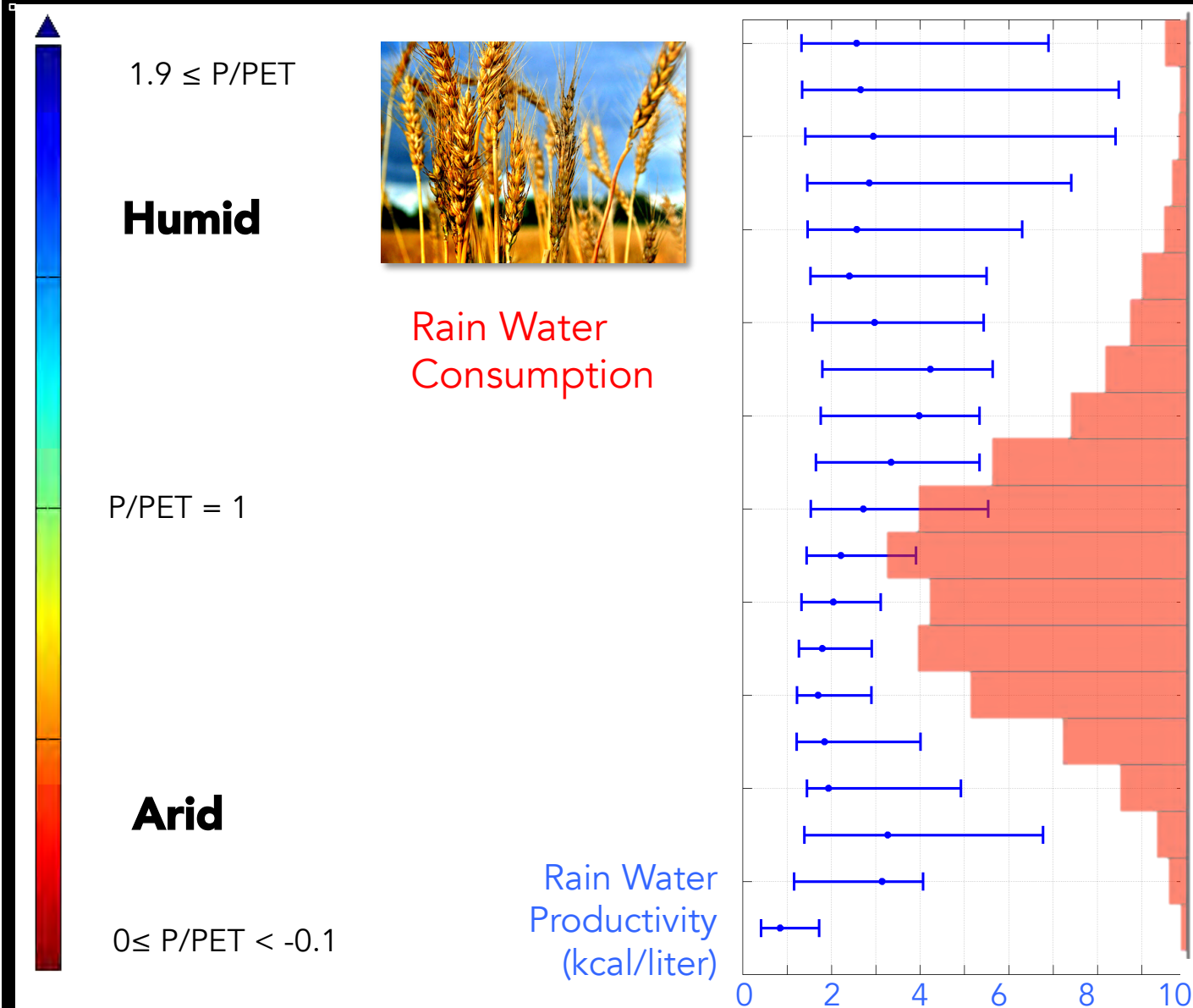
Non-Climate Variables Affect Crop Water Productivity



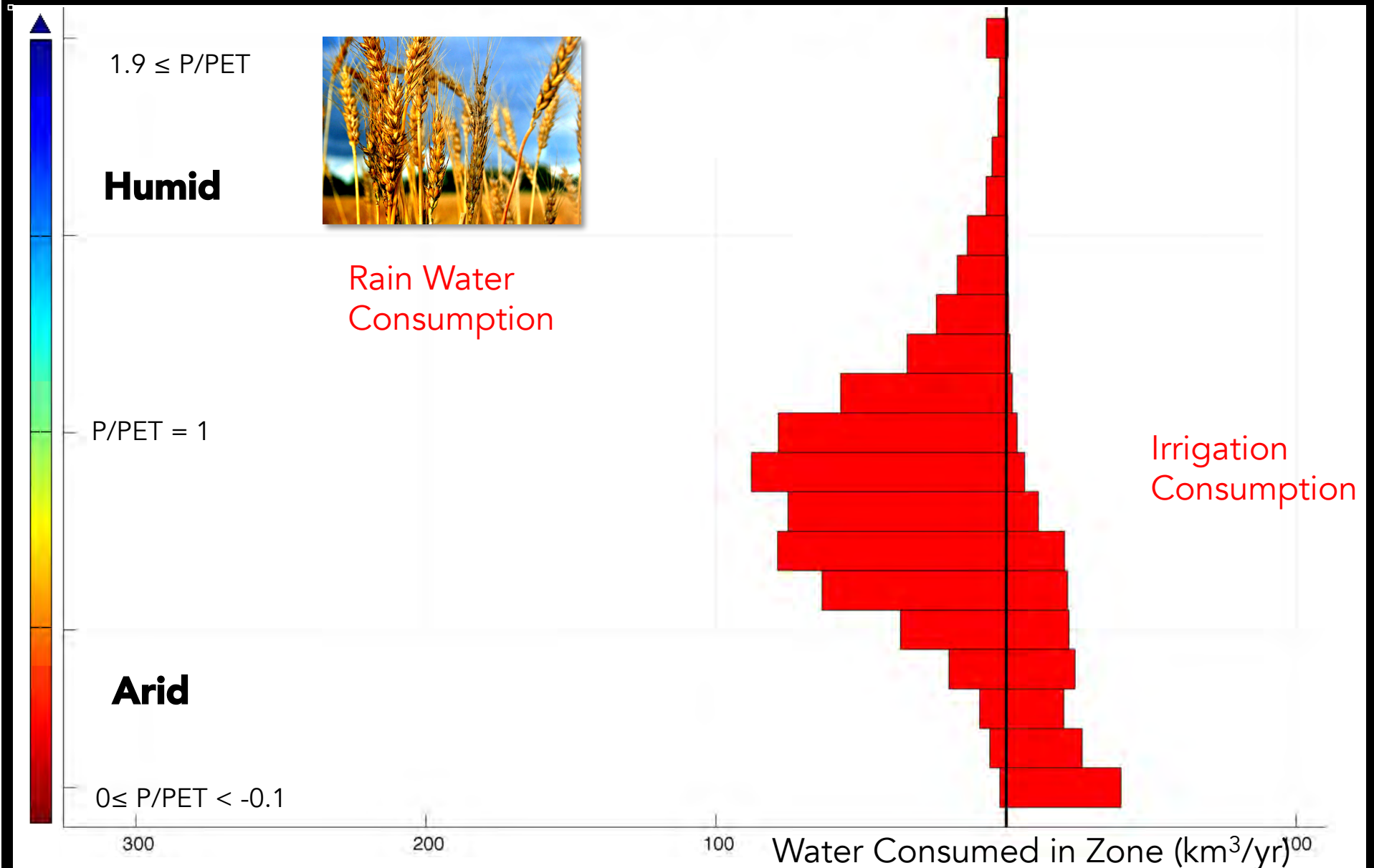
- Non-climate
"Management"
= Addition of
nitrogen fertilizer

University of Minnesota

Range of Wheat Water Productivity



Distribution of Water Consumption



Distribution of Water Consumption

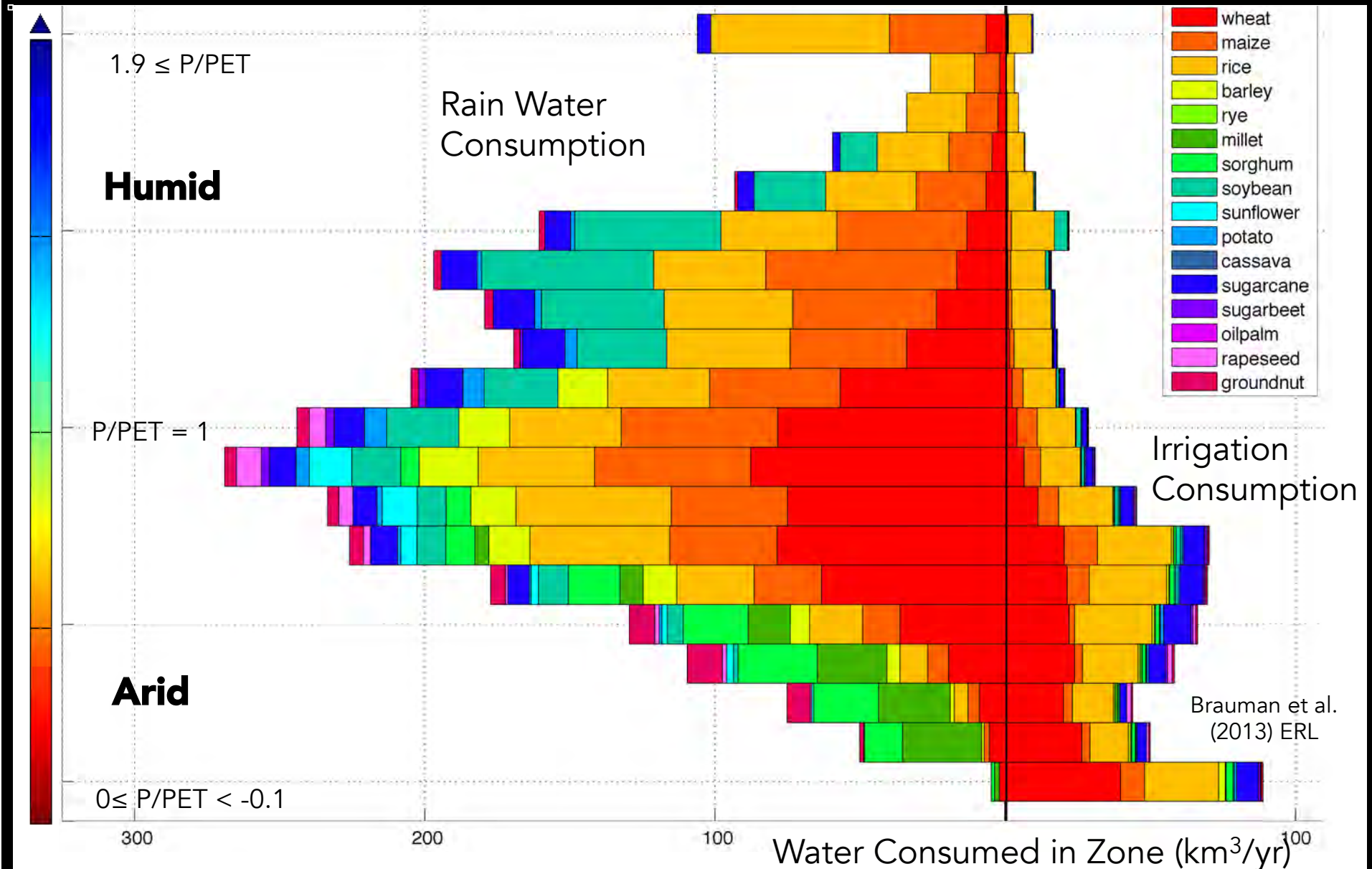
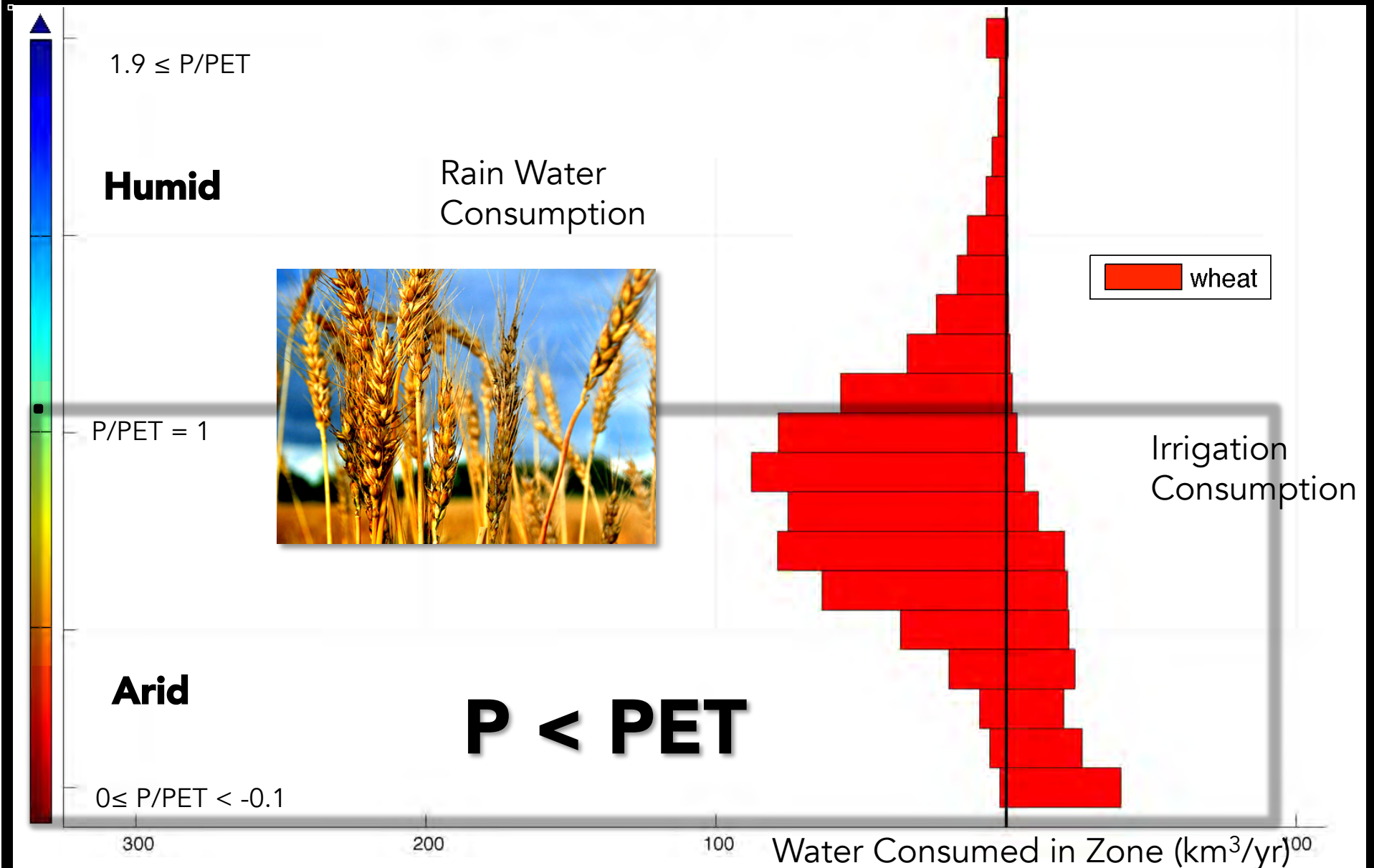




Image: NASA ASTER

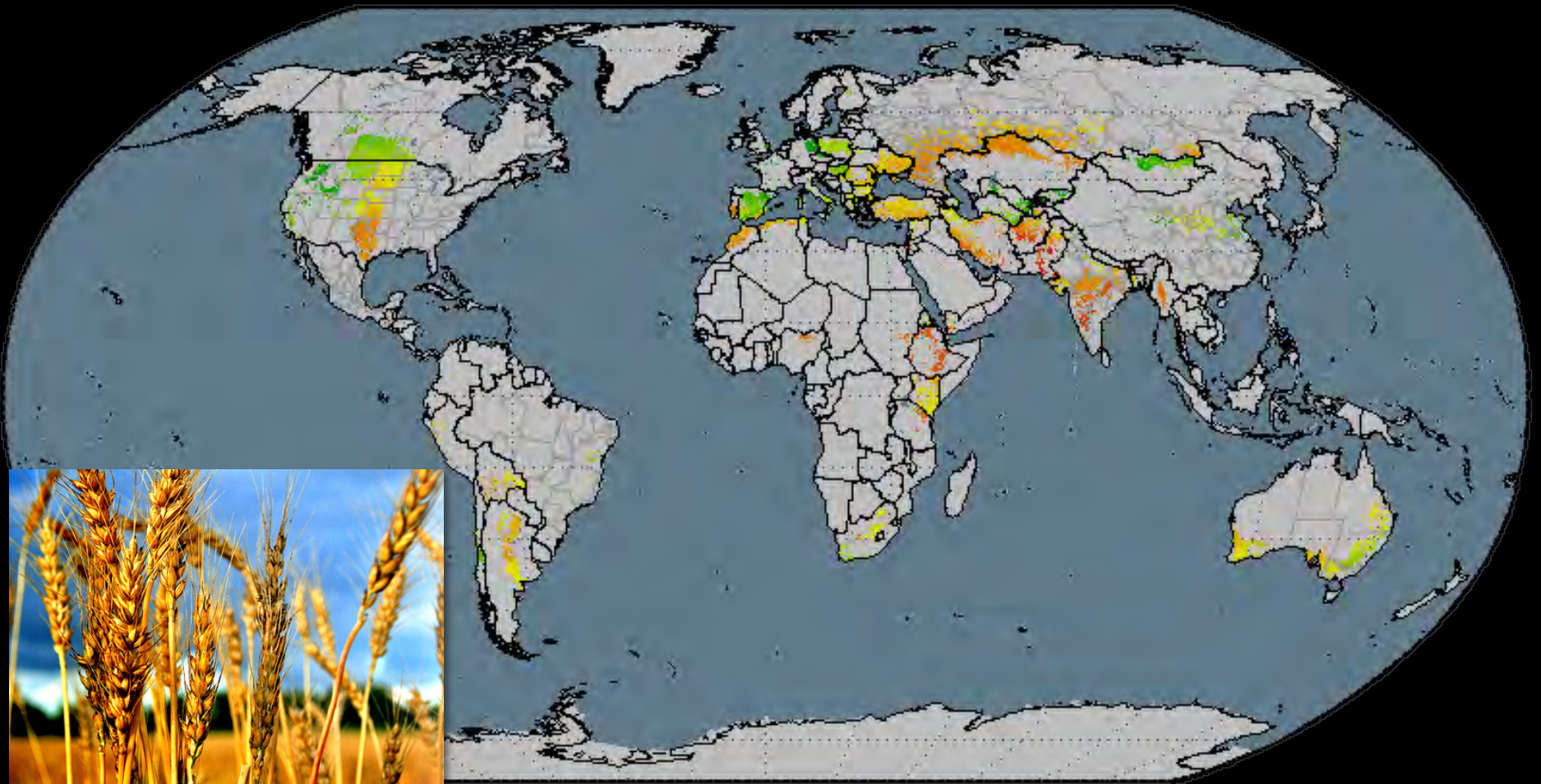
- Management and climate affect crop water productivity
- Identify poor performers

Distribution of Water Consumption

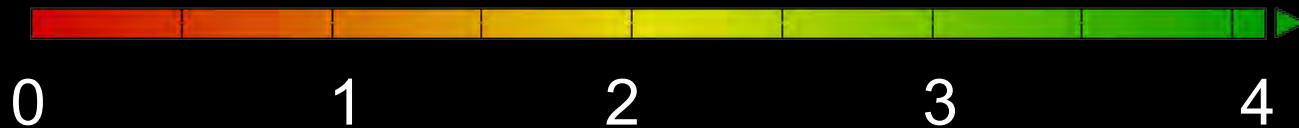


Wheat Rainwater Productivity

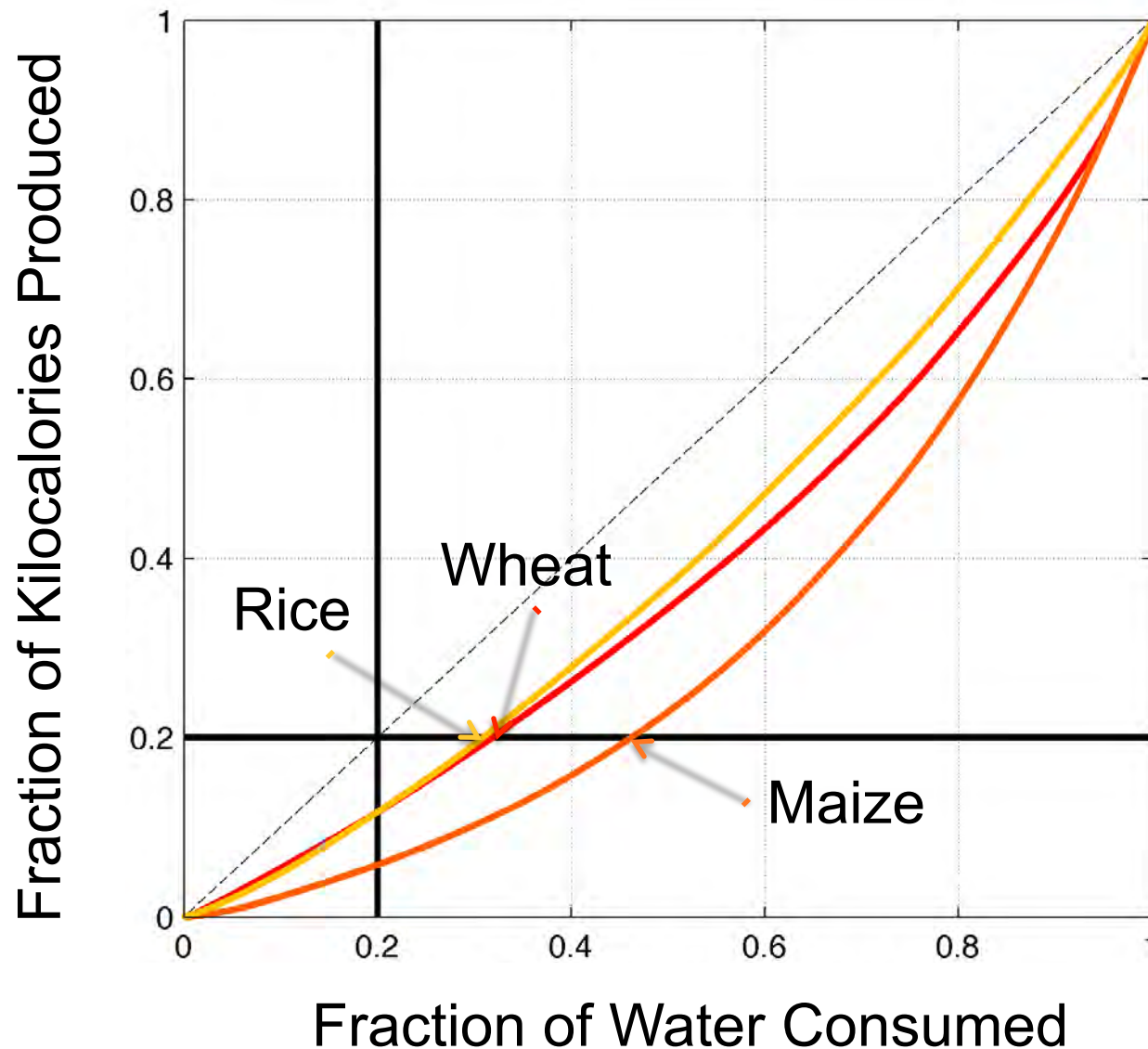
in Water Limited Areas



Kcal produced per liter rainwater consumed

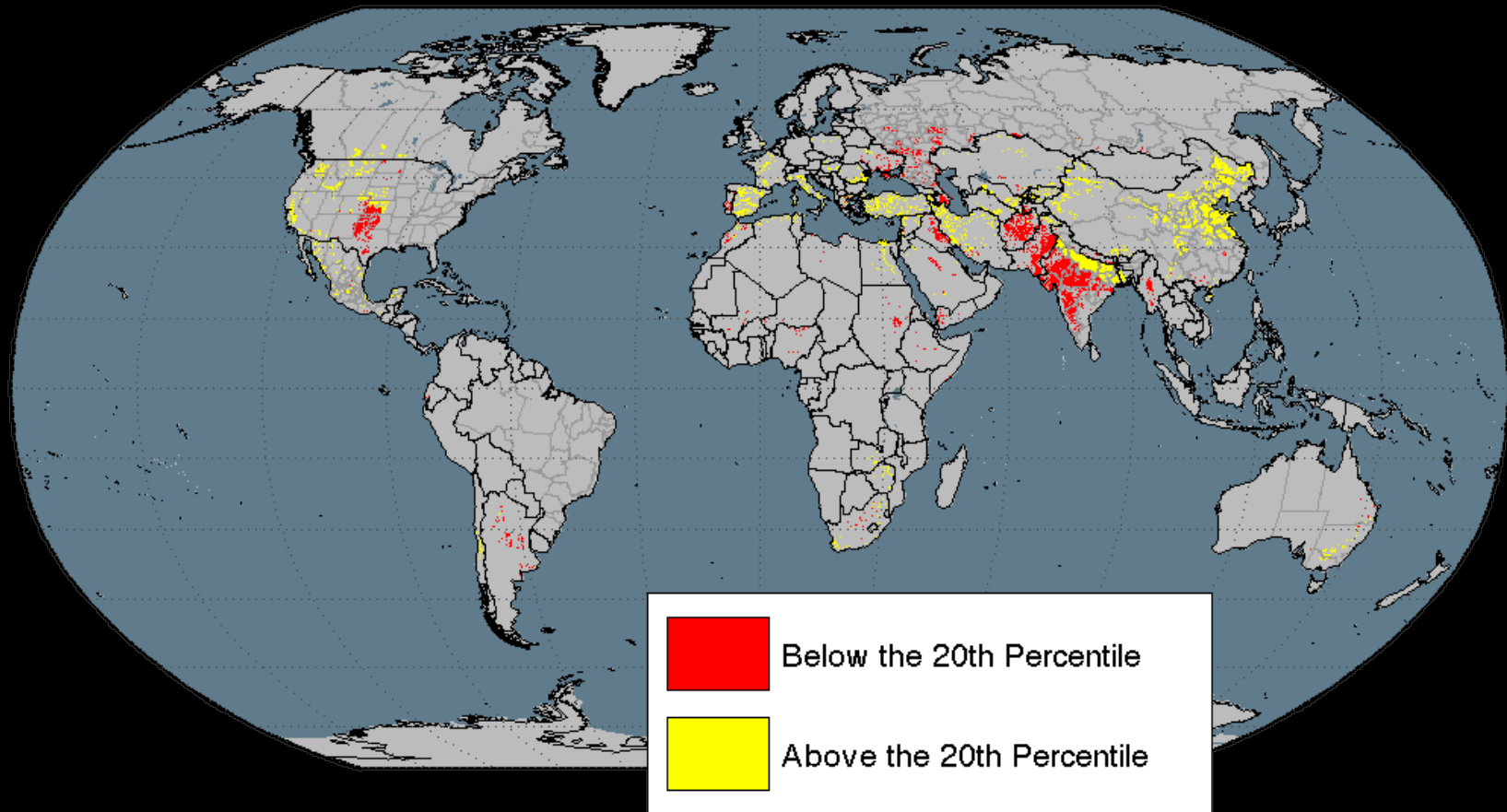


Rainfed: Cumulative Food Production vs. Cumulative Water Use in Water Limited Regions



Wheat Irrigation Water Productivity

in Water Limited Areas





Paul Stover—Stone/Getty Images

US (Washington State) Wheat Harvest

India Wheat Harvest



Narinder Nanu/Agence France-Presse/Getty Images

Wheat mosaic virus, Southwestern US



Illinois Agricultural Experiment Station

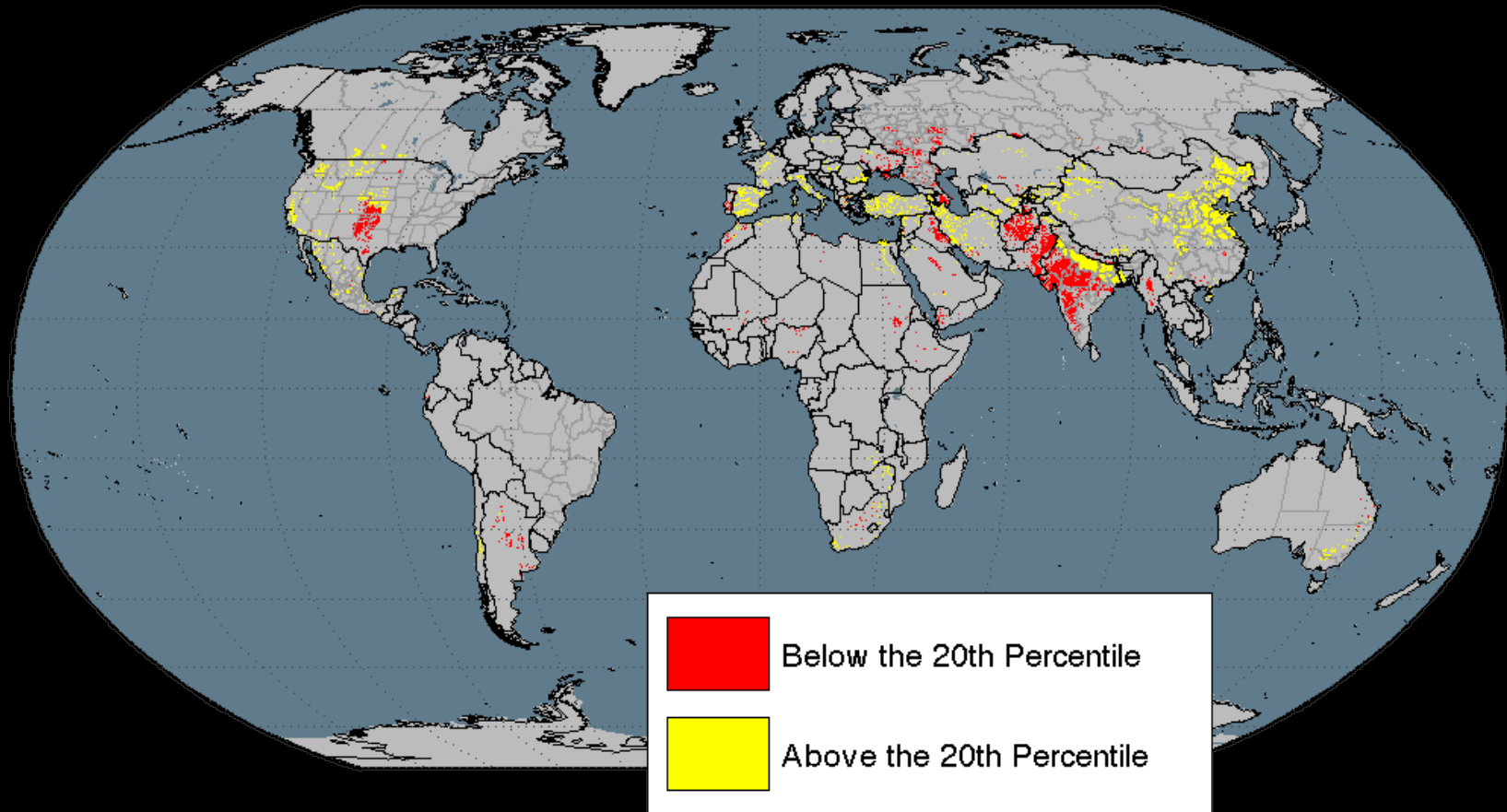


Image: NASA ASTER

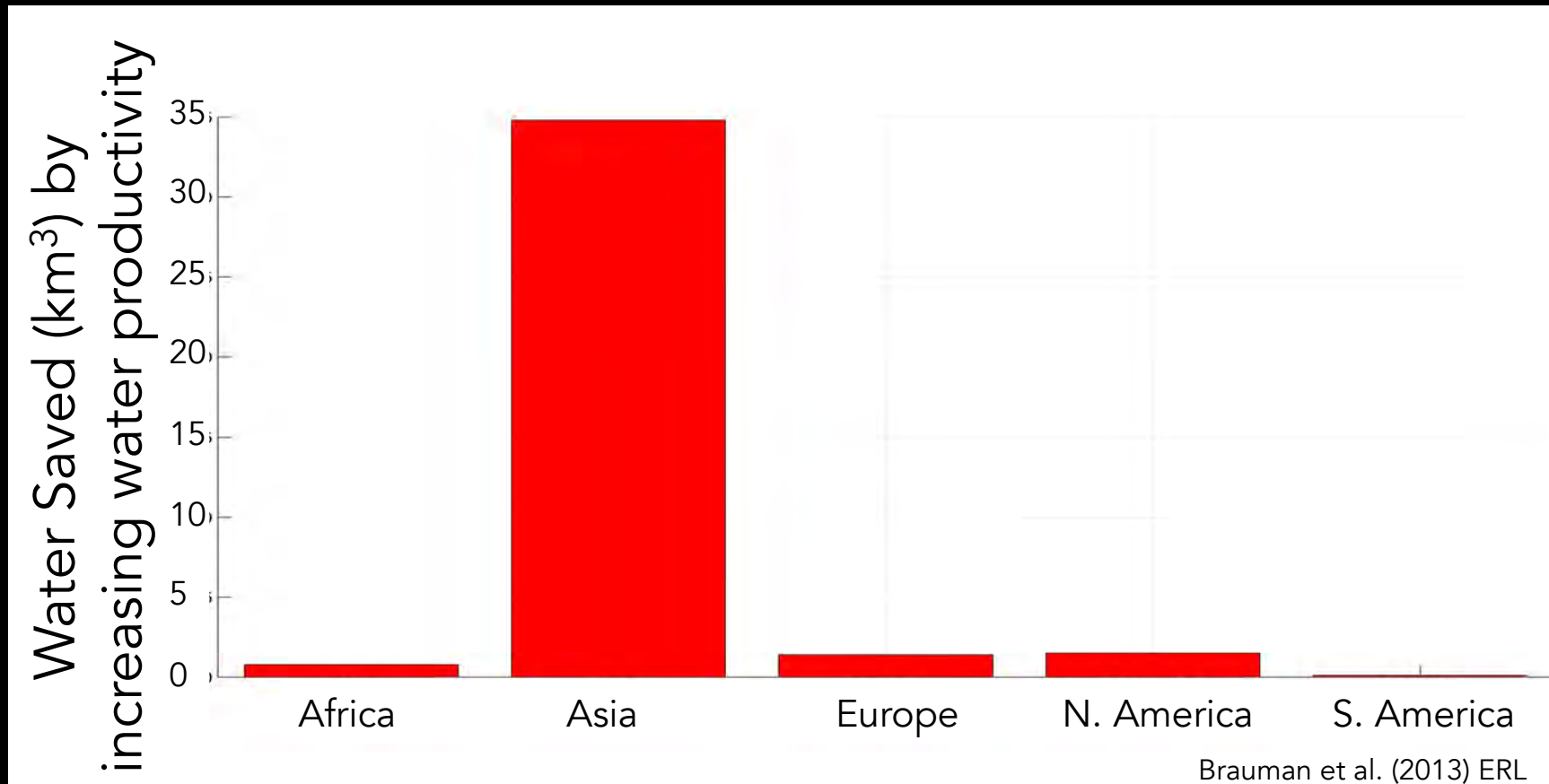
- Management and climate affect crop water productivity
- Identify poor performers
- Targeted interventions can save water and land

Wheat Irrigation Water Productivity

in Water Limited Areas

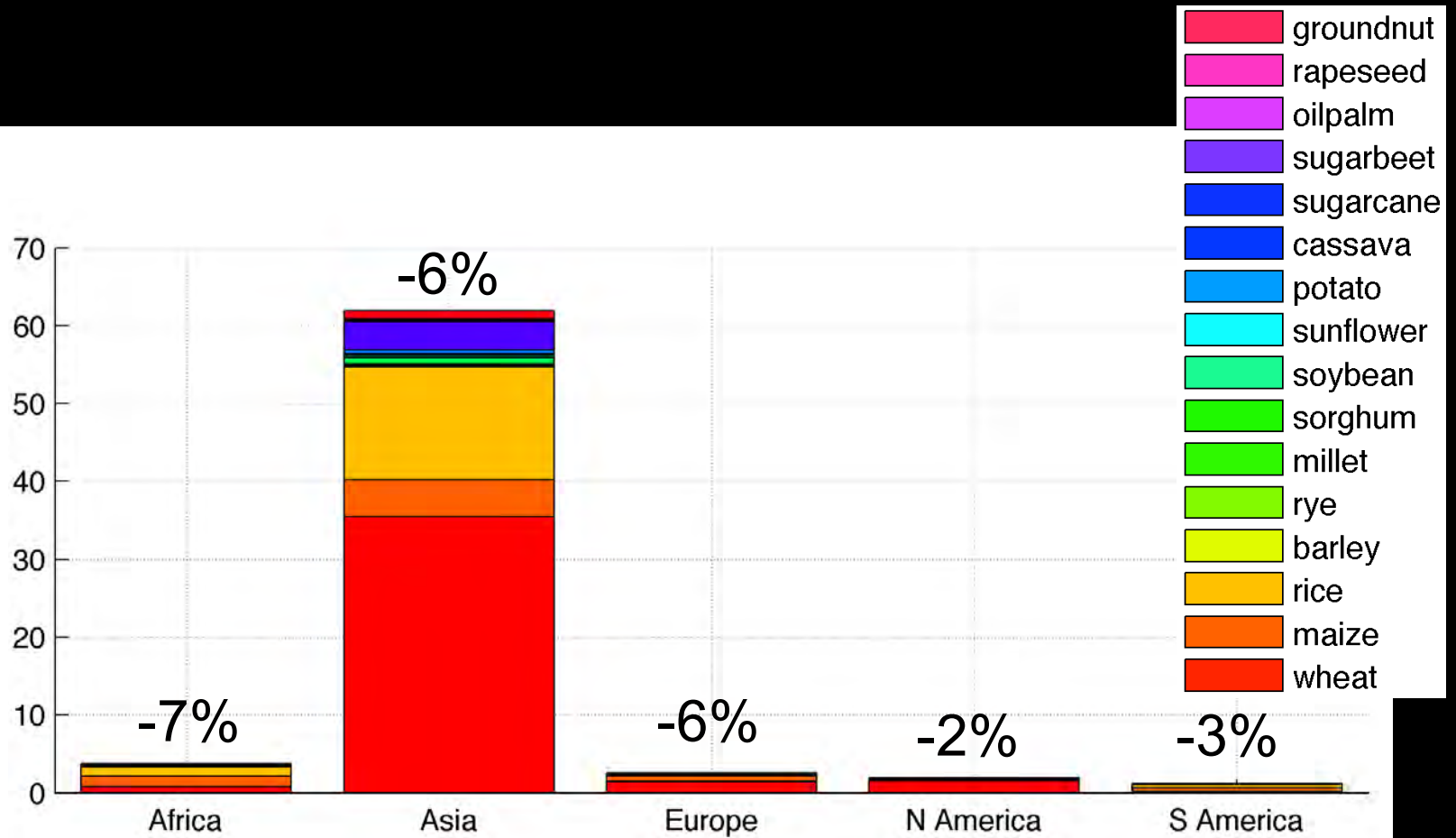


Irrigated Wheat: Water Savings With No Decrease in Food Production by Raising Water Productivity in Water Limited Regions



Irrigated Crops: Water Savings With No Decrease in Food Production by Raising Water Productivity in Water Limited Regions

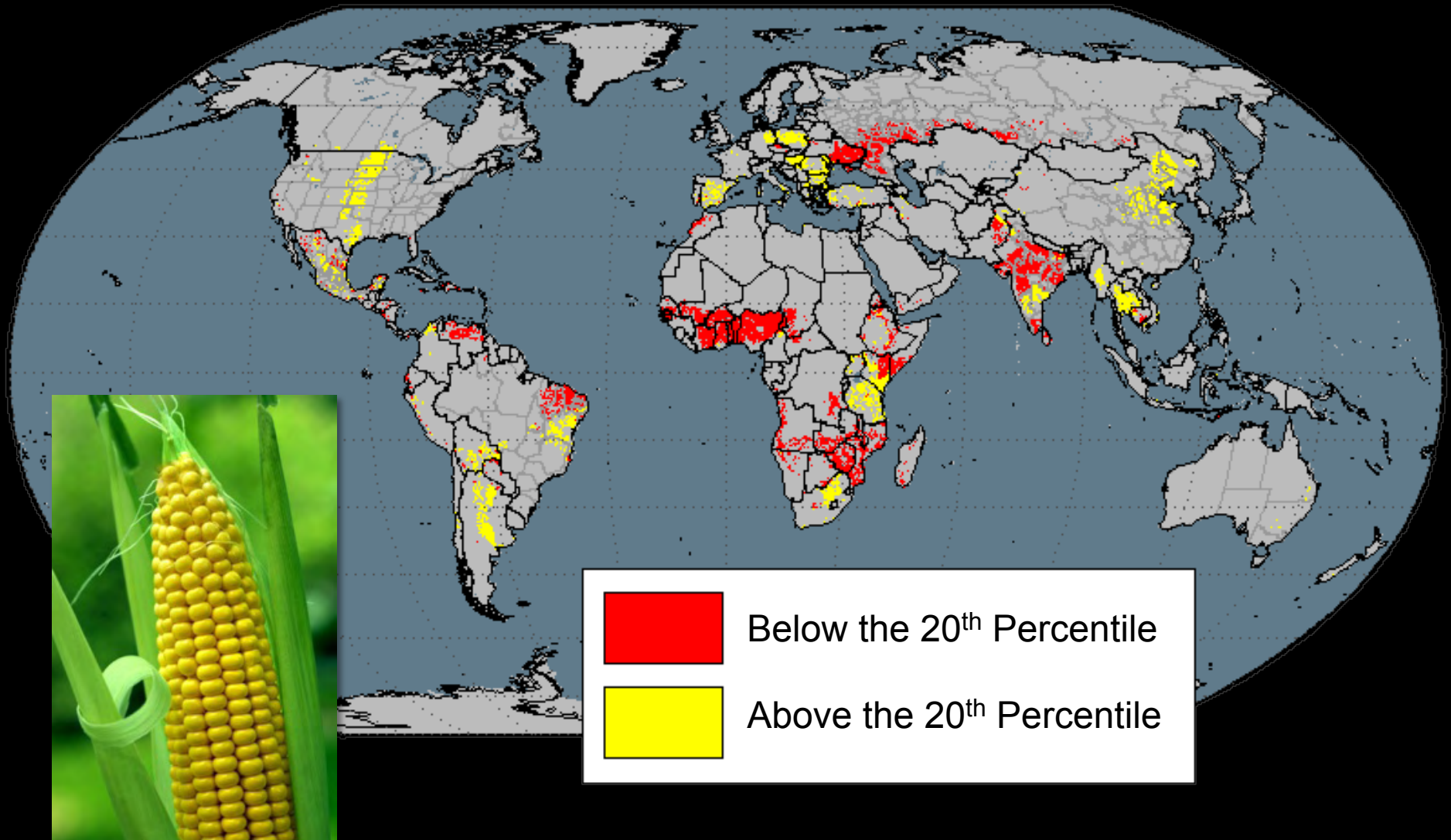
Water Saved (km³) by
increasing water productivity



Brauman et al. (2013) ERL

Maize Rainwater Productivity

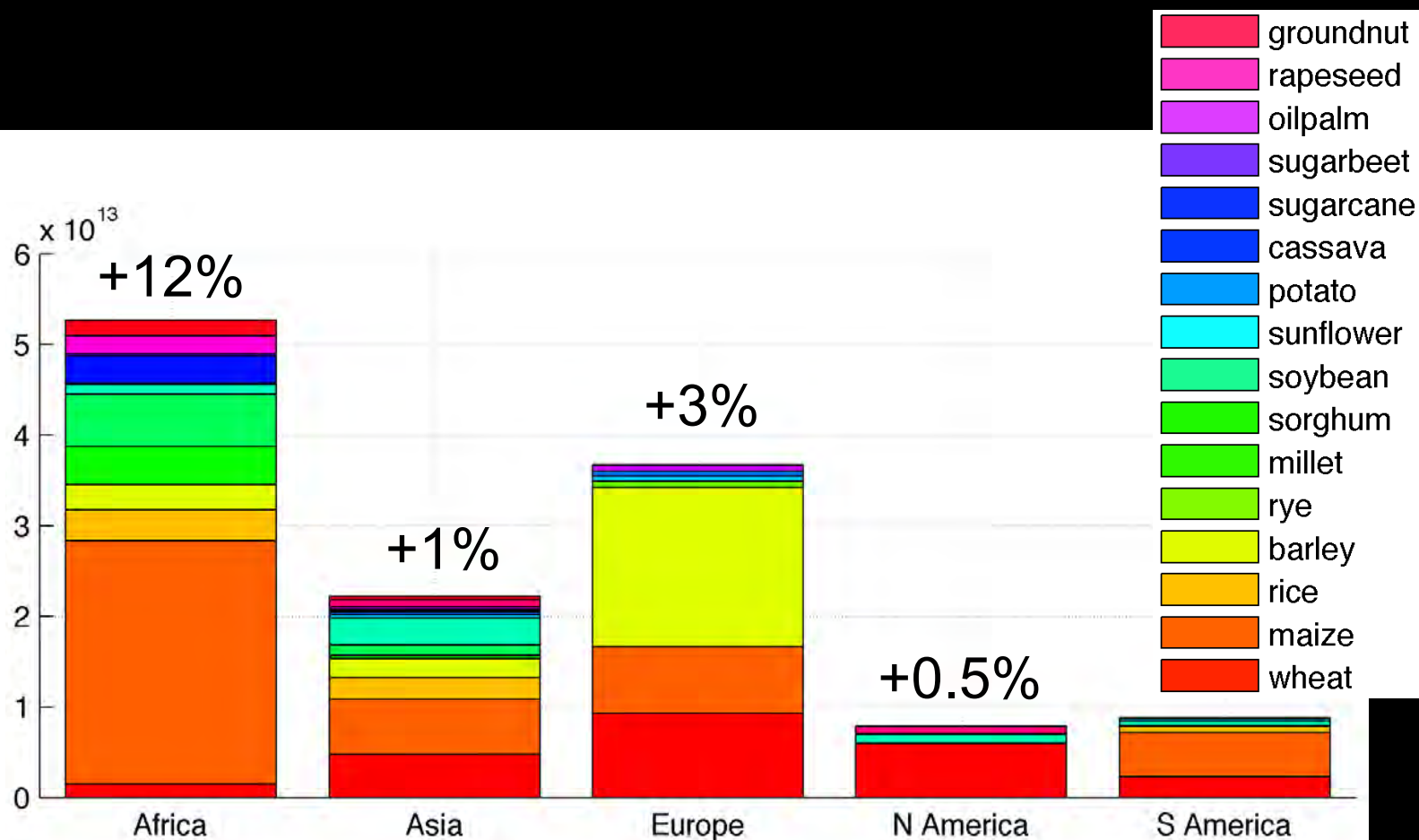
In Water Limited Areas



Rainfed Crops: Additional Food Without Increased Water Use

by Raising Water Productivity in Water Limited Regions

Additional Kilocalories
Produced From the Same
Volume of Water



Brauman et al. (2013) ERL

Irrigated Sugarcane

Regions at the “top of the class” for water productivity

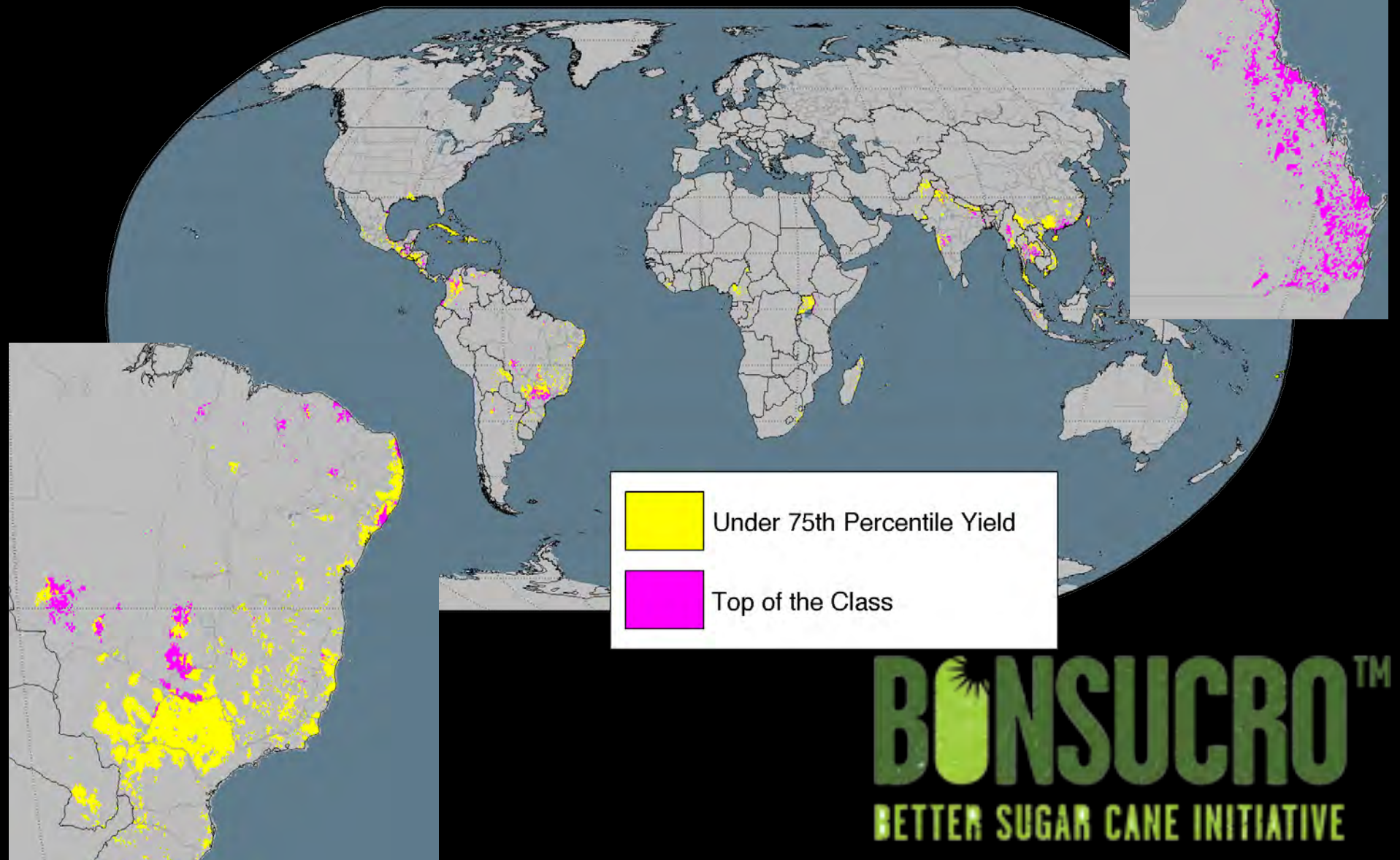
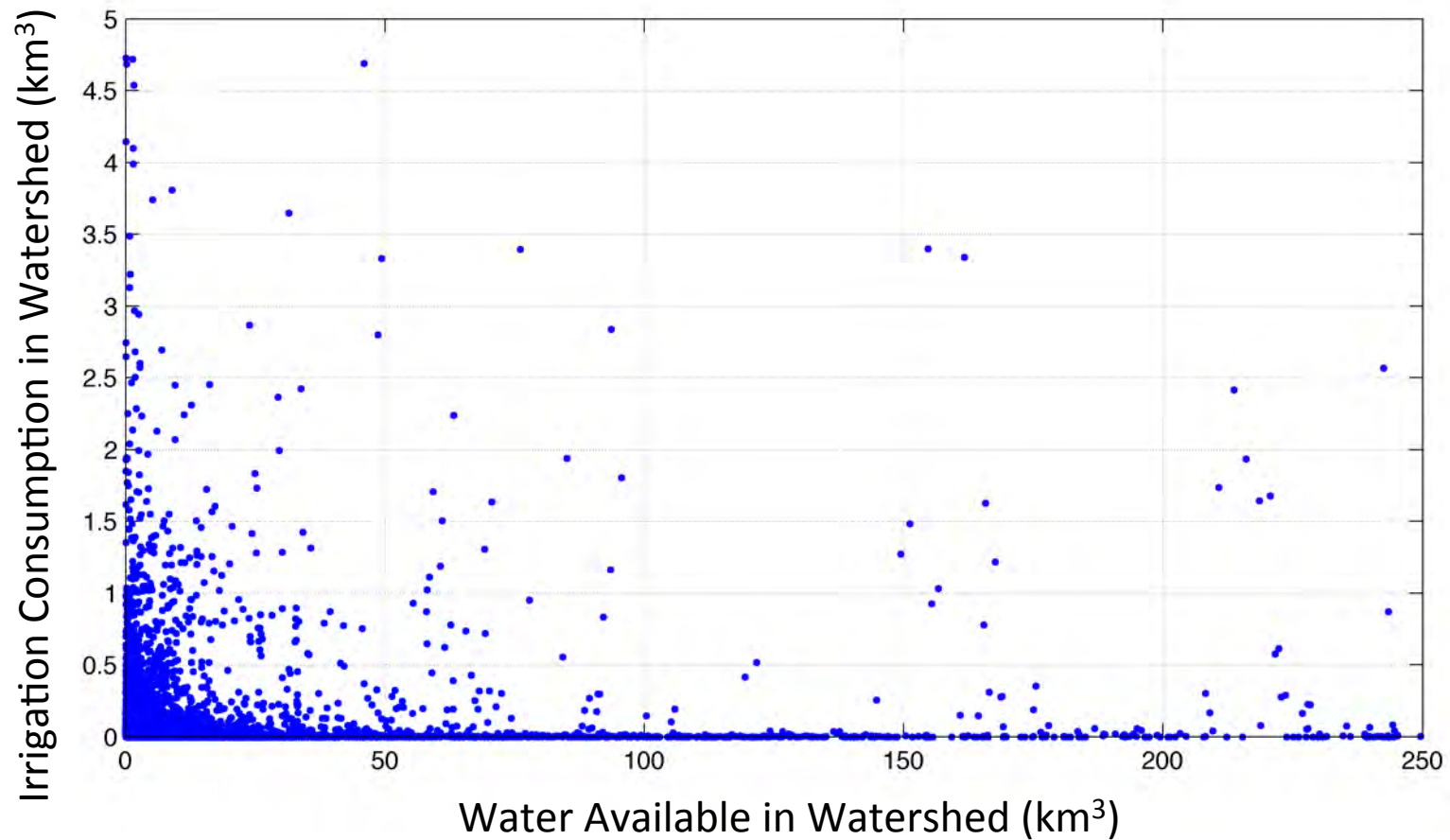




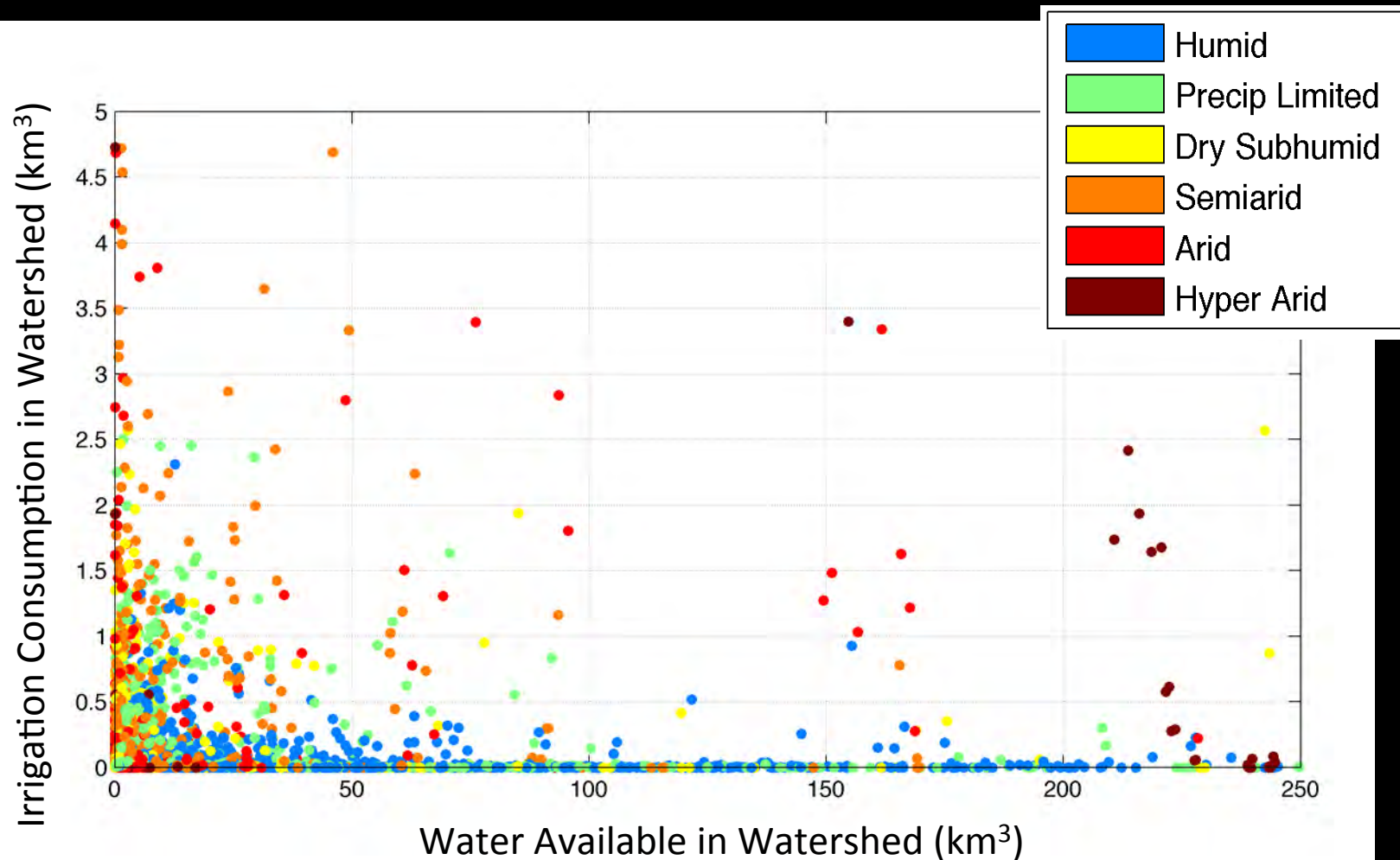
Image: NASA ASTER

- Management and climate affect crop water productivity
- Identify poor performers
- Targeted interventions can save water and land
- Potential for alleviating water competition

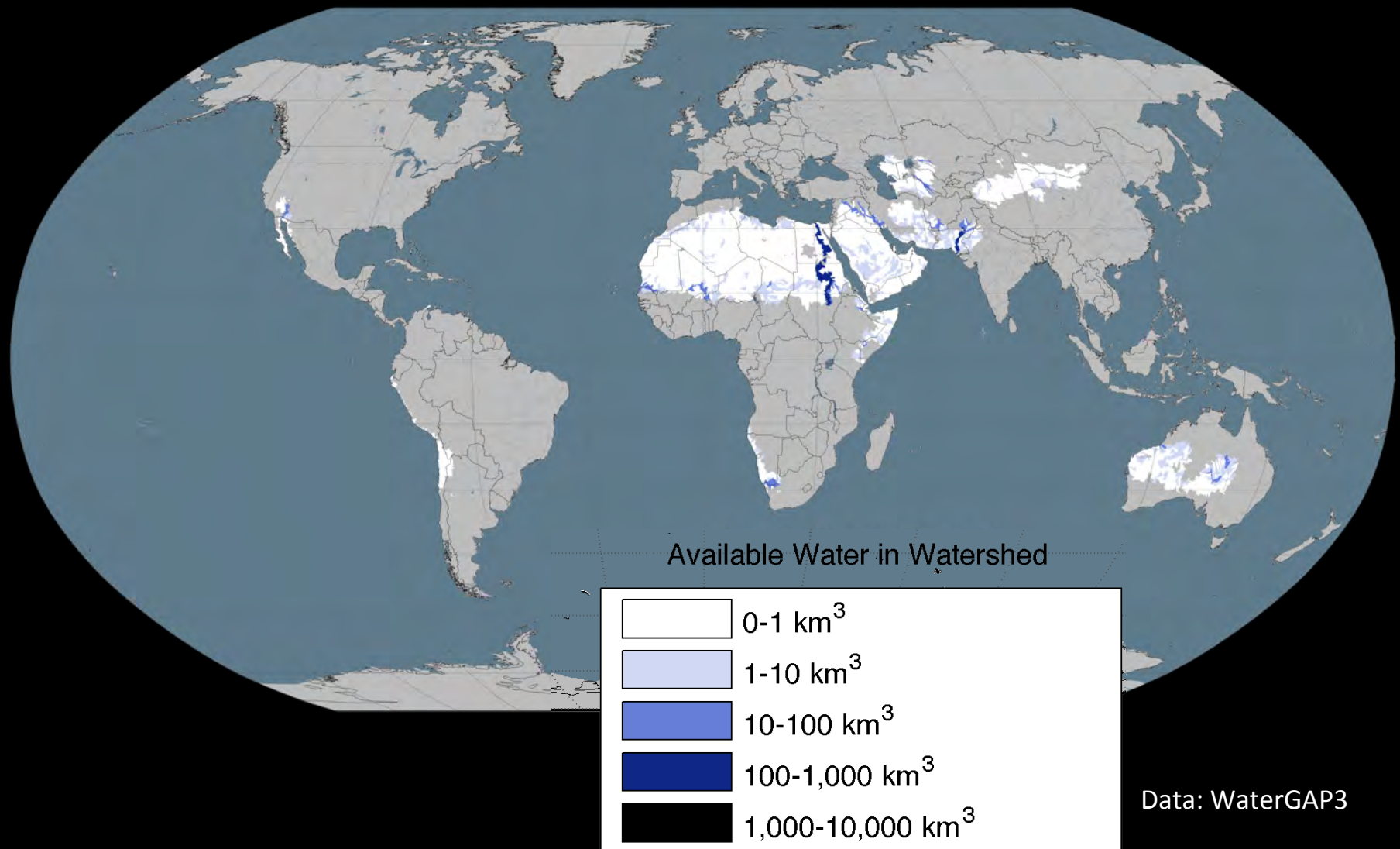
Irrigation Consumption does not Correlate with Water Availability



Climate Explains Some Irrigation Use in Water Rich Regions

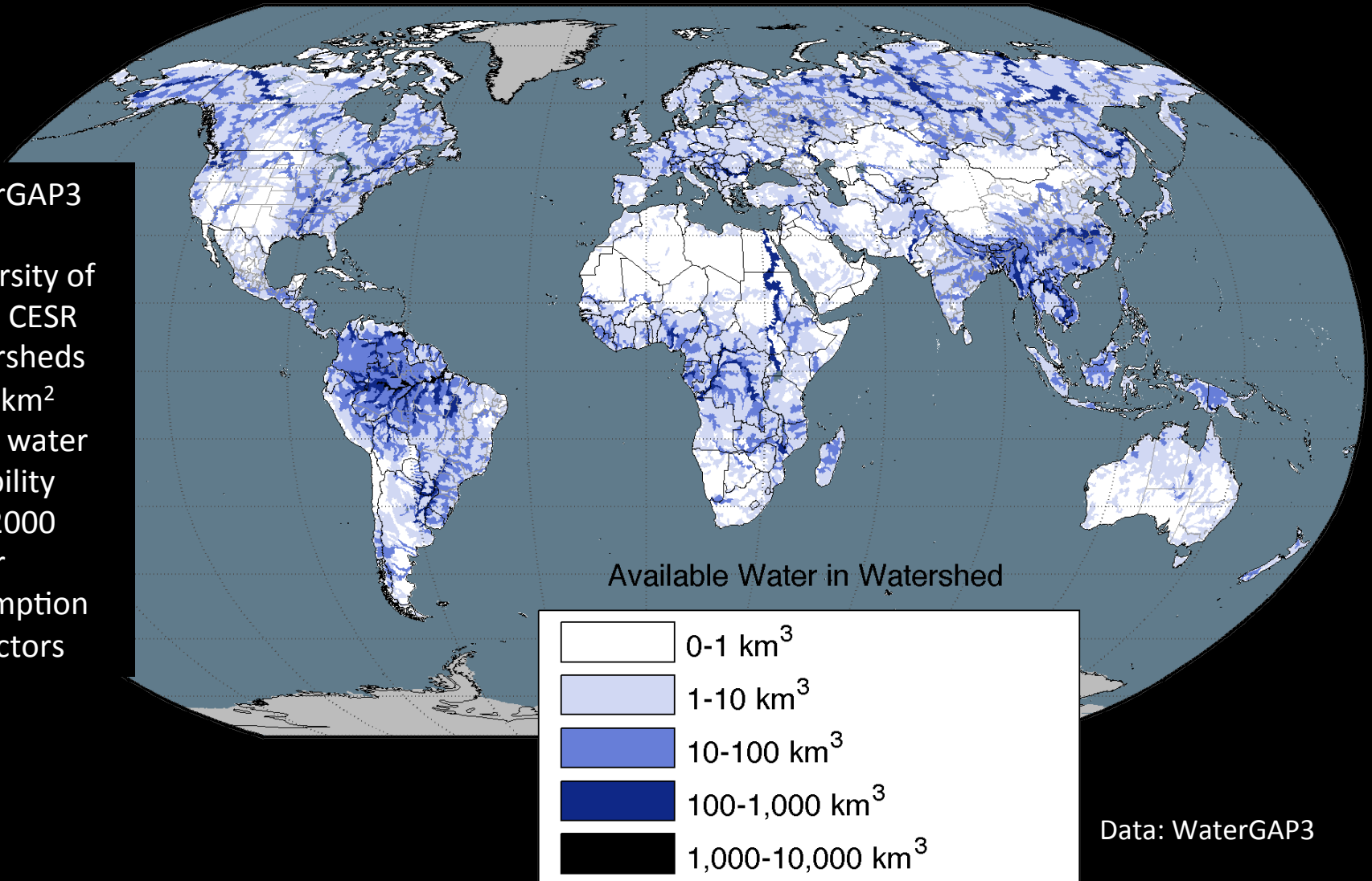


Wet headwaters provide high water availability in arid and hyper-arid watersheds

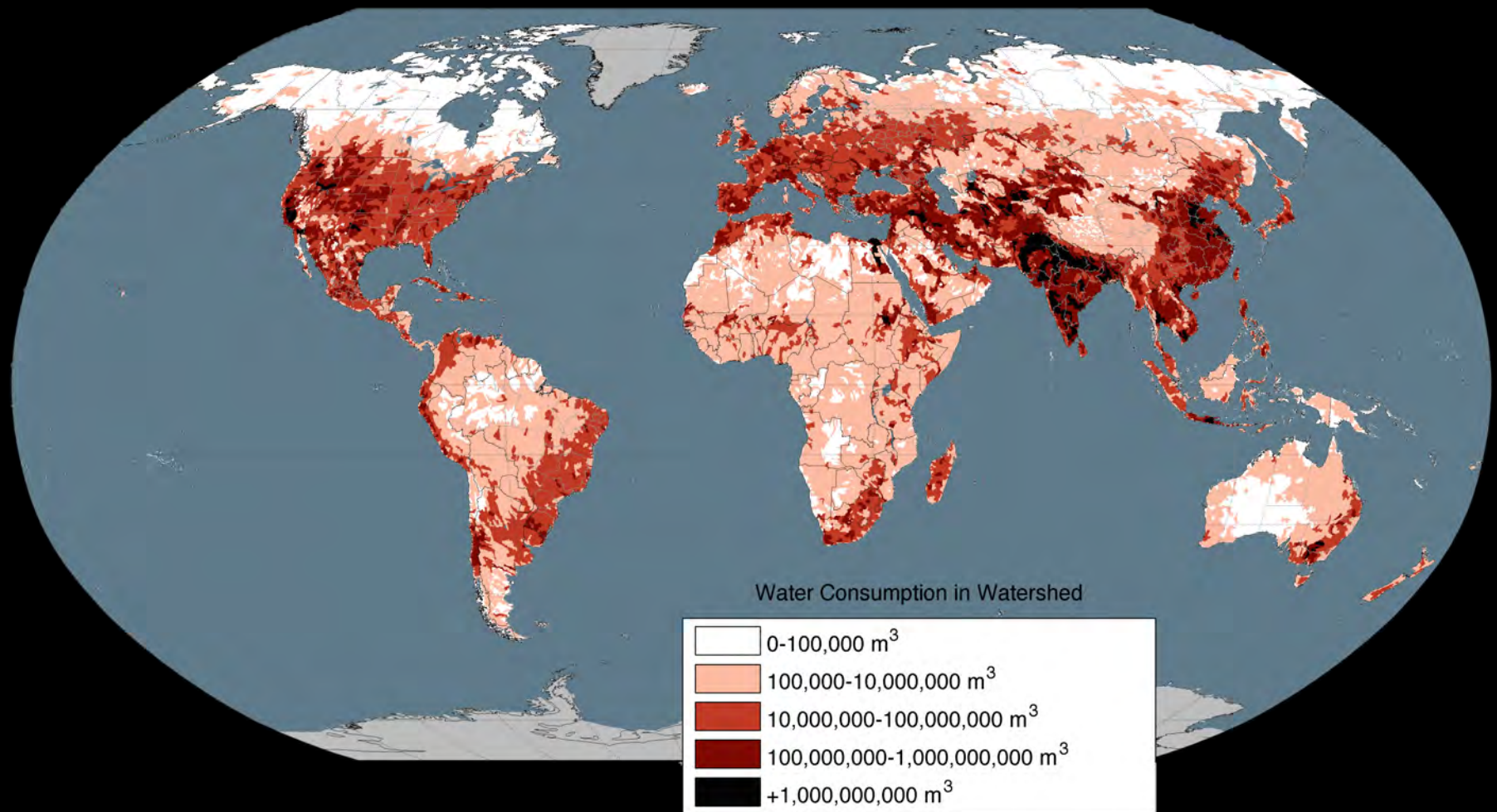


Globally, water availability...

- WaterGAP3 model
- University of Kassel, CESR
- Watersheds >1000 km²
- Mean water availability 1971-2000
- Water consumption in 5 sectors

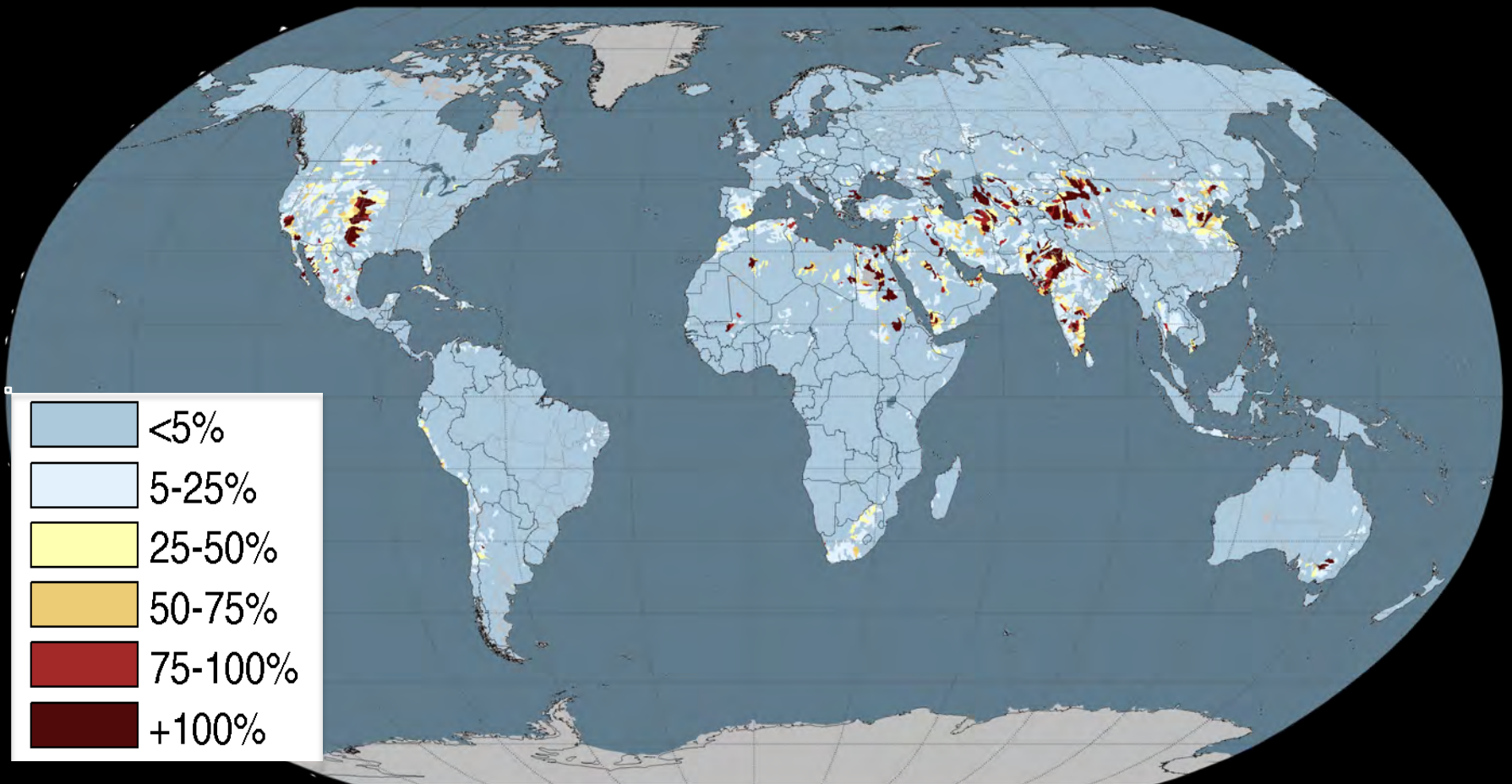


...is not correlated with water consumption



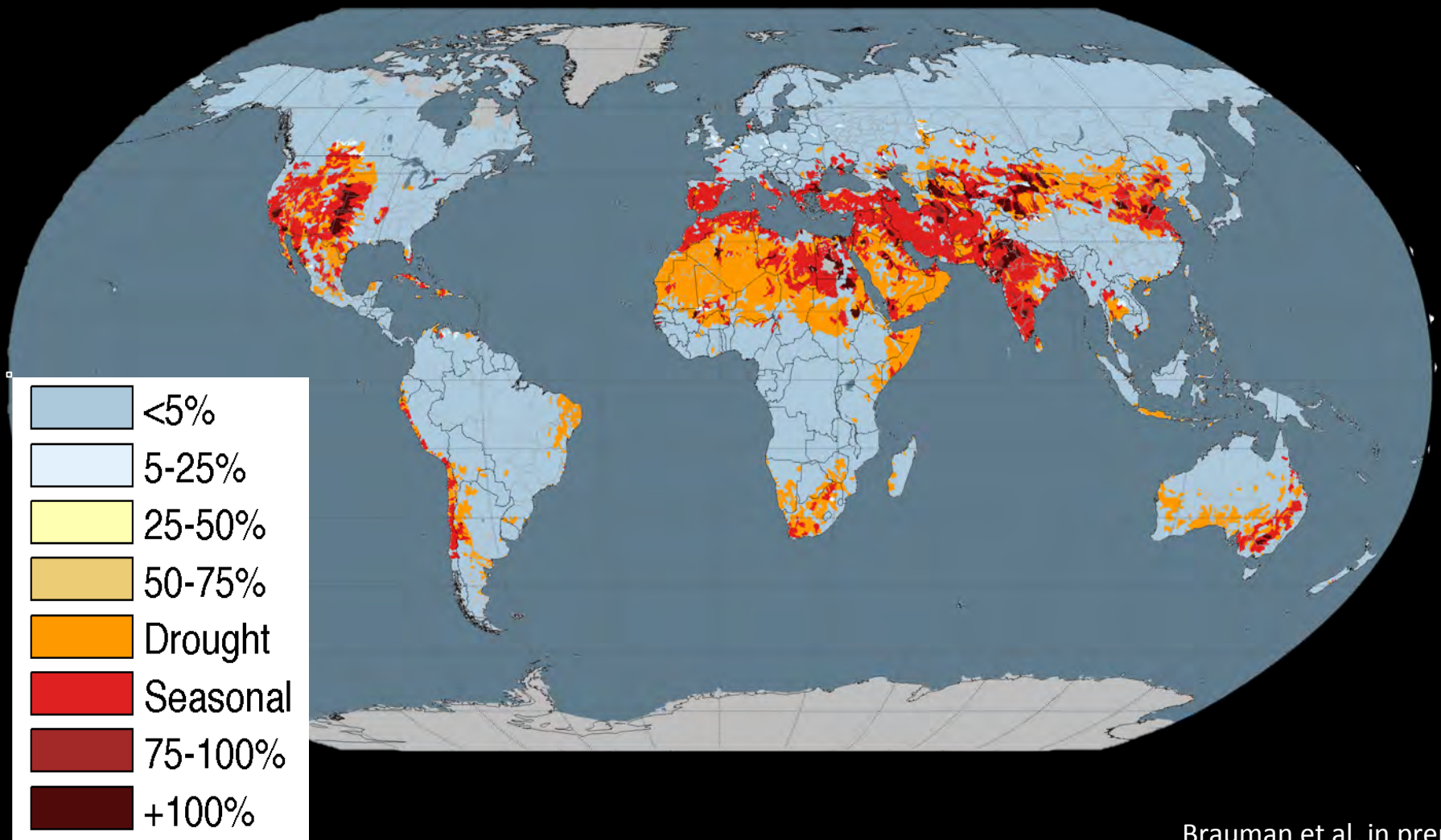
Data: WaterGAP3

Annual Water Depletion (Consumption/Availability) is limited



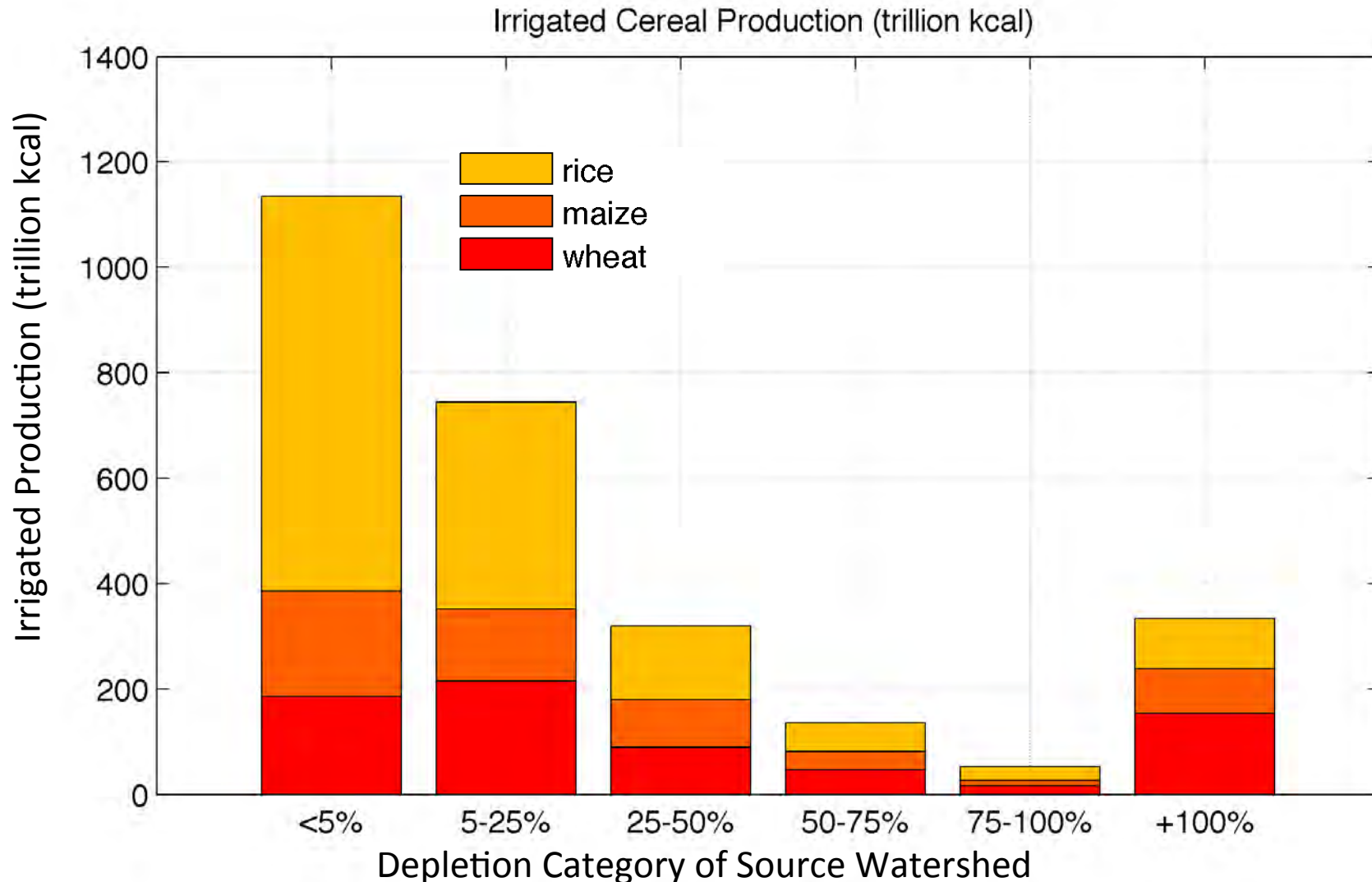
Data: WaterGAP3

Periodic Water Depletion is widespread

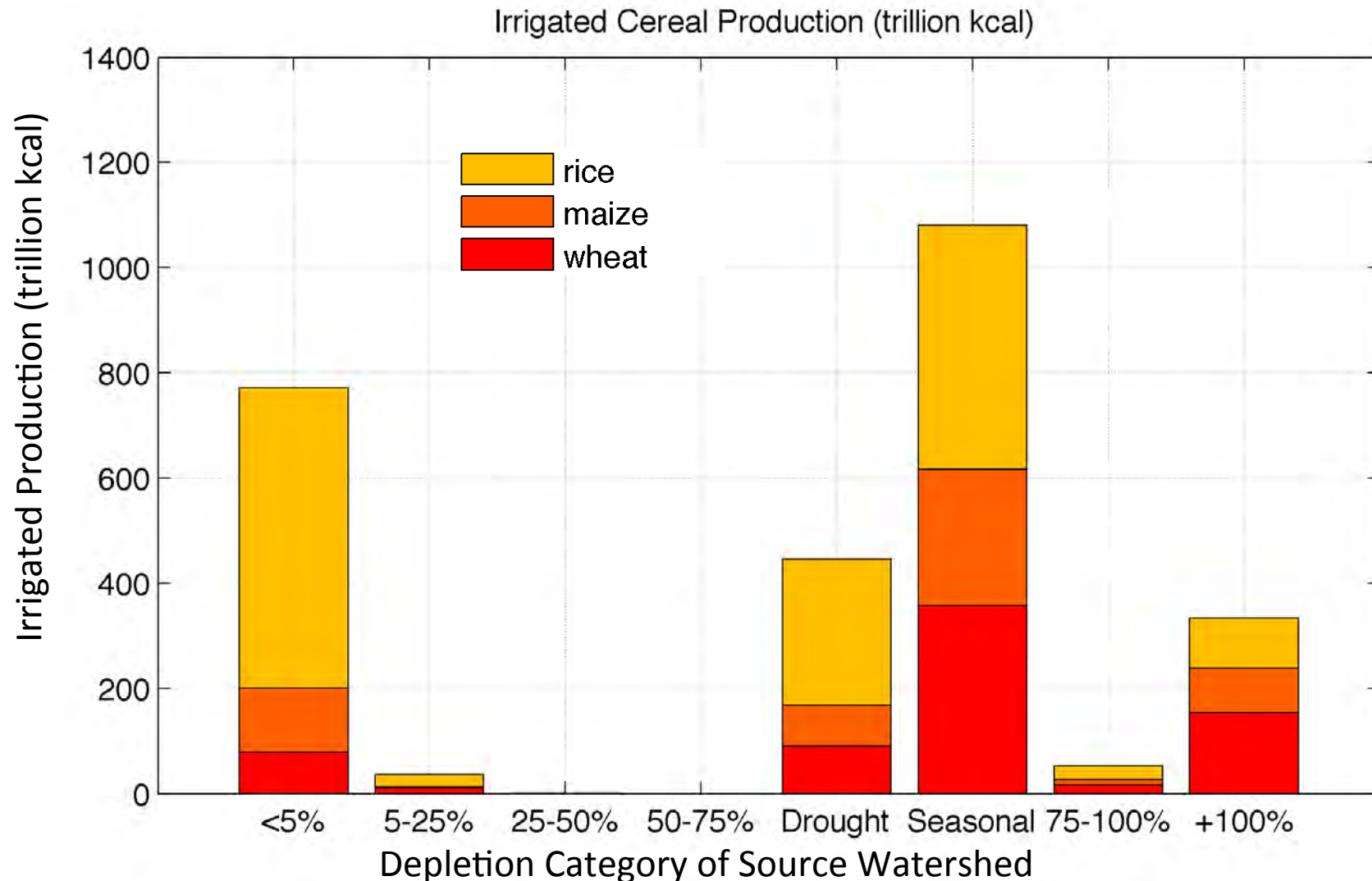


Brauman et al, in prep

~15% of Irrigated Cereals are Grown in >75% Annually Depleted Watersheds



~70% of Irrigated Cereals are Grown in >75% Periodically Depleted Watersheds



Irrigated Wheat in Depleted Watersheds

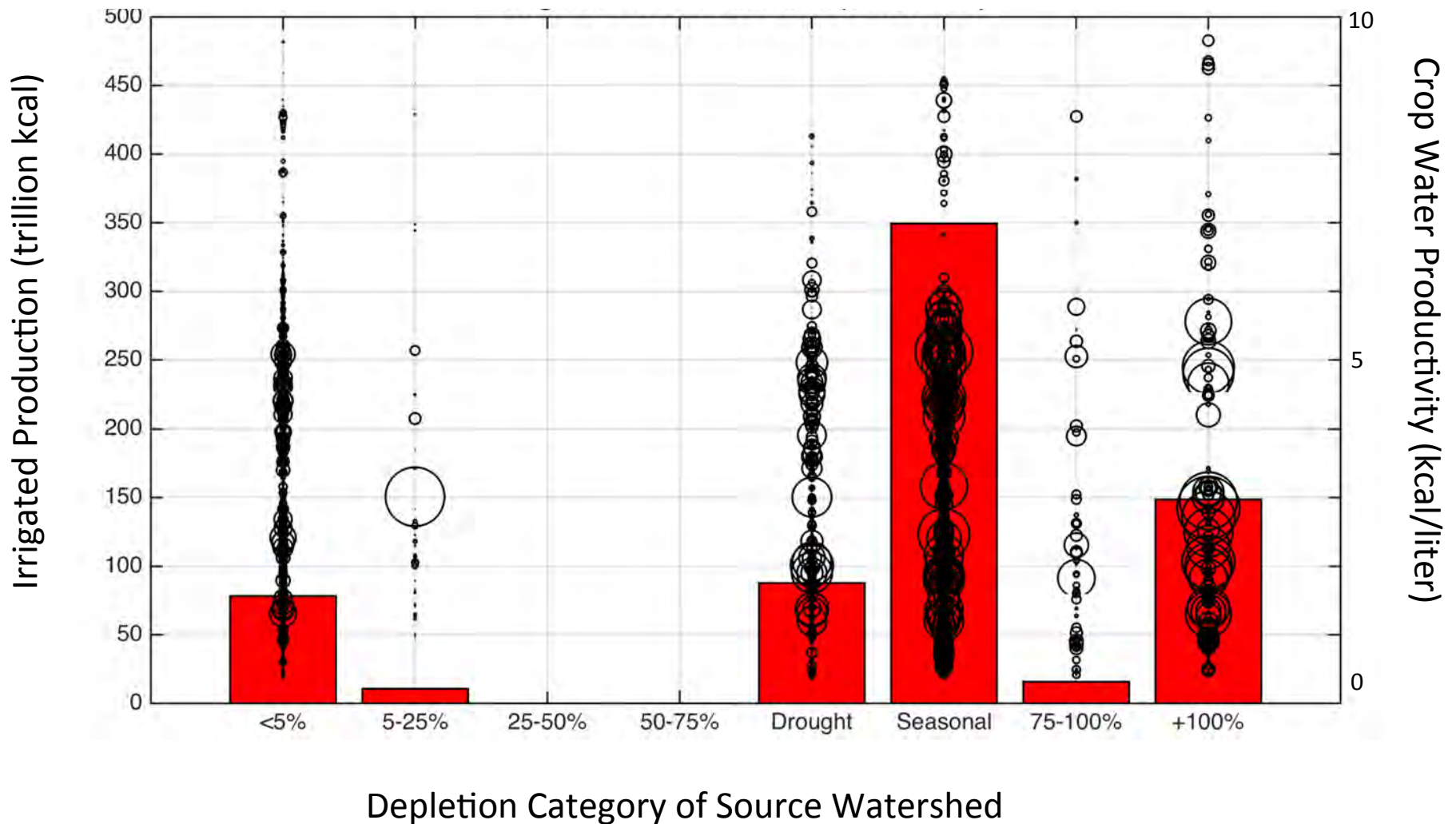




Image: NASA ASTER

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