

Global agricultural economic water scarcity

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Global agricultural economic water scarcity

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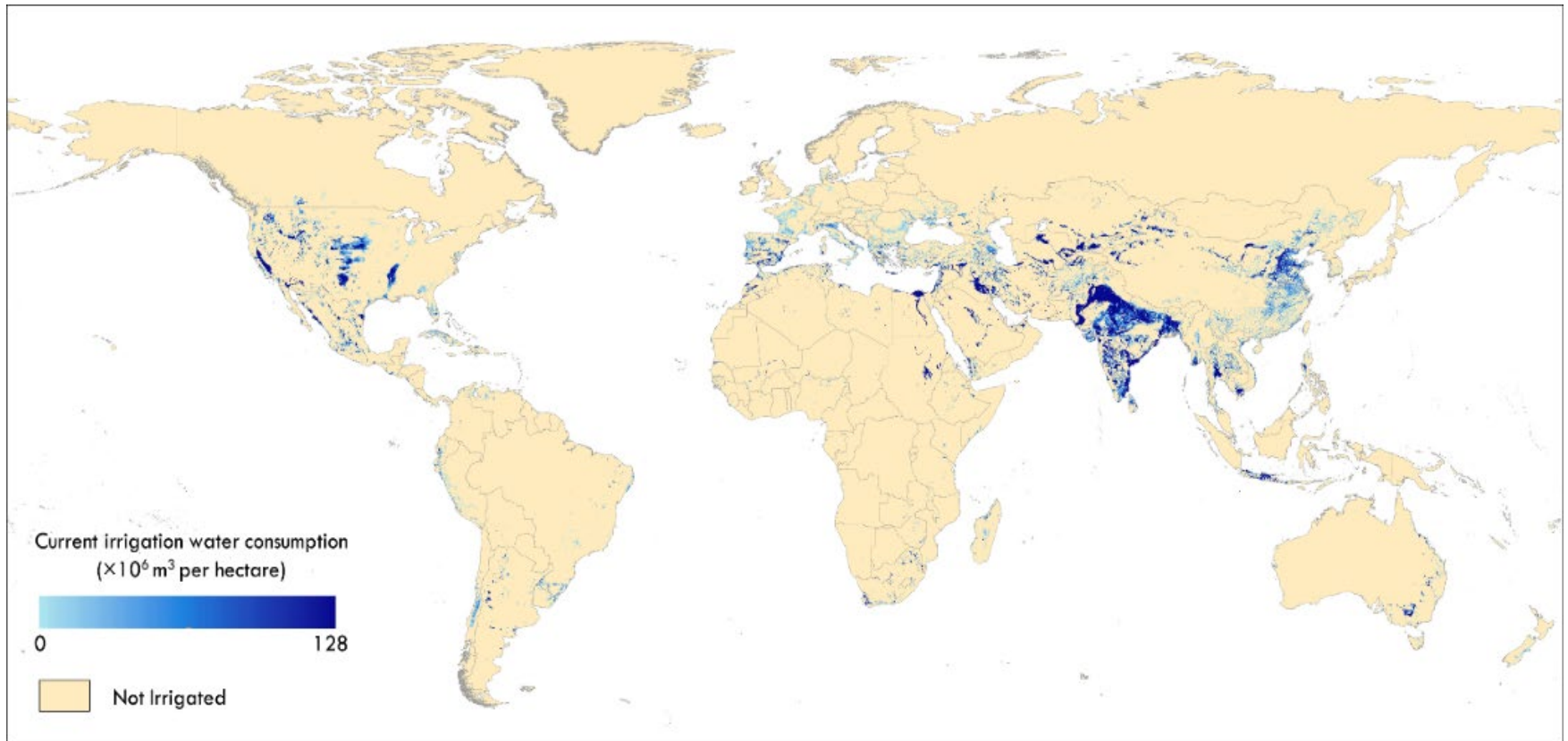
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Irrigation



- Irrigation dramatically increase crop production
- Largest driver of water scarcity around the world



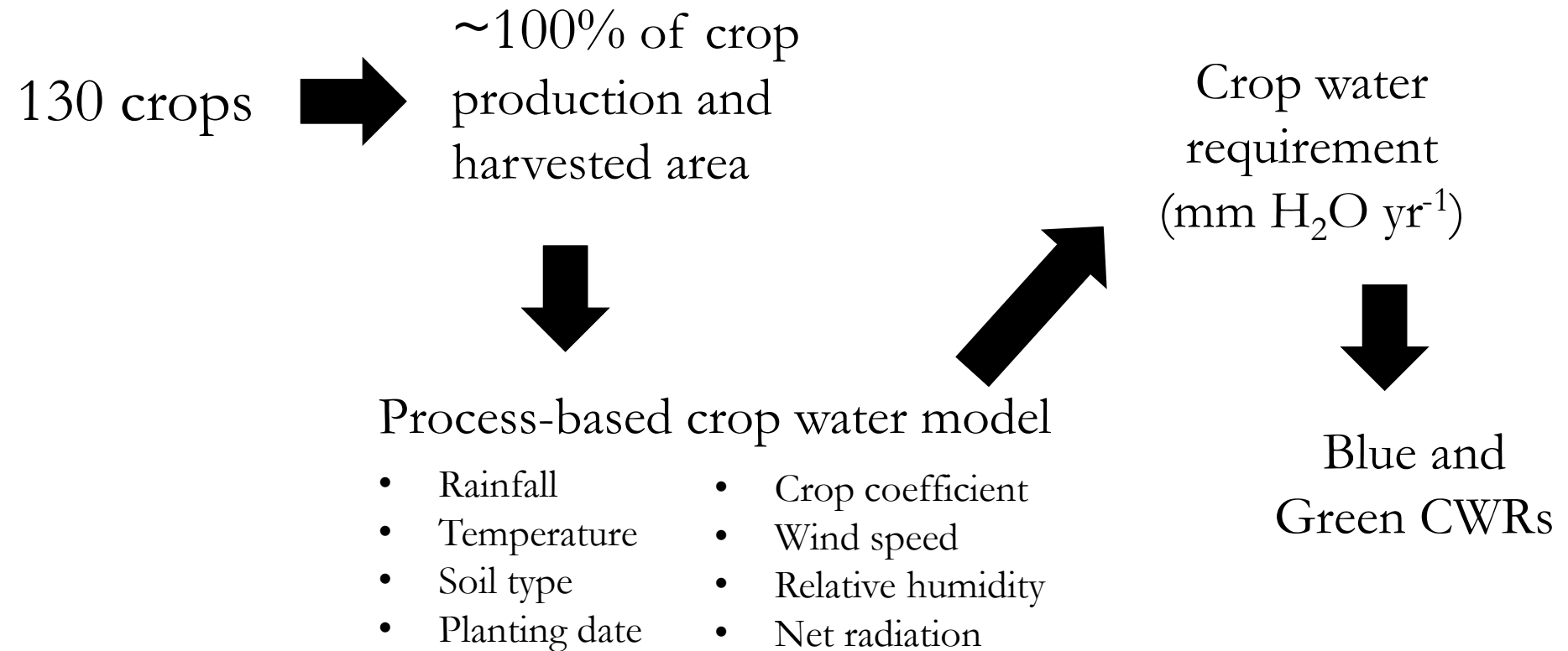
Definition of unsustainable irrigation

$$BLUE\ WATER\ SCARCITY = \frac{BLUE\ WATER\ CONSUMPTION}{RENEWABLE\ WATER\ AVAILABILITY} > 1$$

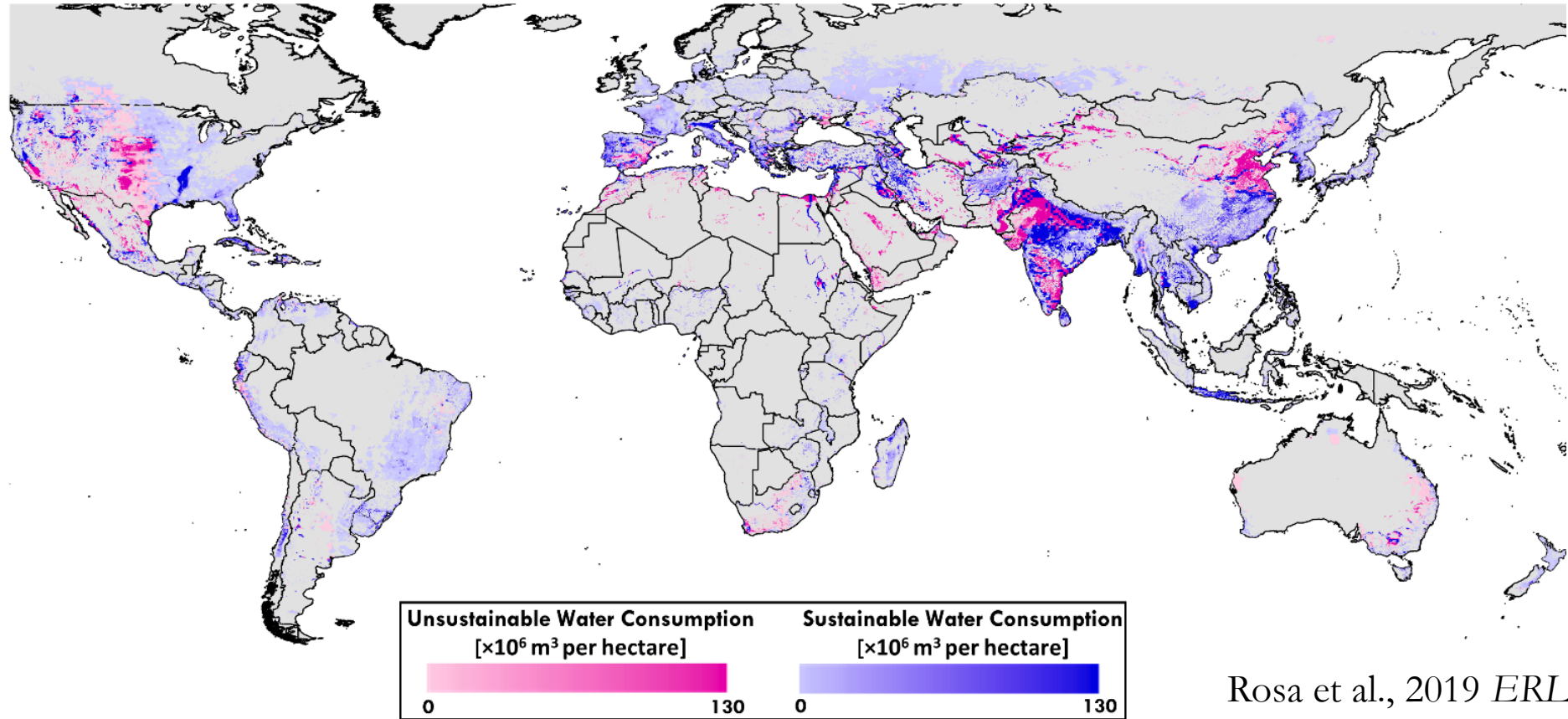
BLUE WATER CONSUMPTION = IRRIGATION + OTHER USES

RENEWABLE WATER AVAILABILITY = RUNOFF – ENVIRONMENTAL FLOWS

Estimating irrigation water demand

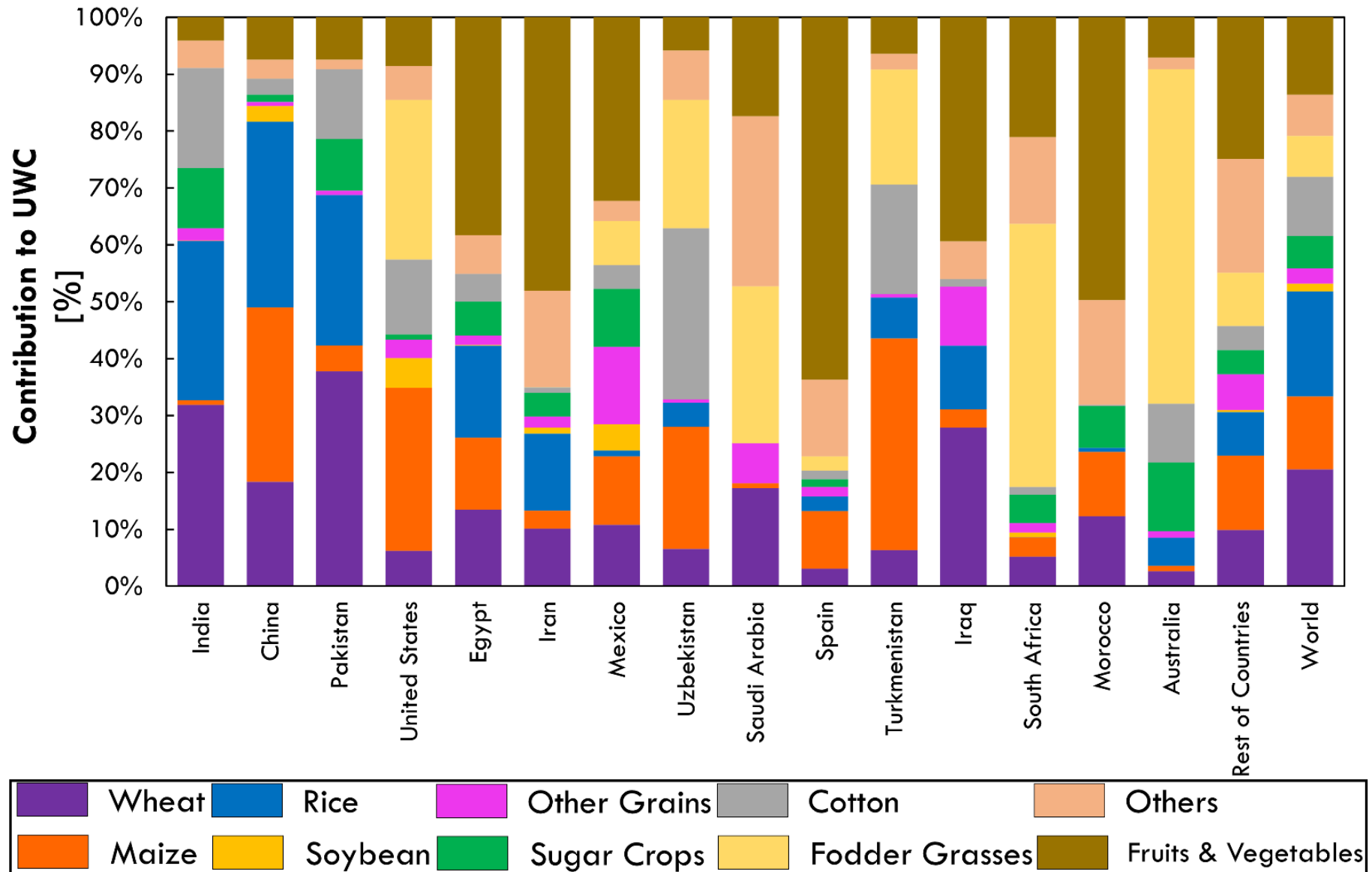


Hotspots of unsustainable irrigation

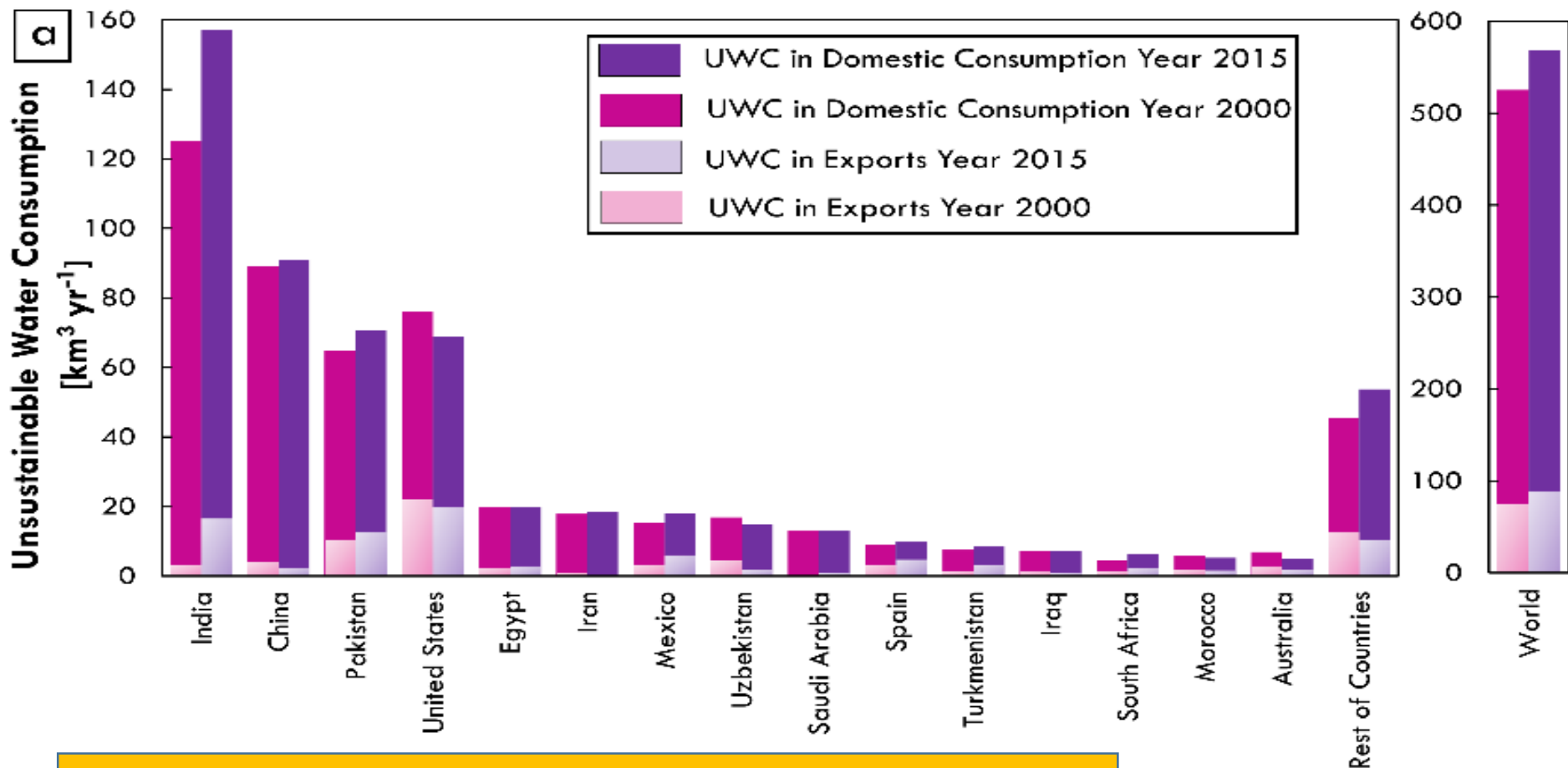


- ~50% of irrigation is unsustainable
- 1.3 billion people are reliant on unsustainable irrigation

Crops and countries contributing to unsustainable irrigation



Unsustainable irrigation in export



15% of unsustainable irrigation is virtually exported

The global food system must:



Food Supply & Nutrition



Farmer Livelihoods



Climate Resilience



Environmental Impacts

How can we meet the increasing food demand?

*Agricultural
Intensification*



Increase yields
(irrigation, fertilizers,
seeds)

*Agricultural
Extensification*



Expand the
cultivated area



Land Use Change
Deforestation
Biodiversity losses

Many scientists advocate for intensification

*Agricultural
Intensification*



Increase yields
(irrigation, fertilizers,...)

...because it avoids habitat destruction

... however, there are negative impacts:

- Unsustainable use of water resources
- Loss of rural livelihoods
- Pollution and biodiversity loss

Croplands can still attain higher crop yields
potentially increasing crop production by **45%-70%**

Mueller et al., 2012

Biophysical factors limiting food production

- Nutrients
- Water is a critical input limiting global food production

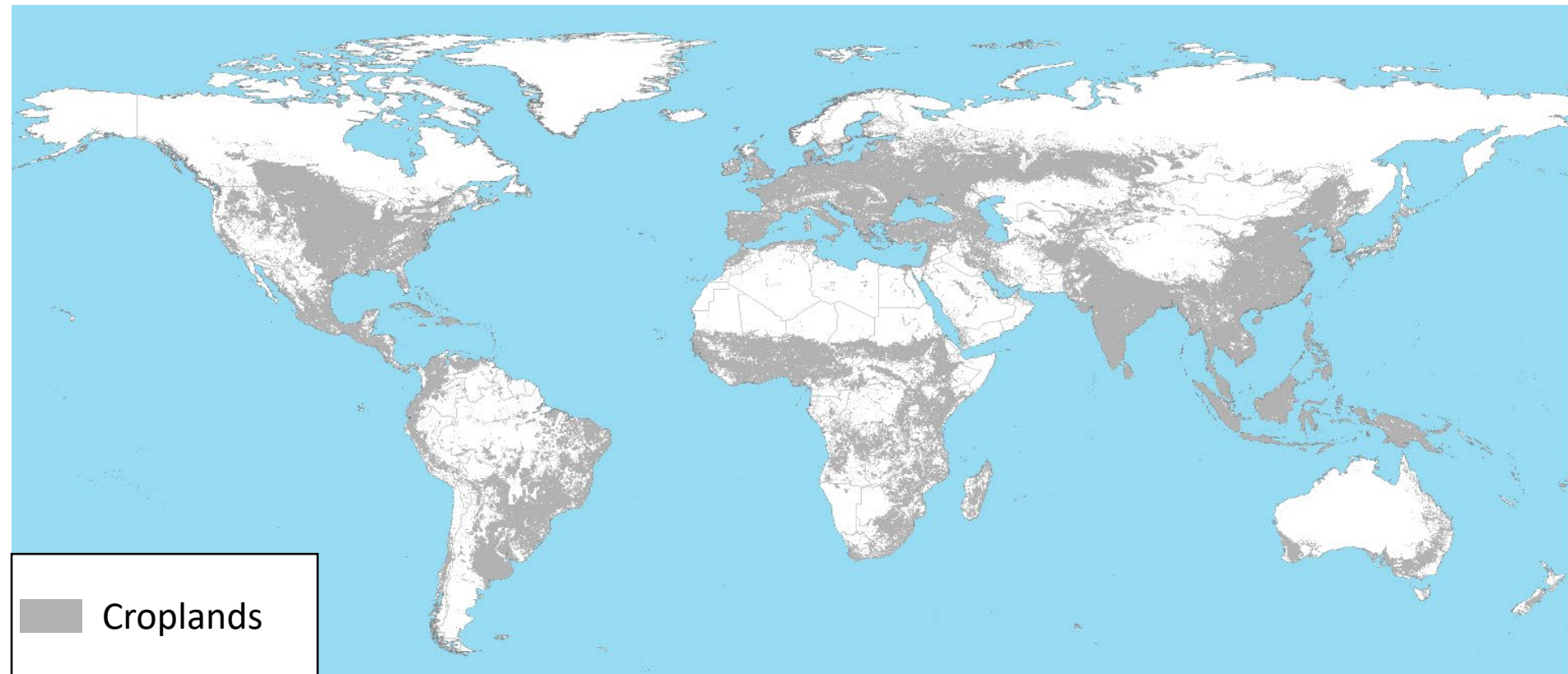
Higher crop yields could feed 4 billion more people

Research questions

- Where and to what extent yield gap closure will be constrained by water availability?
- The extent to which irrigation can be expanded within presently rain-fed cropland without depleting environmental flows remains poorly understood



Global croplands



What is the extent of agricultural green water scarcity?

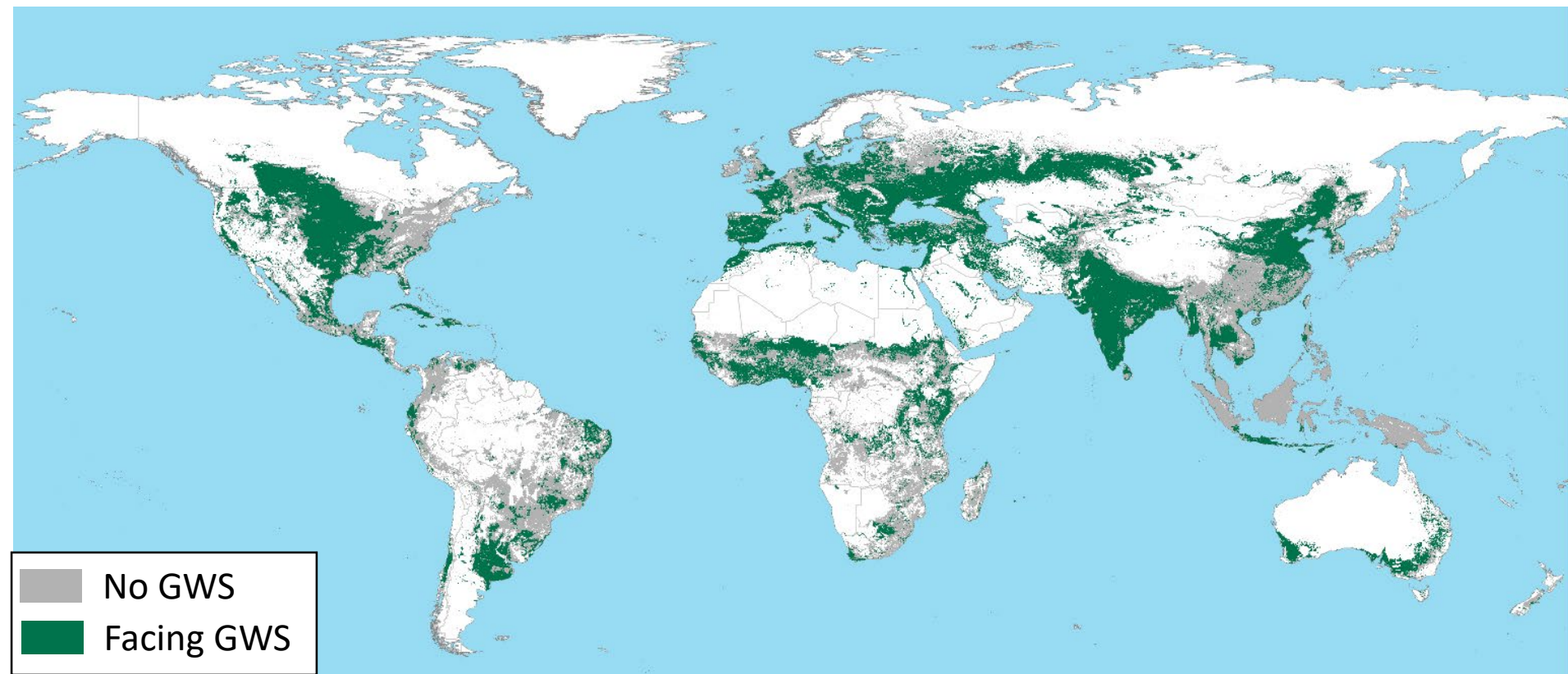
$$GREEN\ WATER\ SCARCITY = \frac{GREEN\ WATER\ DEFICIT}{CROP\ WATER\ REQUIREMENT} > 0.1$$

GREEN WATER SCARCITY: When green water is insufficient to sustain unstressed crop production and irrigation is needed to boost yields.

GREEN WATER: Root-zone soil moisture that is available for uptake by plants.

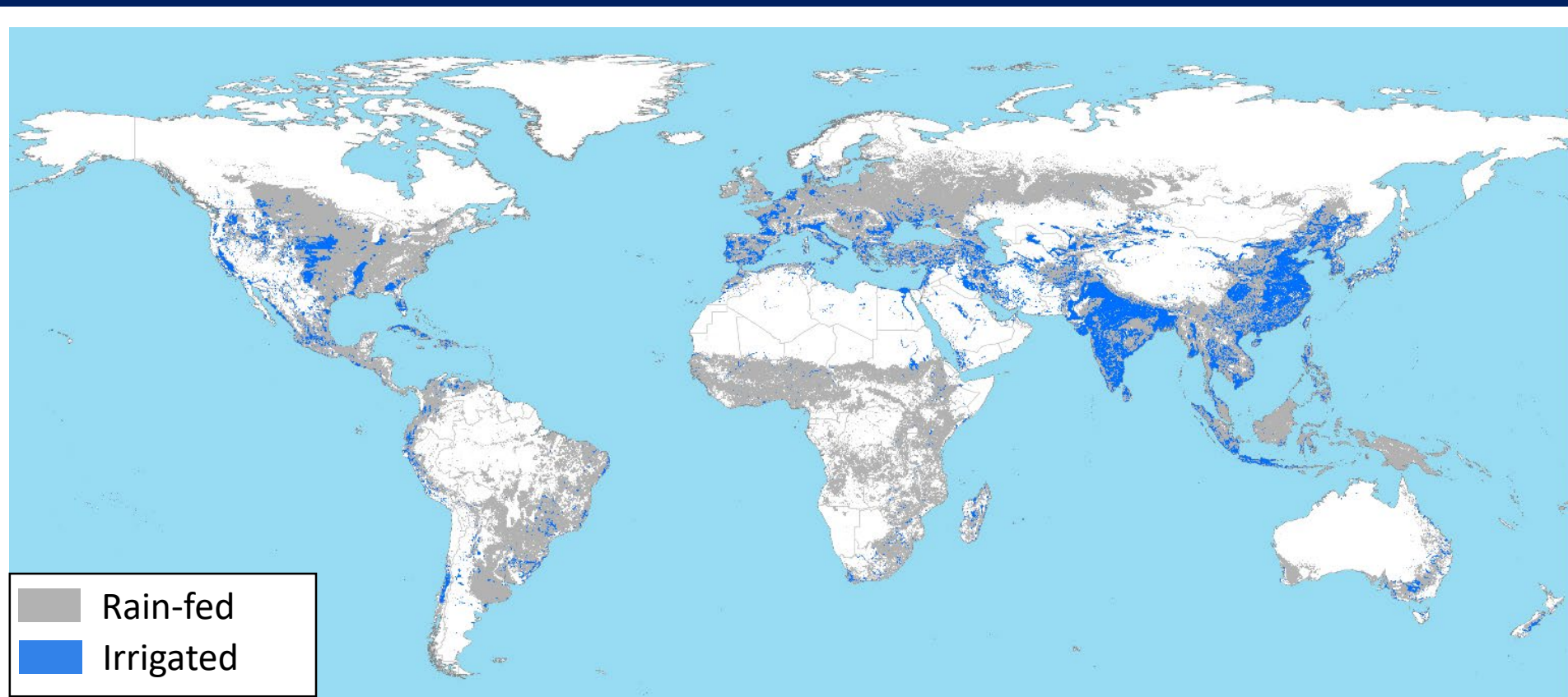
CROP WATER REQUIREMENT: The amount of water needed by a crop to grow in non water stressed conditions.

Agricultural green water scarcity



76% of croplands face GWS

Irrigation



77% of croplands is rain-fed
23% of cropland is irrigated

What is the extent of agricultural blue water scarcity?

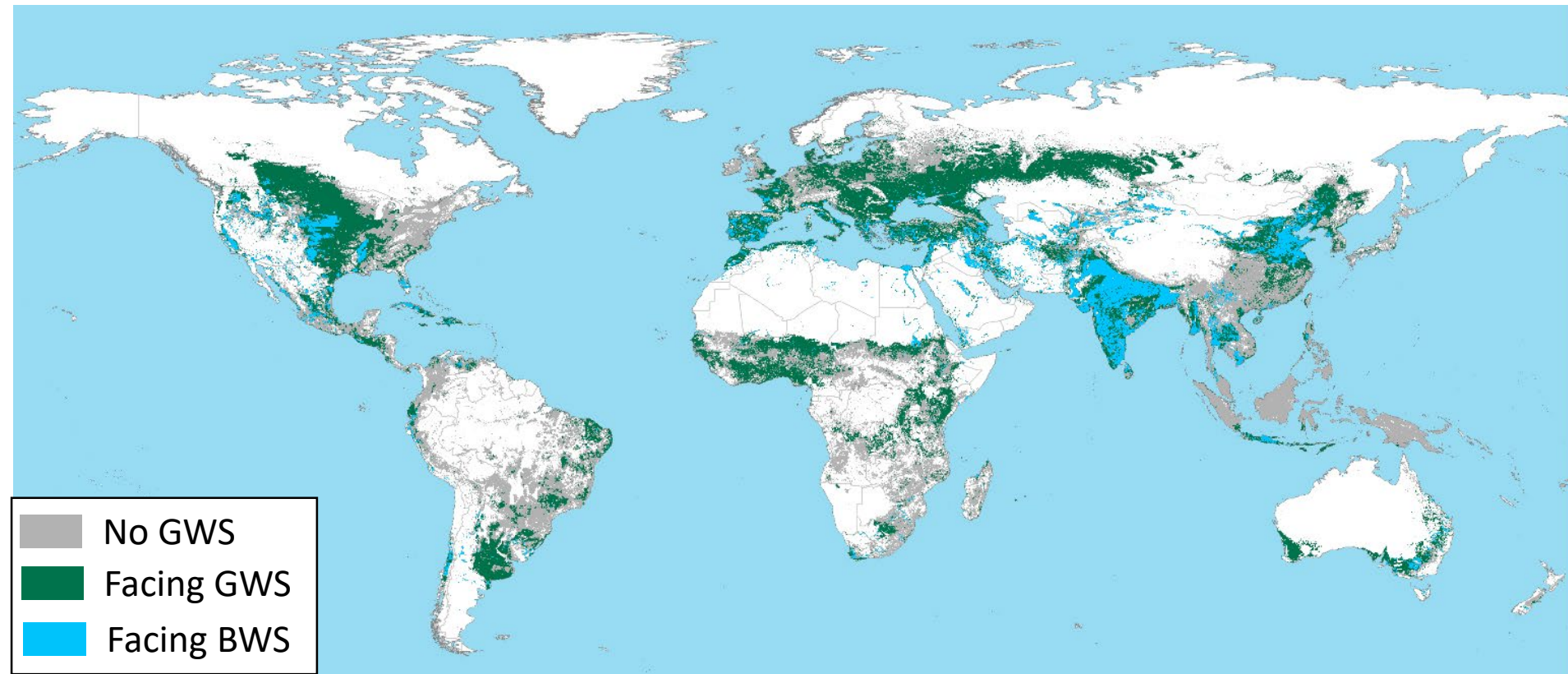
$$BLUE\ WATER\ SCARCITY = \frac{BLUE\ WATER\ CONSUMPTION}{RENEWABLE\ WATER\ AVAILABILITY} > 1$$

BLUE WATER SCARCITY: When irrigation is unsustainable and renewable blue water availability is insufficient to sustainably meet crop water requirements. In these cases, irrigation impairs environmental flows and depletes freshwater stocks

BLUE WATER CONSUMPTION= IRRIGATION + OTHER USES

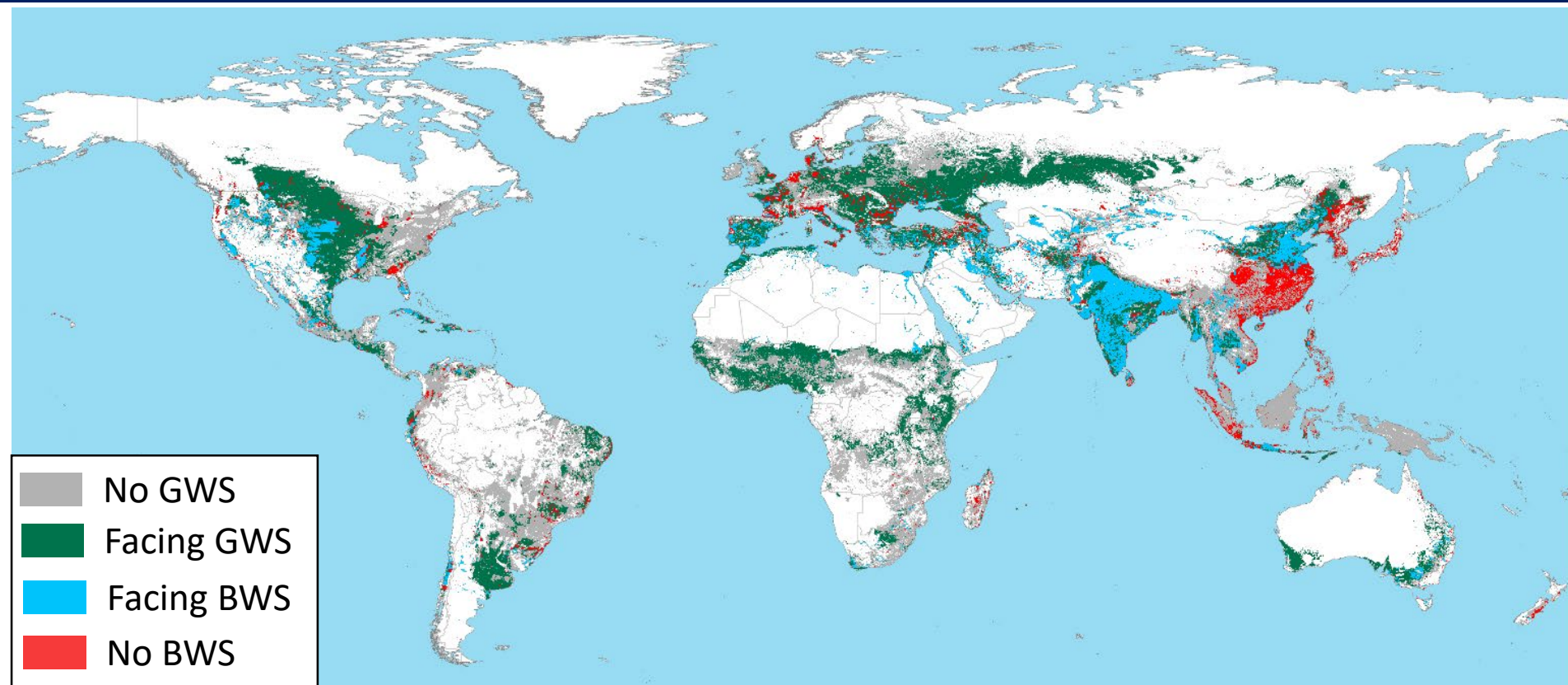
RENEWABLE WATER AVAILABILITY= RUNOFF – ENVIRONMENTAL FLOWS

Agricultural blue water scarcity



16% of croplands face BWS

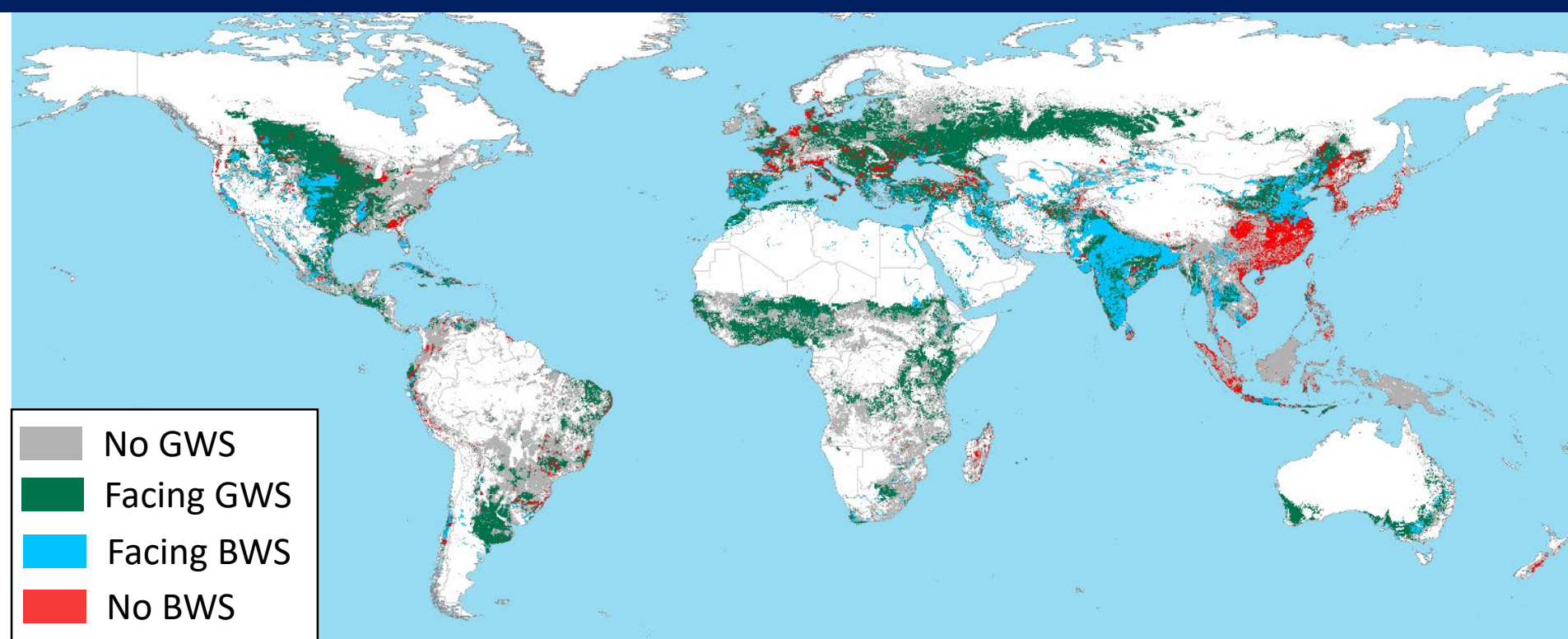
Agricultural blue water scarcity



16% of croplands face BWS

23% of croplands is irrigated

What is the irrigation expansion potential?



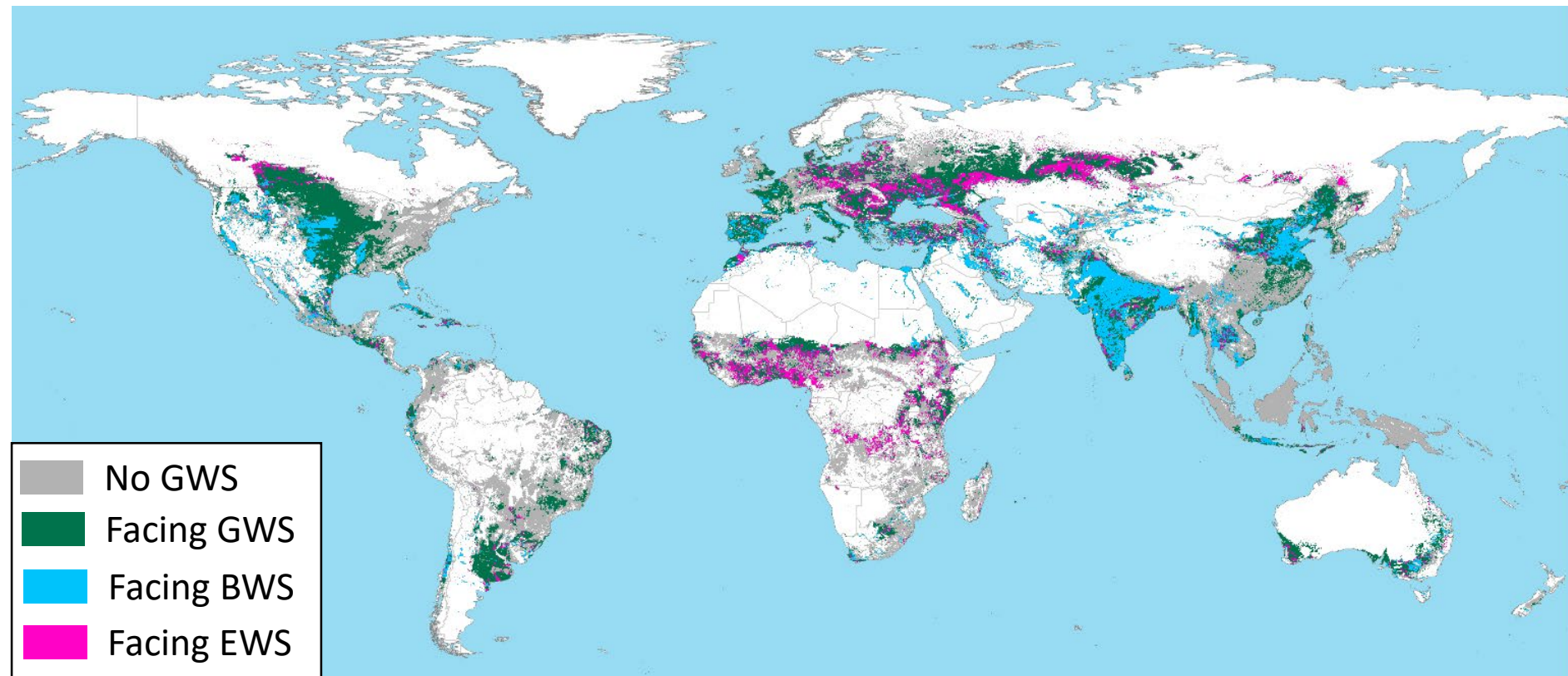
16% of croplands face BWS

What is the extent of agricultural economic water scarcity?

$$\text{ECONOMIC WATER SCARCITY} \left\{ \begin{array}{l} \frac{\text{BLUE WATER CONSUMPTION YIELD GAP}}{\text{RENEWABLE WATER AVAILABILITY}} < 1 \\ \text{Currently not equipped for irrigation} \\ \text{Facing green water scarcity} \end{array} \right.$$

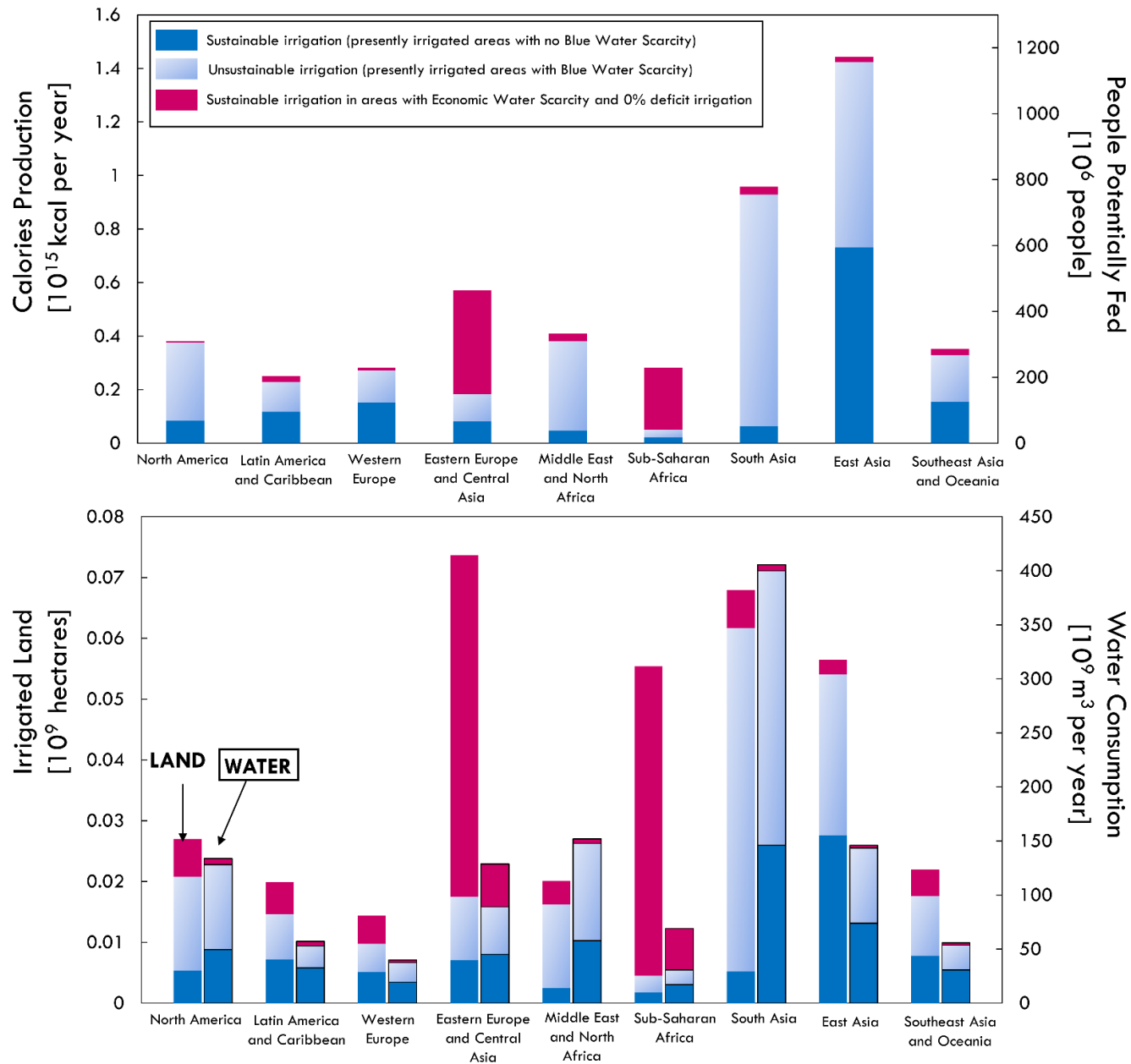
AGRICULTURAL ECONOMIC WATER SCARCITY: Agricultural economic water scarcity is defined as lack of irrigation due to limited institutional and economic capacity instead of hydrologic constraints. Agricultural economically water scarce croplands are underperforming rain-fed croplands suitable for sustainable irrigation expansion.

Agricultural economic water scarcity



~15% of croplands face EWS (140 Mha)

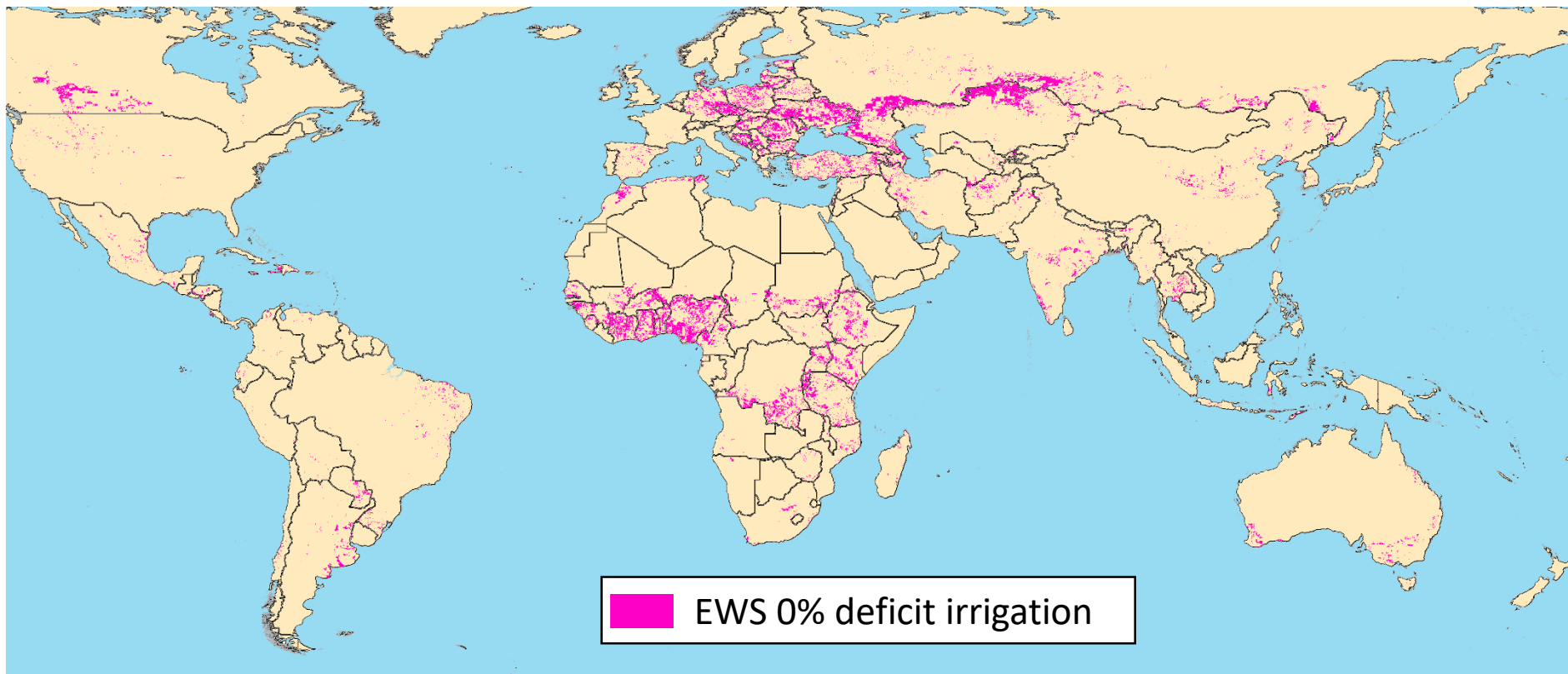
Regional distribution of agricultural economic water scarcity



How water management practices influence EWS?

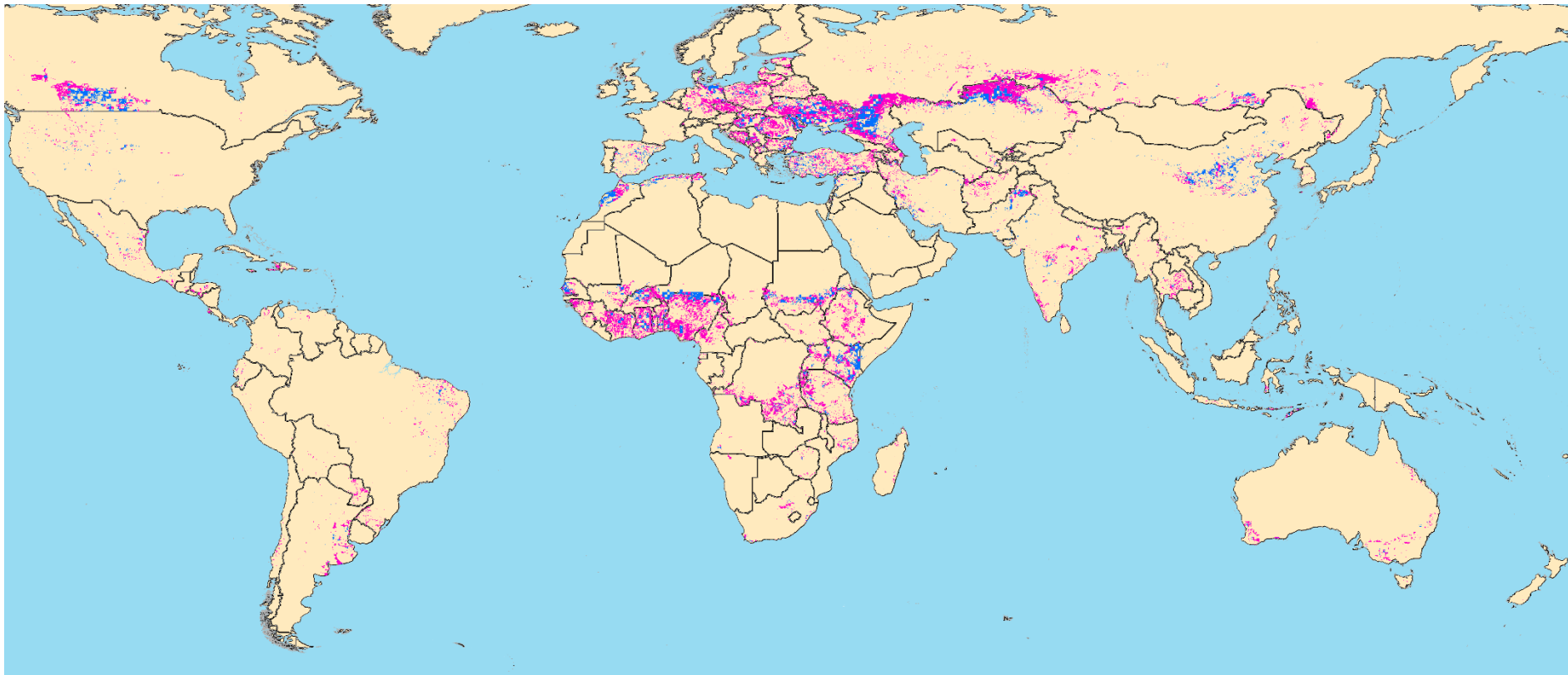
THE CASE OF DEFICIT IRRIGATION

Crops are grown under mild water stress conditions with minimal effects on yields





~15% of cropland area

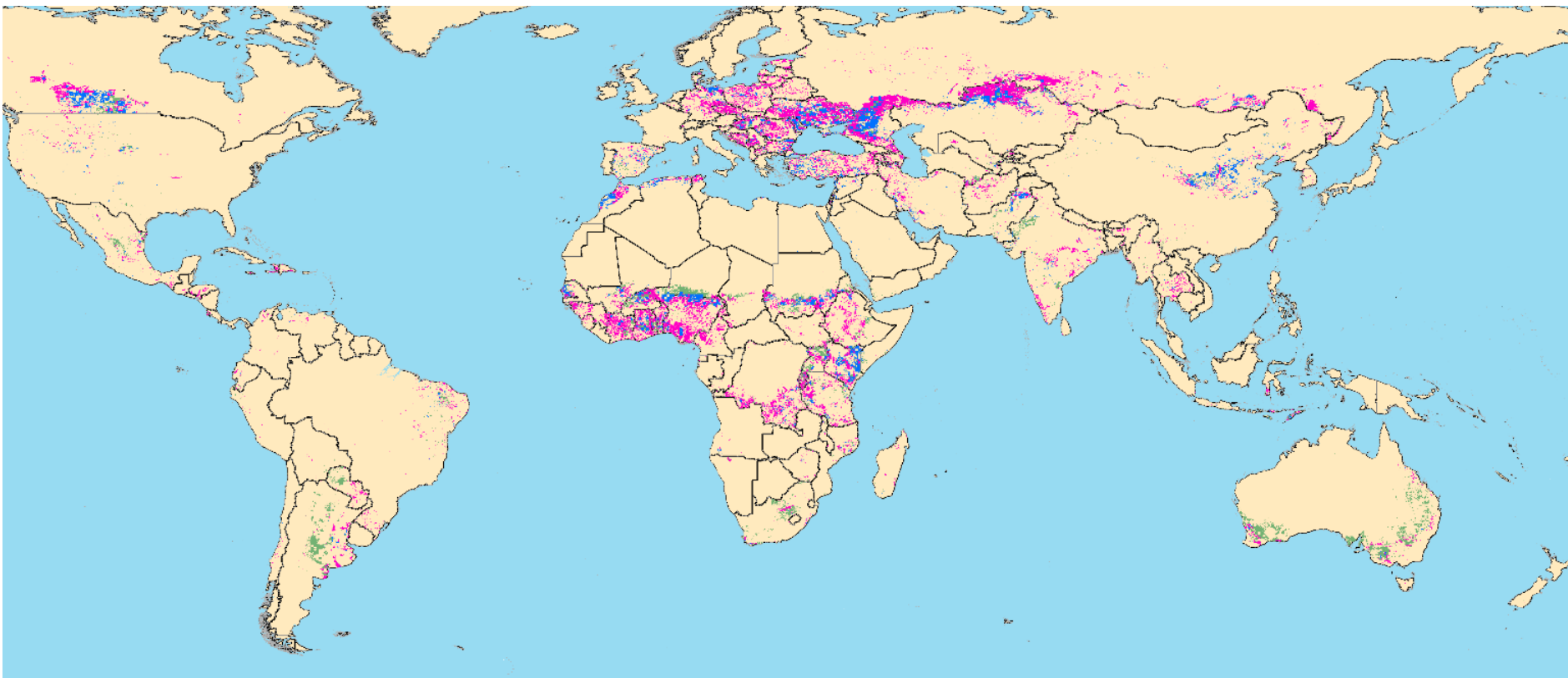
Deficit irrigation



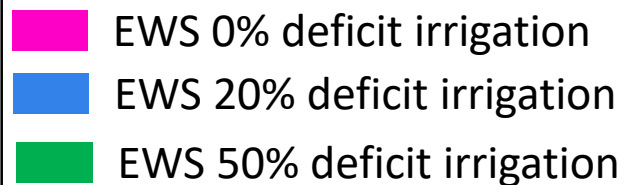
**~20% of cropland area
+50 Mha**

 EWS 0% deficit irrigation
 EWS 20% deficit irrigation

Deficit irrigation



**~25% of cropland area
+50 Mha**



The role of water storage

Monthly Storage (Rosa et al., 2020 Science Adv)	Annual Storage (Rosa et al., 2018 ERL)
+0.8 billion people	+1.9 billion people
+140 Mha +150 Km³	+267 Mha +600 Km³

Small storage and nature-based solutions (mulching, pitting, no-till farming, terracing)



Large storage



Takeaways

- Half of irrigation practices are unsustainable
- The notion of **agricultural economic water scarcity** allows to identify the target areas where irrigation expansion may sustainably increase food production
- 0.8-2.8 billion more people can be sustainably feed
- Over 140 million ha of rain-fed croplands are suitable for sustainable irrigation



Thank you



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