Global Environmental Change and the Sustainable Water-Food-Energy Security

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Rationale

Global change is a term intended to encompass the full range of global issues and interactions concerning natural and human-induced changes in the Earth's environment. The Global Change Research Act of 1990 defines global change as "changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life.

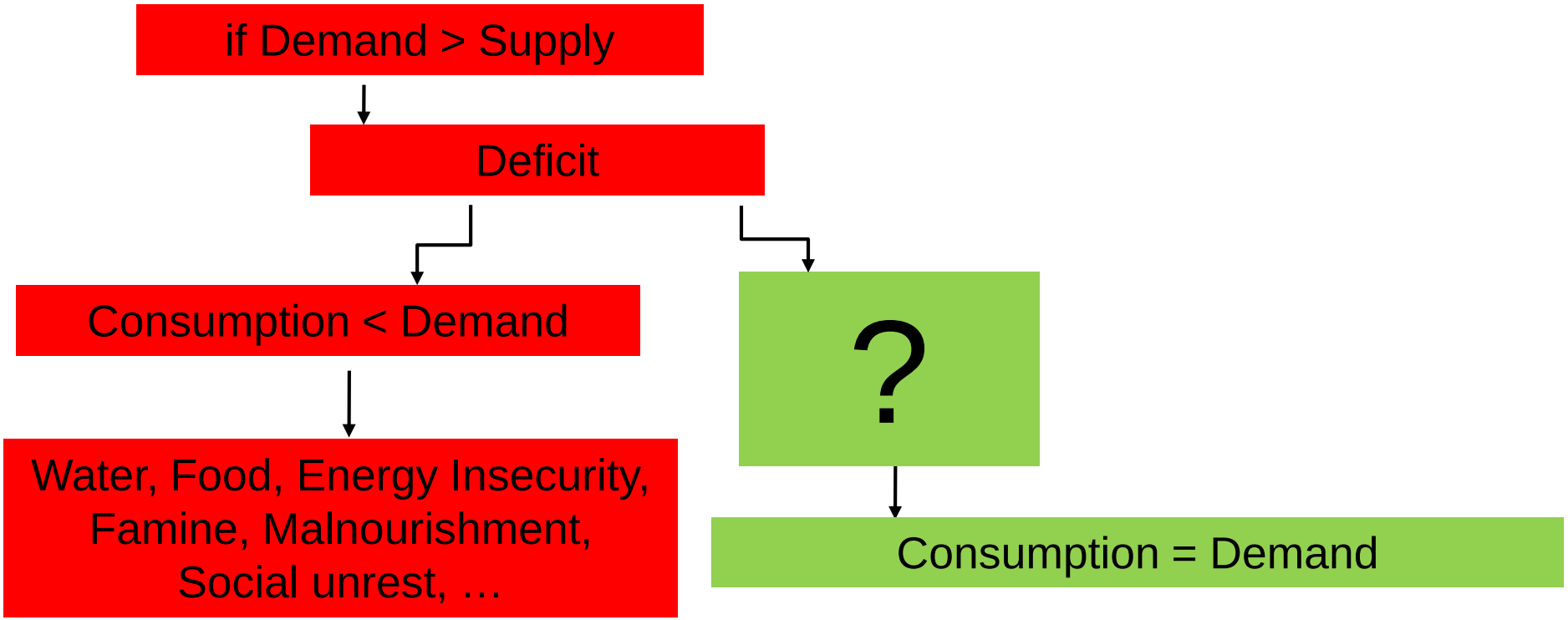
Food security is the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Over the coming decades, a changing climate, growing global population, rising food prices, and environmental stressors will have significant yet highly uncertain impacts on food security (UN Committee on World Food Security).

Water security is the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, for preserving ecosystems in a climate of peace and political stability (UN Committee Water).

Energy security is the uninterrupted availability of energy sources at an affordable price (IEA).

Over the coming decades, a changing climate, growing global population, rising food prices, and environmental stressors will have significant yet highly uncertain impacts on food, water and energy security.

RESOURCES: DEMAND vs AVAILABILITY

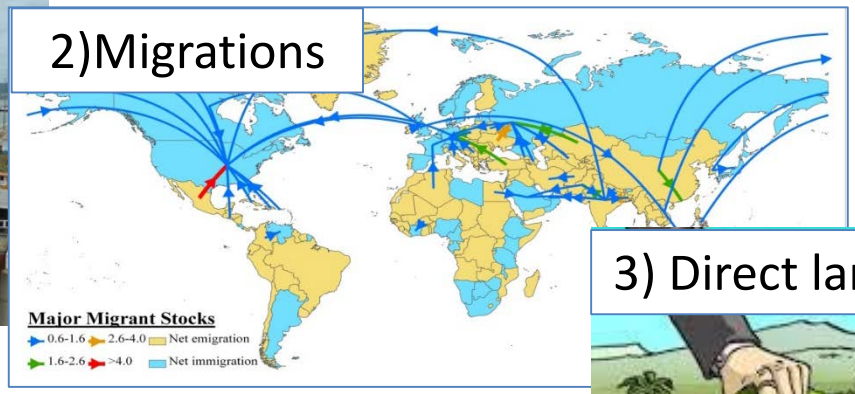


What about to balance Local Supply and Demand?

Societies try to meet their demand by relocating resources, people or directly acquiring land

1)Importation of resources: Trade

2)Migrations



3) Direct land acquisition

(Rulli, Saviori, D'Odorico, PNAS, 2013)

Are we running out of Freshwater Resources for Food (and Energy)?

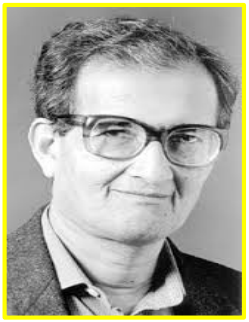
Are we running out of Freshwater Resources for Food and Energy?

Thomas Malthus

Malthus Demographic growth is faster than the increase in resources. In the long run not enough resources to feed everybody.

Technological innovations → increase food production *(Boserup, 1981)*

Esther Boserup



Amartya Sen

Amartya Sen *Poverty and Famines* (1981)
Famines caused by lack of access → not a problem of availability

But the question: "*How many people can the planet feed?*" is still relevant.

Soon, it will be difficult to meet the food & water needs of humanity

(*Rosegrant, 2003; Godfray, 2010; Davis, D'Odorico, Rulli,* 2014)

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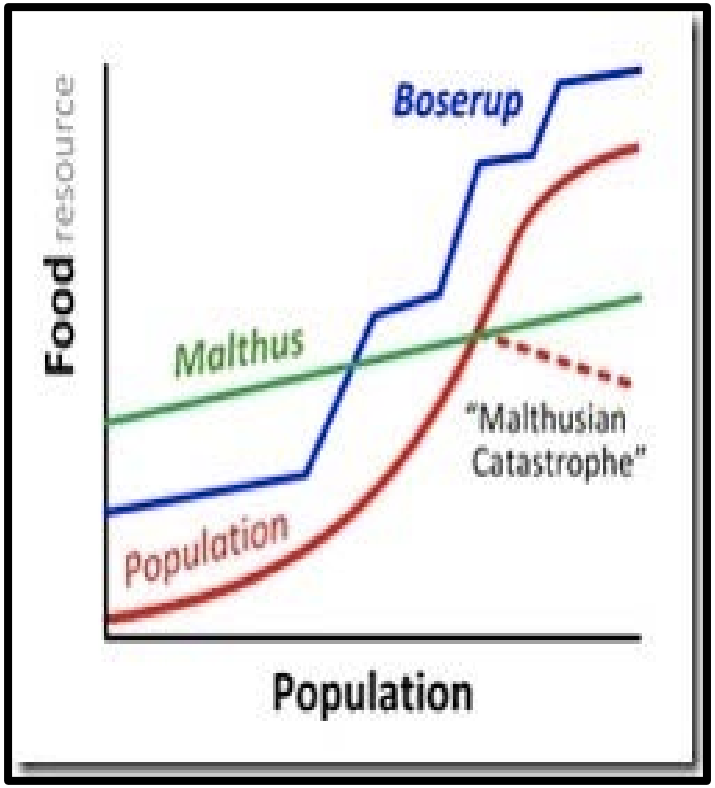


How can we meet the increasing demand of water for food?

How can we meet the increasing global demand for water for food?

Agricultural Intensification

Close the Yield Gap (irrigation, fertilizers,…)

Transition from small scale to Commercial Agriculture

- Loss of livelihoods?

Agricultural Extensification

Expand the cultivated area

Land Use Change

Deforestation

Biodiversity losses

Sustainable Intensification

Improve Efficiency

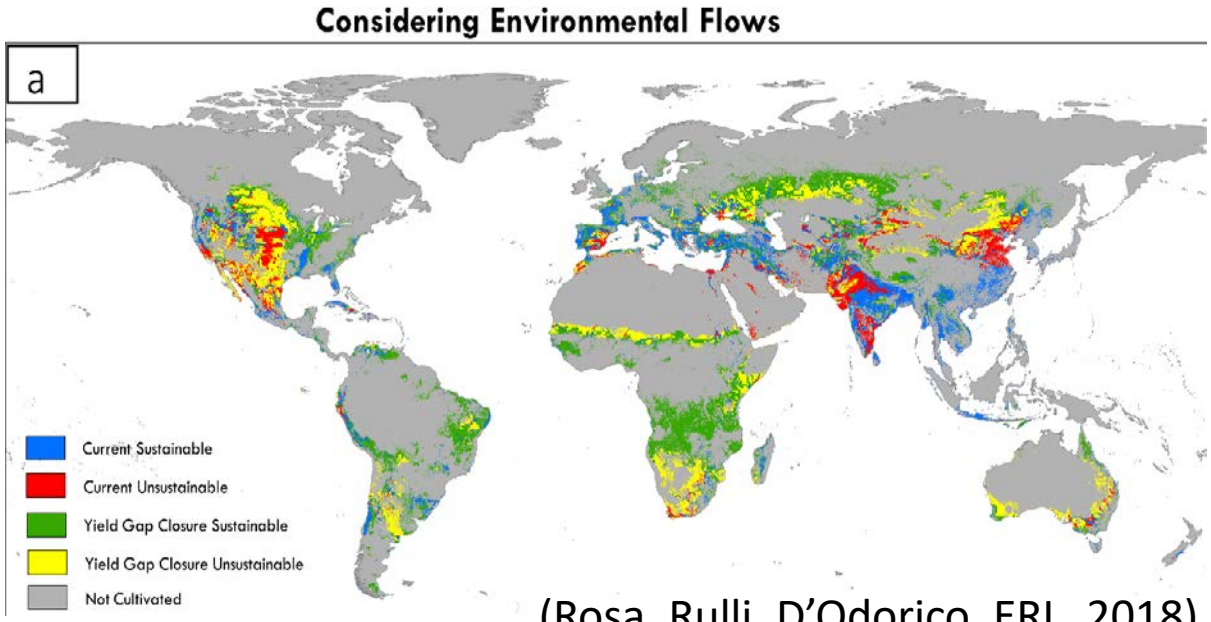
Adopt More Suitable Crops

Increase production without requiring more land, water

Agricultural Intensification: how many people can we feed?

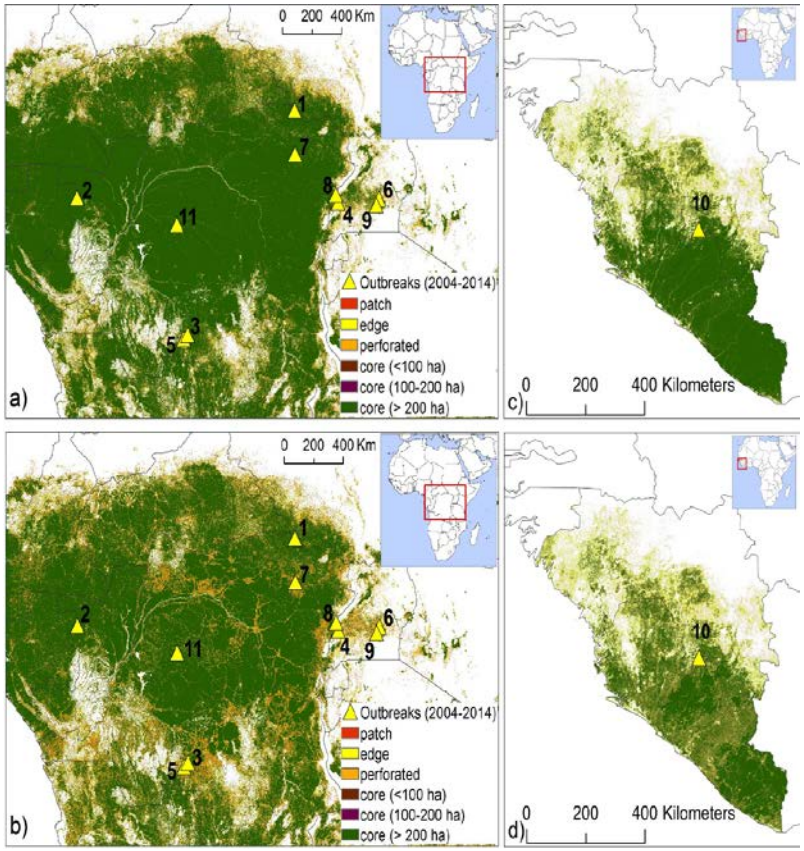
We can feed 4Billion people if we close the yield gap

But, is there enough water to close the yield gap considering the environmental flows?????



(Rosa, Rulli, D'Odorico, ERL, 2018)

Agricultural extensification: What about the direct and indirect consequences ?

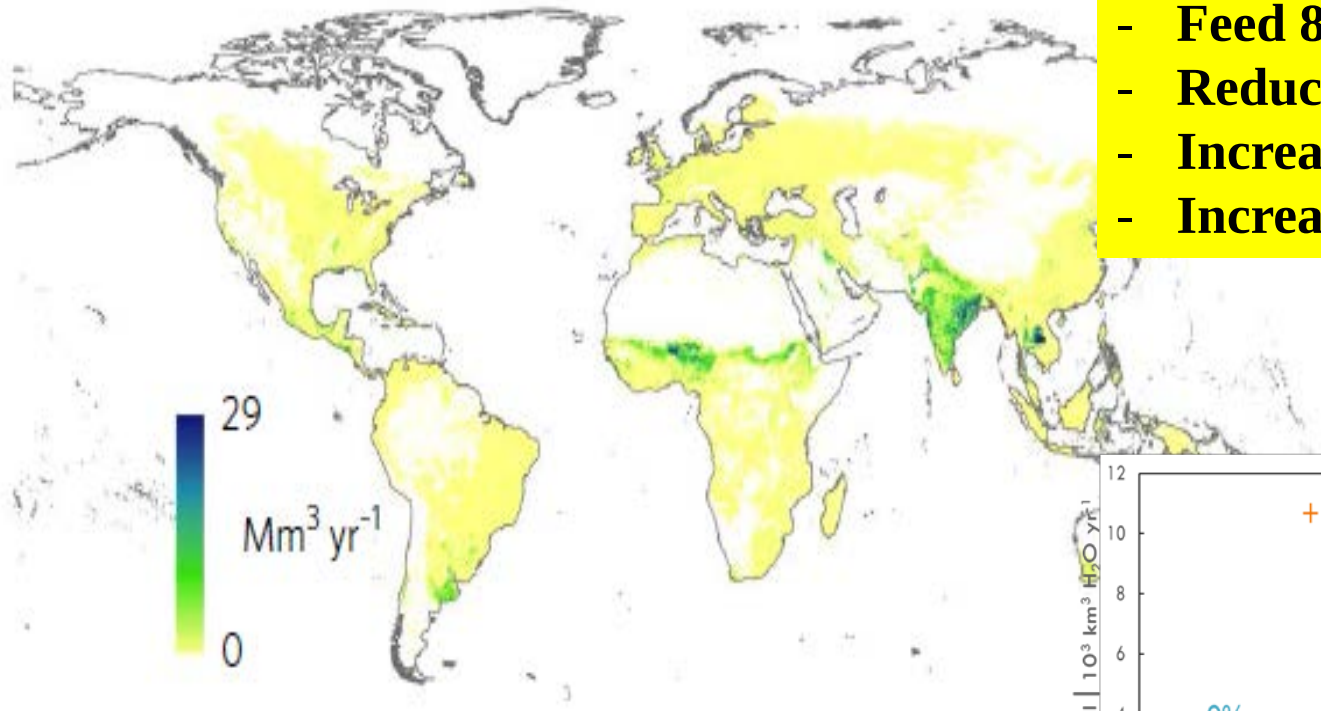


The nexus between forest fragmentation in Africa and Ebola virus disease outbreaks

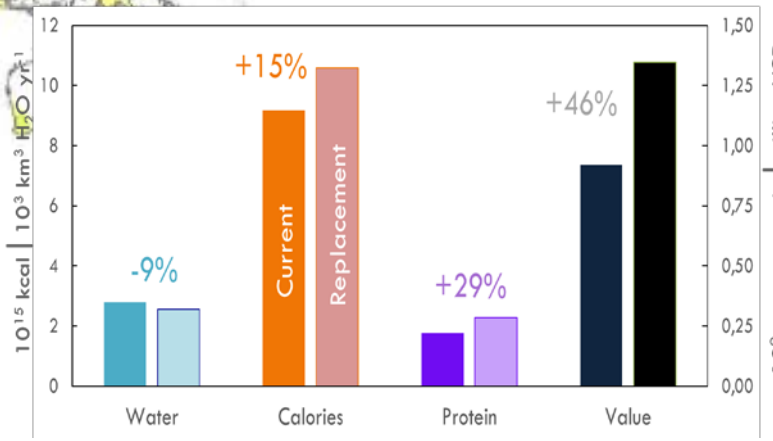
(Rulli , Santini,Hyman, D'Odorico Scientific Reports 2017)

Forest fragmentation in Central and West Africa. Forest fragmentation in Central (panels a, and b) and West Africa (Panels c and d) in 2000 (top panels) and 2014 (bottom panels).

Sustainable intensification

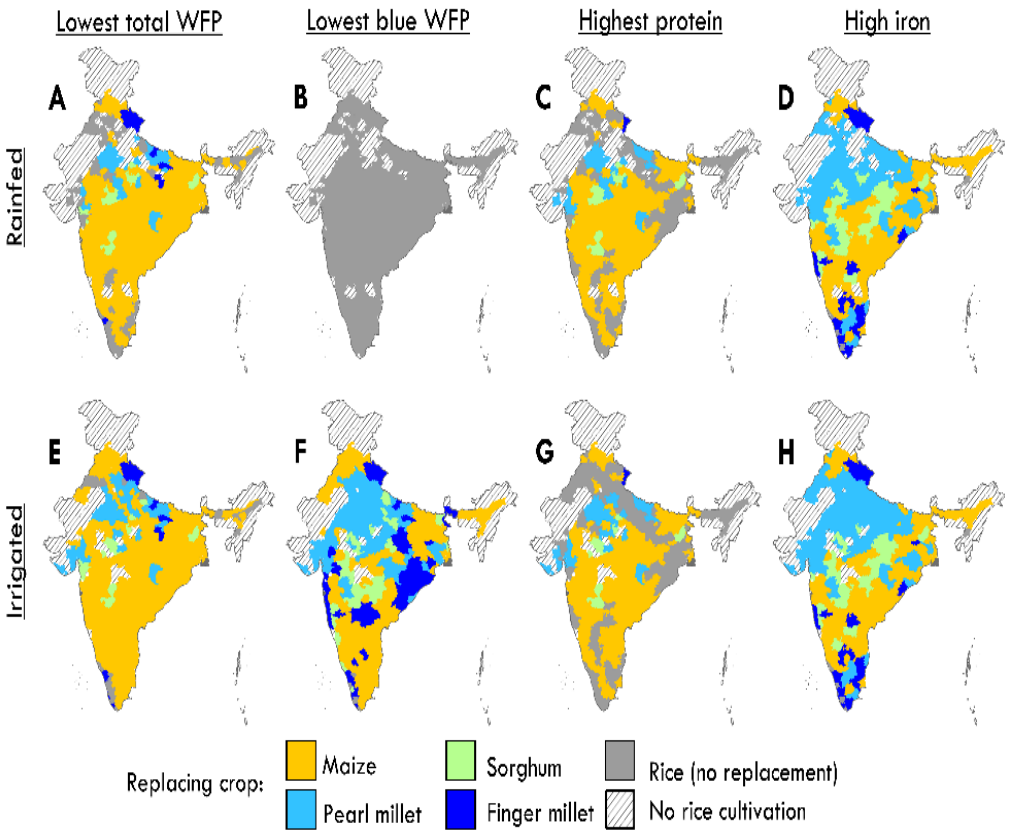


- **Feed 825 million people more**
- **Reduce water use by 10%**
- **Increase calories by 15%**
- **Increase proteins by 29%**



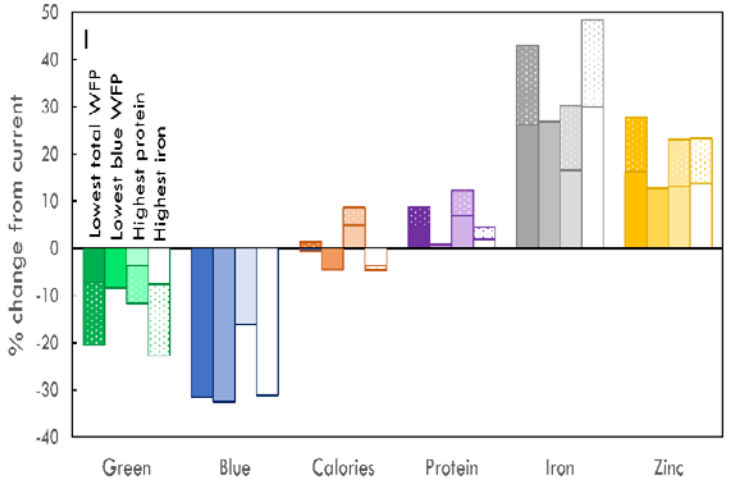
(Davis, Rulli, D'Odorico Nature Geoscience, 2017)

Sustainable intensification



Davis, Rulli et al.,(Science adv, 2018)

The potential nutritional and water use benefits of alternative cereals (i.e., maize, millets, and sorghum)



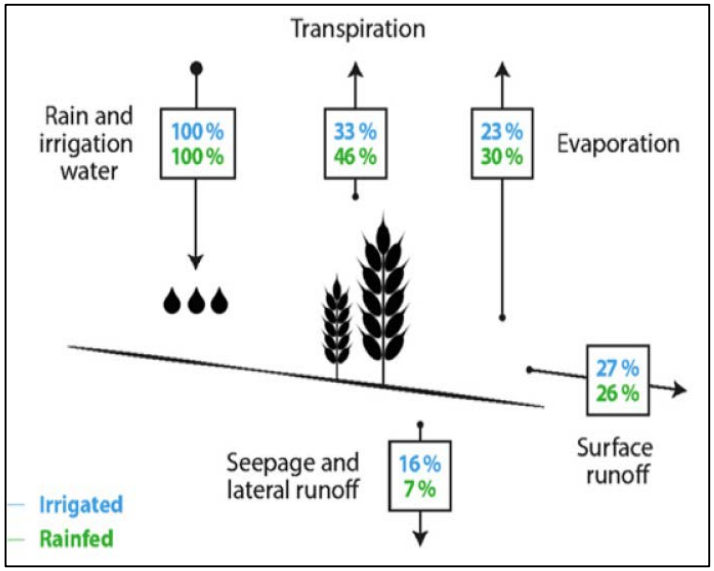
Outcomes of selected rice replacement scenarios

Sustainable intensification

Soil Water Management

- Reduce Evaporation by 48%
- Use the water saved to intensify or extensify irrigation
- Increase Global Production by 41%

(*Jagermeyr et al., ERL, 2016*)



- Soil water management
- Change crop distribution
- Changes in diets
- Reduce food waste

Table 1 | Comparison of savings from water conservation solutions in agriculture

Solution	Potential water savings ($km^3 yr^{-1}$)	Production increase (10^{15} kcal)	Reference
Crop redistribution	416 (green) 56 (blue)	1.4	Davis et al., 2017
Improvements in crop water productivity	77	0.1	Braumann et al., 2013
Promote irrigation efficiency	292	2.5	Jägermeyr et al., 2016
Minimization of food waste	78	0.7	Kummu et al., 2012
Reduced dietary protein from animal products (25% of total)	683	-	Jalava et al., 2014

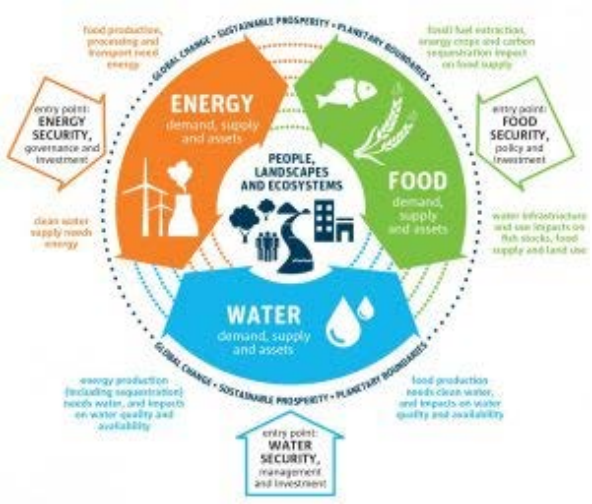
… Towards a sustainable food system

Increase production without requiring more land, water

Improve Efficiency
Adopt More Suitable Crops

… Towards a sustainable food system

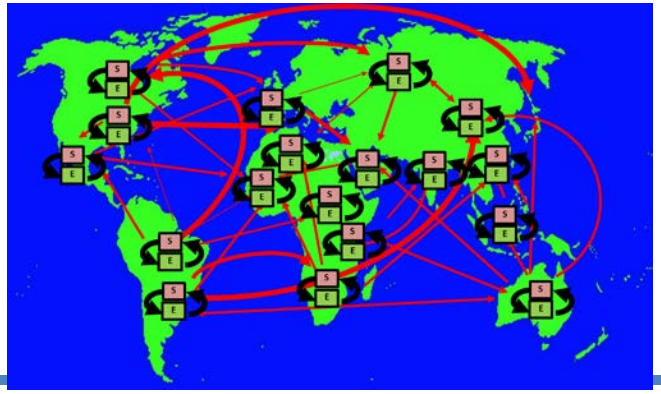
Methods:



The Water-Food-Energy-Environment Nexus perspective

The water-food-energy nexus is central to sustainable development. Demand for water, food, energyis increasing, driven by a rising global population, rapid urbanization, changing diets and economic growth. The inextricable linkages between these critical domains require a suitably integrated approach to ensuring water and food security, and energy production worldwide so having sustainable agriculture and preserving the environment and societies.

(D'Odorico P., …Rulli M.C. (2018) The Global water and Food Nexus, *Review of Geophysiscs, 2018)*



Social Ecological Systems in a Globalized World

All environmental problems ultimately have social and economic impacts on people. Some global issues can have clear impacts on humans throughout the world. But with the increasing interdependence among nations and people apparently localized environmental problems have increasingly pervasive economic and social impacts in other parts of the world.

… Towards a sustainable food system

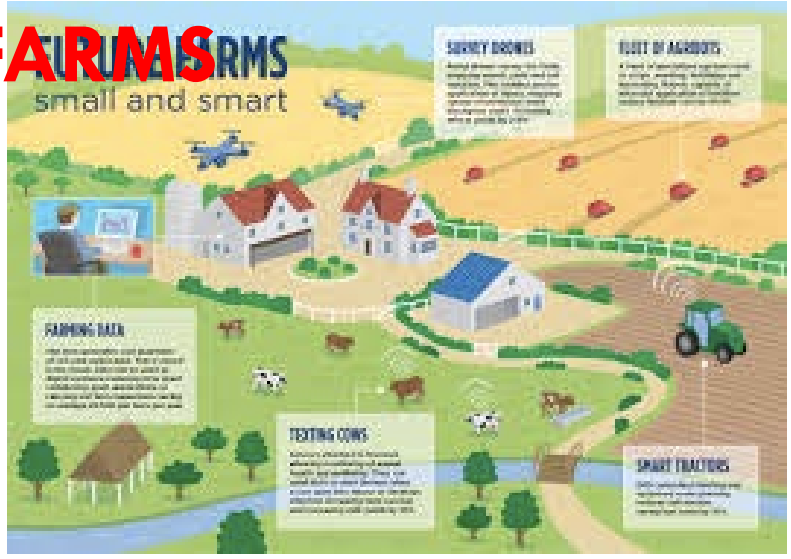
Tools:

Smart irrigation
Big data
IOT
…

… Towards a sustainable food system

Tools:

From large scale farming to SMALL and SMART FARMS



THANKS FOR YOUR ATTENTION

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