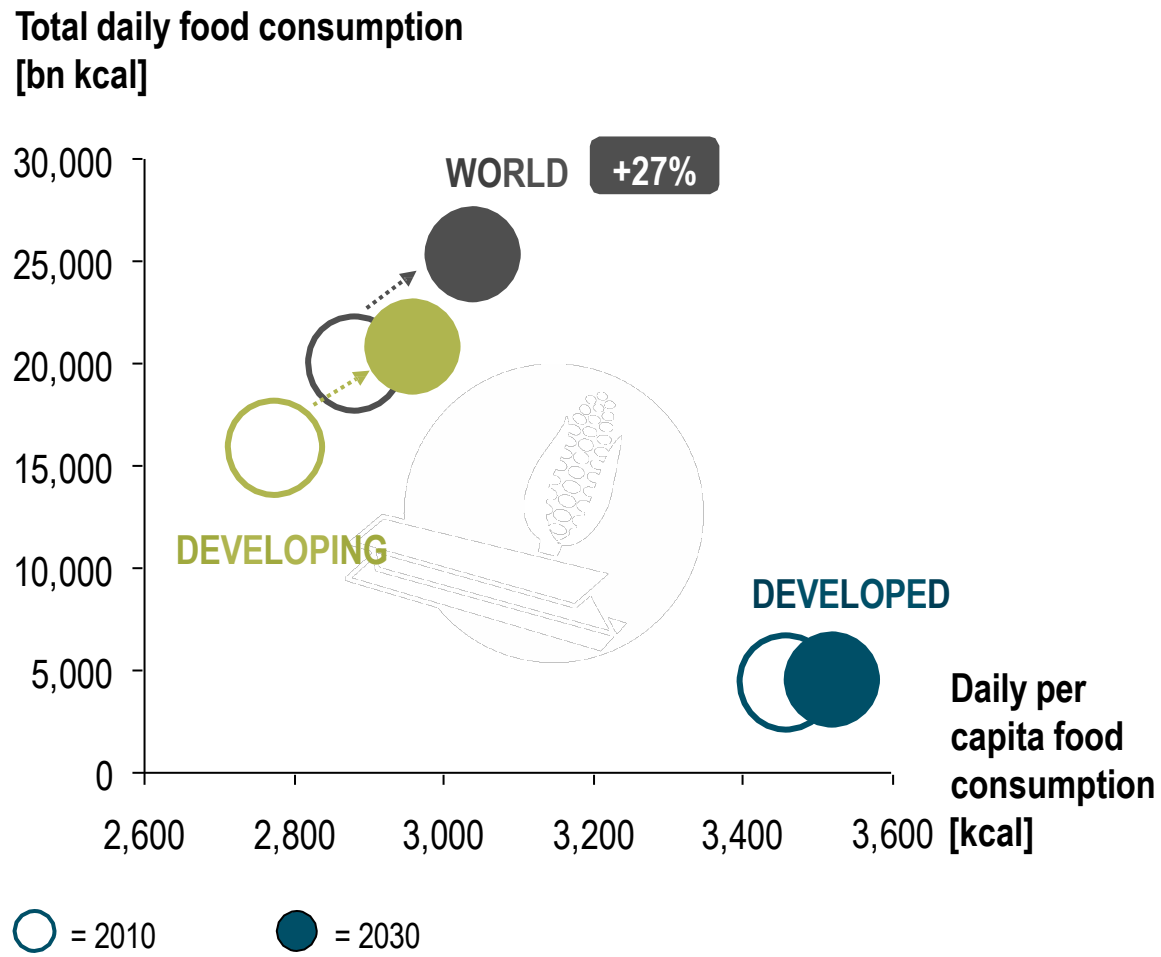
The Role of the Global Energy and Water Cycle Information in the Water-Energy-Food (W-E-F) Nexus

Richard Lawford
Morgan State University
May 9, 2018

2018 GEWEX Open Science Conference:
Extremes and Water on the Edge

Food Demand: A source of growing pressure for the production of agricultural commodities



Source: FAO; Fraunhofer; USGS

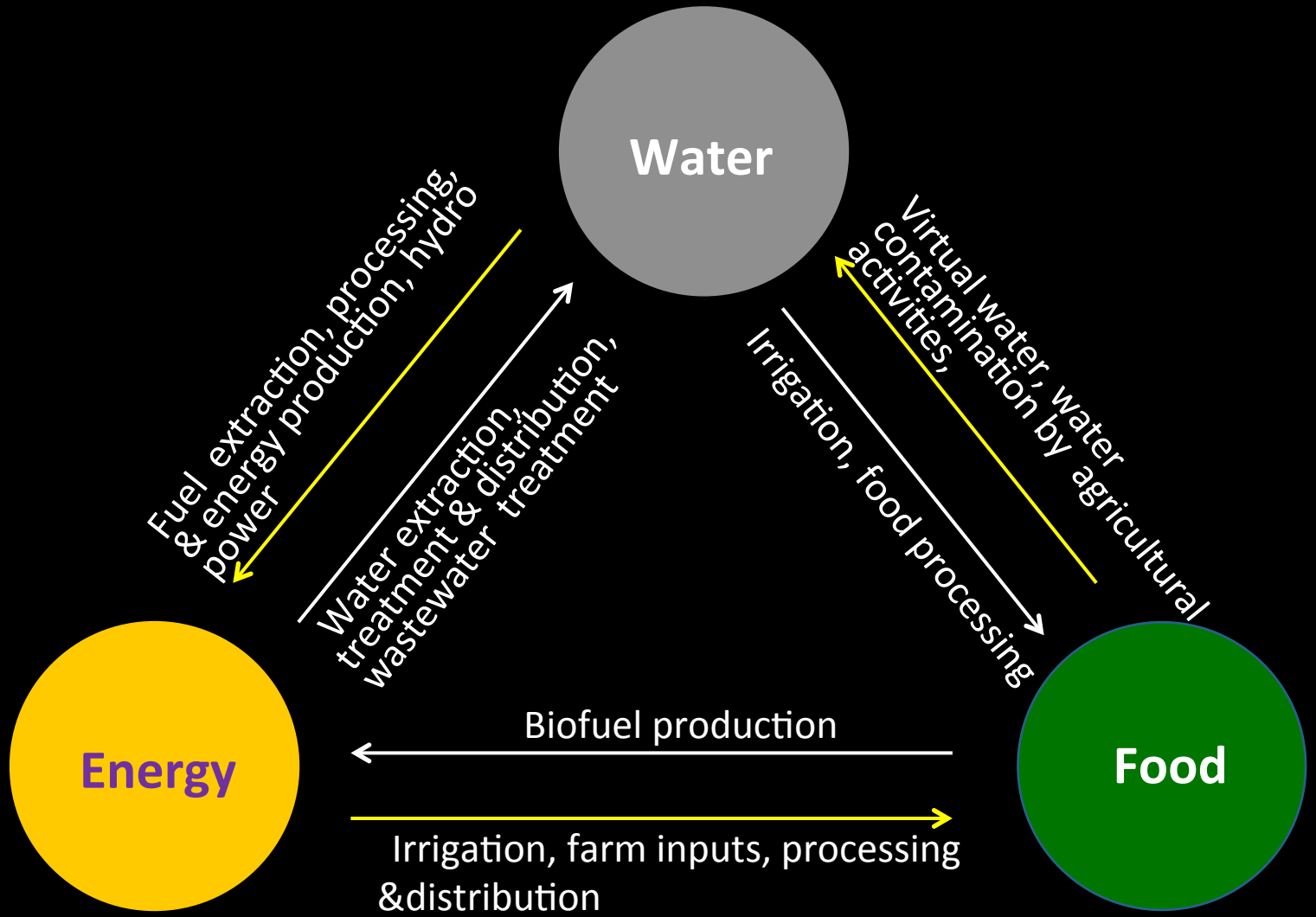
1. WORLD

- **Demand for food will rise** due to growing population and growing per capita food consumption. **However, the growth rates in world agriculture[1] will fall to 1.5% p.a.** by 2030, compared to 2.1- 2.3% p.a. over the past four decades.

2. DEVELOPED VS. DEVELOPING COUNTRIES

In **agricultural products**, demand in developed countries will rise only slightly up to 2030: an average person will consume 3,520 kcal a day. Increase will be larger for developing countries.

Links in the W-E-F Nexus

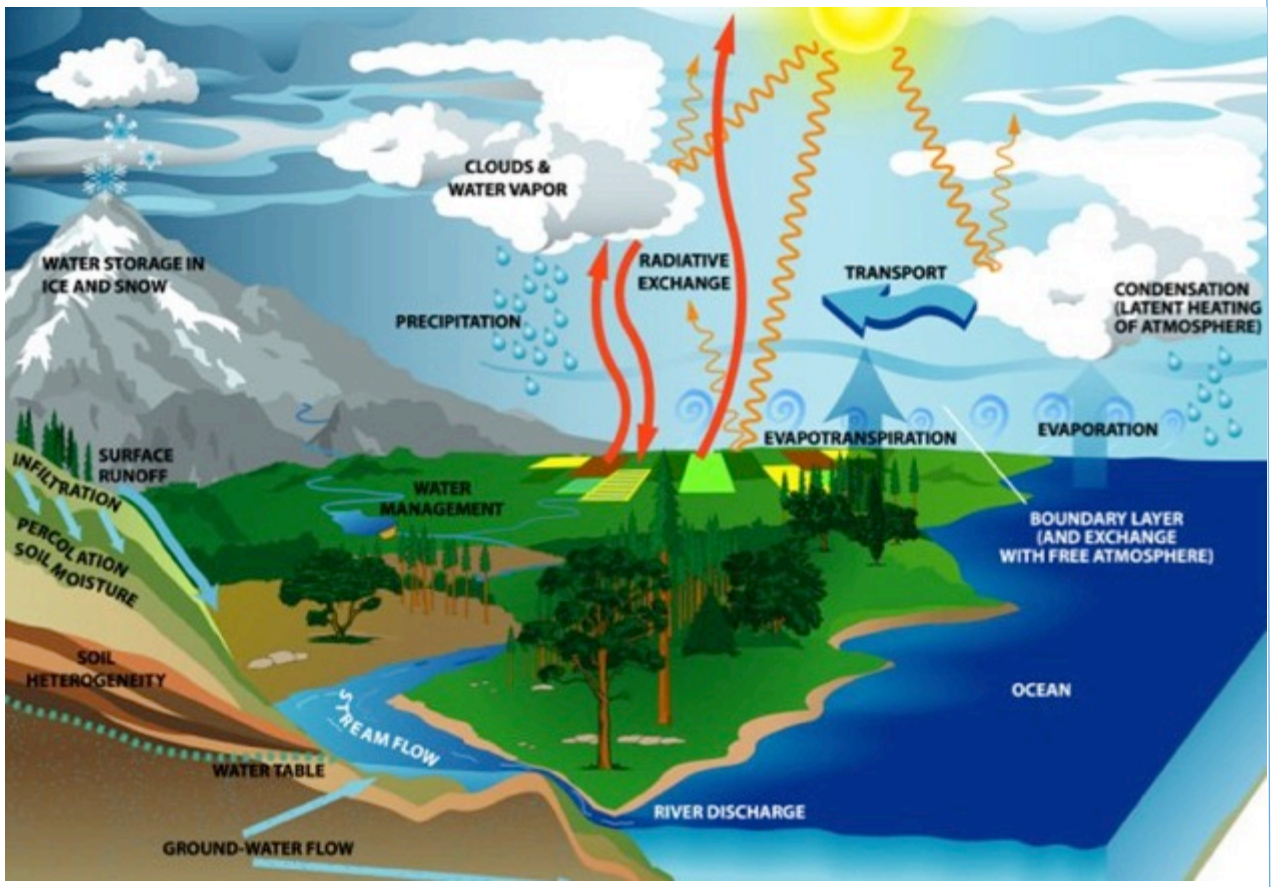


Reasons why removing the silos could lead to better resource management efficiency and lower risk

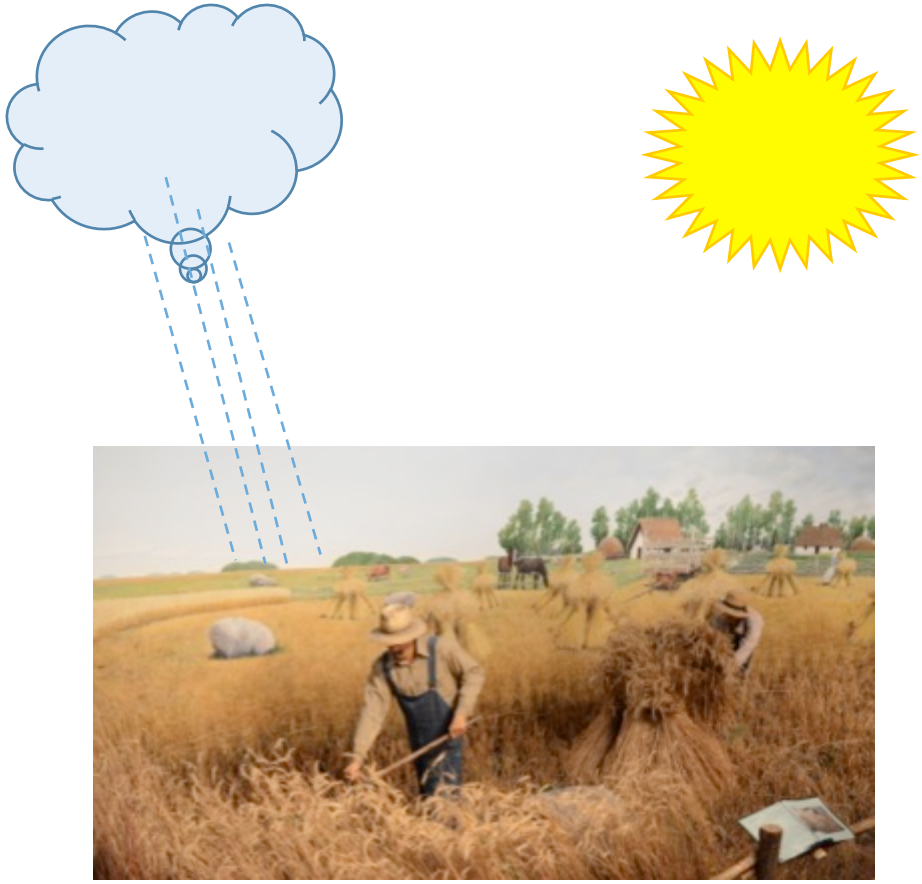
A collaborative W-E-F Nexus approach would address risk and competition in areas of:

- **Climate change (trends, shifts and extremes)**
- **Economic efficiency/ focused investment strategies**
- **Better use of the resource base**
- **Links to environmental services**
- **Pressures from increasing consumption due to demographics.**
- **More effective management of the observation and information resources across scales and sectors.**

The Integrated Water Cycle and the Integrated W-E-F Nexus

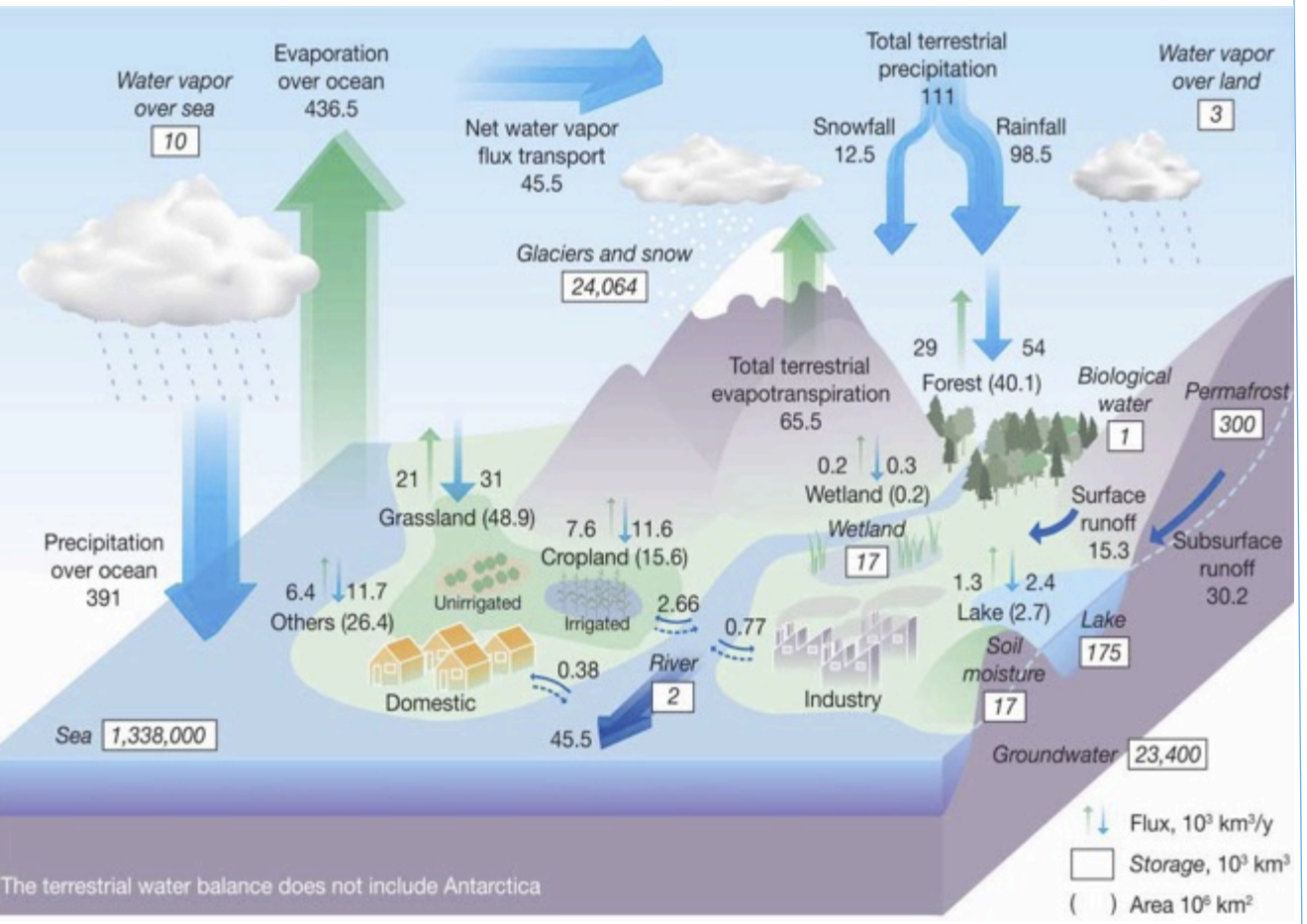


The good old days



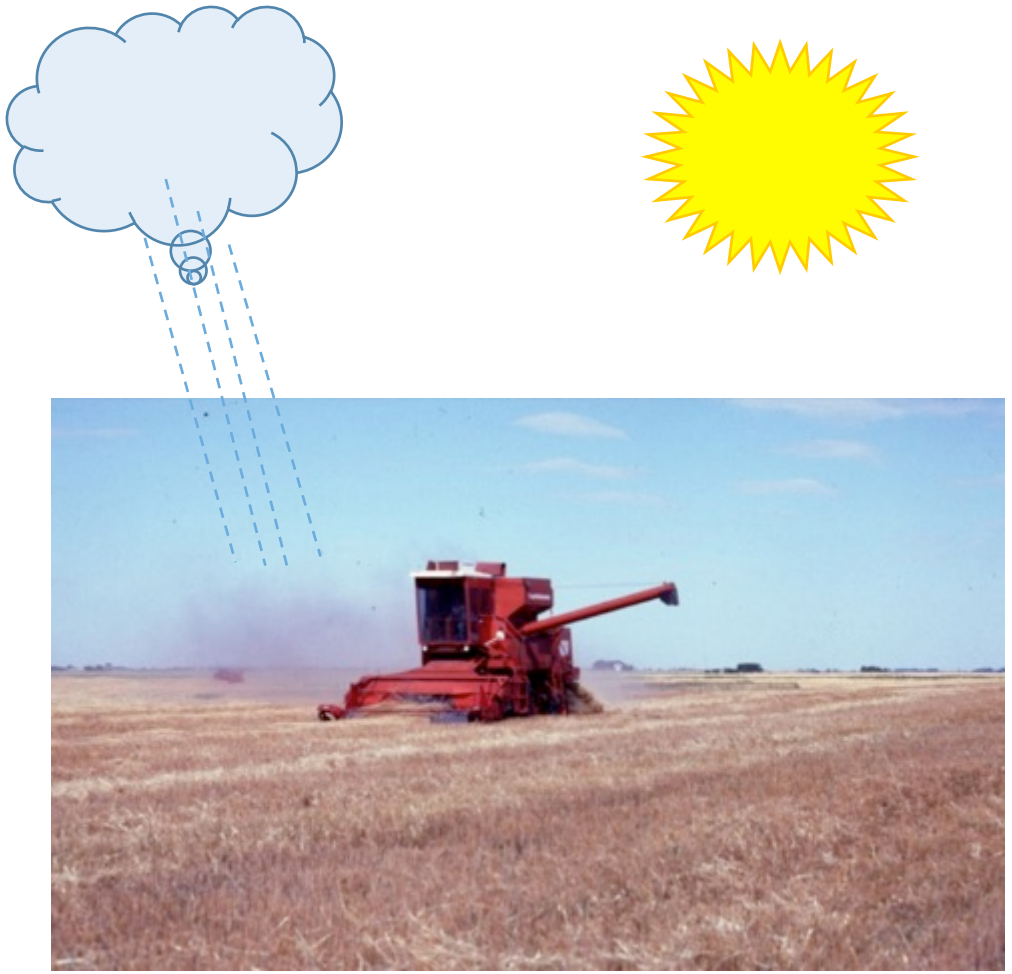

MADE IN CHINA

The Integrated Water Cycle and the Integrated W-E-F Nexus



(After Kanae)

Today (in some places)



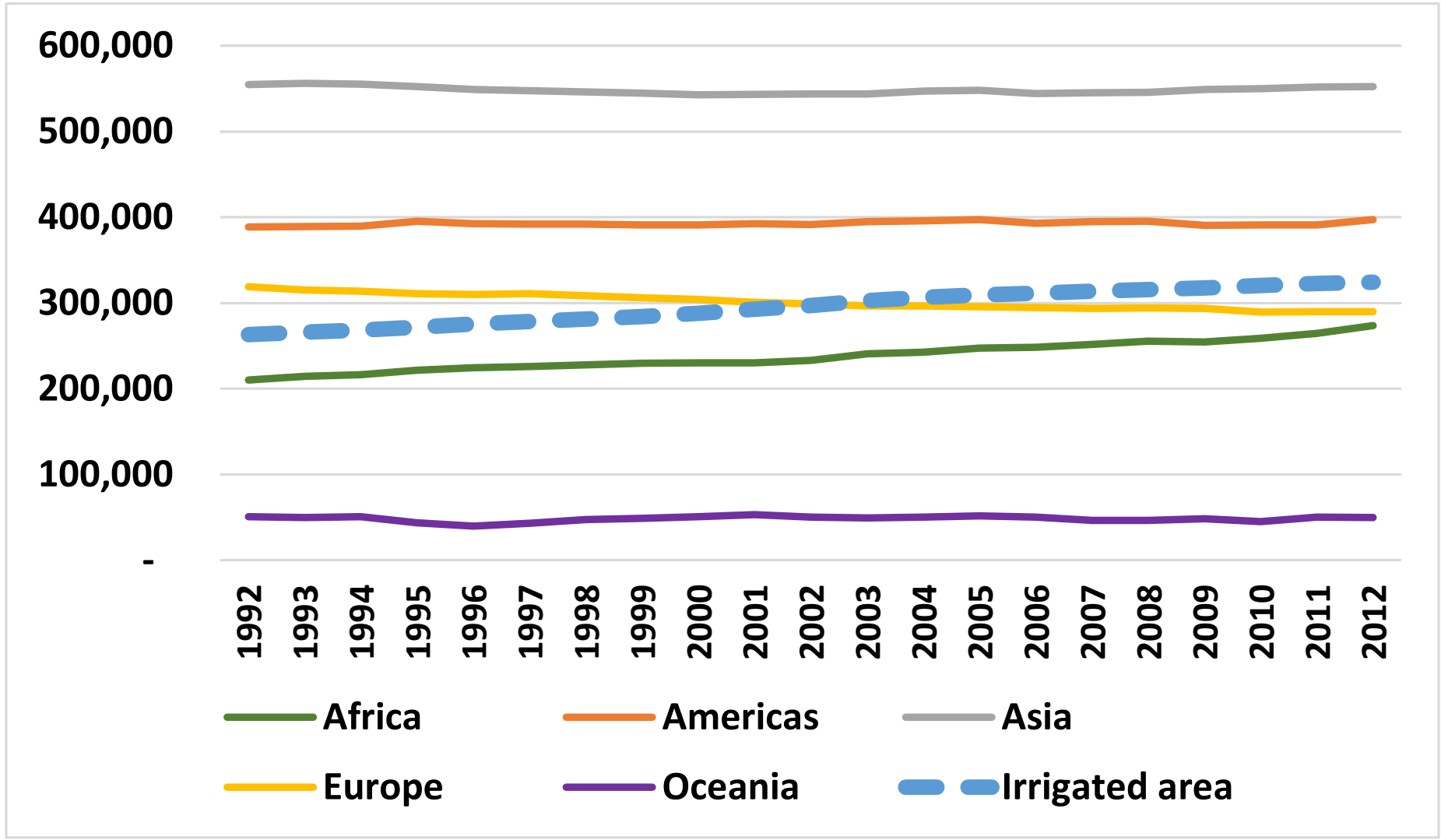
Some Transitions in the Food Sector

Developed countries: With the dawn of mechanization, farmers began to farm larger acreages; began to use extensive irrigation in dry areas, and chemical fertilizers and pesticides to augment production.

In developing countries many farms remained as they were. In some areas large corporations have taken over the land and manage it using a “developed country” model.

Governments often play a role in providing insurance to farmers and in some cases they control the marketing of food for export.

Where's the land for food production?



(Courtesy of C. Ringler)

These developments had impacts on the environment and the water cycle:

- **Irrigation**: drew down surface and sub-surface water supplies.
- **Land drainage** initially removed wetlands; on farm tile drainage influenced the timing of runoff from the soil.
- **By-products** of modern farming practices included eutrophication and contaminated water.

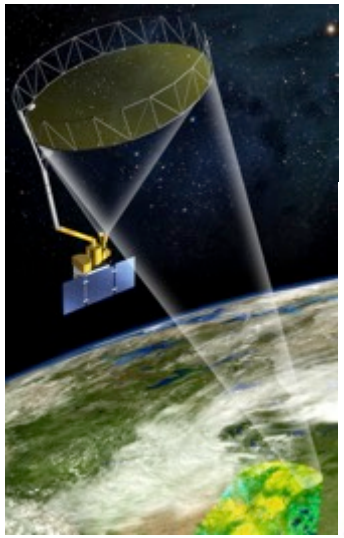
In most countries farming still relies on a large base of relatively independent farmers and farm businesses that make their own decisions. These farmers need information on both the long- and short-term variations of the water and energy cycle.

Lessons from the Future Earth Water-Energy-Food (W-E-F) Nexus Cluster Project (funded by Belmont Forum)

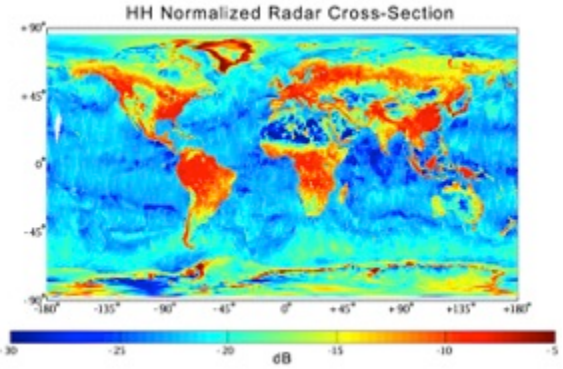
Goal: to assess the potential for the use of **integrated information** and **improved governance** for enhancing the **sustainability of the Water-Energy-Food (W-E-F) Nexus**.

Four regional workshops (USA, Germany, Japan and South Africa) provided insights on the issues, priorities and approaches to the WEF Nexus in different parts of the world.

Information for planning and design

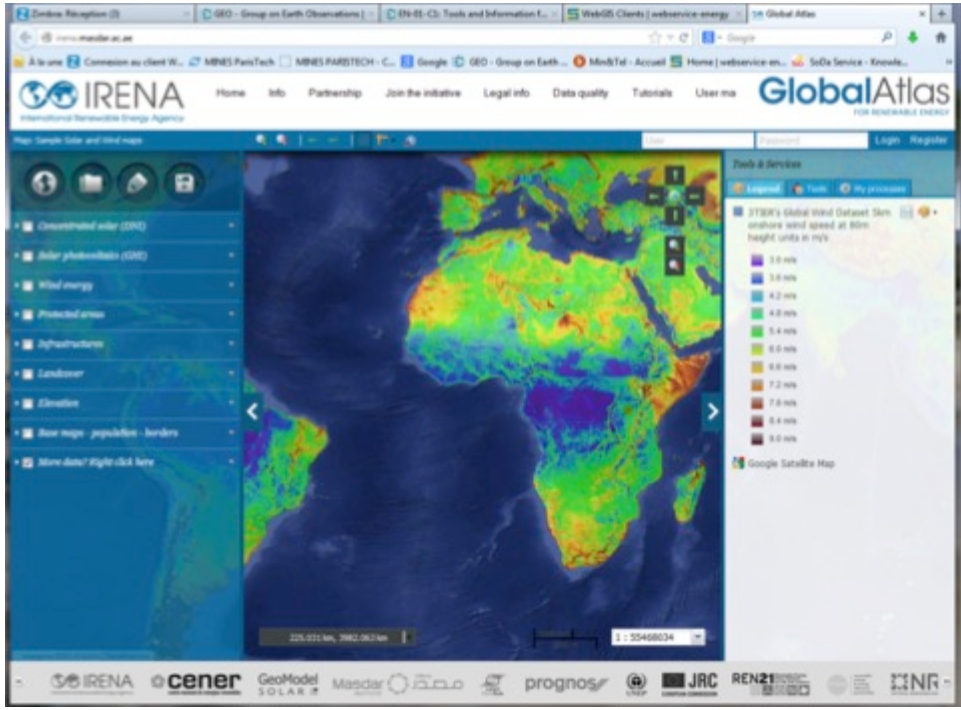


Soil moisture data is useful for planning field operations and assessing potential crop productivity.



Water (Entin, Rodell)

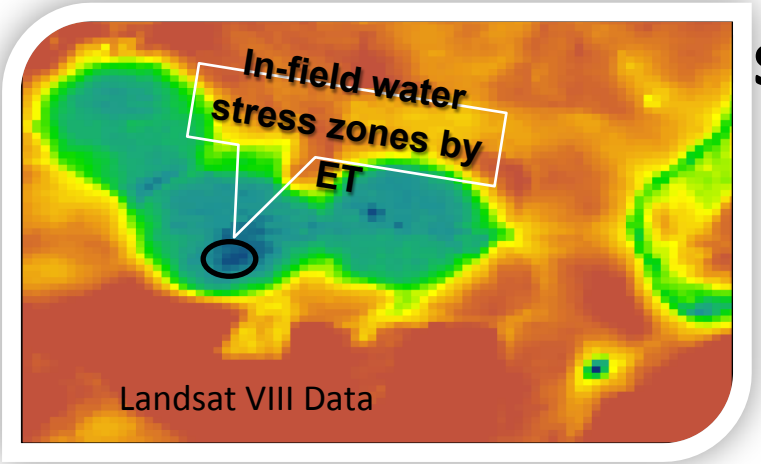
Energy



The IRENA atlas for **renewable energy,** which is provides information that is based on satellite data is useful in siting energy systems.

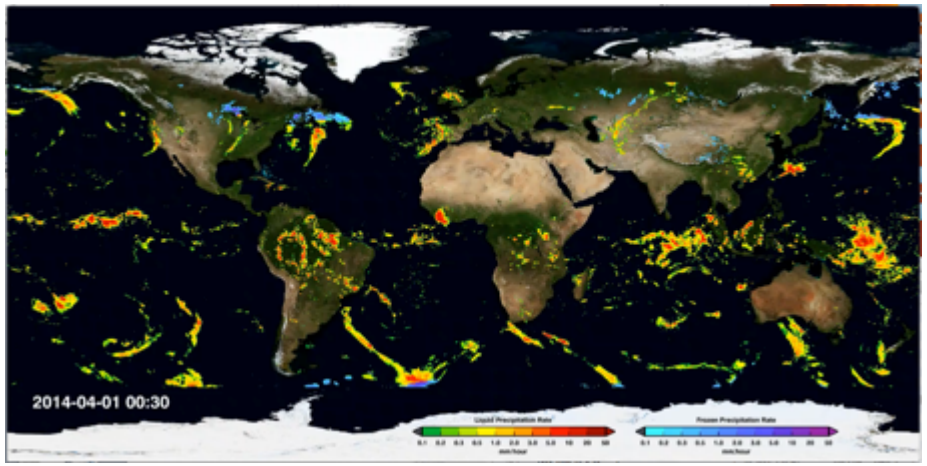
Food: Finding arable land for agricultural expansion is difficult in many areas without help from satellite data (G. Simpson)

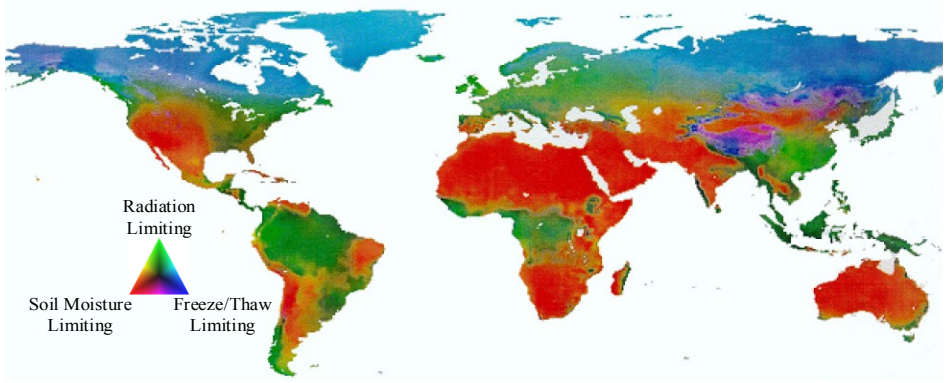
Information for assessing resources



Evapotranspiration (ET) estimates provide assessments of the amount of irrigation required to meet crop needs.

High resolution precipitation maps indicate how much water has been received, allowing the additional amount required for plant growth to be calculated.

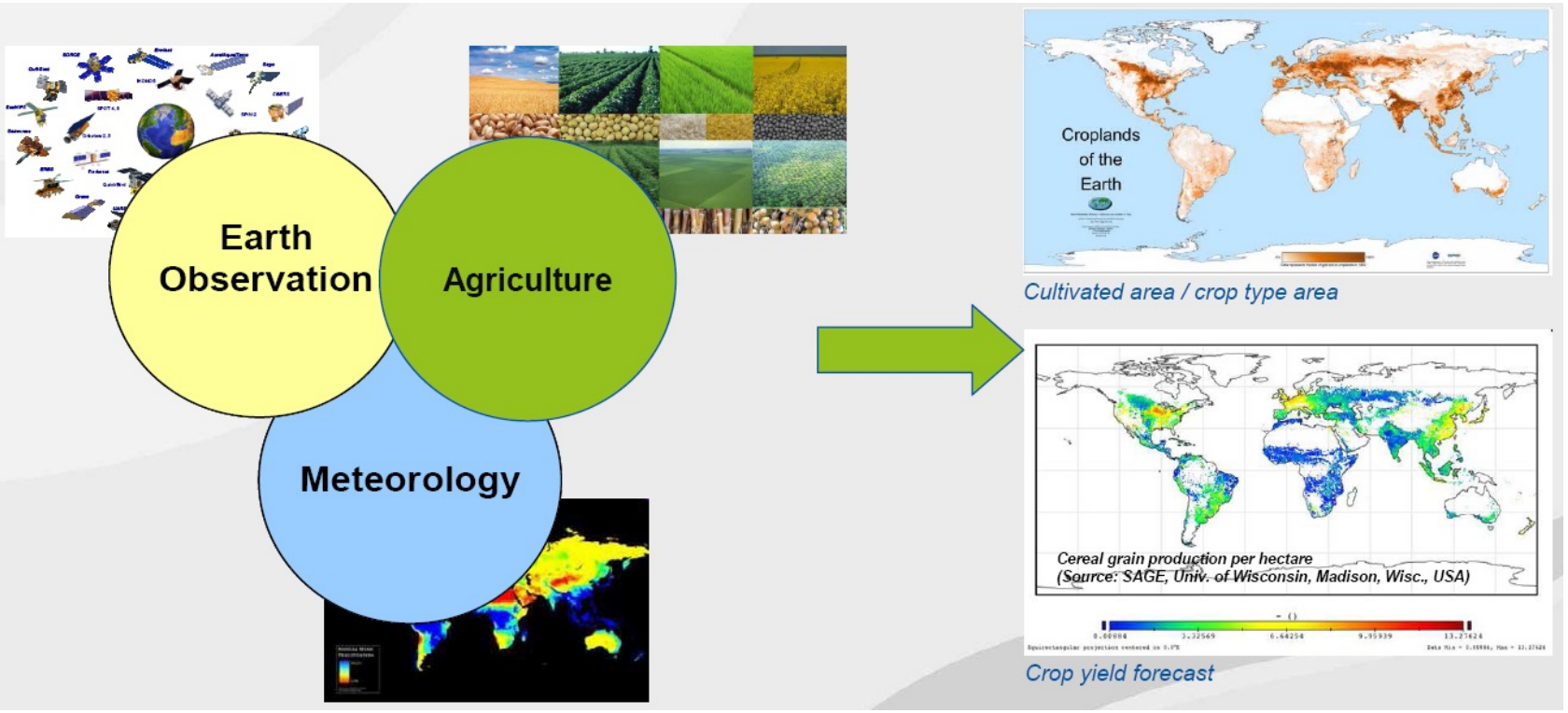




Maps of the factors constraining ET and crop growth can be derived from Earth observations.

Information for advice for management and marketing decisions

Food

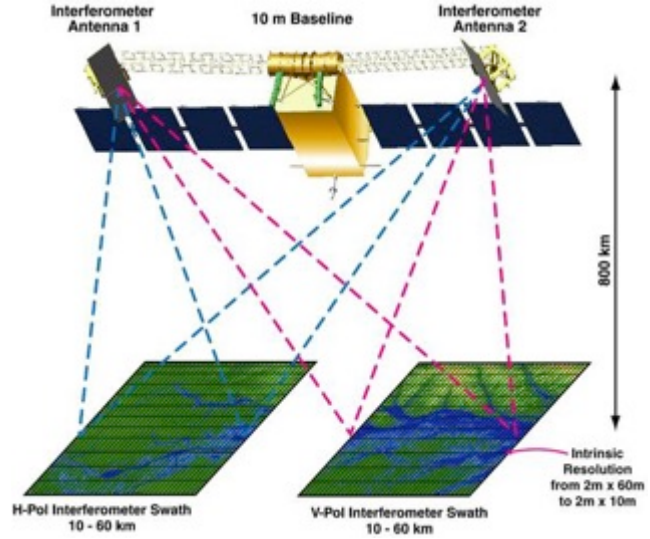


GEO Global Agricultural Modeling (GEOGLAM) provides a capability to forecast yields of different types of crops using satellite data as model input.

Energy/Water

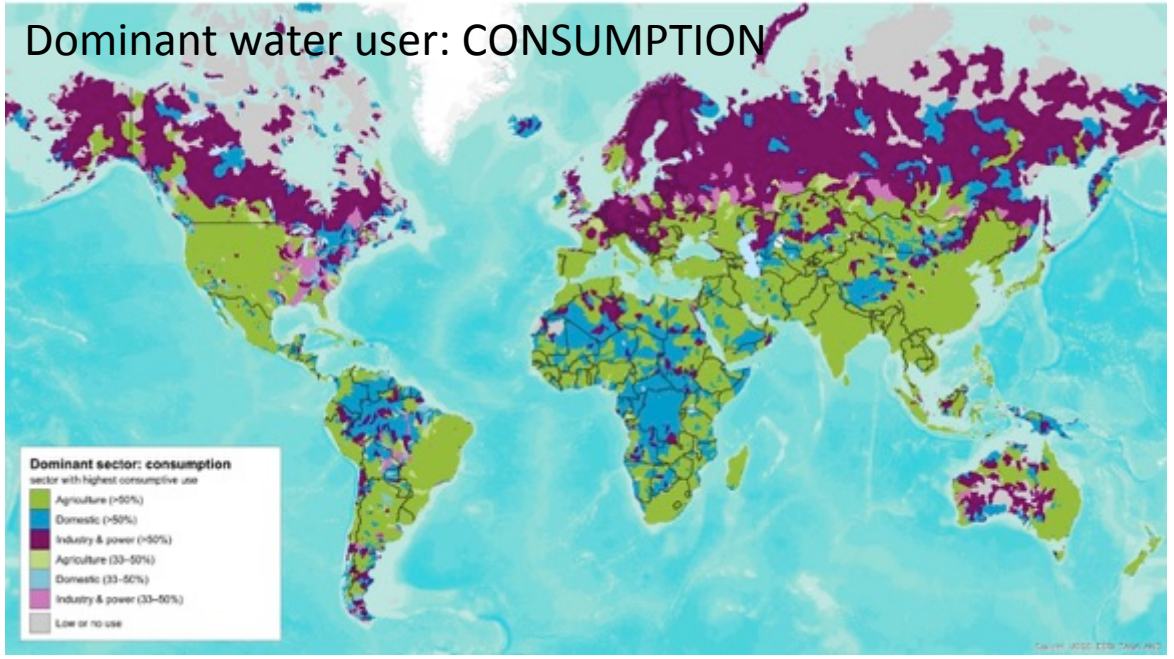
Information for the Surface Water Mission Concept (SWOT) regarding estimated reservoir heights will be useful for planning forward contracts for hydropower production.

Interferometer Concept (JPL) (courtesy M. Jasinski)

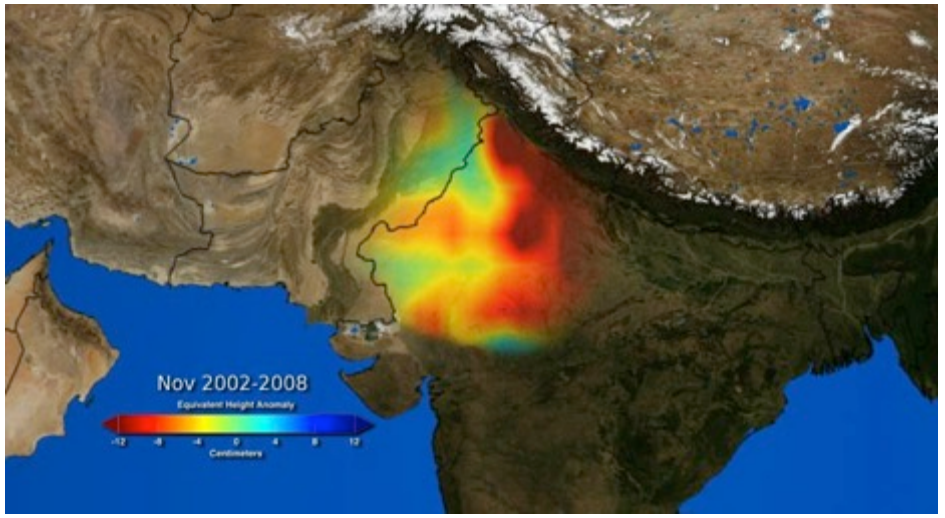


Agriculture issues that affect the water cycle

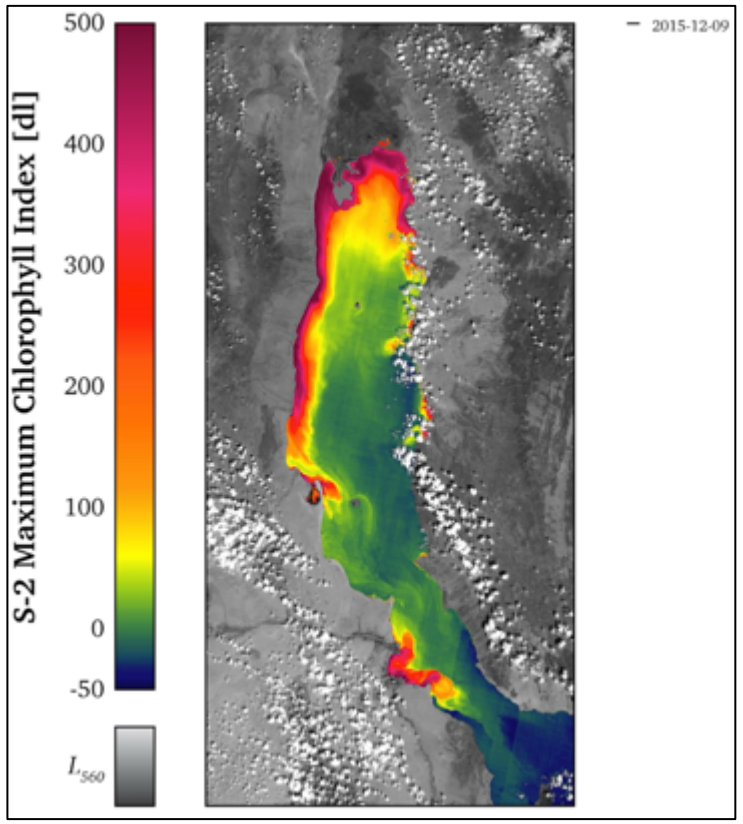
The food sector is responsible for approx. 70% of the water consumed world-wide.



The green revolution in India was aided by policies that allowed farmers in some areas to have unlimited access to free electricity for pumping groundwater for irrigation. Solar energy is now being used to pump irrigation water: What will the implications for groundwater world-wide?

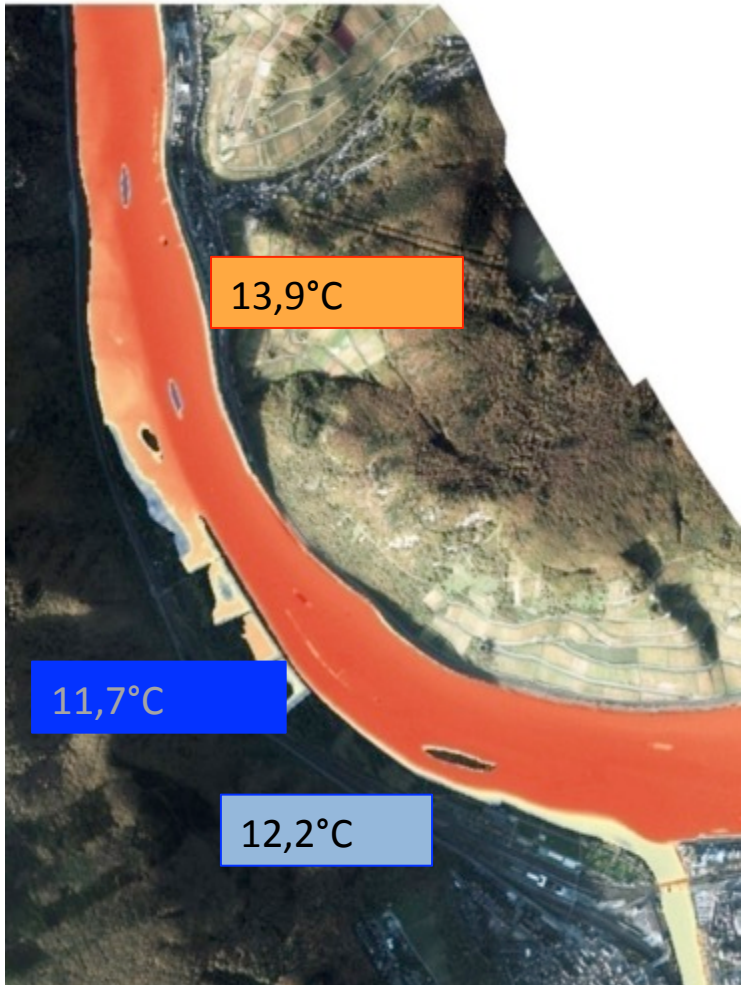


Unwanted Consequences from Food and Energy Production



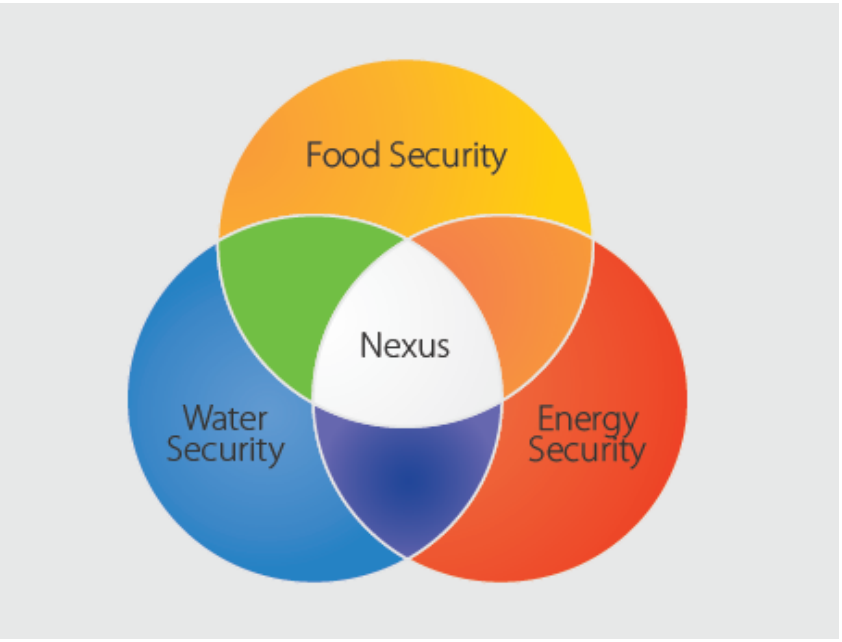
Sentinel-2: 10 m resolution

Nutrient rich runoff from fields is responsible for loading streams, rivers and lakes with N and Ph. Monitoring the effects of fertilizer excesses on chlorophyll blooms observed on lakes and rivers by the Sentinel satellite (Christian Tottrup)

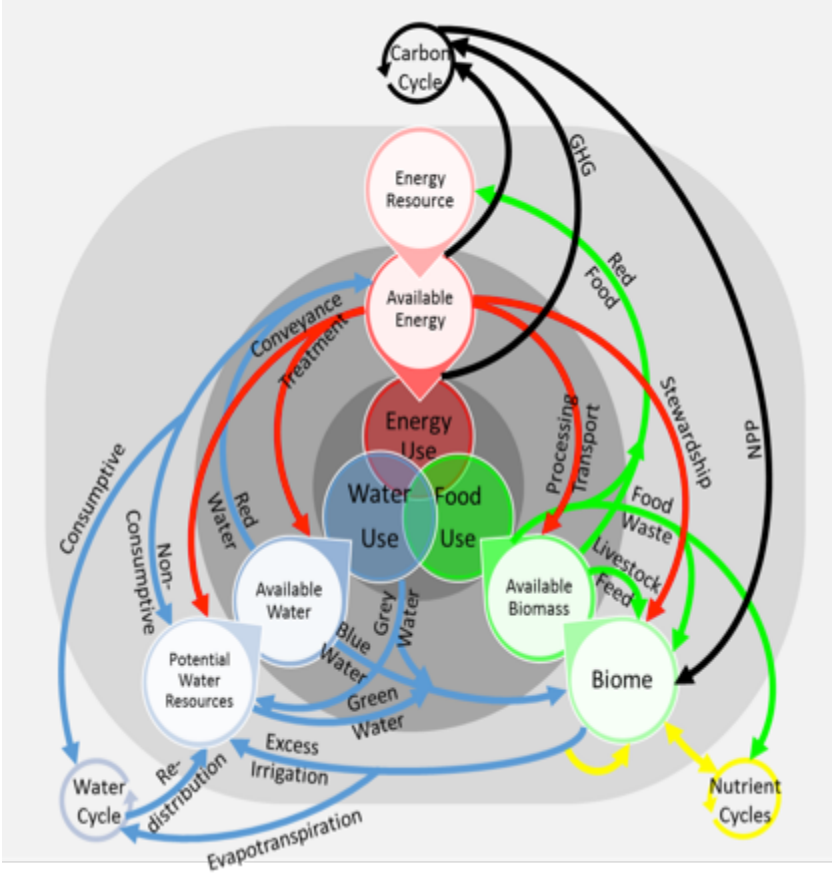


Energy production can lead to thermal water pollution as cooling water is released into natural streams. Aircraft monitoring of thermal emissions (at ~4 m) into the Rhine River (Björn Baschek)

Priority: Define the Water –Energy-Food Nexus Relationships and ontologies



Characterizing the W-E-F Nexus requires a more rigorous definition of the Nexus nomenclature and taxonomy. In addition critical variables need to be defined and measured.

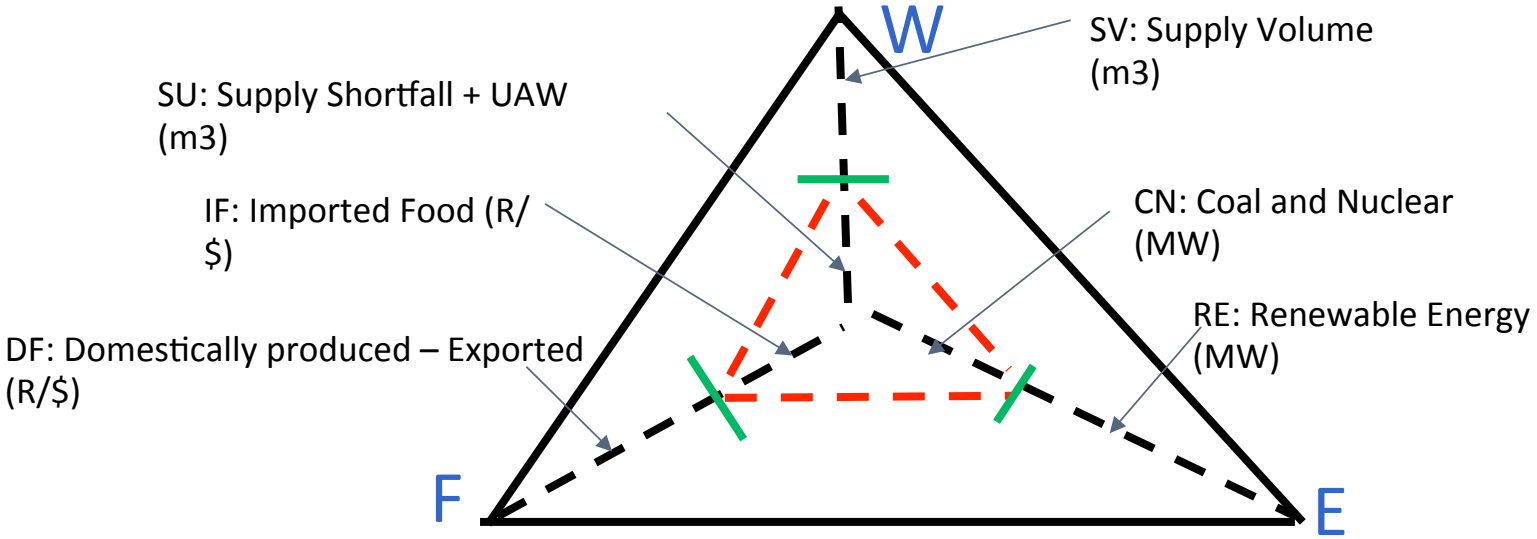


(after Higgins)

Observational/Measurement/Information Issues

1. Citizen Science increases knowledge, data, empowerment, inclusiveness, sphere of influence and citizen learning / responsibility. This opportunity needs to be developed.

2. W-E-F Nexus Indicators need to be developed



W-E-F Nexus Tri-Indicator

- SDG I(W) = SV / (SV + SU)
- SDG I(E) = RE / (CN + RE)
- SDG I(F) = DF / (DF + IF)

- SDG I (WEF) = Area **Δ** – Area **Δ**

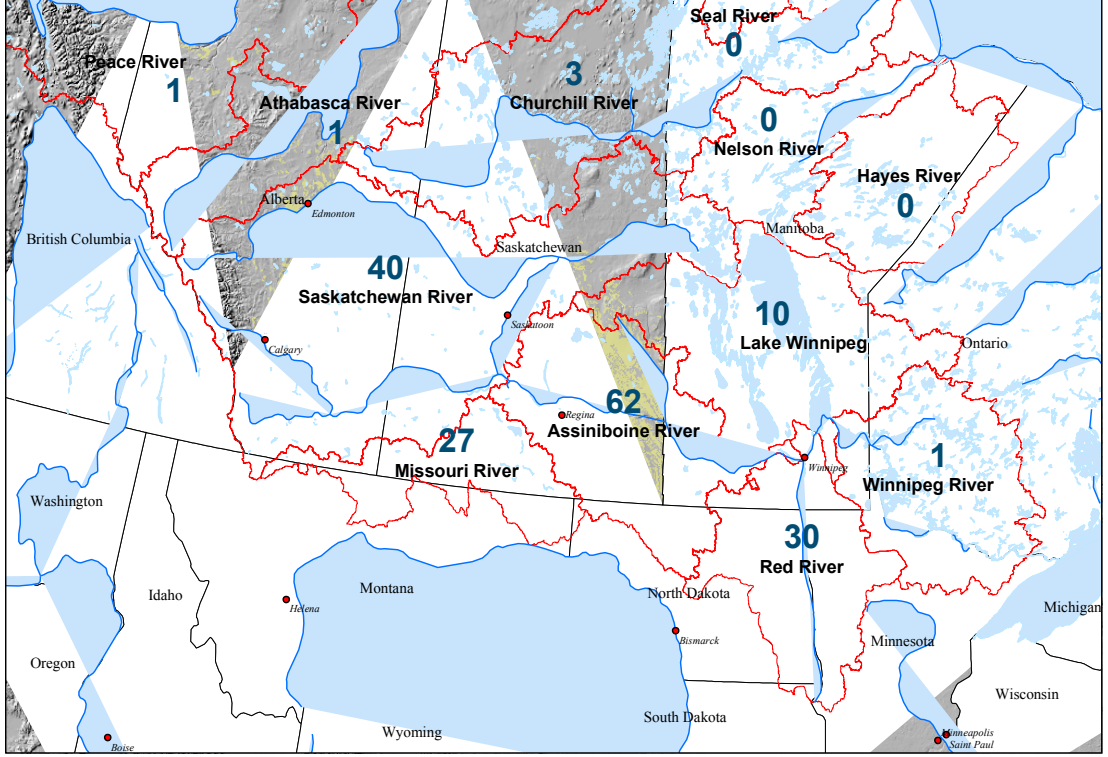
Observational/Measurement/Information Issues

3. A platform (or platforms) for data sets and information from all three sectors with tools to facilitate production of the cross-discipline data products need to be developed.

4. The open exchange of water, energy, agriculture and land data needs to be agreed to for analysis and planning of the W-E-F Nexus on national and basin scales.

5. Variables that are essential for managing the W-E-F Nexus need to be clarified and obstacles to providing those data should be removed. (e.g. address problems such as measurements not taken or information not recorded, information not shared, etc).

6. Pilot projects in demonstration basins need to be launched.



(Map courtesy of GIWS)

Suggestions:

- Developing comprehensive data sets to address existing and anticipated problems (e.g., drainage)
- Implementing new governance approaches in a small catchment where farmers are willing to test out new approaches (e.g., Tobacco Creek)
- Developing an information package on the potential benefits of Nexus thinking
- Carrying out macroscale analysis of consumption/ production issues for the Basin

Red River Basin of the North: A testbed for the WEF initiative?

Trends affecting the W-E-F Nexus in the Lake Winnipeg Basin.

Mega Trend	Global Context	Lake Winnipeg Basin
Governance	Large	Large for some issues
Food consumption patterns	Large	Large
Water availability	Large	Small overall; large in the west
Water quality	Medium to Large	Large
Climate change	Large	Large
Urbanization	Large	Small
Population increase	Large	Small; immigration changes demand
Environmental degradation	Large	Large
Deforestation	Large	Small
Industrial development	Large	Potentially large
Shortage of arable land	Large	Moderate
Soil quality (erosion, salinization)	Large in some areas	Small; large in the west

Comments for GEWEX Community

Implementing the W-E-F Nexus concept will create many opportunities for GEWEX expertise.

Examples of primary needs are:

- Assessing benefits of joint management of the W-E-F Nexus through simulation modeling (using range of behaviours in W-E-F Nexus);
- Identifying information needed to close many gaps related to the W-E-F Nexus (and the needs of humanity); and
- Using the W-E-F Nexus as a framework for evaluating economic benefits of water information and research, a platform for linkages to SDGs and multidisciplinary communities, link to governance discussions, etc.

Thank you for listening

General findings based on consultations

Most common perceptions associated with climate change are:

- 1) longer growing seasons
- 2) earlier snow melt (at mid latitudes)
- 3) warmer night time temperatures

Other general perceptions included:

- A tendency to more extreme events.
- Impacts of water resources which included: more floods and droughts, more intense precipitation events.

In areas where the water supply demand balance is at the upper limit small changes can have large consequences. Examples of changes include:

- The advance of invasive species and their use of water in Africa (e.g. Cape town)
- Urbanization and the focused demand for water
- Increasing competition for cooling and irrigation water
- Minimal attention given to water required to meet the demands of the poor and the

Impacts of Shifts in Renewable Energy

The production of more electrical energy through a distributed system of solar panels has facilitated “free” groundwater abstraction in many areas. It is unclear how large the effect is but there is some indication that the trends in India related to aquifer depletion are being repeated in many other areas of the world.

Investments in the production of ethanol from corn have experienced reduced paybacks where irrigation and water-intensive processing have been required to produce the ethanol. In some cases land for growing biomass feedstock has also become a limiting factor and is often made available at the expense of food production.