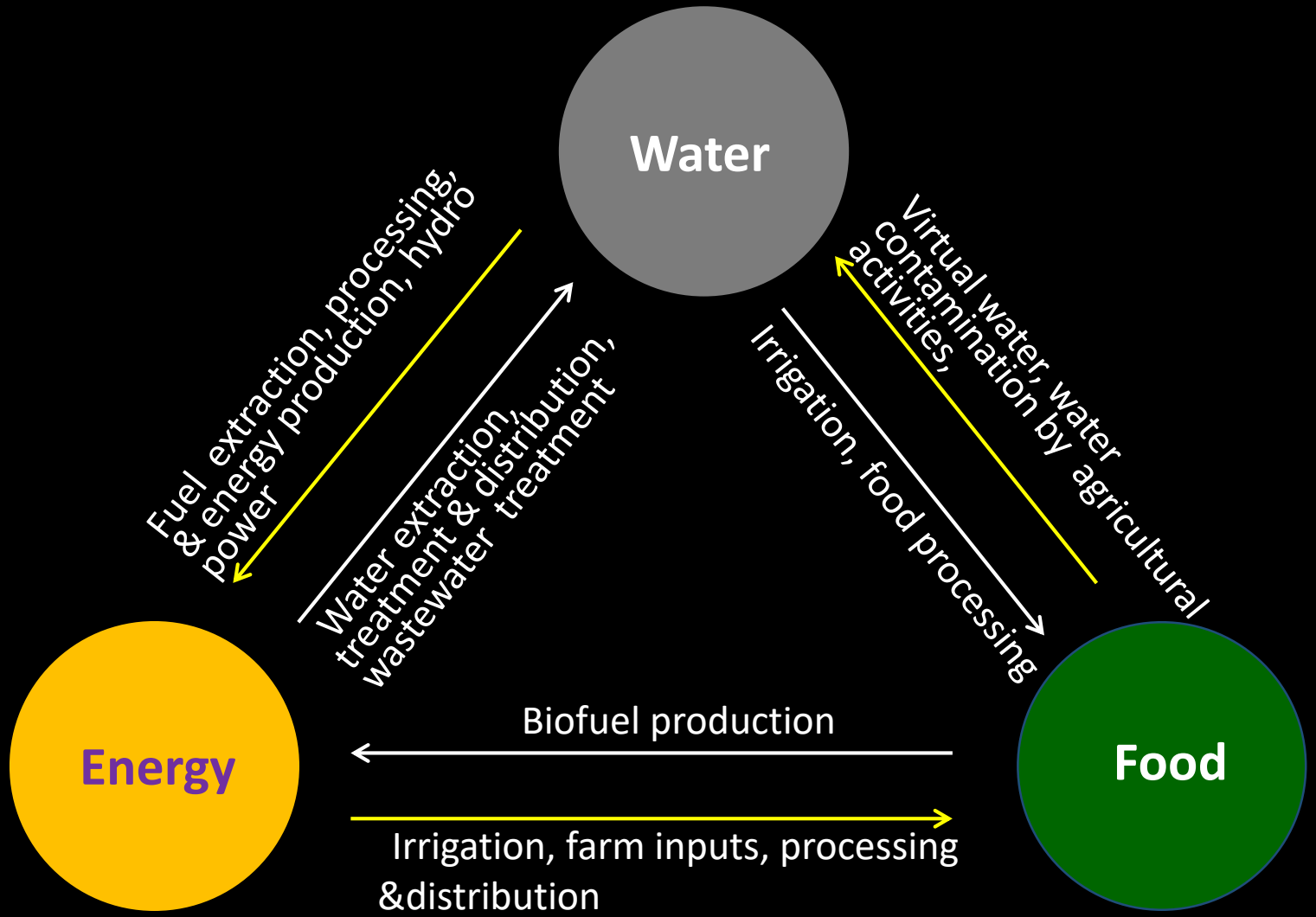
Possible contributions of EO information the Water-Energy-Food (W-E-F) Nexus

Richard Lawford
Morgan State University
October 26, 2018

AO GEOSS AP Symposium
Kyoto, Japan

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.**

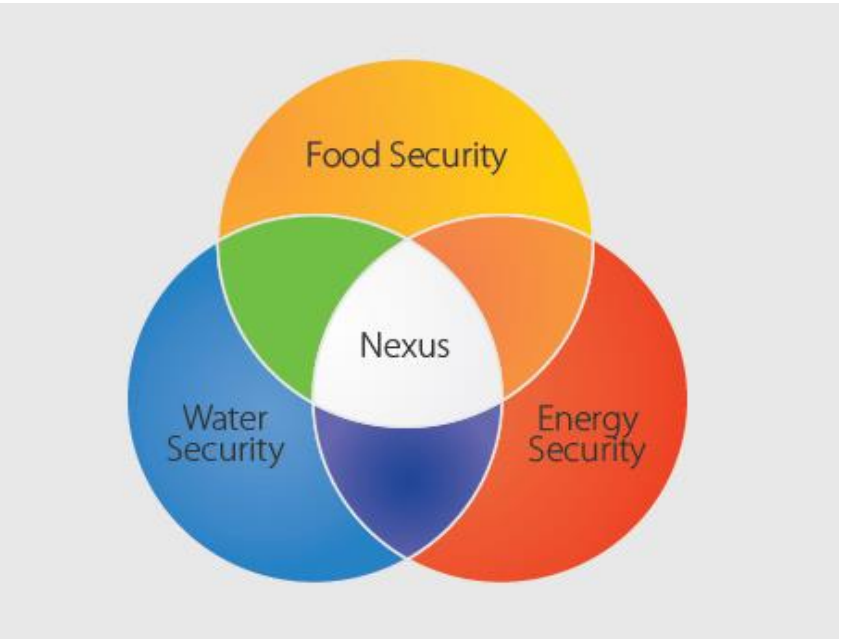
Hypothesis: By developing integrated WEF Nexus platforms and regional networks we can initiate a dialogue and trust needed to implement integrated planning and management of Nexus issues.

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

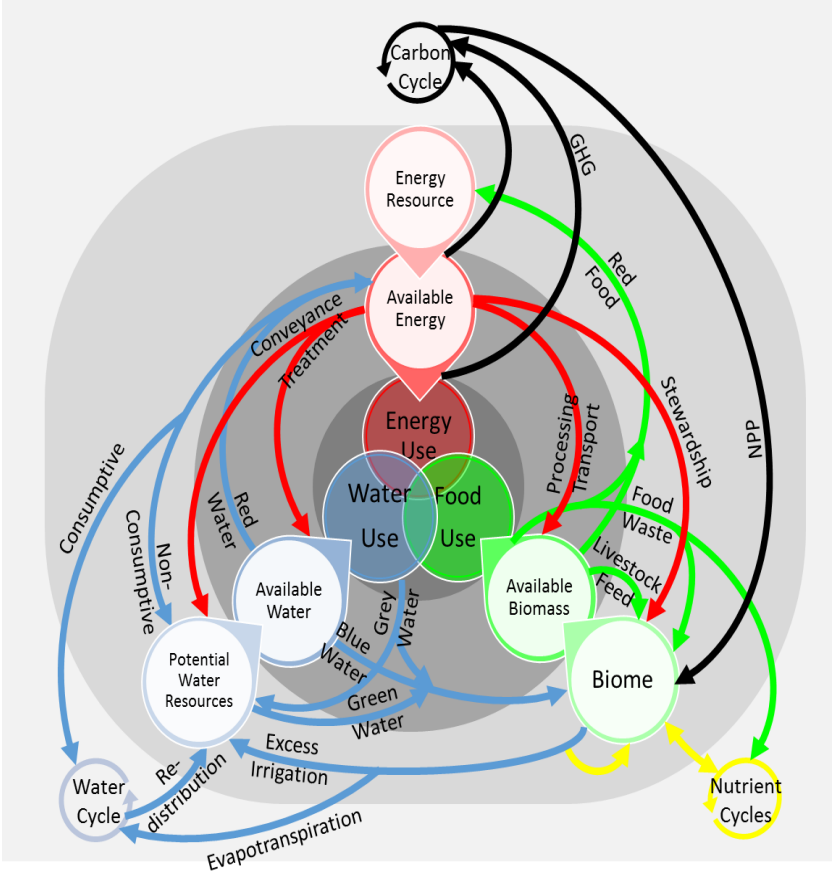
Goal: to assess the potential for the use of **integrated information** and **improved governance** for enhancing the **sustainability of the Water-Energy-Food (W-E-F) Nexus**.

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.

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



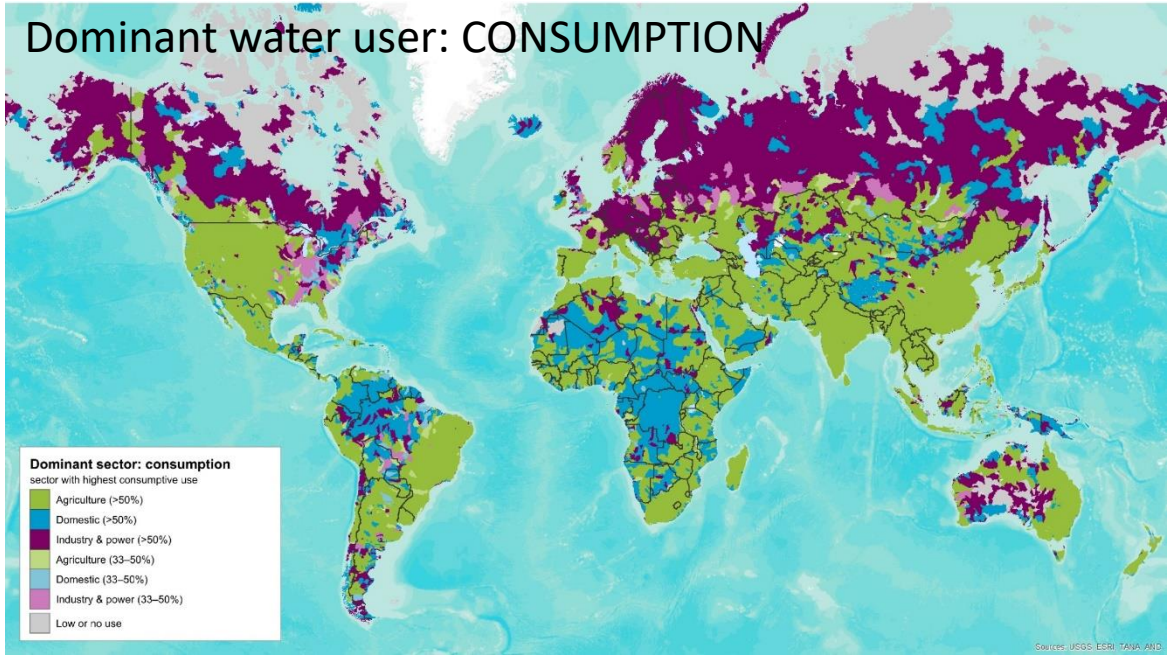
Characterizing the W-E-F Nexus requires a more rigorous definition of the Nexus nomenclature and taxonomy. In addition critical variables need to be defined and measured.



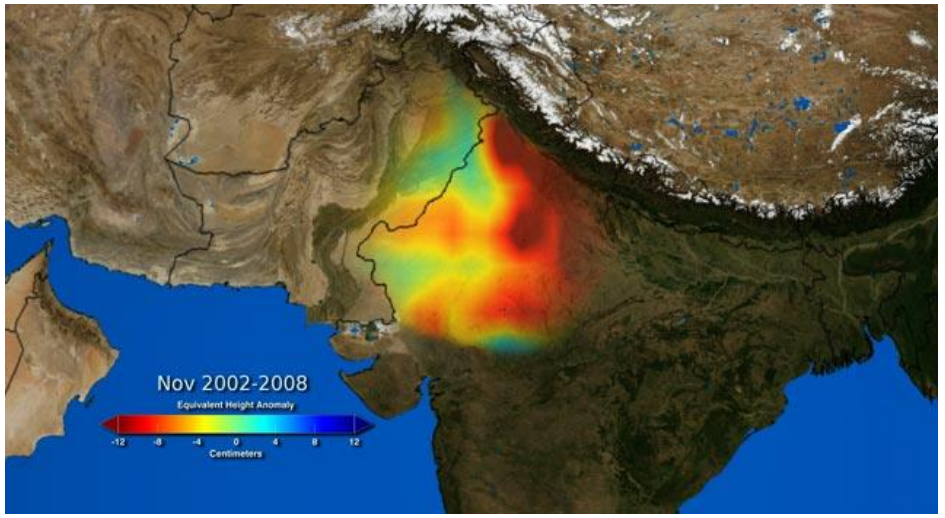
(after Higgins)

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?

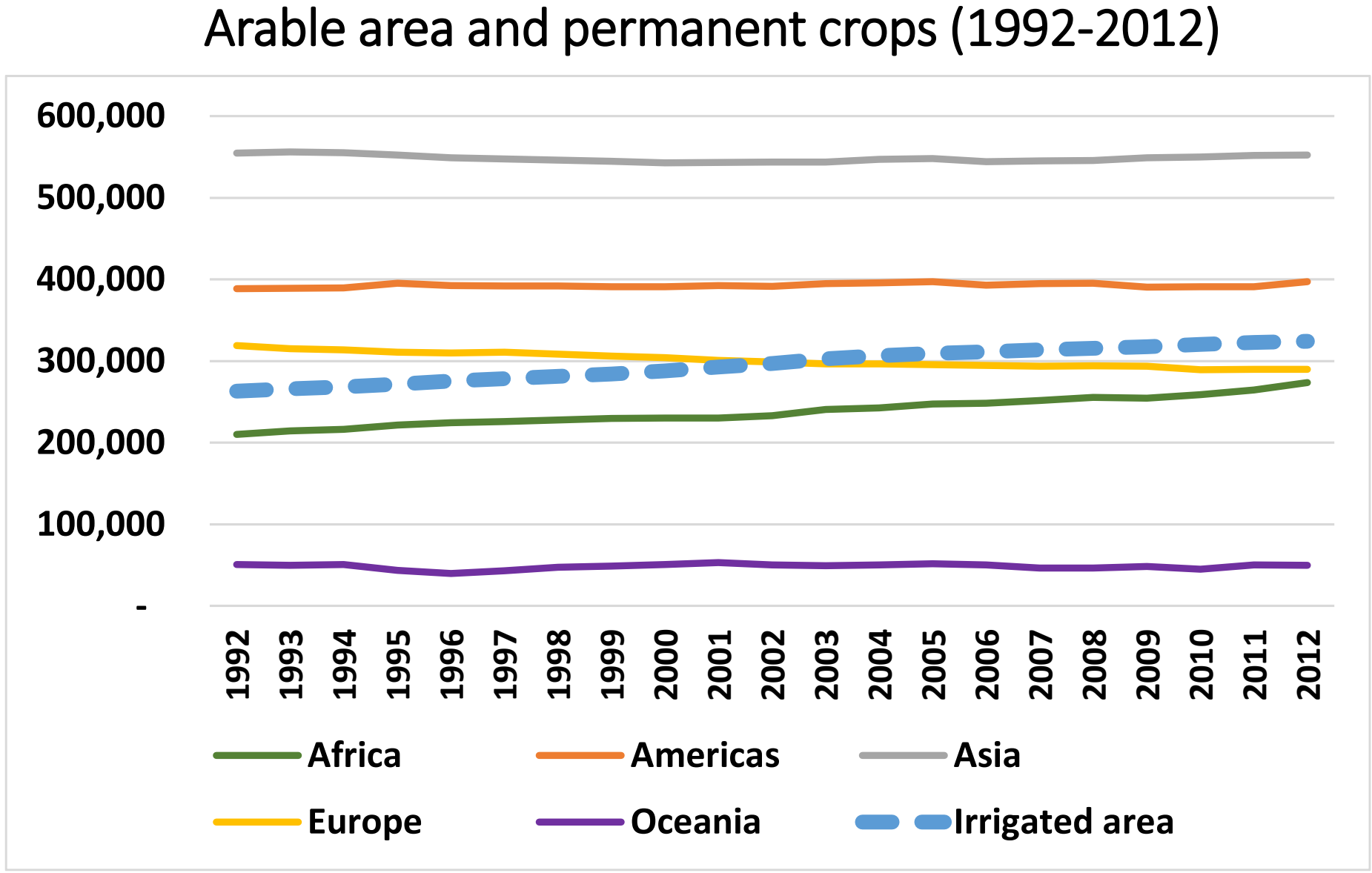


These developments had impacts on the environment and the water cycle:

- **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.

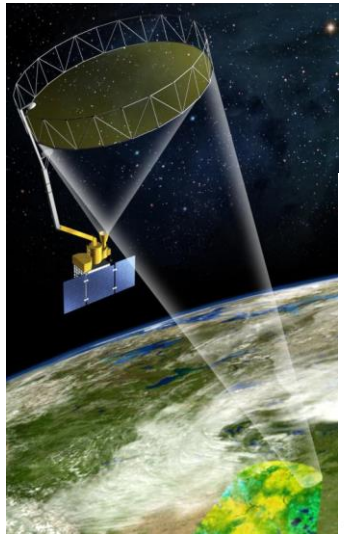
In most countries farming still relies on a large base of relatively independent farmers and farm businesses that make their own decisions. These farmers need information in both the long- and short-term variations of the water and energy cycle.

Where's the land for food production?

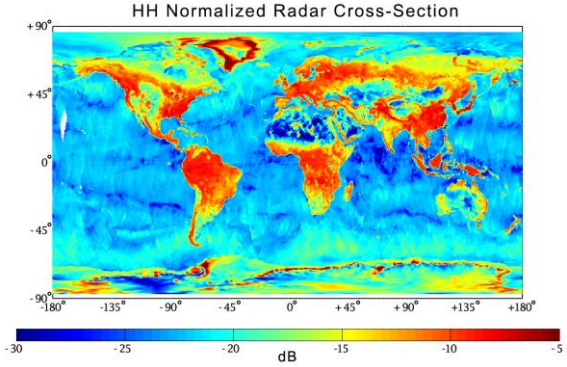


(Courtesy of C. Ringler)

Information for planning and design

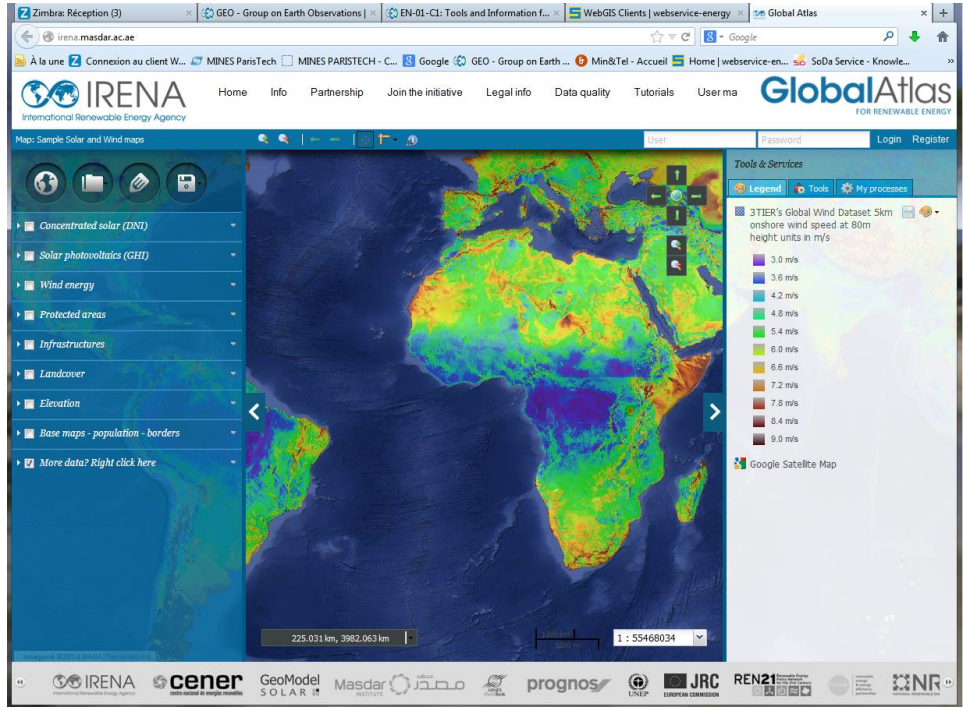


Soil moisture data is useful for planning field operations and assessing potential crop productivity.



Water (Entin, Rodell)

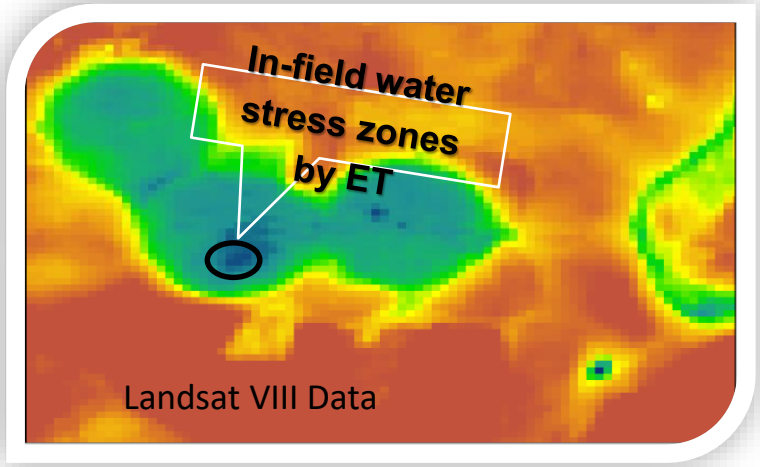
Energy



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

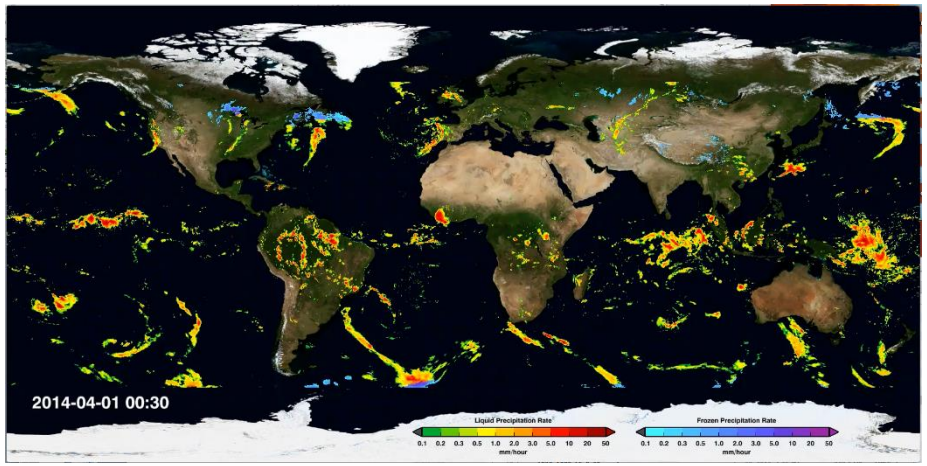
Food: Finding arable land for agricultural expansion is difficult in many areas without help from satellite data (G. Simpson)

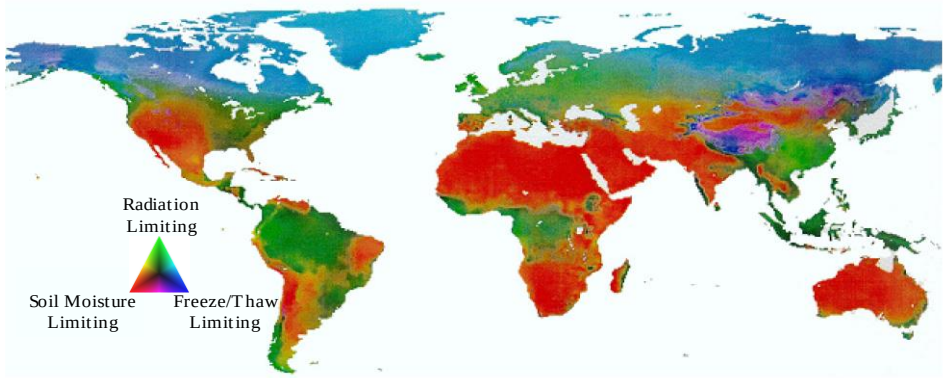
Information for assessing resource requirements



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.

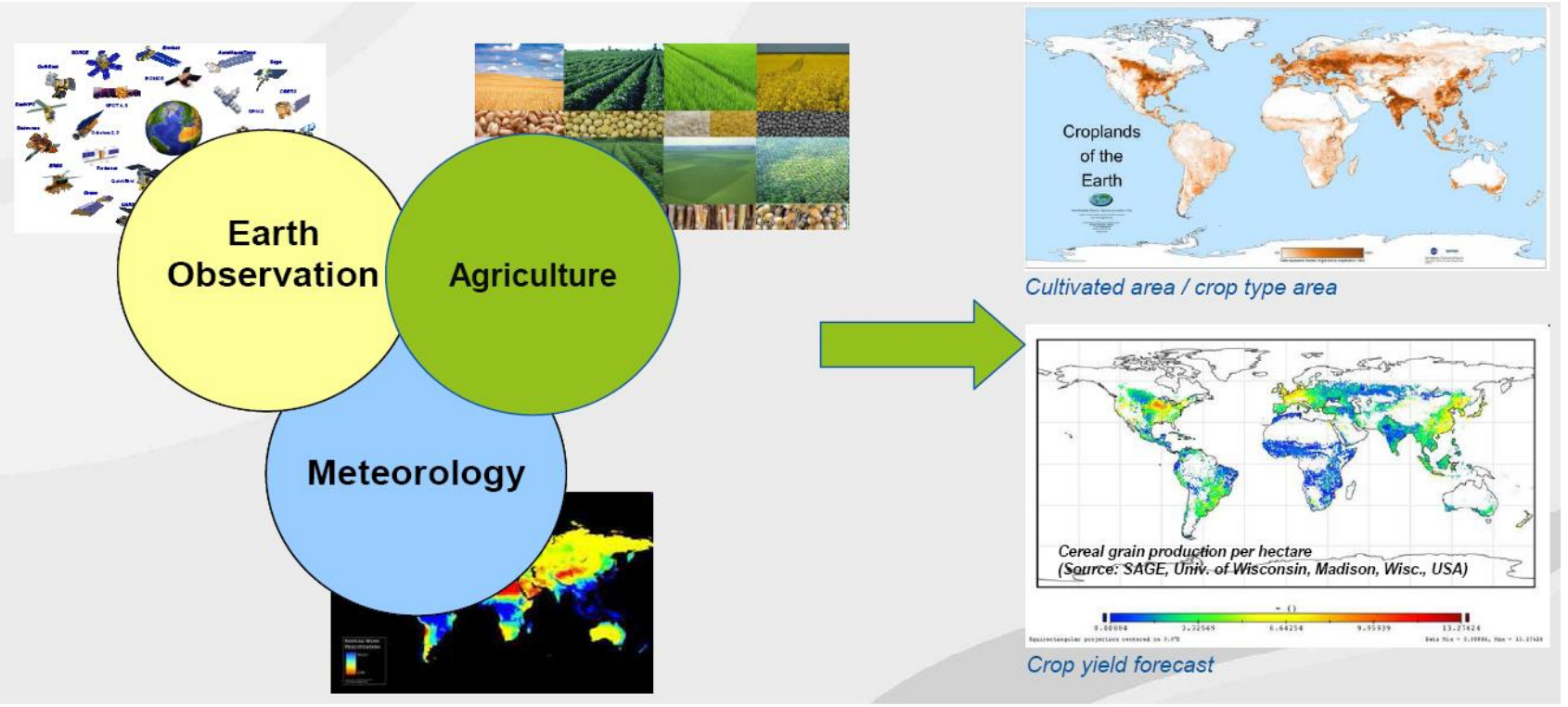




Maps of the factors constraining ET and crop growth can be derived from Earth observations.

Information for advice for management and marketing decisions

Food

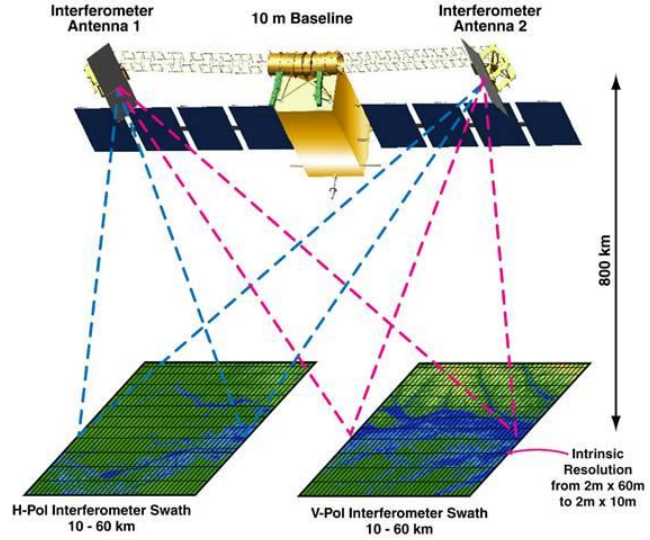


GEO Global Agricultural Modeling (GEOGLAM) provides a capability to forecast yields of different types of crops using satellite data as model input.

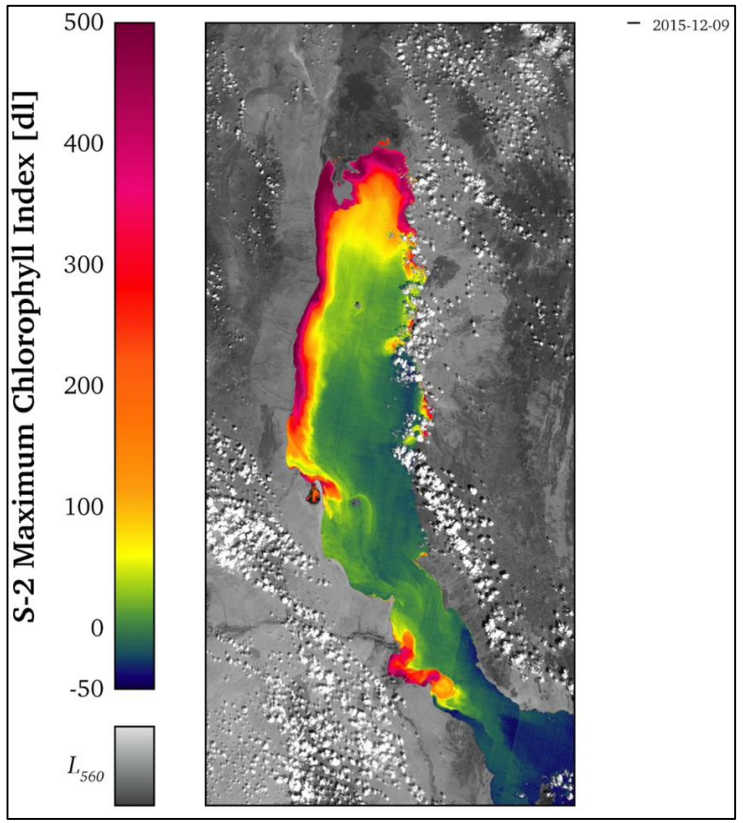
Energy/Water

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)

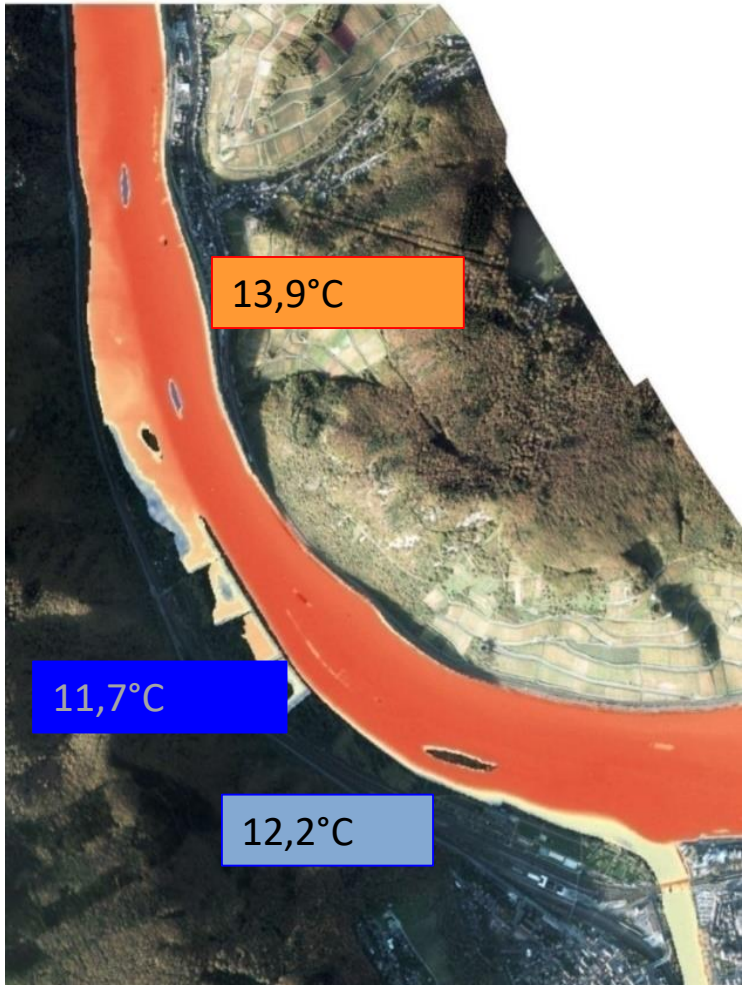


Information to manage by-products from W-E-F Nexus



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)

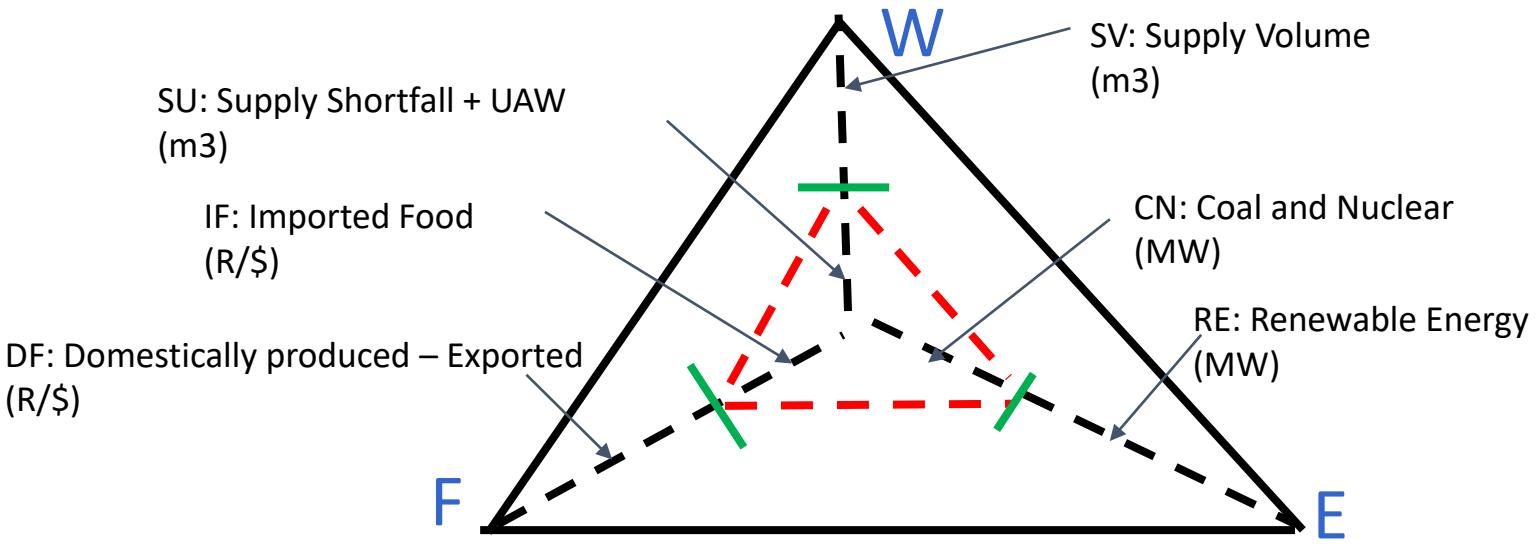


Energy production can lead to thermal water pollution as cooling water is released into natural streams. Aircraft monitoring of thermal emissions (at ~4 m) into the Rhine River (Björn Baschek)

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

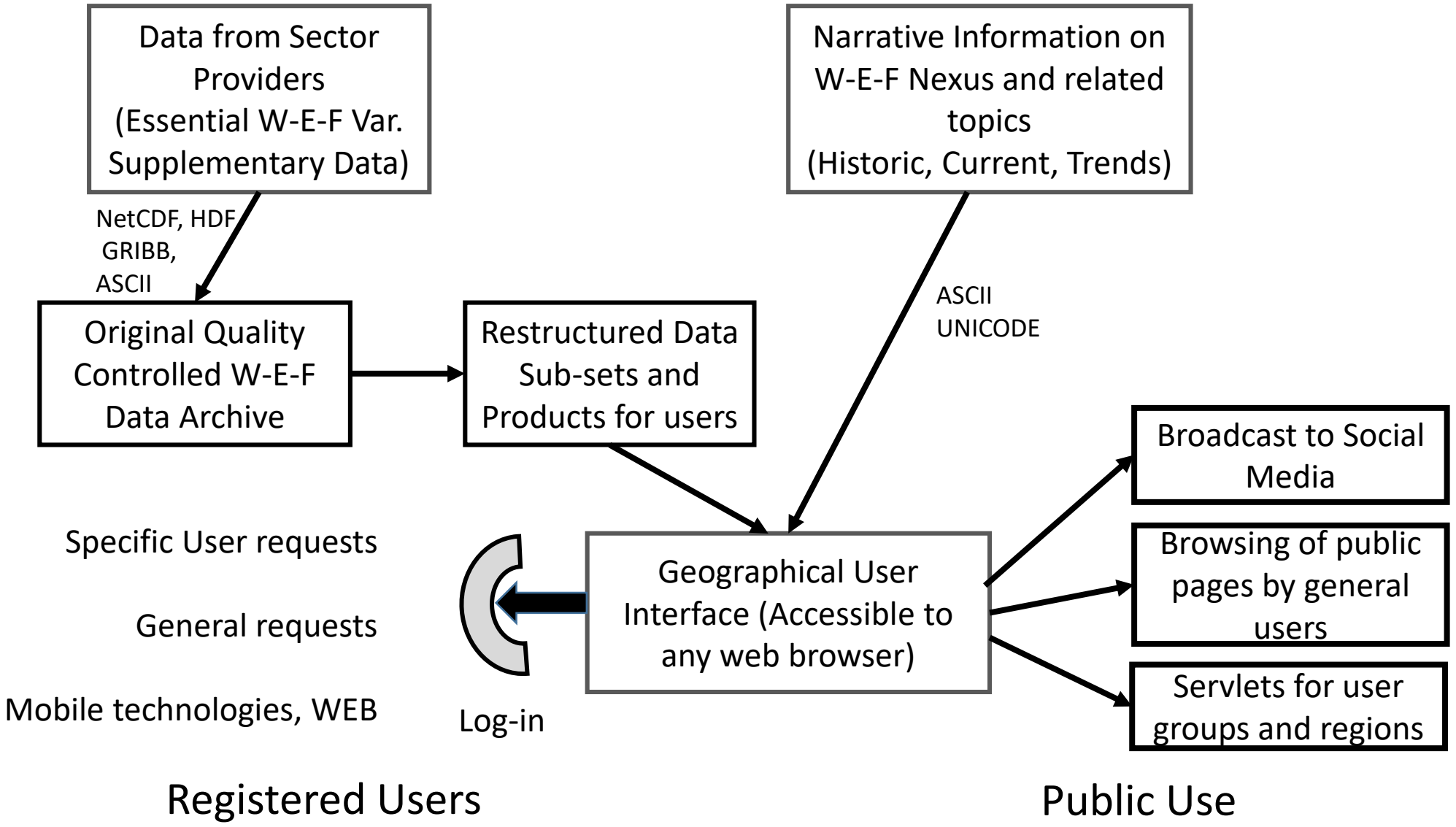
3. A platform (or platforms) for data sets and information from all three sectors with tools to facilitate production of the cross-discipline data products need to be developed.

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.

Data Flows in the W-E-F Data and Information Platform



Thank you for listening

Impacts of Shifts toward 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.

Some Transitions in the Energy Sector

It is estimated that 35% of the energy that is produced globally now supports the food production, processing and distribution. (FAO)

Oil-rich countries: Either directly or through large corporations their energy resources were tapped and their resources were supported local economies and were exported. Oil began to be used in plastics, fertilizers and in many other sectors. Management of the energy supply and delivery is generally in the hands of large private sector companies.

Rich Oil-poor countries: Pretty much the same as Oil-rich countries

Poor Oil-poor countries: Only a limited number of farmers utilize mechanized farming.

Trade-offs and synergies between W,E,F targets

	6,1	6,2	6,3	6,4	6,5	6,6	6.a	6.b	2,1	2,2	2,3	2,4	2,5	2.a	2.b	2.c	7,1	7,2	7,3	7.a	7.b
6,1		1	2	2	3	1	1	2	0	0	0	1	3	3	-1	1	2	2	2	3	2
6,2	1		2	2	3	1	1	3	0	1	1	1	3	3	-1	1	2	2	2	3	2
6,3	2	2		2	3	2	1	3	2	2	2	2	3	3	0	1	2	3	2	3	2
6,4	2	2	2		3	2	1	3	2	2	2	2	3	3	0	1	2	3	2	3	2
6,5	3	3	3	3		2	2	3	3	3	3	3	3	3	0	1	3	3	2	3	3
6,6	1	1	2	2	2		2	1	-1	-1	-1	0	2	2	-1	1	2	1	2	2	1
6.a	1	1	1	1	2	2		2	0	0	0	1	2	2	-1	1	1	2	2	2	1
6.b	2	3	3	3	3	1	2		1	2	2	2	3	-1	3	1	3	2	2	3	3
2,1	0	0	2	2	3	-1	0	1		-1	-1	0	3	1	-1	-1	1	1	1	3	-1
2,2	0	1	2	2	3	-1	0	2	-1		-1	0	3	1	-1	-1	1	1	1	3	-1
2,3	0	1	2	2	3	-1	0	2	-1	-1		0	3	1	-1	-1	1	1	1	3	-1
2,4	1	1	2	2	3	0	1	2	0	0	0		3	3	0	1	2	2	2	3	1
2,5	3	3	3	3	3	2	2	3	3	3	3	3		3	0	1	3	3	2	3	3
2.a	3	3	3	3	3	2	2	-1	1	1	1	3	3		-1	0	3	3	2	3	2
2.b	-1	-1	0	0	0	-1	-1	3	-1	-1	-1	0	0	-1		-1	-1	-1	-1	0	-1
2.c	1	1	1	1	1	1	1	1	-1	-1	-1	1	1	0	-1		1	1	1	1	0
7,1	2	2	2	2	3	2	1	3	1	1	1	2	3	3	-1	1		3	2	3	2
7,2	2	2	3	3	3	1	2	2	1	1	1	2	3	3	-1	1	3		2	3	3
7,3	2	2	2	2	2	2	2	2	1	1	1	2	2	2	-1	1	2	2		2	2
7.a	3	3	3	3	3	2	2	3	3	3	3	3	3	3	0	1	3	3	2		3
7.b	2	2	2	2	3	1	1	3	-1	-1	-1	1	3	2	-1	0	2	3	2	3	

4 = indivisible	(-4) = cancelling
3 = supporting	(-3) = restricting
2 = reinforcing	(-2) = counteracting
1 = enabling	(-1) = constraining
0 = consistent	