Using Earth Observations to address the basin scale information needs of the Water-Energy-Food security nexus

Richard Lawford

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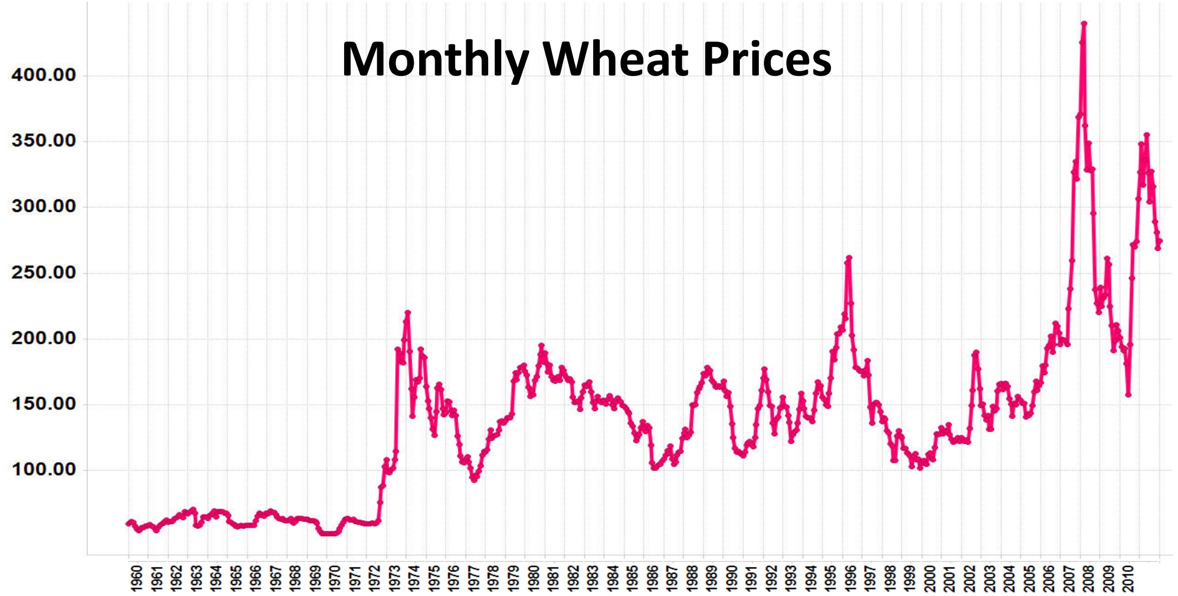
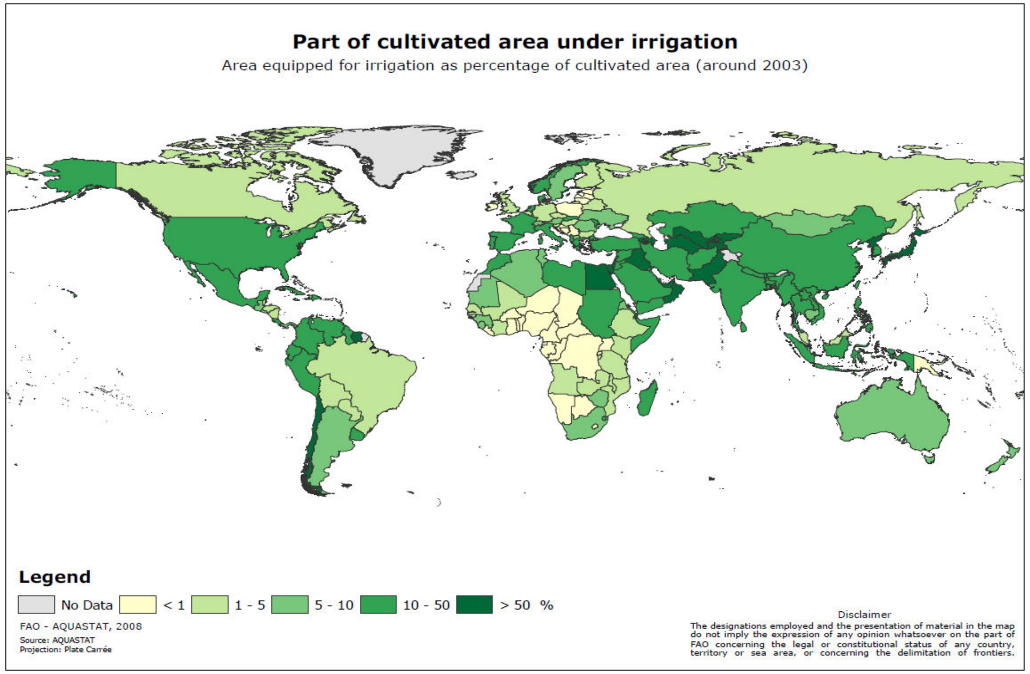
Food: A local and national commodity



Yield is the critical factor – how much will be produced (it is an economic concern as well as a social concern)

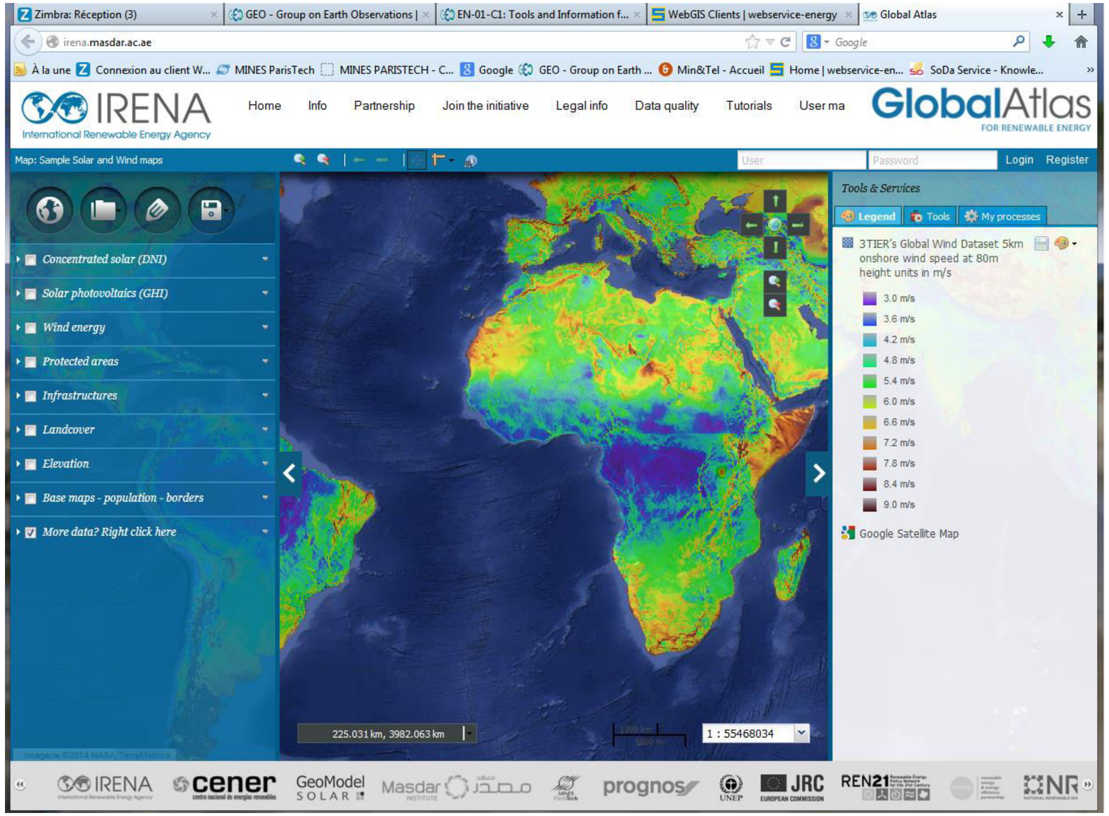
Price is also a critical and volatile factor that rises as production in one grain growing area falls or competition with other demands for foodstock increases.

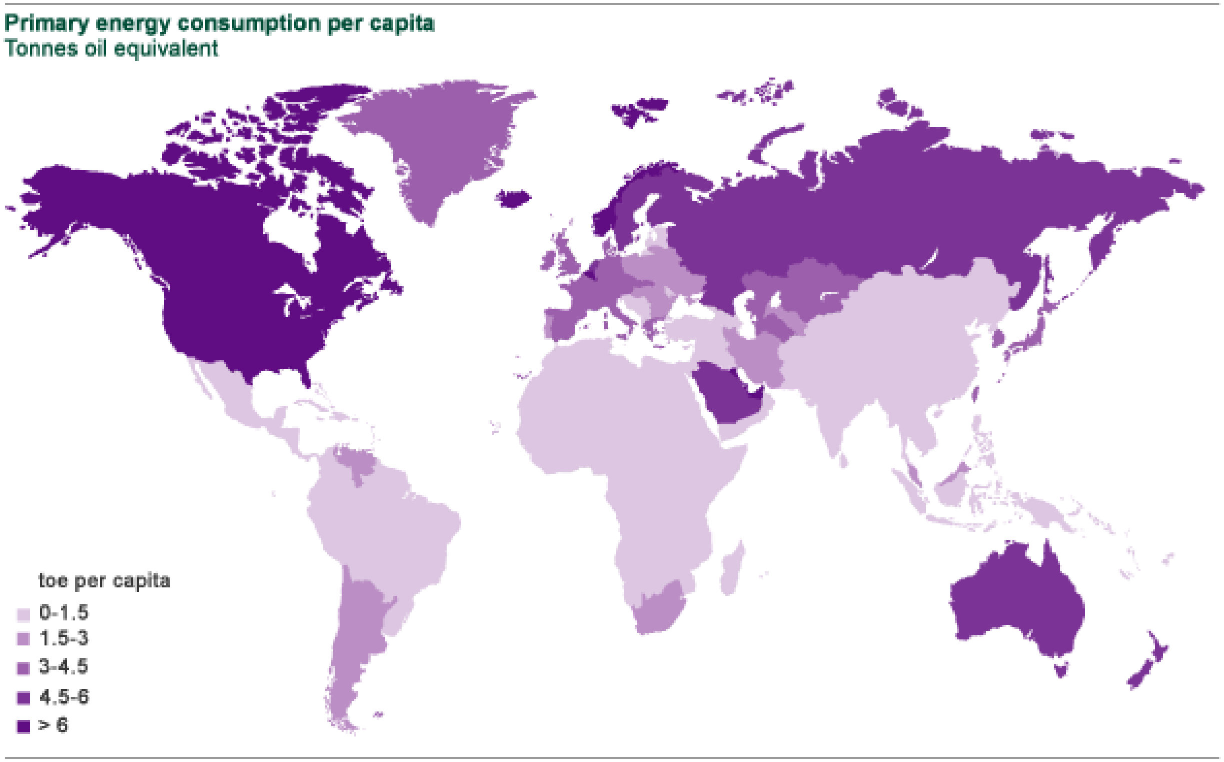


The agricultural community speaks of the yield gap (the difference between what is produced and what could be produced). Irrigation is seen as the way to address the yield gap.

Energy: a case of national haves and have nots

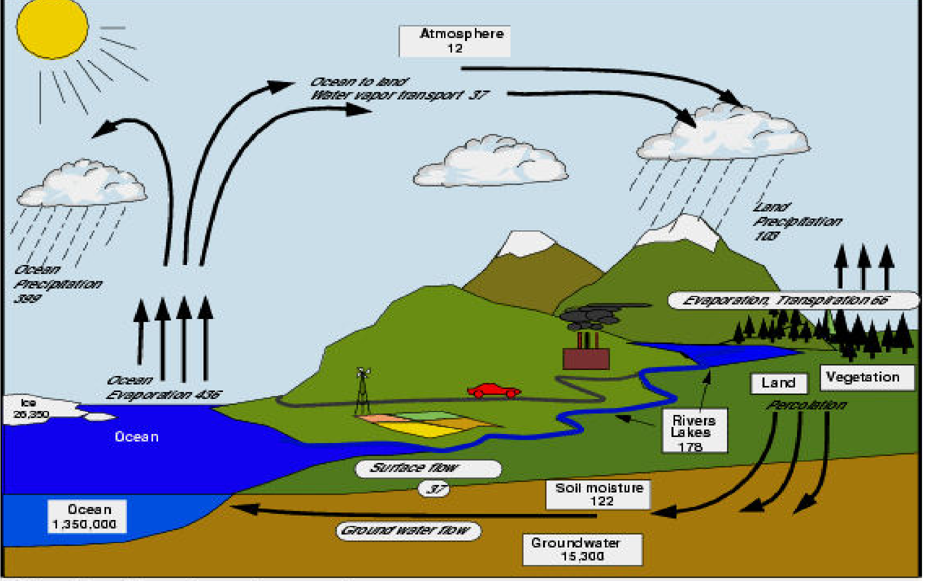
Fossil Fuels are the dominant source of supply. **One-third of the energy produced in a year is used in food production (including fertilizers), processing and distribution.**



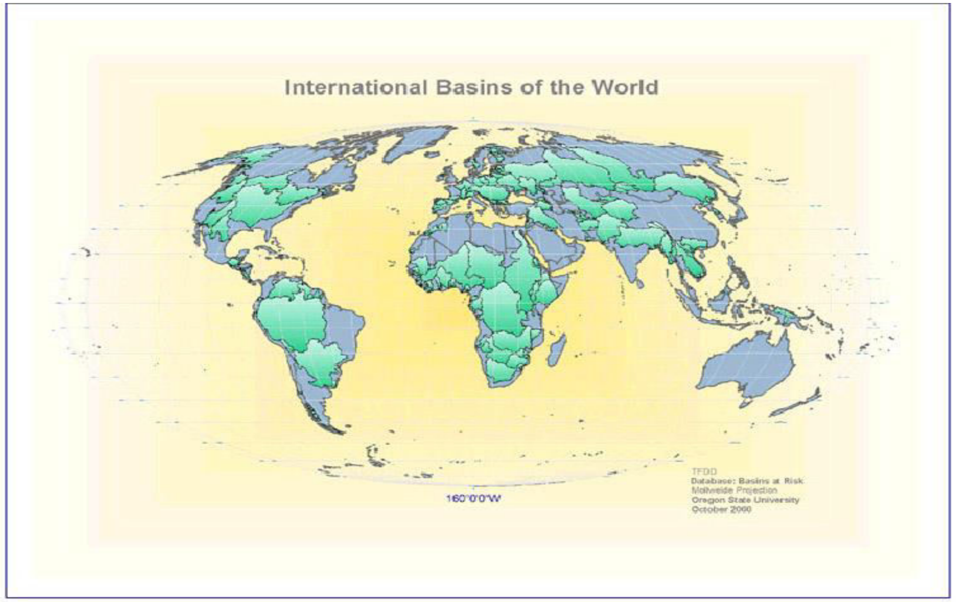


Renewable energy (solar, wind, hydropower) could be used to meet some of these energy needs.

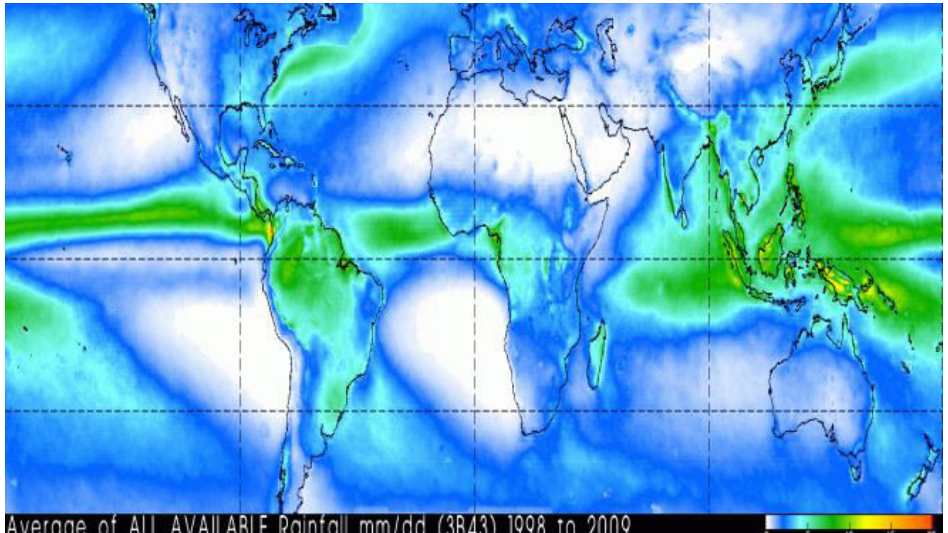
Surface Water Distribution



Hydrological cycle.
Units are thousand cubic km for storage and thousand cubic km/year for exchanges

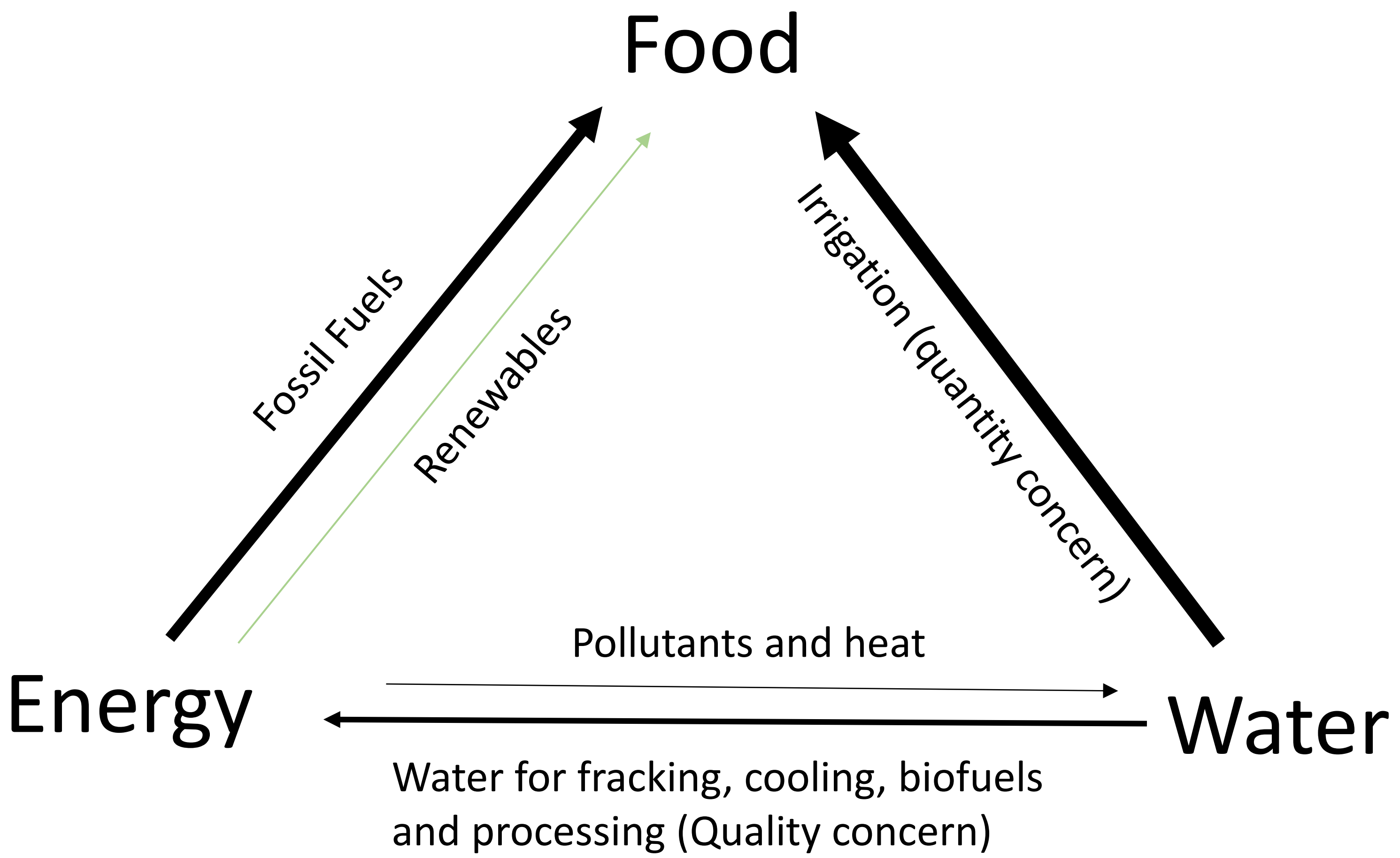


The water in the environment is finite.
Furthermore it is not uniformly distributed.



The landscape determines the boundary of the basin. Water is most naturally managed at the basin scale because water moves through the basin carrying flow deficits and water quality problems from upstream to downstream areas. Of the water consumed by humans ~70% is used for irrigation.

Major Interactions in the Nexus

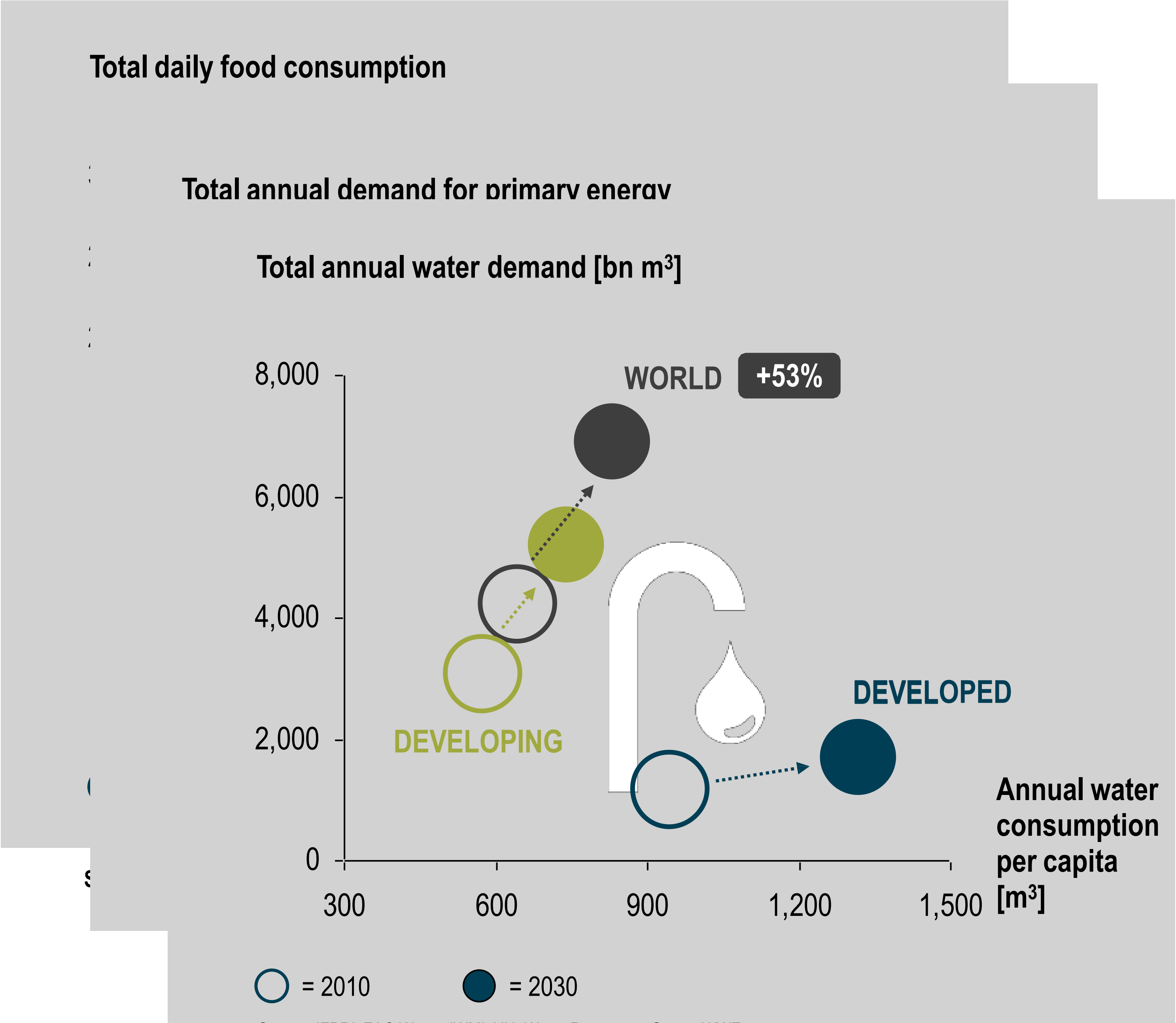


Trends in the Nexus Components

Food

Energy

Water



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An introduction to earth observations:

Earth observations include:

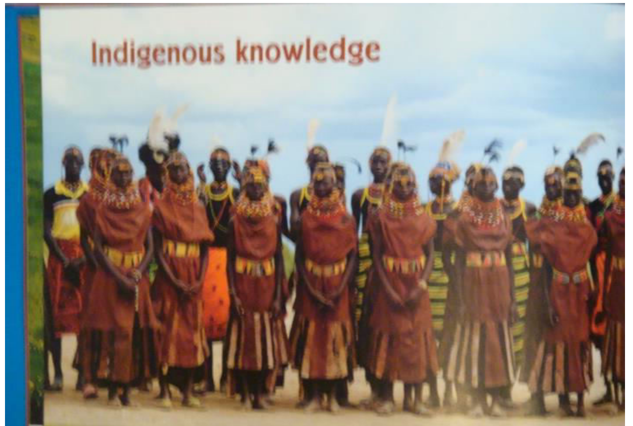
1) Satellite data (global, periodic)
2) In-situ measurements (local, frequent)

On the cusp:

1) Survey information
2) Data Assimilation outputs
3) Model outputs

If we include humans then it will

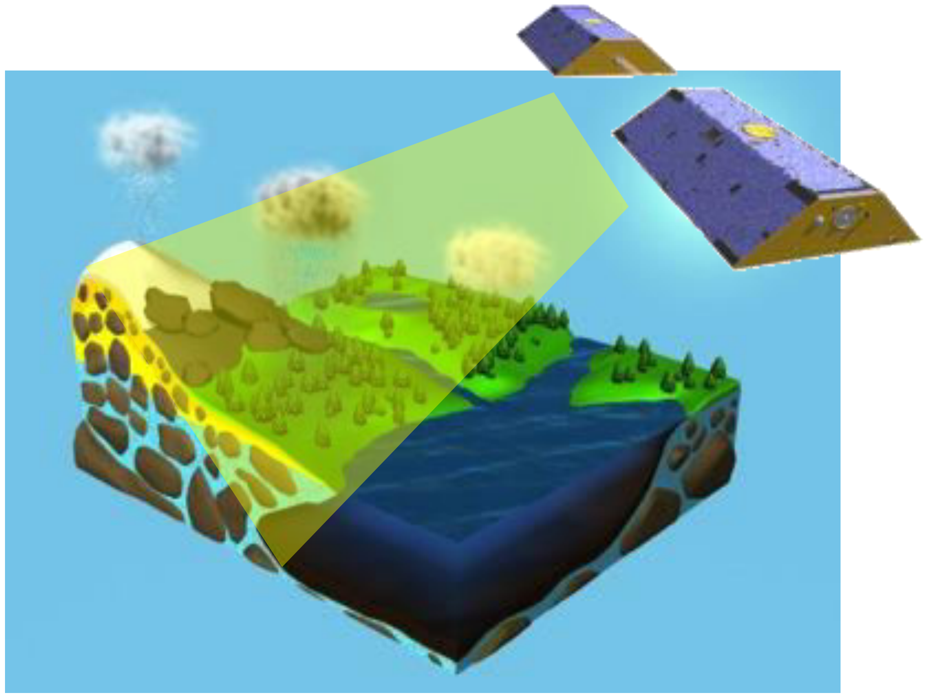
1) Other important data (health data):
2) Socio-economic data and traditional knowledge



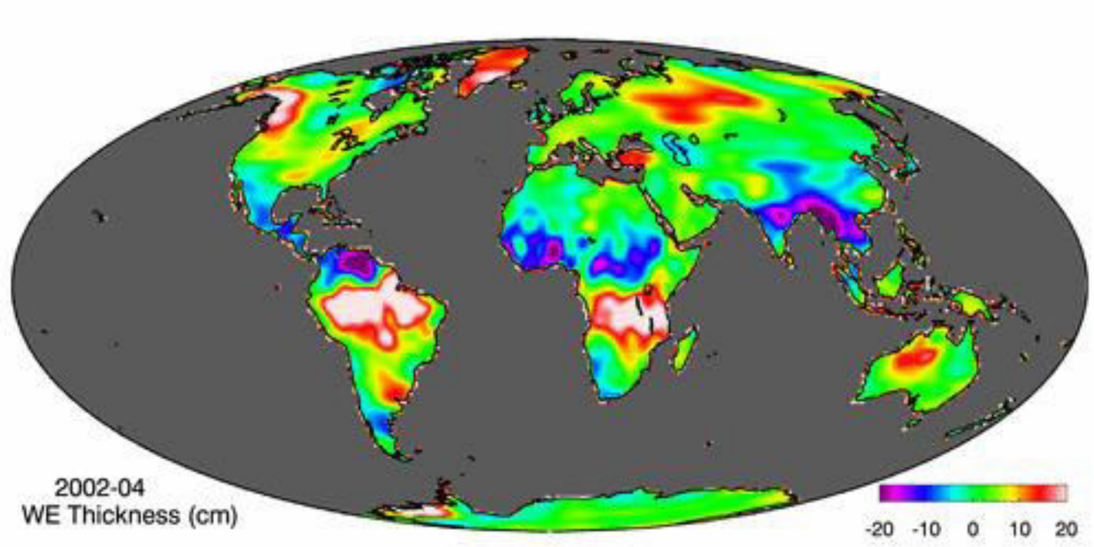
GRACE: an example of global observational capabilities leading to numerous global products (after M. Rodell)

GRACE Science Goal: High resolution, mean and time variable gravity field mapping for Earth System Science applications

Key Result: Information on water stored at all depths on and within the land surface

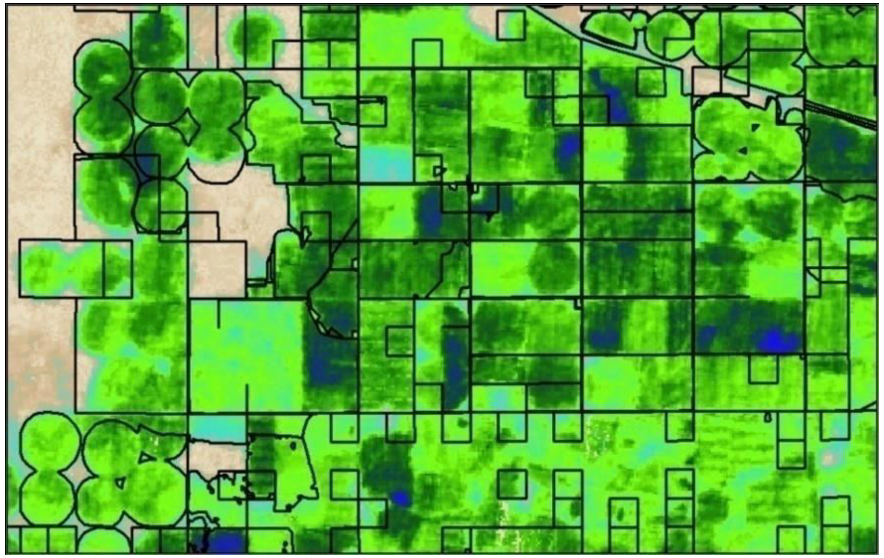


GRACE measures changes in total terrestrial water storage, including groundwater, soil moisture, snow, and surface water.

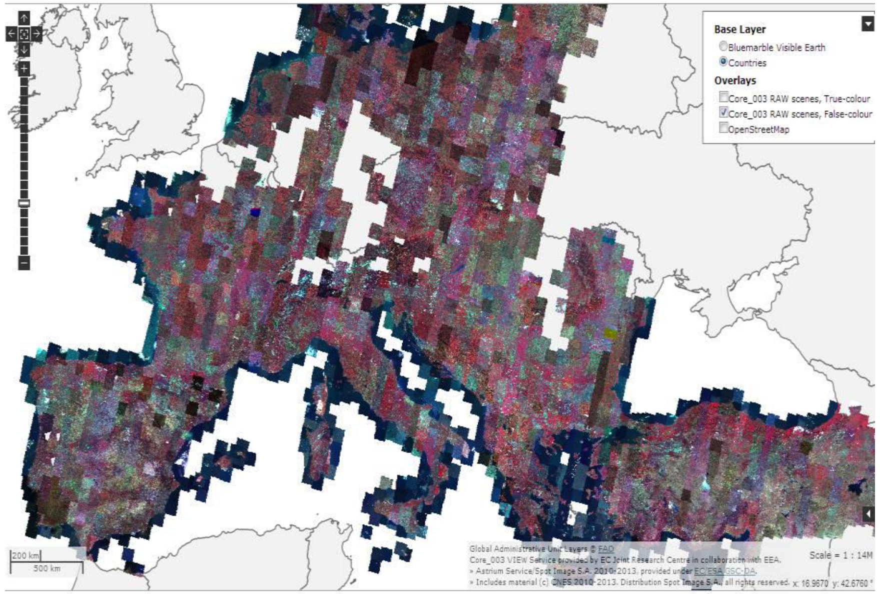


Animation of monthly GRACE terrestrial water storage anomaly fields. A water storage anomaly is defined here as a deviation from the long-term mean total terrestrial water storage at each location.

Satellites with global capabilities frequently lead to regional outputs



Some satellites produce global products but due to the demand full analysis is only carried out for regions of high demand.



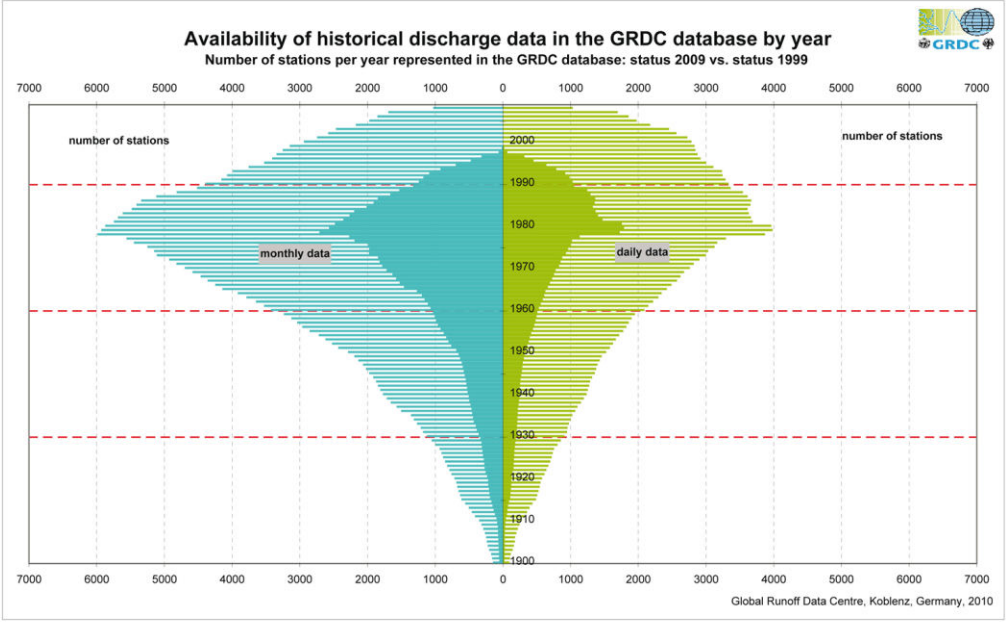
Core_003_Spot2.5 Data Coverage, update dec 2012

Availability of SPOT imagery at 2.5 resolution

Some satellites are turned on at specific points in time (e.g. SPOT and Sentinel Satellites).

The role of In-situ Observations

In-situ observations provide site specific data that can be used to support farm-scale decisions. While many nations readily exchange their in-situ data with global data centres and surrounding nations, there are still a number of countries that do not exchange data.

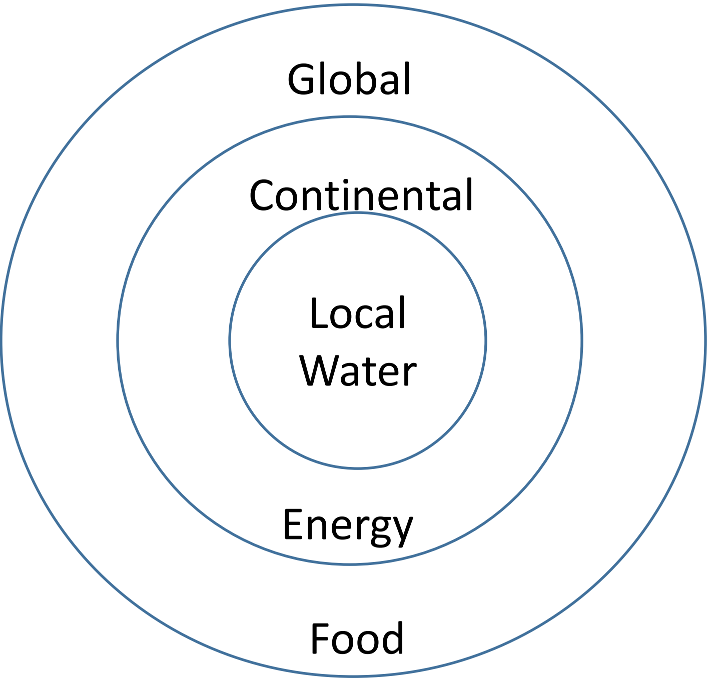


GRDC data holdings

In some regions in-situ data are used to determine when crop insurance payouts should be made. In other areas they:

- provide a basis for water allocations
- are used in flood forecasting
- are used for drought monitoring
- provide data on non-compliance regarding water quality standards,
- etc.

Each basin is unique making it difficult to be prescriptive with a global template

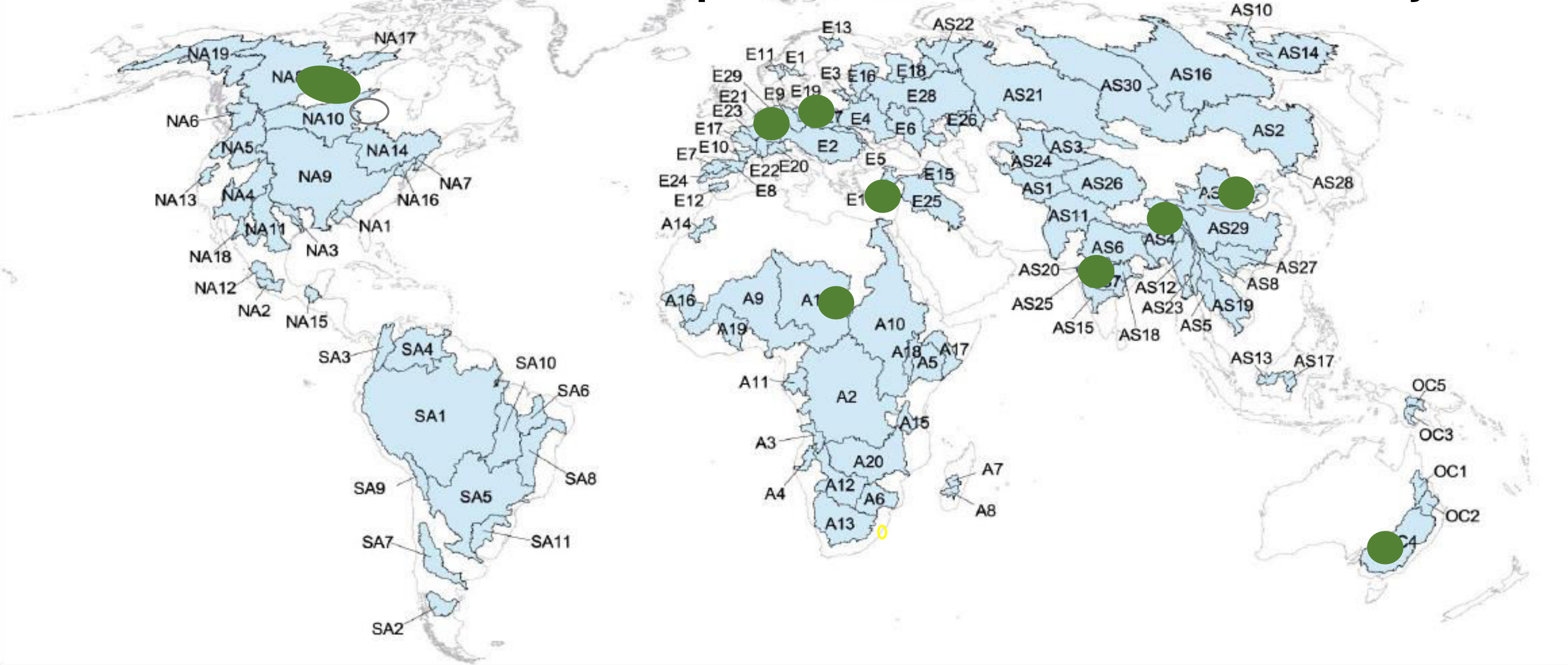


Not all land areas can support agriculture. Some are too cold, others too dry, others too steep, others too urbanized, etc.

Different basins have different economic structures. Some export globally, some compete continentally for energy from regional resources while other basins are dependent on the water resources in the basin.

Nor all basins are the same

The 9 basins with sufficient responses to be included in this analysis.



http://multimedia.wri.org/watersheds_2003/gm1.html

Market-driven basins: Winnipeg, Murray-Darling (*), Incomati, Yellow (*), Danube

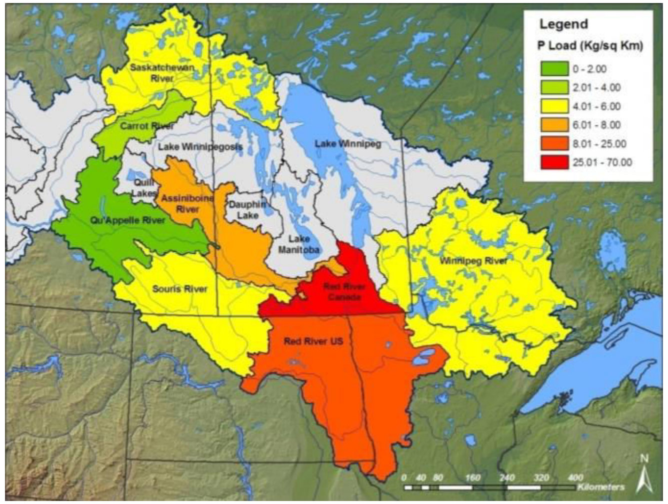
Development agenda-driven basins: Volta, China Interior (*)

Political change-driven basins: Elbe, Jordan

River Basin	Potential factors for water availability							
	Climate Change	Political and Economic System Change	Regional and Economic Development	Demographics (pop. growth)	Urbanization	Land use changes	Aerosols	Basin infrastructure
Amudarya	0,00	0,00	3,00	0,00	0,00	0,00	0,00	0,00
Murray-Darling	3,00	2,00	1,00	0,00	0,00	0,00	0,00	0,00
L.Winnipeg	3,00	0,00	0,00	0,00	0,00	1,00	0,00	2,00
Yellow River Total	1,00	0,00	3,00	0,50	1,00	0,00	0,00	0,50
C.I. Basins	2,00	1,00	0,00	3,00	0,00	0,00	0,00	0,00
Jordan	1,20	2,40	1,00	0,80	0,00	0,00	0,00	0,00
Incomati	0,00	0,00	3,00	1,00	0,00	0,00	0,00	2,00
Elbe	0,00	0,00	1,00	0,00	2,00	0,00	0,00	3,00
Danube	0,00	2,00	1,00	0,00	0,00	0,00	0,00	3,00
importance for water availabilty	1,09	0,82	1,44	0,59	0,33	0,11	0,00	1,17

The Agriculture and Water Dilemma in the Lake Winnipeg Basin:

In order to maintain high production rates farmers often add excess fertilizer to their crops.   These nitrates and phosphates enter the rivers, especially in times of large runoff and find their way to Lake Winnipeg.

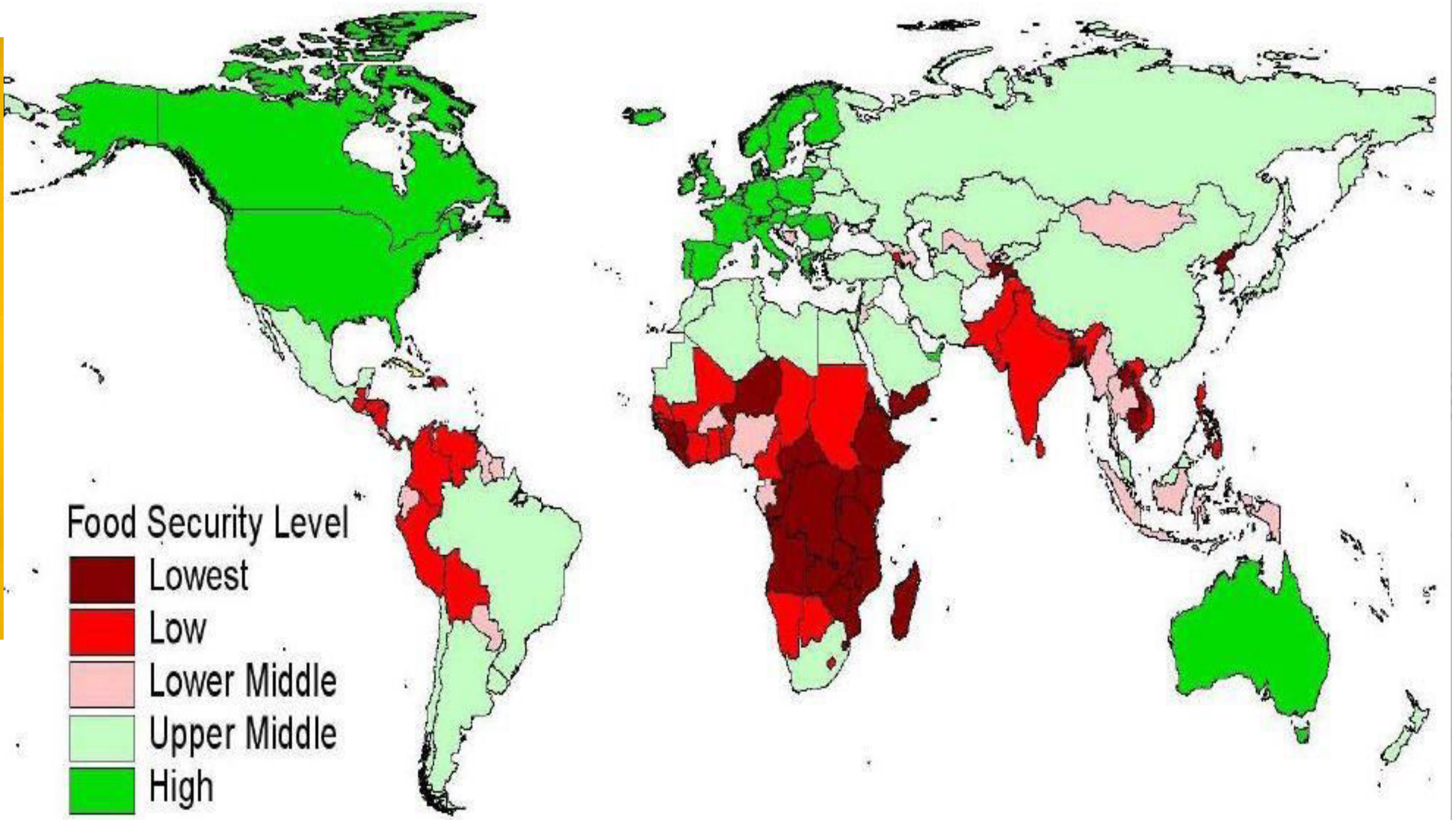


Over the past two decades the effects have been an increasingly large algal bloom on Lake Winnipeg during the summer. While the agricultural industry reaps the benefits of this intensive agriculture, it is the public who must pay for the cleanup.

In 2007, the bloom covered 15000 km^2 on Lake Winnipeg.

Satellites are effective means of identifying and monitoring the development of the growth of these blooms.

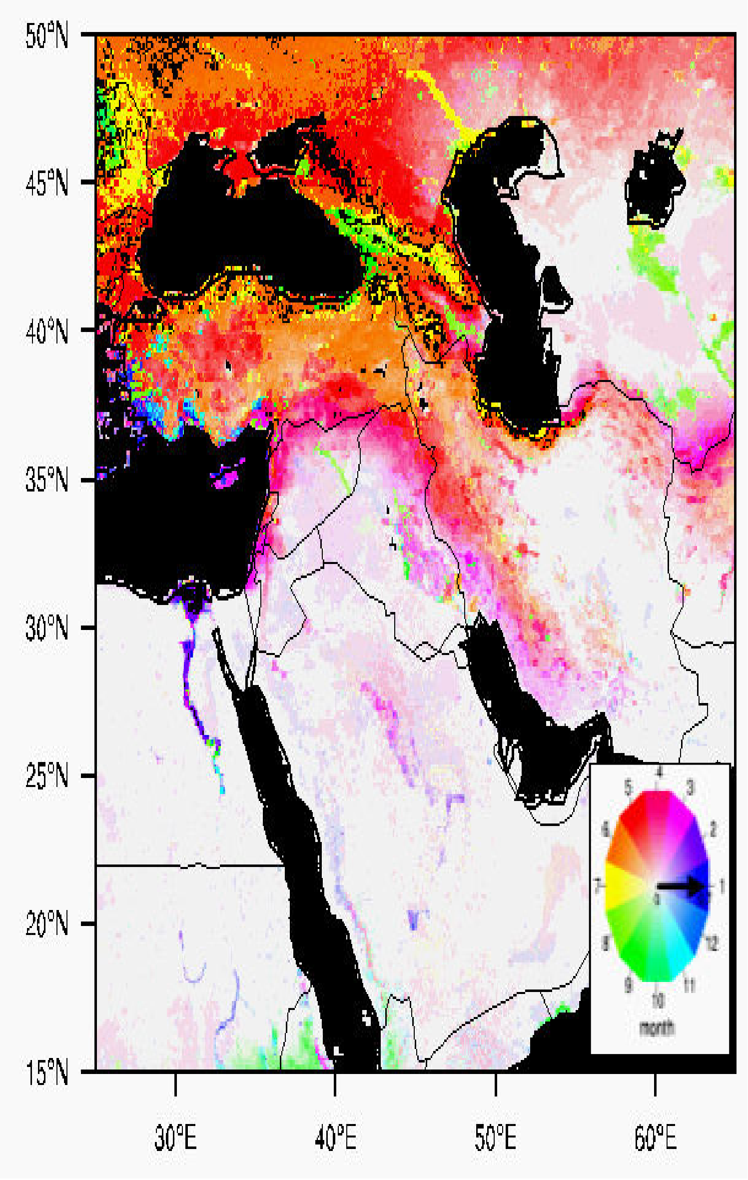
Analysis of national inputs cannot provide a full understanding of many aspects of the Nexus interactions.



The WEF Nexus is a special opportunity area of transboundary basins.

Thought experiment:
If we were to develop a WEF project in the Nile Basin we would encounter a problem in mapping fields and running models because not all countries exchange data (although it is improving thanks to the Nile Basin initiative)

Integrated data products using satellite data as their base could be used to support basin-wide decisions. They are spatially continuous and while their quality may suffer from the lack of in-situ data they would provide continuous data fields. The fields would allow prediction and tracking of flows for WEF purposes. Planning could proceed with quite a high degree of reliability and reluctant countries could see the benefits of sharing their data to produce better products.



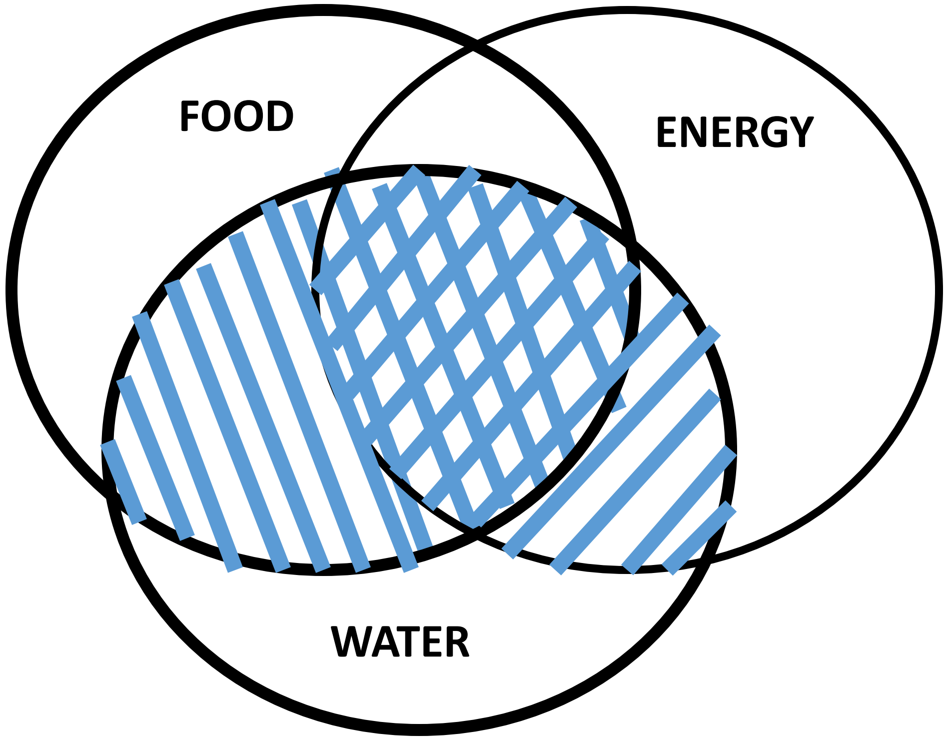
Sub-basins

Other areas for improvement in the WEF Nexus where EO could play a role:

- Irrigation could be used more effectively (more crop per drop) with better planning of applications.
- Greater efforts could be made to keep good arable land in production.
- The water needs of land and ecosystems should be considered along with agriculture
- Renewable energy could play a larger role in meeting the energy needs of agriculture

Earth observations can enable the realization of these improvements. (At this moment this is our hypothesis but it needs to be tested in demonstration projects).

Significant areas of overlap exist between the management needs of water, energy and food. Efforts to jointly utilize EO data should be done in collaboration with other Nexus issues



Some areas where joint risk should be addressed:

- Climate change (trends, shifts and extremes)

- Economics/ investments

- Links to environmental services

- Pressures from increasing consumption due to demographics.

Key Recommendations from the FAO-GWSP-ESA Workshop

1. More effectively integrate users from the WEF community into the design of observational services

2. Select an area where the WEF framework can be implemented on a voluntary basis and use Earth observations to expand the information available to this framework. In this area carry out an analysis of the ways in which Earth observations are used to bring benefits to the management of the Nexus and the degree to which sharing of data opens up opportunities for collaborative approaches in other sectors.

3. A working group should be established to develop ideas, approaches and project proposals that could advance work on the application of Earth observations to the WEF framework.