BOLDLY AUB
THE CAMPAIGN TO LEAD, INNOVATE & SERVE

1866 AUB American University of Beirut
الجامعة الأميركية في بيروت

Faculty of Agricultural and Food Sciences

Green Water and New Water for Agriculture

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Professor and Dean, FAFS

HEALTHY EARTH HEALTHY FOOD HEALTHY PEOPLE

Outline

- Who We Are
- The Global Water and Food Security
- Green Water Potential
- Alternative Water Potential
- Concluding Remarks

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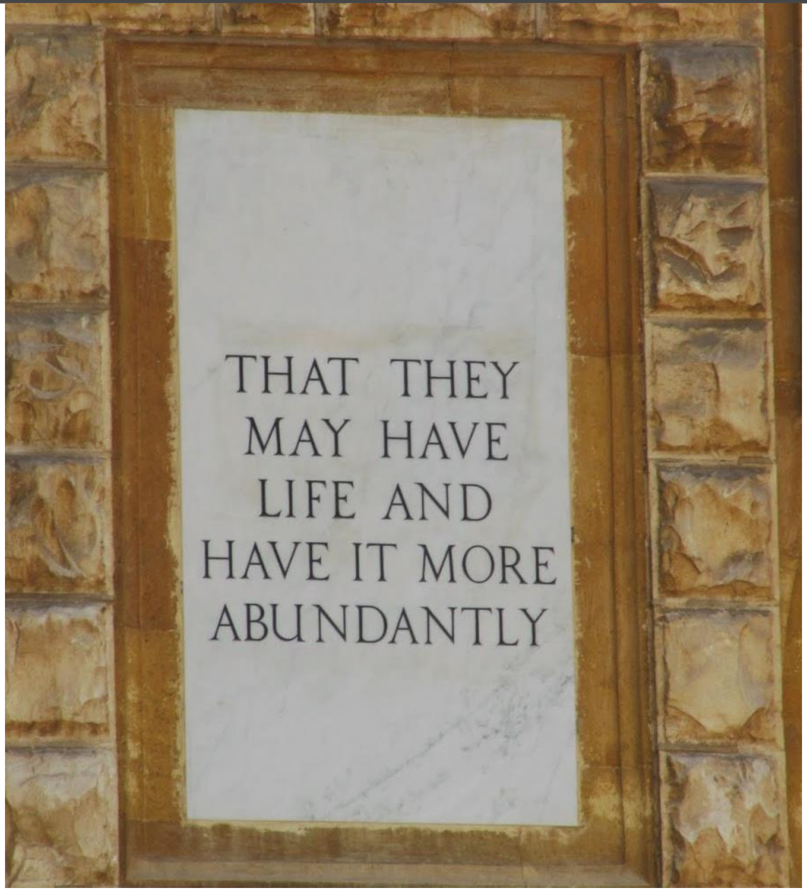

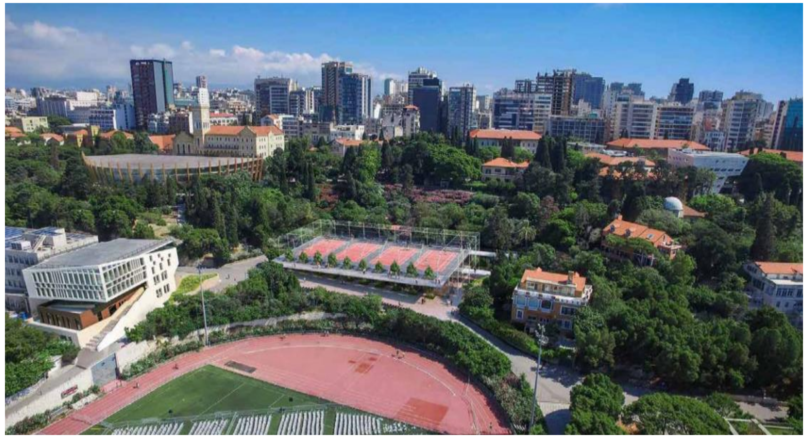

Who Are We?

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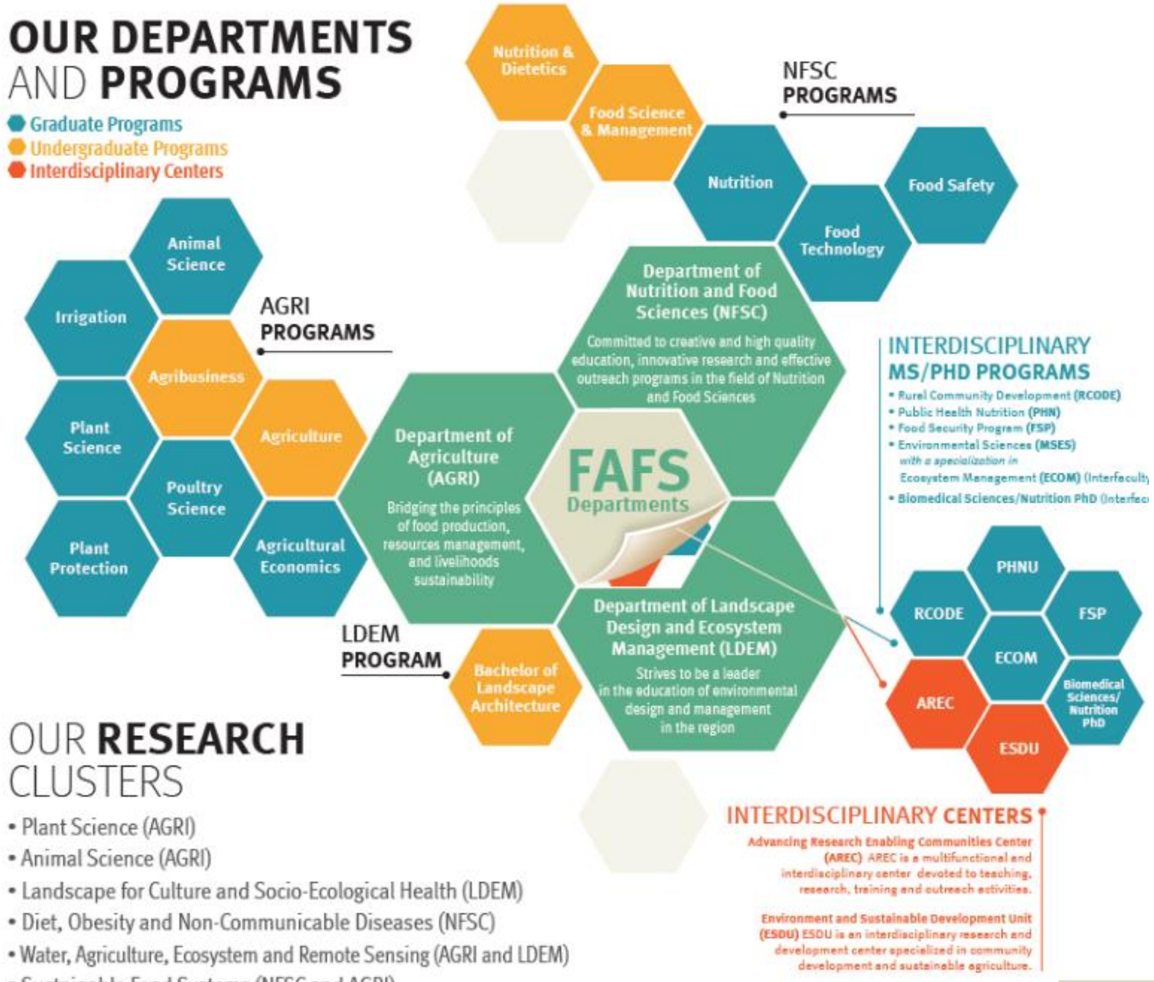
AUB
American University of Beirut
الجامعة الأميركيّة في بيروت

Faculty of Agricultural and Food Sciences (FAFS)

FAFS LEADING THE WAY TO FOOD AND WATER SECURITY IN ARID AND SEMI-ARID REGIONS

Our Strategic Themes:

- Establishing a culture of interdisciplinary thinking and acting
- Enriching our students' educational experience through service learning
- Encouraging and facilitating engagement with stakeholders and communities in Lebanon and the region.



OUR RESEARCH CLUSTERS

- Plant Science (AGRI)
- Animal Science (AGRI)
- Landscape for Culture and Socio-Ecological Health (LDEM)
- Diet, Obesity and Non-Communicable Diseases (NFSC)
- Water, Agriculture, Ecosystem and Remote Sensing (AGRI and LDEM)
- Sustainable Food Systems (NFSC and AGRI)
- Food Applications and Consumer Research (NFSC and AGRI)

HEALTHY EARTH HEALTHY FOOD HEALTHY PEOPLE

WEFRAH

WEFRAH Call for Proposals
December 2018

WEFRAH Workshop
January 24, 2019

17 concept notes submitted

11 invited for full proposal submission

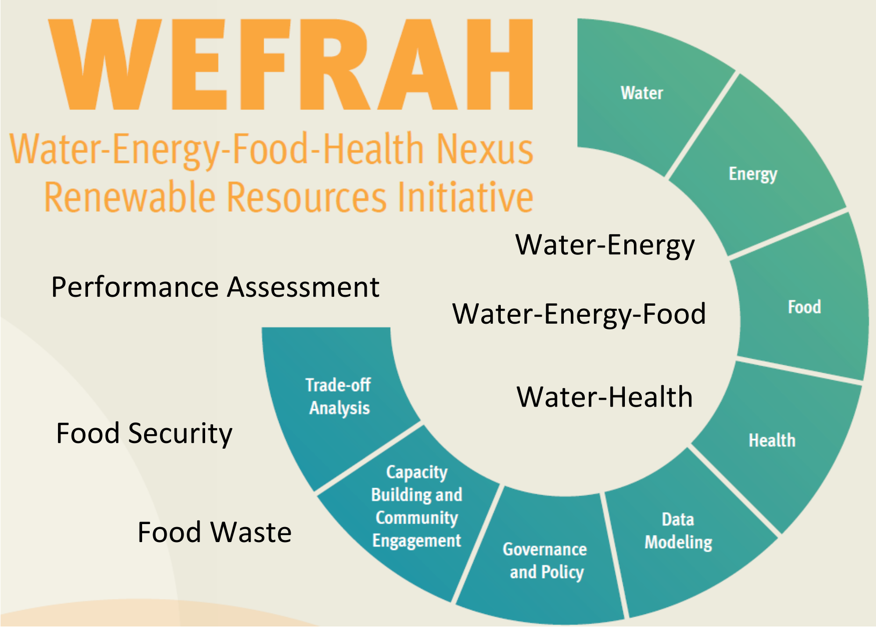
9 proposals selected for seed funding: 3 clustered & 3 independent

+ **2** educational & capacity building projects

Stakeholders Engagement Workshop
& **Design Thinking Workshop**

64 participants
from all faculties and
IT, EHSRM, PPD, IFI, K2P

63 total applicants
>50% from MSFEA & FAFS
17 PIs, **44** Co-PIs and **22** Co-Is



Technology
Business
Policy
Health Care
Agriculture

The WEFRAH Community

Engineering
Social Sciences
Natural Sciences
Arts & Design
Others
Nutrition
Public Health
Nature and Ecosystem

AREC: AUB Research Farm

VISION

AREC as a

Climate and Sustainability Center

Learning, Innovation and Engagement Center

for Renewable Resources and Health

at the American University of Beirut

GOALS

1. Regional Hub for **Water-Energy-Food-Health (WEFH) Nexus**
2. Hub for Participatory **Student Learning Experience**
3. Regional **Community Engagement** Center
4. Center of Excellence for **Emergency Environments**
5. **Value Creation and Entrepreneurship** Hub

Goals:

Texas A&M Water-Energy-Food Resource Initiative

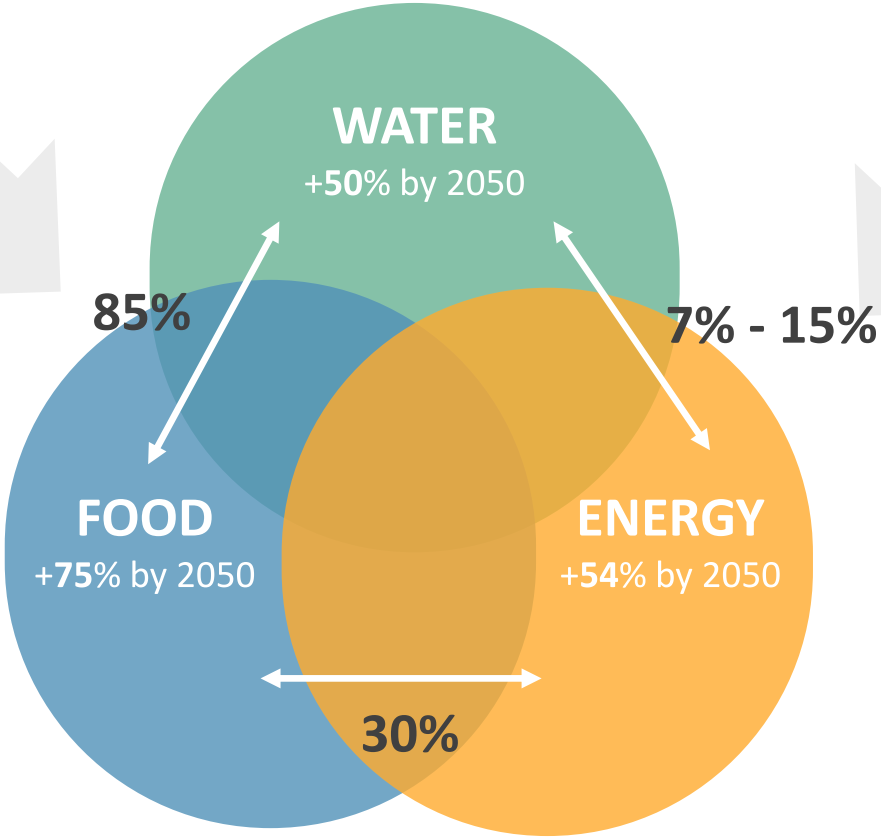
(Launched Oct. 2015: 250 researchers from TAMU and 300 globally)

1. *Expand intellectual capacity and scope of TAMU's Water-Energy-Food Nexus Community by **developing analytics, policy, and governance best practices**;*
2. *Establish a Nexus **Community of Science and Practice**;*
3. *Identify **opportunities and gaps in current WEF Nexus related research**.*

Regional Trends and Challenges

Regional Challenge of Today's Water Allocation Model and Interconnected Primary Resources

Population
598 million by 2050



Climate Change Impact- Situational Analysis

- River flow reduction impacts **water supply and hydropower generation**;
- Rainfall and Stream flow reduction impacts **soil moisture** availability and **food production** and increased **irrigation demand**

Challenges

- **Inequity & variability in distribution**
- **Non-sustainable consumption**
- **Extremes and non-stationarity**
- **Non-sustainable business model**

Opportunities

- **New Values – Based Business Model**
- **Resilient/Sustainable Communities**

IRENA (2015), 'Renewable Energy in the Water, Energy & Food Nexus'

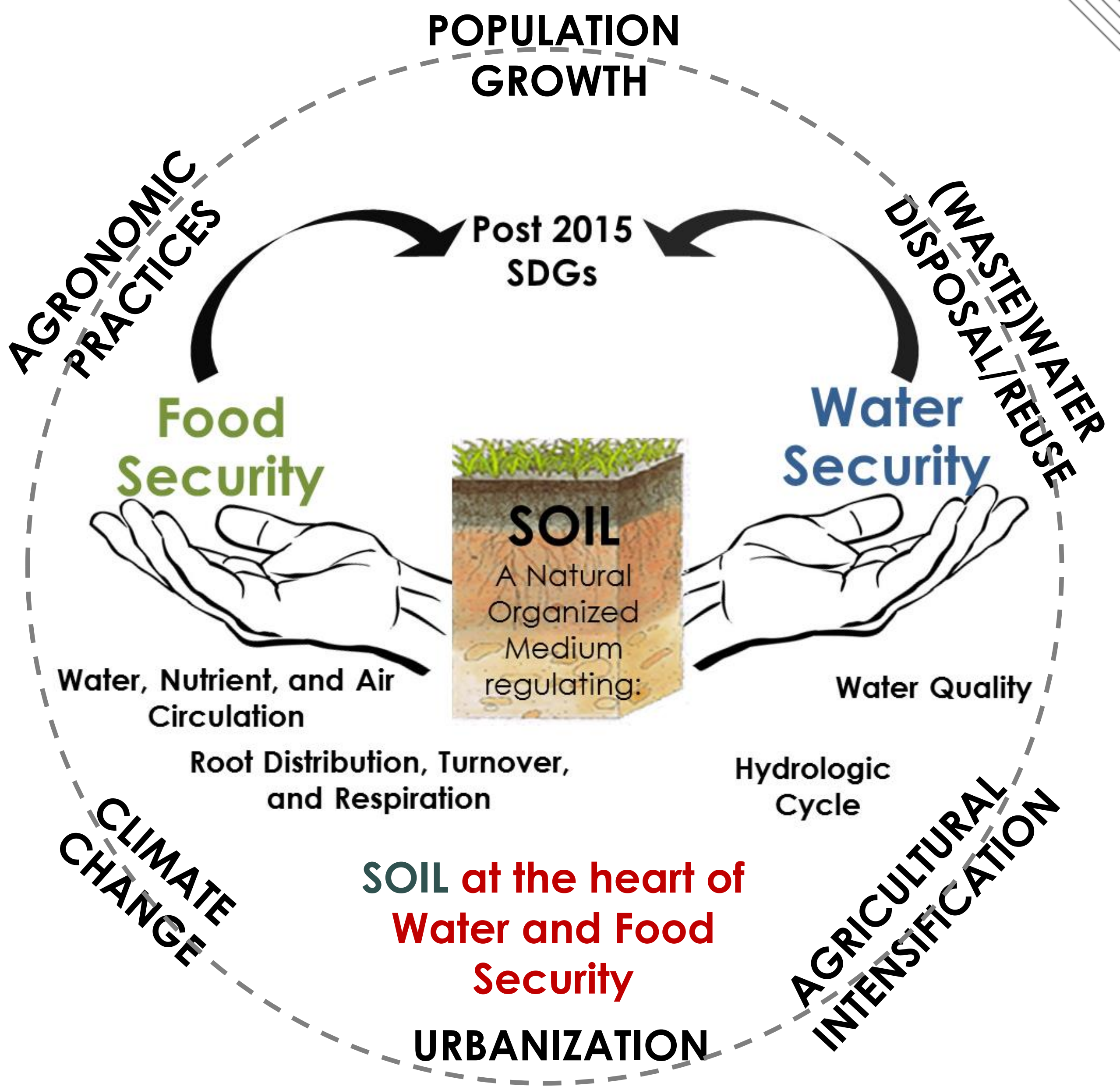
Soil for Water and Food Security

Soil Quality

The key for sustainable management of food and water resources are highly dependent on soil quality.

Characterization of Soil Medium

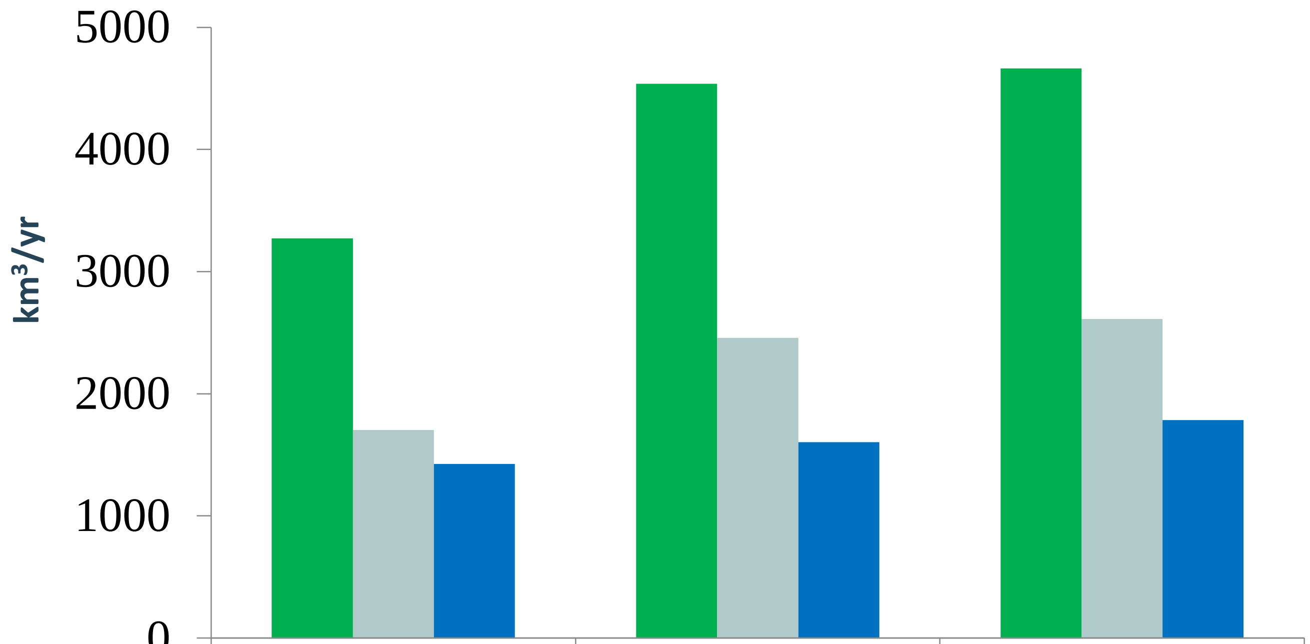
Studying the long-term impacts of the agro-environmental characteristics questions the use of (textured-based) soil information to face such a challenging world!!



Why is Green Water Important?
Green Water: Food Security and Ecosystem Services

- **Sustaining Ecosystem Services!**
- **60% of the Global food production is in rain-fed areas (Green Water).** (Cosgrove and Rijsberman, 2010).
- **70% of blue water is used for irrigation.**
- **Without blue water, Cereals production would decrease by "only" 20%.** (Siebert and Doll, 2010).

Global Total Consumptive Green and Blue Water Use (km³/yr) in Rainfed and Irrigated Agriculture (Sulser et al., 2010)

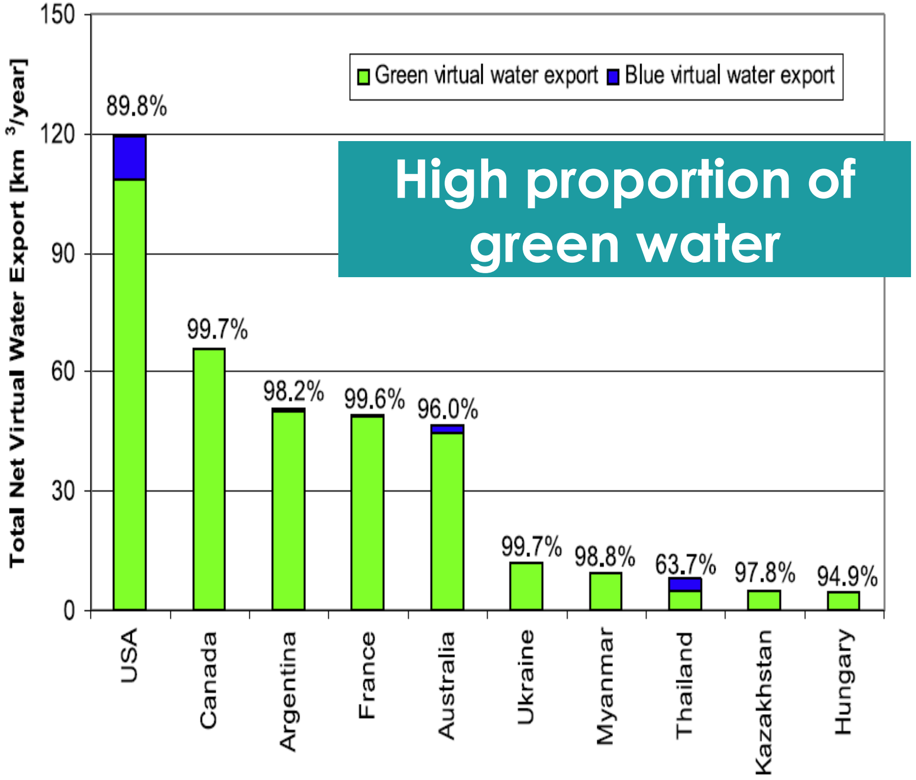


	Year 2000	Year 2025	Year 2050
Rainfed (Green Water)	3272	4539	4663
Irrigated (Green Water)	1703	2457	2611
Irrigated (Blue Water)	1425	1603	1785

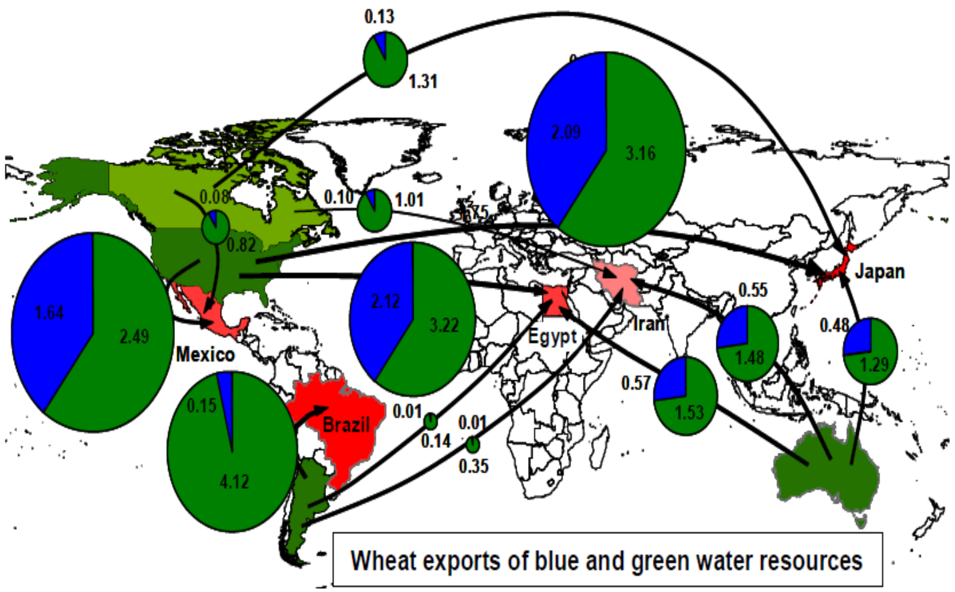
Irrigated green water is harvested from precipitation and used for irrigation.
Blue water is river and surface water

Investing in Green Water!
Green Virtual Water Trade

Total net blue and green virtual water export in major exporting countries (17 crops). Average over 1998–2002 (Liu et al., 2009)



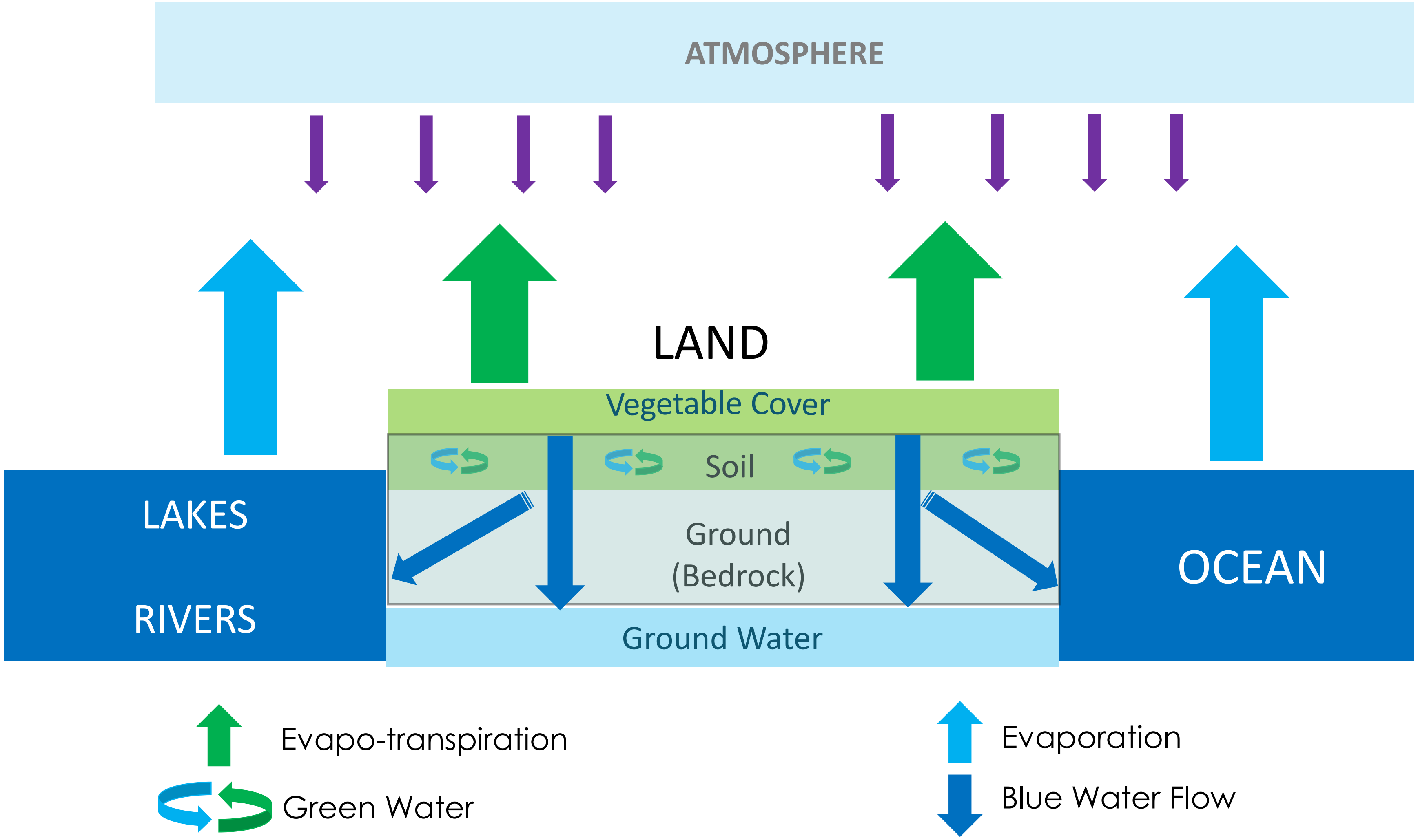
High proportion of green water



Green and **blue virtual-water trade** related to **wheat trade** (km³/year). Period 2000-2004

(Aldaya et al., 2010)

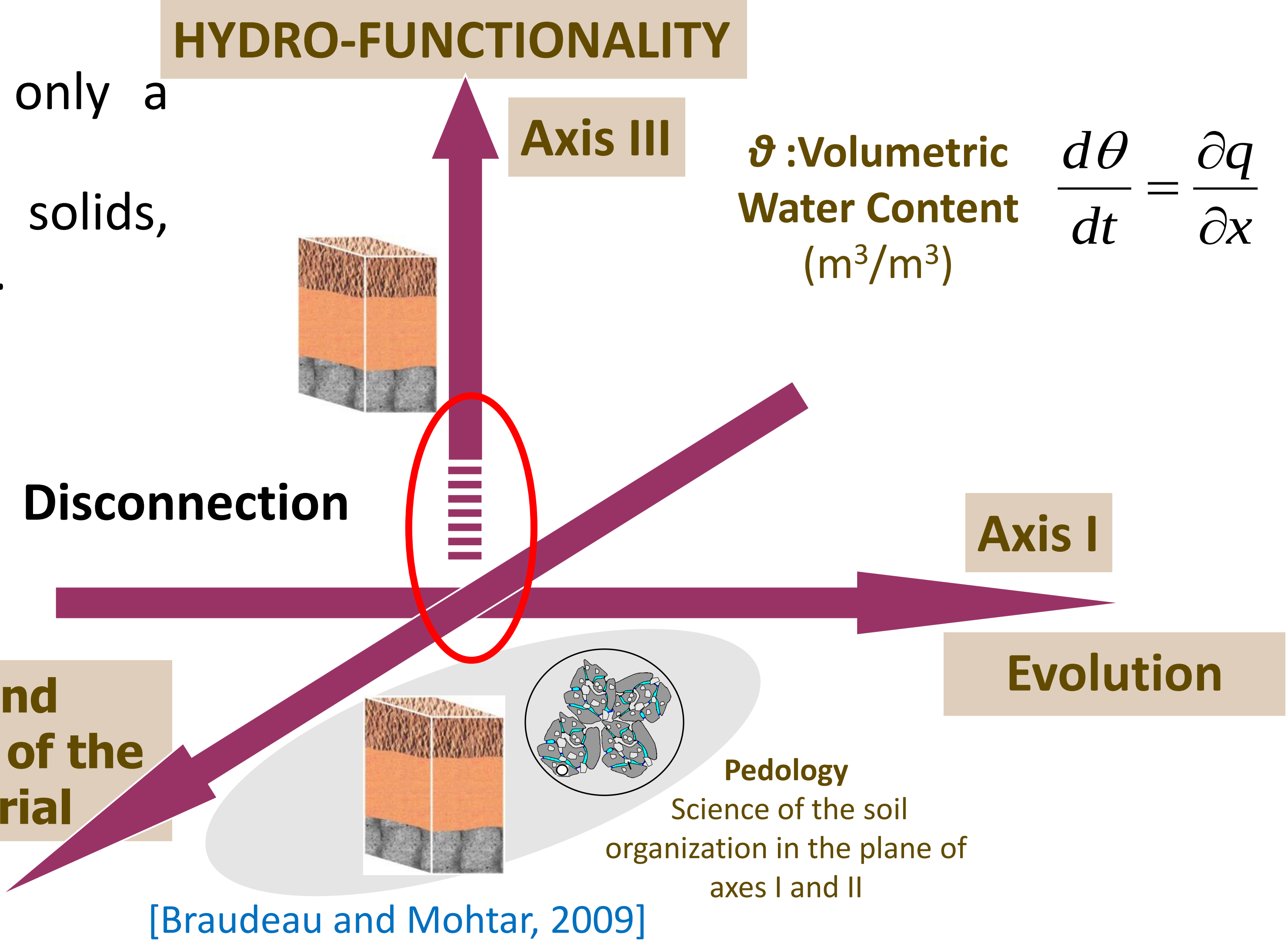
What is Green Water?



1. Rainwater **stored** in the soil as soil moisture?
2. **Storage and actual transpiration (**Gerten et al., 2005)?
3. **Storage and actual evapotranspiration).** Falkenmark and Rockstrom (2006)?

Soil Organization: An Ingredient to Understanding Soil

- Soil is NOT only a homogenous mixture of solids, liquid and air.

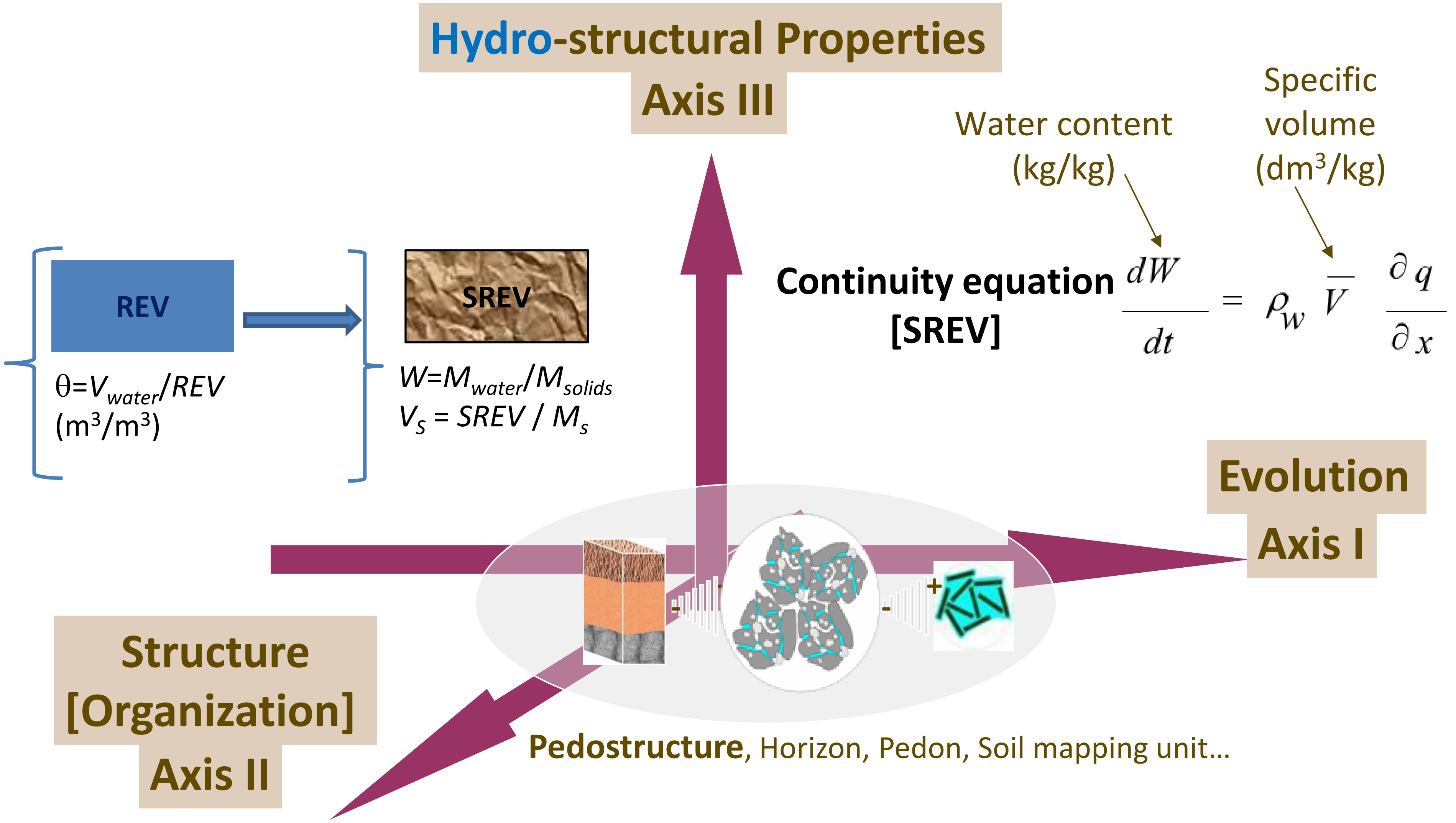


$$\frac{d\theta}{dt} = \frac{\partial q}{\partial x}$$

[Braudeau and Mohtar, 2009]

Accounting for Green Water

1. Linking the soil functionality with soil organization
2. Dynamic Soil Characteristics



$$\frac{dW}{dt} = \rho_w \overline{V} \frac{\partial q}{\partial x}$$

$\theta = V_{water}/REV$ (m^3/m^3)

$W = M_{water}/M_{solids}$

$V_S = SREV / M_s$

(Braudeau and Mohtar, 2009, Mohtar and Assi, 2018)

Pedostructure Characterization Lab

State-of-art apparatus (**Typosoil™**).

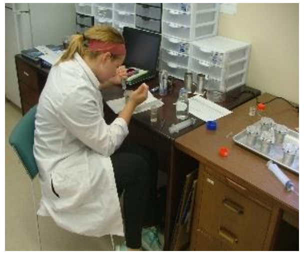
A new paradigm in soil physics: hydro structural Pedology

Main research activities

1. Long term impact of non conventional water reuse on soil health and reproductivity

2. Quantifying and accounting for green water and soil-water holding properties.

Water Management



1. **Efficient Water Management [Green Water Management].**
2. **Impact of Soil Health and Productivity.**

Biochar Additives

Greywater for Irrigation

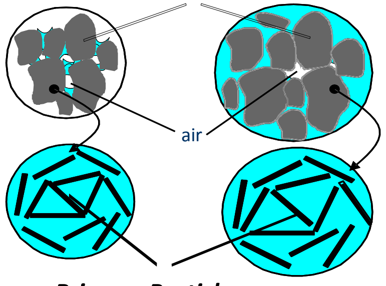
Treated Wastewater for Irrigation

Erik Braudeau, Amjad T. Assi, Rabi H. Mohtar. (2016). **Hydrostructural Pedology**. Wiley-ISTE. 186 pages. ISBN: 978-1-84821-994-6 Link to English Version. Link to the lab: https://wefnexus.tamu.edu/pedostructure-characterization-lab-2/

Pedostructure Concept

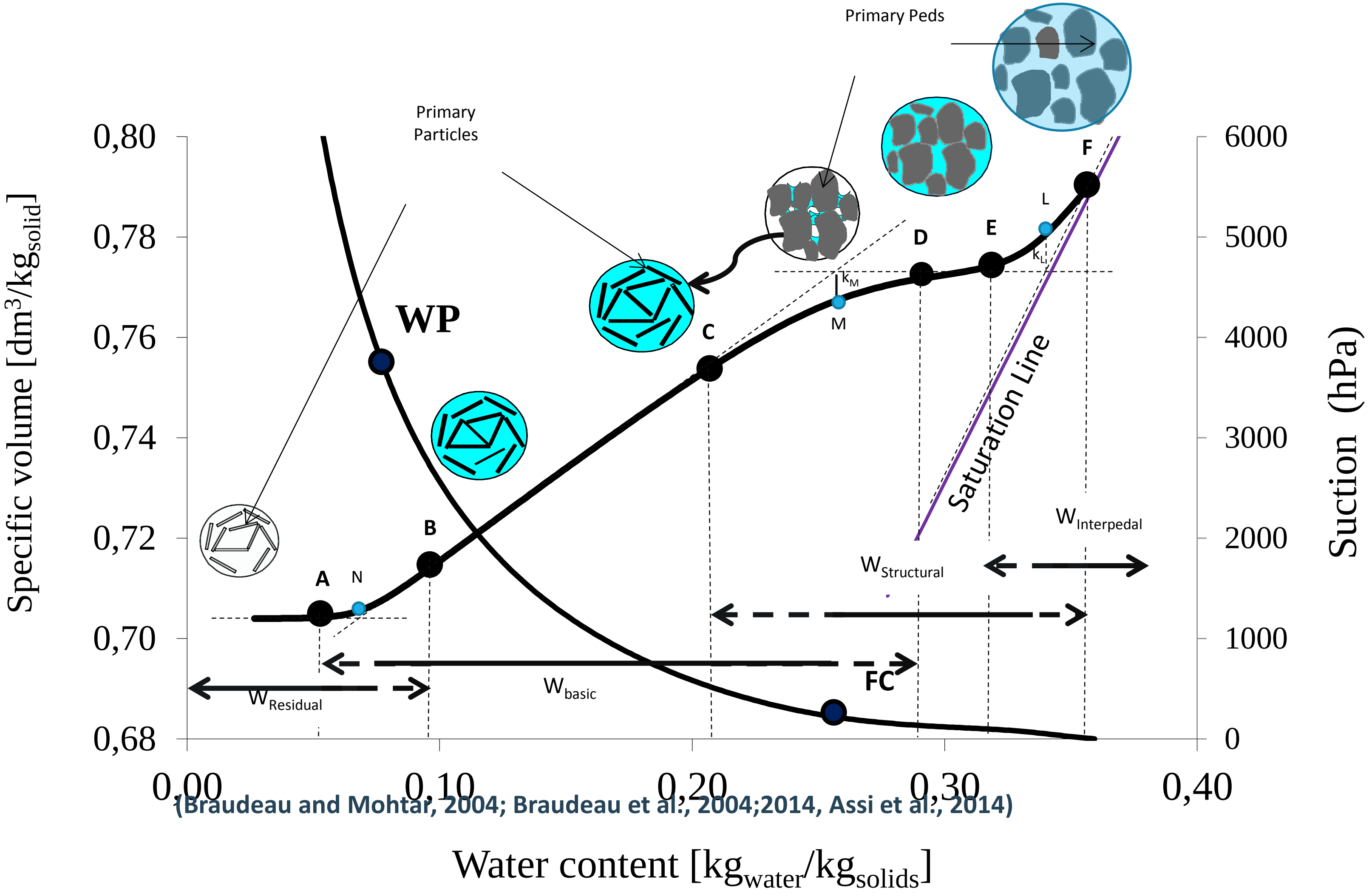
[Soil Aggregates Structure and Its Thermodynamic Interaction with Water]

Standard Soil Core (Φ=5cm, h= 5cm) ~ 100 cm^3



Pedostructure

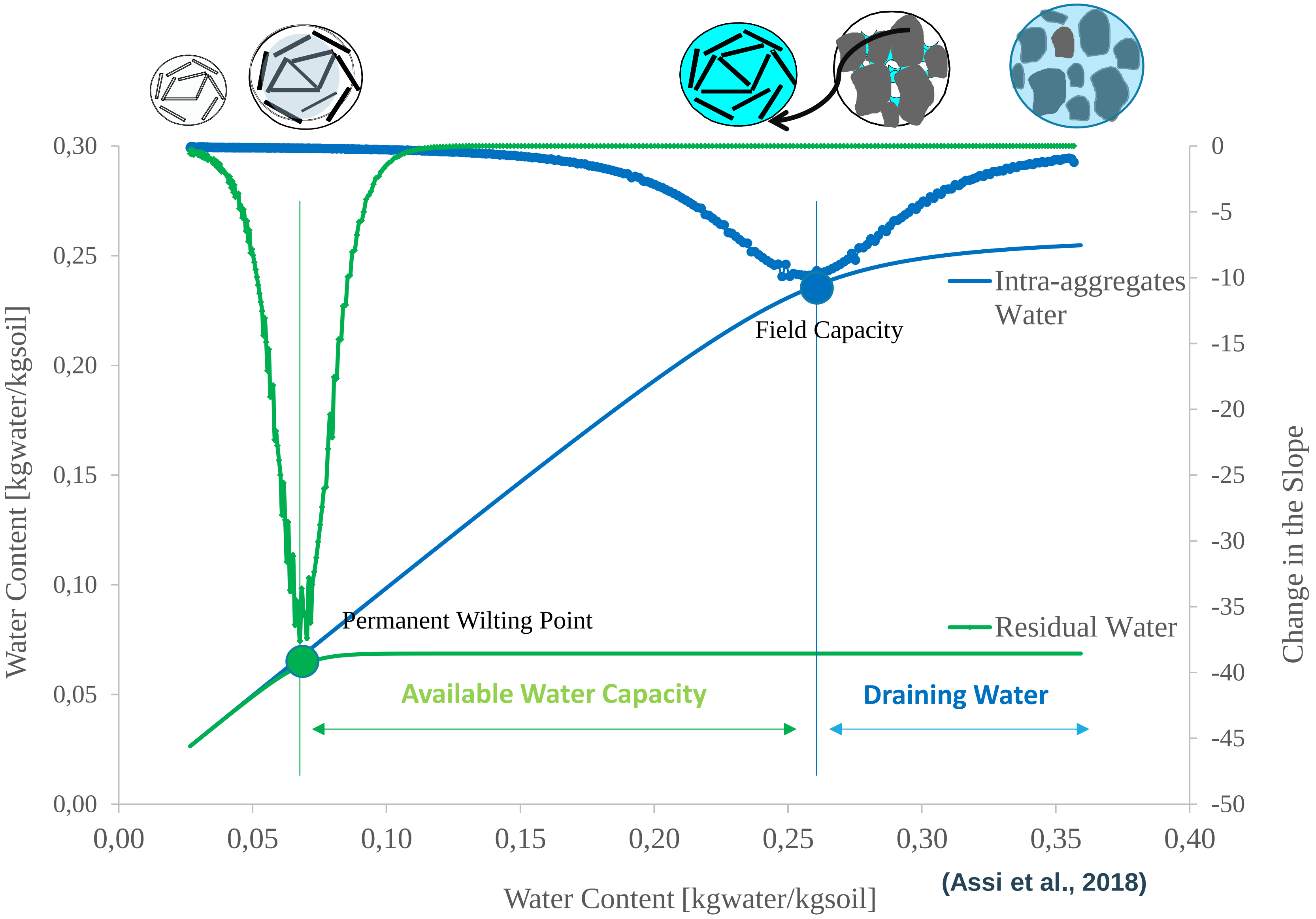
[Soil medium organization as an assembly of primary peds]



(Braudeau and Mohtar, 2004; Braudeau et al., 2004;2014, Assi et al., 2014)

Pedostructure Characterization Lab

[Quantifying and accounting for green water and soil-water holding properties]



(Assi et al., 2018)

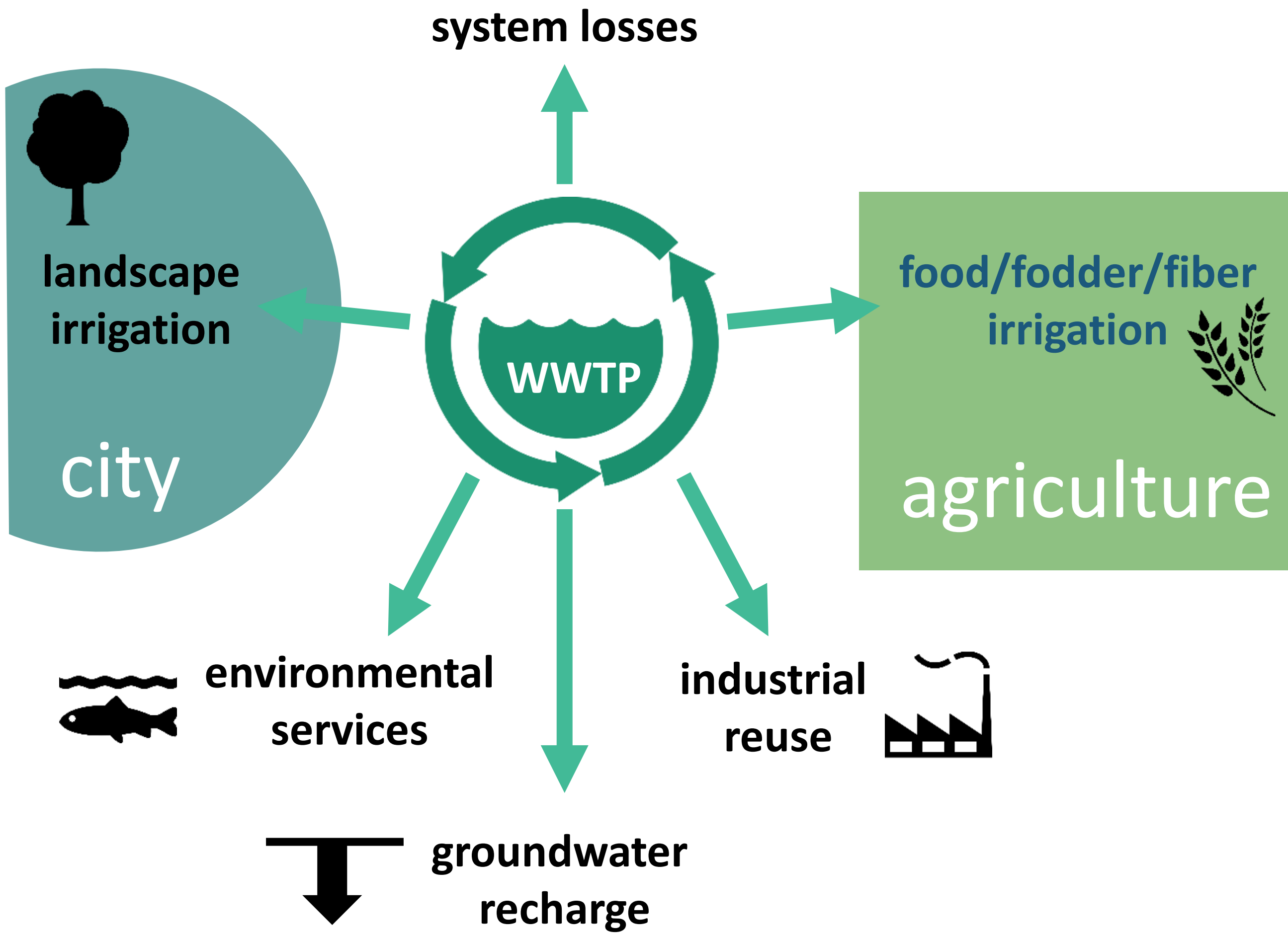
Approach to Study the Feasibility of Wastewater Reuse for Agriculture

- Consider outlets for reclaimed water

- Determine quantity available for agriculture

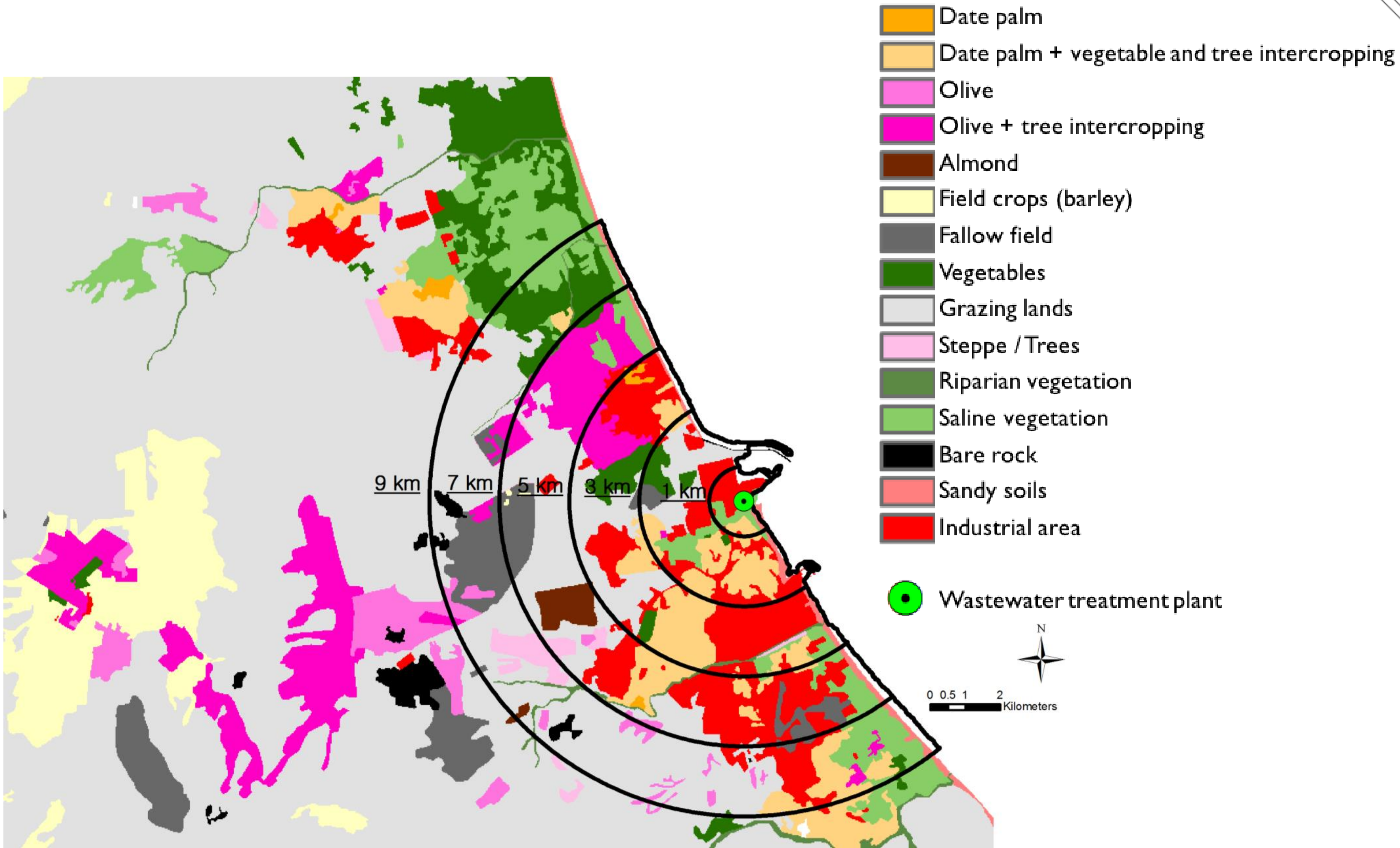
- Map agricultural water demands

- Evaluate water - energy - food nexus tradeoffs as a function of …



Potential for water reuse in agriculture: *A water - energy - food nexus approach*
www.wefnexus.tamu.edu

Case Study: Gabès, Tunisia



Case Study: Gabès, Tunisia

Water

6.2 MCM/yr
made available

Energy

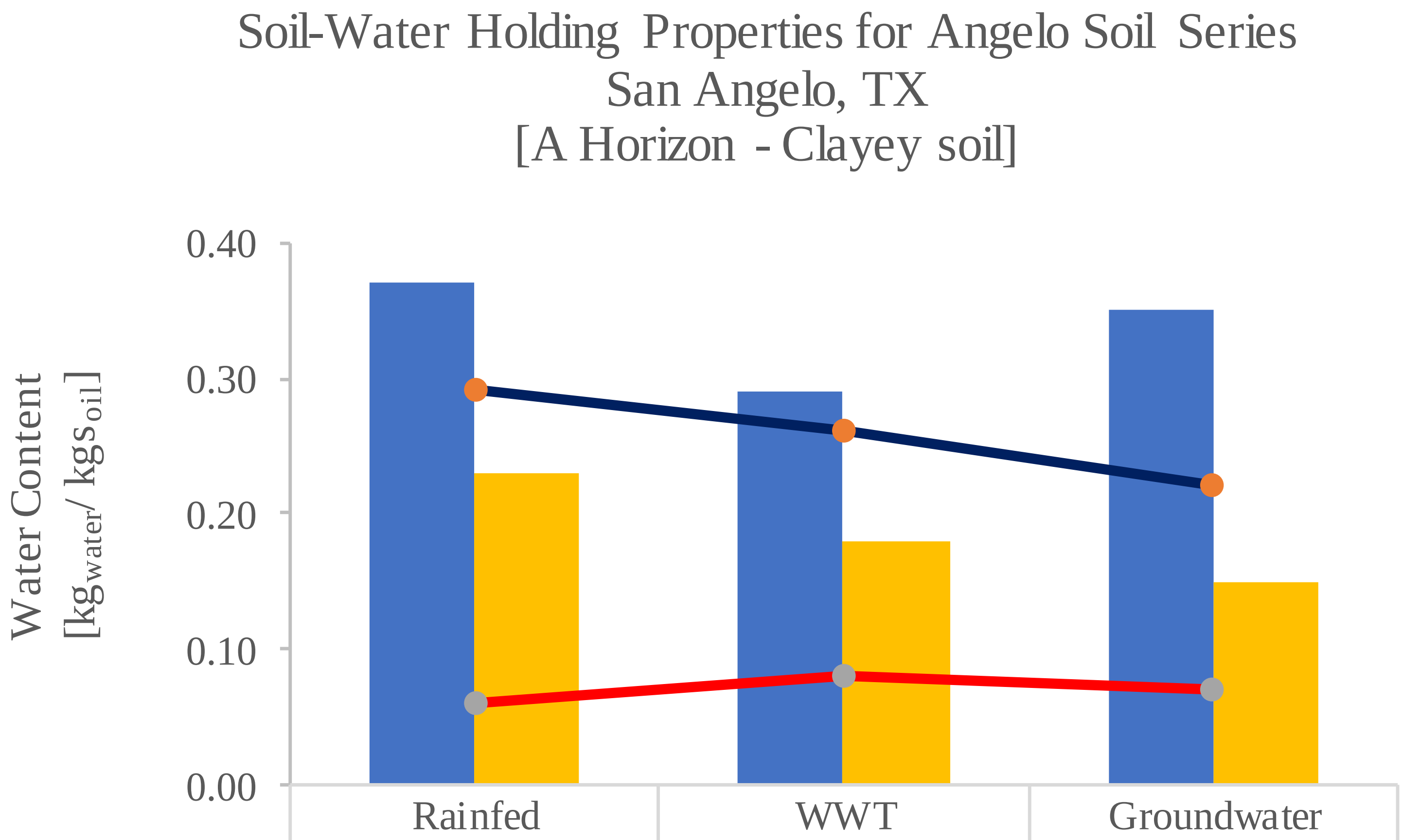
Pumping/trucking
vs.
abstraction

Food

3,646 ha
irrigated crops

Example: The Impact of Wastewater Reuse on Soil-Water Holding Properties

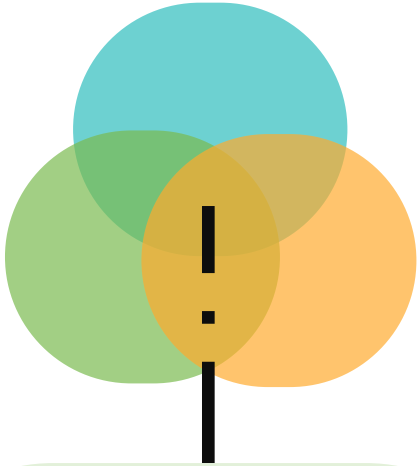
- More than 10 years of WWT reuse in a cotton field in San Angelo, TX.
- The famer reported an increase in the cotton yield with wastewater reuse.
- The analysis shows a change in the soil-water holding properties.
- Implications on water and nutrient management are being studied.



	Rainfed	WWT	Groundwater
Wsat	0.37	0.29	0.35
Available Water	0.23	0.18	0.15
FC	0.29	0.26	0.22
PWP	0.06	0.08	0.07

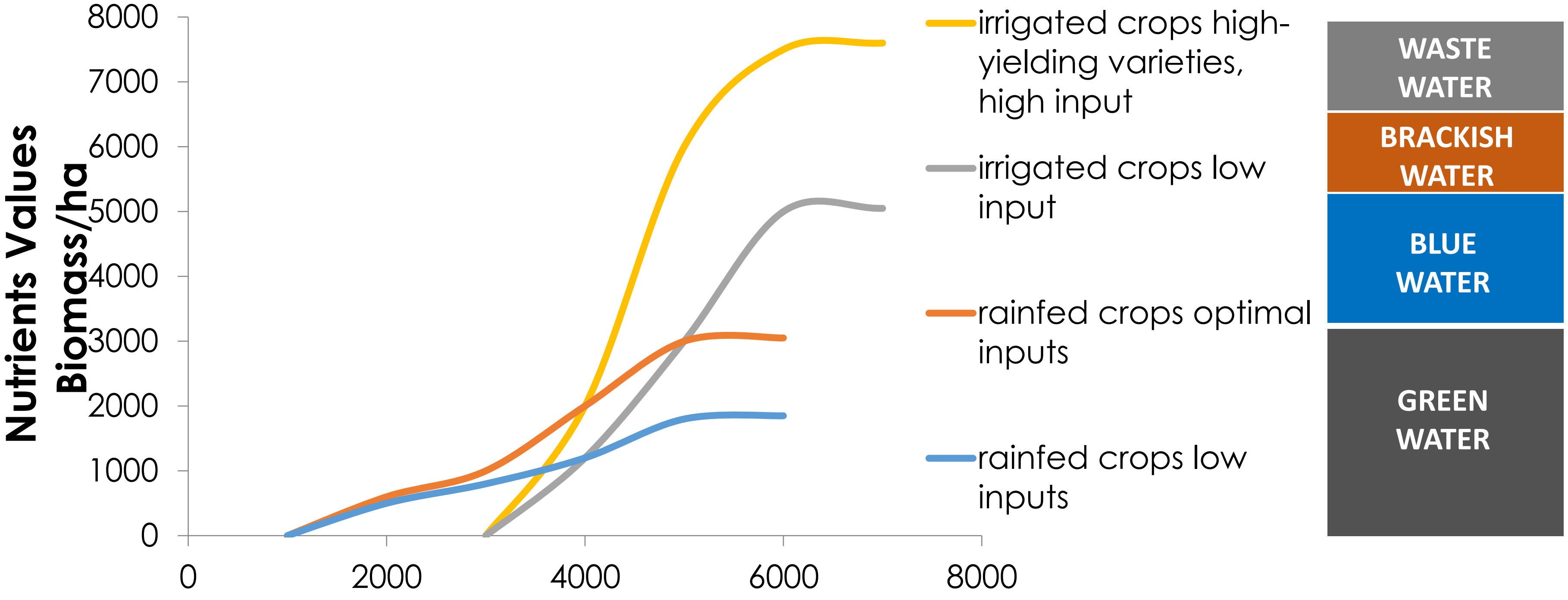
(Loy, Assi and Mohtar 2017)

Example of Synergies: Towards Water Productivity and Valuing Resources: Efficiency is Necessary, but not Sufficient



Footprints Calculations is a Key for Successful Trade-offs Analysis and Decision Making

How do we quantify the impact of water reuse on soil health and productivity?



Water Used/ha

Energy Used/ha

Air and Water Quality

Impact on Soil Health

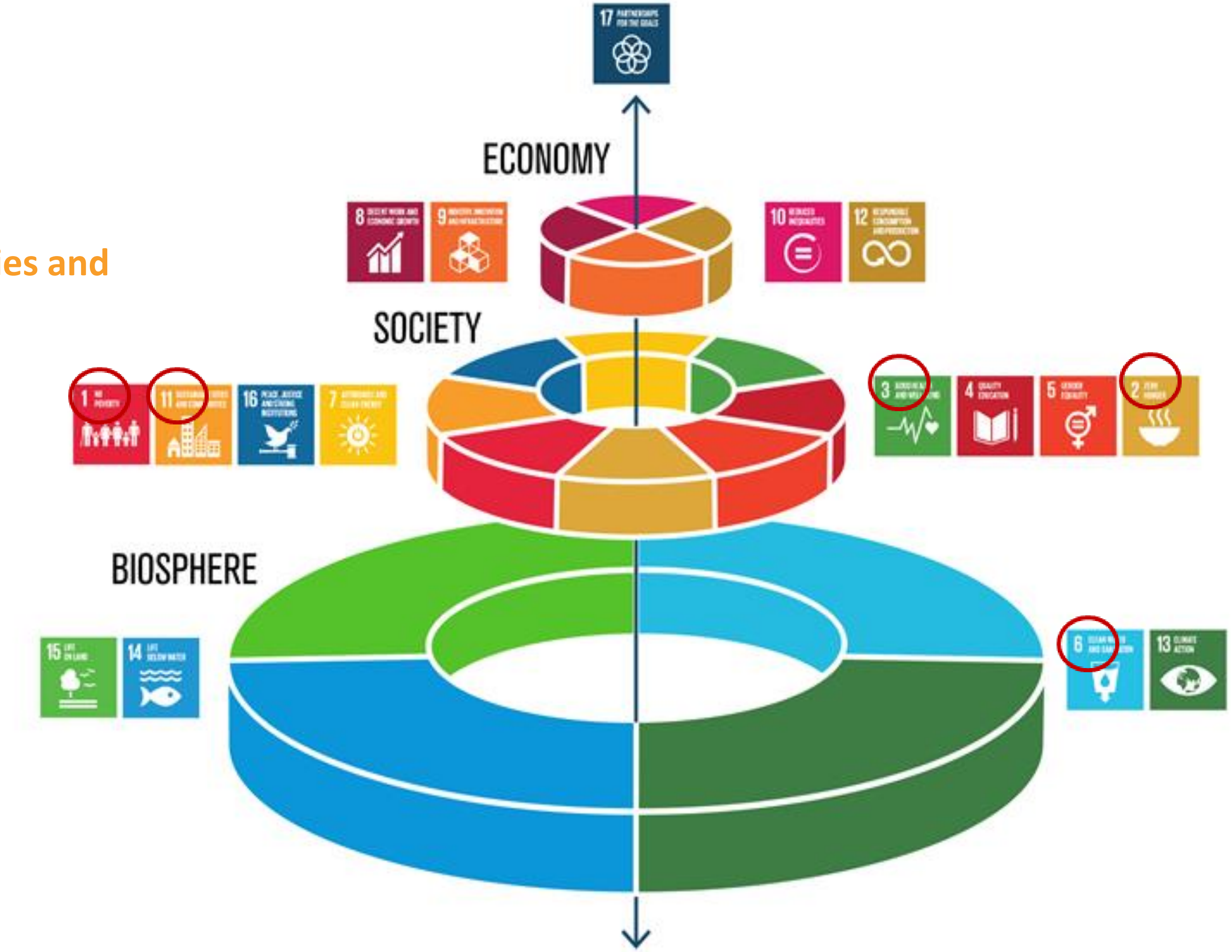
Health Risk

(Mohtar, 2014)

Significance of Alternative Water in Addressing SDGs

1. No Poverty

11. Sustainable Cities and Communities



2. Zero Hunger

3. Good Health and Well-being

6. Clean Water and Sanitation

Concluding Remarks

Green Water:

Develop a functional definition for the Green Water.

Develop quantitative methods for accounting for Green Water.

Develop methods for GW Soil-Plant-Atmosphere Continuum at Field & watershed scales.

New Water:

Non-traditional water for irrigation in arid and semi arid agricultural.

Quantify long term impact of reuse on soil health & productivity

Quantify inter-linkages & tradeoffs of social & environmental risks & water allocation strategies

Thank you!