Dimensions of the Water-Energy-Food Nexus

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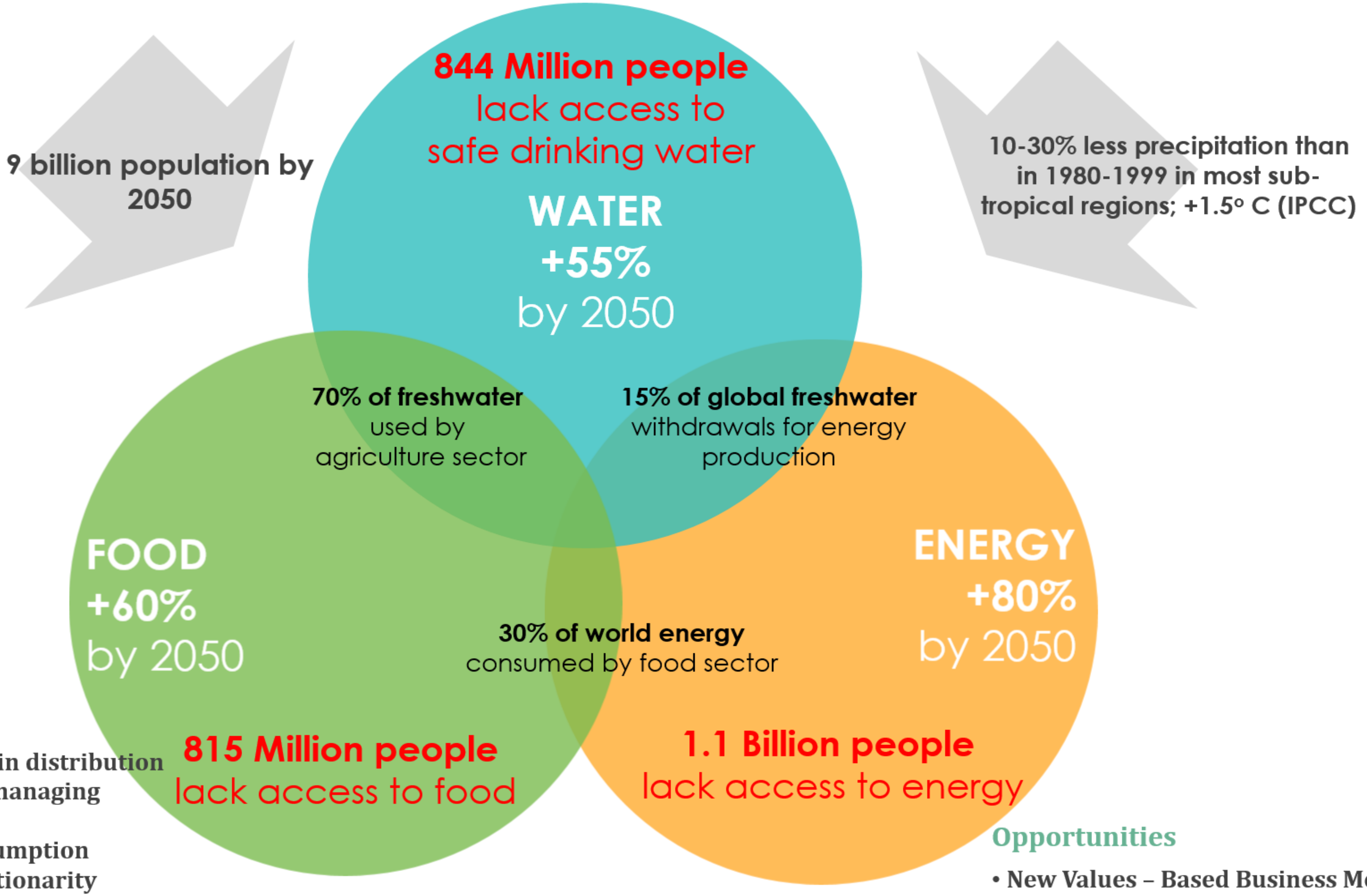
Outline

WEF Nexus Research Group

- Who We Are
- The Global Water-Energy-Food security
- Resources Nexus and applications
- Pedostructure concept
- Applications to soil & water management
- Concluding remarks



Challenges

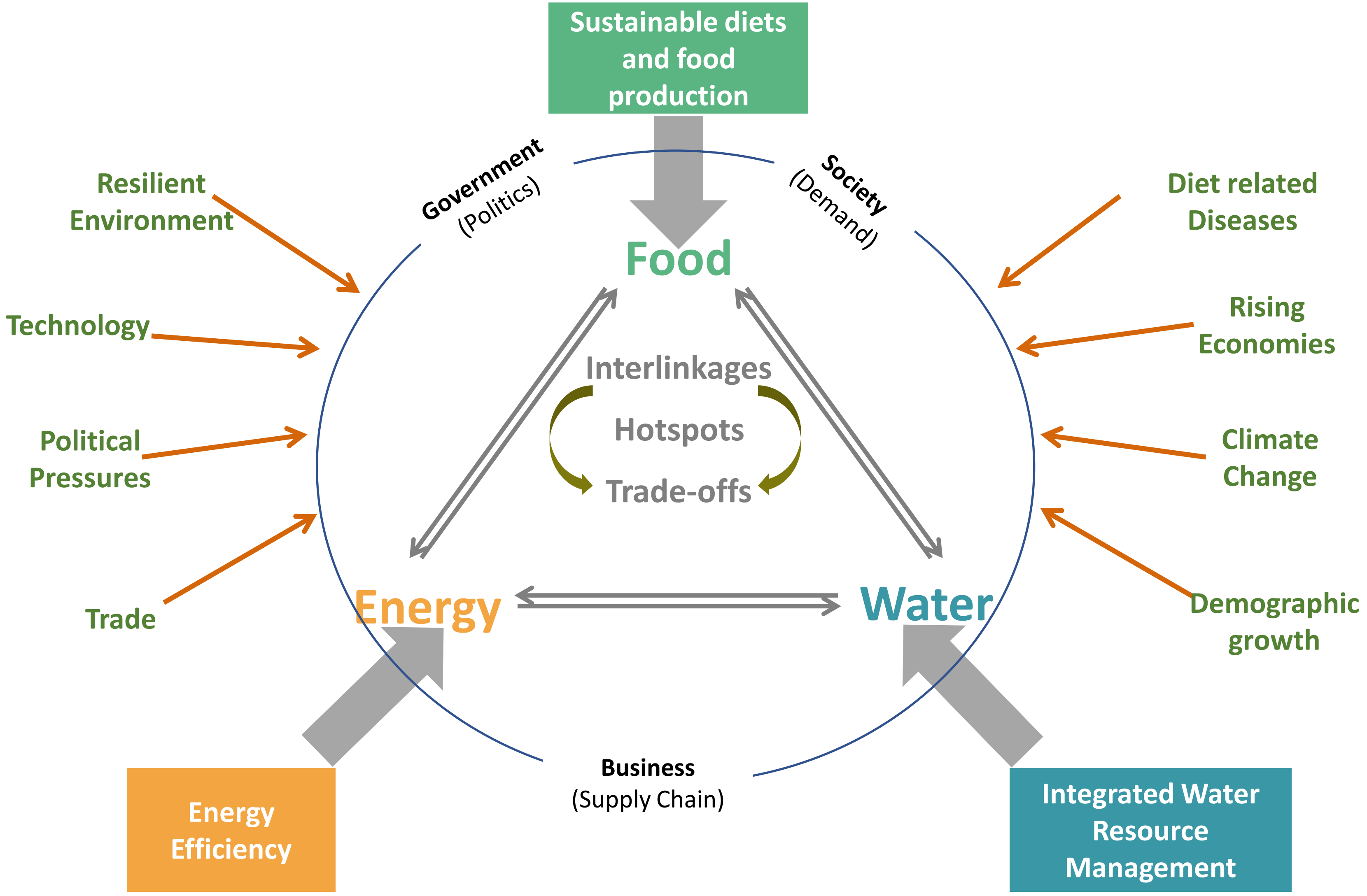
- Inequity & variability in distribution
- Allocation model for managing resources
- Non-sustainable consumption
- Extremes and non-stationarity
- Non-sustainable business model

Opportunities

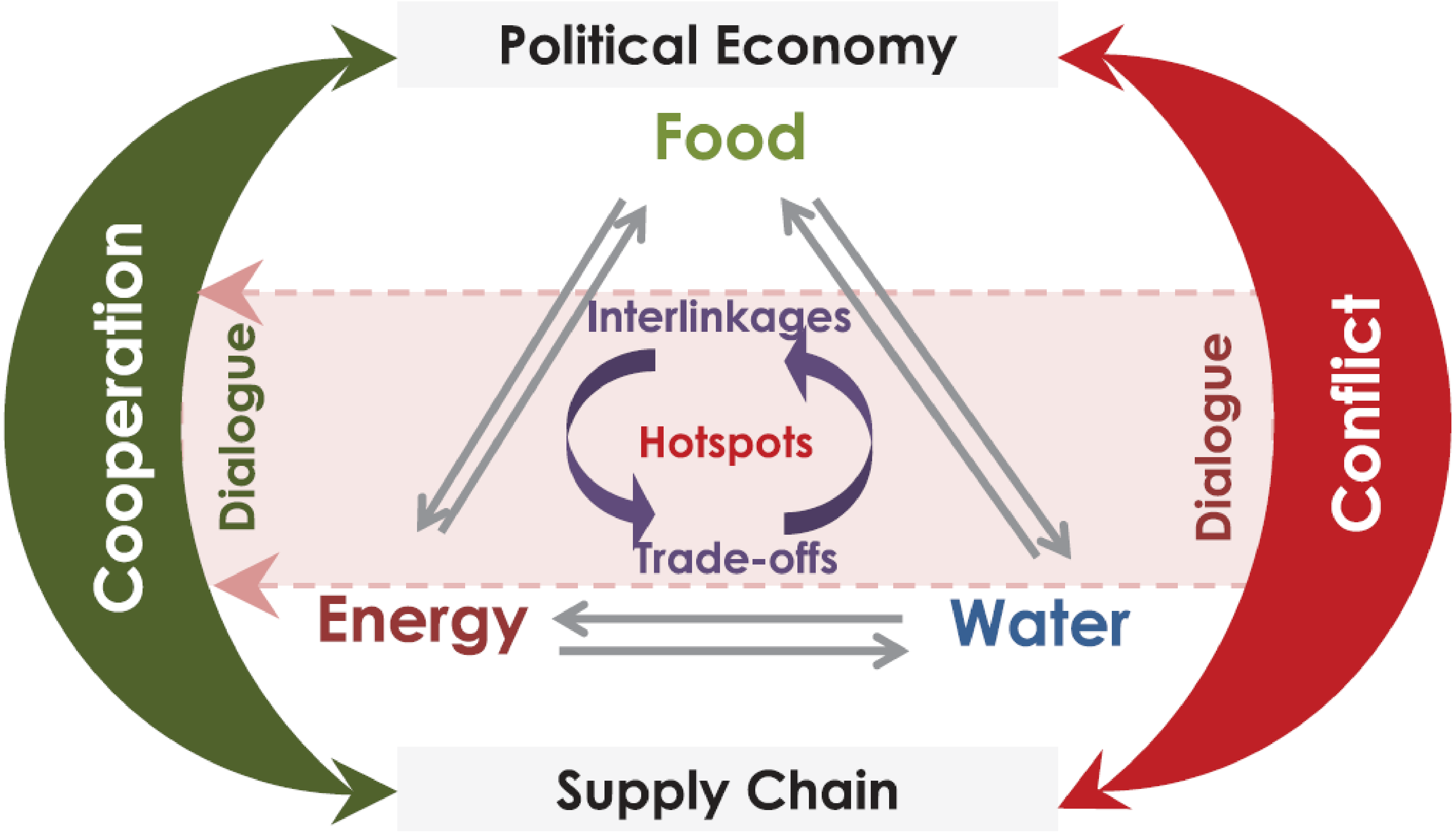
- New Values – Based Business Model
- Resilient/Sustainable Communities

Mohtar (2021)

A Systems Approach is Needed to Address Water, Energy, Food Securities



WEF Nexus Framework:
From Science to Politics and the Nexus



Rabi H. Mohtar and Bassel Daher (2016). **Water-Energy-Food Nexus Framework for Facilitating Multi-stakeholder Dialogue**, *Water International*, DOI: 10.1080/02508060.2016.1149759

Selected WEF Nexus Case Studies from Around the World

Food Security (Qatar)	**Water Gap** (Texas)	**Fracturing-Water-Transportation** (Texas)	**Renewable Energy Deployment**	**WEF Nexus in** Mekong Basin	**WEF Nexus in Gediz Basin** (Turkey)
Phosphate Industry (Morocco)	**Hydropower & Food Security** (Nigeria)	**WEF and SDGs** (Morocco)	**WEFN Nexus in** Lebanon	**WEF Nexus in San Antonio** (Texas)	**WEF Nexus in Matagorda** (Texas)

Success stories around the world

Web-Based WEF Nexus Tool

ADMIN interface

Local Characteristic Data

- Local Yields
- Water Requirements
- Energy Requirements
- Land Availability
- Import Data
- Other

Science

NEXUS 1.0

A Resource Management Strategy Guiding Tool

USER interface

Scenario Components

- Food Self-Sufficiencies
- Water Sources and Amounts
- Energy Sources and Amounts
- Sources of Import Countries

Policy

Tool Output

Water Requirement (m3)	**Financial Requirements ($)**
Local Requirement (ha)	**Energy-Import (kJ)**
Local Carbon Emissions (ton CO2)	**Carbon-Import (ton CO2)**
Land Requirement (ha)	

Sustainability Index of Scenario

WEF Nexus Tool 2.0

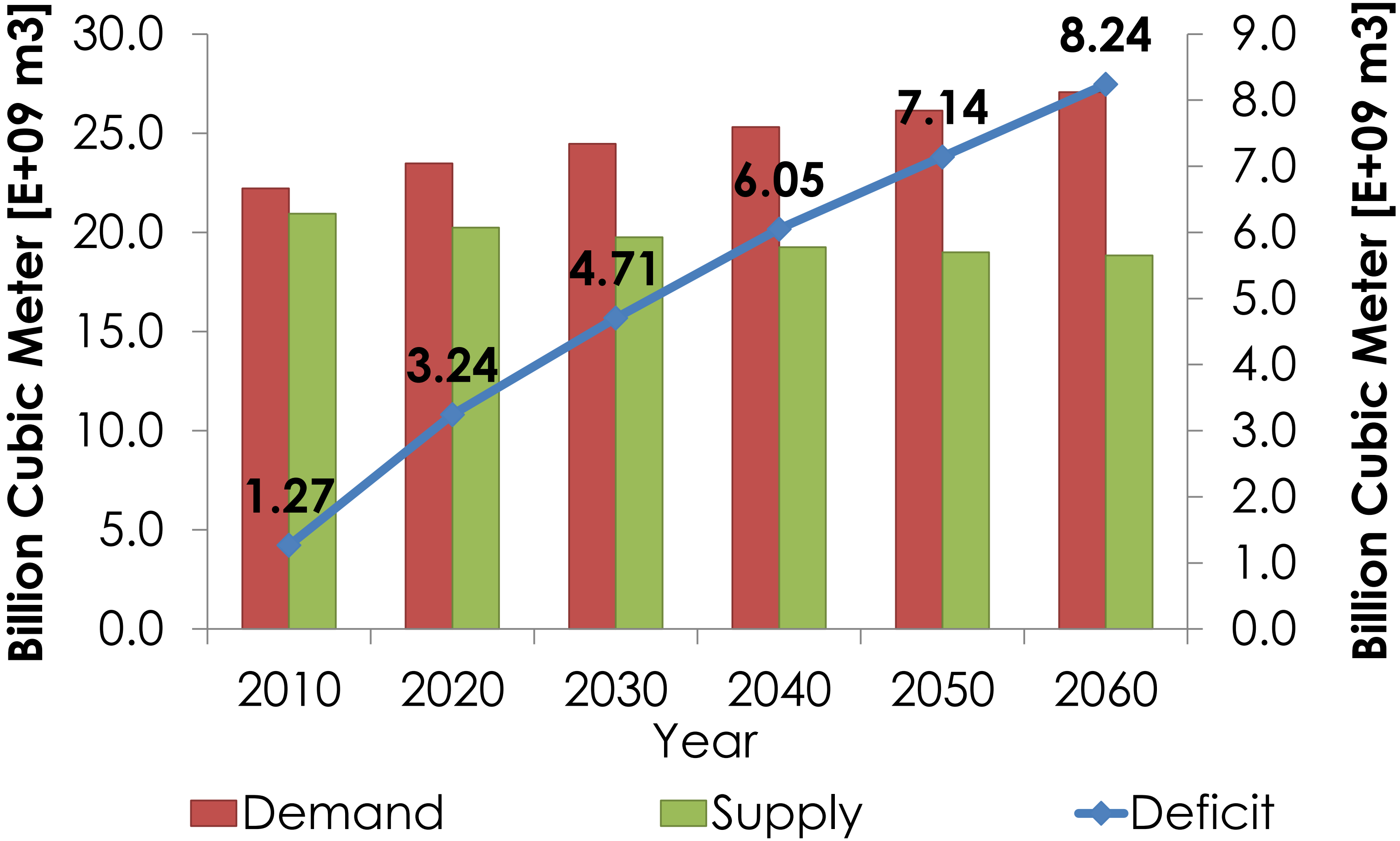
The Resource Management Strategy Guiding Tool

معهد قطر لبحوث البيئة والطاقة
Qatar Environment & Energy Research Institute
عضو في مؤسسة قطر
Member of Qatar Foundation

Mohtar, R.H., Daher, B. (2012). **Water, Energy, and Food: The Ultimate Nexus.** In *Encyclopedia of Agricultural, Food, and Biological Engineering Second Edition*, Dennis R. Heldman, Carmen I. Moraru (Eds.) (pp. 1-15) Abingdon, UK: Taylor & Francis. DOI:10.1081/E-EAFE2-120048376

Success stories around the world

Projected Water Deficit in Texas Mirrors the Global Trends



<u>By 2060:</u> **8.24 Billion** cubic meters of NEW water supply is needed.

Source:
TWDP – 2012 State Water Plan

Texas Water Gap

Lubbock:

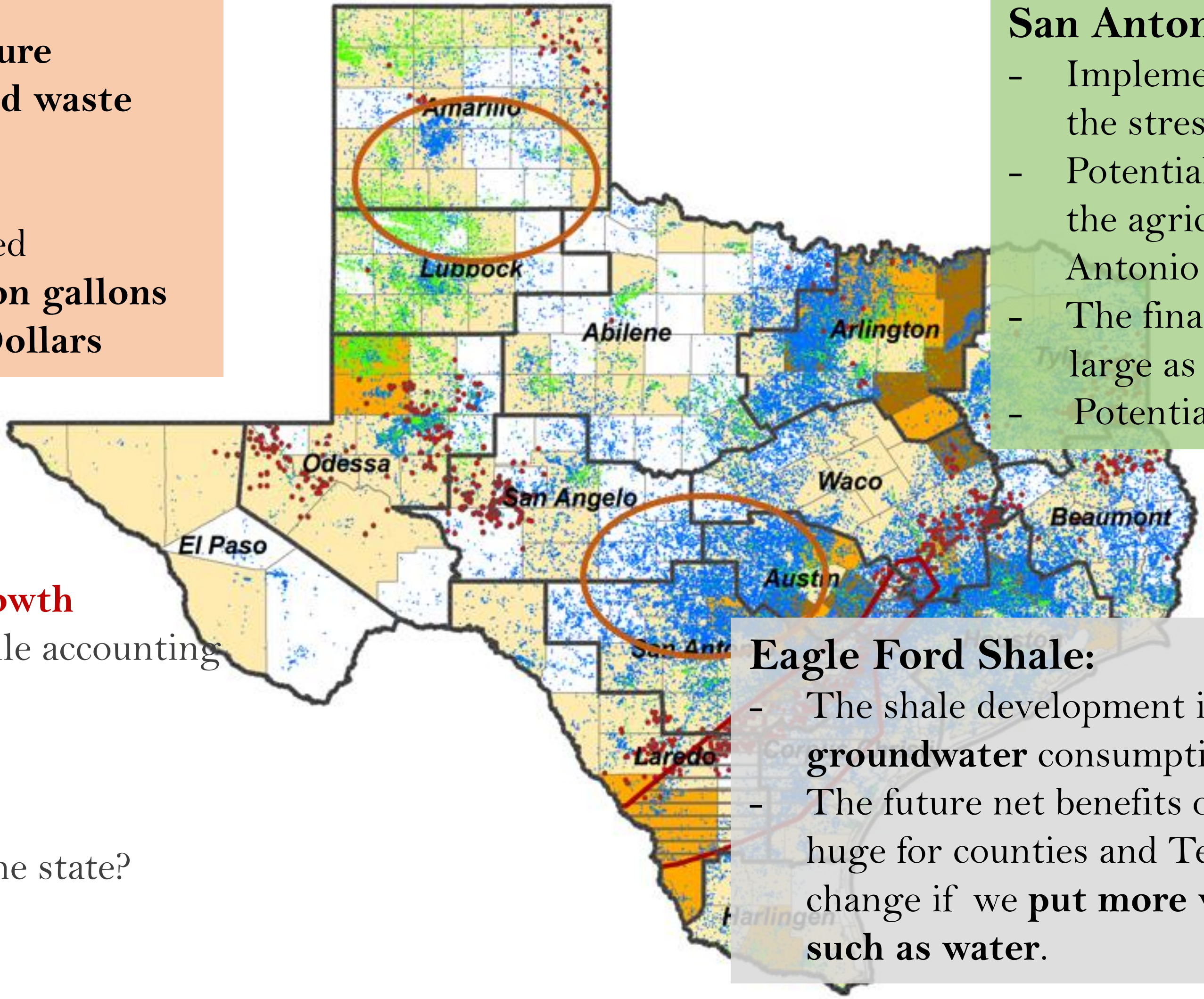
- Encourage **dry land agriculture**
- Increase reliance on **reclaimed waste water** for agriculture
- Invest in **renewable energy**

→ **Financial investment** required

→ Potential of bridging **3 billion gallons**
Potential cost: **121 Million Dollars**

San Antonio Region:

- Implementing LIDs would elevate some of the stresses on water for agriculture
- Potential of additional **47 billion gallons** to the agricultural water supply in the San Antonio region every year.
- The financial cost could be as large as **4 Billion Dollars**
- Potential for urban agriculture



How can we bridge the
Texas water gap
(8.9 Billion cubic meters in 2070),
given projected **population growth**
&**climate change stresses**, while accounting for :

- **variable water availability**
- **water demanding sectors**
- across **different regions** of the state?

Eagle Ford Shale:

- The shale development in Eagle Ford increases the **groundwater** consumption in South Texas
- The future net benefits of hydraulic fracturing industry are huge for counties and Texas, but the amount of benefit will change if we **put more value on other natural resources such as water**.

STOTEN Special Issue: reporting on the San Antonio Case Studies of the Texas A&M WEF Nexus Initiative (2015-2018).

Success stories around the world

Circular FAS

Inputs:

- Renewable Water
- Renewable Energy
- Recycled Nutrients

Outcomes

- Nutrition/Human Centric
- Reduced CO2 emission
- Reduced Chemical/ Biological Pollutants
- Reduced Food Waste and Loss
- Reduced Water, Land, Energy Footprint

Mohtar, 2021

Alternative Water for Food Sources

Soil as a Nexus Tool: The Role of Soil in Water & Food Security [Soil Health & Productivity]

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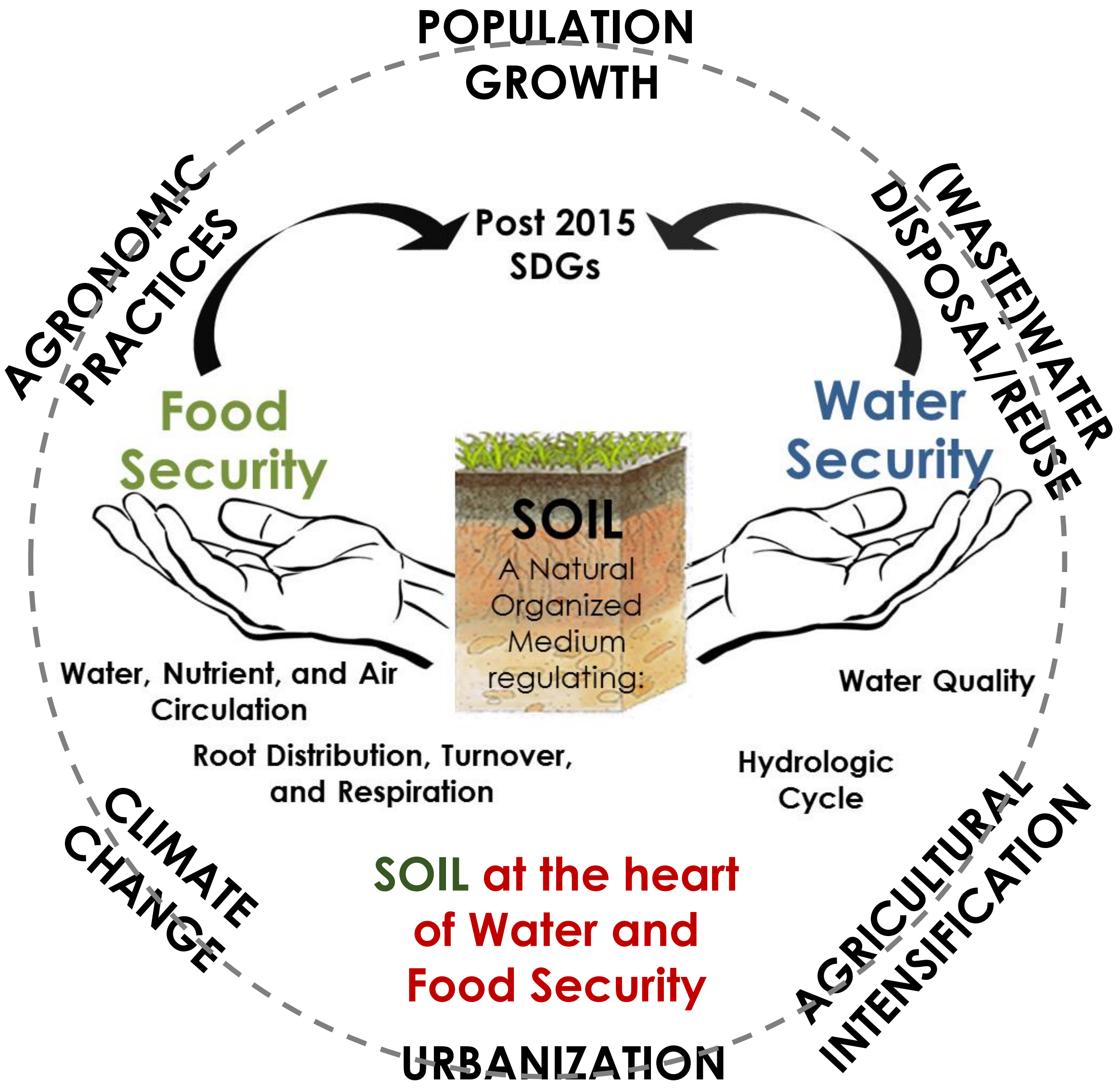


Soil Quality

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

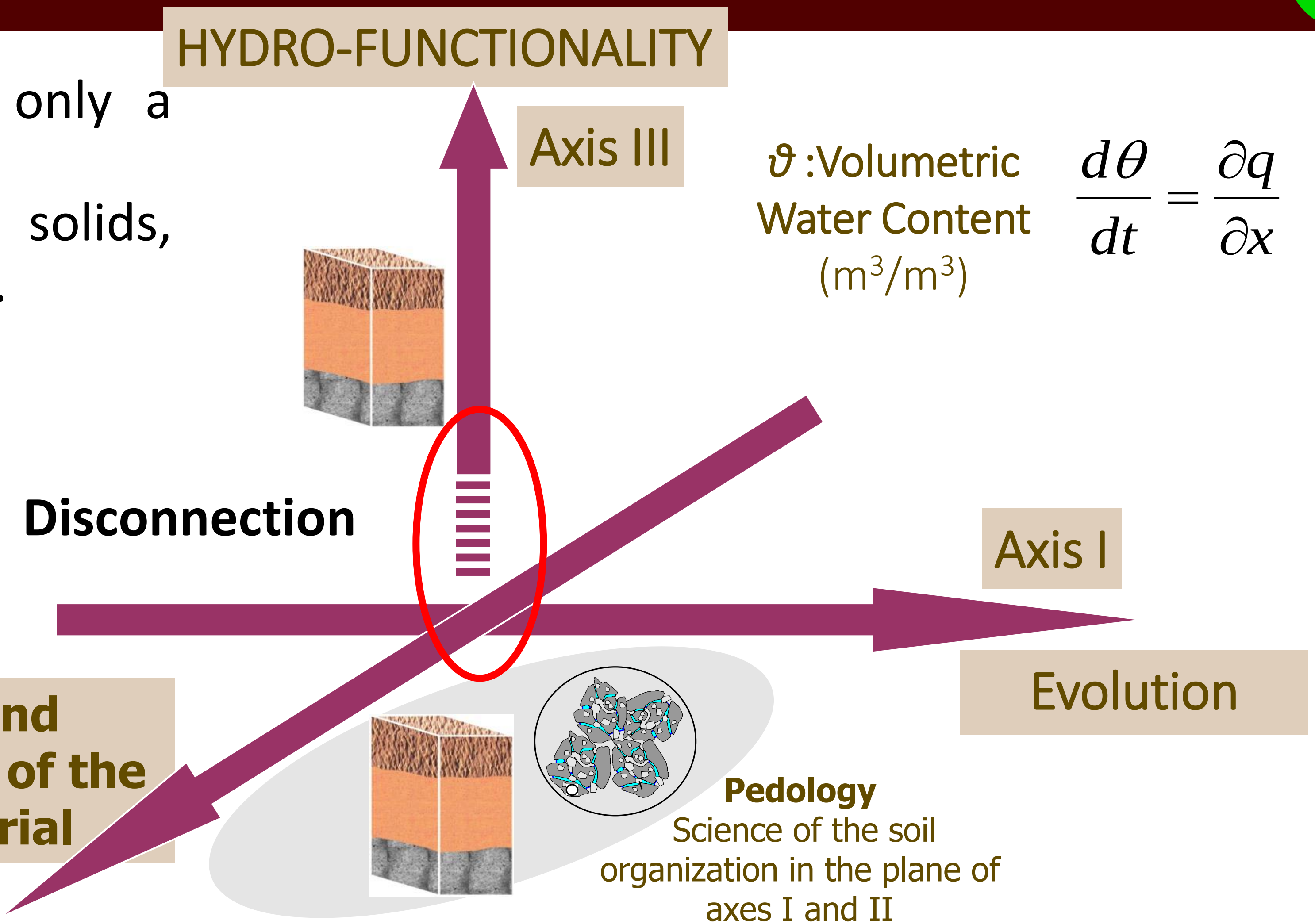
Characterization of Soil Medium

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

Mohtar (2021)

Soil Organization: Necessary to Understand Soil

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



[Braudeau and Mohtar, 2009]

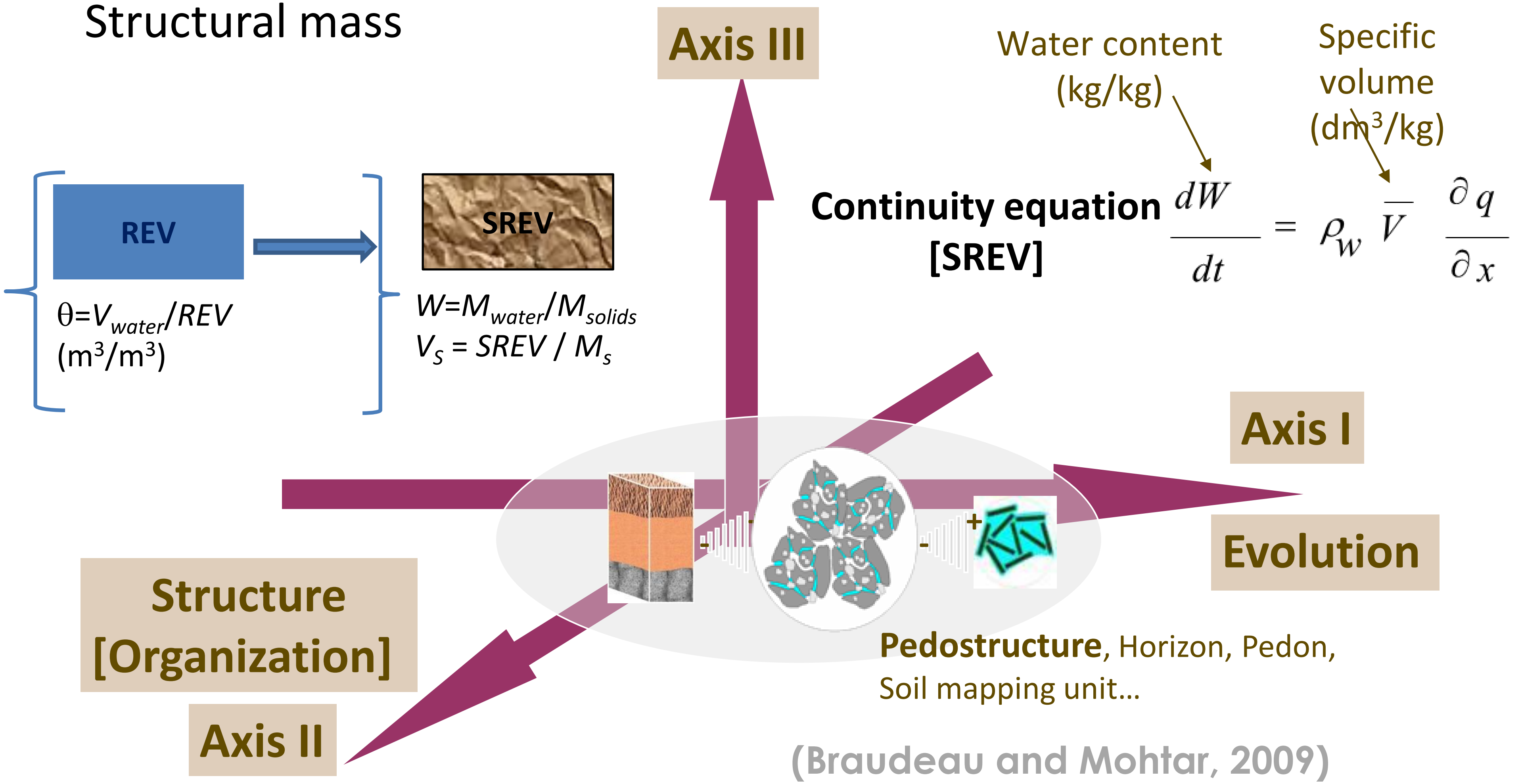
Hydro-Structural Pedology Paradigm [System Approach Theory]

WEF Nexus Research Group

➢Reference:

Hydro-structural Properties

Structural mass



(Braudeau and Mohtar, 2009)

Pedostructure Characterization Lab

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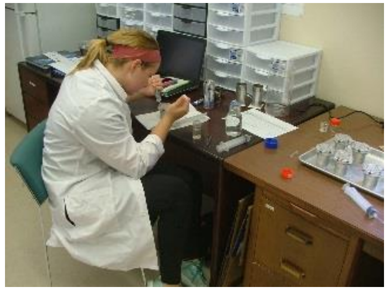
Typosoil™: facility based on a new soil paradigm:

1. Long term impact of non-conventional water reuse on soil health and productivity.
2. Quantifying & green water and soil-water holding properties.
3. Monitoring hydro-structural characteristics after applying different concentrations of biochar and carbon nanotubes soil additives

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 Characterization Lab

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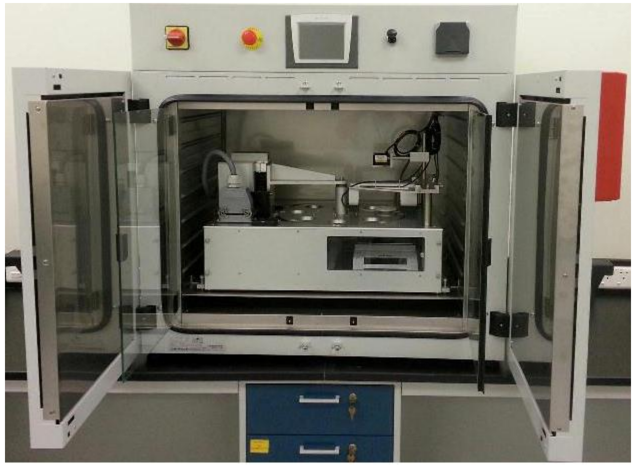
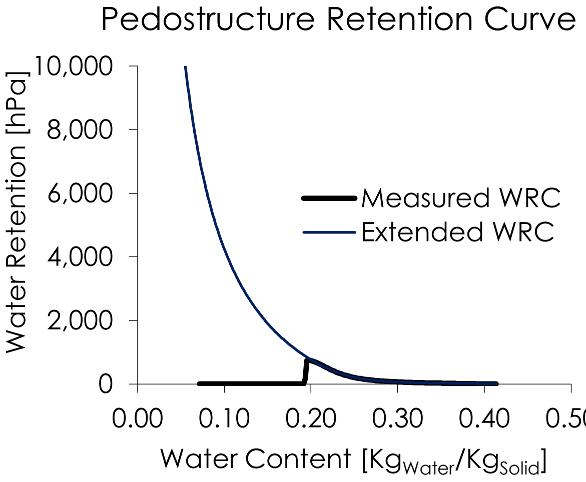
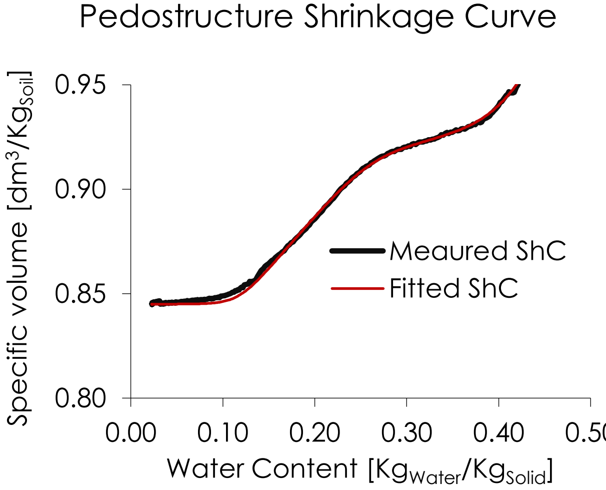
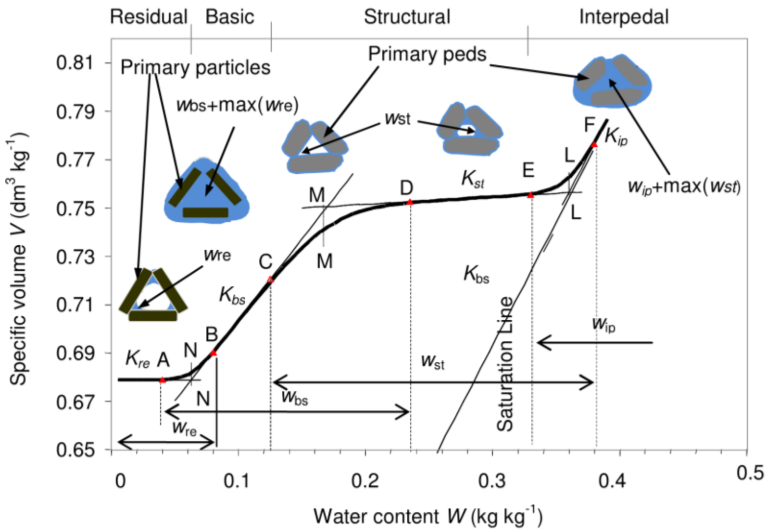
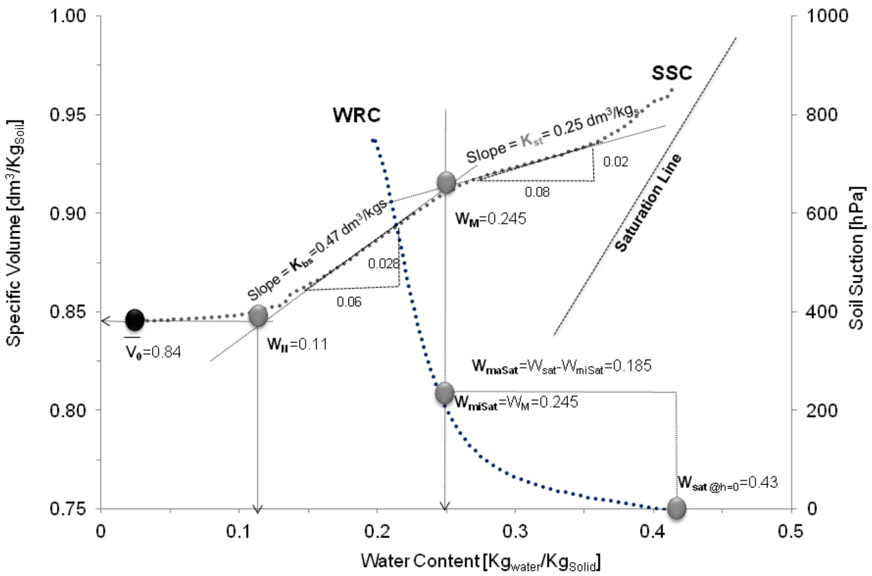






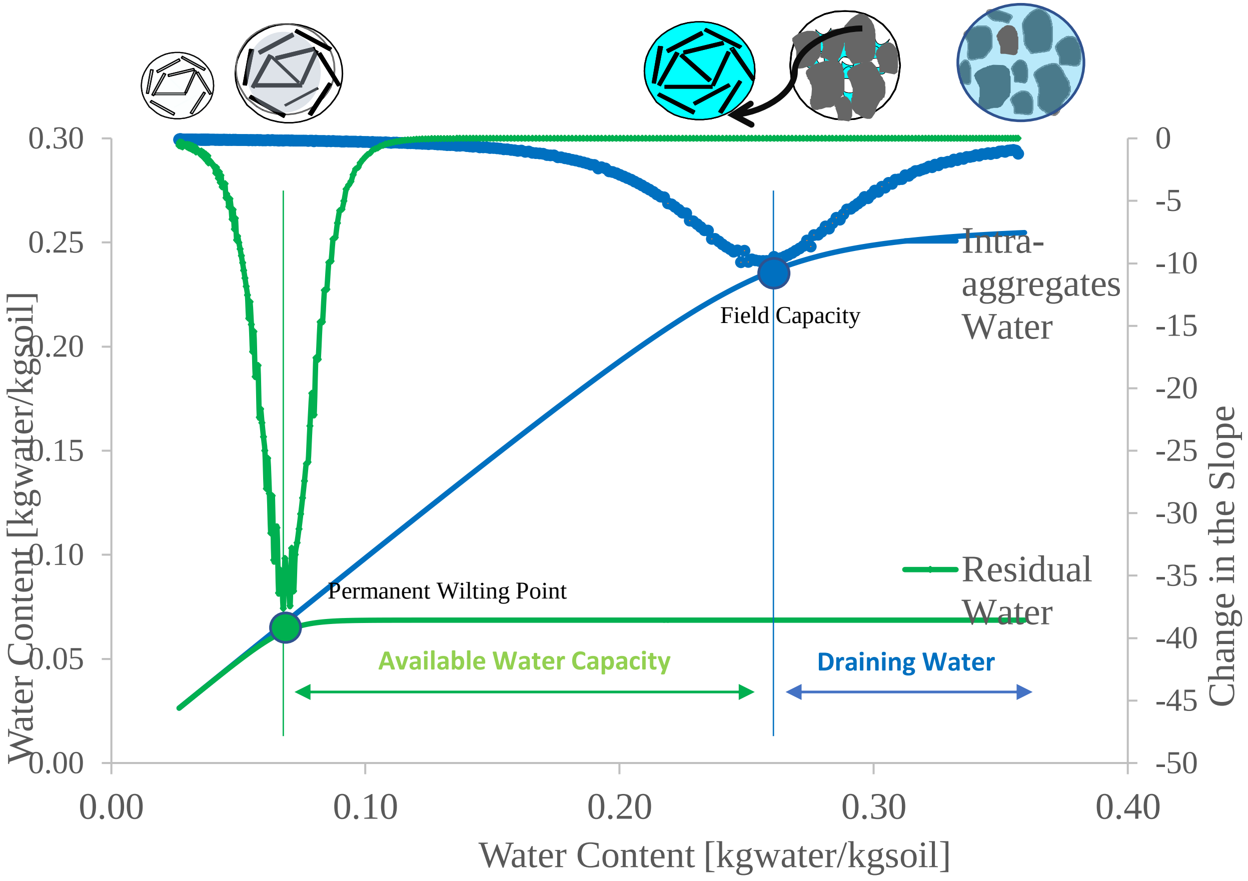




At Aggregates Scale [Pedostructure Scale]

(Assi et al., 2014)

Quantifying Soil-Water Holding Properties



Blake et al 2019

Computers and Electronics in Agriculture 86 (2012) 15–25

Contents lists available at SciVerse ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Cropping System and Soil Mapping

Toward delineating hydro-functional soil mapping units using the pedostructure concept: A case study

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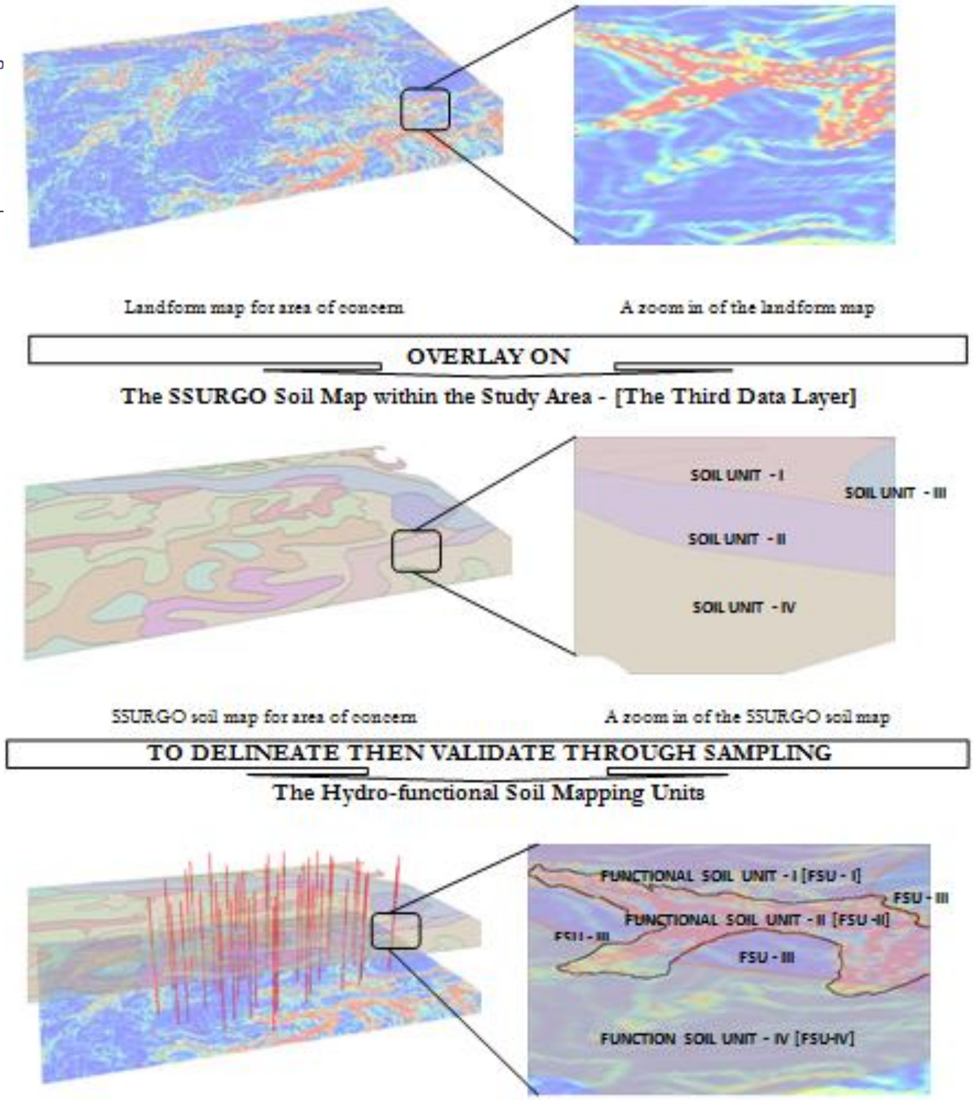
[b] Qatar Environment and Energy Research Institute, Qatar Foundation, Doha, Qatar
[c] Agricultural Biological Engineering Department, Purdue University, West Lafayette, IN 47906, USA
[d] Institute for Research Development, IRD, Bondy, France
[e] Agronomy Department, Purdue University, West Lafayette, IN 47907, USA

- Delineate a hydro-structural Soil Mapping Units.
- These units contains not only **qualitative** data but also **quantitative** data (hydro-structural parameters).
- These units can be used in Larger scale models to guide cropping system and land use management.



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Closing Remarks

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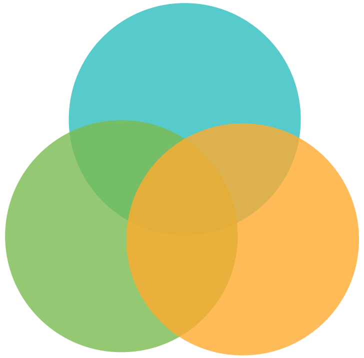
Today's Nexus



1. Projected resource gaps
2. Low resilience to climate change and increased demand
3. Inequity and variability in distribution
4. Trade-offs among interventions
5. Unsustainable FAS

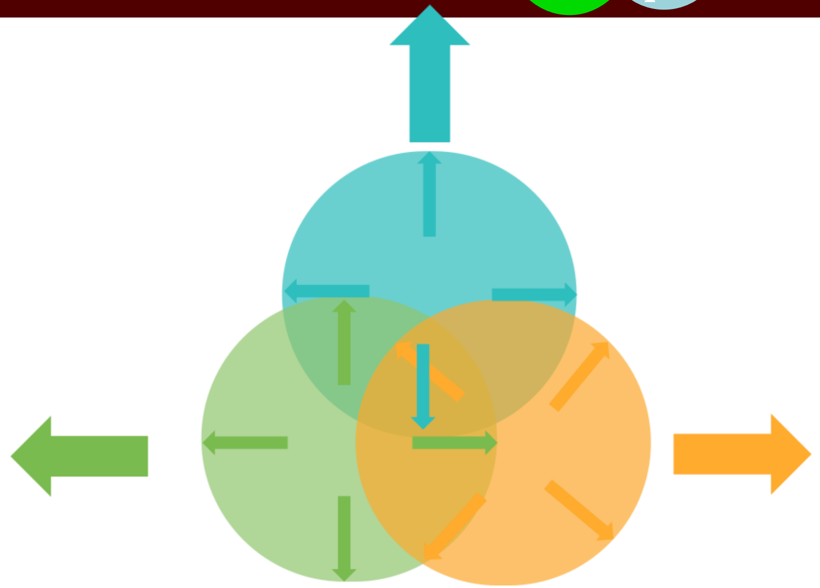
Future Leap

LEVERS

1. Technological/Science
2. Social
3. Political
4. Economic

ROLE for:

1. Private Sector
2. Public Sector
3. Civil Society



1. Create synergies
2. Reduce interdependencies
3. Improve equity and distribution
4. Achieve SDG
5. Improved resilience
6. Circular FAS (Soil at the core)

AccelNet-Design: Soil and Land Management for Food & Water Security, Adaptation and Mitigation of Climate Change

… soils interconnected system at the nexus of soil, water, land and climate systems.

Goals of Soil for Society Network:

i. *investigating* role of soils in water and food security and climate change adaptation and mitigation across scales and cultures,

ii. *implementing* research-driven hypotheses to develop new theories and applied research to address location-based solutions that incorporate local knowledge, economic and cultural values,

iii. *developing* a global platform for sharing transformative experiences via access to and synthesis of knowledge across multiple disciplines,

iv. *developing* a diverse, inclusive and equitable next generation (NextGen) workforce.

For more information, please contact us at: ALS-NET@gmail.com

THANK YOU!