John Venn (circa 1880)

Depicts Integration or Spheres of Influence

Also promotes endless philosophical discussions and lack of specificity or of detailed thinking...
Resilience & Adaptive Capacity Defined

The ability of a system to maintain desired performance in response to expected/unexpected challenges over time, while considering intra-system and inter-generational distribution of impacts and sustainability capital.
Components of Resilience

- Resilience Action Plan
  - Prioritization and Screening
- Principles of the Community Resilience Action Cycle - Community-Led: Build on what is there, Participatory, Evidence-Based, and Ensure we do no harm through being conflict-sensitive, gender-sensitive, and environmentally sensitive.
Resilient communities require resilient infrastructure and a means for assessing & integrating the outcomes into planning processes.
Identify & Map Resilience Indicators

Examples of Resilience Indicator Categories

- Social
  - Community
  - Governance
  - Policy & Planning
  - Services
- Economic
- Environmental
  - Built
  - Natural
  - General

- Sustainable Resilience
  - Horizon: achieved after or concurrently with wellbeing – ensures continued wellbeing and survival under uncertainty.
  - Needs: ability to systematically anticipate, prepare, respond, recover, adapt/transform through structured approaches (monitoring, analysis, planning, coordination, partnering, etc.).

- Well-being
  - Horizon: achieved after securing survival and sustained at acceptable levels of access and quality.
  - Needs: healthcare, education, services, amenities, etc.

- Survival
  - Horizon: immediate and sustained over multiple generations.
  - Needs: food, water, energy, shelter, safety, etc.
Food-Energy-Water Nexus & Connections to Resilience
<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Resources to Environmental Protection</th>
<th>Resources to Public Health Efforts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontier Phase</td>
<td>No realization of synergy; low commitment.</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Epidemic Phase</td>
<td>Acute effects recognized; synergy awareness; public pressure &amp; health costs rise.</td>
<td>$$</td>
<td>$$$$$</td>
</tr>
<tr>
<td>Wellness Phase</td>
<td>Life spans increase; acute &amp; chronic environmental impacts begin to be understood.</td>
<td>$$$$$$</td>
<td>$$$$$$$</td>
</tr>
<tr>
<td>Synergy Conscious Phase</td>
<td>Distant future? A legacy to wipe out (or up)? The only chance to reduce $$.</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
猎人采集者阶段

Man moved where all three were present: food + fuel + water to support wildlife and man.
Agrarian phase

Started moving where water was available to increase production of food stores and diverted water to agricultural locations.
Early Industrial phase

Water becomes a source of energy; we move water to formerly non-arable land expanding food production and increasing the importance of water as population begins to grow more rapidly.
Man discovers new sources of energy and moves water, energy and food to population centers. The three phases and society becomes dependent on the efficient movement of resources to people.
With larger population we start to understand the interdependence of the resources and the destructive interference of one to the other if there is over exploitation of any input.
Food – Energy – Water Nexus

Credit: University of Nebraska-Lincoln Institute of Agriculture and Natural Resources
All areas of the world have many of the same challenges but to a different degree. Awareness of the scarcity & interdependence is different in different areas.
• Relative abundance of groundwater and surface waters
• Primarily livestock impact during short term droughts
Tennessee Today for Food-Energy

- ENERGY
- FOOD
- WATER

- Mechanized Farming
- Fertilizer
- Transportation
Tennessee Today for Energy-Water

ENERGY

FOOD

WATER

- Mechanical efficiencies
- Wastewater Optimization
- Water loss and infiltration reduction
Water Loss and Plant Optimization

• Developing approaches for minimizing water loss for water utilities, utility districts, and municipalities.
  – In 2017, water loss alone cost more than $64 million and accounts for over 51 billion gallons of wasted water a year.
  – Current focus areas: Community Development Block Grant scoring criteria and associated guidance documents for water projects to incentivize actions which address water loss; design of an online water loss training curriculum for multiple end users.

• Building out programming associated with TDEC’s Water and Wastewater Energy Efficiency Partnership and Nutrient Optimization programs
  – Two existing and impactful programs with opportunities for collaboration
  – Executed a day-long event featuring facilitated sessions identifying pros and cons of each existing program and of combining the programs in the future; suggestions for structuring the future program(s); best practices in institutionalizing culture change; and an action plan for solidifying the future program(s).
  – Program plan which will likely include core plant optimization training and specialized training for energy efficiency, nutrient optimization, and culture change.
Resources Needed for WWTP Optimization

- Scientific curiosity
- Professional pride
- Respect for ratepayers
- Instant data
- Adjustable equipment
- Automated controls
- Executive champion
- Regulatory support

MONEY IS NOT THE LARGEST RESOURCE REQUIRED!
Get Food Smart TN seeks to promote using food wisely and enhance the sustainability of Tennessee’s food resources.
Gasification Plant produces heat and electricity (energy) to power WWTP (water) and biochar that can be used as a soil supplement for ammonia adsorption (food)
Another way to be green...

MWS Central WWTP
Biosolids→Anaerobic Digestion→(Methane Gas→fuel for heating digester and kiln to dry)→marketable pellets for soil augmentation

ANAEROBIC DIGESTERS with flexible storage tank tops
Kilns and Pelletizers
Final Thoughts

- Food-Energy-Water Nexus Research Needs
  - New energy conversion technologies in the market place
  - By-product uses for water and wastewater residuals
  - Cost effective decisions relative to centralization – decentralization with respect to water and wastewater distribution and collection systems
  - Energy and water efficient food production and distribution
- Integration is critical for overall productive solutions that minimize sub-optimization… and critical for resilience!
Questions?

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