

Data & Data Sc. Challenges in Food-Energy-Water Nexus

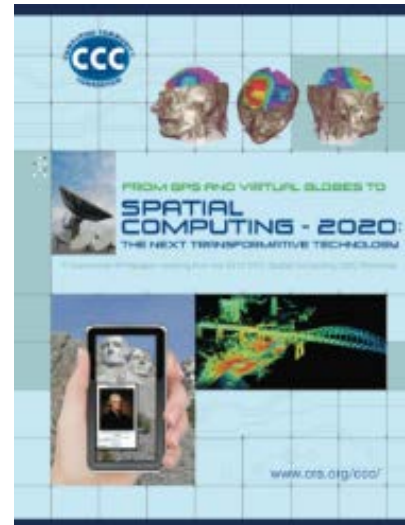
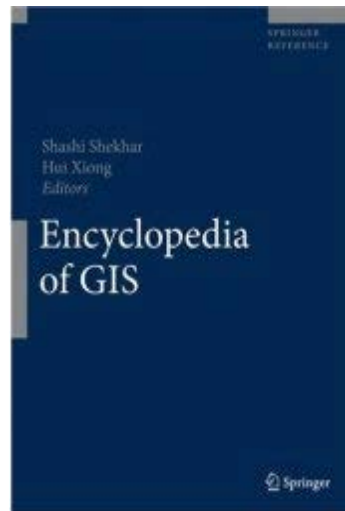
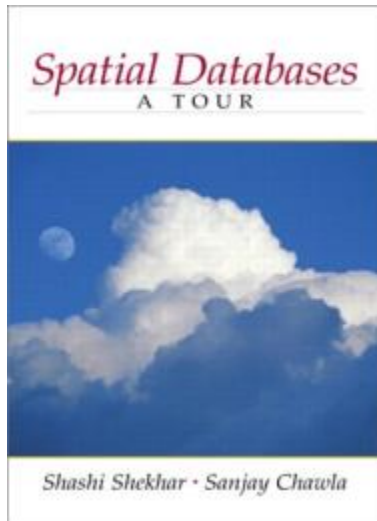
Sept. 8th-9th, 2016

NSF/IAF High Latitude F-E-W Workshop

Ack: NSF INFEW Data Science Workshop Grant

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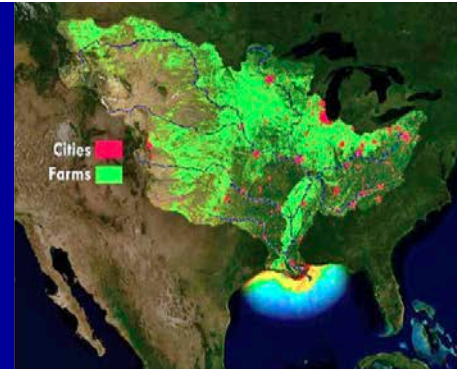


Outline

- FEW Nexus
 - Context
 - History
- Role of Data Science
- Data Science Challenges in FEW Nexus
- Next

Downside of Piece-meal Approach

- Piece-meal policies => unanticipated problems
 - Ex. Fertilizers affect Water quality (e.g., Great Lakes, Mississippi River)
 - Ex. Bio-fuel subsidy => Rise in food prices (2008)

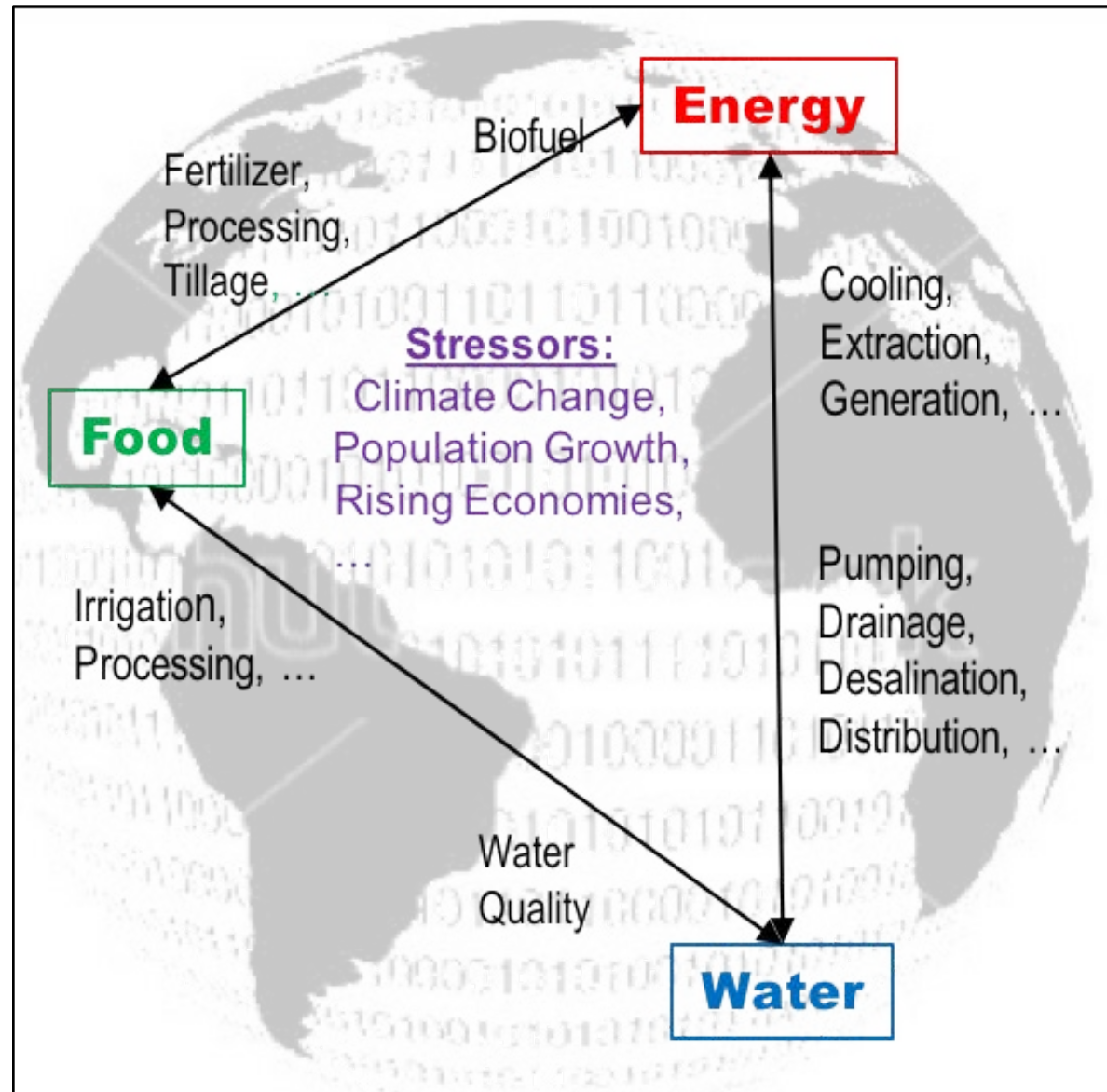


Courtesy: Wikipedia

- Crucial to understand interactions across Water, Food, Energy Systems
 - National priority
 - Reports: USDOD/NIC, NSF, USDA USDOE, USGS, ...
 - **Research Initiatives: NSF/USDA, USDOE**
 - Global priority with initiatives from U.N. University and many countries

Interactions among Food, Energy, Water Systems

- Piecemeal decisions in one affect the other
- **Efficiency** or abundance in one reduces scarcity in others!
- **Chokepoint:** Scarcity in one constraints growth in others!
- **Stressors:**
 - Population Growth
 - Climate Change
 - Rising Economy



Outline

- FEW Nexus
- Role of Spatial Computing
 - Precision Agriculture
 - Crop Monitoring
- Computing Challenges in FEW Nexus
- Next

Deconstructing Precision Agriculture

#AgInnovates2015

Wednesday, March 4, 2015

Reception | 5:00 to 7:00 pm

House Agriculture Committee Room,
1300 Longworth House Office Building,
Washington, DC

Think Moon landing.

Think Internet.

Think iPhone and Google.

Think bigger.

Come hear U.S. farmers, leading agriculture technology companies, and scientists tell how they work together to fuel U.S. innovation and the economy to solve this global challenge.

The event will exhibit three essential technologies of precision agriculture that originated from a broad spectrum of federally funded science: Guidance Systems and GPS, Data & Mapping with GIS, and Sensors & Robotics.

Moderator

Raj Khosla, Professor of Precision Agriculture at Colorado State Univ.

Farmers

David Hula, of Renwood Farms in Jamestown, Virginia

Rod Weimer, of Fagerberg Produce in Eaton, Colorado

Del Unger, of Del Unger Farms near Carlisle, Indiana

Speakers

Mark Harrington, Vice President of Trimble

Carl J. Williams, Chief of the Quantum Measurement Division at NIST

Bill Raun, Professor at Oklahoma State Univ.

Marvin Stone, Emeritus Professor at Oklahoma State Univ.

J. Alex Thomasson, Professor at Texas A&M Univ.

Dave Gebhardt, Director of Data and Technology at Land O'Lakes/WinField

Shashi Shekhar, Professor at the Univ. of Minnesota

RSVP

<http://bit.ly/1CoOYoa>

Hosted by
the Congressional Soils Caucus

In partnership with

Agricultural Retailers Association
American Society of Plant Biologists

American Physical Society

American Society of Agronomy

Association of Equipment Manufacturers
Coalition for the Advancement of Precision Agriculture

Computing Research Association

CropLife America

Crop Science Society of America

PrecisionAg Institute

Soil Science Society of America
Task Force on American Innovation

Texas A&M AgriLife

Trimble

WinField



This is about feeding the world.

Precision Agriculture

- Reduce fertilizer run-offs, water use
- Improves yield
- Computing is critical
 - Cyber-Physical Systems
 - Data & Data Science Elements

Yield
Monitors

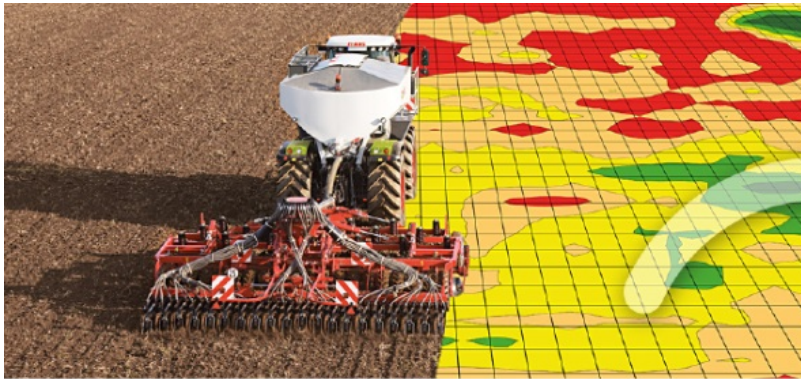
Direct &
Remote
Sensing

Precision
Navigation

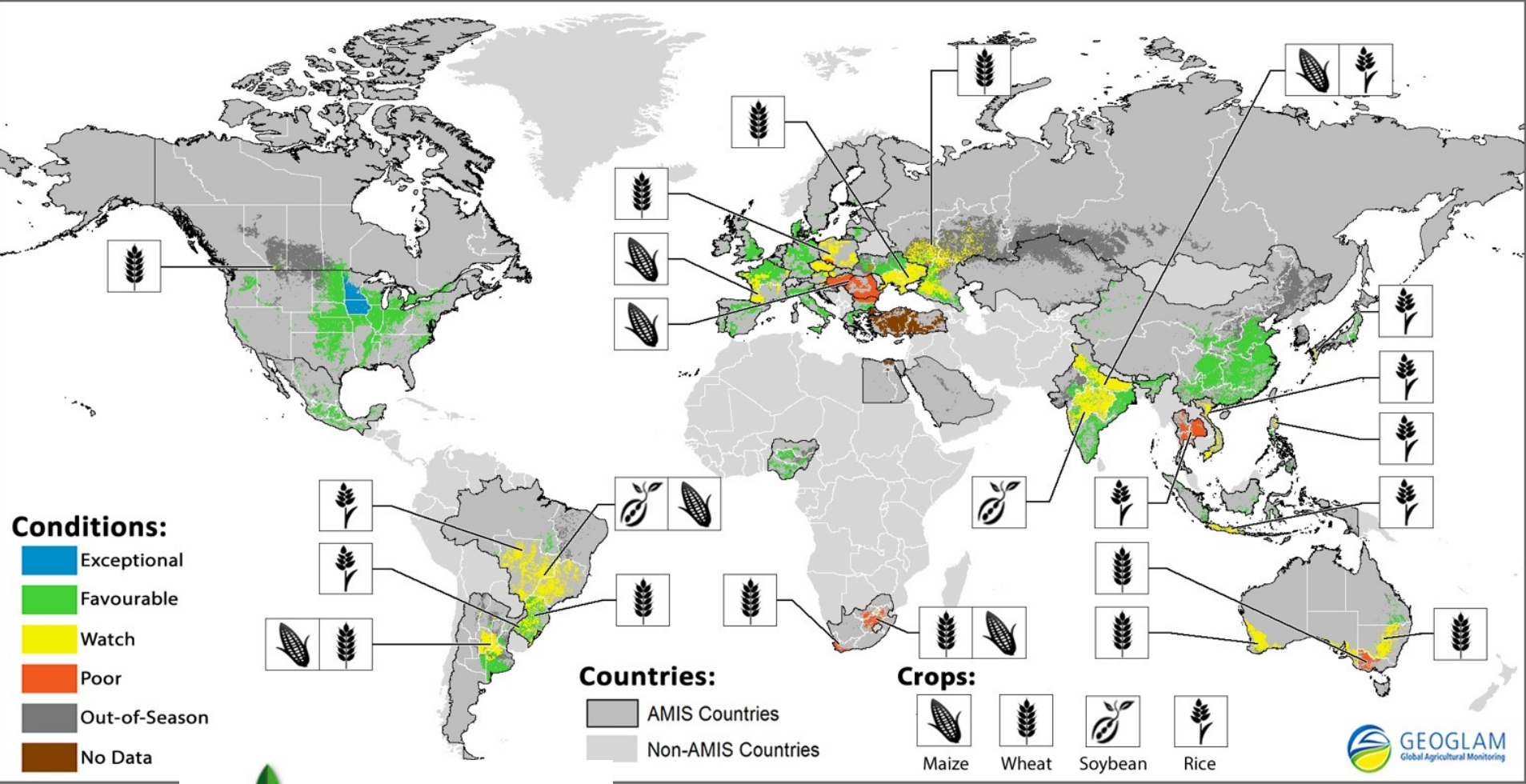
Variable
Rate
Technology

Global Positioning Systems

Geographic Information Systems



Support (Global) Decisions and Policy Making



Outline

- **FEW** Nexus
- Role of Spatial Computing
- **Data Science Challenges in FEW Nexus**
 - NSF **INFEWS** Data Science Workshop (Oct. 2015)
 - Data and Data Science Gaps
- Next



NSF INFEWS Data Science Workshop



- **Goals**

- Develop visions, Identify gaps
- Develop a research agenda

- **At** USDA NIFA, Oct. 5th-6th, 2015

- **Co-organizers:** Shekhar, Mulla, Schmoltdt

- **URL:** www.spatial.cs.umn.edu/few



- **Draft report available for comments:**

http://www.spatial.cs.umn.edu/few/few_report_draft.pdf

- **55 Participants** (Data-driven FEW & Data Sciences)

| Gov. | Aca. | Industry |
|------|------|----------|
| 26 | 24 | 5 |

| Food | Energy | Water | DataSc. |
|------|--------|-------|---------|
| 14 | 10 | 11 | 20 |



Outcomes: F-E-W Nexus Data Gaps

- **Water:** Need US water census
 - Equivalent of Ag. Census and US-EIA

The New York Times

MARCH 17, 2016

Water Is Broken. Data Can Fix It.



Independent Statistics & Analysis

U.S. Energy Information
Administration

- Other Data Needs:
 - **Energy, Food**– consumption & **FEW** Interaction data
 - **A FEW** nexus data community (BD FEW Spoke)
 - Upper Latitude, e.g., Alaska DEM
- Data Integration Challenges
 - Varied data collection (e.g., aquifer withdrawal meter in TX & CA)
 - Heterogeneous data format (e.g., raster climate data, vector population)

Outcomes: Data Science Gaps

1. Methods to help stakeholders reach consensus on FEW issues

- Social science methods: scenario-based discussion, design exercises, etc.
- Computational tools: visualization, explainable/interpretable models, interactive simulation and optimization

2. Spatio-temporal modeling

- Dealing with data collected multiple spatial, temporal scales,
- missing values

3. Fusion of multiple model types

- Data-driven, (causal) process-driven, economic, etc.
- (Spatial)-context aware

4. Lifecycle thinking for the FEW Nexus

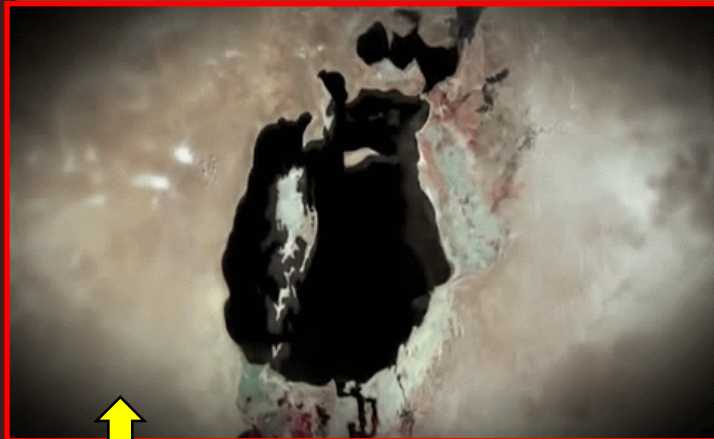
- modeling human behavior, understanding indirect effects of perturbations, supply chains, opportunity costs, agent-based modeling

5. Data uncertainty, incompleteness, bias

- provenance, conflict of interest, capturing and visualizing uncertainty

Monitor resources & trends to detect risks

Communicate with public and stakeholders



Aral Sea Shrinkage (1978-2014)
Due to Cotton Farms

Alerts

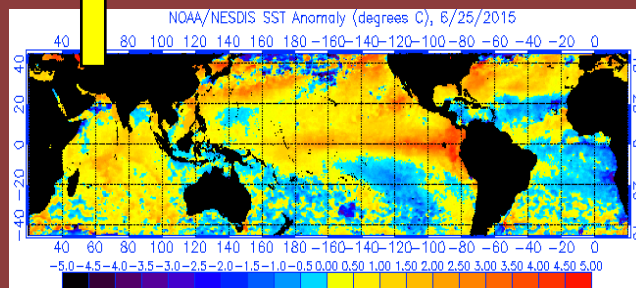


State

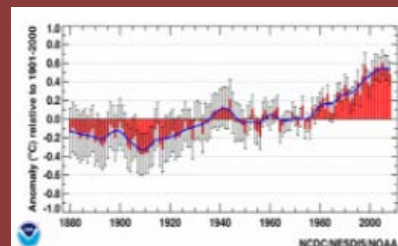
Nexus Dashboard



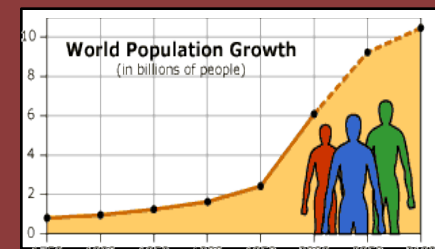
Trends



Sea-Surface Temperature Anomaly



Global Temperature

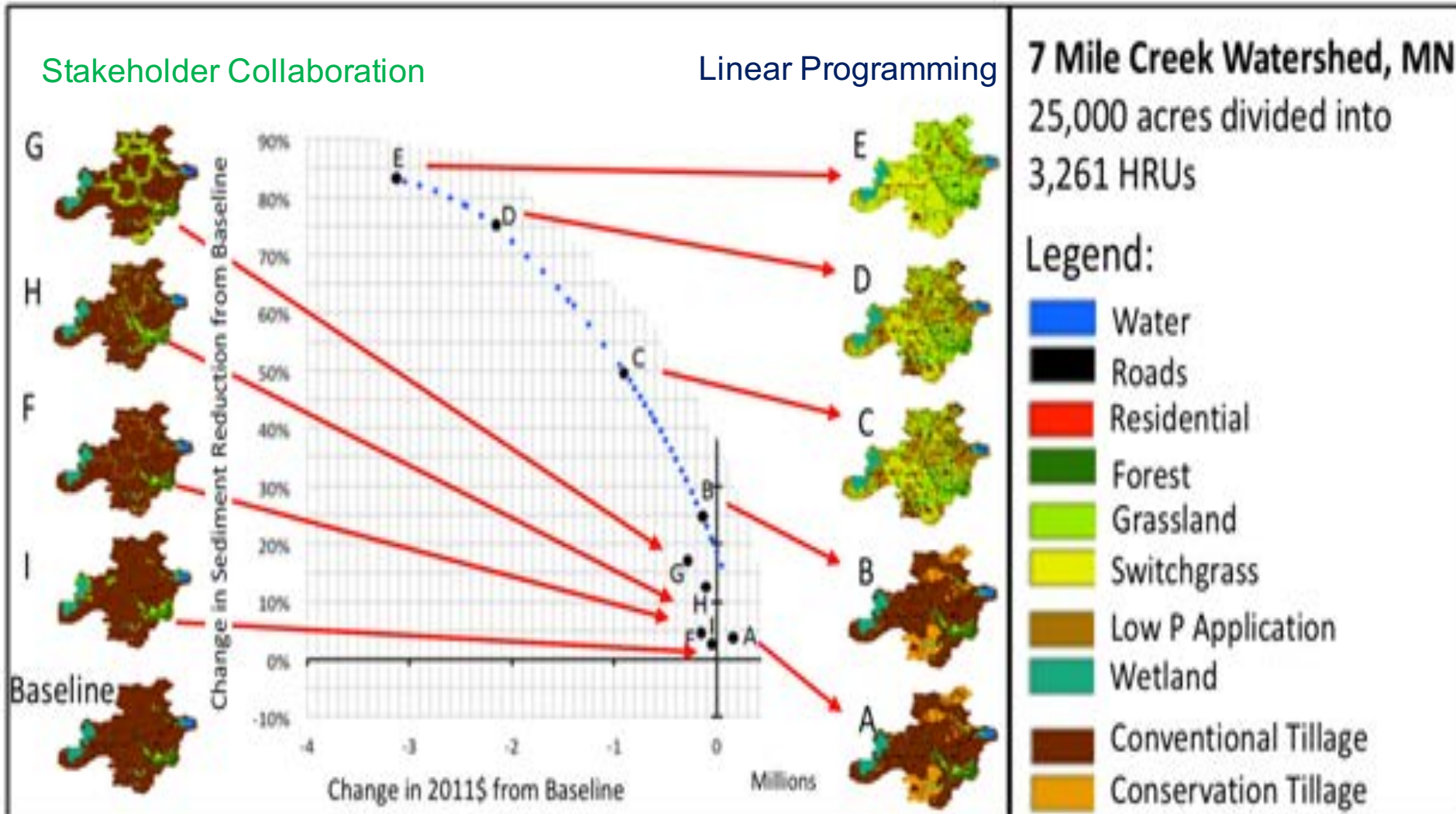


Global Population

Gap Example: Spatial Fragmentation in Optimization

Landscape geodesign

- stakeholder collaboration (designs F, G, H, I)
- linear programming (designs A, B, C, D, and E) – **farmers dislike spatial fragmentation**



Outline

- F-E-W Nexus
- Role of Spatial Computing
- Computing Challenges
- Related Events
 - Dec. 2015: NSF INF_EW_S Solicitation
 - Jan. 2016 : NCSE
 - Mar. 2016: Midwest Big Data Hub – FEW Spoke
 - Mar. 2016: Whitehouse Water Summit
 - Aug. 2016: ACM SIGKDD Workshop on FEW
 - Dec. 2016: AGU session proposal