



NORTHERN ILLINOIS UNIVERSITY

Institute for the Study of the
Environment, Sustainability & Energy

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Supporting Drought Adaptation Policies

Dynamic Systems – Conflict Resolution – Policies

*Illinois Lake Management Association
28th Annual Conference, 4-6 April 2013, Bloomington IL*

- **Background**
- **Project objective, approach, tools, and models**
- **Demo of the tool prototype**



Source: africa.theworldatlas.net

**Lessons
Learned?**



www.merriam-webster.com

Outline

- **Simple Definition: a period of water shortage**
 - Crop and livestock damage
 - Water supply shortages
- **Severity depends on:**
 - Duration
 - Degree of moisture deficiency
 - Size/location of affected area



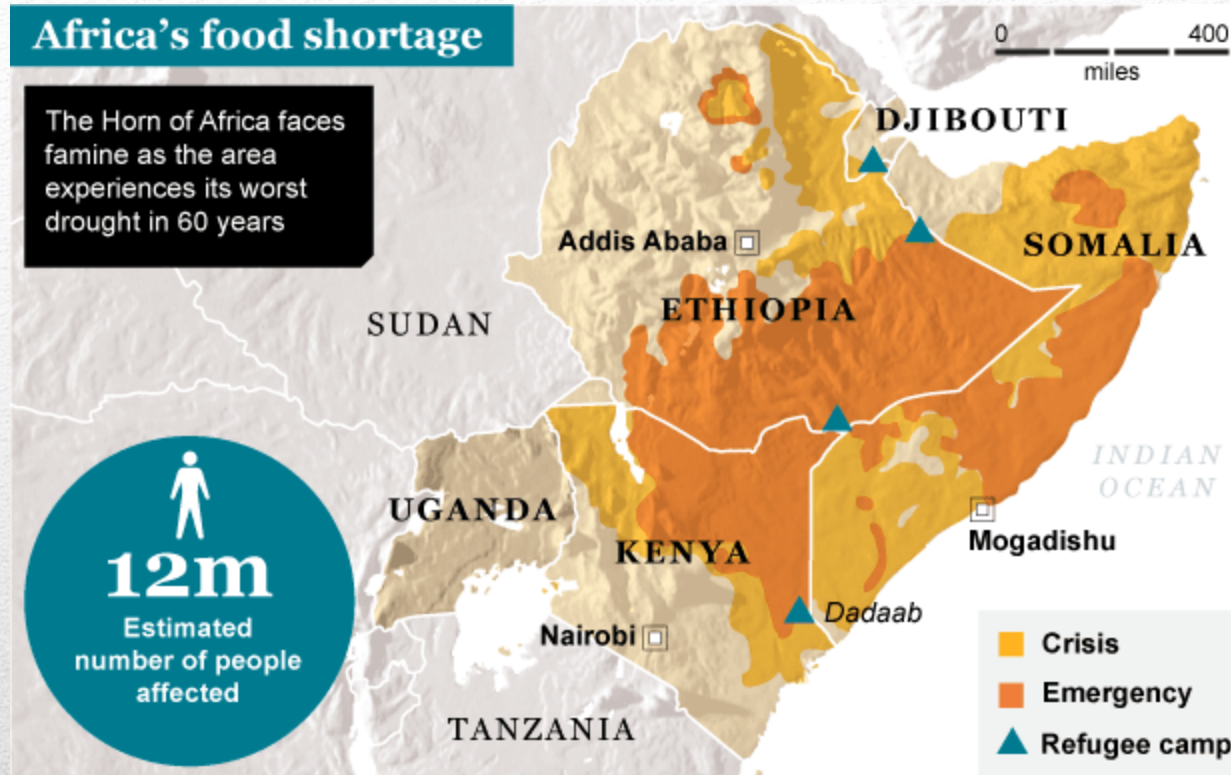
Source: UN OCHA Crisis in the Horn of Africa

Drought

Africa's food shortage

The Horn of Africa faces famine as the area experiences its worst drought in 60 years


12m
Estimated number of people affected



<http://humanitarian.worldconcern.org/tag/horn-of-africa/page/2/>

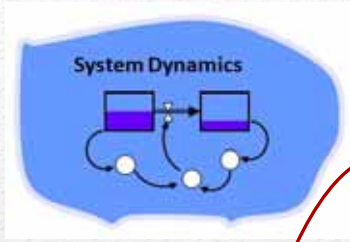
Build a **system-based tool** to support policies to mitigate drought impacts

Research Objective

TOOLS for System Modeling and Analysis

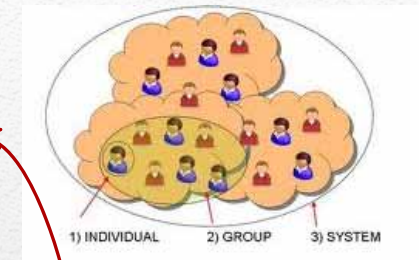
System Dynamics

Agent-Based Model



Biological, physical, and engineered systems

Behaviors of actors and social systems

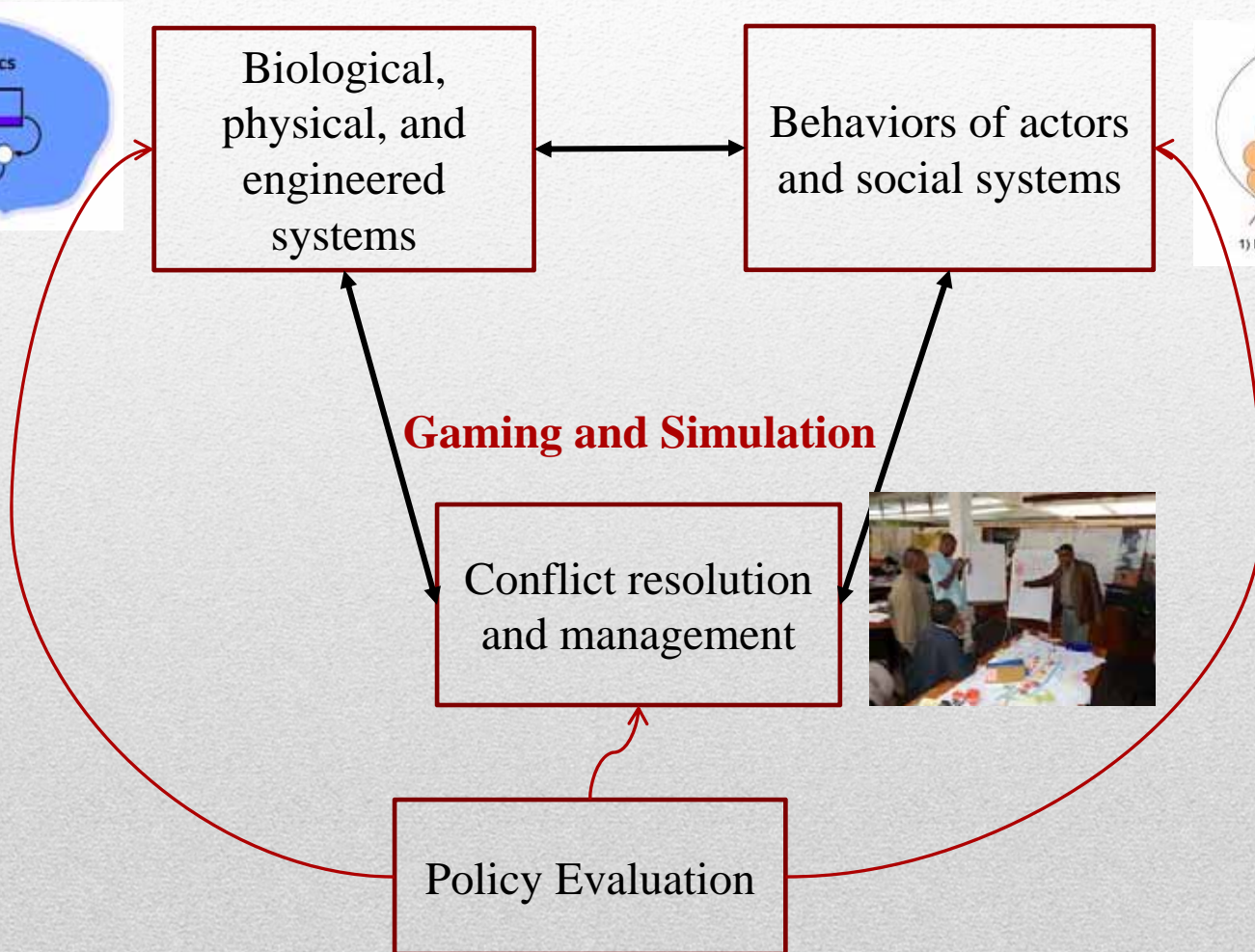


Gaming and Simulation

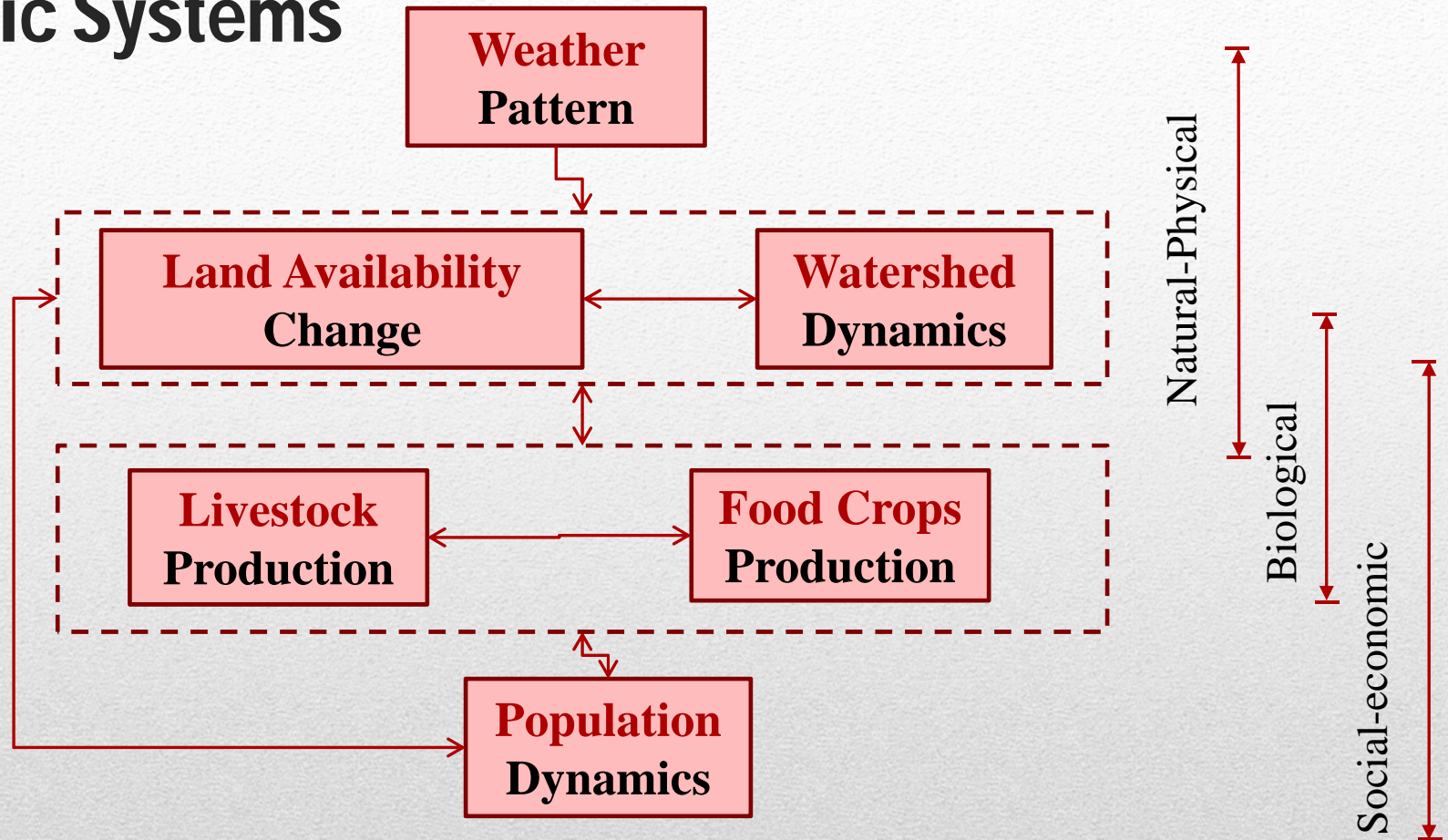
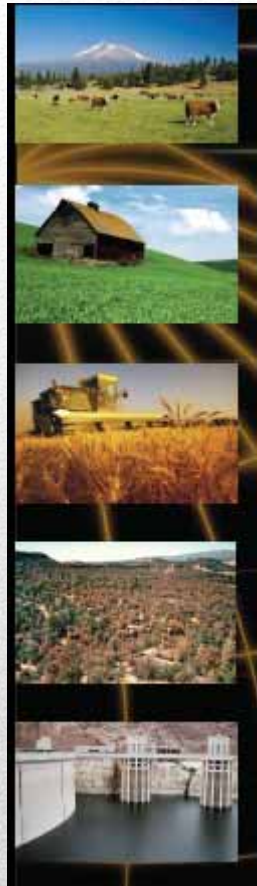
Conflict resolution and management



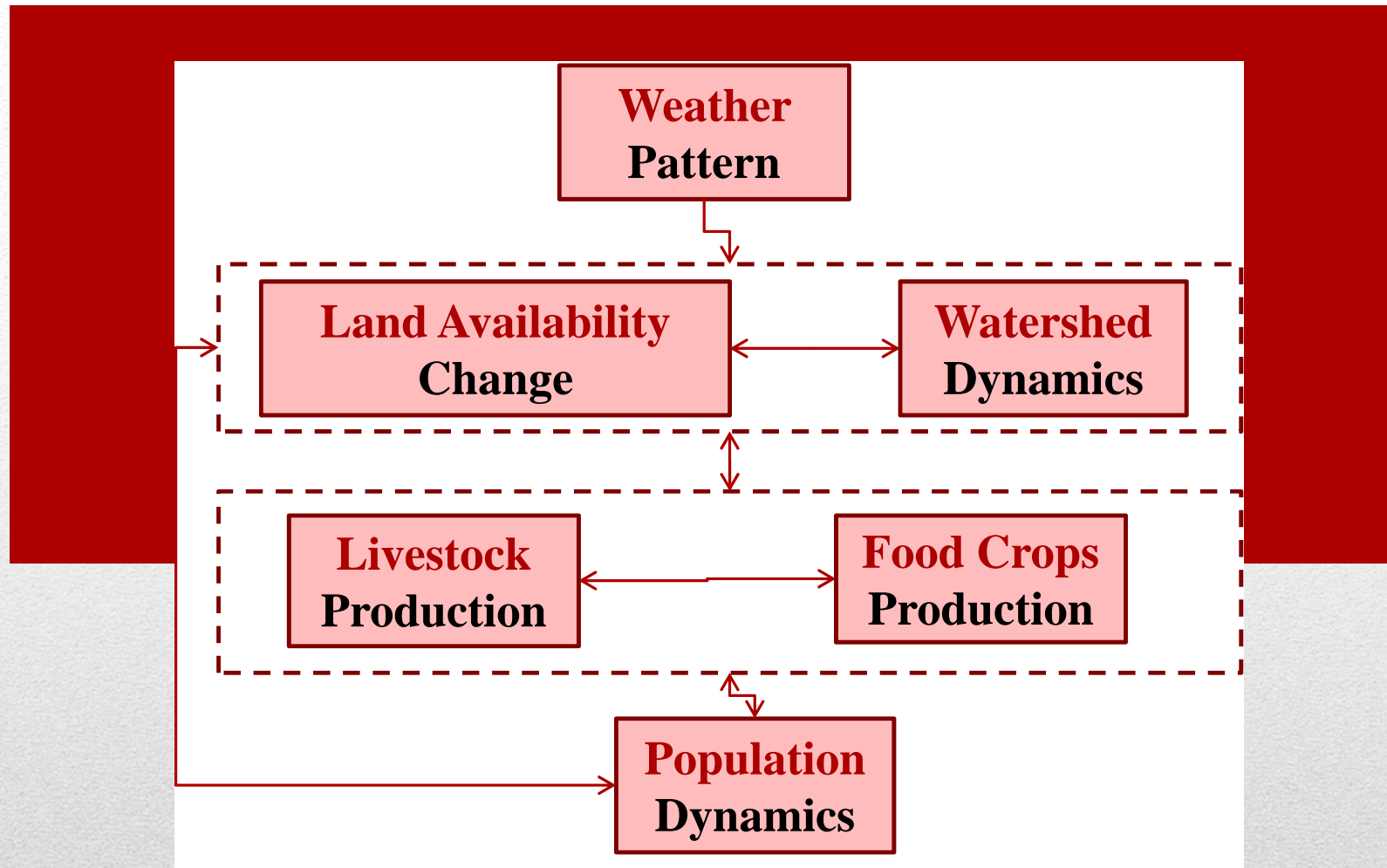
Policy Evaluation



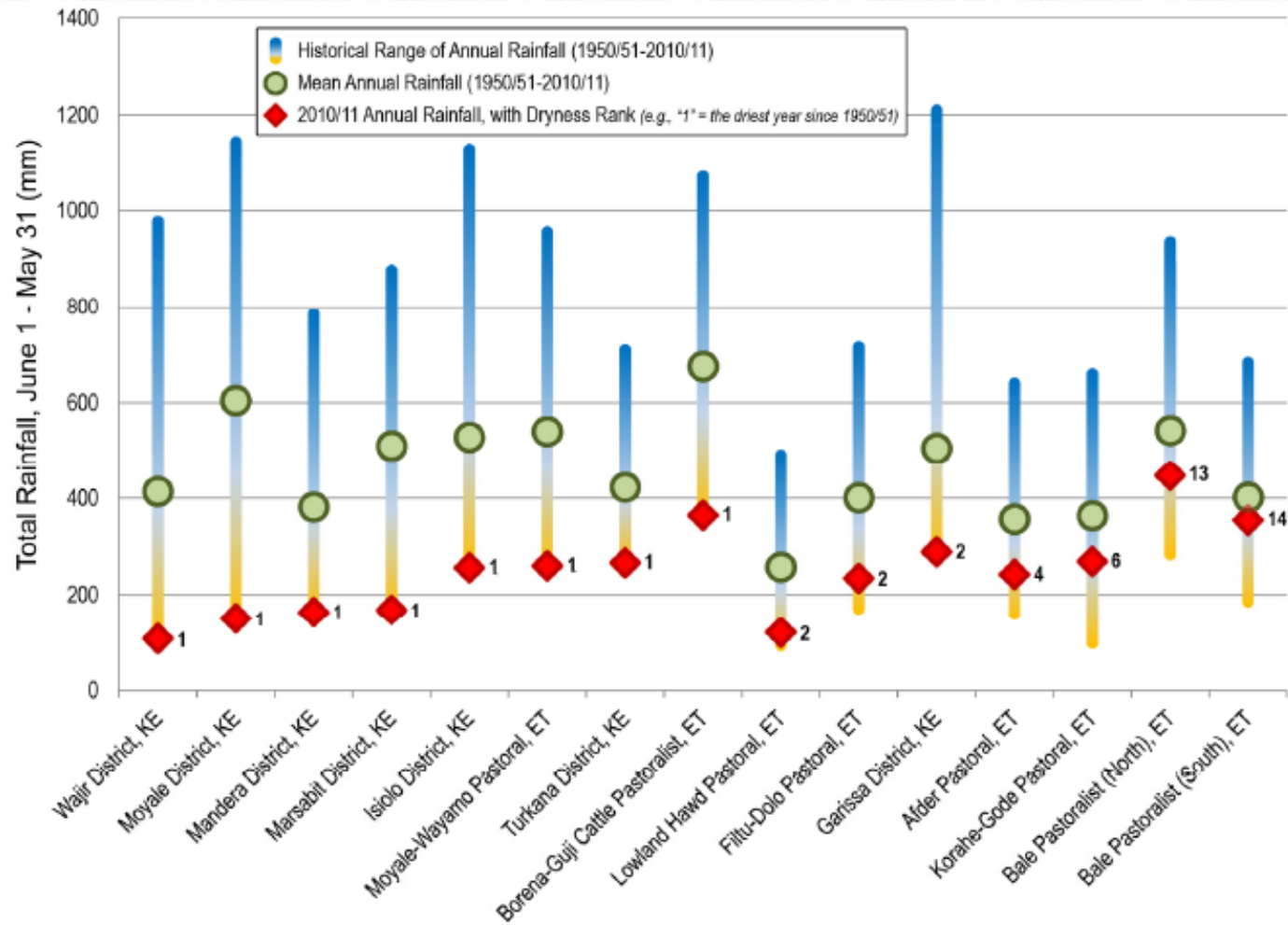
Dynamic Systems



- **Understand** fundamental causes, process, interdependencies, and impacts of drought
- **Build** a representative systems model

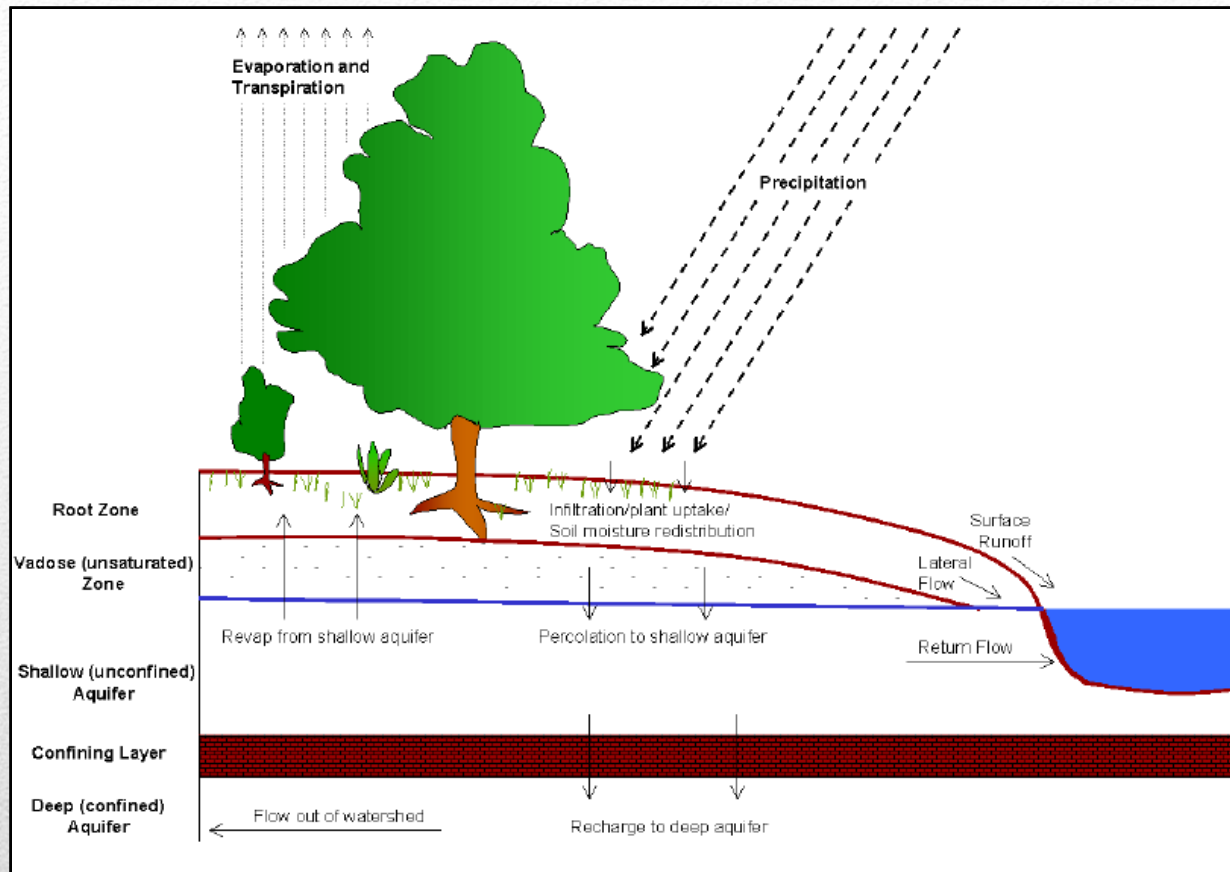


SYSTEM ELEMENTS



Source: FEWS NET/USGS and FEWS NET/NOAA Graphics: FEWS NET

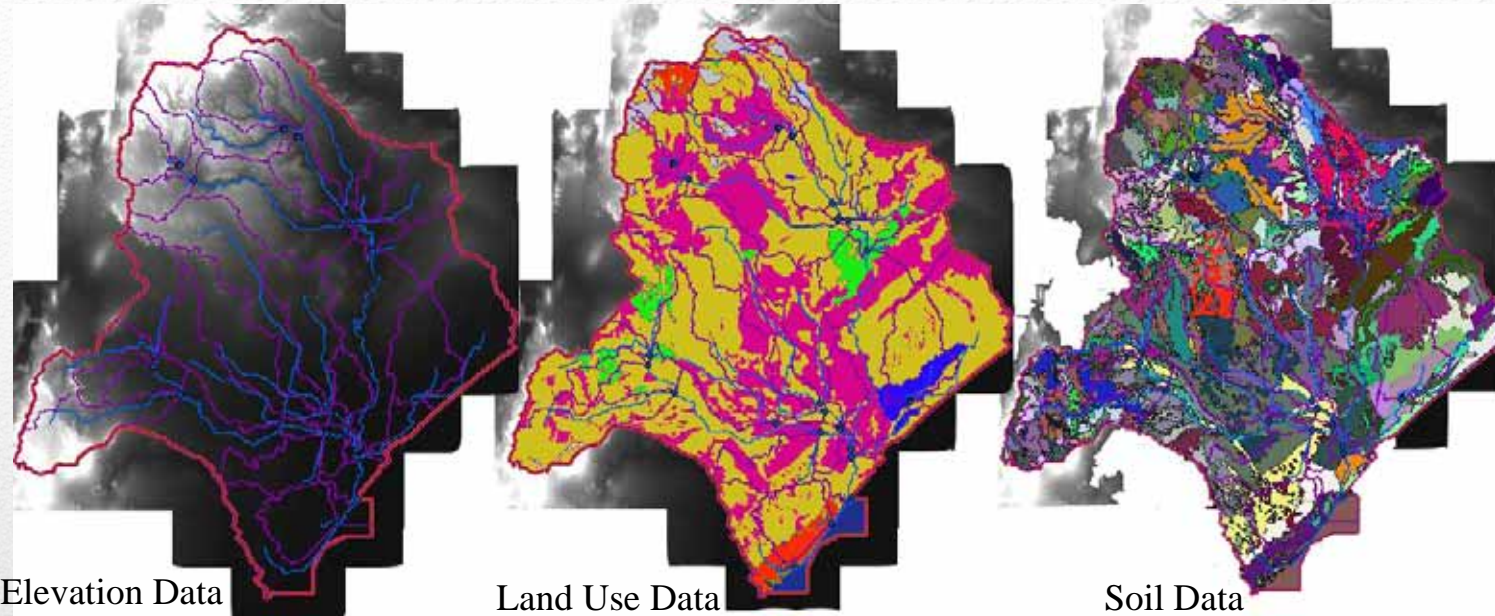
Weather Pattern: Rain Fall



SWAT2009 Theoretical Documentation

- Soil & Water Assessment Tool (SWAT) Model
 - Simulates hydrologic cycle based on water balance

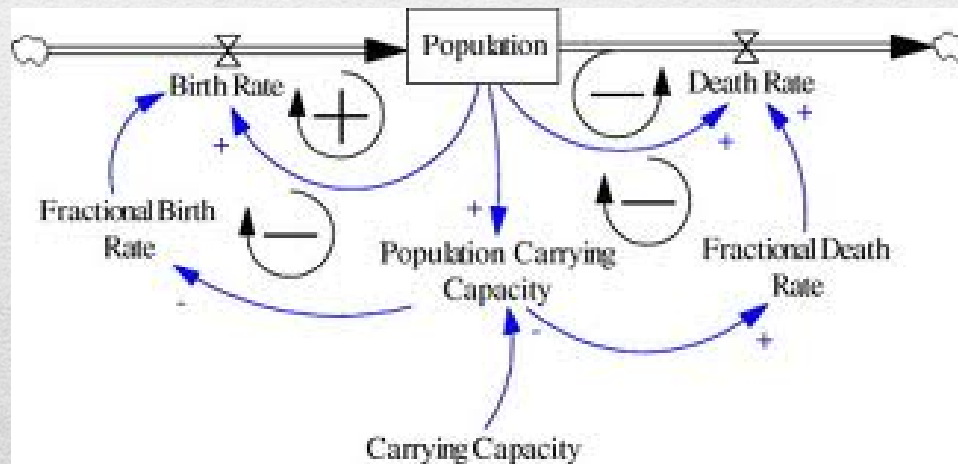
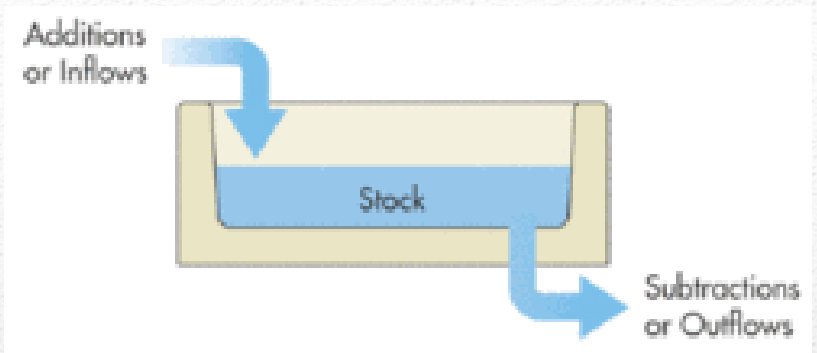
Watershed System Model



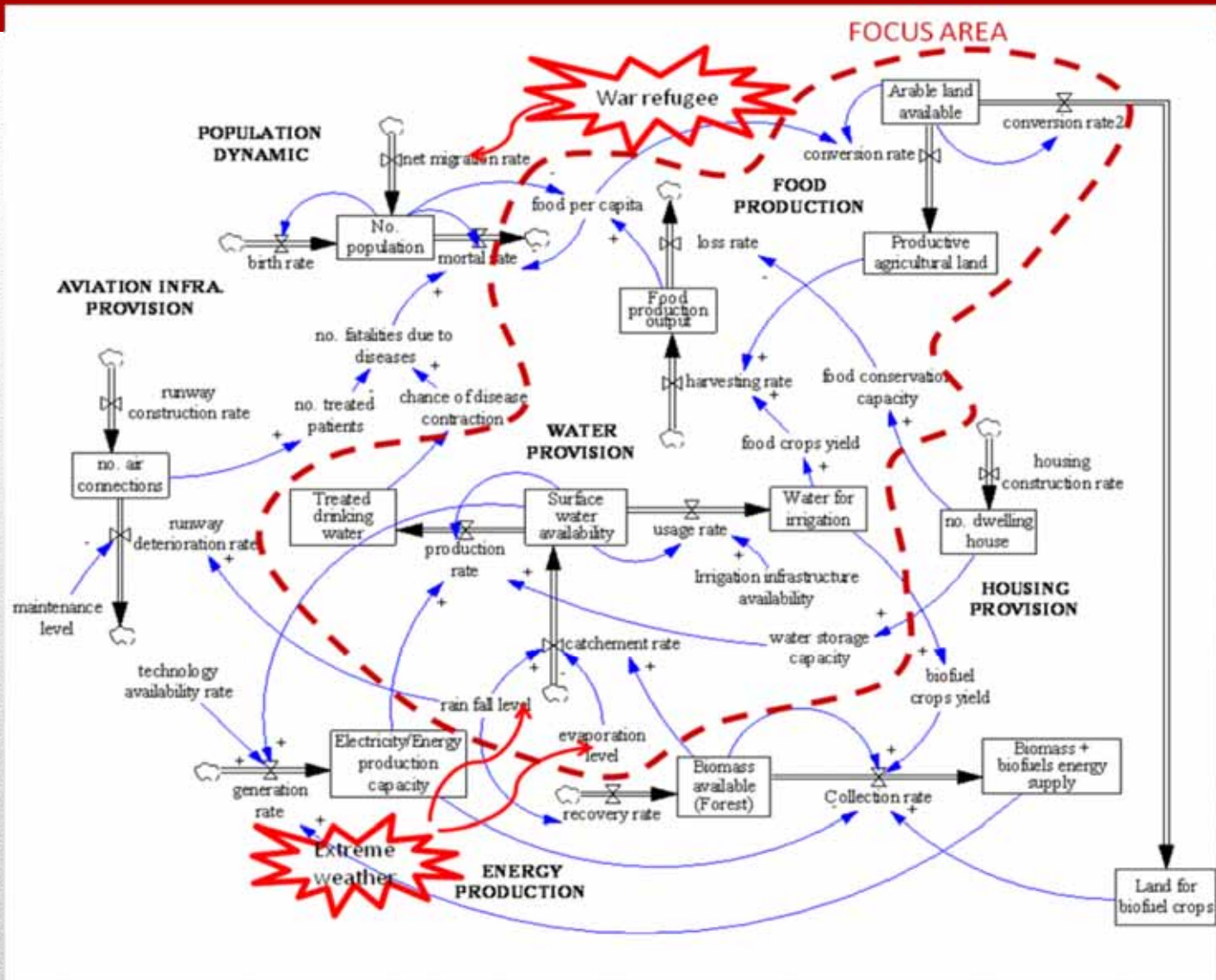
- Physically based model
 - Requires weather, soil, topography, vegetation, and land management data
- Hydrologic Response Units (HRUs)
 - Lumped land areas within a subbasin based on unique land cover, soil, and management combinations

SWAT Model

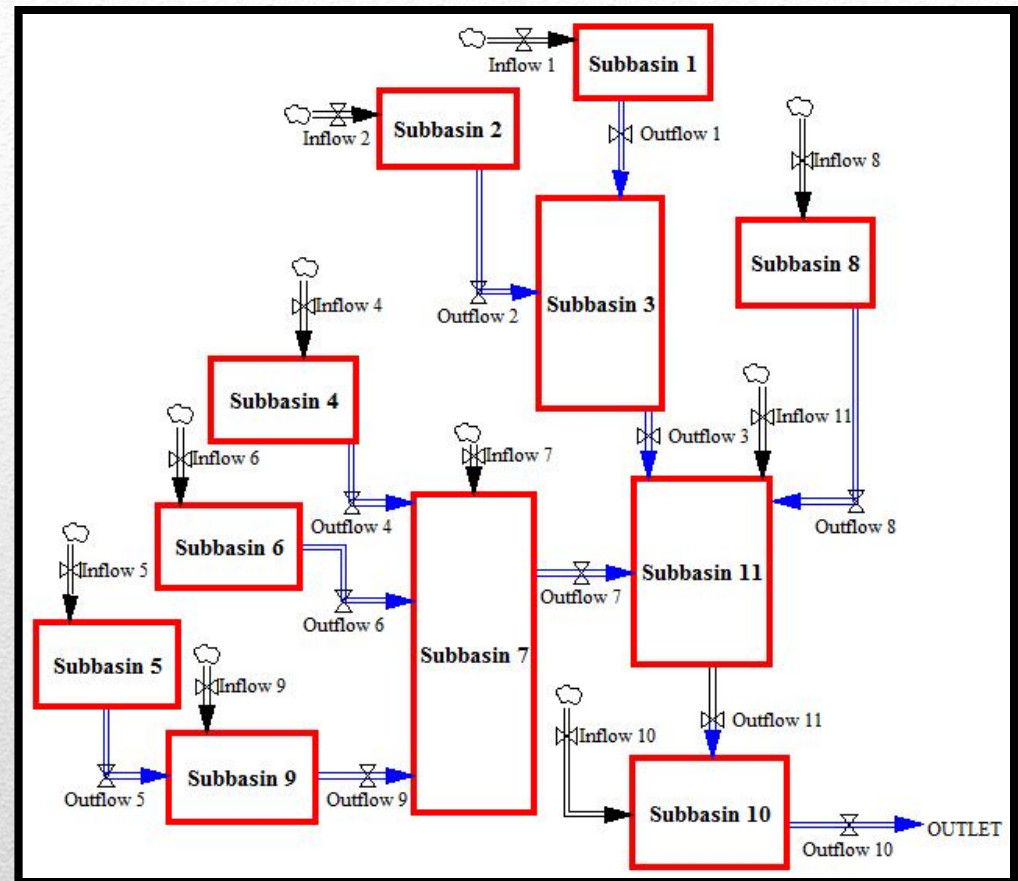
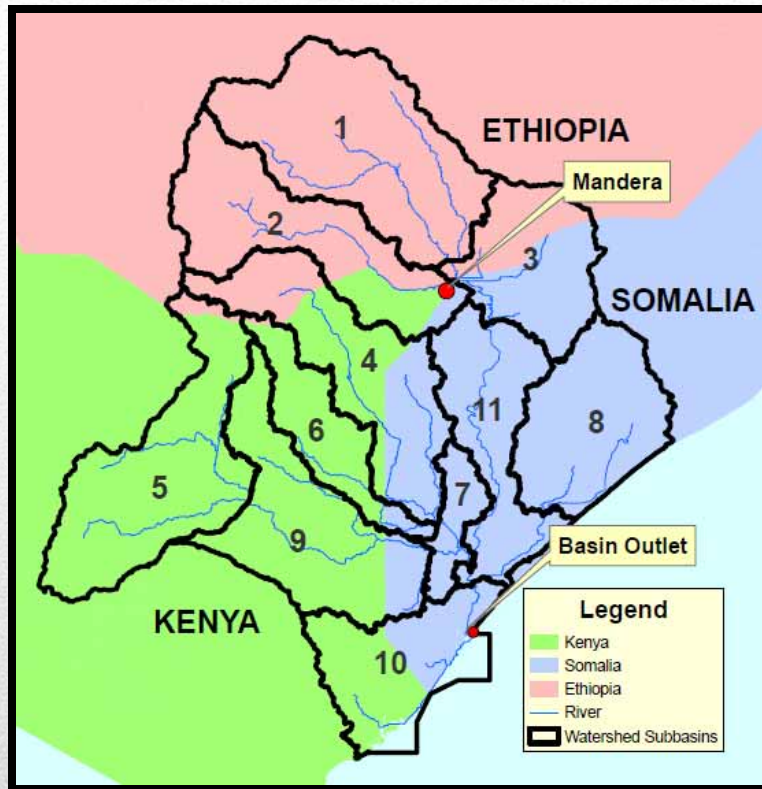
- Basic representation: **stock and flow diagram**



System dynamics model (1)



System Dynamics Modeling



- Sub-basin Model

Watershed System Scope

- Data: Remote Sensing (NDVI), Human Settlement, and Soil

- Four types of land:

- Rich and Poor **Agriculture Land**

- 25 miles of human settlements

- Rich and Poor **Grazing Land**

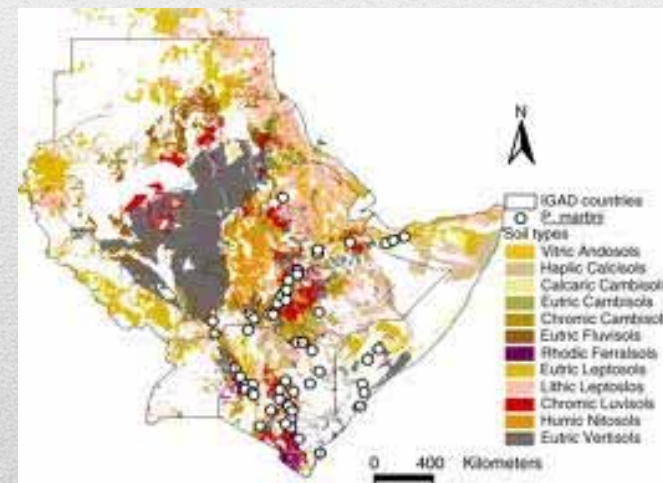
- Grazing areas for Pastoralist

- **Degraded Land**

- **Conservation Land**

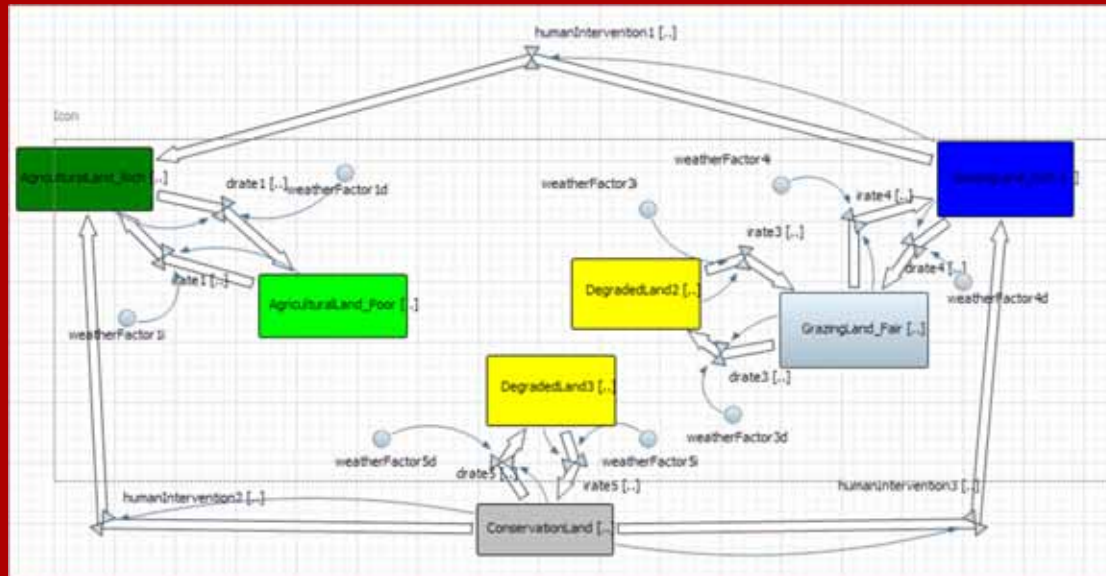


waterresources.at



Acta Tropica Volume 90, Issue 1, March 2004, Pages 73–86

Land availability dynamics



DEMO: SYSTEM TOOL

Land Change Dynamics



- Dry land agriculture
- Three types of crops:
 - Corn
 - Sorghum
 - Drybean

Maize: $Y = 6.7761 + 0.0085(X)$; (Hollinger and Changnon, 1993);

Dry beans: $Y = 0.389(X) - 13.765$; (Padilla-Ramírez J.S. *et al*, 2003);

Sorghum: $Y = 1.27 + 0.002(X)$; (Rowhani et al 2011);

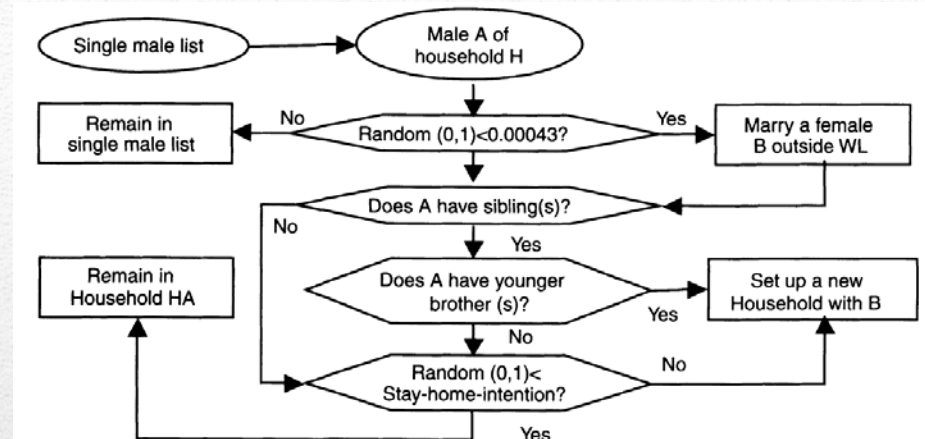
Y: yield (tons/ha), X: annual precipitation (mm)

Food production dynamics

- Effects on birth and death rate
- Migration induced by drought
- Decisions are captured in a set of **decision rules**.
- Implemented in Agent-based Model
- Major issue: Influx of Internally displaced people (IDP)

Population Dynamics

Actors' decision rules

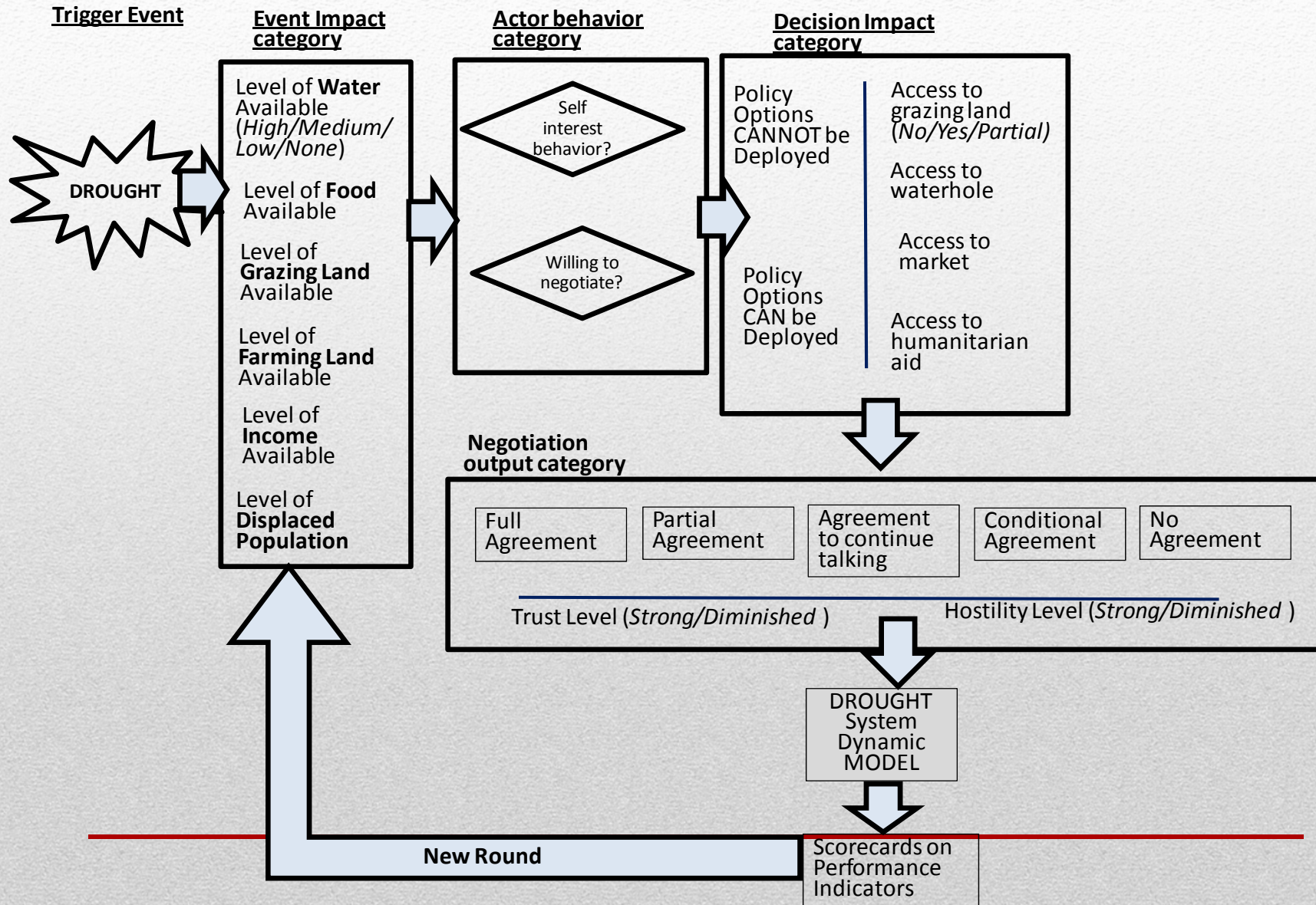


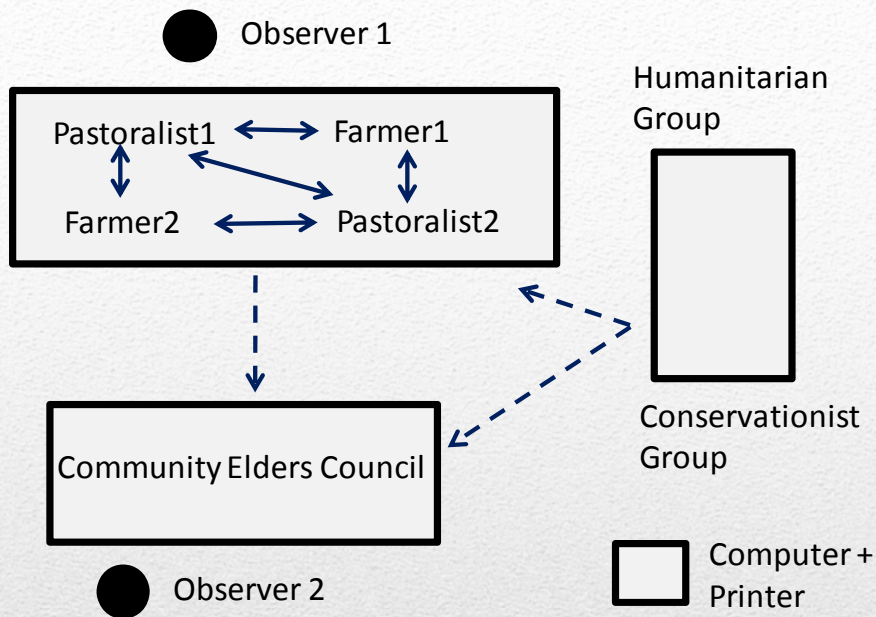
<http://iheardtheory.com/>

Role-playing Game-Simulation for Conflict Resolution



Role-Playing Game-Simulation Design





↕ Local negotiation
 - - - Global negotiation

Layout
 Activity and time allocation

- Use African Study Class for try-out

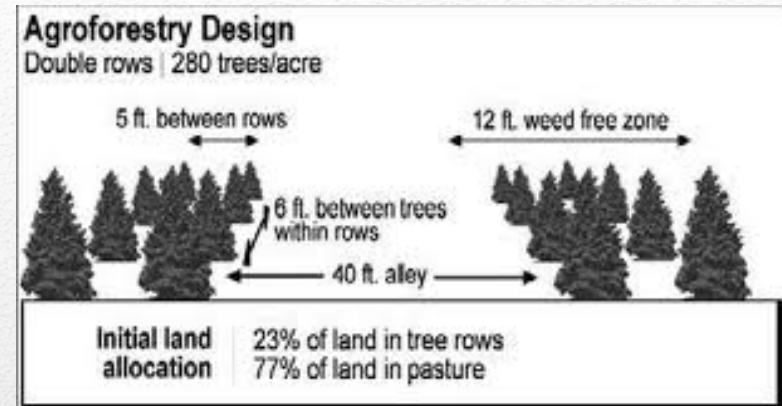
RPG Set-up

Step	Activity	Timing (Indicative)
1	Reasoning (at individual level)	5 min
2	Local Negotiation	5 min
3	Global Negotiation	5 min
4	Dynamic Simulation (1 year)	5 min
5	Results and Indicators New Water & Land Use	2 min



POLICY DESCRIPTION

- Combining trees and shrubs with crops and/or livestock
- Potential benefits:
 - Stabilize erosion
 - Improve water and soil quality
 - Improve crop yield by 98 %



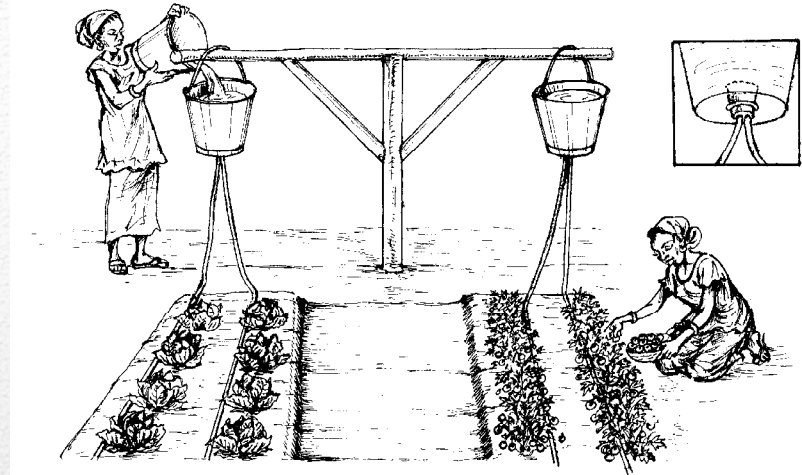
Source: smallfarms.oregonstate.edu



<http://www.abc.net.au/rural/content/2008/s2502403.htm>

Agroforestry

- Drip irrigation is a unique method suitable for use as “supplementary irrigation”
- Enable farmers to grow high value crops, hence increase incomes
- The introduction of fertilizers through the drip irrigation system: **fertigation**
- Crop yield improvement up to 98%
- Water saving up to 79%



<http://www.developmentart.com/alin.htm>



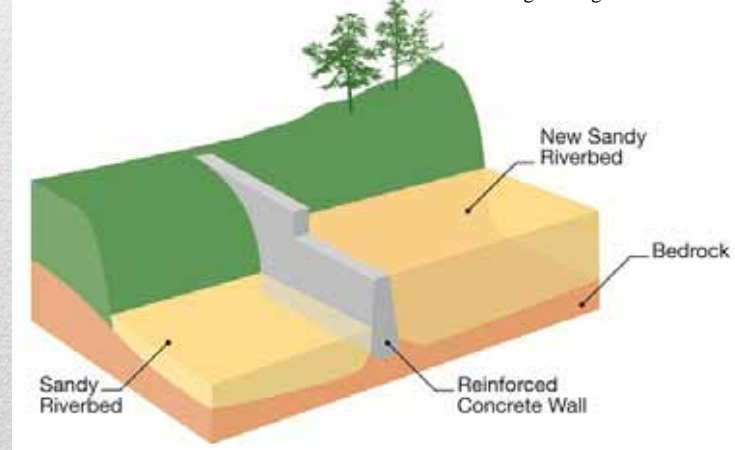
Doubleharvest.org

Drip Irrigation

- Hydraulic Infrastructure
 - Sand dam
 - Dam built along river, must have a sand bed
 - Stores water in “perched” aquifer
 - Natural filtration
 - Evaporation is less of a factor
 - Multiple extraction options



ECHO Technical Note: Water Harvesting Through Sand Dams



Excellenteducation.co.uk

Hydrological Policies (1)

- Rainwater harvesting (RWH)
 - Rooftop tanks store rainwater collected from impermeable surfaces for use at later times
 - Ponds/Pans are strategically dug to collect runoff, evaporation and siltation are key issues
- Wells
 - Hand dug wells require little technical skills and are inexpensive but can dry up during droughts
 - Deep (Boreholes) are reliable during times of drought but are costly, require high technical skills, knowledge of surrounding subsurface hydrology, and encourage settlement



Worldagroforestry.org

Pond



FAOSWALIM.org

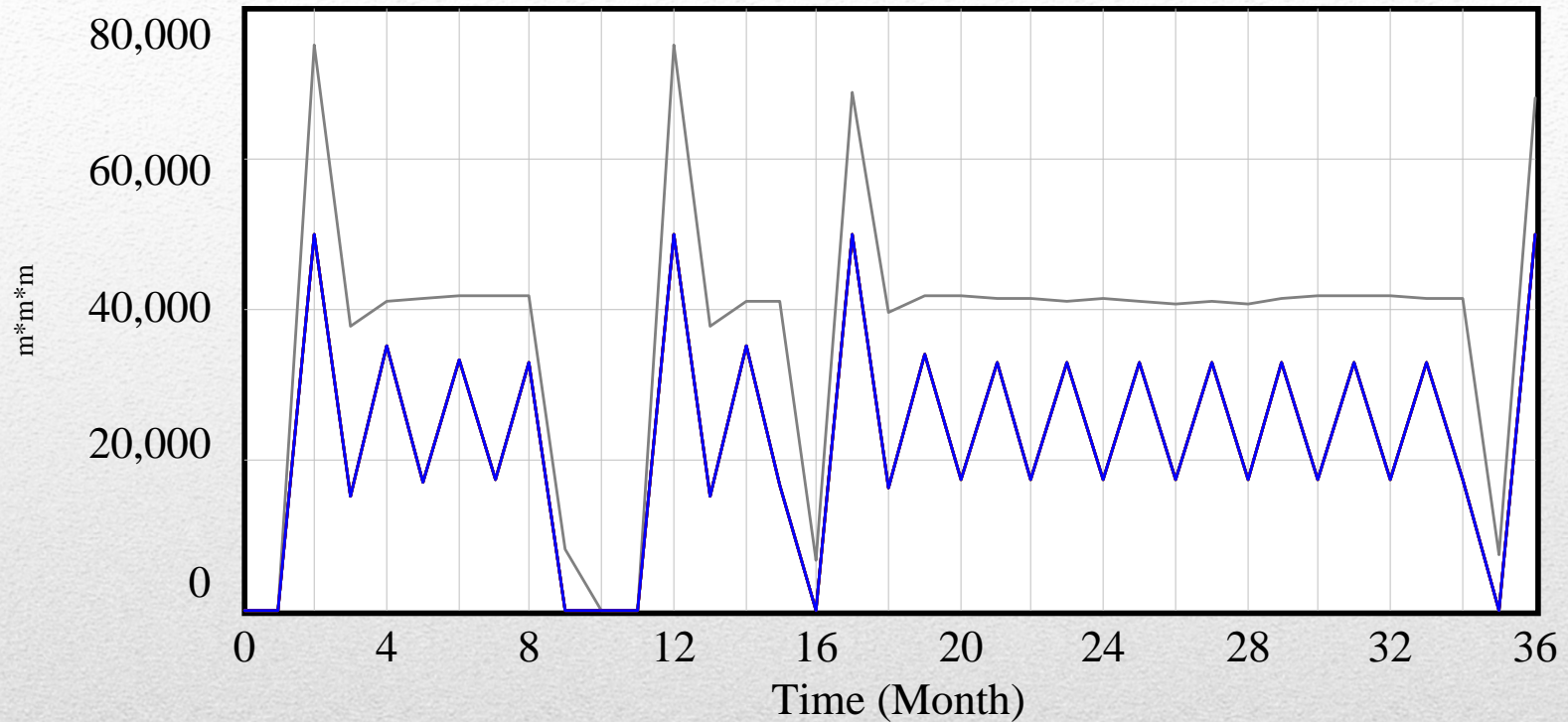
Borehole



Unicef.org

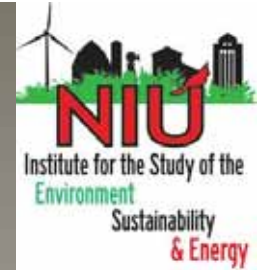
Hydrological Policies (2)

Available Surface Water



Available Surface Water : Original
Available Surface Water : Sanddam
Available Surface Water : RWHtanks
Available Surface Water : Ponds
Available Surface Water : HanddugWells
Available Surface Water : Boreholes

Policy Evaluation Tool



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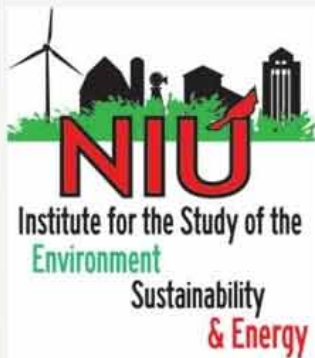


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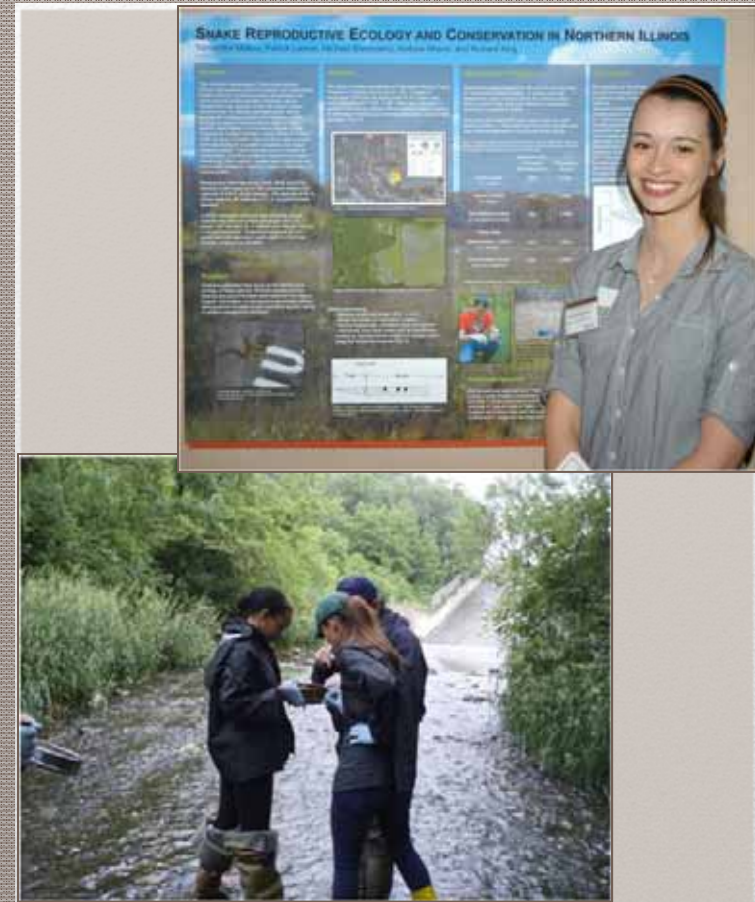
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- >15 faculty from 13 different departments
- A broad range of global and regional research activities and expertise

NIU Environmental Studies

- 🌍 Biodiversity & Environmental Restoration
- 🌍 Energy Studies
- 🌍 Human Experience
- 🌍 Environmental Policy
- 🌍 Non-Governmental Organizations
- 🌍 Water Studies



Samantha Melton (ENVS student) conducting stream monitoring for the Illinois EPA and presenting her research on snake reproductive ecology and conservation

Thank You!



Source: africa.theworldatlas.net

**Lessons
Learned?**



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