SIMULATING THE FEASIBILITY AND PERFORMANCE OF A REAL-TIME WATER MARKET BY COUPLING AN AGENT-BASED MODEL AND RAPID MODEL - A CASE STUDY IN GUADALUPE RIVER BASIN

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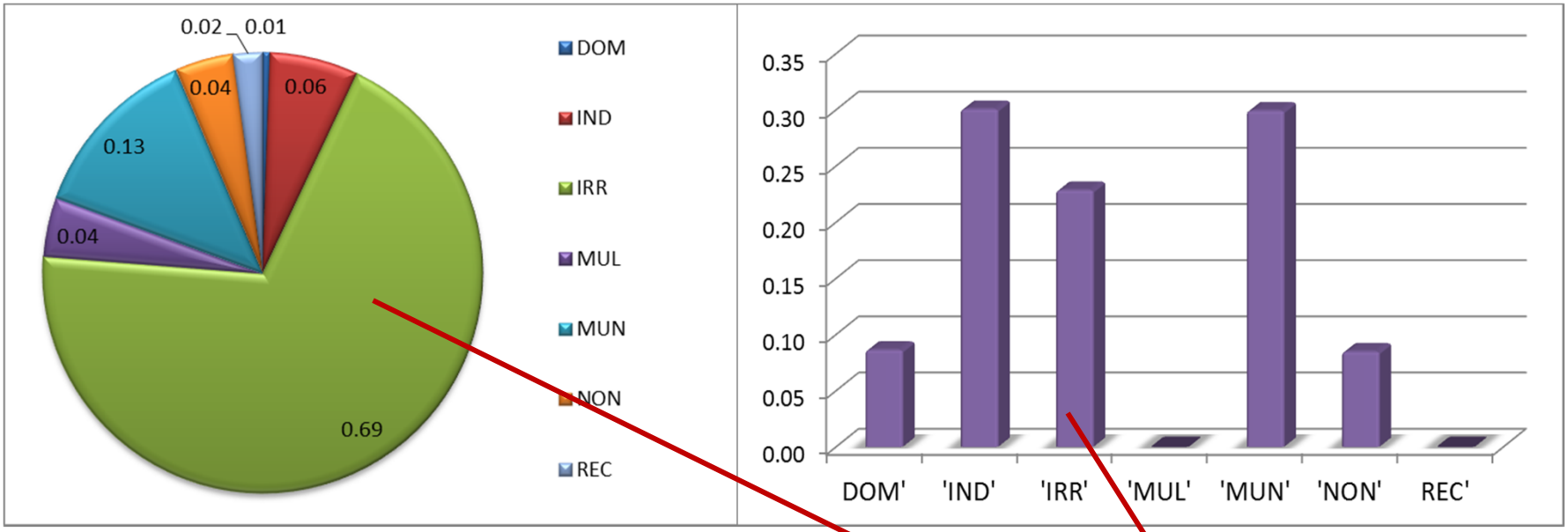
Research Question:

- What would be the potential impacts of a real-time water market in Guadalupe River Basin (GRB)?
  - Assess impacts on:
    - Profits and losses
    - River flows
    - Resilience to drought

Coupled agent-based modeling and RAPID river flow modeling approach

Irrigation Water Use



Number of water right holders

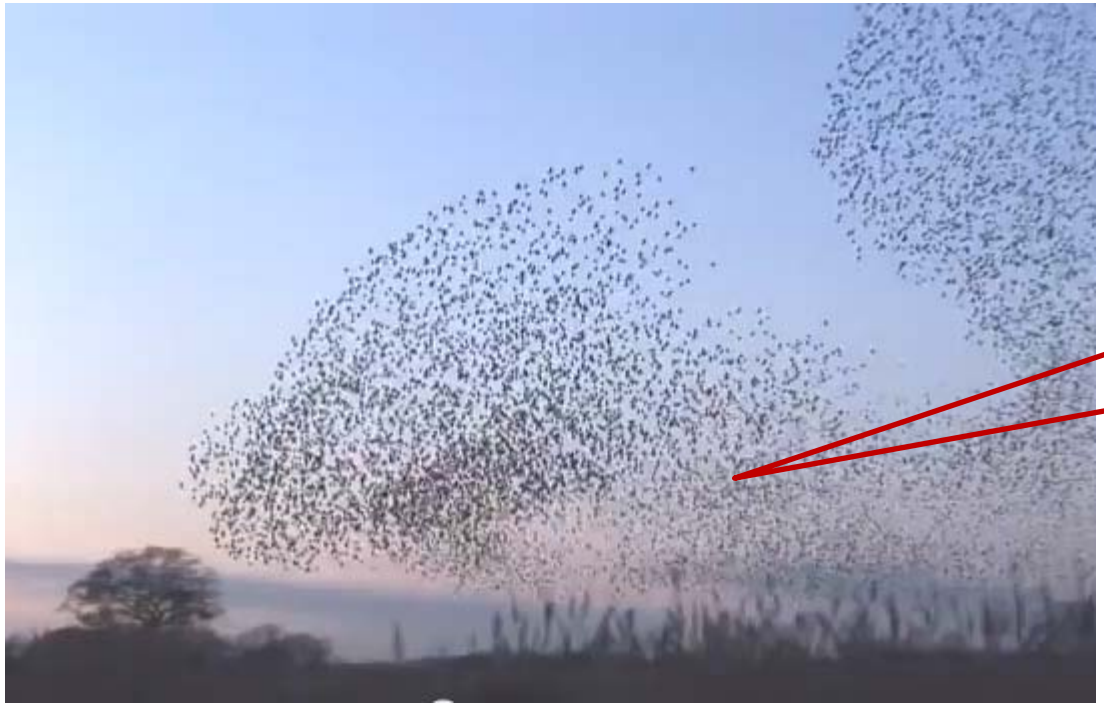
Water consumption in 2011

Water Use Type in GBR			
DOM	Domestic	MUL	Multiuse
HYD/P	Hydroelectricity	MUN	Municipal use
IRR	Irrigation	NON	Non-consumptive
IND	Industry	REC	Recreation
INS	In stream	OTH	Other use

Irrigation users are major water right holders and water consumers: initial study focus.

Agent-based Modeling

simulate the actions and interactions of **autonomous agents** (each agent follow individual behavior rule and can learn to update the rule) with a view to assessing their **effects on the system as a whole**.



Starling flock pattern

Snapshot from www.YouTube

Agent-based Modeling Components

Agents & Attributes

Entity = Customer

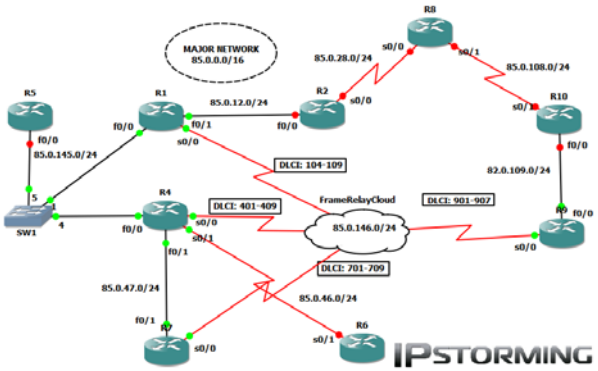
- Customer ID
- First Name
- Surname
- Date of birth
- Address
- Phone no.

These are the 'attributes' for the entity 'customer'

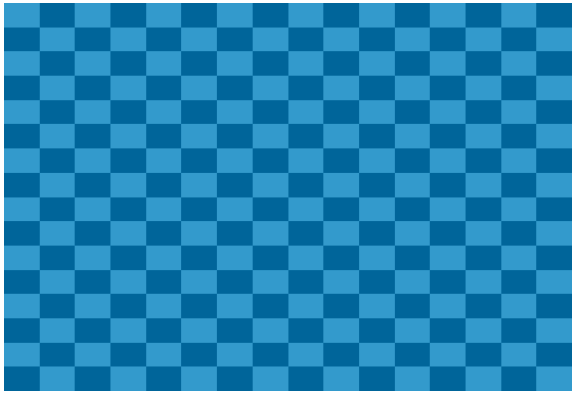
Teach-ICT.com

Behavior & Learning Rules

Interaction Topology



Environment



Initial Study: Agricultural Water Rights Trading

Assess impacts of water rights trading on:

- Crop yield
- Irrigation technology diffusion rate
- Resilience to drought

http://activelymovingwater.com

www.npr.org

www.threemilecanyonfarms.com

Define Agriculture Agents

- Assumption: farmers are utility maximizers -- their objective is to maximize profit from crop yield

$$\max: Y = Y_d + (Y_m - Y_d)\left[1 - (1 - I_r/I_m)^{\beta}\right], \text{(Hu, 2013)}$$

Y : crop yield (bushel/acre)

Y_d: rain-fed yield without artificial irrigation (bushel/acre)

Y_m: maximum yield without water shortage(bushel/acre)

I_m: maximum irrigation amount (inch/acre)

I_r: Irrigation amount (inch/acre)

β : Irrigation efficiency index, $0 < \beta < 1$

Agriculture Agent Attributes

- 1) Soil types

Agent Attribute 1: Soil Type		
Type	Ym (bushel/acre)	Yd (bushel/acre)
1 #	152.57	67.74
2 #	181.75	159.21
3 #	257.29	63.04

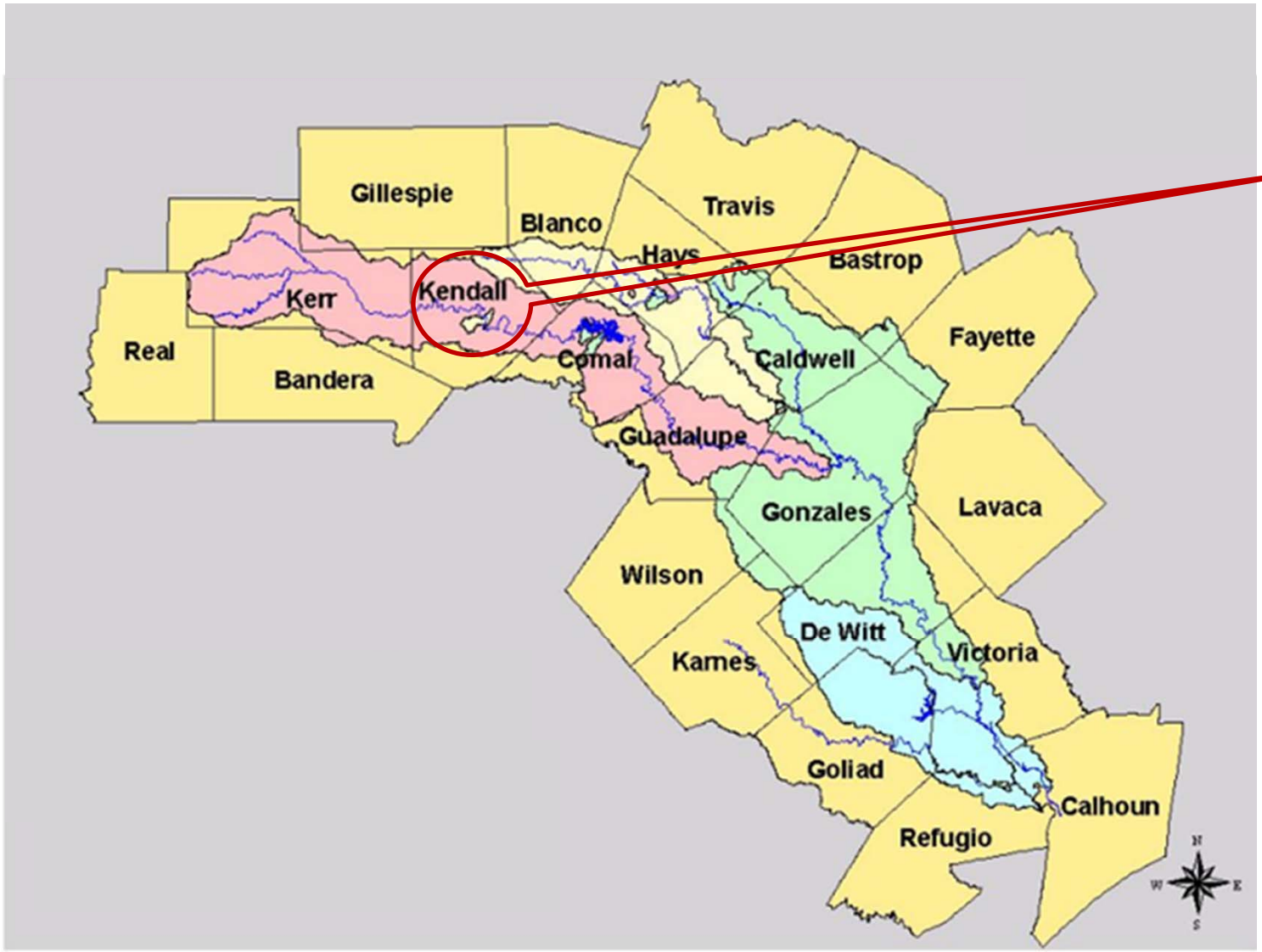
- 2) Water rights priority order

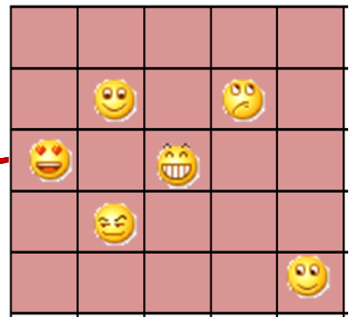
Agent Attribute 2: Water Right Priority Order			
Order	1 #	2 #	3 #

- 3) Irrigation technology diffusion index

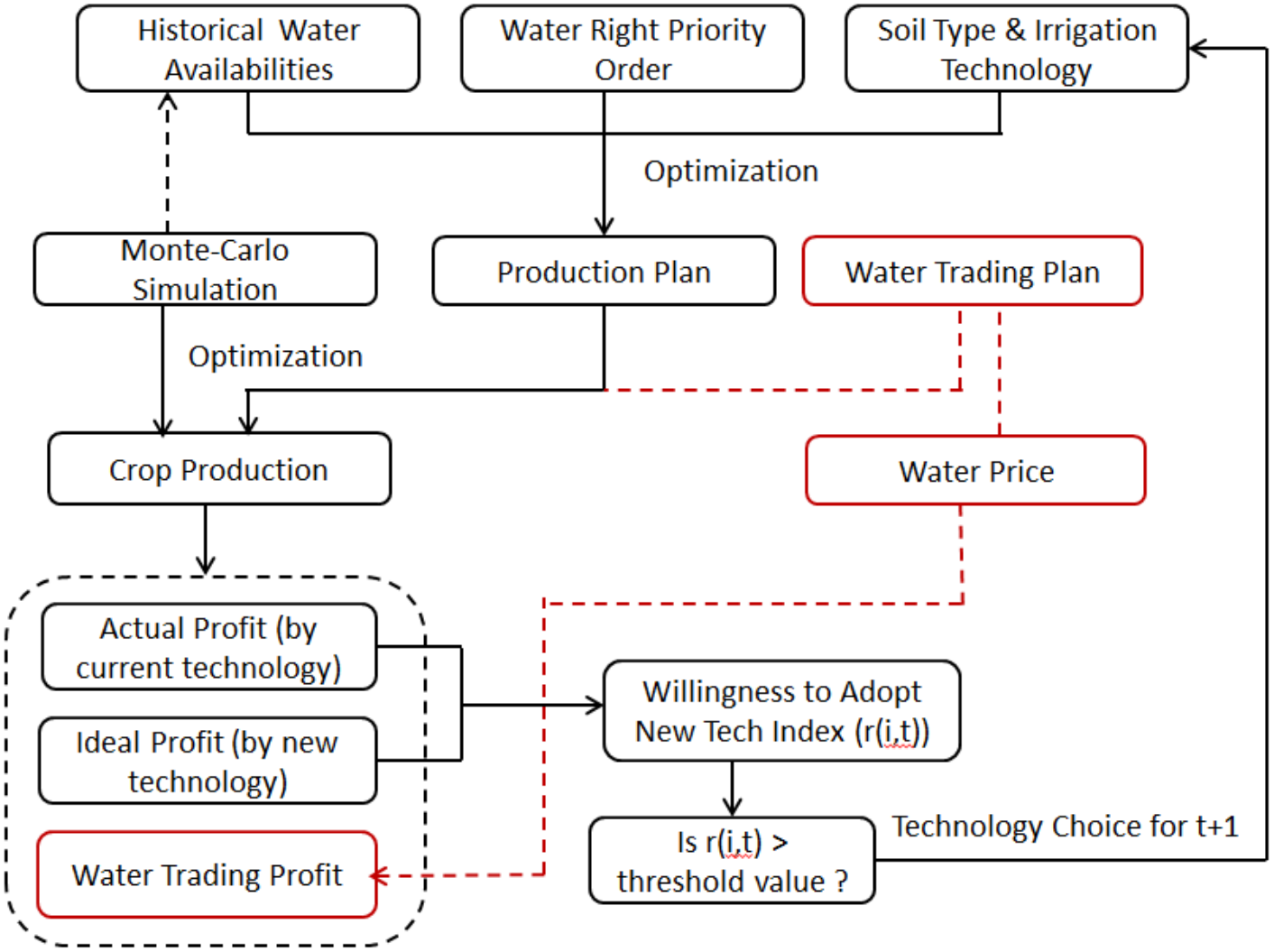
Agent Attribute 3: Irrigation Technology Diffusion Index		
Type	Index (θ)	Investment Payback Period
1 #	0.2	5 years
2 #	0.5	2 years

Agent Interacting Environment

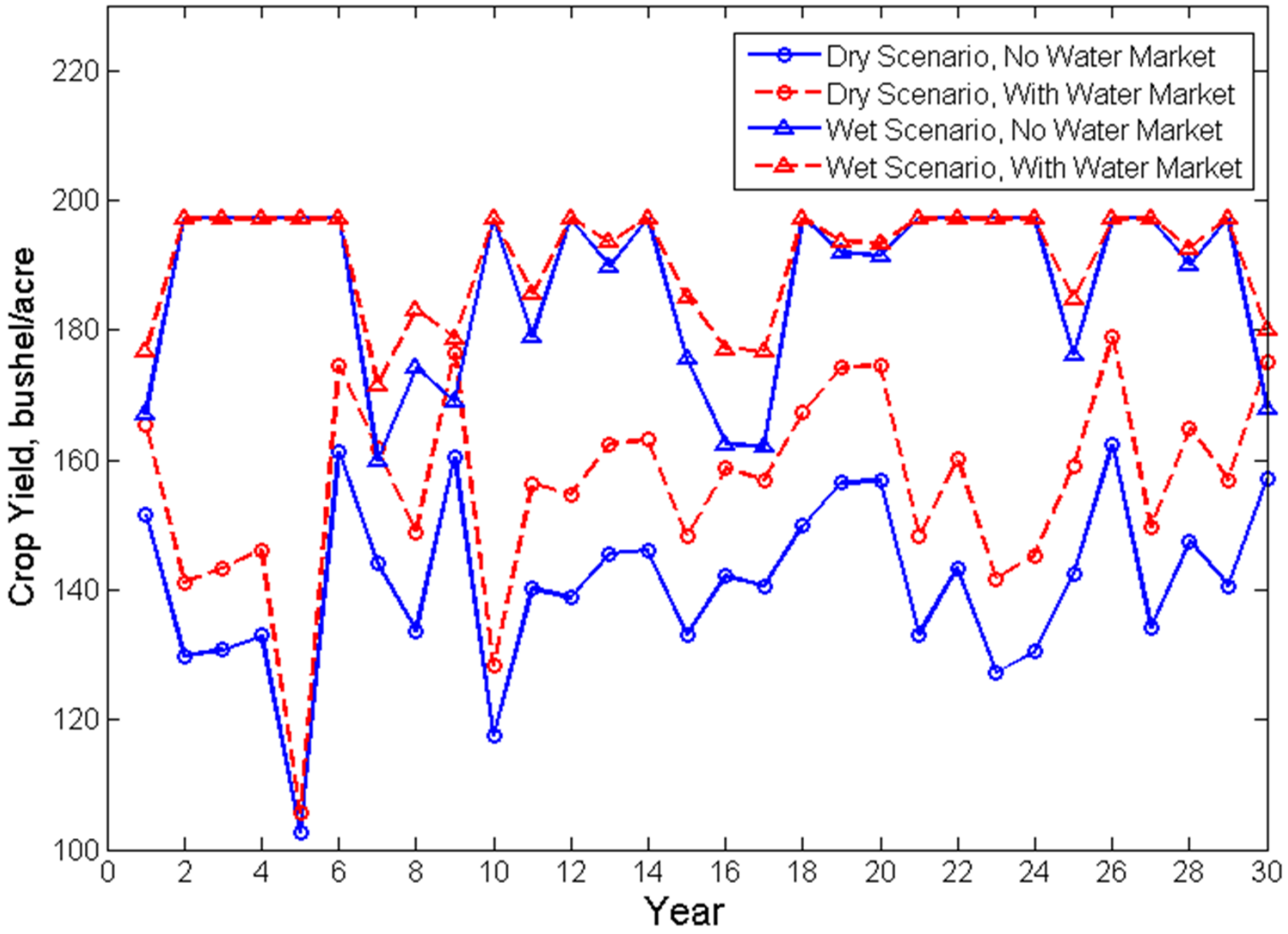




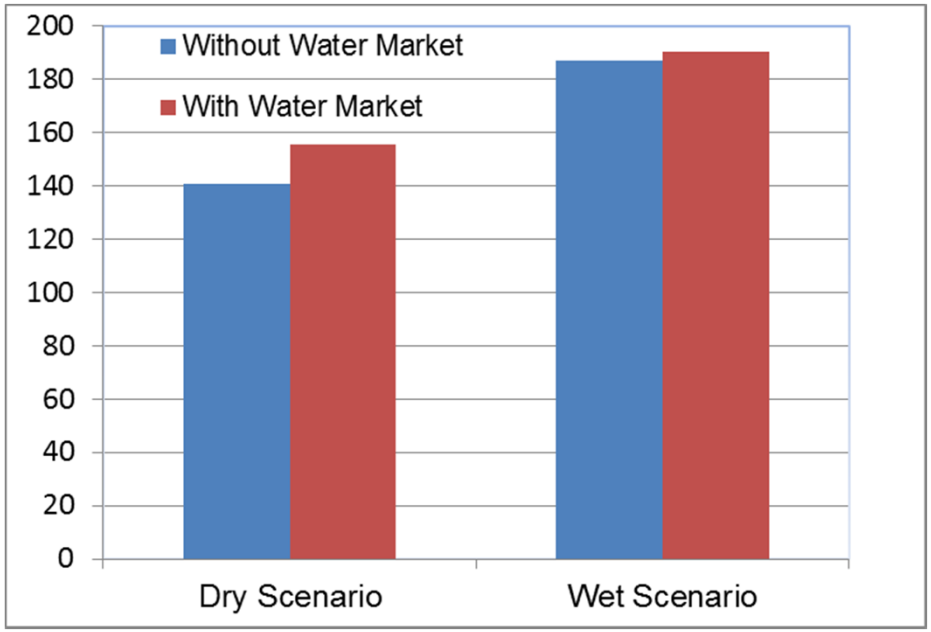
Agent-based Modeling Setup



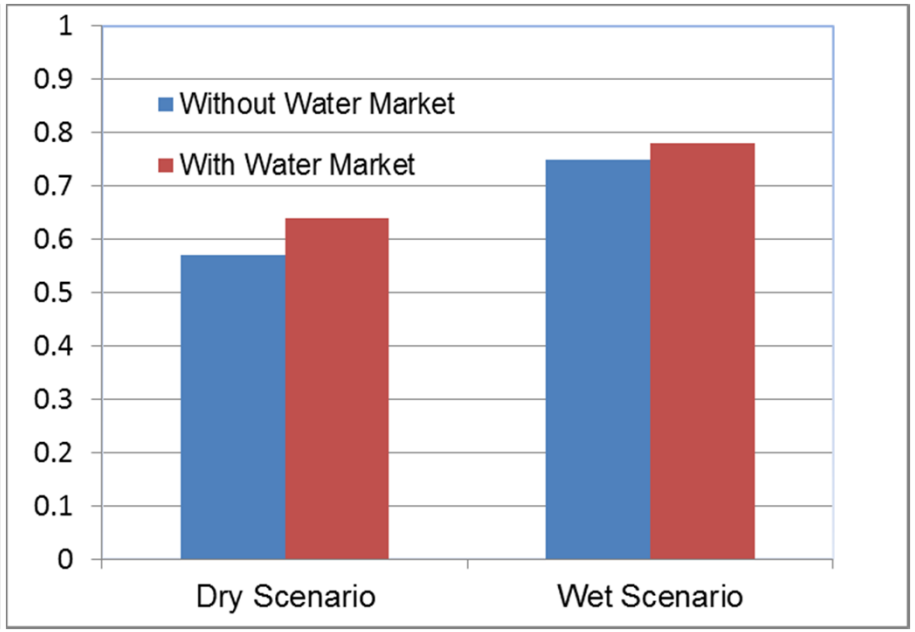
Results for Kendall County: Crop Yield



Results for Kendall County: Crop Yield & System Resilience



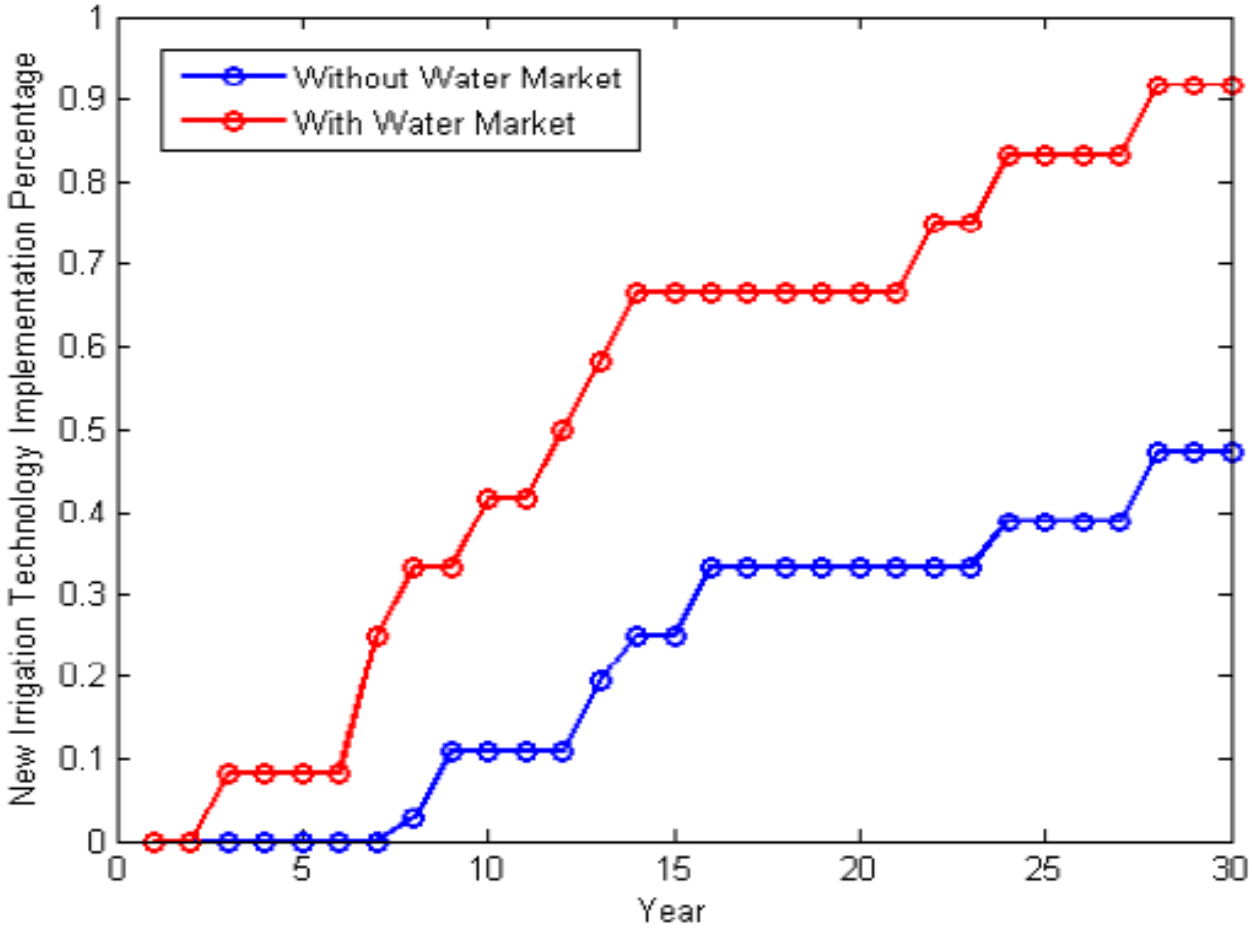
Crop Yield Comparison



Agriculture System Resilience to Drought

Both crop yield and agriculture system resilience improve about 10% by using a water market when conditions are dry.

Results for Kendall County: Irrigation Technology Diffusion



Irrigation technology adoption rate is faster if farmers are allowed to trade their water rights.

Conclusions

- Allowing agriculture water right trading could increase crop yield and resilience to drought
- Irrigation technology could diffuse faster with a water market

Future Work

- Couple RAPID model with agent-based model to evaluate water market's impacts on river flow
- Include other water users
- Consider transaction costs of water trading and effects of incomplete information on agents' decision-making processes
- Evaluate different auction mechanisms for water trading