Development of a field based Decision support Tool integrated with socio-economical model for managing Water Quality and Quantity

Sudipta K. Mishra, Gaurav Kanade, Deng Ding, David Bennet, Jerald L. Schnoor, Silvia Secchi, and Marian Muste

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DEVELOPMENT AND APPLICATION OF THE SWAT MODEL

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INTRODUCTION:

- Human activity is intricately linked to the quality and quantity of water resources. Although many studies have examined **human-water dynamics**, the complexity of such coupled systems is not well understood largely because:

  (a) gaps exist in our knowledge of **water-cycle processes** which are heavily influenced by **socio-economic drivers**;

  (b) typical analyses utilize a narrow range of **disciplinary expertise** and are often inward-looking; and

  (c) appropriate tools and data for **multidisciplinary research** do not exist (Schnoor et al., 2009).

- Do ***decision-makers understand the tradeoffs among economic return and environmental impact*** given alternative assumptions about the application of nutrients? Does such understanding ***change the way farmers manage the landscape or regulators set policies?***

- New tools are needed to ***sense and model the water cycle and its interactions*** with the environment and bounded human activities (Muste, 2009)

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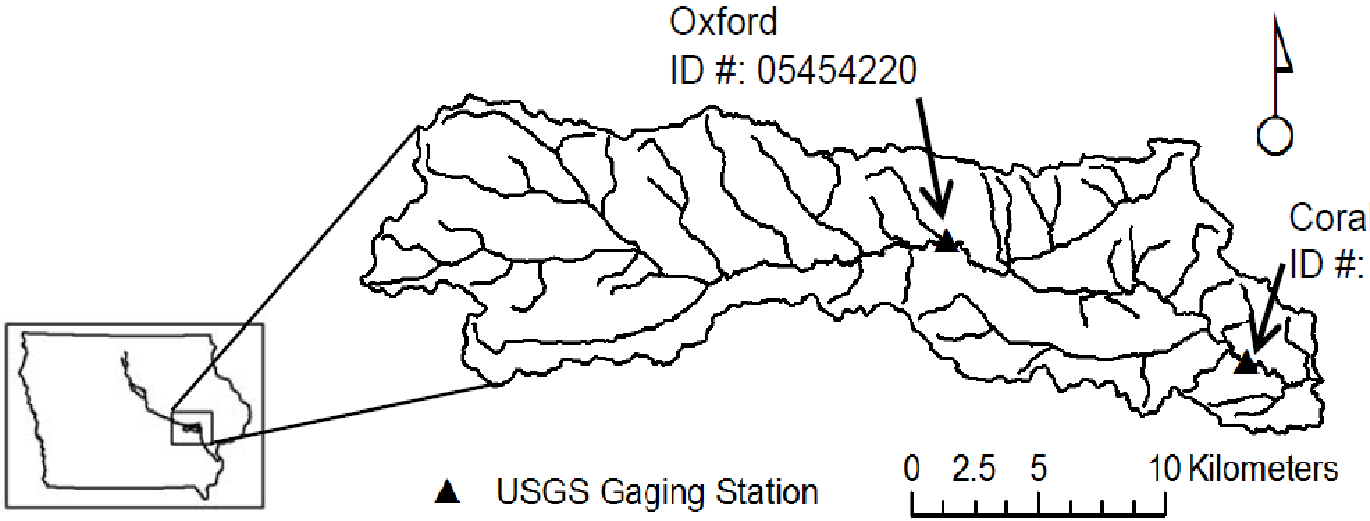
Study area and data used:

- The Clear Creek watershed is a **267 km^2** HUC (Hydrologic Unit Code) 10 units located in east-central Iowa.
- Approximately **85%** of the land cover in the watershed is **agricultural or grassland**, 8% is forest, 6% is roads or urban, and the remaining area is water or barren (Iowa DNR 2008).



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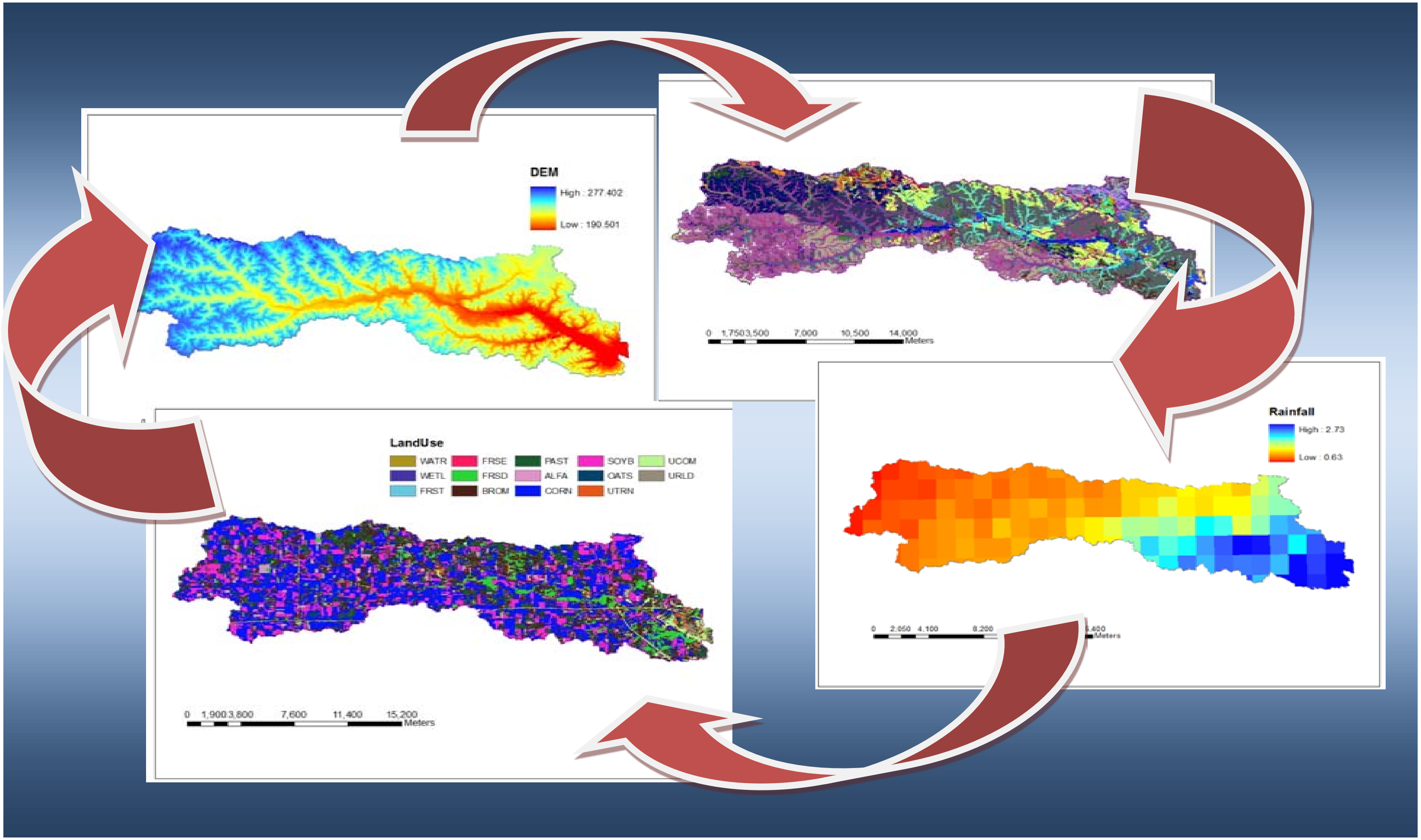

Figure . DEM, Landuse and Soil and Rainfall map for Clear Creek.

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Building a coupled SWAT-ABM modeling framework:

Agent Based Modeling (ABM) and scenario development

- Agent-Based Model (ABM) is a cyber-enabled approach of ***simulating the actions and interactions of heterogeneous autonomous agents*** in complex adaptive systems (CAS) such as a land-use system (Bennett and McGinnis, 2008).

- Agents in the system ***make decisions and behave based on specific decision-making heuristic, learning and adaption rules***.

- In land use modeling, the ABM could capture and represent:

  1) the ***heterogeneous set of driving forces on land-use decisions***,

  2) the ***interactions among agents, and between agents and environment***, and

  3) the ***complex feedback mechanisms and non-linear dynamics***.

- Thus it is considered as a useful alternative to traditional approaches in this field.

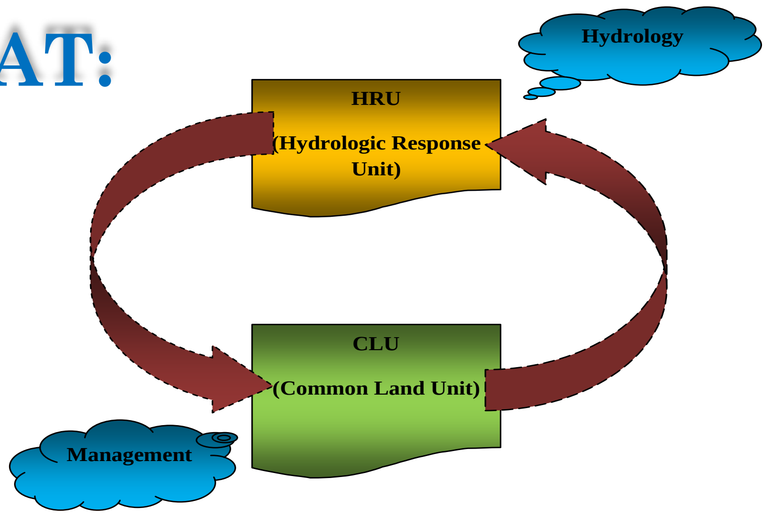
CONTINUED:

- While making farmland management decisions, ***farms interact with complicated environmental and social-economic factors.*** These factors include climate, government policies about energy (e.g. 2007 Energy Bill), government policies about environment and agriculture (e.g., the conservation reserve program), and market prices of crops and fuels, and etc.

- The ***complicated interactions and feedbacks compose a farm-based complex adaptive system*** which could be well simulated by an agent-based model. Thus the system may respond differently in various environmental and social-economic scenarios.

- To study **human decision-making processes** under different uncertainty, in our agent-based model (ABM), we will develop alternative scenarios based on three main driving forces of farm-based decision making: ***climate, federal energy and agricultural policies, and market value of crops and fuels.***

Coupling ABM with SWAT:



Old HRUs

1	1	2	2
3	3	2	2
3	4	4	4
5	4	4	4

CLUs

1	1	1	1
2	2	3	3
4	5	5	6
4	5	5	6

New HRUs

11	11	21	21
32	32	23	23
34	45	45	46
54	45	45	46

Figure 4. HRU reconfiguration algorithm

Algorithm: New HRU Index = Old HRU Index * B + CLU Index; where B equals to 10 here

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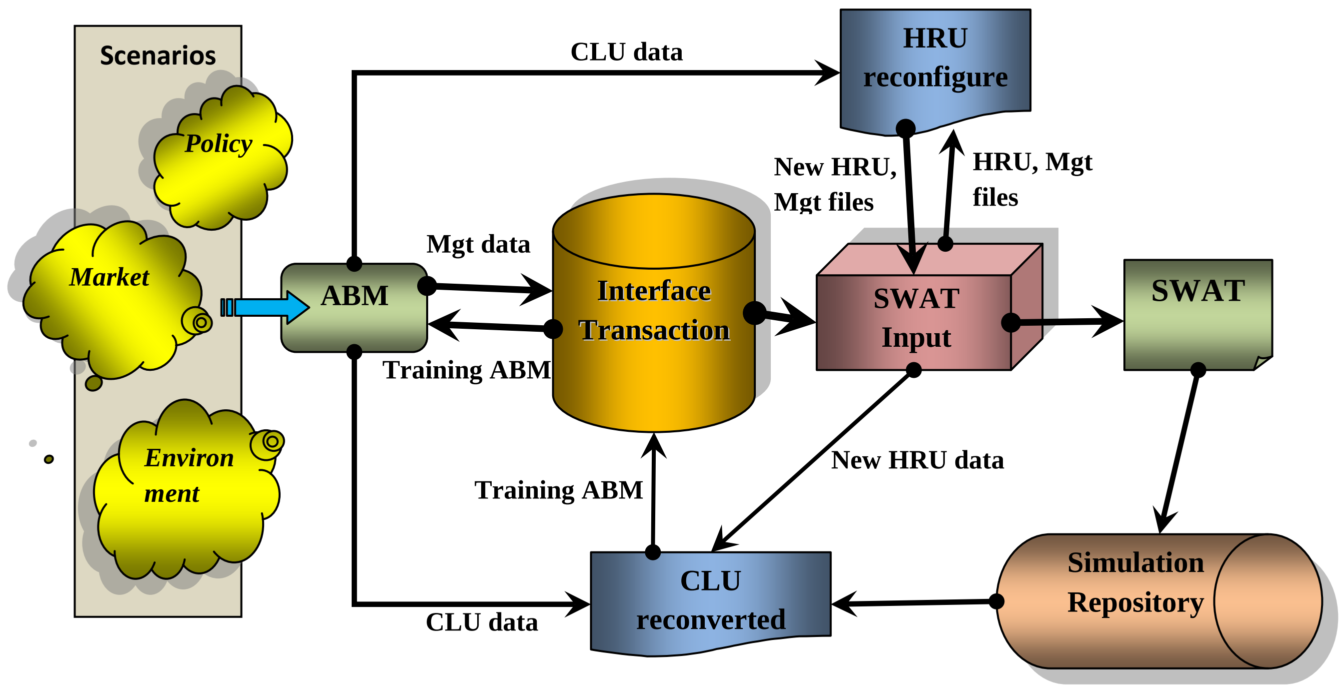

Figure. Coupled SWAT-ABM

INITIAL IMPLEMENTATION:

- ***Model parameterization:***

  The model has been ***auto-calibrated over 8 years (2000-2008)*** considering ***yearly corn-soybean rotation*** over the watershed. Sensitivity analysis has also been done and parameters sensitivity ranks.

- ***Case study: generating corn market scenarios:***

  In this work, the agents (farmers) ***make decisions on corn-soybean rotation based on the comparisons of the profitability*** of the two crops in their land parcel. There are three kinds of agents in the model: ***1) farmer; 2) land parcel, 3) farmer net.***

  With the model, we conducted an experiment about the ***influence of corn price increase on the land parcel allocations between corn and soybean.*** The number of farmer nets in the experiments is set to be 300.

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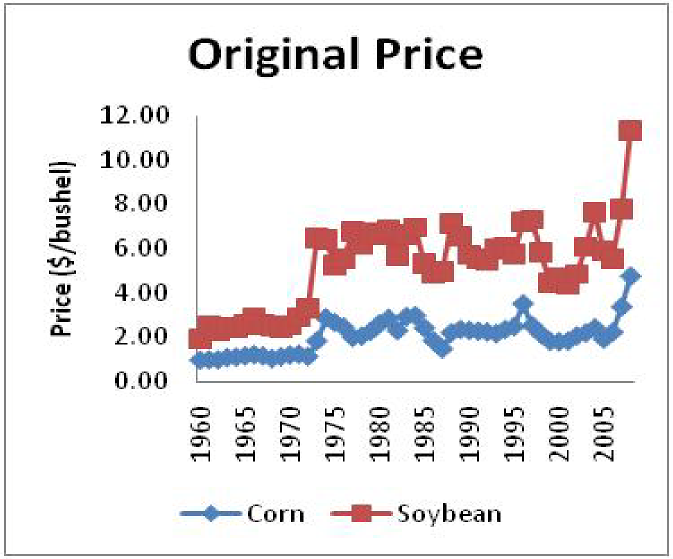

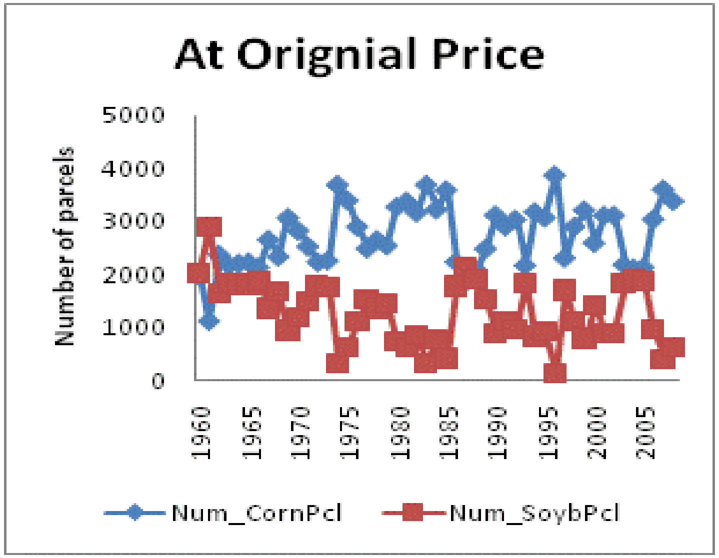

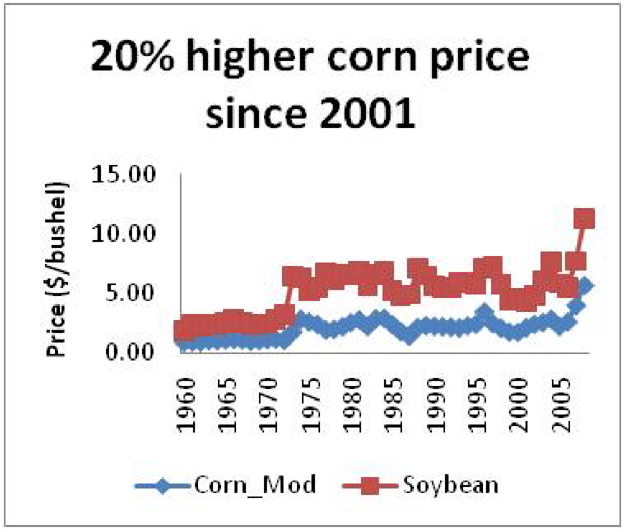

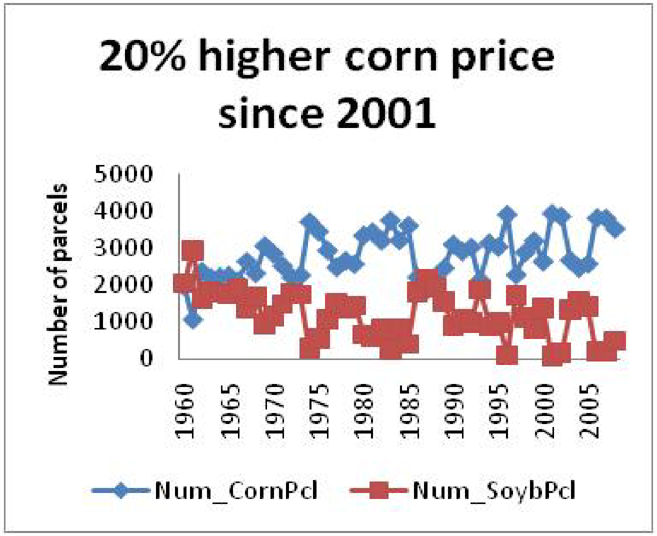

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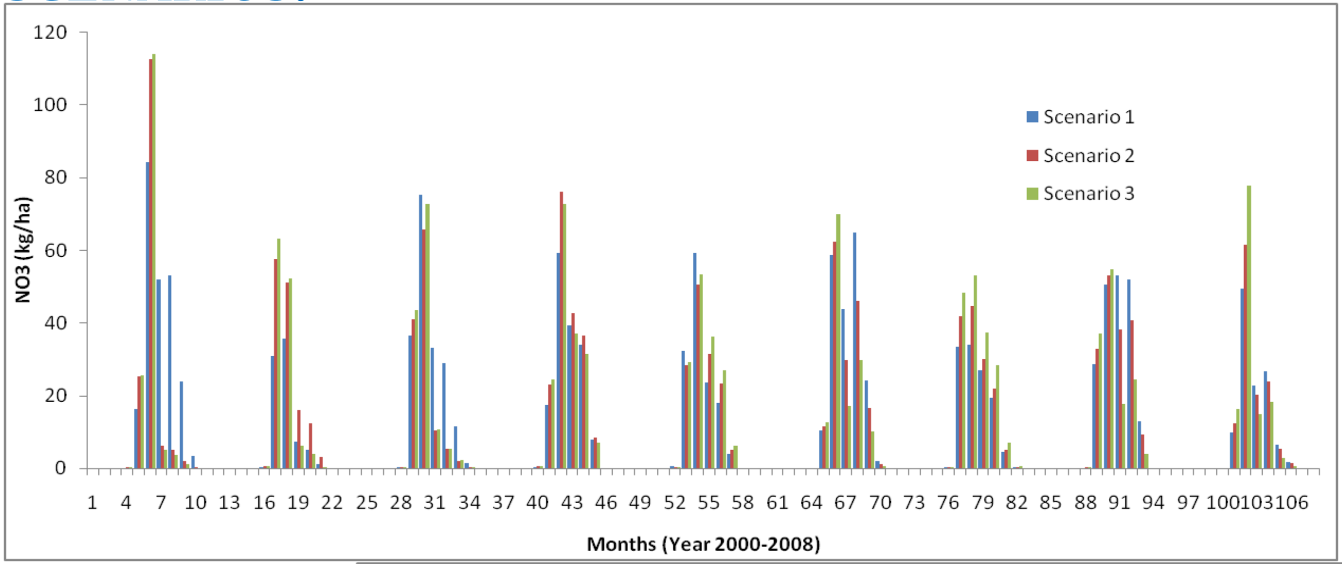
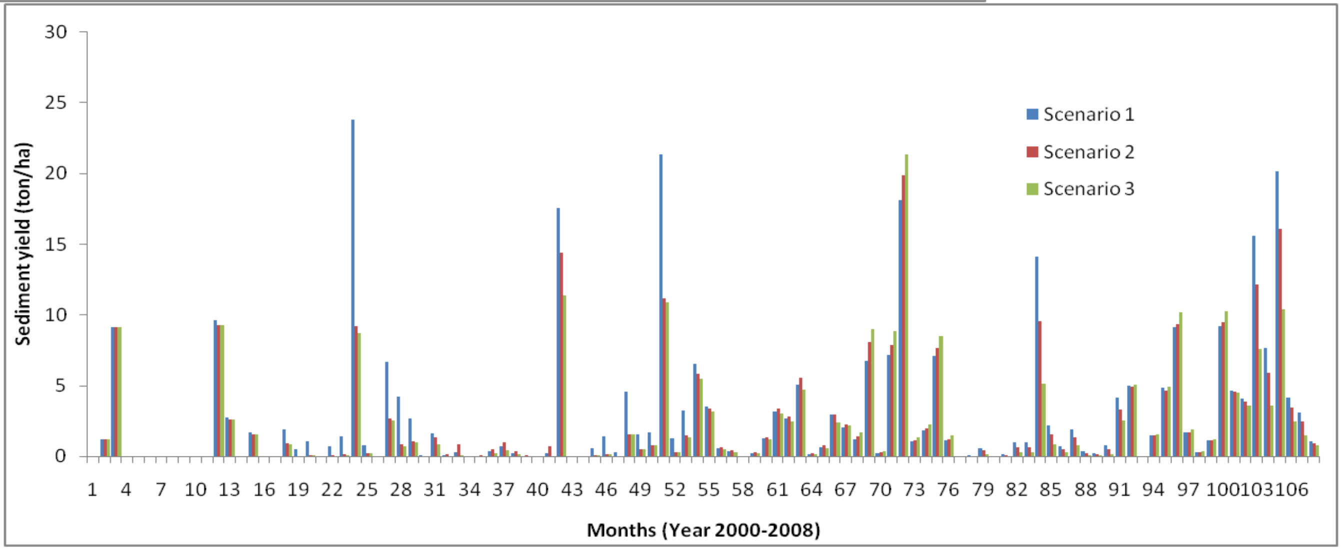
SIMULATING COUPLED SWAT-ABM MODEL FOR DIFFERENT SCENARIOS:





Scenario1: original corn price
Scenario2: 25% increase on original corn price since 2000
Scenario3: 50% increase on original corn price since 2000

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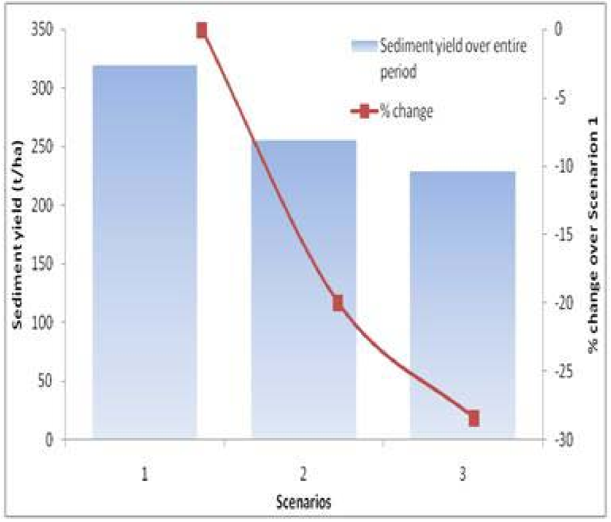

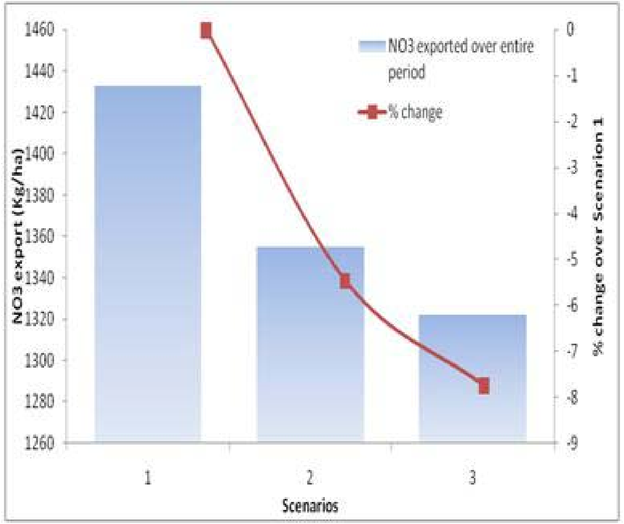

- Above results show that ***increase in corn price will result into reduction in NO_3 export from field***. This will also reduce sediment yield at watershed outlet.

- But the scenario developed might have ***interaction with other scenarios*** (e.g. Climate change, rainfall extreme variability over spring and fall and their changing pattern) and that can have considerable impact on the final response.

- Authors intend to do more robust study by merging simple scenarios (like the one here) and ***built on complex, interacting scenarios*** in later part of the study.

Conclusion and Future Direction:

- ***Environment, market and policy scenario*** has considerable impact on natural system which is evident through its responses in terms of water quality and quantity. Through this scenarios studies stakeholders can better understand ***implication of certain policy decision on natural system*** and thus may help in formulating more eco friendly policies in long term.

- Effort for modeling **coupled Natural-Human system** and understand there interactions. The research effort carried out through this work will produce a **prototype Intelligent digital watershed (IDW)** which is envisioned to be comprehensive, real-time operational in next stage.

Thank You

For your kind attention
Have a question?

Sudipta K. Mishra
Email: *sudiptakumar-mishra@uiowa.edu*