Biomass has emerged as a major source of energy production in many countries. In the United States, the Energy Independence and Security Act (EISA) of 2007 has envisaged a major share of fuel requirement of the country to be met from biofuel, by targeting a production of 36 billion gallons of biofuel by 2022 (Cinb et al., 2012). Ethanol production using corn and soybean causes unhealthy competition among food and fuel, and hence EISA has suggested to put an upper cap on such grain-based ethanol production and to meet the remaining bio energy requirement from second generation biofeedstocks such as crop residues (corn stover, wheat straw etc.) and perennial grasses (Switchgrass and Miscanthus). In the present case, use of fertilizers and pesticides in corn and soybean fields has resulted in huge amount of nutrients being delivered to downstream rivers. Introduction of perennial grasses can improve the in-stream water quality compared to the row cropped systems. However, these grasses are associated with high production cost and hence less established. In such a situation, a simulation-optimization framework can be employed to develop economical switchgrass and Miscanthus plantations that can be adopted in the watershed to improve water quality, simultaneously achieving grain and biofuel production targets.

**Methodology**

**STUDY AREA**

St. Joseph watershed encompasses an area of around 2830 km² in northeastern Indiana, northwest Ohio and south central Michigan. Major land use is agriculture, dominated by corn/soybean (39%) and pasture (25%). SWAT model setup was done for the watershed with 417 sub basins and 940 grids. Model calibration was done with stream flow data from USGS (United States Geological Survey) and water quality data from St. Joseph River Watershed Initiative (SJRWI).

- 16 parameters were selected by sensitivity analysis for flow calibration.

Model Calibration and Validation

**Objective**

- Calibrate and validate SWAT model for simulating stream flow, sediment and water quality simulations for the study area.
- Develop a simple exponential decay based in-stream process model for the watershed to loose-couple with the calibrated SWAT model.
- Develop a pseudo model representation of the calibrated SWAT model and to link it with the exponential decay based in-stream process model.
- Develop optimal cropping pattern aiming at sustainable bio-energy production scenarios using a multi-objective simulation-optimization framework considering economic and water quality attributes, and food security constraints.

**Problem Statement**

Environmental sustainable second generation biofuel production through optimal land use planning

**A minimum of 100 million gallon of bioenergy is to be produced**

- Corn Stover Removal (30%)
- Corn Stover Removal (50%)

**Model Calibration and Validation**

- Instead of the SWAT in-built in-stream model (QUAL2E), an external exponential decay model was loose coupled with SWAT for simulating nutrient transport in streams. This simple coupled model slightly better performance compared to the default model.

**Nitrates transport**

\( \frac{dC}{dt} = \alpha - \beta C \)

\( \alpha = \text{Downstream nutrient load} \)

\( \beta = \text{Upstream nutrient load} \)

\( \gamma = \text{Distance decay coefficient} \)

\( k = \text{Reach distance} \)

**Conclusions**

- Replacing the current cropping practices with Switchgrass and Miscanthus reduces downstream nutrient delivery in comparison to the baseline scenario. Moreover, this ensures sufficient biomass production.
- Stover removal options can improve the biomass potential of the watershed with minimum impacts on corn grain yield reduction.
- Optimization results provides options for economically and environmentally sustainable biofuel production from the watershed with various cropping patterns.

REFERENCES

- Cinb et al., 2013. Optimal Land Use Planning on Selection and Placement of Energy Crops for Sustainable Biofuel Production. (Doctoral Dissertation): Purdue University, USA.

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