# A CyberGIS Decision Support Platform for Sustainable Bio-based Systems Development

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With increasing population and depleting resources, achieving energy independence and food security, without sacrificing environmental health, is necessary for a sustainable world. Integrating bio-based production systems analysis with CyberGIS can contribute to solving societal problems in energy, food, and the environment.

Cellulosic based biofuels, for example, are considered to be a sustainable transportation fuel of the future. The U.S. has proposed a Renewable Fuel Standard to produce 16 billion gallons of cellulosic ethanol in 2022 (EPA, 2010). To facilitate sustainable biofuels development, extensive studies have been conducted from novel bioconversion technologies development (Lange, 2007), environmental and social benefit analysis (Hill et al., 2006), land-use change (Searchinger et al., 2008), to supply chain systems informatics and analysis (Lin et al., 2013).

The nature of biomass production imposes spatial and temporal constraints that must be considered for successful biofuels production and delivery. Spatially, farm number, cropland area, soil fertility, and biomass yield vary geographically. The transportation distance between facilities varies based on their spatial distribution. The harvestable biomass yield and probability of working day vary with both location and time. Given this complexity, there are several reasons why CyberGIS will be essential in facilitating the analysis of bio-based systems in the future.

1. **Complex problem solving.** Biomass supply chain optimization is proposed to facilitate analysis of large-scale biomass and food provision systems. Most existing optimization models have been developed using mixed integer linear programming, which requires significant resources for large-scale problem solving in terms of memory and computational time.
2. **Spatial result visualization.** The numerical results from the optimization models are often complicated, which causes major challenges for interpretation of results. Conventional GIS has been applied to visualize numerical results, but not in an integrated workflow. Providing a seamless workflow, integrating optimization models with spatial visualization functions would increase the potential impact of these analyses.
3. **Large group application.** Most developed optimization models are PC-based, not web based. Model accessibility remains a major bottleneck. Web-based decision support platform provides an easy access to larger user groups. Furthermore, an interactive web interface could facilitate scenario analyses. In order to provide solid and prompt support for large group applications, high-throughput computing will be essential.

Several modeling tools are under development for analysis of bio-based systems, including cellulosic biofuel production, prevention of postharvest losses for increased food security, and for best management practices in agricultural drainage water management. Each will have similar challenges related to computational load and spatial analysis. These software tools aim to provide decision support from strategic planning, such as technology selection, facility locations, and resource allocations, to tactical planning decision, such as day-to-day decision making and scheduling.

CyberGIS provides a seamless integration of cyber infrastructure (CI), GIS, and spatial modeling analysis, which is becoming important to facilitate large-scale problem solving, data management, model accessibility, and visualization (Wang et al., 2013). Supported by the high performance CI and service oriented middleware, this paper suggests that integrating CyberGIS and software designed for the analysis of bio-based systems will facilitate analysis of complex problems through the use of high-performance distributed computing, service oriented computing application, and web-based platforms. This combination will improve decision support in high impact problems affecting society, the environment, and future bio-based economies.

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