GIS-based multi-criteria decision support model for energy crop system analysis

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Abstract

Bioenergy provides a sustainable and renewable alternative to fossil fuels, which is crucial for reducing greenhouse gas emissions across various sectors of the U.S. economy and achieving energy supply stability. The production of the energy crop feedstocks for bioenergy production is an intricate process that requires multi-criteria decision-making. Land availability and land use changes are crucial factors that influence the suitability of an area for energy crop production, as effective energy crop management is required to preserve food and fiber production. To address these challenges, we have developed a Python-based Crop Production System (CPS) for analyzing land availability and land use changes required to produce energy crops (e.g., Miscanthus). The CPS model uses GeoPandas to integrate GIS for geospatial analysis and visualization. Additionally, the CPS model offers a framework to integrate additional land selection criteria, facilitating targeted and sustainable decision-making.

The model was used to analyze Miscanthus production in Tennessee (TN) at the county level. This model is designed for a biorefinery with a capacity of 200 dry tons per day, requiring approximately 9,400 acres of land annually. The model operates by curating land use and availability data and then classifying the availability of cropland, pastureland, and woodland in each county for energy crop production. The model prioritizes the partial transformation of pastureland for Miscanthus production to minimize the impacts of land use change. Furthermore, as an additional suitability layer, the model adds the CDC's Social Vulnerability Index (SVI) to filter out socio-economically vulnerable communities. Finally, the model integrates socio-demographic data of available farm- and pasture-land owners to promote the utilization of farms owned by underrepresented communities.