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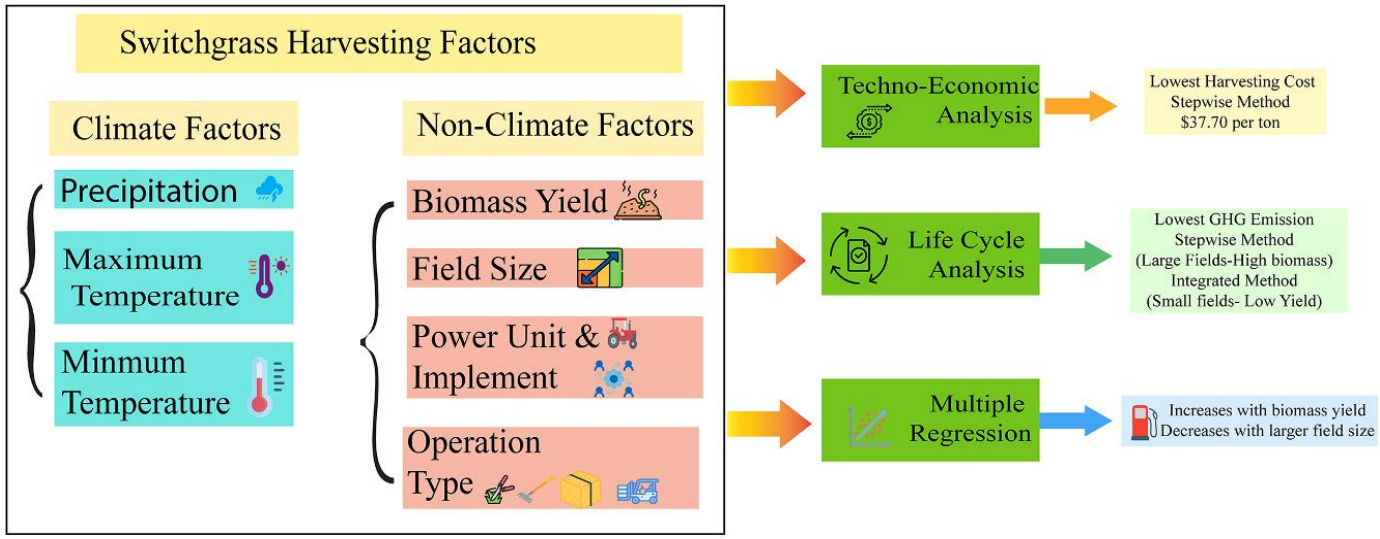
Optimizing Bioenergy Biofuel Harvest: A Comparative Analysis of Stepwise and Integrated Methods for Economic and Environmental Sustainability

Background/Objective

Switchgrass is a promising bioenergy feedstock due to its high biomass yield potential, adaptability to marginal lands, and low carbon intensity. Optimization of the energy-intensive harvest process is important for the overall sustainability of switchgrass cropping systems. This work uses comparative techno-economic analysis and life cycle assessment (TEA/LCA) to assesses two potential switchgrass harvesting methods.

Approach

Researchers compared two harvest methods: the stepwise method which separates operations into multiple stages and the integrated method which combines mowing and raking into a single pass. Three years of field-scale switchgrass harvest data from 125 sites were used to quantify greenhouse gas (GHG) emissions, energy consumption, and harvest costs using the GREET model and TEA for both harvest methods.



Climate and non-climate factors shape fuel use, GHG emissions, and harvesting costs in switchgrass, with lowest costs ($37.70 t^{-1}) under stepwise methods and yield–field size trade-offs.

Results

The stepwise method was most cost-effective for large fields with high biomass yield ($37.70 per ton), leveraging field efficiencies to reduce GHG emissions and fuel consumption. The integrated method performed better in small fields and low-yield conditions, reducing GHG emissions by 9% and energy use by 5% but slightly increasing cost.

Significance/Impacts

These results provide actionable insights for optimizing harvest strategies based on field-specific conditions and operational goals.

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