Fuzzy Optimization of Rice Straw Utilization in the Philippines Based on Carbon and Nitrogen Footprints

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Submission Category:

(A) Technical research proposal to solve concrete problems

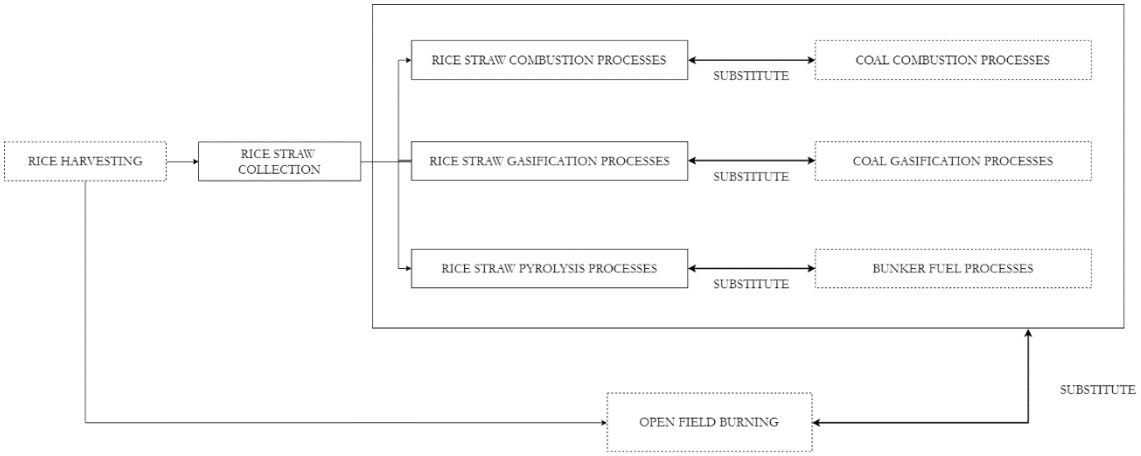
SDGs Targets/Indicators:

The study aims to optimize the environmental effects of rice straw utilization to contribute in SDG 7 which is to ensure access to affordable, reliable, sustainable, and modern energy for all, specifically to increase the share of renewable energy in the global energy mix.

Abstract:

The Philippines produces almost 20 million metric tons of rice annually. This is accompanied by a huge amount of rice straw. Currently, rice straw is being openly burned in fields as it is considered as waste. However, rice straw can be converted to higher value products. This study considered thermochemical conversion pathways such as combustion, gasification, and pyrolysis, which produce electricity, methanol, and bunker fuel. These rice straw-based products may provide less environmental impact as compared to that of coal-based or crude oil-based products. Environmental performance was measured using carbon and nitrogen footprints as these two footprints may exhibit trade-offs. It was discovered, for example, that in bunker fuel production, crude oil-based processes had more carbon footprint while rice straw-based processes had more nitrogen footprint. A life cycle inventory was performed to analyse the emission effects of the pathways per process. After this, an optimization model was created to minimize the environmental impacts while meeting the demand capacity for each product. The study considered rice straw harvesting, collection, chopping and open burning, electricity production from rice straw and coal, methanol production from rice straw and bituminous coal, and bunker fuel from rice straw and crude oil. The study has found that rice straw-based product pathways were preferred with a 3.33% and a 0.71% reduction in carbon and nitrogen footprint respectively. For the total available rice straw, 0.01% was sufficient to meet the demand for both methanol and bunker fuel. The balance was then allocated to electricity production, but even with this volume, this pathway only had a 9% demand fulfilment. The next steps for this study is to determine how the supply chain can be operationalized in the Philippines by conducting sensitivity analysis in its transportation network and possibly involving economic factors in the optimization.

Graphical Abstract:



LEGEND:

Broken Line - current utilization and product pathways Solid Line - proposed rice straw utilization process