

DESIGNING A MULTI-LEVEL BIOMASS LOGISTICS NETWORK FOR SUSTAINABLE AGRICULTURAL RESIDUE MANAGEMENT: A CASE STUDY OF NORTHERN THAILAND

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ABSTRACT

Open-field burning of agricultural residues remains a major environmental challenge in Northern Thailand, contributing to seasonal PM_{2.5} pollution while leaving valuable biomass resources underutilized. Although previous studies have emphasized biomass conversion technologies and logistics optimization, limited attention has been given to integrated regional logistics frameworks that ensure reliable biomass supply. This study proposes the Multi-Level Biomass Logistics Network (MBLN) Framework, an adaptive regional planning framework for sustainable agricultural residue management, based on field investigations conducted in Chiang Rai, Chiang Mai, and Lamphun provinces, Thailand. A mixed-methods approach was employed, combining literature review, field surveys, stakeholder interviews, and geographic mapping to examine biomass availability, logistics infrastructure, collection capacity, and industrial demand. The proposed framework integrates Physical, Information, Coordination, and Value Creation Networks to support adaptive biomass collection, aggregation, distribution, and stakeholder collaboration under different local conditions. The findings indicate that effective biomass logistics depends not only on transportation efficiency but also on integrated coordination and supply reliability capable of supporting continuous industrial demand despite the seasonal availability of agricultural residues. The proposed MBLN Framework provides a scalable regional planning approach for improving biomass utilization, strengthening circular economy development, and reducing open-field burning. It also provides a foundation for future research on logistics optimization, hub location analysis, vehicle routing, and digital decision-support systems.

Keywords: Agricultural residue management; Biomass logistics; Multi-Level Biomass Logistics Network (MBLN); Circular economy; Supply chain integration; Sustainable biomass supply

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