

BIOMASS SUPPLY CHAIN OPTIMIZATION FOR RICE INDUSTRY IN PERLIS REGION

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ABSTRACT

The efficient utilization of agricultural biomass holds significant promise in addressing energy and sustainability challenges. This study focuses on the optimization of the rice biomass supply chain in the Perlis region, aiming to enhance the resource utilization and minimize environmental impact. The abundance of rice residues generated after harvesting presents an opportunity to create a sustainable energy source while managing agricultural waste. This research encompasses a comprehensive analysis of the entire rice biomass supply chain, from residue collection at farms to the final biomass conversion process. Geographic information systems are employed to assess rice cultivation patterns and estimate potential biomass yield. Mathematical models are utilized to design an integrated supply chain network that considers collection, transportation, storage, and biomass conversion. Key factors influencing the supply chain are identified, including transportation costs, storage infrastructure, seasonal variations in biomass availability, and technological feasibility of conversion processes. Environmental implications are also evaluated, considering emissions reduction through the displacement of fossil fuels. The outcomes of this study contribute to the establishment of an efficient and sustainable rice biomass supply chain in the Perlis region. The developed optimization framework can serve as a blueprint for similar agricultural biomass utilization initiatives in other regions. The research not only addresses the technical aspects of biomass supply chain management but also considers the broader economic, social, and environmental implications, paving the way for a more resilient and resource-efficient agricultural sector.

Keywords: Rice biomass, Supply chain optimization, Perlis Region, Sustainability, Mathematical modelling.

INTRODUCTION

Biomass is an organic matter where it is made of material that comes from living organisms such as animals and plants which is used for bioenergy. Agricultural waste records for 91% of biomass, the majority of which is derived from palm oil mill residues. Some other sources of biomass are from rice industries.

Malaysia produces a significant amount of rice. In Perlis, the total physical area for paddy is 130, 282 hectares, and the total area for paddy fields developed under MADA Administration is 100, 685 hectares (1). There are estimated to be 405,000 tonnes of rice produced in MADA (Kedah and Perlis), and 60750 of those tonnes (or 15%) are from Perlis (2). Rice biomass refers to the various organic

materials derived from the cultivation and processing of rice. It encompasses different parts of the rice plant, including the straw, husks, and bran, which are byproducts generated during the production of rice. Concerning Perlis, statistical research indicates that rice husks are the most abundant biomass. Rice husks can be utilized to generate electricity but most of the rice husk will either be burned or disposed of as waste (3).

Biomass supply chain is defined as the flow process of biomass waste from the land to its end used to produce beneficial products such as bioenergy in the form of electricity, heat, or biofuels to power plants, industries, or households. The biomass supply chain is

essential for renewable energy, waste management, economic benefits, agricultural and rural development, carbon neutrality, and the promotion of a circular economy, making it a crucial component of sustainable resource management. The creation and use of good design techniques may considerably improve the financial viability and environmental efficacy of biomass supply operations (4).

A few obstacles to upscale biomass utilization include variations in biomass accessibility, unique traits of each biomass variety, the harvesting process, logistics and transport issues, facility location, and the advancement of biomass usage technological advances efficiency. The cyclical nature in the biomass supply chain is compounded worse by seasonality and weather uncertainty (5). There will still be difficulties even though the biomass supply chain is being strengthened. Therefore, it's important to conduct regular studies to determine innovative fields of focus for development (5).

The development and implementation of efficient design methodologies can greatly enhance the sustainability of biomass supply processes from an economic and environmental perspective. The biomass supply chain must be thoughtfully planned to reduce the price of energy produced from biomass and guarantee a consistent supply of feedstock.

Although many products or energy can be generated from rice waste, it only studied in research phase, main biomass such as rice bran, rice straw and rice husk still treat as low

waste value (6). Even though there are industries that utilize biomass for bioenergy conversion but is still not effective in the rice industry, especially in Perlis. This is because there is no implementation of biomass supply chain and no effective management for specific data collection in conversion and consummation of biomass in Perlis region. Thus, it will cause some of the conversion of biomass into bioenergy lavish as waste without any use.

The utilization of the biomass supply chain can be optimized to maximize capacity while minimizing waste. Mathematical modeling techniques can be employed to summarize and describe the biomass supply chain. This study is to conduct a market survey to map the production of biomass in Perlis region. Then this study also to identify the various operation activity in biomass utilization with various variable including conversion factor, waste characteristic, waste production, harvest time, storage capacity, pretreatment required, and transportation cost (6). Furthermore, it also conducts to correlate the activity with production processes.

METHODOLOGY

Model development for optimal biomass supply chain.

In order to implement a model-based optimisation strategy for the required decision-making process as shown in flowchart 1. Building a superstructure model of the supply chain that connects all potential routes for converting the indicated biomass resources into numerous bioproducts utilising

the processing technology options is a crucial phase in the process. A linear optimisation model based on the superstructure is then developed, with the model parameters mostly being established by estimations utilising data from both the open literature and inputs from our collaborator's operation and expertise. It is

noted that several types of surrogate modelling techniques may be used during parameter estimation. This research also has the capability to conduct sensitivity analysis to determine the resilience of the proposed supply chain as part of the solution interpretation for practicality (7).

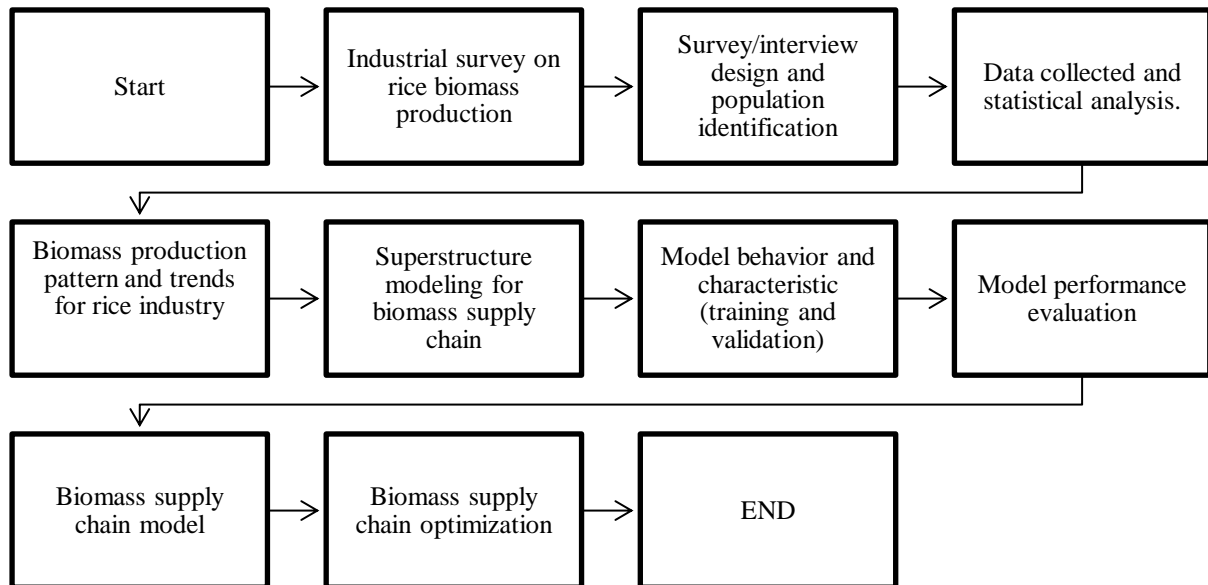


Figure 1: Flowchart of the modeling framework adopted in this work.

Industrial survey on rice biomass production

An industrial survey on rice biomass production involves collecting data and information about various aspects of producing biomass from rice crops. The survey aims to understand the quantity and quality of rice biomass produced, biomass utilization practices, challenges faced by biomass producers, and the potential for biomass-based products. The survey methodology includes developing a questionnaire, piloting it, identifying, and approaching participants from the rice

biomass industry, conducting the survey, analyzing the data, and reporting the findings. Depending on the chosen methodology, conduct face-to-face interviews, online surveys, or telephone interviews. Record the responses accurately and ensure the privacy and confidentiality of the participants. The results are summarized in a comprehensive report, which is shared with relevant stakeholders to disseminate the information and engage in discussions about rice biomass production. Conducting a survey involves several key steps to ensure a well-designed and effective data collection process.

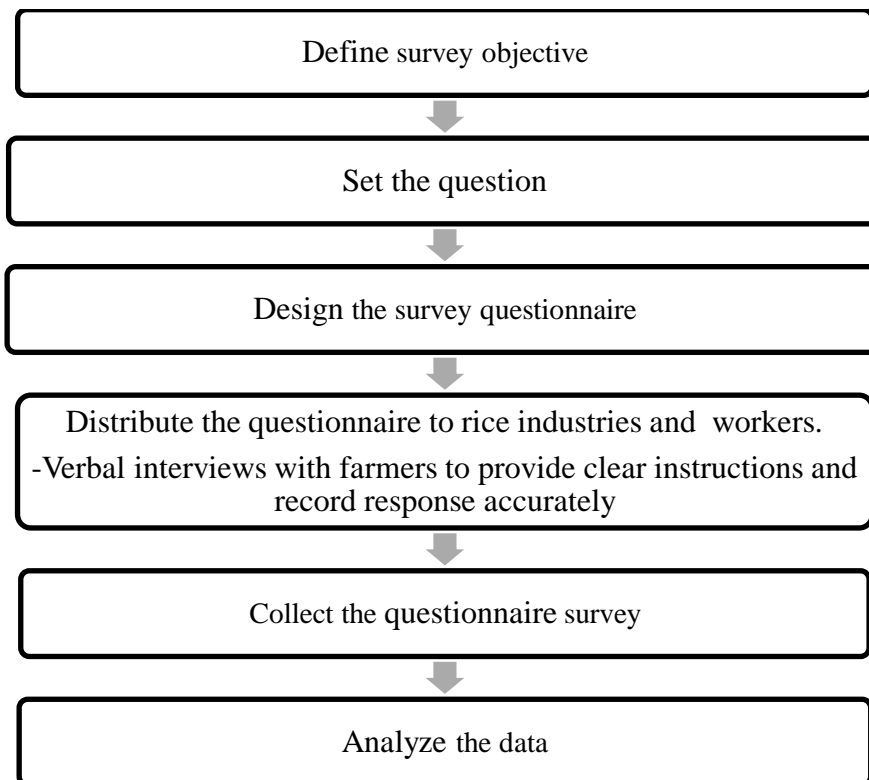


Figure 2: Flowchart of the steps to conduct survey.

Data and statistical Analysis

Once the survey is completed, data will be compiled and analyzed. Use statistical software or other tools to analyze quantitative data. Identify patterns, trends, and insights from the survey responses. Interpreting the data to the research will be objectives based and draw conclusions based on the findings. Prepare a comprehensive report summarizing the survey findings, including key statistics, trends, and recommendations (8). Present the results in a clear and accessible format.

Optimization supply chain analysis software

To obtain biomass supply chain, supply chain analysis software will be used to optimize the result (8). The survey, interview and researched data will be analyzed and will be input into the supply chain software. Before

conducting the optimization of Supply chain software, the basic foundation of the software will be studied (9).

RESULT AND DISCUSSION

The development of biomass supply chains study to optimize the utilization of biomass resources, such as rice husk, rice straw, and rice bran. By efficiently collecting, processing, and converting biomass, the supply chain ensures maximum resource utilization, reducing waste and enhancing sustainability. The development of biomass supply chains can stimulate economic growth and create employment opportunities. In this study also expected that all rice residue is fully utilized without being wasted to save cost and environment. Additionally, the development of related industries, such as biomass power

plants or biorefineries, can contribute to local and regional economic development.

The study and development of biomass supply chains drive technological advancements and innovation. This includes the development of efficient biomass conversion technologies, improved logistics and storage systems, and advancements in biomass characterization and analysis. Such innovations can have broader applications beyond biomass supply chains. Biomass supply chains offer environmental benefits by reducing carbon emissions and promoting sustainable practices. Biomass-derived energy sources have lower net carbon emissions compared to fossil fuels. Furthermore, the use of agricultural residues or forest biomass as feedstock can help reduce waste and mitigate environmental pollution. Biomass supply chains play a crucial role in diversifying energy sources and reducing reliance on fossil fuels. This contributes to enhanced energy independence and reduced greenhouse gas emissions. The study and development of biomass supply chain can be sustainability, while ensuring a balance between economic growth of rice production, environmental care, and social well-being(10).

The anticipated outcome is projected to be visually represented in the range of Figure 2 to figure 4, where these figures illustrate the network comprising sites and paths. Subsequently, Figure 4 depicts the graphical representation of the expected optimization results. A supply chain network's superstructure may be modelled using four generalized elements. Based on this idea, a web-based optimization system was created. The input data for the design challenge was automatically used to construct the mathematical formulation for the optimization problem. A case study was used to illustrate how the designed system affected users. As per the research findings, there is an expectation that the Perlis region in Malaysia, known for its plentiful paddy biomass, would adopt the proposed method for establishing a biomass supply chain system. Furthermore, there is an anticipation of extending its application to address other challenges, such as evaluating resource recycling systems and fostering the development of carbon-negative societies. This is because the suggested features have the potential to represent diverse supply chain networks.

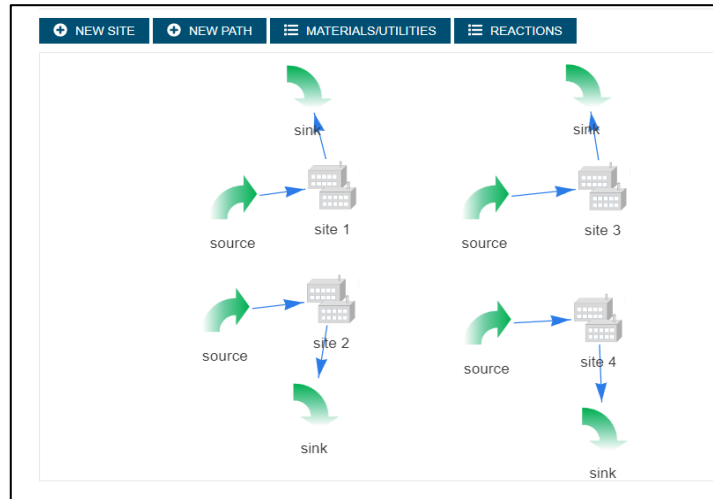


Figure 3: Example of diagram of the network comprising consisting of sites and paths.

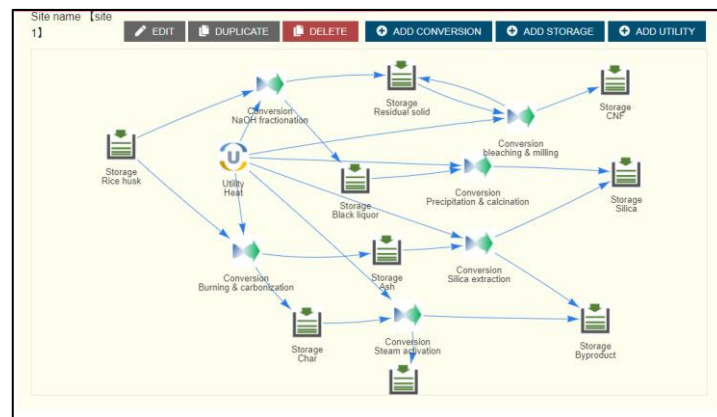


Figure 4: Example of diagram chain of the reaction path network in a site drawn using conversion, storage, and utility models.

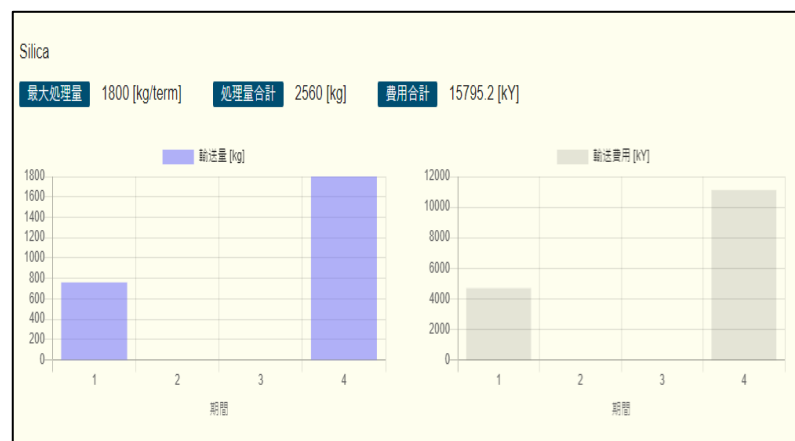


Figure 5: Example of diagram of graphical representation of the optimization results.

CONCLUSION

The utilization of the biomass supply chain can be leveraged to optimize and enhance utilization capacity, all the while minimizing

waste. Additionally, it is fine-tuned to achieve specific objectives, including increasing revenue, reducing operational costs, lessening

environmental impact, or decreasing fuel usage.

The biomass supply chain may be summarized and described using mathematical modelling techniques. The choice taken after considering many, often unclear aspects that have an impact on the effectiveness of a biomass supply chain will greatly determine how well it performs.

ACKNOWLEDGEMENT

The permission to use the supply chain optimization software by Prof Ken-Ichiro Sotowa from Kyoto University, Japan, is greatly appreciated.

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