Biomass value chains and the environment-food-energy-water nexus in the Philippines: whole-systems analysis and optimisation

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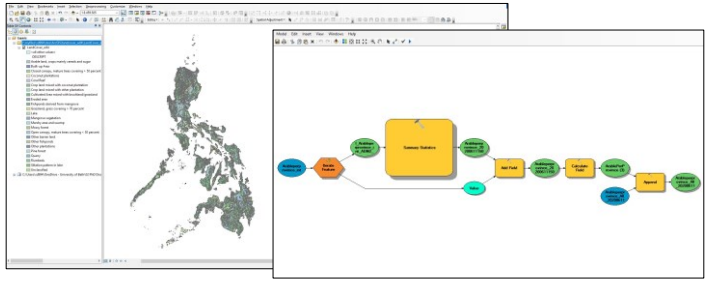
PROJECT DESCRIPTION

A growing body of research shows that our scarce primary resources: food, water, energy, and the environment are becoming ever more interconnected due to a growing global population, the rise of many mega-cities, and our on-going struggle against climate change. Thus, instead of being considered in isolation, all these primary resources must now be managed holistically as a system, referred to as the nexus, and its fragile balance must be maintained for a sustainable future. With biomass now rapidly and widely tapped, the nexus is vulnerable to disruption due to the large quantities of land, water, and energy needed. Biomass value chains or the series of activities (e.g. cultivation, conversion, transport, and distribution), which transforms crops to various bio-products, also produce greenhouse gases (GHG) and other pollutants. For biomass to truly become a part of the clean energy solution while ensuring food security, water conservation and climate protection, holistic approaches in policymaking are critically needed

My PhD is focussed on the development of comprehensive computation planning tools which are based on published mathematical models and optimisation techniques. These large-scale optimisation models are designed to make critical *decisions* such as what biomass crops to grow, where to locate plantations, what conversion technologies to invest in, which transport modes to use, and how to distribute related bio-products. Answering these critical decisions will result in a more systematic, strategic, and data-driven deployment of biomass while minimising costs, GHG emissions and freshwater consumption.

Studying the Philippines' biomass supply chains and their impacts to the nexus of the country is a significant context as there little to no studies conducted yet, which can fill research gaps in understanding their interactions for a tropical developing nation where there is high biomass potential and its growing importance but in the midst of dwindling land and water resources and increasing risk to climate change-related hazards and calamities. The primary value of the project is in providing sound guidance for policy-making of sustainable and nexus-compliant implementation of biomass in the country. When this is realised, the Philippine society's welfare and development can potentially secure clean renewable resource, generate more rural growth, and gain infrastructure changes savings, while at the same time contributing to climate mitigation, biodiversity preservation, and safeguarding the nexus balance.

METHODOLOGY

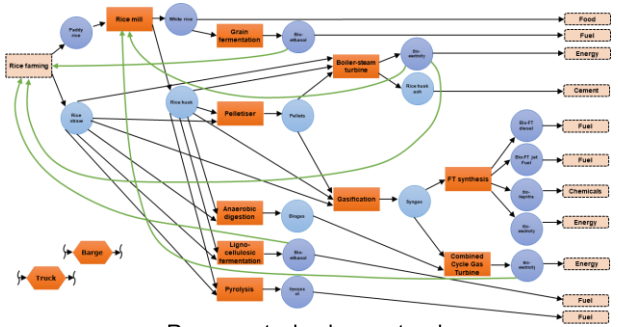


Mapping and spatial analysis

Data-driven approach

$$\begin{aligned} \text{minimize} \quad & \sum_{j=1}^{n} c_j x_j \\ \text{subject to} \quad & \sum_{j-1}^{n} a_{ij} x_j = b_i \quad (1 \le i \le m) \\ & x_j \ge 0 \quad (1 \le j \le n) \\ & x_j \text{ integer} \quad (1 \le j \le n). \end{aligned}$$

Mathematical optimisation and techniques



Resource technology network

JOURNAL PUBLICATIONS

1. Tapia, J. F. D., **Doliente, S.S.**, & Samsatli, S. (2021). How much land is available for sustainable palm oil? Land Use Policy 102, 105187. https://doi.org/10.1016/j.landusepol.2020.105187
2. **Doliente, S.S.** & Samsatli, S. (2021). Integrated production of food, energy, fuels and chemicals from rice crops: Multi-objective optimisation for efficient and sustainable value chains. Journal of Cleaner Production, February 2021, 124900. https://doi.org/10.1016/j.jclepro.2020.124900.
3. **Doliente, S.S.** & Samsatli, S. (2021). Data for spatio-temporal modelling and optimisation of multi-product rice value chains. Data in Brief 34, February 2021, 106694. https://doi.org/10.1016/j.dib.2020.106694.
4. **Doliente, S.S.**, Narayan, A., Tapia, F., Samsatli, N. J., Zhao, Y. & Samsatli, S. (2020). Bio-aviation fuel: A comprehensive review and analysis of the supply chain components. Frontiers in Energy Research, 8 (110), 1 – 38. https://doi.org/10.3389/fenrg.2020.00110.
5. **Doliente, S.S.** & S. Samsatli. (2020). Integrated production of fuels, energy and chemicals from Jatropha curcas: Multi-objective optimisation of sustainable value chains. Chemical Engineering Transactions, 80. https://doi.org/10.3303/CET2080058.
6. **Doliente, S.S.** & Samsatli, S. Multi-objective spatio-temporal optimisation for simultaneous planning, design and operation of sustainable and efficient value chains for rice crop. In Anton A. Kiss, Edwin Zondervan, Richard Lakerveld, Leyla Özkan (editors), 29th European Symposium on Computer Aided Process Engineering (ESCAPE-29), Computer Aided Chemical Engineering 46, 1453 – 1458. https://doi.org/10.1016/B978-0-12-818634-3.50243-5.
7. Tapia, J.F.D., Samsatli, S., **Doliente, S.S.**, Martinez-Hernandez, E., Ghani, W.A.B.W.A.K., Lim, K.L., Shafri, H.Z.M. & Shaharum, N.S.N.B. (2019). Design of Biomass Value Chains that are Synergistic with the Food-Energy-Water Nexus: Strategies and Opportunities. Food and Bioproducts Processing 116, 170-185. https://doi.org/10.1016/j.fbp.2019.05.006.

AWARDS

First Place, 2018 AIChE Annual Meeting Poster Competition, Poster title: Planning, design and operation of sustainable and efficient multi-product rice value chains using multi-objective spatio-temporal optimisation.