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RESEARCH PHILOSOPHY

The increasing urgency to address the global and regional sustainability challenges requires a multidisciplinary approach integrating social, economic, environmental, and technical perspectives. In this context, my research lies at the intersection of life cycle sustainability assessment, system dynamics-based integrated assessment, and decision support systems, with a core focus on promoting and supporting the transition towards more sustainable production and responsible consumption (Sustainable Development Goal 12). By combining these methodologies over the last three years, my research work has provided businesses/industries/policymakers and individuals (consumers) with a broader system-level analysis and simple metrics to understand the dynamic interactions over time on the potential environmental, social, economic, and technical implications of decisions and choices to support sustainable production and consumption.

Figure 1: Conceptual model of my research scope

PREVIOUS RESEARCH

From an industrial perspective, my previous research has focused on supporting industries in Quebec to understand the baseline environmental footprint of the manufacture of their products, identify alternative improvement strategies, determine the potential environmental reductions/detriments associated with the use stage of their products, decide on the optimal upcycling method to treat co/by-products and assess the sustainability implications of replacing human quality-based evaluation with an online computer vision system. Previously, I assessed the environmental footprint of a commercial feed additive (protected B-Vitamins) manufactured in Quebec, Canada, identified hotspots and drivers of environmental impact and explored the strengths and drawbacks of alternative strategies that could serve as the basis for redesigning, implementing, and monitoring environmental impact reduction associated with the production system. I analyzed the trade-offs associated with alternative improvement strategies based on the hotspot through a multidimensional efficiency analysis along the lines of eco-efficiency, socio-eco-efficiency, and supply-demand market dynamics. The result of this study is currently under review in the Journal of Resource, Environment, and Sustainability. Building on this background and in collaboration with the same industry

partner, I investigated the net environmental impact of adopting different nutritional strategies with vs. without supplementing protected B vitamins, a protease technology, and protected organic acid and essential oils to mitigate net greenhouse gas emissions during dairy, broiler, layer, and swine production systems across different regions in the world. These studies have resulted in five scientific papers currently under peer review or submitted in industry-leading journals such as the Journal of Sustainable Production and Consumption., the International Journal of Life Cycle Assessment, and Cell Report Sustainability. Additionally, I worked with a fruit and vegetable processing company in Quebec to develop a holistic, sustainable evaluation framework that provided management with a broader system-level analysis of co/by-product upcycling and circularity potential for pomace while considering economic opportunities, environmental impact aversion, social implications, and technical efficiencies. Considering six treatment methods, the framework generated preliminary evidence to support decision-making on the optimal pathway for pomace waste upcycling. From this research, I understood that positively intended solutions to address current waste problems from food process industries through circularity and upcycling may lead to unintended adverse outcomes. However, a multidimensional analysis before industrial valorization, circularity, and upscaling value-added products from waste in a primary production system could generate evidence to support management-level decision-making toward sustainable production. Part of my ongoing research with another industry partner is focused on assessing the potential multidimensional sustainability implications of replacing human pork meat quality evaluation with an online computer vision system and artificial intelligence models. Ultimately, this study seeks to generate a comparative analysis of the carbon footprint, socio-eco-efficiency, and potential susceptibility to adversarial attack when using the online computer vision system compared to humans.

From a consumer perspective, I designed, developed, and tested a decision support system: Dashboard for Improving Sustainable Healthy (DISH) food choices for stimulating dietary change. The DISH application employs behavioral change features, traffic light labels, and nudges to inform end-users about the nutritional health performance and environmental implications of their meal choices before purchase. Four different versions of the DISH application (DISH v1.0 and v1.1, McGill DISH, DISH for Research) have been developed and tested on two university campuses and in a local community in Quebec (ongoing). The implementation and testing of the DISH application have received funding from the Office of Innovation and Partnership, Fonds de recherche du Québec – Nature et technologies (FRQNT), Danone Institute of North America (Danone Sustainable Program), and GPSC Marcantonio Research Grant. The outcomes of these research studies have been reported in two published articles, one manuscript under peer review, and two currently in writing. The different versions of the DISH application are currently available online and can be assessed from any mobile device. Additionally, I developed and tested a deep-learning-oriented decision support system called Food System Rapid Overview Assessment through Scenarios (FS-ROAS). FS-ROAS enables food system stakeholders and policymakers to explore diverse intervention scenarios in the context of short-medium- and long-term goals for catalyzing sustainable future food systems. The testing FS-ROAS was conducted in collaboration with policy advocates and think tanks such as AKADEMIYA 2063 (a pan-African non-profit research organization with headquarters in Kigali, Rwanda, and a regional office in Dakar, Senegal) to explore resilient and sustainability strategies to tackle the

complexities and interconnectedness of agricultural, socio-economic and climate factors within the African food system. Furthermore, FS-ROAS was used to explore future scenarios of the implications of recommitment to the Malabo Declaration of the Comprehensive African Agriculture Development Program (CAADP) in 2025 by African heads of state. The results of this research are reported in three articles (two published and one currently under a second round of review). Additionally, FS-ROAS is presently being tested in an ongoing Food Convergence Innovation for Africa project that has received funding from the EU.

OTHER RESEARCH FOCUS

As I approach the end of my doctoral studies, the remaining part of my research is focused on applying system dynamic-based integrated assessment models such as the Full of Economic-Environment Linkages and Integration (FeliX) model to explicitly incorporate dynamic interactions between feed additives, their environmental impact reduction potential and livestock production at different spatio-temporal scales. My goal is to leverage the FeliX model to quantify emission pathways when feed additives are potentially used as basic ingredients nationwide for different livestock feeding programs and production systems in Canada. Other remaining research will also focus on developing decision support tools to enable the industry partner for this project to communicate their sustainability performance to clients in an easy and understandable form. This tool, called Feed Additive-EcoInsight, will allow sales personnel and customers to simulate potential environmental reductions and cost savings when feed additives are introduced into the daily rations of livestock, leveraging regionally specific data and physical models that characterize production performance and resource efficiency. The tool will be an elevator for sales personnel to close deals with potential clients. This can increase sales as sustainability has become a core theme in agricultural production, particularly livestock production.

GRANTSMANSHIP AND COLLABORATIONS

Furthermore, I will build on my experience in contributing to securing funding of over CAD 8 million for multiple innovative projects for the Sustainable Agrifood Systems Engineering Lab (McGill University) to secure funding for my research. I plan to actively seek out and apply for grants from various sources such as government agencies such as the National Science Foundation and the United States Department of Agriculture. As is the custom throughout my doctoral studies, I plan to collaborate with industry partners to drive sustainable production, valorization, circularity, and upcycling of co/by-products in the United States. I will publish my research in industry-leading journals and collaborate with other researchers, universities, research centers, and policy advocates to conduct interdisciplinary research to increase the scope and chances of securing funds for my proposals. I will participate in conferences and workshops to present my research and to network with other researchers and potential funding sources.

In summary, my research will focus on driving sustainable production and consumption through industry-academia and consumer-academia partnerships, leveraging three fundamental techniques: life cycle sustainability assessment, decision support systems, and system dynamic modeling. I am confident that my research will significantly contribute to the field of transition to a sustainable and circular bioeconomy and benefit society as a whole.