Waste and By-Products Re-use and Recovery Opportunities in Agriculture Sector

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Introduction

The awareness on limited availability of natural resources brought about discussions on the importance of adopting sustainable practices of production in agriculture sector as well as design of integrated approach to managing the resulting waste, by-products and side stream products, in a circular bioeconomy context.

Bioeconomy encourages transition to a system based on the sustainable use of natural resources. Within such system, agricultural waste and by-products are considered valuable resources with the potential to be transformed into new products and materials, thus generating added value for the agricultural sector.

Circular economy was defined as a closed loop system where products, raw materials and waste are maintained in a continuous cycle of use and regeneration within various sectors of the industry and value chain. In the context of the agricultural sector, the circular bioeconomy is dealing with to use organic waste and by-products (husks, straw, bran, seeds etc) for the production of biofuels, organic fertilizers or biodegradable materials. The application of bioeconomy and circular economy principles is a priority and a challenge all over the word. The agriculture sector is not an exception from this statement, especially if we consider the relevant statistic indicators for describing the impact of agriculture on environment but also on economic performance indicators.

This research aims to explore opportunities for reuse and recovery of waste and by-products in the agricultural sector, considering the perspectives offered by the circular bioeconomy.

Methodology

The aim of this research is to present a methodology, based on the dynamic systems analysis in order to provide innovative solutions for ensure the balance between the farmers wellbeing and the optimal conservation of natural resource.

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Methodology

System dynamics is representing a computer-based approach for the study of the possible interactions within a specific system. It is usually applied to enhance increasing the knowledge on complex systems. Some authors refer at system dynamics as being a systemic approach built upon feedback thinking or rational cause-effect relationships, relying strongly on the feedback concept.

For tis study, we used Vensim™ software. Vensim is an interactive simulation software that allows the development, exploration, analysis and optimization of simulation models. The first step of the modeling process, involved the design of causal diagram (CLD) of the desired system. This is used to understand the causal relationships between the different components of the system. This diagram provides a graphical representation of the interactions between system variables and identifies causal loops that can influence system dynamics. For example, these loops can highlight positive or negative feedbacks between parameters that can amplify or attenuate the effects of actions taken in the system.

The second step involved identifying the key parameters and variables to be included in the model. Parameters are the constant values or random variables that influence the behavior of the system, such as crop growth rates, crop yields, waste degradation rates. Variables are quantities that change over time and are influenced by parameters and other variables in the system, such as the amount of by-products generated, the amount of fertilizer produced from waste.

Results

The use of the simulation environment enhanced us to analyse variables that bring critical feedback loops influencing the sectors' performance and development. The chosen drivers include an integrated approach to the circular agriculture, considering economic, social, and environmental pillars. The practical implementation of this research technique has led to a qualitative analysis by identification of interrelated key variables and discovery of causal loops between them and the drivers (Figure 1).

"Climate" was included in the drivers list as a starting point for discussions, as it is generally considered an issue of global importance felt at local scale that requires the adoption of mid and long-term actions regarding sustainable use of resources.

Results

"Natural resources" represent the essential inputs for agriculture sector, including soil, water, and biodiversity highlighting the importance of their sustainable management and conservation. "Farm management" is linked to on-the-ground strategies and practices employed by farmers to optimize resource use, minimize waste, and enhance overall productivity and resilience. "Technology" is linked to the role of innovation in driving efficiency and enabling the adoption of circular practices, such as precision farming and renewable energy solutions. "Policy" represent the baseline of any system, influencing the daily activity of all economic and social activities around the world. The policy seeks to improve the use of locally available resources through the implementation of innovative processes.

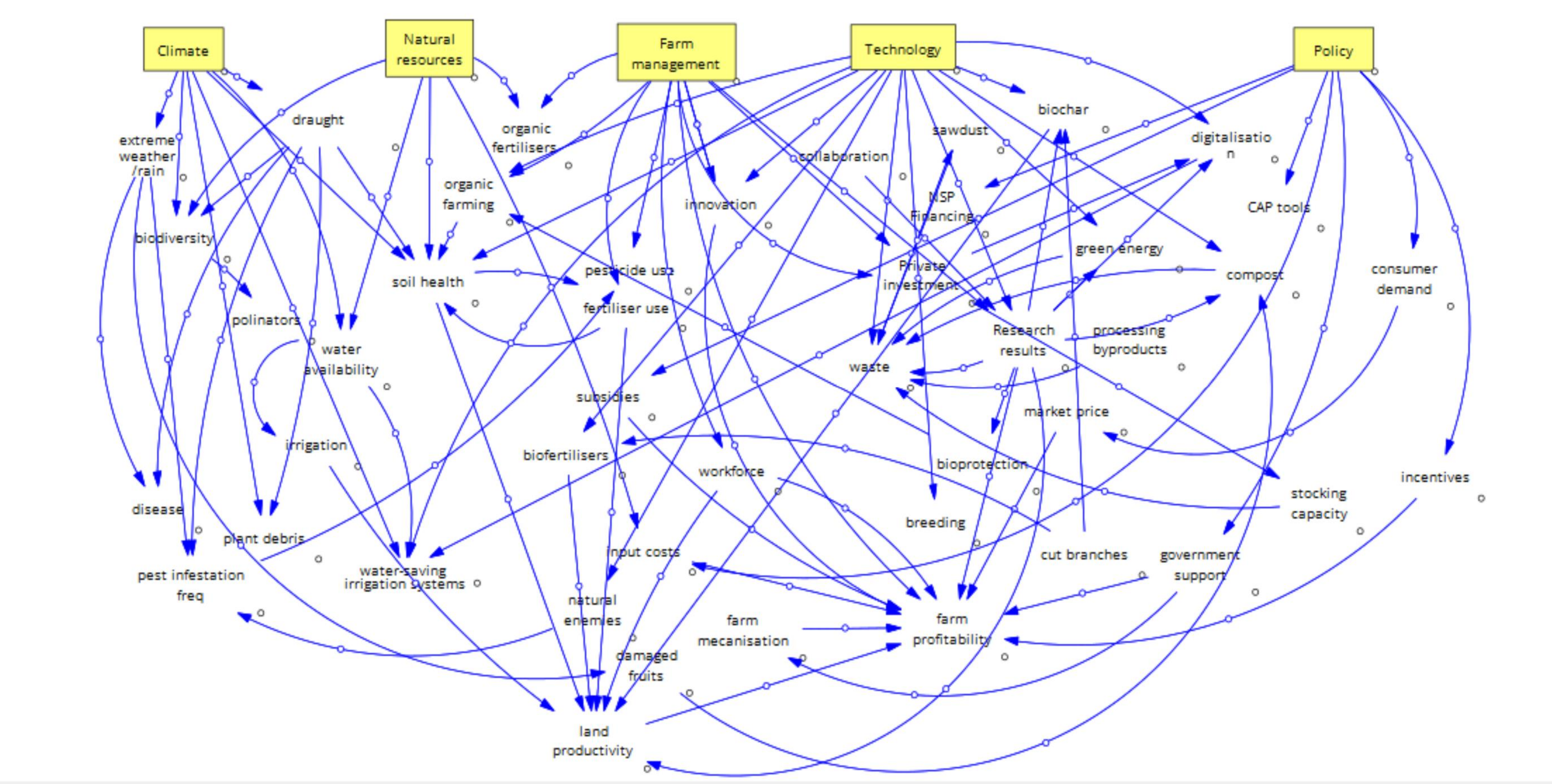

Figure 1 Causal loop diagram of for circular system

The causal pathway analysis generated a number of 53 variables that were identified (Table 1). These variables are representing either opportunities or barriers for the Re-use and Recovery Opportunities in Agriculture Sector

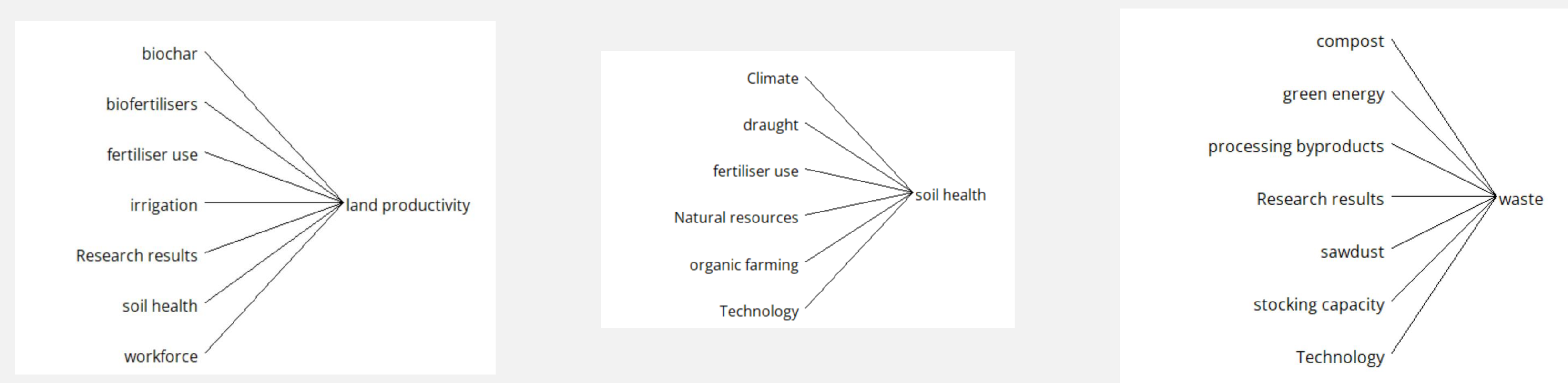

Figure 2 Examples of Tree Diagram of structural relationships for the most interlinked variables

Main conclusions

The practical implementation of this research technique has led to a qualitative analysis by identification of interrelated key variables and discovery of causal loops between them and the drivers.