Environmental modelling in the food supply chain - Future perspectives

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KEYWORDS

Environmental modelling; food supply chain; sustainable development goals.

ABSTRACT

Interaction of food systems and the environment has been in research focus for many years. In order to explain this interaction, scholars have developed and use various approaches in modelling and understanding this phenomenon. This paper gives an overview of three main perspectives in analyzing this issue and provides some future perspectives associated with sustainable development goals developed by the United Nations.

INTRODUCTION

Many studies have confirmed, calculated or estimated environmental impacts associated with food. Knowing that food and food processes have a significant impact, researchers are developing various strategies and models covering food production throughout the food supply chain.
Depending on the subject in focus, environmental models in the food supply chain scale up in three perspectives, modelling food products, food processes and/or food companies (Djekic et al. 2018), Figure 1. By multi-scaling it can elevate to modeling the entire food supply chain.

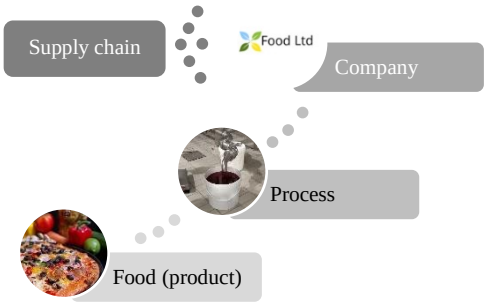

Figure 1. Environmental perspective of food modelling

ENVIRONMENTAL MODELLING OF FOOD

Life Cycle Assessment is recognized as the predominant methodology applied in analyzing environmental impacts of products with an observed application seen in all types of food throughout the agri-food sector (Arzoumanidis et al. 2017; Djekic et al. 2018). Complexity of food systems is pronounced due to the interlink between the nature and the technosphere.
Mapping the process and setting the scope and boundaries as outlined in ISO 14040 (ISO 2006) in some occasions can differ from the "farm to fork" perspective when consumers/households are considered, stretching the chain from farms to food waste disposal. Functional unit for expressing the environmental impacts are either physical units (mass/volume), agricultural areas (ha of land) or nutrients such as proteins (Djekic et al. 2018).

ENVIRONMENTAL MODELLING OF FOOD PROCESSES

When modelling food processes from an environmental perspective, there are two main dimensions: (i) from a technological point of view, when environmental perspective is modelled as part of the overall model and, as in the case of novel food technologies, is developed to improve quality / food safety with optimal environmental impact (Pereira and Vicente 2010) (ii) when energy and water are optimized in the water-energy-food (WEF) nexus (Djekic et al. 2018).

ENVIRONMENTAL MODELLING IN FOOD COMPANIES

Different authors and approaches show the complexity of environmental modelling applicable in food companies. According to Trystram (2012), application of different models in real-life conditions is very low. Analysis of the level of implementation of different environmental models in the European food sector based on the survey of over 200 companies in 12 countries, outlined that big food companies, companies operating in developed parts of Europe and companies with implemented environmental management systems show a higher level of

environmental modeling compared to small and medium-sized companies and companies operating in less developed parts of Europe (Djekic et al. 2019).
One of recognized causes is lack of resources and knowledge, bearing in mind that most models are not "user-friendly" as they were developed mainly for research purposes. As confirmed by Jones et al. (2017) this makes it difficult for users to make a business-adapted use of models.
When it comes to monitoring and measurement of environmental data within food companies, used as necessary inputs in further modelling, majority of answers is between 'no analysis' to 'collecting and evaluation only basic environmental data' with no further analysis per processes / functional units / environmental footprints (Djekic et al. 2019).

ENVIRONMENTAL MODELLING AND SDGs

In line with the promotion of sustainable development goals (SDG) associated with food production, modeling of various environmental footprints in the food supply chain is gaining more attention (UNESCO 2017). Out of 17 SDGs developed by the United Nations (UN), eight are recognized as goals directly or indirectly linked with food (FAO 2015). Future perspective should focus on developing various models associated with the SDGs deployed to the three perspectives – food, food processes and food companies, Figure 2.

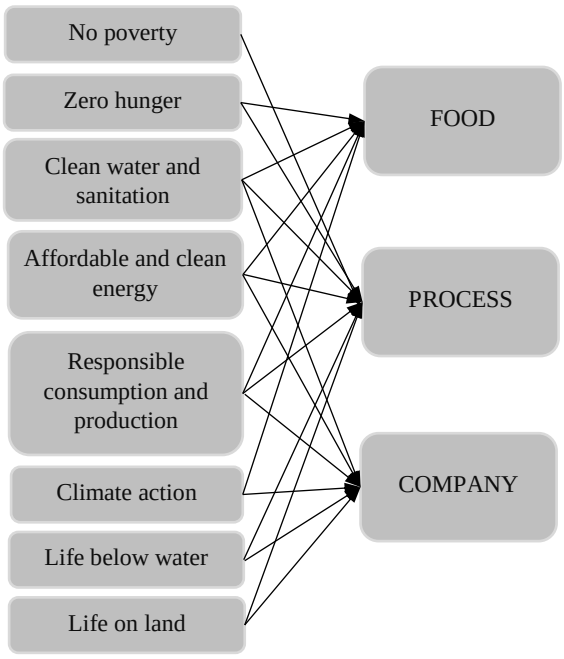

Figure 2. SDGs and environmental modeling

'No poverty' – Agriculture is recognized as the largest employer, mainly in rural areas (UN 2019) so agricultural growth strives for models that will enable increase of productivity and quality with minimal environmental pollution caused by agricultural production as well as optimal response to climate change affecting this type of production.

'Zero hunger' – this goal is dedicated to tackle food insecurity and malnutrition (FAO 2015) through promoting sustainable food production. Environmental models should focus on eco-design of the new generation of functional food as well as development of environment-friendly food technologies.
'Clean water and sanitation' – global assumptions stress that crops and livestock use 70% of water withdrawal (FAO 2015). Environmental models focus on food production processes using less water and companies developing environmental goals associated with water consumption and discharge (Djekic et al. 2019). Water footprints are deployed as green and blue water footprints associated with water consumption and green water footprint linked with water pollution (Hoekstra et al. 2011). Both can be expressed per food product or per food company.
'Affordable and clean energy' – energy is one of the most important resources necessary for food production, with 30% of world's energy associated with food (FAO 2015). Energy efficiency models are often used food processes with environmental goals linked with energy consumption, mainly since energy costs affect food prices. Special focus is on increasing the share of renewable energy (UN 2019) and developing energy models to decrease greenhouse gases emission caused by energy.
'Responsible consumption and production' – estimations point that around one third of total food produced is lost or wasted in the food supply chain (FAO 2015). Food sustainability should focus on modelling food processes carried out in 'sustainable' companies, with optimal use of natural resources, prevention of pollution and decreasing food waste/losses. Most of the largest food companies annually report about their sustainability efforts.
'Climate action' – according to estimations, 25% of all greenhouse gas emissions are linked with the food supply chain (Hachem et al. 2019). Developed models, mainly life-cycle assessments are used to calculate the global warming potential of all types of food (Djekic et al. 2018). In parallel, many companies calculate their carbon footprints, on a company level as outlined in various models for reporting these emissions, such as the Green House Gas Protocol (GHG 2015) or ISO 14064 series of standards (ISO 2018).
'Life below water' – Almost three billion people consume animal proteins from fish, so modeling of sustainable fisheries should balance growth vs conservation deployed to industrial and artisanal fishery (FAO 2015).
'Life on land' – soil is recognized as a non-renewable resource slow in recovery with large portions of crops and animal diversity at risk or lost (FAO 2015). Biodiversity risk is pronounced since three cereal crops (maize, rice and wheat) provide 60% of energy intake in human diets, or only ten species provide 30% of marine fisheries. Environmental models should focus on conserving biodiversity and developing means of land recovery. Modelling should also consider 'sustainable diets' focused on diets with

optimal healthy and low environmental impacts (Burlingame and Dernini 2012).

CONCLUSION

Different approaches and different models are in use explaining the diversity of food systems and their interaction with the environment. In general, perspectives for performing environmental research in food industry can be elevated from food and food processes to food companies and food supply chains. Further research should focus on developing models to fulfill sustainable development goals associated with food.

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BIOGRAPHIES

ILIJA DJEKIC works as a full professor at the Faculty of Agriculture, University of Belgrade. Holding an engineering PhD in life-cycle assessment joint with over 25 years of experience in the food sector his teaching and research areas comprise of food sustainability, food safety and food quality modelling. He (co)authored over 70 publication indexed in ISI Web of Science, 5 book and 5 book chapters. During his academic career, he lectured various courses at all levels of studies to over 1,200 students and (co)supervised over 50 PhD, master and bachelor's theses.

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