Embedding Health Equity into Net Zero: From causal loop diagrams to stock and flow diagrams

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Extended Abstract

1. Introduction

System dynamics simulation models have traditionally been employed to capture the cross-sectoral connections in sustainability such as En-roads and World-3. These models are powerful to encompass various aspects of climate change, including the transition to sustainable food (Leon and Kopainsky 2019), transportation (Wang, Lu, and Peng 2008; Fan et al. 2018), and the impacts on health (Homer 2020). They have been developed through diverse sources, such as literature-based analyses and group model-building workshops (Eker et al. 2018). Some have also derived simulation models from a causal loop diagram developed from literature and participatory stakeholder validations. However, when models are developed directly from causal loop diagrams, there may be challenges in translating the diagram into stock-and-flow modeling. Moreover, when the model is being developed through a participatory process, it is important to consider how the validity of the model's structure can be assessed early on during its translation from CLDs. This aspect requires further reflection.

While existing literature has outlined the steps of developing quantification models from participatory approaches (Pluchinotta, Zhou, and Zimmermann 2024), the process of how CLD, especially when they are large size, can be integrated in the formal modeling process is loosely defined, posing a challenge for modelers to make informed decisions on the systems boundaries based on their own experience. However, when dealing with large-scale models involving multiple sectors, the iterative process (Homer 1996) can become complex and modelling transparency (Jalali and Beaulieu 2023) can become difficult to achieve. Additionally, challenges in modeling cross-sectoral connections in sustainability are exacerbated as the number of variables and links grow.

The primary objective of this paper is to explore the process of constructing stock and flow structures based on a CLD using a case study currently under development focusing on cross-sectoral interconnections related to the climate and net zero and their effects on health. We reflected a process of developing a simulation model based a casual loop diagram and, where available, existing bits of stock-and-flow structures. For the purpose of this process, we considered the draft model structures that allow us to reflect on the criteria for such a process of translation from a CLD to a stock and flow

model. In doing so, this paper transparently discusses the process of working with CLDs and stock and flow structures.

This paper has a twofold contribution. On the one side, we contribute to understand how to explore move from CLDs to stock-and flow diagrams for simulation model, explicating reflecting on the challenges of modelling decisions. On the other side, we contribute to net-zero research by discussing the need for policies that comprehensively address health aspects and cross-sectoral interconnections to ensure that the sustainable transition through SD models is useful to put health considerations at the centre of strategic transitions.

2. Modeling background

The simulation model explores how health equity can be considered in strategic net zero transitions. The aims of the model are to understand how to embed health equity into strategic net zero transitions, and how alternative health pathways can be achieved through strategically considering cross-sectoral interconnections and their implications in health. The modeling methods include a few steps: 1) Building a CLD integrating literature review, existing system models, and participatory systems workshops (anonymous, submitted in another paper for the conference); and 2) Translating the CLD into stock and flow structures iteratively discussing with the stakeholders exploring the core elements and interconnections that need to be simulated across sectors.

3. Reflections about the process

The translation of the CLD to the stock and flow structures generated reflections about how to improve such a process for building useful models. For the process, the author/modeller made judgments about stocks and flows based on: 1) Stock definition—stocks characterize the state of the system and provide the basis for action and provide the system with inertia and memory (Sterman 2000, 197). For this reason, stocks such as adoption of heat pumps, heating, and cooling use as consumption patterns, and public transportation users as transportation patterns, are decided to be stocks. 2) Modelling experience - The modeller's skills played a pivotal, for instance judging when a bi-flow or flow were needed. Within the model structures shared, health benefits are loosely defined as a combination of various factors from other sectors in the CLD, which is aggregated to a variable impacting a simplified population structure moving population between healthy and unhealthy stocks. 3) Data availability - The translation process has also been impacted by data-searching processes; for example, as the data about EV adoption and heat pump adoption are available, the modeler made decisions of representing these as stocks that can be compared with available data.

However, these bring also reflections on what other factors should be considered for translating large-size CLDs to stock and flows models. The criteria could possibly include: 1) Aggregation level - the simplification and aggregation decisions would be considered, for the time, spatial aspects of the variables, as part of the iterative process. For example, the flooding events would be impacting regional, however the warmer temperature could be a chronic impact across cities. 2) Variables selections - it is usually

recommended to include every variables from the CLD, causing large and difficult to mange stock and flow structure, with a higher level of uncertainty; the model size would also influence the modeling conversations between stakeholders and researchers necessary during co-design process. 3) Knowledge expertise: the need to consult additional modelers on specific sectors could be useful in order to have variable- or sector-specific reflections on the modeling choices, including understanding the parametrization and nonlinear impacts between sectors; 4) Unit checks - explicit considerations of tests of units before the formal simulation, as such process may help the accurate representation of the models; and 5) Innovation - for cross-sectoral interconnections, innovative design of methods to capture the quantification systematically seem to be useful to ensure the modelers make informed decisions on the systems boundaries based on their own experience and the system boundary.

To conclude, this paper present a preliminary draft model structures from CLDs of net zero and climate change. This paper reflects on the criteria for such a process of translation from a CLD to a stock and flow model, with the aim to transparently discusses the process of working with CLDs and stock and flow structures. While the paper showe only preliminary model structures and modelling progress, it provides useful reflections about improving the transparency and documentation of how to translate CLDs to stock-and-flow diagrams.

5. Reference

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