Supplemental Note 1: Detail on Causal Loop Diagram construction

Background

Systems thinking has been defined in many ways. It is broadly defined as "a cognitive paradigm that involves an implicit tendency to recognize various phenomena as a set of interconnected components that interact with one another to make up a dynamic whole"[1]. By using systems thinking as a problem-solving framework, one can see a problem in its entirety, recognizing multiple causal roots[2]. Systems thinking, applied through system dynamics models and tools, can not only arrange and describe the complicated connections among each element in different levels, but can also deal with dynamical processes with feedback[3]. Finally, system dynamics tools allow for a system to be built virtually, to capture and explain the behaviours of complex systems in a descriptive way[4].

With this in mind, we use VenSim PLE software (version 8, 2019) to create a causal loop diagram to represent the interactions of the global environment-agriculture-trade system in a generalised manner (Figure 1, main text). Because of the complexity of the global food system, our causal loop diagram will no doubt be unable to represent the full complexity and subtleties of the system. However, its main role is to show that there are many interactions within the food system, and to emphasise the importance of biodiversity in the context of global food security amidst increasing agricultural production and trade. We aimed to show the complexity of the system through the causal loop diagram, and use systems thinking as a framework to encourage this form of exploration in future studies. In the following paragraphs, we provide more detail about the construction of the diagrams in the review.

The variables

In developing a critical understanding of the state of research to address the interactions in the environment-agriculture-trade system, we reviewed scientific papers from recent literature to identify important influences on biodiversity from a food systems perspective. We derived a number of important interacting variables with a global scale in mind because of the immense scale of interactions in the food system, including the spatial decoupling of production from consumption through international trade. In this way, we keep the framework fairly generic and broad, to map and visualise the interconnectivity between variables without focussing on a particular crop, commodity, or geographical area. We noted that many recent studies focus on interactions between the environment and agriculture in unidirectional feedbacks (e.g. land use change → biodiversity, or climate change → agriculture). As a result of a review of recent literature, we found that there are many understudied interactions apart from these relatively well-studied directional feedbacks, and that there are few approaches which consider the whole system with sufficient importance given to biodiversity.

Starting with the main elements of agriculture, biodiversity, trade and climate change, we identified influences on these main nodes as described in the scientific literature. For example, land use, agricultural expansion and intensification are known to negatively influence biodiversity[5,6], and are increasingly influenced by demand for food due to greater affluence[7]. These elements were discussed among all the authors.

Mapping interactions

After an initial list of important variables was derived, their connections to each other and the four main nodes were completed using the available tools in the Vensim software, which are arrows and symbols to denote the polarity of the interaction (i.e. positive or negative), and following general principles of causal loop diagrams[8]. By adding these connections to the four main nodes, we developed a visualisation of the complex web of interactions in the food system. We examined published evidence for connections and interactions, considering whether connections were uni- or bi-directional. Although we identified effects as predominantly positive or negative, based on published evidence, we note that many interactions may be both positive and negative in different contexts, or perhaps have a more ambiguous connection that requires more understanding.

Upon review and discussion by the authors, the figure was colour coded for easier visual interpretation. Finally, this figure was reviewed and revised again as necessary upon assessment by all the authors and the reviewers.

Supplemental References

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