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A framework for assessing the impact of COVID-19 on food supply chains

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Key messages

- Measures to COVID-19 response has disrupted food supply chain
- COVID-19 led to labor shortages, unemployment, loss of income and contraction of economies that affected food and nutritional security.
- A system dynamic model is adopted to understand the complexity of Covid-19 and food and nutritional security.
- Promoting food reserves can enhance food supply for sustainable food and nutrition security

COVID-19 and food systems in Africa

COVID-19 pandemic has triggered devastating health, economic, and food crises across the world, particularly among the most vulnerable groups such as women, the elderly, and marginalized groups in informal settlements. In Africa, the global recessions likely to be generated by the pandemic are expected to accelerate the fragile food systems. COVID-19 threatens access to food through loss of income and assets and high food prices, availability through disruption of food supply chains, and stability through trade-related distortions. With about 50% of the African population dependent on agriculture for their food and livelihoods, any disruption of the food supply systems threatens the food and nutrition security of many countries in the region. The COVID-19 response mechanisms including lockdowns, closure of borders, isolation, and quarantining have resulted in labor shortages, contraction of economies, and disruption of food supply chains. Subsequently, this has affected negatively the four main pillars of food and nutritional security (availability, accessibility, utilization, and stability).

In Africa, poverty, inequality, food insecurity, the limited capacity of healthcare systems, and the large informal economies make it difficult to properly quantify the impact of COVID-19 on the population. Food security and nutrition are tightly connected to the evolution of household income during and after lockdown and the capacity of food systems to produce foodstuff under the constraints of social distancing along the supply chain. Therefore, considering the complexity of interactions between the COVID-19 lockdown impacts, government response measures, analysis of household income and food security under the pandemic calls for the application of a holistic approach such as system thinking. Given the fact that agriculture is central to Eastern African economies and employs more than half of the economies' labour force who allocate a large share of their disposable income to food, a system dynamics approach to food systems analysis becomes even more relevant.

The objective of this study, therefore, was to demonstrate using a system-dynamic approach the impact of COVID-19 on food and nutritional security in East Africa. The framework considers food systems with their complex web of production, distribution, and consumption while considering the feedback structures from both the pandemic contamination and the consequence on health impact. The acumen from the dynamic analysis provides useful insights to governments in East Africa on how the pandemic is contributing to food and nutritional insecurity in the region. The framework can be adopted for other similar future pandemics.

Data and methodology

This study adopted a system thinking approach and a dynamic framework to map the pandemic and bring out the visualization of how the pandemic affected the *food supply chains*, along with the *health* and *contagion* components of the system. A generic structure of the system thinking model consists of *susceptible (S), exposed (E), infected (I), and recovered(R); dead (*D) (SEIRD) compartment

modelling. A similar model has been applied in related forecasting studies to inform decision-making in the health and economic sectors during the COVID-19 pandemic with varying degrees of success. The approach follows two steps; in the first step, the potential COVID-19 impact on food and nutritional security is illustrated as a causal-effect loop diagram, while in the next step, the impact is developed into a stocks and flows diagram for simulations and scenario analysis. The casual-effect loop diagram is based on key assumptions that reflect the multifaced and interconnected relationships among countries' sub-systems and components, as well as the views, interests, and power of the multitude of actors and stakeholders that has been triggered by the pandemic. The study utilized epidemiology and socio-economic data obtained from various certified open data sources including World Health Organization (WHO), the European Center for disease prevention and control (ECDC), the Centre for disease control and prevention (CDC), and the African Center for disease control and prevention (ACDC) and UNICEF.

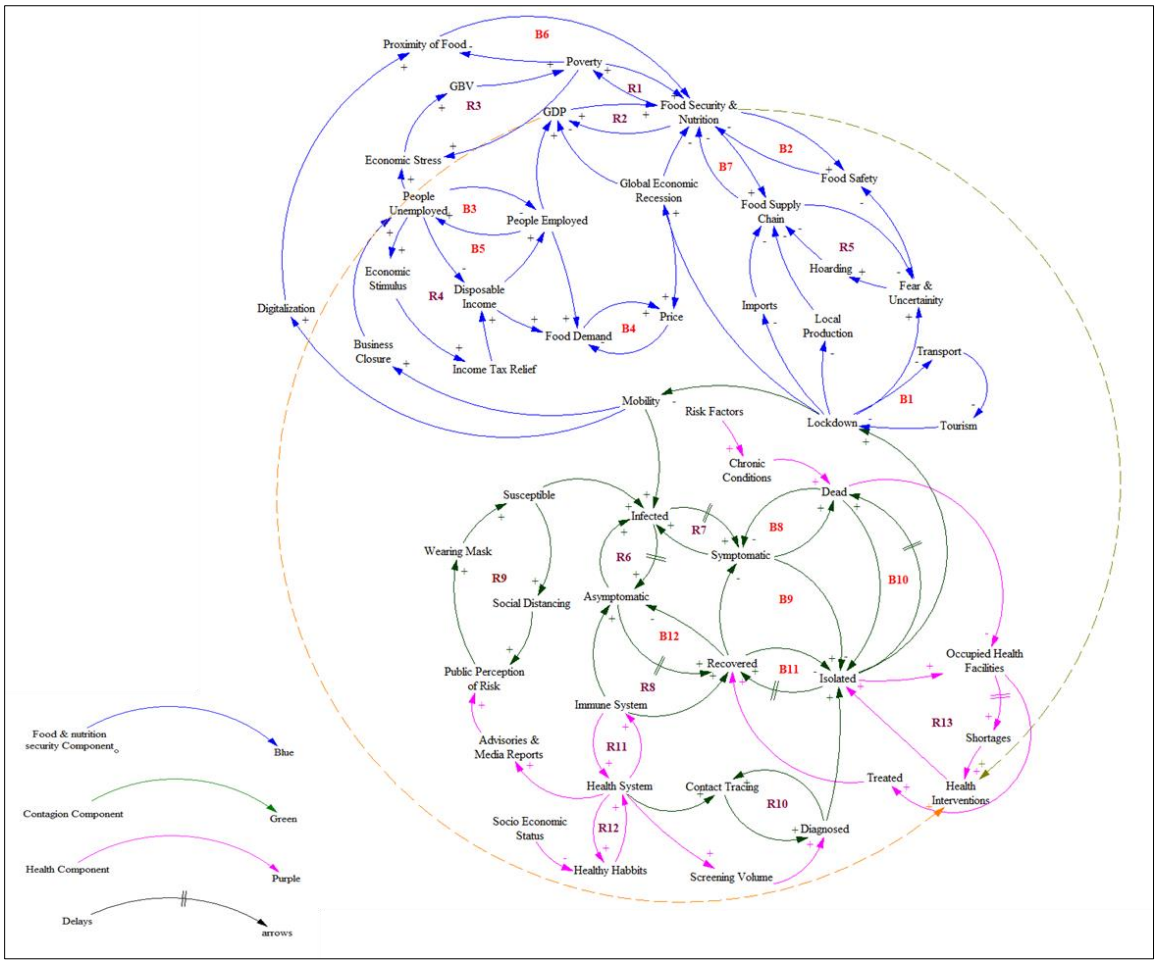

***Figure 1**. A causal-effect loop diagram for visualizing the interconnection between variables of COVID-19 contagion, health, and food & nutrition security components*.

A causal-effect loop diagram (CLD) illustrates the interaction between the *contagion, health, and food* the components and elements and feedback loops of COVID-19, and its impacts on food and nutrition security (***Figure 1***). In a CLD, a cause represents an element from which the arrow begins, while the effect is an element that obtains the arrow. The positive sign (+) or negative sign (-) establishes the types of association. The CLD also includes balancing loops (B) and reinforcing loops (R) which help to know how the variables connect. For this study, the interacting system consists of 12 balancing loops (B1-B12) and 13 reinforcing loops (R1-R13) (Figure 1); (i) Food Security component (blue) has 7 balancing loops (B1-B7) and 5 reinforcing loops (R1-R5); (ii) Contagion component (dark green) has 5 balancing loops (B8-B12) and 5 reinforcing loops (R6-R10); (iii) Health component (purple) has 3 reinforcing loops (R11-R13). A detailed description of the loops and their implications are provided in the manuscript (*Tonnang et al, 2022*).

The CLD shows how food and nutrition security is declining during the pandemic. For instance, the lockdown disrupted transport affecting food supply chains including local production, and imports, hence reducing food availability and access and increasing food prices. Subsequently, this had a negative effect on food security and nutrition **(*Figure 1*).**

After developing the CLD, it was converted to a stock and flow diagram for each of the three components to explain the different loops and potential effects of policies that governments could adopt to reduce the negative effects of the pandemic. The stock and flow diagram for the food security and nutrition component of COVID-19 is shown in ***Figure 2***.

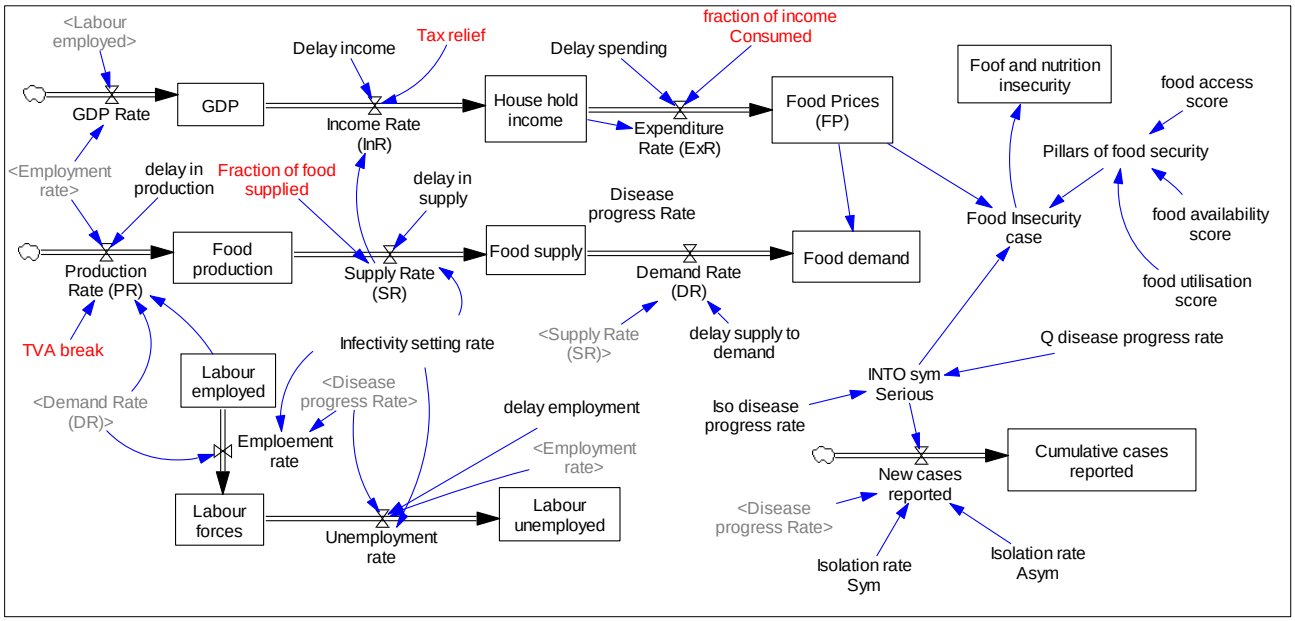

Figure 2: *Generic stocks and flows diagram of the Food Security & Nutrition component for a country in East Africa with the respective policy intervention in red colour.*

Key findings

Using data from Kenya, we demonstrate how East African countries could utilize the CLD model to estimate the impact of COVID-19 on food security and nutrition. Our simulations show that three months after the occurrence of the first cases of COVID-19, food and nutritional insecurity increased in October 2020 and continued up to December 2021 (***Figure 3A***). During this period, food expenditure rate and food prices were interrupted which is demonstrated by a cyclical trend in ***Figure 3B.*** With respect to food demand and supply, demand increased significantly while supply experienced a reverse trend (***Figure 3C***). In general, our analysis demonstrated that delayed implementation of measures to limit the spread of Covid-19 interfered with food prices, demand, and supply across all the East African countries. Besides, some measures did not sustainably stabilize the food prices and supply. For instance, although Rwanda introduced free food distribution in the capital city -Kigali, the epicenter of COVID-19, the food supply was temporary, creating a shock in food prices after a short period of the intervention.

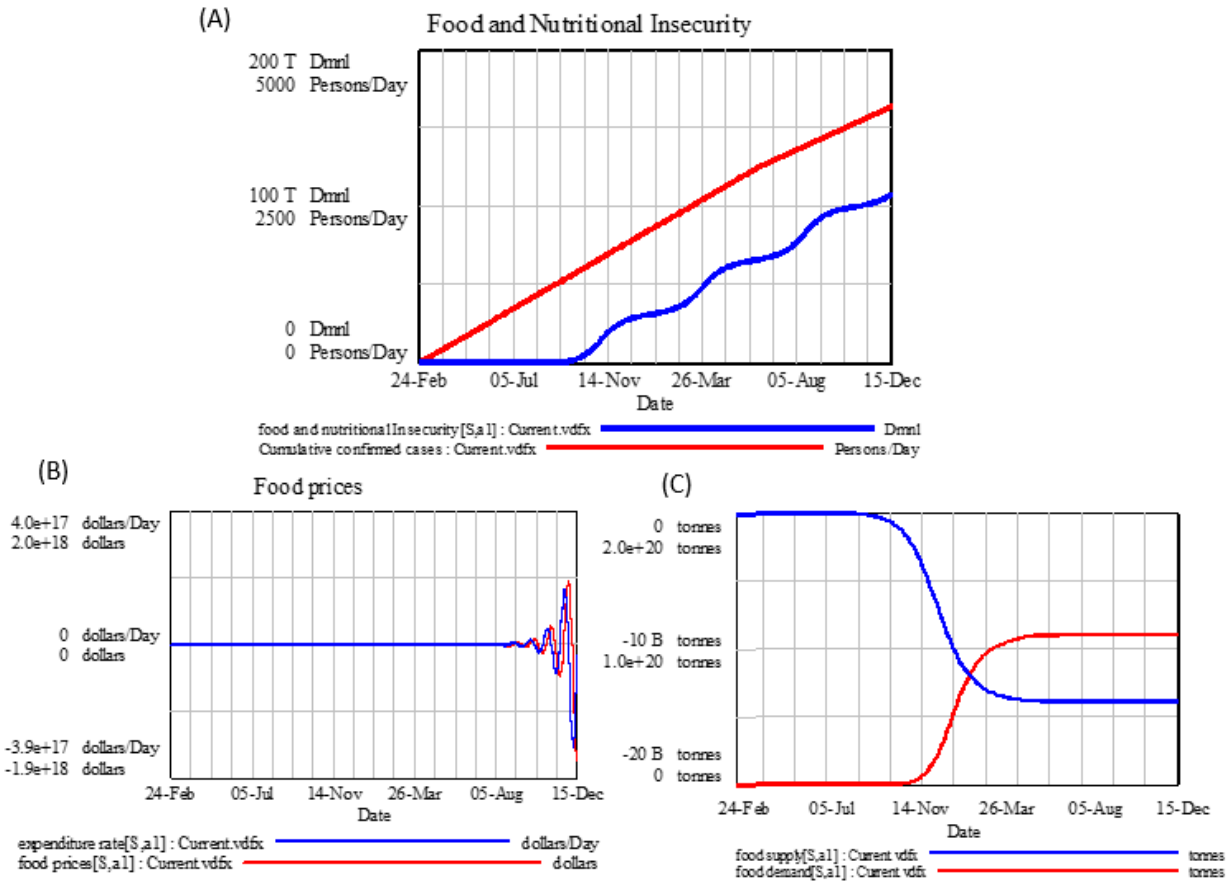

Figure 3: Impact of COVID-19 on Food and Nutritional Security

Policy Implications and Recommendations

The interaction between food and nutrition security and pandemics such as COVID-19 is highly complex yet important for policy direction. In developing countries, the complexity is enhanced by the fragile food systems that are influenced by other multiple challenges including frequent draughts, invasive pest invasion, and poor food distribution infrastructure among others. Using the case of Kenya and Rwanda, the framework suggested in this study has demonstrated that the pandemic contributed to social, behavioural, and economical scenarios, which translated to negative food supply chains that compromised food and nutrition security. The framework could be adopted as a decision-making tool to reduce severe impacts of future pandemics on food and nutritional security in developing countries. To mitigate such effects, the East Africa region could establish resilient food systems that mitigate and manage shocks through for instance establishment of food reserves. All the nodes of the food value chain, including storage, transport, processing, and distribution should also be strengthened, as well as partnerships and collaborations among governments to implement innovations for continued food production and trade within and across the countries.

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