System Dynamics Modeling of Community Sustainability in NetLogo

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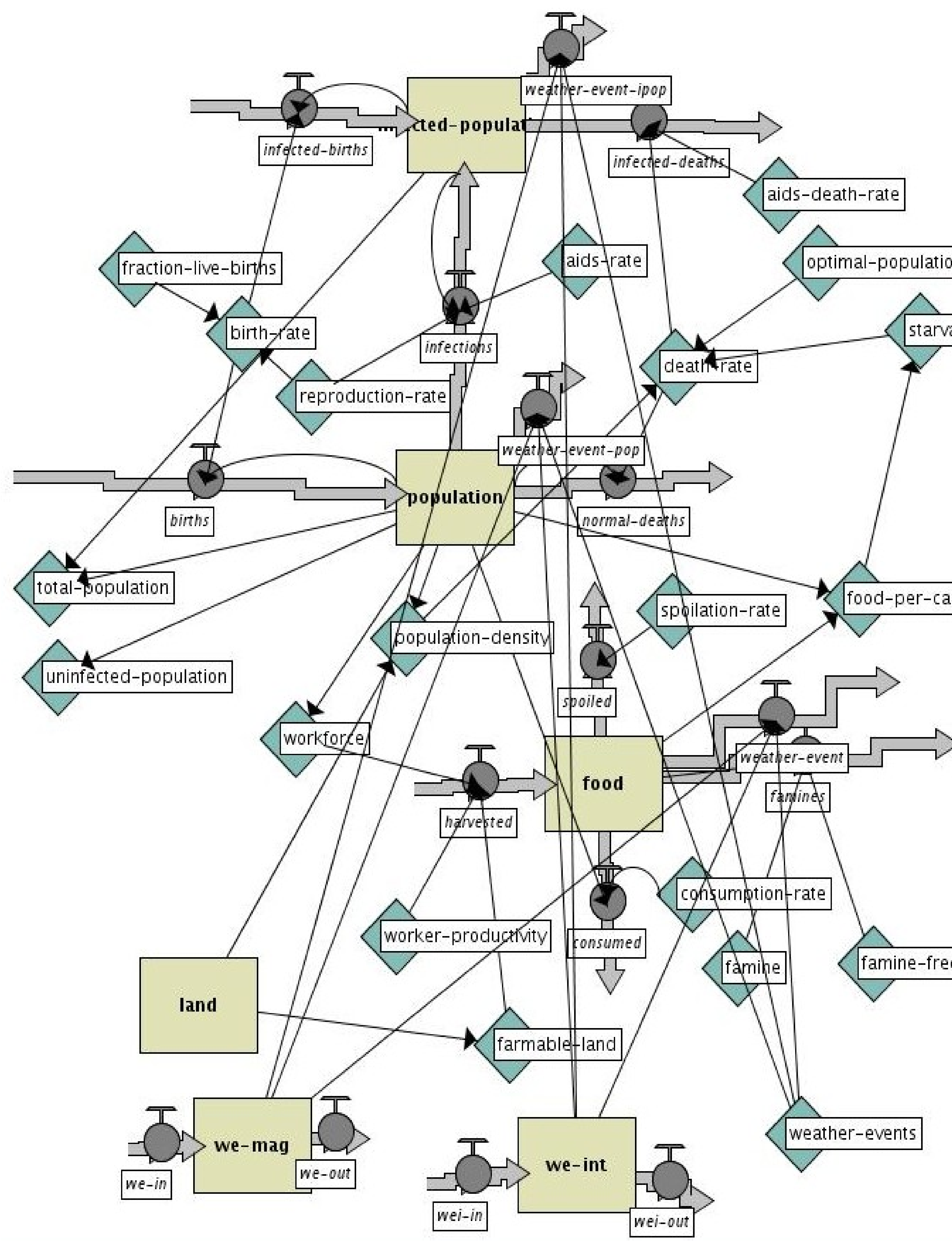
Abstract: The goal of this project is to apply system dynamics modeling to the question of sustainability of both population and resources. This project models a basic arbitrary system representative of more realistic systems. The results of the model are displayed to the user graphically. Though the model is a study of sustainability, it is important not to value sustainability over realism in the model. Even when the system is not sustainable the results of the model are significant.

Development Procedures: The foundation for this model are the two stocks, food and population, and their respective flows: births, deaths, food grown, food destroyed. An element of periodicity is provided by famines, and randomness by weather events. Limits are imposed on the model in the form of a definite quantity of land and population density.

Introduction: The numbers on which the system is based, instead of being simply arbitrary, are based loosely on data for Kenya from the CIA World Factbook (https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html). The basis for the system is the relationship between food and population. The key facets of the model are regular spoiling, consuming, and growing of food and births and deaths amongst the population. AIDS provides for the outflow of persons from population into infected-population, which has a higher death rate. The disease is unsustainable by nature, yet its very destructiveness provides certain insights into the nature of a sustainable model. Likewise, weather events provide randomness in interval and magnitude and have a very significant effect on the model.



System Model showing all Stocks, Flows, and Variables

Figure 1:

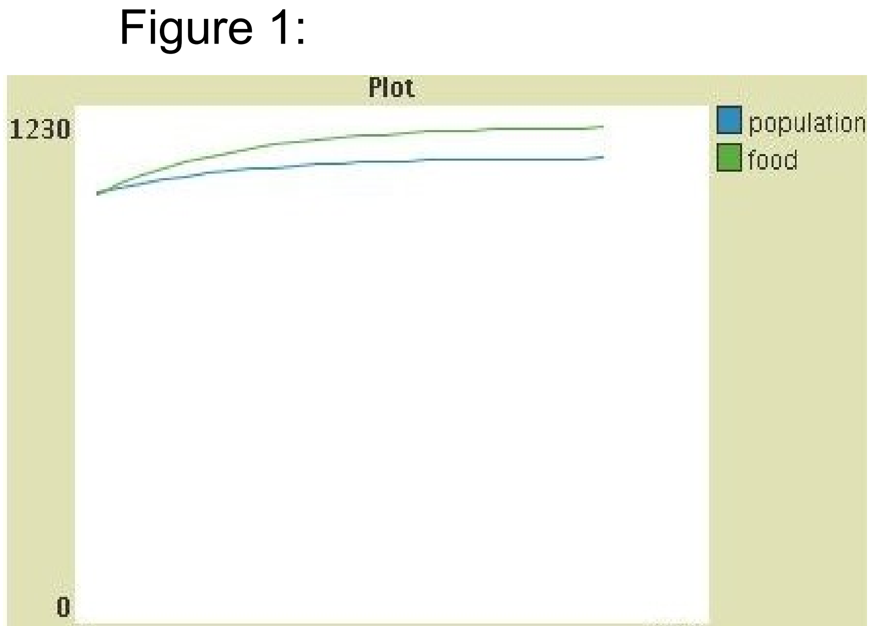
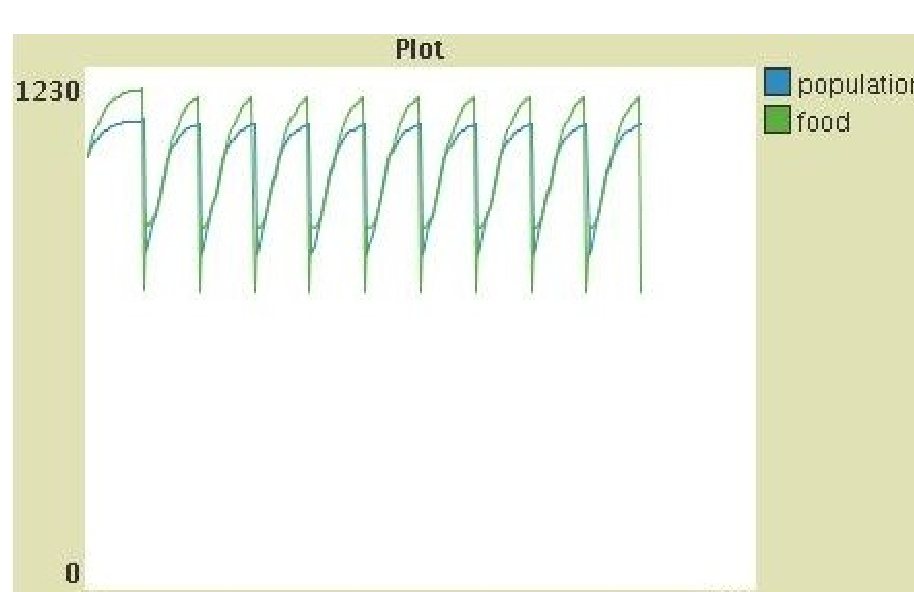


Figure 2:



Potential outcomes: Blue indicates uninfected population, green is food stocks, and orange is infected population. Figure 1: basic model with population density, note the ceiling. Figure 2: addition of basic famines with regular interval and magnitude. Figure 3: AIDS (extinction) without famines. Figure 4: AIDS with famines. Figure 5: full functionality- population density, famines, AIDS, and weather events.

Figure 3:

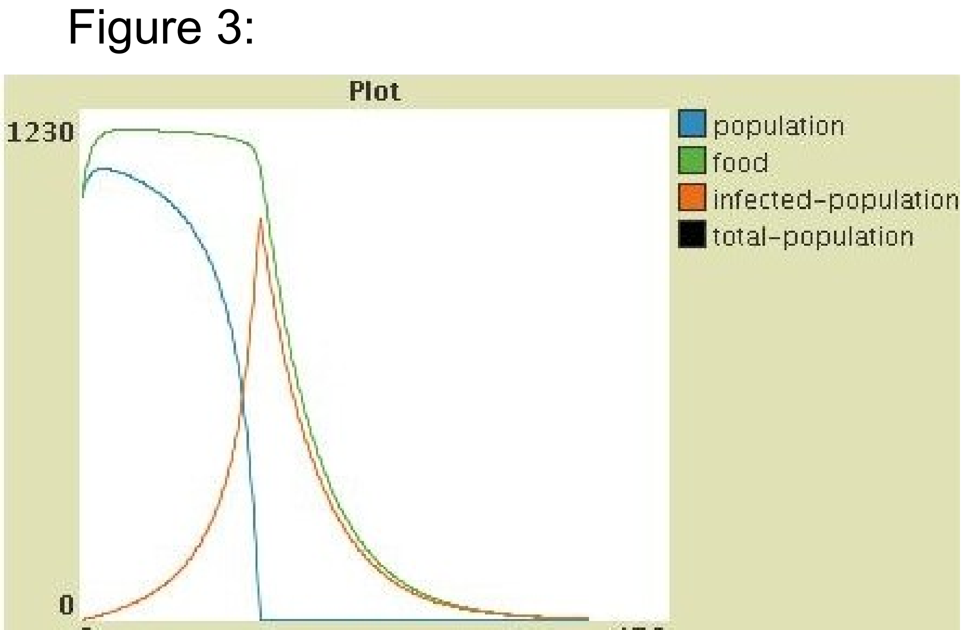


Figure 4:

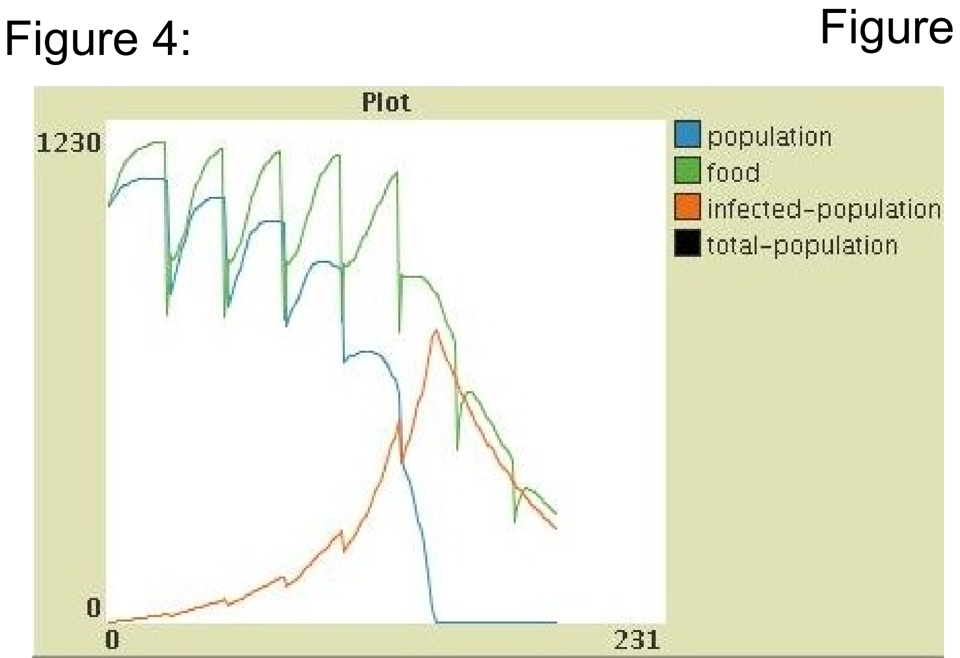
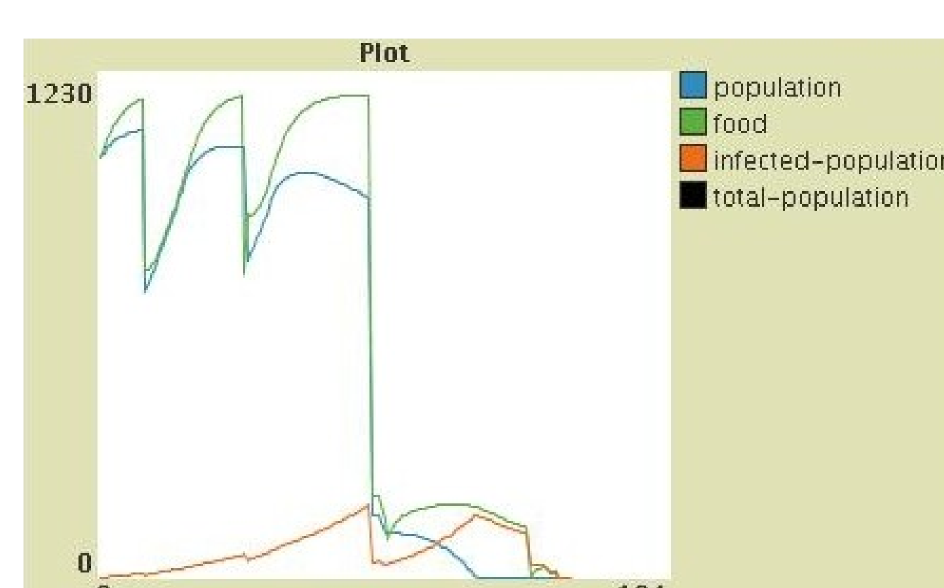


Figure 5:



Results and Conclusions:

As of now, the model is generally sustainable. It is difficult for famines to destroy the population entirely, and population density prevents overshoot. Only AIDS and weather events, which in the context of this model are inherently unsustainable, cause extinction. After 1000 steps, or years, the model with neither famines nor weather events will reach a sustainable maximum of 1184.78 for population and 1109.35 for food, the starting values being 1000 for each. However, for famines of interval 50 steps and magnitude 50 (out of 100), the values range from 592-1184 for food and 714-1109 for population. Thus, though there is a fluctuation of over 40%, the model still maintains its maximum value and is, barring weather events, as sustainable as before.

The population-food model fulfills the intention of the project in that it is well-suited to system dynamics. The basic stocks and flows, if not the more complex variables, allow for an easy understanding of the interactions on the most basic level, and the testing methods lend themselves to good analysis of the model's sustainability. The random factors of weather events mean that the model outcome will never be exactly the same. The interactive elements of the program allow for user immersion and a better understanding of both system dynamics and sustainability.