

Modeling Sustainability: Need to Couple Earth and Human System Models

Safa Motesharrei, Jorge Rivas
Eugenia Kalnay
University of Maryland, College Park

University of Connecticut
13 April 2018

The Human System now dominates the Earth System, and since 1950 the population and GDP per capita have been both growing at about 2%/year, indicating that the total use of Earth resources is doubling every 20 years, a clearly unsustainable path. We point out that the IPCC Earth System models (and Integrated Assessment models) are not bi-directionally coupled with Human System. Without fully coupling the Earth and Human Systems it is not possible to model the positive and negative feedbacks and delays needed to represent climate change and sustainability, in the same way that without a fully coupled ocean-atmosphere model it is impossible to simulate El Niño, since it is the result of two-way feedbacks and delays between the ocean and the atmosphere. We describe a prototype of a fully coupled Earth System model, including government policies.

A simple coupled Human and Nature Dynamical Model (HANDY) with Elites and Commoners allows performing “thought experiments”. They show that an egalitarian society can reach equilibrium with nature, whereas the presence of either large inequality or excessive use of natural resources both lead to societal collapse, as has happened with many civilizations in the last 5000 years. Introducing non-renewable resources into the HANDY model results in an explosive population growth similar to that observed since the use of fossil fuels triggered the Industrial Revolution in the 1800’s and the Green Revolution in the 1950’s.

References:

Safa Motesharrei, Jorge Rivas, Eugenia Kalnay, 2014: Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies. *Ecological Economics*, 101, 90-102.

<http://www.sciencedirect.com/science/article/pii/S0921800914000615>

S. Motesharrei and coauthors, 2016: Modeling Sustainability: Population, Inequality, Consumption and Bidirectional Coupling of the Earth and Human Systems. *National Science Review*:

<https://academic.oup.com/nsr/article-pdf/3/4/470/10871064/nww081.pdf>