General ecological models for human subsistence, health and poverty

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August 31, 2016

Abstract

The world's rural poor rely heavily on their immediate natural environment for subsistence and suffer high rates of morbidity and mortality from infectious diseases. We present a general framework for modeling human subsistence and health of the rural poor based on coupling simple models of population ecology with economic growth. We show how feedbacks among biological systems, such as infectious diseases and renewable resources, can lead to poverty traps, in the form of either bistable outcomes or globally stable poor equilibria in ecological-economic space. Analyses of specific systems that exemplify the general formulation lead to the following results : 1) all systems exhibit one of three regimes depending on parameters: a globally stable development equilibrium, a globally stable poor equilibrium, or bistability, where both equilibria coexist and are locally stable, with the long-term outcome determined by the initial values of the state variables; 2) bistability emerges as a general property of generalized disease-economic systems and it represents a nontrivial portion (20%) of the feasible parameter space; 3) the addition of more complex ecological feedbacks in renewable resources results in a more likely outcome of globally stable poverty; 4) in each of the systems, the overall proportion of parameters leading to poverty is larger than that resulting in healthy/wealthy development; 5) all of the systems are consistently most sensitive to human disease parameters. The presented framework highlights both parameters that are important to measure in future development models and pathways that need to be avoided.