Coupled Dynamical Models of Ecological Drivers of Poverty and Economic Growth

Calistus N. Ngonghala[1], Matthew H. Bonds[1]
[1]Harvard Medical School, Boston, MA 02115, USA
Calistus_Ngonghala@hms.harvard.edu, Matthew_Bonds@hms.harvard.edu

Keywords: Mathematical modeling, Infectious diseases, economic growth, poverty traps, renewable resources, coupled natural-human systems

Understanding the causes of the persistence of extreme poverty continues to challenge policy and research in the biological, social and mathematical sciences. Generally, the extremely poor depend on their immediate environment for subsistence and suffer high morbidity and mortality from infectious diseases. In pursuit of general integrated mathematical frameworks for the ecology of poverty, we present a road map for modeling how ecological drivers of poverty such as infectious diseases, renewable resources, population growth, etc., interact with economic dynamics to cause persistent poverty or "poverty traps" [1]. The nonlinearities associated with these interactions can give rise to multistability such that there are thresholds that determine whether populations experience virtuous versus vicious cycles in ecological-economic space. Our analysis indicates that 13-30% of the feasible parameter space results in bistability, and hence poverty traps. We find out that the existence of bistability depends on both key ecological and economic parameters including the disease transmission and recovery rates, the number of pathogens in the system and the investment rate in human capital. In particular, the number of pathogens in the system increases the intensity of ecological-economic feedback, making poverty traps inevitable at sufficiently high numbers of pathogens that prevent the acquisition of human capital. Our framework provides an approach for theoretically and empirically exploring the dynamics of coupled ecological-economic systems, equally reliant on existing paradigms in the social, biological and mathematical sciences. More specifically, it offers a model on the relationship between human health, renewable resources and economic growth. This is a new multidisciplinary research area with significant implications for both policy and research in the biological, social and mathematical sciences.

References

[1] C. N. Ngonghala et al., *Poverty, disease, and the ecology of complex systems*, PLoS Biology **12** (4) e1001827, 2014.