

# **Community and Natural Resource Management: Modeling Complexity in Natural & Human System Interactions**

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Natural resources – water, forests, soil – are foundational to the livelihoods of the poor. These natural resources that the poor depend on are coupled by a complex set of interactions and feedbacks. Moreover, the interplay across these diverse set of coupled resources and poor communities shape the quantity and quality of natural resources and influence community response to these vital natural resources. In this study we aim to understand the influential feedback mechanisms between communities that depend on natural resources and the natural resources themselves influencing these communities and the social arrangements over time. That is, what are the complex interactions between poor communities and the diversity of natural resource systems that they depend on?

## **Background & Rationale**

People have significantly impacted water, forests, and soils in a relatively short period of time (Simmons, 2008). People living in poverty depend on these resources for their basic livelihood and survival. As these resources decline, poor households face increasing pressures to improve their economic conditions and thus face the prospect of overexploiting natural resources, forming a reinforcing dynamic threatening the security of households and natural resources in a community. Institutional arrangements (formal and informal rule systems) have potential to not only moderate this decline but also play a vital role in the restoration of natural resources and improvement in the economic conditions of households. However, understanding when and how these benefits occur has proven to be a difficult problem since social and natural systems are inextricably embedded within household, community, and institutional systems through a set of nested feedback relationships (Berkes, 2007). Previous research has advanced our knowledge of how communities depend on and manage natural resources, but has been unable to capture the nonlinearities, uncertainties, and dynamics that characterize human and natural system interactions (Agrawal, 2007; Agrawal, 2001; Agrawal and Chhatre, 2006; Ostrom, 2007). This has led to low-leverage policies and panacea-like interventions that have little or no impact, fail to adequately address unintended consequences of interventions, or when successful, are difficult to transfer from one community to another (Forrester, 2007; Ostrom, 2007; Ostrom, Janssen, & Anderies, 2007). Ostrom (2007, p. 15182) has therefore exhorted scholars to engage in empirical work to advance three broad questions: what patterns of interactions and outcomes result from using a particular set of institutional arrangements? What is the likely endogenous development of different governance arrangements with or without external financial inducements or imposed rules? And, how robust and sustainable is a particular configuration of users, resource system, resource units, and governance system to external and internal disturbances?

## **Specific Research Questions**

We seek to understand the complex interactions between poor communities and the diversity of natural resource systems that they depend on by answering the following questions:

1. How do changes in community based natural resource governing arrangements influence the availability, diversity, quality, distribution, and use of vital natural resources – forests, soil, and water?
2. How do social, political, and economic processes underway in a community impact the availability, quality, distribution, and diversity of natural resources?
3. How do changes due to social, political, or economic influences in one type of natural resource affect other vital resources that are tightly coupled?
4. How do community institutional arrangements evolve over time to change the availability, quality, diversity, and distribution of vital natural resources?
5. How do state policies and directives from local to central influence the governance, use, and condition of vital natural resources either directly or indirectly by way of a response from community institutions to policies and directives affecting natural resource use and governance?

In answering these questions within the context of natural resource dependent poor communities in India, we will arrive at a better understanding of the complex interactions and feedback mechanisms between social, political, and economic processes in poor communities and life sustaining natural resources.

## **Method**

To accomplish this, we propose a multiple case study embedded design combining participatory techniques with system dynamics and agent based computer modeling of feedback, discontinuity, legacy and time lag effects that characterize the complex interactions between community and natural resources. System dynamics and agent based modeling will allow us to tackle the compound puzzles characteristic of coupled natural and human systems at multiple levels. The project will be embedded within three regional offices of the Foundation for Ecological Security (FES) in India involving projects that address different types of rural communities and natural resources. Baseline data will include time series and spatial information on availability of natural resources, biodiversity, hydrology, agricultural activity, physical infrastructure, and community participation. Primary data sources will include community surveys, biodiversity surveys, hydrology and agricultural data, measures of soil fertility, physical experiments for model parameter estimation and validation, key informant interviews, and group model building sessions with FES staff and villagers using methods previously tested in Andhra Pradesh, India.

## **Scientific Merit**

This study will unpack the “black box” of dynamically complex relationship between communities and natural resource systems that they depend on resulting in a set of simulation models that span multiple regions and involve several types of natural resources. The project will also open up

a new approach to studying natural and human systems that emphasizes the importance of a process-based approach to model building that fosters community and organizational learning and engages participants in the modeling process. Such models can be used to identify high leverage policies, anticipate and mitigate potential unintended consequences, and increase the likelihood that lessons learned can be transferred from one community to another.

### **Broader Impact**

This study will expand opportunities for undergraduate and graduate students at Washington University to be involved with interdisciplinary international research and utilize participatory, system dynamics, and agent based computer modeling techniques in a variety of community and ecological restoration projects. This project will also broaden participation of underrepresented groups, particularly marginalized poor communities, in model building and scientific research. Additionally, the study will enhance a research and educational international partnership with FES for system dynamics and agent based modeling of communities and fragile ecosystems.

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