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Dynamic decision making in coupled social ecological systems

Integration of small-scale farmers’ goals, resources and strategies for natural resource management in Amhara region, Ethiopia

Introduction

Providing food for an expanding and more demanding world population while at the same time addressing environmental and social concerns requires transformations in local, national and global agricultural and food systems (e.g., Ingram et al., 2010). Food systems are social-ecological systems that consist of biophysical and social factors which are linked through feedback mechanisms (Berkes et al., 2003; Ericksen, 2008b). As social-ecological systems are both complex and adaptive, they require stakeholders to continuously test, learn about, and develop knowledge and understanding in order to cope with change and uncertainty (Carpenter & Gunderson, 2001; Ericksen, 2008a; Folke et al., 2005).

Ethiopia is one of the countries in sub-Saharan Africa that exhibits very high food insecurity levels (FAO et al., 2013) and that is at the same time most seriously threatened by land degradation (Holden & Shiferaw, 2004). Land degradation poses an acute challenge to rural livelihoods and aggravates vulnerability to shocks and stressors such as droughts and associated famines. About 82% of the country’s population lives in the rural areas, and a majority of them are engaged in subsistence farming (World Bank Open Data). The average total land per household is 1.77 ha (Central Statistical Agency & The World Bank, 2013). With an annual population growth rate currently around 2.1% (World Bank Open Data), the area of the average family plot size continues to decline. This situation has led to very high utilization pressure on cultivated lands, forests, grazing lands, wetlands and marginal lands. Additional drivers of land degradation in Ethiopia are unsustainable agricultural practices, climatic shocks, insufficient tenure security, and inadequate soil conservation practices. Land degradation thus results both from macro-level dynamics and micro-level decision making.

The complex and dynamic behavior of natural resource management suggests that a simulation model may be ideal for revealing important und unexpected insights for decision makers at various levels (Richardson & Pugh, 1981; Sterman, 2000). Such model, however, needs to integrate the perspectives of the various stakeholders affecting resource management decisions. Participatory modeling in system dynamics (e.g., Antunes et al., 2015) provides tools and techniques to elicit and re-represent knowledge about natural resource management. In this study, we analyze data from in-depth interviews with smallholder farmers in Amhara region, Ethiopia. We re-represent their knowledge about natural resource management in causal-loop diagrams and reflect on the use of participatory system dynamics modeling both to validate and expand farmers’ perspectives and to integrate perspectives of additional stakeholders such as change agents, researchers and policy-makers.

Methods

We compare and integrate farmer-generated causal loop diagrams of natural resource management dynamics. For this purpose, we conducted in-depth interviews with 20 smallholder farmers in the Empire region at the margin of church forests in Amhara, Ethiopia. The Amhara region is in the Ethiopian highlands, where most of the population of the country lives. Terrain with deep river valleys and mountainsides with steep slopes characterizes the highlands. When it loses its vegetative cover, this terrain is very prone to land degradation, the major manifestation of which is soil erosion.

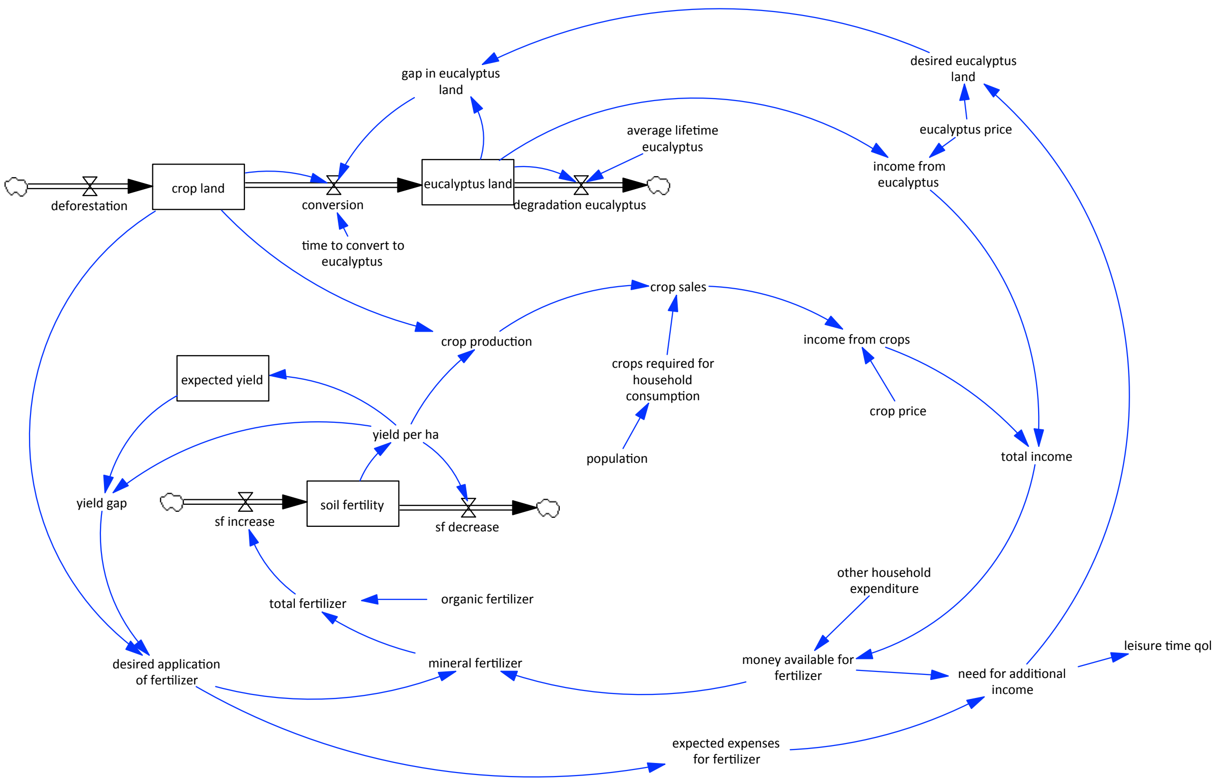
The goal of the interviews was an initial engagement of small-scale farmers and a conceptualization of natural resource management issues for subsequent participatory system dynamics modeling (Hovmand, 2014). A method based in grounded theory is used to translate the qualitative text data from the interviews into causal maps for system dynamics modeling (Kim & Andersen, 2012; Turner et al., 2013). This method uses well-structured text-coding methods to systematically elicit causal structures from text data, resulting in causal loop diagrams that may be used to help conceptualize and validate formal simulation models. Causal loop diagrams are diagramming tools to capture the structure of a complex dynamic system (Sterman, 2000). They consist of variables connected by arrows denoting the causal influences among the variables and the feedback loops in the system.

The causal loop diagrams are generated completely independently from each other. None of the interview participants was aware of other participants' perspective on resource management dynamics in the region.

Results and discussion

A preliminary causal loop diagram that integrates farmers' perspectives across our sample is shown in Figure 1.

Figure 1: Initial causal loop diagram representing smallholder farmers' perspective on natural resource management dynamics



The interviews showed that farmers perceive land degradation as driven internally by reinforcing feedback loops. That is, the dynamics of the system, if unchanged, will continue to escalate land degradation and food insecurity. Any balancing forces are introduced exogenously, e.g., through land tenure reform. In addition, some of the variables in the reinforcing feedback loops could be de-coupled. For example, if alternative cooking technologies were available in rural areas, farmers could turn to these rather than being forced to use crop residues and animal dung, which would otherwise have found their way back into the soil. This indicates that promoting natural resource conservation will require external intervention.

The finding that persistent food security problems are caused only in lesser part by the mismanagement of natural resources and more by demand-side factors (policy-led or induced by demographic growth) is in line with results from other regions in sub-Saharan Africa (e.g., Mortimore & Harris, 2005). This implies that any effort to conserve natural resources while at the same time providing food for a growing and more demanding population will only succeed if they address the root causes of resource degradation. Researchers and policy makers designing resource management programs tend to emphasize macro-level drivers of resource degradation, about which they have data and knowledge and be largely unaware of knowledge held by resource users such as small-scale farmers.

Participatory modeling in system dynamics and more specifically group model building (Vennix, 1996) provides tools and techniques for involving different stakeholder groups to enhance shared and systemic understanding of natural resource management issues and generate more robust interventions. Participants in group model building learn from each other rather than being exposed to expert lectures. In addition, parameterizing causal loop diagrams with quantitative data is an important next step in the model-building process. A quantitative simulation model allows participants in group model building settings to explicitly state their assumptions about how a system works and then test those assumptions and see for themselves the implications of changing the system (Vennix, 1996). This study demonstrated that approaches for integrating local and more science-based knowledge on natural resource management dynamics are important for the design of effective programs and moving the policy discussion forward in a meaningful way.

References

Antunes, M. P., Stave, K., Videira, N., & Santos, R. (2015). Using Participatory System Dynamics in Environmental and Sustainability Dialogues. In M. Ruth (Ed.), *Handbook of Methods and Applications in Environmental Studies*.

Berkes, F., Colding, J., & Folke, C. (2003). *Navigating Social-Ecological Systems. Building Resilience for Complexity and Change*. New York, NY: Cambridge University Press.

Carpenter, S. R., & Gunderson, L. H. (2001). Coping with collapse: Ecological and social dynamics in ecosystem management. *BioScience, 51*(6), 451-457. doi: 10.1641/0006-3568(2001)051[0451:cwceas]2.0.co;2

Central Statistical Agency, & The World Bank. (2013). Ethiopia Rural Socioeconomic Survey. Survey Report: Central Statistical Agency Ethiopia, The World Bank.

Ericksen, P. J. (2008a). Conceptualizing food systems for global environmental change research. *Global Environmental Change, 18*(1), 234-245.

Ericksen, P. J. (2008b). What is the vulnerability of a food system to global environmental change? *Ecology and Society, 13*(2 C7 - 14).

FAO, IFAD, & WFP. (2013). The State of Food Insecurity in the World. The Multiple Dimensions of Food Security. Rome: Food and Agriculture Organisation.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources, 30*(1), 441-473. doi: doi:10.1146/annurev.energy.30.050504.144511

Holden, S., & Shiferaw, B. (2004). Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: a bio-economic model with market imperfections. *Agricultural Economics, 30*(1), 31-49. doi: 10.1111/j.1574-0862.2004.tb00174.x

Hovmand, P. S. (2014). *Community Based System Dynamics*. New York, Heidelberg, Dordrecht, London: Springer.

Ingram, J. S. I., Ericksen, P. J., & Liverman, D. (Eds.). (2010). *Food Security and Global Environmental Change*. London & Washington DC: Earthscan.

Kim, H., & Andersen, D. F. (2012). Building confidence in causal maps generated from purposive text data: mapping transcripts of the Federal Reserve. *System Dynamics Review, 28*(4), 311-328. doi: 10.1002/sdr.1480

Mortimore, M., & Harris, F. (2005). Do small farmers' achievements contradict the nutrient depletion scenarios for Africa? *Land Use Policy, 22*(1), 43-56. doi: http://dx.doi.org/10.1016/j.landusepol.2003.06.003

Richardson, G. P., & Pugh, A. (1981). *Introduction to System Dynamics Modeling*. Williston, VT; Waltham, MA: Pegasus Communications.

Sterman, J. D. (2000). *Business dynamics. Systems thinking and modeling for a complex world*. Boston et. al.: Irwin McGraw-Hill.

Turner, B. L., Kim, H., & Andersen, D. F. (2013). Improving coding procedures for purposive text data: researchable questions for qualitative system dynamics modeling. *System Dynamics Review, 29*(4), 253-263. doi: 10.1002/sdr.1506

Vennix, J. A. M. (1996). *Group Model-Building: Facilitating Team Learning using System Dynamics*. Chichester: Wiley.