Journal of Environmental Management 209 (2018) 93–104

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

The socioeconomic factors that facilitate or constrain restoration management: Watershed rehabilitation and wet meadow (*bofedal*) restoration in the Bolivian Andes

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A R T I C L E I N F O

Article history:
Received 31 January 2017
Received in revised form
8 December 2017
Accepted 10 December 2017

Keywords:
Aymara
Bofedal
Common pool resource
Erosion control
Restoration ecology
Socio-ecological system

A B S T R A C T

Restoration ecology holds promise for addressing land degradation in impoverished rural environments, provided the approach is adapted to rural development settings. While there is a need for increased integration of social dynamics in land restoration, few systematic studies exist. We explored the socioeconomic factors that influence restoration management, including local motives and perceived benefits, incentives, land tenancy, institutional factors, conflict resolution, accessibility, off-farm labor, and outmigration. The study area is a successful watershed rehabilitation and wet meadow restoration project in the Bolivian Andes that began in 1992. We used household survey methods (n = 237) to compare the communities that had conducted the most restoration management with those that had conducted the least. Results suggest that several factors facilitate investments in land restoration, including aligning restoration objectives with local motives and perceived benefits, ensuring incentives are in place to stimulate long-term investments, conflict resolution, private land tenancy, and accessibility. However, higher levels of organization and active leadership can facilitate land restoration on communal lands. Increased livelihood benefits from land restoration helped slow the rate of rural to urban migration, with 24.5% outmigration in the highest restoration management communities compared to 62.1% in the lowest restoration management communities. Results suggest that land restoration projects that integrate community development into project planning and implementation will achieve greater success.

1. Introduction

Reversing land degradation in impoverished rural environments is a global priority (Gisladottir and Stocking, 2005). An estimated 23% of the global land area has degraded as measured by a long-term decline in net primary productivity (Bai et al., 2008). Land degradation affects an estimated 2.6 billion people worldwide, with the consequences disproportionately felt by the rural poor (Gisladottir and Stocking, 2005). Land degradation stresses societies by reducing the flow of ecosystem services (Lamb et al., 2005; Scherr, 2000; Carter et al., 2007), leaving populations vulnerable to food scarcity, civil conflict, involuntary migration, and infectious disease (Myers, 1997; Collins, 2001; Patz et al., 2004; Theisen, 2008; Reuveny and Moore, 2009). These stressors can, in turn, trigger fundamental social changes that reduce the local ability to sustain the investments of time, energy, and resources required to return degraded ecosystems to full functionality (Brown and Lugo, 1994).

Restoration ecology provides a promising framework to address land degradation in rural development settings, but it will need to be modified when applied to heavily managed rural environments (Brown and Lugo, 1994; Lamb et al., 2005; Shackelford et al., 2013). Restoration theory and practice developed in Europe and North America, where projects are often located in protected areas segregated from human populations, are focused on biodiversity conservation and wetland restoration, and are implemented through strong regulatory processes (Bullock et al., 2011). The major challenge for restoring heavily managed rural environments lies in increased integration of social dynamics into restoration efforts (Burke and Mitchell, 2007; Temperton, 2007; Aronson et al., 2010; Shackelford et al., 2013). There is an emerging body of

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https://doi.org/10.1016/j.jenvman.2017.12.025

literature which suggests that local and indigenous people can be effective at land restoration, provided there are sufficient levels of coordination and mobilization by local communities (Walters, 2000; Long et al., 2003; Amede et al., 2007; Stringer et al., 2007; Weston et al., 2015; Hartman et al., 2016a). Restoring ecosystem services also creates a series of benefits that help maintain rural livelihoods, such as increased food and water security, timber resources, and protection from floods and other natural disasters (Badola and Hussain, 2005; Walton et al., 2006; Blay et al., 2008; Nielson-Pincus and Moseley, 2013; Barral et al., 2015; Reed et al., 2015; Szücs et al., 2015; Hartman et al., 2016b). While these studies provide evidence that land restoration in rural development settings is possible, the conditions that enable impoverished rural communities to invest in land restoration remain poorly studied.

Local communities need robust social systems to be able to initiate and sustain land restoration, or at the very least, such systems need to be developed in the course of land restoration (Leach et al., 1999; Anderies et al., 2004; Amede et al., 2007). People make land use decisions in response to a complex set of individual, social, economic, institutional, and environmental factors that 'pressure' or 'nudge' change (Zimmerer, 1993; Lambin et al., 2003). The imperative is to identify the key factors that either facilitate or constrain restoration trends, and which can be addressed by community development or policy initiatives.

Previous studies have identified several factors that influence land management decisions in rural development settings. These include aligning restoration objectives with local motives and perceived benefits (Blay et al., 2008; Bullock et al., 2011; Reed et al., 2015); credits and incentives to stimulate long-term investment (Mekuria et al., 2011; Montagnini and Finney, 2011; Schiappacasse et al., 2012); road networks and accessibility (Jungerius et al., 2002; Nyssen et al., 2002; Pender, 2004; Valentin et al., 2005); land tenancy and institutional factors (Agrawal and Gibson, 1999; Leach et al., 1999; Hodge and McNally, 2000; Gebremedhin et al., 2004); conflict resolution (Amede et al., 2007; Theisen, 2008); and pursuit of alternative economic opportunities through off-farm labor and outmigration (Gray, 2009; Baptista and Rudel, 2006; Izquierdo et al., 2008). However, the influence of these factors in facilitating or constraining land restoration are poorly studied. Here we report an exploratory analysis to investigate the socioeconomic factors that facilitate or constrain land restoration at a long-term and large-scale watershed rehabilitation and wet meadow restoration program in the highland Andes.

2. Study area

The study area is a watershed rehabilitation and wetland restoration program in the Bolivian Andes. It is located in the Ayllu Majasaya-Aransaya-Urunsaya, an indigenous *Aymara* territory situated along the Cochabamba-Oruro Highway in the Tapacarí Province, Department of Cochabamba, Bolivia (Fig. 1). Ayllus are communal territories, with agropastoral activities conducted through institutions such as the *ayanoka* (communal planting areas), the *mink'a* (communal planting and work days), the *ayni* (reciprocal work exchanges between families), and traditional authorities such the *hilakata* (regulation of communal planting and grazing activities). Population densities are low (14.7 people/km^2), with families living in dispersed and isolated *ranchos*. The climate is semi-arid, with the majority of the rain falling between November and March. Elevation ranges from 3800 to 4600 m with vegetation dominated by Puna grasslands with seeps and wet meadows (bofedales) embedded in the grassland matrix. Local communities graze llama and sheep in high elevation grasslands, with agriculture concentrated in the valleys.

Humans have influenced the highland Andes for at least 7000–8000 years (Baied and Wheeler, 1993; Chepstow-Lusty et al., 1998). Land degradation in the study area is a result of modern population growth, cultivation on steep slopes, and overgrazing, which led to severe gully erosion, reduced agropastoral production, and bofedal degradation (Siebert, 1983; Harden, 2001; Brandt and Townsend, 2006). Bofedales provide important dry season grazing, and impacts to these ecosystems negatively affects local communities (Squeo et al. 2006; Washington-Allen et al., 2008). According to oral histories, land degradation intensified after the land reforms of 1952, which superimposed private land tenancy over the *ayllu* system and created a complex of individual, communal, and intra-communal land use rights (Appendix S1.1) (La Fuente, 1997; Delgado Burgoa, 2001; Rist et al., 2003). The complex of land use rights created unclear resource use boundaries, weakened the traditional *ayllu* system of agropastoral management, and worsened resource disputes. Land degradation exacerbated the levels of poverty and contributed to a reliance on off-farm labor and outmigration to urban centers (*e.g.* to Cochabamba and Oruro) and to the coca (*Erythroxylem coca*) regions in the Chapare (La Fuente, 1997). People began working in the city for 3–4 weeks out of the year to earn money as a supplement to their declining production in order to buy such things as sugar and kerosene. Over the years, people took longer trips to the city, and some families established households in the city or moved abroad (*e.g.* Argentina and Spain).

To address land degradation and declining agropastoral production, land restoration began in 1992 through a partnership between the Ayllu Majasaya-Aransaya-Urunsaya and the Dorothy Baker Environmental Studies Center (Centro de Estudios Ambientales Dorothy Baker, CEADB). Land restoration was planned through participatory workshops in 1992 and 1995 (La Fuente, 1997), and revised through feedback from community leaders, work groups and project *promotores* (Appendix S1.2). CEADB documented the restoration process in project records that included quarterly monitoring, annual evaluations, unpublished reports, and thesis studies. The partnership between CEADB and the Ayllu Majasaya-Aransaya-Urunsaya eventually grew into to a program that included over 30 communities and multiple governmental and non-governmental organizations. One of these organizations (Food for the Hungry International, FHI) used a food-for-work program to encourage terrace construction in exchange for foodstuffs. When land restoration efforts began, community members identified conflict as a major impediment to building erosion controls. The sources of conflict identified included 1) disputes over land tenancy and resource use rights; 2) intergenerational conflict due to the younger generation leaving for military service, and upon their return, not respecting the old ways, and 3) interpersonal disputes (Hartman, 1996; La Fuente, 1997). Effective land restoration requires a high degree of coordination, and community members perceived conflict resolution to be a critical step before land restoration could begin. To help address resource use disputes, several communities elected to privatize communal lands, allocating 42 ha to each family (Appendix S1.3) (CEADB project records).

Land restoration was conducted by community work groups (*aines*). Community work groups began by building check dams in the headwaters of gullies along the paved Cochabamba-Oruro Highway, working their way down slope as gullies stabilized. Other erosion control structures (ECSs) such as terraces, infiltration ditches, gabions, tree planting, and grazing exclosures were introduced in later stages of project development. The project was highly successful, and community members built over 30,000 ECSs. Based on ground measurement and a time series of Normalized Difference Vegetation Index (NDVI), ECSs led to increased *bofedal* vegetation and standing water in gullies, and increased green vegetation on approximately 50 km^2 of rangeland (Hartman et al.,