Forest Policy and Economics 95 (2018) 85–101

Contents lists available at ScienceDirect

Forest Policy and Economics

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

What drives forest degradation in the central Himalayas? Understanding the feedback dynamics between participatory forest management institutions and the species composition of forests

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ARTICLE INFO

Keywords:
Van panchayats
Community forest management
Oak forests
Pine forests
Deforestation
Central Himalayan forests

ABSTRACT

Human populations and their socio-economic conditions, such as road networks and poverty, are thought to be the main drivers of deforestation. However, a high deforestation rate can also alter the species composition of forests, providing further feedback to the socio-economic drivers of deforestation as well as weakening the community forest management institutions. In this paper, we model the feedback linkages associated with the degradation of forests and the weakening of the local institutions to understand how they impact the long-term sustainability of these linked socio-economic-ecological systems. In particular, we explore the impact of excessive harvesting of forests for fuelwood and fodder on a shift in the species composition from oak to pine trees in the central Himalayan region of India. This shift provides adverse feedback to the communities' livelihoods and erodes the quality of their participatory management institutions. A change in the species composition also increases forest fire risks, which further exacerbates the ecological as well as socio-economic feedback effects. We develop and apply a dynamic optimization model of community forest management where, through optimally controlling harvesting efforts over time, a weighted sum of community and environmental objectives is maximized. Findings indicate that factors such as population size, the extent of dependence of the community on fuelwood, the strength of community institutions, and the degree of feedback effects, affect the long-term sustainability of forests. When faced with forest fire risks, there is a discounting effect present which increases deforestation and institutional entropy.

1. Introduction

Our planet is losing its forests at an alarming rate, owing largely to human population pressures (Busch and Ferretti-Gallon, 2017). Between 2000 and 2012, over 2 million km^2 of forests were cleared globally, a majority of this loss occurring in the tropics (Hansen et al., 2013). Several measures have been implemented at local and global scales to prevent further deforestation, including payment for ecosystem services (PES), reducing emissions from deforestation and forest degradation (REDD+), and international treaties that prevent illegal trade in timber (Obidzinski et al., 2006; Wunder, 2007; Jayachandran et al., 2017). Additionally, dense and ecologically sensitive forests have been designated as protected areas (Joppa and Pfaff, 2009). In developing countries, community management of forests has been promoted as a mechanism for ensuring their sustainability (Lynch and Talbott, 1995). However, the impact of these various intervention measures remains ambiguous. In a meta-analysis of 121 studies conducted between 1996 and 2013, road networks and population pressure consistently emerged as strong drivers of deforestation (Busch and Ferretti-Gallon, 2017). Whereas, contrary to expectation, poverty was associated with a lower deforestation rate. Further, PES programs were found to reduce deforestation, but community forest management programs (CFM) did not show any significantly higher or lower impacts.

Community forest management is a promising idea, which in principle, could lead to a better protection of the earth's remaining forests through decentralizing their ownership and management and creating local institutions with sufficient autonomy and rewards for those involved. This approach is especially attractive in developing countries where the state may not have sufficient infrastructure and monitoring capabilities for protecting forests. Somanathan et al. (2009) find that community managed forests in the state of Uttarakhand in India were seven times cheaper to manage as compared to state managed forests, and yet there existed no significant difference in the level of degradation across the two forest types. Brandt et al. (2017) compare different management regimes in open forests in the Himalayan temperate

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https://doi.org/10.1016/j.forpol.2018.07.010
Received 11 March 2018; Received in revised form 14 July 2018; Accepted 24 July 2018

forests across India, Nepal, Burma, China and Myanmar to assess their effectiveness in reducing deforestation. While controlling for exogenous forces such as population pressure and socio-economic factors, they find that the average annual deforestation rate, for the period 2000 to 2014, was about 0.5% for Bhutan and Nepal, whereas, it was higher at about 1.3% for China and India. Also, countries that had a greater share of forests under protected areas (which are managed directly by the government) had a lower rate of deforestation (Brandt et al., 2017).

In India, the state of Uttarakhand, which has a unique 'van panchayat' based community management system (referred to as VP hereafter), has had the lowest deforestation rate among all states. However, along with deforestation, forest quality degradation also needs to be considered. In the central Himalayan forests of India, lopping for fuelwood and fodder collection by local communities has been the key anthropogenic driver of forest degradation (Baland et al., 2010). Population pressure, directly as well as indirectly, adds to degradation through increasing harvesting and weakening the community institutions (Sarkar, 2008). Human intervention (through lopping, cutting, fire, grazing, encroachment, etc.) has also been responsible for the takeover of banj oak forests by pine forests in uttarakhand (Ralhan and Singh, 1987). Displacement of oak trees by the pine trees further degrades forest quality and threatens the future sustainability of the forests. Finally, forest fires rank first among the natural causes of forest degradation in the Himalayas. Between 1998 and 2012, on average 12,850 ha of forests were burnt annually in Uttarakhand. Pine dominated forests have a higher risk of forest fires as compared to oak based forests. There were, on average, 421 fires in the pine forests annually between 2001 and 2012, whereas only 312 fires occurred in the oak forests (Verma, 2017).

For Uttarakhand, Baland et al. (2010) compared the extent of degradation in forests managed by VPs with those that were open forests or protected forest areas. They used various measures of forest quality (such as canopy cover density, lopping rates, etc.) for forests adjacent to randomly selected villages. Their findings suggested that VP managed forests had a lower level of degradation and were 20 to 30% less lopped compared to other forest types. Baland et al. (2010) further note that there could be endogeneity bias leading to an under-representation of the actual efforts made by VP communities towards improving their forests. This bias arises from the fact that VP institutions have emerged as a response to prevent forest degradation and may be located around forest areas that are particularly degraded. The number of Van Panchayats in Uttarakhand has increased from 6000 in 2002 to 12,089 in 2013 (Brandt et al., 2017).

Despite the noted effectiveness of VPs in reducing deforestation, a steady decline has been observed in their quality over time (Balooni et al., 2007). This has adversely affected the density and species richness of VP managed forests. Several factors have contributed to this decline in institutional quality. Interference by the forest department has resulted in a loss of autonomy for the VPs (Nagahama et al., 2016). The forest department not only controls the revenues generated from sale of timber and non-timber forest products (NTFPs), such as resins, honey and fruits, but also imposes strict restrictions on their harvesting. There does exist a revenue sharing mechanism between the VPs and the forest department, but most of the money goes towards sustaining the bureaucracy. A reduced availability of forest products has eroded the regulatory control the VPs earlier exerted over their populations. The clash of interests within the community becomes stronger when the forests do not generate enough revenues and resources for the local community to share among its members. Such clashes further weaken the VPs, resulting in various forms of illegal activities, such as timber harvesting, forest grazing and encroachment (Baland et al., 2010). Germain et al. (2017) sampled 400 village households from 4 districts of Uttarakhand to assess whether forests had enough biomass to provide the daily fuelwood and fodder needs of the local communities. The sampled respondents unanimously agreed that the forests were unable to meet their daily needs.

Additionally, a CFM system has its own set of unique weaknesses, including lack of transparency and accountability, nexus between VP leaders and the forestry officials leading to elite capture of the resources, lack of training, lack of involvement of women, etc. (Mansuri and Rao, 2004). The forests generate substantial commercial benefits through timber sale as well as through NTFPs. A high profit leads to a strengthening of the nexus between the forestry regulating bodies, the timber mafia and the influential members of the van panchayat.

There is another aspect associated with a weakening of the institutions that provides further feedback to the CFM challenge. Excessive logging can change the species distribution within the forests, leading to lower fuelwood and fodder supply, as well as exacerbating forest fire risks. Ballabh et al. (2002) compare two villages in Uttarakhand with respect to the forest type that was dominant in their vicinity. The village managing a predominantly banj oak forest had relatively better level of enforcement of fuelwood harvesting related regulations. Banj oak forests have higher species richness and are more suitable for meeting communities' livelihood needs. Whereas, the pine tree dominated village had a complete absence of regulatory mechanism. Similarly, Balooni et al. (2007) find that pine dominated forests in the Uttarakhand village of Dalpokhra had a much higher level of institutional entropy and corruption as compared to the broad-leaf based oak tree dominated Parwara village. Broad-leaf trees are more useful to the local community in terms of meeting the fodder and fuelwood needs, which leads to a higher resistance to any community member breaking the rules. In contrast, pine forests turn into open access zones. Institutional entropy has indeed been increasing over time. Between, 1992 and 1996, a total of roughly 1000 fines were imposed by the VPs for unauthorized activities, of which more than 600 went unpaid. The default rate was less than 50% in 1992 but increased to about 75% in 1996 (Balooni et al., 2007).

While the existing literature has compared the effectiveness of the VPs vis-à-vis other forms of forest management approaches (for instance, see Tompsett, 2014), there are various aspects that remain to be understood in greater detail. Agrawal (2001) provides an extensive summary of the existing literature on VPs in the Himalayan region. Whether community heterogeneity provides adverse feedbacks to the VPs is a question that hasn't been explored adequately. However, the absence of significant caste and class-based differences in the Kumaon and Garhwal region of Uttarakhand has been noted. Agrawal and Gibson (2001) suggest that future evolution of VP institutions could be determined through women's participation, which is a function of the livelihood profiles of these communities. Due to their noted comparative effectiveness in conserving forests and supporting community livelihoods, VPs are also being promoted as role models for large scale implementation through PES and REDD+ programs (Tompsett, 2014; Rawat and Kishwan, 2008). Again, there exists a debate over whether a transition from subsistence-based forestry management system to market orientation of VPs is desirable.

There also exists an extensive body of literature looking at the various ecological aspects of different forest types (oak versus pine trees). Between the two tree types, pines have an advantage over oak in terms of higher regeneration and spread rates. That is, when oak trees are harvested, the cleared areas grow back with pine trees as their seedlings are better able to survive in exposed environments. Removal of litter exposes the oak acorns to light, thereby reducing their viability. Whereas, pine seeds can survive in poor soil conditions (Singh et al., 2014). Field experiments have shown that pine has twice the nutrient extraction capacity from soil as compared to banj oak (Nautiyal and Babor, 1985). As a result, chir-pine forests have been displacing the oak forests in Uttarakhand, due to intensive harvesting of the oak trees by the local communities (Singh and Singh, 1992). In Jakholi, banj oak has been entirely replaced with chir-pines (Nautiyal and Babor, 1985).

As is obvious from the above review of the literature, there exists an extensive body of work covering institutional as well as ecological aspects of VP based CFM in the Uttarakhand region. Yet the question of