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A recipe for co-management of forest and livestock — Results of bio-economic model at a village level in Iran

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ABSTRACT

The ecosystem in the Zagros region of Iran, where this study was conducted, is characterized by joint occurrence of trees and grasses. Here multiple-use of forest and livestock is a common practice followed by the local people. This study develops a deterministic non-linear dynamic programming bio-economic model at a village level to analyse the possible implications of such a management regime over a period of three and a half decades into the future. Required data were obtained from field surveys and secondary sources. The model was run under four alternate management regimes represented by model scenarios. Comparison of "business as usual", "no goat" and "no sheep" model scenarios brought out that combining forest resources and livestock will not only be mutually beneficial but will also improve villagers' welfare. The results showed that state policies, like imposing ban on goat and sheep husbandry, are important in influencing area under different land uses. Sensitivity analysis highlighted the role of economic factors, e.g., prices of milk and meat and discount rate, ecological conditions, e.g., grass productivity and fire parameters in affecting the traditional forest management, land use and local community's welfare.

1. Introduction

Agriculture and forestry are the two main uses of land in rural areas in many parts of the world (FAO, 2006). The situation is no different in Iran where 10% and 7.4% of country's territory is under cropland and forests (Karamidekordi, 2010; Sagheb-Talebi et al., 2004). Although both these sectors have lost land to urbanization and infrastructure development over time, the shift in land use between these two sectors continues to be more predominant (Dunn, 2004; Gregory and Ingram, 2000; Murty et al., 2002; van Vliet et al., 2012). Growth of population and income over time has led to increased demand for food thereby bringing both challenges and opportunities for these sectors (Gregory and Ingram, 2000). Cropping and animal husbandry offer benefits to society mainly by way of providing food, fibre, nutrition, employment (Abler, 2004) and reduction in poverty (Christiaensen et al., 2011; Thirtle et al., 2003), whenever the rural households successfully manage to integrate in the market. Crop and animal husbandry have, however, also been associated with some negative consequences. Animals need a significant amount of land for grazing and browsing that may damage trees (Riggs and Urness, 1989), especially young ones; compact soil and aggravate soil erosion (Zhong et al., 2005). Such forest and soil degradation processes add to global warming by increasing greenhouse gas emissions (Schade and Crutzen, 1995). Thus the link between these two sectors gets complex due to the dependence of agricultural sector, especially livestock husbandry, on forest resources (Babulo et al., 2008; Narain et al., 2008; Soltani et al., 2014a).

The forest sector in developing countries has another challenge relating to ownership and uses of forests. In many parts of Africa and Asia large parts of forests are owned by state *de jure* (Thomas, 2008) and managed by some public agency (Soltani and Eid, 2013; Valipour et al., 2014). Such agencies often view people and their livestock as the main drivers of regeneration failure and forest loss (Enters et al., 2000; Soltani and Eid, 2013; Valipour et al., 2014; Yachkaschi et al., 2010). Therefore, state policies have often been aimed at excluding or reallocating local communities and their livestock from forest areas. Such policies have not only proved expensive (McKean and Ostrom, 1995; Yachkaschi et al., 2010) but often difficult to implement with little success in protecting the forests (Ebrahimi Rastaghi et al., 2003; Enters et al., 2000; Ghazanfari et al., 2004). Many local communities still continue to use traditional practices for managing common forests successfully (e.g. Berkes, 1989; Hanna et al., 1996; Ostrom, 1990; Pagdee et al.2006), including those in Zagros region of Iran (Ghazanfari et al., 2004; Soltani and Eid, 2013; Valipour et al., 2014; Yachkaschi et al., 2010).

Zagros region is located in western part of Iran. In this region, semi-arid oak forests with an area of five million ha account for almost 40% of Iran's total forest wealth (Sagheb-Talebi et al., 2004). The vegetation is

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characterized by two dominant life forms, namely, oak trees and grasses, with varying ratio of tree–grass area (Fattahi, 1994). The forests are mainly regenerated through coppicing (Sagheb-Talebi et al., 2004) and are characterized by seasonal water availability (Jazirei and Ebrahimi Rastaghi, 2003). Majority of rainfall is confined to a single season and wild fires are a common occurrence (Mohammadi et al., 2014; Pourreza et al., 2009; Pourreza et al., 2014). Therefore, vegetation of Zagros has sometimes been categorized as oak–pistachio savannas (van Zeist and Wright, 1963).

Animal husbandry, consisting of goat and sheep, is the main source of income for local communities (Salehi et al., 2010). This activity is heavily dependent on forest resources (Soltani et al., 2012, 2014a). While goats are mainly browsers, feeding on seedlings, sprouts and branches of oak trees, sheep are grazers, consuming mainly grass (van Soest, 1982). The tree–grass biomass ratio influences the composition of goats and sheep herds to a great extent (Yachkaschi et al., 2010). In general, while sheep are the dominant livestock in areas with greater grass and herbs biomass, goats thrive better in areas with more seedlings, sprouts and shrubs (Pfister and Malechek, 1986). Collecting firewood and making charcoal are other secondary economic activities undertaken by the local communities (Soltani et al., 2012; Soltani et al., 2014a; Yachkaschi et al., 2010).

The Forest, Range and Watershed Management Organization (FRWO) of Iran has adopted a set of policies to conserve forests in Zagros (e.g. Valipour et al., 2014; Yachkaschi et al., 2010). This includes ban on harvesting of live trees, lopping of trees and making charcoal, and reallocation or exclusion of livestock from forest areas (Soltani and Eid, 2013; Valipour et al., 2014). Conflicts between state (FRWO) and local communities have often resulted in increased incidence of fire during the recent decades (Mohammadi et al., 2014; Pourreza et al., 2009; Pourreza et al., 2014). This has brought additional costs to FRWO for protecting the Zagrosian forests. Fire is a negative feedback, which limits tree development (Ryan and Williams, 2011). It kills seedlings and consumes live foliage. Due to dependence of livestock husbandry on forests (Soltani et al., 2014a), fire may ultimately influence livestock production negatively. Conversely, urbanization, out-migration and state policy to exclude livestock from forests have also reduced the number of livestock in Zagros. If the grass biomass produced during the rainy season is not consumed by livestock, the incidence of fire will increase during the dry season (Bachelet et al., 2000; van Langevelde et al., 2003). Therefore, there may be an advantage in combining livestock husbandry and forestry as a management tool to reduce fire hazards as documented by some earlier studies (e.g. Bachelet et al., 2000; Higgins et al., 2000; Madany and West, 1983; Mohammadi et al., 2014; van Langevelde et al., 2003; Zimmerman and Neuenschwander, 1984).

For combining livestock husbandry and forestry, it is essential to understand the interactions among trees, grass, livestock and human beings. Generating such knowledge can be useful in reducing friction between agriculture and forestry sectors (Castro and Nielsen, 2001; Fay and Michon, 2005; Yachkaschi et al., 2010). Evidence on the effectiveness of traditional rules in maintaining and managing common pool resources can be utilized for reducing friction between state and local communities (Angelsen, 2001; Arnold, 1998; Bruce, 1999; Kusters et al., 2007). The current study follows an interdisciplinary approach for analysing the real world complexities with a view to fill the existing knowledge gaps. It aims at answering the following specific research questions:

1) How do state policies of imposing ban on wood harvesting, goat and sheep rearing influence traditional forest management and forest resources?
2) How do interactions between goat and sheep populations affect the economic conditions of village inhabitants?
3) How sensitive are the traditional forest management and optimal forest land use to variations in economic and ecological parameters?

2. Materials and methods

2.1. Description of study area

A village named Ghamishale from Zagros region of Iran was selected for the purpose of in depth analysis. It is located at 35° 40′ N and 46° 16′ E and represents the agro-climatic and socio-economic conditions characteristic of the region fairly well. Ghamishale is 25 km from Marivan town and 101 km from Sannandaj, the provincial capital of Kurdistan (Fig. 1). The village has 43 households with a population of 221. The total land area is 2710 ha, of which 2570 ha and 140 ha are under forest/pasture and cropland. The forest is characterized by low-value stocking parameters. Number of trees, regeneration (seedlings and sprouts) and basal area were 628, 7074 and 10.1 m^2 per ha respectively during the study year (Soltani and Eid, 2013). Oak trees are dominant in the forest with *Quercus brantii*, *Quercus libani*, and *Quercus infectoria* as the main species accounting for 21, 14, and 6% of basal area respectively (Soltani and Eid, 2013). The forest density (biomass per ha) is significantly lower, but the grass biomass per ha is much higher on the sunny side of Ghamishale valley (FRWO, 2005; Soltani and Eid, 2013).

The forest and pasture are formally owned by the state since 1963. Consequently the access of local people to natural resources is *de jure* restricted by enforcement of state law. Due to high dependence of local people on forest resources and weak enforcement, the traditional and customary rights to forest resources are still under de facto regime even though it is not formally accepted by forest authorities. According to traditional management practices followed in Ghamishale village, forest and pasture are divided into three management regimes, namely, *Gala-jar*, *Alef-jar* and *Bayer*. Under the *Gala-jar* regime tree lopping, grazing, and collection of firewood and non-wood forest products (NWFPs) are practiced. According to traditional rules, villagers are not allowed to fell trees below 40 cm diameter at breast height (dbh). Instead, these trees can be used for lopping. Fresh branches of oak trees are trimmed and then stored for use in the winter season. Leaves, limbs and fresh and young branches are used as fodder for goats, while the woody part of branches is used as firewood mainly for cooking and baking bread. The lopping areas are further divided into four parts with lopping permitted in one part each year, thereby following a 4-year rotation. In *Alef-jar*, villagers collect grass for feeding sheep during the winter months. Browsing and grazing are traditionally forbidden from March until June. Collection of grass, firewood and NWFPs, and felling of trees are allowed in this area all year round. The *Bayer* part of territory is mainly used for grazing, felling of trees and collection of firewood and NWFPs. Villagers often collectively decide on a few oak trees in *Gala-jar* and *Alef-jar* that must not be felled or lopped. The purpose of preserving these trees is to provide shade for humans and livestock during the summer months as well as to facilitate regeneration of trees from seeds (Soltani and Eid, 2013).

According to Soltani and Eid (2013) the spatial organization of the three traditional forest regimes is mainly based on ecological (altitude, aspect and grass–trees ratio) and economic considerations (distance from settlement). Therefore, *Gala-jar* with relatively higher tree density is located near the settlement areas from where lopped branches of trees can be easily brought home in a short time. *Alef-jar* is situated relatively at higher altitudes and farther from settlement. It has better ecological conditions for the growth of grass. The traditional forest management is quite flexible depending on the local requirements. Whenever villagers need more area for tree lopping, some parts of *Alef-jar* may be converted to *Gala-jar*. Based on a study by Soltani and Eid (2013), the area under *Gala-jar* has witnessed an increase over the last 30 years. This has come as a result of villagers' response to increasing goat population