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Analysis

Mediating factors of land use change among coffee farmers in a biological corridor

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ABSTRACT

Trees in agricultural landscapes are important for the provision of environmental services. This study assesses the loss of shade coffee during a 9 year period in a biological corridor in Costa Rica, and investigates the mediating factors of land use change. Following a conceptual framework that presents how household and farm characteristics mediate the interplay between underlying and proximate causes of land use change, the effect of the mediating factors is determined by applying an ordered probit model to household and land use data for 2000 and 2009 from 217 former and present coffee farmers. Additional 224 telephone interviews supplement the data on land use change. Results show a 50% reduction in the coffee area and a corresponding loss of trees. Family labor, age of household head, coffee prices, and use of shade tree products significantly reduce the probability of converting the coffee field, while the number of family members engaged in other agriculture and non-farm work increases the probability. A stronger tie to coffee farming is found to abate the influence of underlying drivers, whereas the younger generation downgrades the labor intensive coffee farming. Payments for environmental services are proposed as a policy instrument that may influence land use.

1. Introduction

The estimated 24–38% of the Earth's land area that is devoted to agricultural use is projected to increase by 18% by 2050 (MEA, 2005; Tilman et al., 2001). In the period 1980–2000, 55% of new agricultural land in the tropical world came from intact forests and another 28% from disturbed forests (Gibbs et al., 2010). If this trend continues, the expected expansion of agricultural land will lead to further destruction of forests and loss of environmental services from natural ecosystems. In return, this will increase the pressure on agricultural areas to provide a larger part of the provisioning, supporting, cultural, and regulating ecosystem services deemed important for human well-being (MEA, 2005). This calls for a land-use management that aims both for agricultural production and the conservation of environmental services; a dual objective which may be met through 'ecoagriculture' management (McNeely and Scherr, 2003). Trees are widely recognized as essential for the provision of several important environmental services in agricultural landscapes. This is recognized in the Costa Rican national program of payments for environmental services (PES), where coffee farmers are among those eligible to receive payments for planting and conserving trees in agroforestry systems (Cole, 2010; Pagiola, 2008). Coffee growing has been among the main culprits of forest conversion in Central America during the first half of the twentieth century and still is in some areas of Asia (Kinnaird et al., 2003). However, shade coffee systems are generally perceived as being ecologically important in terms of watershed functions, carbon sequestration, and habitat for fauna and flora (Correia et al., 2010; Dossa et al., 2008; Perfecto et al., 1996; Verbist et al., 2005). As such, coffee farmers are important actors in ecoagriculture landscapes such as buffer zones and biological corridors (McNeely and Scherr, 2003; Pagiola and Ruthenberg, 2002; Perfecto et al., 2009). Conversion to other land uses may have implications that go beyond the household and cultivated fields if a reduced tree cover results in loss of environmental services.

As other landowners, coffee farmers face multiple factors that influence land use decision making, such as changing markets, policy interventions, cultural change, poverty, as well as synergies among factors (Lambin et al., 2001, 2003). A decade ago historical low coffee prices was the main driver of land use change in coffee producing areas, especially in the tropical America (Eakin et al., 2006; Varangis et al., 2003). Fluctuating prices and costs of production continue to influence the profitability of coffee production (ICO, 2009) and thus land use decision making. Among the few studies of clearing of coffee systems, Blackman et al. (2008, 2012) apply classic land rent models to determine the drivers of clearing. In both studies, they find that coffee plots closer to towns with coffee markets are less likely to be cleared, highlighting the importance of cost advantages. The cultural context of land use choices is also important, as concluded by Ponette-Gonzáles (2007), who found that households maintain coffee production even when it is not economically viable. Agroindustrial

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intensification is another driver for change in coffee landscapes, as traditional small scale coffee agroforests are transformed into industrial plantations with higher dependence on inputs and mechanization (Perfecto et al., 1996). Agricultural intensification often occurs concomitantly with the expansion of non-farm income opportunities through increased mobility of labor and higher levels of education (Rigg, 2006). This is the core of the deagrarianization process, which manifests itself in a declining farm/non-farm labor ratio and decreased dependence on farm income among rural households (Bryceson, 1996).

Understanding the drivers of land use change is necessary in order to manage trees and forested areas in agricultural landscapes. The objective of this study is to assess the rate at which coffee fields are converted to other land uses, and investigate household and farm characteristics as determinants for land use change among coffee farmers. Based on a survey of 217 coffee producing households in a biological corridor in Costa Rica, the changes in the coffee area during the period 2000 to 2009 are analyzed using re-call data on household and farm characteristics corresponding to the year 2000. The nine year time span allows for sufficient data on land use changes, but also presents challenges in data collection as described in Section 4. Further, the temporal difference in household and land use data aims to avoid endogeneity, which is a potential issue in land use studies that model independent and dependent variables based on contemporary data. Temporal priority only reduces the risk of endogeneity that may also arise from other problems in the sampling or data collection. The study contributes to the micro-level (household) subsystem of the substantial land change science as argued for in Section 2, where the background and a conceptual framework for land use change are presented. In Section 3 the study area is described, while Section 4 presents data collection, the development of an ordered probit model, and variables. The results and the discussion are presented in Sections 5 and 6, while Section 7 concludes the article.

2. Land Use Change Framework

Land use change science has developed into an interdisciplinary field that seeks to understand land use and land cover changes based on the human and environment dynamics as a coupled system (Rindfuss et al., 2004; Turner et al., 2007). Integrative approaches are often applied, where different theories, modeling techniques, data collection methods, and levels of data aggregation are integrated, e.g. Castella et al. (2007) and Manson and Evans (2007). Other studies contribute with increased understanding of specific outcomes in subsystems of land change science, which helps to improve the components of the more holistic approaches. Examples of the latter are presented in the synthesis of research efforts by Lambin and Geist (2006). This study aims to increase the understanding of how micro-level (household) factors influence land use decisions, in this case among coffee farmers. Manson and Evans (2007) call for a better understanding of decision making at the micro-level in order to develop the integrated approaches. To do so, the level of data aggregation on both sides of the equation, i.e. the land change variable and the explanatory variables, should be at the micro-level, not least to avoid ecological fallacy (Brown et al., 2004). Relationships found at the aggregate level (e.g. aggregate census data) do not necessarily reflect relationships at the micro-level (e.g. household demographic data) (Rindfuss et al., 2004).

In this study, a conceptual framework is developed that illustrates the linkage between underlying causes, mediating factors, and proximate causes of land use change among coffee farmers (Fig. 1). In their synthesis of land use and land cover change research, Geist et al. (2006) summarize the main underlying causes of change and arrange them in five broad categories of factors that have been widely used in land change studies — biophysical, economic and technological, demographic, institutional, and cultural factors. Fig. 1 includes a modified version of the five categories, adapted to this study. A category of societal factors replace and encompass the cultural factors as well as social processes such as deagrarianization. The categorization of factors is not clear-cut, e.g. urbanization is often categorized as an economic factor but may also represent a societal factor if focus is on the related changes in social structures. The underlying causes are mostly exogenous to coffee farmers, but underpin the proximate causes of land use and land cover change, i.e. human activities or immediate actions at the local level such as agricultural expansion (Geist and Lambin, 2002). The proximate causes are often the focus of land change studies, especially regarding the dominant topic of land change science; deforestation (e.g. Margulis, 2004; Marquette, 1998; Serneels and Lambin, 2001). This study focuses on the conversion of coffee fields to other land uses that are either more or less intensive. As such, attention is not solely directed to processes of agricultural intensification, another dominant land change topic since Malthus and Boserup (Turner and Ali, 1996).

In-between the underlying and proximate causes are the mediating factors that can be described as the characteristics and attributes of the land use agent and of the resources to which the agent has access, that shape and modify the interplay between underlying drivers and proximate causes of land use change. This is a modified version of the definition given by Geist and Lambin (2004), as it specifically group household characteristics and farm characteristics within the mediating factors. Furthermore, it encompass the biophysical factors of the farm, such as soil and topography, that Geist and Lambin (2001) describe as pre-disposing environmental factors. The choice of mediating factors is based on observations from the field and on reviews of studies of land use change affected by or related to household income and assets (e.g. Chowdhury, 2006; Pacheco, 2009), household life cycles (Perz, 2001; Walker et al., 2002), household demographics and educational level (Caviglia-Harris, 2005; Pan and Bilsborrow, 2005; Pichon, 1997), duration of residence and land ownership type (Chowdhury, 2010; Pichon, 1996), and land availability (Ponette-Gonzáles, 2007). The explanatory variables in the econometric model developed in Section 4.2 comprise the mediating factors, which are presented in Section 4.4.

With notable exceptions, the majority of studies on land use of individual households are based on contemporaneous land use and household/farm data (e.g. Blackman et al., 2008; Ponette-Gonzáles, 2007) or use land change data that predates the explanatory variables (Wyman and Stein, 2010). This makes it difficult to demonstrate the direction of possible causation; whether land use is a result of household characteristics or vice-versa. Furthermore, static analyses do not take path-dependencies into account (Verburg et al., 2006). If, for example, a coffee farmer regrets a decision to clear the coffee area, there is a substantial investment and loss of income associated with a re-introduction of coffee and the time lag before the first coffee harvest. Many households will not have the economic capacity to assume such costs, and will therefore find themselves locked to their new land use. The influence of land management and existing land use on future land use decisions is represented by the 'Land use/cover' box in Fig. 1.

3. Study Area

The study was carried out in the Volcan Central Talamanca Biological Corridor (VCTBC) located in the Cartago and Limón provinces in Costa Rica. The corridor covers an area of approximately 115,000 ha with altitudes ranging from 160 to 3340 masl at the top of the Turrialba Volcano. No less than nine protected areas are connected by the biological corridor, emphasizing its importance in the regional conservation network. The climate is very humid with annual rainfall exceeding 2600 mm, most of which falls in the period from June to December.

Agriculture has been practiced for at least 3000 years in the area, on fertile soils mainly of volcanic and alluvial origins. Coffee production was introduced in the beginning of the 19th century and quickly became one of the dominant land uses. Dairy and cattle farming