Agricultural opportunity costs assessment based on planting suitability: a case study in a mountain county in southwest China

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Abstract: Payment for ecosystem services (PES) has become an increasingly popular means of ecosystem conservation. Opportunity cost is an important factor to increase the investment efficiency of PES projects. However, the distribution of opportunity cost is usually unclear in mountainous regions due to the obvious environment changes. In this study, we developed a framework to assess the distribution of agricultural opportunity costs in mountainous regions and applied this method to Baoxing County, a typical mountainous county in Sichuan Province of southwest China. Planting suitability of 17 crops was assessed based on agricultural statistics and natural conditions data within a GIS environment. Agricultural opportunity cost was quantified with a weighted summation of farmers’ willingness to cultivate and each crop’s opportunity cost. Finally, specific agricultural opportunity cost was obtained according to the spatial areas of the protection programs and land use status. The results showed that agricultural opportunity costs of PES in Baoxing County were estimated to be more than $30 million, with a mean of 400.85 $/ha. Agricultural opportunity costs in mountainous regions displayed some obvious spatial variation and areas with lower agricultural opportunity costs could be selected as priority areas for PES. Our findings revealed that the planting suitability evaluation can make agricultural opportunity costs mapping more reasonable. It will be helpful for the PES programs implementation in mountainous regions.

Keywords: Opportunity cost; Planting suitability; Willingness to accept; Ecosystem service; Spatial variation; Baoxing County

Introduction

Payment for ecosystem services (PES) is a market-based instrument to translate external, non-market environmental services into financial incentives for landowners to preserve the
ecosystems that provide the services (Wünscher et al. 2008). PES has become an increasingly popular way to manage ecosystems (Li et al. 2009a; Farley and Costanza 2010). To mitigate undesirable ecological/environmental condition, China has been trying to implement PES at different scales (Dong et al. 2011). Development of scientific PES criteria with spatial differences is critical to the success of PES. The development of PES criteria is mainly dependent on two factors: (1) the provided ecosystem services values, and (2) the cost of providing ecosystem services (Wünscher et al. 2008; Liu et al. 2015). In theory, the provided ecosystem service value is the maximum payment standard, while the cost of providing ecosystem services, requires minimum payment (Eco-compensation 2007). The provided ecosystem services values are generally much higher than the ability of people to pay for the service. Some studies have proposed that comprehensively and accurately calculating the costs is more important than assessing ecosystem services values in the design and implementation of PES at the current level of social and economic development (Tan 2009).

The PES costs include the ecological protection costs, environmental protection costs, and opportunity costs (Liu et al. 2015). Compared with the ecological protection and environmental protection costs, opportunity costs are usually much higher and dominate the total PES costs. In the Dongjiang River source area, the opportunity costs accounted for 80.96% of the total PES costs (Shi et al. 2012). Similarly, in Inner Mongolia, the total PES costs of grasslands were 105.36 $/ha, and the opportunity costs accounted for 74.45% of that total (Gong et al. 2011). Take water source reserves as an example, compared with the forestation and daily maintenance costs required to protect the water source reserves, the opportunity costs are comparatively higher because the water source reserves encompass large areas of cultivated land; yet if farmers give up farming to protect the water source, they will also experience reduced incomes. Some authorities propose that conservation opportunity emphasizes the opportunity cost as an important element to determine the willingness of farmers to engage in private land conservation (Conradie et al. 2013). Thus, the opportunity cost is the foundation for the development of PES criteria (Immerzeel et al. 2008; Pagiola et al. 2007). For a Water Conservation Program in Tibet, some studies have proposed that farmers would be willing to change their practices in return for payments, only if the opportunity cost per unit of water conserved is less than the price paid for the water (Immerzeel et al. 2008). Pagiola et al. (2007) suggested that all existing PES implicitly or explicitly base payments on the opportunity costs of the main alternative land uses.

Opportunity cost refers to the maximum benefit that could have been gained from an alternative use of the same resource (Gregory 2003); in PES, the opportunity cost refers to the foregone income and development opportunities to protect the ecosystems and environment (Li et al. 2009b; Duan et al. 2010). In particular, opportunity costs of PES can generally be divided into two parts, land and labor opportunity costs (Wunder and Albán 2008). The labor opportunity cost is harder to calculate, whereas the land use is more closely associated with the ecosystem and environment. Different land uses produce different economic outcomes; however, the same land use can also have different economic benefits, e.g., cultivated land with different plant species and management actions will yield differing incomes. In PES for watersheds or water sources, the opportunity costs mainly involve agricultural opportunity costs, however, if only one land use type is considered, it cannot reflect the varied farming conditions, thus the calculation of opportunity costs is not accurate.

Local natural environments can be considered to accurately estimate the agricultural opportunity costs. There are many factors that influence the suitability of land for the production of agricultural goods, such as soils, geology, topography, climate, water resources, flora and fauna, and the anthropogenic activities (Silva et al. 2013). Not all lands can produce highly profitable crops, especially mountainous areas with obvious natural and anthropogenic spatial differences (He 2002). Planting suitability has to be evaluated to reflect these differences. Many scholars have researched the planting suitability of economically desirable plants (e.g. walnut, Tea tree and Chinese herbal medicines among others) for introduction (Shi et al. 2008; Xie et al. 2011; Huang et al. 2013). Others have researched planting suitability by