Ecological Economics 91 (2013) 28–37

Contents lists available at SciVerse ScienceDirect

Ecological Economics

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

Analysis

# Adoption and continued use of contour cultivation in the highlands of southwest China

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ARTICLE INFO

*Article history:*
Received 8 October 2012
Received in revised form 19 March 2013
Accepted 22 March 2013
Available online 2 May 2013

*Keywords:*
Soil erosion
Contour cultivation
Adoption
Continued use
Yunnan

ABSTRACT

This paper examines the use and continued use of contour cultivation in Yunnan Province. Descriptive analysis shows that even with easy-to-adopt conservation practices such as contour cultivation, we do not observe high rates of adoption without subsidy or monetary incentives. Multivariate analysis shows that households with larger plots, more fertile land and male and younger decision makers are more likely to use contour cultivation. Households relying more heavily on agricultural income tend to continue to use contour cultivation. The findings suggest that the trends in China's agriculture sector (increasing off-farm employment, aging and more female farmers on farm) are not conducive to the use of soil conservation practices. To alleviate soil erosion problems, the government should increase investment in agricultural extension and provide farmers with monetary incentives to encourage the adoption of environmental conservation measures. Policies should also target marginal land where conservation efforts may be lacking.

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## 1. Introduction

Soil erosion is one of the most serious environment problems that threaten the agricultural development of China, especially in mountainous areas with steep uplands. In China, up to 6 million ha of farmland with slopes exceeding 25° are affected by soil erosion (Weyerhaeuser et al., 2005). As a result, about 85% of China's soils lacked sufficient nutrients, and the organic matter in the soil dropped from 12% in the 1940s to less than 2% (McBeath and McBeath, 2009). Crop yields on sloping land in South China have decreased by 30% to 60% because of soil erosion (Gao and Zhou, 1988). In addition to land degradation and declines in agricultural productivity, soil erosion also results in the silting of rivers and lakes, flooding and landslides, causing tremendous loss in human life and economic costs.

China's government has been investing large amounts of money in promoting soil erosion practices including contour cultivation, minimum or no tillage, mulching, intercropping and agro-forestry (Han, 2006). Extension efforts are designed not only to treat soil erosion, but also to improve farmers' income and advance local economic development. However, most projects are carried out through administrative orders. There is little concern as to whether farmers adopt these measures or the extent by which they have been influenced by the projects. In spite of the government propaganda and technical assistance from environmental agencies and institutes, Chinese farmers' adoption of conservation practices is painfully rare (Sanders, 2000). With a set of households from four provinces in northern China, Wang et al. (2010) report that conservation agriculture is adopted on only about 1.5% of the cultivated land in China. This is in line with the low adoption rate observed in other regions of the world: only 2.3% in Asia, 0.4% in Africa, 1.4% in Europe and 11.4% in Australia and New Zealand (Li et al., 2011).

Outside China, there is a large literature examining the factors that encourage or dissuade farmers to use conservation practices (Comboni and Napier, 1995; Ervin and Ervin, 1982; Knowler and Bradshaw, 2007; Prokopy et al., 2008). Partly due to the severe land degradation caused by soil erosion in African countries, a group of scholars has examined the use of conservation practices in the region. Shiferaw and Holden (1998) examine what factors affect the perception of the soil erosion problem and lead to removal (full and partial) or retention of conservation structures by farmers after they were introduced in Ethiopian highlands. Amsalu and de Graaff (2007) examine the factors that lead to adoption and continued use of stone terraces in the central highlands of Ethiopia. Tesfaye et al. (accepted for publication) study the use of soil, stone and fanya juu (terrace) bunds in the upper Blue Nile Basin. Kassie et al. (2012) analyze the use of a range of sustainable agricultural practices (e.g., conservation tillage and soil and water conservation practices such as terracing and plant barriers) in rural villages of Tanzania. In these studies, key factors leading to the adoption of conservation practices include plot or farm characteristics such as size, slope and fertility, farmer or household characteristics such as age, education, labor availability and off-farm employment, institutional factors such as land tenure security and finally farmers' perception of erosion problems. Other factors including the profitability/productivity of the conservation practice and access to credit and information are also found to be relevant.

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http://dx.doi.org/10.1016/j.ecolecon.2013.03.015

Inside China, most studies have focused on farmers' adoption of new agricultural technology, not soil conservation practices. Wang et al.'s (2010) study is among the few papers that have analyzed farmers' adoption of conservation agriculture. Their paper, however, does not look at the continued use of conservation practices.

Following the literature discussed above, this paper will examine four sets of factors including farm, farmer and technology specific factors and institutional factors that influence farmers' decision to adopt and to continue the use of soil conservation practices. We focus on a specific type of practice, contour cultivation, plowing across a slope and following elevation contour lines. Contour cultivation can significantly alleviate soil loss that would have occurred under the traditional downslope cultivation. The rows formed can slow water run-off during rainstorms. In addition to alleviating soil erosion, contour cultivation also allows more time for water to settle into the soil. On the experiment plots of Yunnan Agricultural University that grew maize in 1998 and 1999, contour cultivation reduced up to 99% of potential soil loss (Milne, 2001). The magnitudes of the reduction in soil loss due to contour cultivation depend on the slope of the land and other factors such as the intensity of rainfall. In a wet year, contour cultivation significantly reduced erosion on slopes of 3 to 10°, but not steeper slopes. However, in a drier year, contour cultivation was more effective on steeper slopes. The reason to focus on contour cultivation is that it can be easily adopted by farmers. It is a practice that has been used by farmers in our study site but only sporadically. The main cost of contour cultivation is labor. In the experiment conducted by the SHASEA project, 294 man-days/ha were used on plots under contour cultivation, in contrast to 272 man-days/ha under traditional downslope cultivation (SHASEA, 2003). Focusing on this simple conservation practice allows us to examine only a small set of factors in studying farmers' adoption behavior.

The study area is located in Yunnan Province. Soil erosion is particularly serious in Yunnan Province with its mountainous topography, the heavy rainfall in the monsoon season, and loosely structured soil. Located in the upper reaches of the Yangtze River in Southwest China, 94% of the land in Yunnan Province is mountainous. Agricultural production in the province relies heavily on the summer monsoon rainfall. Over 80% of the annual rainfall falls between May and September. The monsoon rains are highly variable in terms of their amount, reliability and erosivity (Fullen et al., 2000). In addition, the soil of Yunnan Province is categorized as Red Soil that has a loose structure and is easily carried away by the heavy rainfall in the monsoon season (Subedi, 2005). Increasing population and higher food demands have led to the encroachment of cultivation onto fragile steep-sloped uplands. Erosion has been occurring at an accelerated rate. The forest cover in Yunnan Province has declined from about 60% in the 1960s to 24% in 1990 (United Nations Environment Programme, 1990). The eroded area has reached 36.9% of the total land area in 2003 (Yunnan Province Environment Protection Bureau, 2003). Better soil management in Yunnan Province will not only contribute to the agricultural development of the local region, but also reduce sediment levels in the Yangtze River, which will in turn reduce flooding downstream. In addition, adopting soil conservation practices has been found to be one of the major forms of adaptation strategies used by farm households to climate change in the Nile Basin of Ethiopia (Di Falco et al., 2011). They could play similarly important roles in rural China. However, despite the importance of this issue, little published work is available on analyzing farmers' behavior of adopting soil conservation practices in Yunnan Province.

The objective of this paper is to quantify factors influencing the adoption and continued use of contour cultivation in Wang Jia Catchment over a three-year period. Farmers' adoption behavior of the contour cultivation has been traced in three years. Their social-economic background is also included. The paper is organized as follows. Section 2 describes the research site and data. Section 3 describes specifications of the econometric models. Section 4 explains the selections of explanatory variables. Section 5 discusses results from both descriptive analysis and multivariate analysis. The final section concludes.

## 2. Research Site and Data

The research site is Wang Jia Catchment located in Kedu Township, Xundian County in Yunnan Province. The watershed is about 60 km northeast of the provincial capital, Kunming, and 12 km from the Kedu Township government. The elevation of the watershed ranges from 1860 m to 2473 m (SHASEA, 2003). The average annual rainfall is 1043 mm. About 80% of total rainfall occurs between June and October. The total cultivated land in Wang Jia Catchment is 40.1 ha, of which 61% have slopes between 10 and 25° and 7% greater than 25°. The land belongs to 162 households in Kelang Village.

The village is facing high population pressure. The population density of Kelang Village is 456 people per km$^2$, about 4 times that of the average in Yunnan Province (109 people per km$^2$). In 1999, the total population of the village was 3560 and the total cultivated land was only 159 ha. This gave a per capita arable land of 0.045 ha, which is about one third of the national average and half of the provincial average. The pressure to meet demand from a fast-growing population has driven farmers in Kelang Village to clear forest land for agriculture. At least 5% of cultivated upland comes from a deforested land. Partly due to deforestation, the share of cultivated upland that is steeper than 25° is as high as 49%, above the provincial average of 38% (Liu, 2007). Most land cultivated in the watershed grows two seasons of crops. The main crops are maize, tobacco and legumes in the summer season (March to August) and wheat and pea in the winter season (September to February). Most crops are rainfed. The practice of intensive cultivation and extensive deforestation have degraded soil structure and decreased soil nutrients. Scientists of the SHASEA project tested the soil samples from the catchment for pH value, calcium, potassium, nitrogen and phosphorus. Results showed that about 63% of the land is of low quality, 19% is of medium quality and only 18% of the land is of high quality (Li, 2004). In terms of land use and the extent of soil erosion, Wang Jia Catchment is typical in Yunnan Province.

Data for this study come from a household panel survey collected in 1999 and 2001. Partly because the survey was conducted only two years apart and because permanent migration (the whole household moved to a different county or even a different province permanently) was uncommon in the region, we were able to interview all of the 1999 households again in 2001 and there was no attrition in the panel survey. A structured survey questionnaire was used to interview farmers. The household survey collected basic household information such as household size and demographic composition. It also collected information on agricultural production activities, off-farm employment and other economic characteristics such as household income.

In addition, data from a plot survey were also used. The plot survey was conducted by the SHASEA project team during the cropping seasons of 1999, 2000 and 2001. One hundred plots were selected from all the plots in Wang Jia Catchment to be the control group to the experiment plots of the SHASEA project. A stratified sampling strategy was used. All plots in the catchment are located at elevations ranging from 1879 m to 2183 m. The relevant range of the elevation was first divided into segments. Multiple plots were then selected from each segment, which included plots with different orientations (facing west or east) and different slopes. The research team recorded the characteristics of the plots (e.g., soil fertility and slope). The research team also recorded the cultivation method (e.g., contour or downslope cultivation) of the plots that grew maize for five years between 1999 and 2003. Years 2002 and 2003 were included in data collection because the SHASEA project team promoted the use of contour cultivation by providing some monetary incentives to farmers. The households that cultivated the 100 plots were all included in the household panel survey.

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