ELSEVIER

Journal of Environmental Management 85 (2007) 736–745

Journal of Environmental Management

www.elsevier.com/locate/jenvman

Social and economic impacts of carbon sequestration and land use change on peasant households in rural China: A case study of Liping, Guizhou Province

W. Xu[a,*], Y. Yin[b], S. Zhou[c]

[a]*Department of Geography, University of Lethbridge, Lethbridge, Alta., Canada T1K3M4*

[b]*Adaptation and Impacts Research Group, Environment Canada and Sustainable Development Research Institute, University of British Columbia, Vancouver, BC, Canada V6 T 1Z2*

[c]*Key Laboratory of Meteorological Disasters, Nanjing University of Information Science and Technology, Nanjing, China*

Received 22 April 2005; received in revised form 6 September 2006; accepted 12 September 2006
Available online 28 November 2006

Abstract

Numerous innovative approaches to mitigate effects of excessive emission of greenhouse gases (GHGs) on global climate change are being proposed and formulated. Sequestering carbon to terrestrial ecosystems represents one of the important clean development mechanisms. Reforestation through converting various non-forest lands to forests is undoubtedly an important dimension of carbon sequestration. Using Liping County in Guizhou Province as a case region, this study examines the perceived change in social and economic livelihoods of peasants and the factors responsible for the variations in the changes. The results of the study reveal that socio-economic changes associated with the government-financed project are multifaceted and profound. Because of the financial subsidies provided by the central government, this environmental action in many aspects can be regarded as a poverty reduction measure in the underdeveloped area where rural poverty is widespread. A majority of peasant households have benefited from project participation. The land conversion project with continued financial support also contributes to the social transformations of traditional rural society in remote areas to a more mobile, less subsistence agriculture-based, and open society.

Keywords: Carbon sequestration; Rural land use conversion; Household socio-economic changes

1. Introduction

Since the Industrial Revolution, human activities including the burning of fossil fuels and land use change have contributed to a great increase in the amount of carbon dioxide (CO_2), atmospheric methane, carbon monoxide (CO), and other greenhouse gases (GHGs) in the atmosphere (Mickler, 2004; Sims and Bradford, 2001). Over the past several decades, many scientists have agued that this human-induced change in atmospheric GHGs is to a large degree responsible for global climate change and variability (IPCC, 2001). Governments, environmental organizations, and the general public are responding to such concerns (Kiss et al., 2002; Olesen and Bindi, 2002). While atmospheric concentrations of CO_2 can be lowered by either reducing emissions or sequestering it in ecosystems, so far most reductions of GHGs are realized through energy-related measures such as energy efficiency improvements and investment in renewable energy technologies (Berndes et al., 2003; Hall, 1997). However, there are growing interests in exploring alternative approaches of reducing GHGs, and particularly looking to forests as carbon sinks that absorb atmospheric CO_2 through photosynthesis (Albrecht and Kandji, 2003; Dumanski et al., 1998; Fearnside, 1999; King et al., 2004; Olesen and Bindi, 2002; Smith, 2004; Sperow et al., 2003; Williams et al., 2004; Zhang and Xu, 2003). Afforestation and reforestation have been the important means proposed to offset increasing CO_2 emissions (Alig, 2003; Robert and Saugier, 2003; Silver et al., 2000).

*Corresponding author. Tel.: +1 403 380 1876; fax: +1 403 329 2016.
E-mail addresses: wei.xu@uleth.ca (W. Xu), yongyuan.yin@sdri.ubc.ca (Y. Yin), zhousuoquan@jsmail.com.cn (S. Zhou).

0301-4797/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2006.09.013

Over the past several decades, China's environments have degraded and deteriorated severely due to increasing population pressure and escalating economic growth. It is now widely recognized that the long-term destruction of ecological environments in China has caused natural disasters such as floods and droughts to become more frequent and widespread, and in turn contributed to rural poverty in disaster areas, resulting in further damages to regional and national social and economic developments (Li, 2004; Ming and Zhang, 2000; SFA, 2005a). Stimulated by the major flood disasters in the Yangtze River and Songhua River regions in 1998, the central government implemented a nationwide "Grain-For-Green" scheme—a key forest restoration program that aims to replant forest or grassland on agricultural lands with a slope of over 25° (SCPRC, 2000; Xu et al., 2004). This land use conversion scheme has become an important measure as China attempts to restore the ecological integrity of the western regions. It is hoped that gradual but long-term reforestation of the sloping agricultural land will help reduce excessive soil erosion, conserve water resources, and alleviate the desertification process. While carbon sequestration was not part of the original project objectives, the large-scale implementation of the "Grain-For-Green" scheme will ultimately contribute to global carbon sinks and reduction of atmospheric CO_2 over the long run.

China's national scale reforestation projects prioritize the importance of restoring the ecological environment. But such long-term development strategies can only be possible if they also bring social and economic benefits at the local level because it is the local peasants who implement and operationalize reforestation schemes. How have rural peasants responded to the implementation of national environmental restoration projects? What are the social and economic effects of the projects such as the "Green-For-Green" project on rural families? Research into these questions is of critical importance to the formulation and implementation of environmental protection policies in the future. The empirical objective of this study is to investigate the socio-economic changes of the land conversion project implemented at the local level. Using Liping County in Guizhou Province as a case region, this study examines the perceived change in social and economic livelihoods of peasants and the factors responsible for the variations in the changes among peasant households. The following section will introduce the study area and research approaches. The empirical results will then be presented. The paper concludes with a discussion about the implications of the national implementation of the "Grain-For-Green" project.

2. Empirical research approaches

2.1. Study area and data collection

In this study, Liping County in Guizhou Province was selected as the case region (Fig. 1). Liping is a typical rural county of southwestern China in terms of physical landscape and social and economic conditions. Located in southeastern Guizhou, it is part of the foothills of Yunnan-Guizhou Plateau, and 95% of its land is covered by mountains and hills with an average elevation of 800 m above sea level (LGCC, 1989). Sub-tropical forests dominate the landscape with rich biodiversity. The rate of forest cover is about 60%, and in 2003 less than 5% of its land was in agricultural production (LGCC, 1989; LSB, 2003). The long-term excessive logging and deforestation have led to the conversion of forestlands to farmland even if a large proportion of the land is actually not suitable for cultivation due to its marginality (LGCC, 1989). In Liping, there were over 2.9 million hectares of agricultural land on steep slopes of varying degrees and these erosion-prone areas are extensively distributed throughout the county (Yang, 2001).

Because of the long-term severe ecological and economic consequences of deforestation in Liping, protecting its precious forestlands has always been an important task of local governments (LSB, 2003). Liping has been the pilot site of several nationwide forest protection projects, including the State Natural Forest Protection project (SFA, 2005b). In 2000, Liping was selected as a pilot site to experiment with the "Grain-For-Green" project, which was later, implemented nationwide. The central government provides 150 kg of food and 20 yuan (1 USD = 8.27 yuan in 2004) in cash to subsidize every mu (1 hectare = 15 mu) of land converted (SCPRC, 2000). The government compensation will last 5–8 years depending upon the types of trees planted. In 2003, The County Forest Bureau officially promulgated the local regulations to implement "Grain-For-Green" land conversion (Liping Government, 2003). Between 2000 and 2003, about 7775 ha of cultivated land on slopes of over 25° were converted to forestland (LSB, 2003; Lu and Chen, 2001; Yang, 2001). The ecological benefits of land conversion from agricultural land to forestland are multifaceted but social and economic consequences of implementing such an ecological project are largely unknown. This study attempts to investigate some of these social and economic consequences of land use conversion by analyzing the data collected in Liping.

Published and unpublished government documents and statistics were collected in 2002, 2003, and 2004. Three general surveys were conducted in Liping. The analysis in this study is mainly based on the household survey conducted in the summer of 2004. With the help of local officials from Liping Forest Bureau and its local forestry stations throughout the county, a total of 277 peasant households were surveyed. A systematic sampling scheme was adopted in order to cover as many townships as possible. The surveyed peasant households were distributed in 19 of the 25 towns/townships in Liping. About 10–20 households in each town/township were selected to complete the pre-designed structural questionnaire. The selection of these peasants was assisted by the local officials

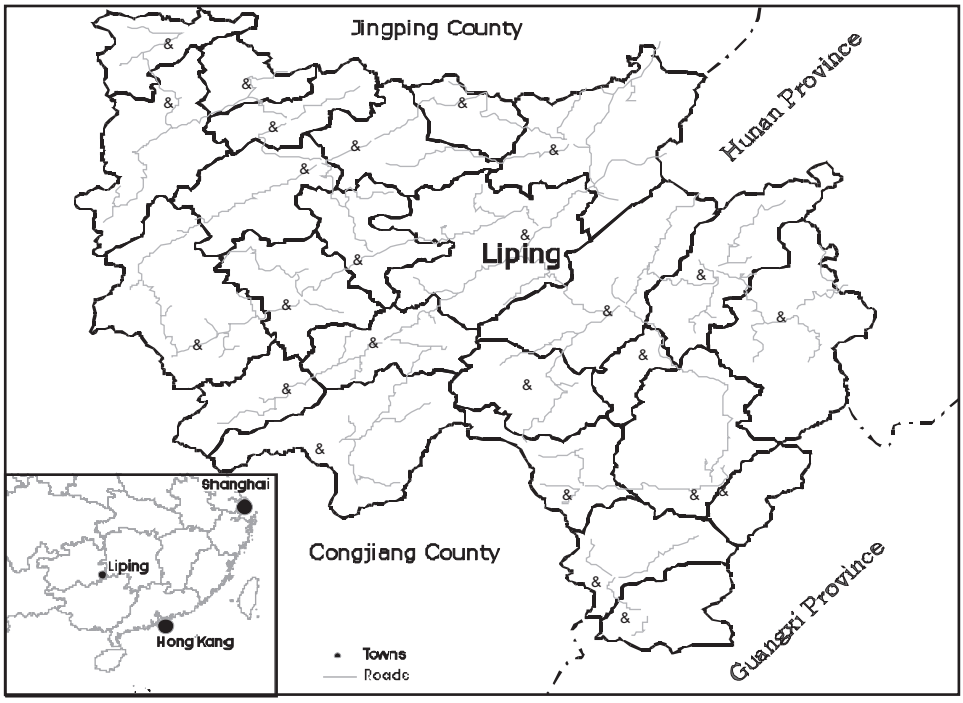

Fig. 1. Location of Liping County, Guizhou Province, China.

who ensured that the selected peasant households had been involved in the land conversion project, and could represent the rural households that had participated in the land conversion project. Because the accompanying local officials were directly involved in the organization and implementation of land conversion activities and were quite familiar with local conditions and circumstances in the region, they were often asked to validate the accuracy of collected information. The predesigned questionnaire included thirteen categories of questions covering personal characteristics, land use and conversion activities, perceived social and economic changes by peasants and so on. Peasants were asked to complete the questionnaire in a designated room. The collected survey information was then stored in a computer database for analysis.

2.2. Analytical methods

The collected information was analyzed using a variety of methods, including various descriptive statistics of social and economic variables relating to peasant families. Cross- tabulation and χ^2-tests were used to summarize data and investigate the relationships among relevant variables. One important modeling technique used in analyzing empirical data is a binominal logit qualitative choice model. The model was used to understand the relationship between the perceived change of peasants' economic conditions and a set of independent variables. It was also employed to understand what factors were related to the probability of household members becoming migrant workers after the land conversion. The modeling results are reported in the next section. The modeling techniques are discussed here.

The qualitative choice model is used to determine the probability that an individual with a given set of attributes will make one choice rather than one or more alternative choices (Menard, 2001; Skaggs, 2001). Choice models predict the likelihood that an individual, household, or firm will choose an option that will have some relationship to their attributes (i.e., personal characteristics, demographics, socio-economic characteristics, or attitudes) (Skaggs, 2001).

Because for a binominal dependent variable the probability of being classified in the first category, $P(Y=0)$ is equal to 1 minus the probability of being classified into the second category, $P(Y=1)$ if we know one probability, we know the other: $P(Y=0)=1-P(Y=1)$ (Menard, 2001).

To avoid the problem that the predicted values may be less than 0 or greater than 1, the probability that $Y=1$ is replaced with the odds that $Y=1$. The odds that $Y=1$, written as odds$(Y=1)$, is the ratio of the probability that $Y=1$ to the probability that $Y\neq 1$ (Menard, 2001).

The odds ratio, or the probability of making one choice relative to the other is

$$\text{Odds}(Y=1)=\frac{P(Y=1)}{1-P(Y=1)}. \quad (1)$$

The odds has no fixed maximum value, but like the probability, it has a minimum value of 0. In order to produce a variable that varies, in principle, from negative infinity to positive infinity, one further transformation of

the odds is required (Menard, 2001). The natural logarithm of the odds is called logit of Y, and is as follows:

$$\mathrm{Ln}\{\mathrm{odds}(Y=1)\} = \mathrm{Ln}\left\{\frac{P(Y=1)}{1-P(Y=1)}\right\}. \quad (2)$$

If we use the natural logarithm of the odds that $Y=1$ as our dependent variable, we no longer have the problem that the predicted probability may be larger than 1 or less than 0. The binominal model equation that predicts the relationship between the likelihood that an individual chooses an option and their attributes then becomes

$$\mathrm{Logit}(Y) = \alpha + \beta X_1 + \beta_2 X_2 + \cdots + \beta_n X_n. \quad (3)$$

From Eqs. (2) and (3), we have

$$\mathrm{Odds}(Y=1) = e^{\ln\{(\mathrm{odds}(y=1)\}} = e^{(\alpha+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n)}. \quad (4)$$

According to Eqs. (1) and (4), the probability that $Y=1$ is

$$P(Y=1) = \frac{e^{(\alpha+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n)}}{1+e^{(\alpha+\phi_2 X_1+\beta_2 X_2+\cdots+\beta_n X_n)}}. \quad (5)$$

Eq. (3) represents the general form of the binominal logit qualitative choice model that is employed in our empirical analysis. The β coefficients for the logit model are estimated using maximum likelihood techniques. The SPSS statistics software is used to estimate the regression models.

3. Results

Historically, Liping has been an underdeveloped region in China. Largely due to a lack of regional accessibility and resource scarcity, its economy has not benefited as much in the reform period during which China's coastal areas have experienced an impressive economic miracle (Xu and Tan, 2001). In 1989, Liping's per capita GDP was only 538 yuan (LSB, 2003), which was only 71.7% of the provincial average and 35.6% of the national average (LSB, 2003; NBS, 2004). The economic gap between Liping and the rest of China has been enlarged tremendously over the last two decades. In 2003, its per capita GDP increased to 1566 yuan, which was only 43.5% of the provincial average and 16.7% of the national average (LSB, 2003; NBS, 2004).

Liping's economy has been dominated by agriculture and forestry. Agricultural production and output constitute the majority of the peasants' income and determine their very livelihood. In 2003, the share of primary production accounted for 51% of GDP. Output of industries only accounted for 23.9% of the total gross output of industry and agriculture (LSB, 2003). In Liping, out of a total of 503 thousand residents, over 92% are rural. In contrast to a per worker income of 7970 yuan in urban sectors, the annual net income per peasant was only 1410 yuan in 2003 (LSB, 2003). Therefore, peasant households are very dependent upon agricultural and other primary production for their economic income. Even though much of the peasants' land in cultivation is often marginal or on terraced slopes, any change in land use may affect their economic livelihood significantly.

3.1. Perceived economic change of land conversion to forestlands

The peasant household survey was conducted to reveal the social and economic effects of land use conversion from agriculture to forestland. Among the respondents, a majority was male (89%) and of national minority origin (98%). Average age of respondents was 43.3 years. Among those households surveyed, the average family size was 5.15 persons, with 3.07 able-bodied laborers. Per capita income in 2003 was 1137.5 yuan, which is below the county average, and per capita land area 1.13 mu, which was higher than the county average. The surveyed households on average had converted 8.66 mu of cultivated land. Because converting agricultural land to forest area will not only result in loss of income from agriculture, it will also involve costs of land construction and planting trees. According to the survey, peasant households experienced some income loss, with an estimated average loss of 129.6 yuan/mu of the land converted. As peasant households are compensated by the central government in grain (150 kg/mu) and cash (20 yuan), peasant households were expected to be better off after the land conversion.

When peasant respondents were asked how they perceived changes in economic living conditions after the land conversion, a majority of them (78%) indicated that their economic conditions improved. There were 59 out of 270 respondents whose economic livelihood was not improved.

The varying responses to the above question indicate the heterogeneity of peasant households in coping with the challenges and opportunities brought by the land use conversion project in the region. Theoretically, the variation in the peasants' perceived economic changes after the land conversion could be attributed to a variety of factors at different levels. At the personal and household level, age and education are important human resource factors in determining and coping with land use change, and consequently possible outcomes of such change. Gender and ethnicity may also affect the way of coping with change in land use (Found, 1971; Irwin and Geoghegan, 2001). Economic resources available to peasants are often important differentiating factors in the process of change of land use and therefore the consequences of change. For example, family income, available land and labor are often significant factors in determining if individual households will be economically successful after the land use conversion (Adams et al., 1996; Dejong et al., 1995; Irwin and Geoghegan, 2001; Stoorvogel et al., 2004). The actual cost involved in the conversion, the economic return prior to the conversion, and the types of tree planted in reforestation may be other basic factors differentiating peasant households in perceiving the change of their economic fortunes (Dejong et al., 1995; Stoorvogel et al., 2004).

Attitudes to the implementation of a land conversion project can be an important factor in affecting peasant families depending upon whether they willingly participate in the project (Found, 1971). All these factors may act together and cause variation in the change of economic situations after land use conversion.

In order to identify the role of various factors in differentiating changing economic conditions of peasant families, a list of dependent variables was selected for the analysis. Table 1 presents the mean values of the selected variables. The binominal logit choice model outlined in Section 2.2 was employed here to investigate the relationship between the perceived economic change by individual peasant responses and their attributes. The result of the regression analysis is presented in Table 2.

The model of logistic regression analysis is statically significant ($F = 44.9$), indicating that the perceived changes in economic livelihood after the land conversion are related to a variety of factors specified in the model. The regression model predicts correctly 78.6% of the values of the dependent variables. However, among the selected independent variables, only a few variables are significant. First, age is an important factor in shaping the outcome of land conversion. As indicated in Table 2, both coefficients of age and age squared are significant, but with different signs, suggesting that as one becomes older, the chance of economic improvement increases, albeit at a decreasing rate. The coefficient of family income variable is also significant. This indicates that peasant families with higher income and more economic resources to cope with changes are associated with more positive perception of land use conversion. In addition, the coefficient of perceived profitability from agriculture is also significant in the betterment of economic livelihood of peasant families.

Table 2
Results of logistic regression analysis

	B estimates	Standard error	*P*-value
Intercept	–5.534	3.128	0.076
Age	0.276	0.135	0.042**
Age squared	–0.003	0.002	0.034**
Gender	0.455	0.681	0.505
Ethnicity	18.543	16 945.289	0.999
Elementary school	–0.342	0.969	0.724
Junior high school	–0.684	1.034	0.508
High school or above	–1.017	1.108	0.358
Family income in 2003	0.0001	0.000	0.043**
Family size	0.115	0.224	0.606
Area of leased land	–0.129	0.194	0.504
Able bodied labor	–0.106	0.235	0.653
Land per capita	0.680	0.862	0.430
Land income prior to conversion	0.001	0.001	0.226
Cost of land conversion	0.000	0.000	0.377
Conversion to fruits	–0.982	0.601	0.103
Converted to ecological forest	0.011	0.600	0.986
Perceived profitability from agriculture	1.842	0.785	0.019**
Land suitability	1.043	0.775	0.178
Government compensation	0.732	0.673	0.277
Willingness to change land use	–1.147	1.106	0.300
Closeness to county seat	–0.082	0.435	0.851
Model χ^2 statistics	44.885		0.002
–2 Log likelihood	209.825		
Cox & Snell R^2	0.166		
Nagelkerke R^2	0.258		
Percentage predicted correct	78.6		

Table 1
Variable definitions and sample means

Variables	Definitions	Means
Change in family quality of life	0 for no change 1 for better	0.78
Age	Respondents' age	43.3
Age squared	Square of respondents' age	1991.3
Gender	1 for male, 0 for female	0.89
Ethnicity	0 for minority, 1 for Han	0.03
Education		
Elementary school	1 for elementary education, 0 for others	0.3
Junior high school	1 for junior high school education, 0 for others	0.45
High school or above	1 for high school education or above, 0 for others	0.17
Family income in 2003	Yuan	5858.51
Family size	Number of family members	5.15
Area of leased land	Amount in mu	8.66
Able bodied labor	Number per household	3.07
Land per capita	Amount of land divided by number of family member	1.13
Land income prior to conversion	Yuan	471.24
Cost of land conversion	Yuan	517.8
Conversion to fruits	1 for converted to fruit; 0 for others	0.31
Converted to ecological forest	1 for converted to ecologic forest; 0 for others	0.48
Perceived profitability from agriculture	1 for perceiving no profit from agriculture; 0 for others	0.25
Land suitability	1 for those perceive land unsuited to agriculture; 0 for other	0.16
Government compensation	1 for those valuing government incentive; 0 for others	0.47
Willingness to change land use	1 for those consider conversion as a forced actions; 0 for others.	0.03
Closeness to county seat	1 for those living close to county seat; 0 for others.	0.29

3.2. Reasons for participating in land use conversion

The above regression results provide some understanding of how the perceived changes in economic livelihood after the land conversion vary according to the various characteristics of peasant families. The model reveals that when peasants cannot perceive any gain from agricultural production, land use conversion from agriculture to forests can often lead to a positive economic outcome. In the questionnaire survey, we specifically asked peasants the reasons for participating in the land use conversion project. Among all of the responses, only eight respondents indicated that they were forced to take part in the land conversion project, accounting for a mere 2.9% of the surveyed peasants (see Table 3). This gives an indication that the government-funded land conversion project has a high rate of acceptability by the public. Our field observations and casual interviews with peasants also indicated that the conversion project was welcomed by the peasants in general. Through a cross-tabulation analysis of the data, it is found that only three out of these eight respondents claimed that they had benefited from the land conversion, a rate much lower than that of the rest of the respondents. But, the small sample size does not permit a meaningful statistical test to confirm this under-representation.

There were 43 respondents who claimed that their lands under cultivation were not suitable for agricultural production, accounting for 15.5% of all surveyed peasants (Table 3). Among them, 35 respondents claimed that they had experienced economic improvement after the land conversion. However, this pattern is consistent with that of the rest of the surveyed peasants. A χ^2-test indicates that the peasants' perceived economic changes after the land conversion was not related to whether peasants consider the agricultural suitability of their lands or not, confirming the conclusion from the above logistic regression analysis.

A total of 70 respondents, about a quarter of the surveyed peasants, claimed that one of the major reasons that they participated in the land conversion project was because they could not obtain enough income from agricultural production (Table 3). For these peasants, the economic factor was the most important motivation for their participation in the land use conversion. One would certainly expect that those who were economically motivated might do better during the process of land use change. The above regression model already confirmed such a theoretical articulation. The survey result showed that almost 90% of these respondents had experienced positive economic change after land use conversion. The rate of economic success of the peasants was much higher than the rest of the survey peasants. The χ^2-test results ($\chi^2 = 7.44$) confirm that the difference was statistically significant.

Among all of the respondents, 18 peasants (6.5%) indicated that one of the reasons to participate in agricultural land conversion to forests was that they were ready to find jobs in non-agricultural sectors (Table 3). Because forestry is less labor intensive than crop production, agricultural land conversion to forestland might release some family labor. The surplus family laborers might then find non-agricultural work locally or in other areas, and provide some supplementary income to families. However, even though these families might expect income from non-agricultural sources after the land conversion, they might not be able to realize such aspirations over a short time period because finding a non-farm employment position had not been an easy task in the region. Compared to the rest of the respondents, these respondents who were interested in finding non-agricultural jobs did not perform well economically, Out of the total of 18 respondents, only eleven respondents (64.9%) indicated that they experienced economic improvement after the land conversion, and for the rest of the respondents, 79.1% of the respondents experienced positive economic change.

When respondents were asked about the main reasons for their participation in the land use conversion project, close to half of the respondents (47.3%) indicated that government compensation was the reason (Table 3). Liping is a relatively poor region, and average net income that could be generated from agricultural land on a steep slope is very limited. For the surveyed respondents, average annual net income was only 55.6 yuan per mu of land. Because the central government provides 150 kg of grain (roughly equivalent to 150 yuan in 2003 in Liping) per mu of land converted for 5–8 years, the land conversion becomes a venue to make some easy income for many families. It indeed became a poverty reduction measure in Liping. When they were asked for their opinion on the land conversion project, the majority of respondents were concerned with the time period that the government compensation would last. About 39% of the respondents

Table 3
Reasons for participating in the land conversion project

Reasons to participate in land conversion	Number of peasants responded yes to the question	Percent of peasants responded yes to the question
Forced conversion	8	2.9
Land not suitable for agriculture	43	15.5
No profit in agricultural production	70	25.3
Ready to move out of agriculture for non-agricultural work	18	6.5
Government compensation for conversion	131	47.3

hoped that the governments could extend the compensation for a longer period of time. Another 31% of the respondents wanted the government somehow to provide income insurance for them. Whether or not peasant households will be able to obtain a stable income from the reforested lands is a critical factor in ensuring the long-term sustainability of reforested land in Liping.

3.3. Social impacts of land reforestation

Liping is quite an isolated place, with a very low level of regional accessibility. It has no railway or airline connections with other parts of China. Liping's interior is mountainous and lacks any meaningful transportation network. Therefore, rural Liping has been a traditional society dominated by Dong and other national minorities. The implementation of the reforestation and land conversion project has produced not only noticeable economic changes, but also transformations of the social fabric of the region.

3.3.1. Changing social mobility

One of the social impacts of land use conversion is related to the change in social mobility. Cultivation and agricultural production on the steep slopes is very demanding on family labor in time and effort. The conversion of the land to forest may save peasant families a lot of labor time and effort. As such, households involved in the land conversion project may experience a labor surplus. The surplus labor can then look for other economic opportunities in other sectors. One of the possible outcomes during this process of change is that some surplus laborers become regional or inter-regional migrants. Such out-migration will certainly enhance the social mobility in the region, which will further alter the traditional static society and bring some profound change to the existing social structure.

In order to understand the extent of such possible impact, in the questionnaire survey peasants were asked if there were any family members who became migrants due specifically to a decrease of family labor demands in agricultural production. Out of 277 respondents, 58 peasants (20.9%) indicated that they had at least one family member becoming migrant workers due to reforestation and the logging ban. All of these became migrant workers after 1998 when the State Natural Forest Protection policy was issued by the central government, and a majority of peasant migrants (82.4%) moved out after 2000 when the land conversion project was implemented.

A binominal logistic regression was conducted to understand why some peasant families have migrant workers while others do not. Six independent variables were selected to explain the variation in creating migrant workers (Table 4). The model is significant, and stable. It predicts correctly 77.5% of the values of the dependent variable. To examine the relative importance of independent variables, we find that the number of able-bodied laborers available to peasant families was the most important factor in determining whether a family would have a migrant worker. Because of the reduction in labor requirement after the land conversion, families with more able-bodied laborers would have more surplus labor, and hence a higher probability of sending migrant workers to other sectors and other regions. Both family size and land per capita were not significant factors in explaining whether a peasant family would have migrant workers after the land conversion. This was because land per capita was relatively uniform under the household production responsibility system implemented at the beginning of rural reform. That the variation in family size was less relevant was because larger families might have the same amount of labor resources as small families. The regression model indicates that economic conditions were a significant factor. Families with higher income were more likely to be associated with migrant workers after the land conversion (Table 4).

Table 4
Results of logistic regression analysis

	B estimates	Standard error	*P*-value
Intercept	–1.854	0.630	0.003
Able bodied labor	0.372	0.177	0.036
Family size	–0.133	0.094	0.158
Perceived economic improvement	–0.116	0.390	0.766
Land per capita	–0.045	0.252	0.860
Foreseen non-farm opportunity	−19.971	9322.008	0.998
Family income	0.00009	0.000	0.041
Model χ^2 statistics	44.885		0.001
−2 Log likelihood	247.934		
Cox & Snell R^2	0.082		
Nagelkerke R^2	0.126		
Percentage predicted correct	77.5		

The enhanced labor mobility in the region could have some potential impact on the traditional rural society over the long run. In China, migrant workers commonly send remittances home on a regular basis (Liu and Reilly, 2004; Secondi, 1997). This remittance accounts for about 20% of rural family income in regions of out migration (World Bank, 1997). Hence, out-migration becomes an important economic growth strategy in rural China (Liu and Reilly, 2004; Russell, 1986; World Bank, 1997). The increased number of migrant workers associated with the land conversion project may contribute to poverty reduction in Liping. Also, returned migrants can bring new knowledge and ideas. Through various migration activities, the interaction between remote mountainous rural Liping and other areas will increase, rural society will become more open, and market accessibility enhanced. These will jointly lead to a profound transformation of the traditional social structure.

3.3.2. Time allocation in economic tasks and domestic duties

Agricultural cultivation on the slope land is a very arduous and labor-intensive job, but it was a major occupation of peasant families before the conversion of these lands. Following conversion to forestland and reduction of agricultural work, less work and time are needed in the fields, and the allocation of the various economic and domestic duties of peasant families became transformed. In the questionnaire survey, we asked the peasants about the changes of time allocation in fulfilling eight types of economic and domestic duties in order to understand the impact of the land conversion project on the families.

The results of responses to these questions are summarized in Tables 5a and b. Male respondents accounted for over 92% of the first family members and female respondents represented 80.5% of the second family members. As indicated in Tables 5a and b, one of the major outcomes of the land use conversion was declining time allocation to agricultural cultivation. For both family members, about half of the responses indicated a slight decrease in time spent in agricultural production, and over 12% of responses showed a big decrease. Shifting away from agricultural cultivation on the slope land led in general to an increase in livestock production. Over 50% of responses from both family members reported a slight to a large increase in time allocation to livestock production. After the land conversion, peasants allocated more time to tree plantation, forest protection, forest product processing and marketing. Over 38.6% of the responses from family member one reported a big increase, and another 36.4% indicated a slight increase in time allocation to forest protection. In forestry production, 17.4% and 41.3% of the responses indicated a large and slight increase in time allocation, respectively (Table 5a). The changing patterns were similar for family member two (see Tables 5b). Because time allocation has increased in forest management and often fuelwood collection became part of forest management tasks, time spent on fuel wood collection declined (Tables 5a and b). The data on time allocation for both family members do not show strongly that land conversion has increased non-farm industrial opportunity. A majority (63.3%) of peasants responded that there was no change, and about a quarter of responses indicated a slight to big increase in time allocation to non-farm work. In terms of time allocation to domestic duties, there was little evidence indicating any significant changes after the land conversion. For both family members, more respondents indicated a decline in time allocated to childcare and domestic work.

4. Concluding remarks

Confronting global climate change and promoting sustainable development represent critical challenges to humankind in the contemporary world. Numerous innovative approaches to mitigate the effects of excessive emission of GHGs affecting global climate are being proposed and formulated. Sequestering carbon to terrestrial ecosystems represents one of the important clean development mechanisms. Reforestation through converting various types of non-forest lands to forests is undoubtedly an important dimension of carbon sequestration. At the same time, reforesting sloping agricultural land helps restore ecological integrity in fragile tropic and subtropic environments and reduces soil erosion and the frequency and severity of floods. This study has examined the social and economic effects of the reforestation project

Table 5

Economic and domestic duties	Percent of responses on time allocation change				
	Big increase	Slight increase	No change	Slight decrease	Big decrease
(a) Time allocation change by peasant family member: family member one					
Agricultural cultivation	3.4	14.4	17.8	51.5	12.9
Livestock production	11.0	39.4	36.7	10.2	2.7
Fuelwood collection	0.8	8.7	31.4	30.3	28.8
Forest protection	38.6	36.4	17.8	3.8	3.4
Forestry production	17.4	41.3	25.4	11.4	4.5
Non-agricultural work	8.0	17.8	63.3	7.6	3.4
Child nursing	5.3	15.1	51.7	15.1	12.8
Domestic work	3.8	11.8	46.8	24.0	13.7
(b) Time allocation change by peasant family members: family member two					
Agricultural cultivation	4.2	15.7	20.7	47.1	12.3
Livestock production	11.5	40.2	35.6	8.0	4.6
Fuelwood collection	1.1	8.0	33.7	29.5	27.6
Forest protection	29.5	39.1	21.5	4.2	5.7
Forestry production	16.5	38.3	28.4	10.0	6.9
Non-agricultural work	7.7	14.2	64.0	10.0	4.2
Child nursing	6.2	15.0	52.3	15.0	11.5
Domestic work	4.2	15.1	47.9	22.4	10.4

"Grain-For-Green" at the peasant household level in China. The results of the study reveal that socio-economic changes associated with the government-financed project are multifaceted and profound. Because of the financial subsidies provided by the central government, this environmental action in many aspects can be regarded as a poverty reduction measure in the underdeveloped areas where rural poverty is widespread. A majority of peasant households have benefited from project participation (also see Zhou et al., this issue). The land conversion project with continued financial support also contributes to the social transformation of traditional rural society in remote areas to a more mobile, less subsistence agriculture-based, and open society.

The empirical results of this study also indicate that there are several concerns that need to be addressed in order to further the implementation of the "Grain-For-Green" project and to ensure the sustainability of such an undertaking. The financial subsidies currently provided to peasants are distributed evenly among peasant households and across different areas. This study indicates that at the local level a differentiated subsidy distribution system may be of greater assistance to those families with less income and able-bodied labor. Many peasants were concerned with the long-term financial prospect of the forested lands, and financial uncertainty will arise when the government subsidies end in five or eight years after the implementation of the project. To avoid future land conversion back to agricultural cultivation, local governments need to help peasants in forest management and forest production and marketing. More research is needed to understand how peasants have coped with the changes and what strategies they have adopted to be successful during the process of land use change. Studies into how local governments can facilitate the transformation of rural economic and social systems after the land conversion will be valuable in providing policy guidance to ensure the long-term success of the "Grain-For-Green" project in China.

Acknowledgments

The fieldwork for this paper was conducted under the project entitled Confronting Global Warming: Enhancing China's Capacity for Carbon Sequestration, which received the financial support of the Canadian International Development Agency. We are grateful for the research assistance provided by Na Kang, Zongwei Ji, and Jie Wang. We would like to thank reviewers for their helpful comments on an earlier draft of this manuscript.

References

Adams, D.M., Alig, R.J., Callaway, J.M., McCarl, B.A., Winnett, S.M., 1996. The Forest and Agricultural Sector Optimization Model (FASOM): Model Structure and Policy Applications. Introduction. USDA Forest Service Pacific Northwest Research Station Research Paper, p. 1.

Albrecht, A., Kandji, S.T., 2003. Carbon sequestration in tropical agroforestry systems. Agriculture Ecosystems & Environment 99, 15–27.

Alig, R.J., 2003. US landowner behavior, land use and land cover changes, and climate change mitigation. Silva Fennica 37, 511–527.

Berndes, G., Hoogwijk, M., van den Broek, R., 2003. The contribution of biomass in the future global energy supply: a review of 17 studies. Biomass & Bioenergy 25, 1–28.

Dejong, B.H.J., Montoyagomez, G., Nelson, K., Sotopinto, L., 1995. Community forest management and carbon sequestration—a feasibility study from Chiapas, Mexico. Interciencia 20, 409.

Dumanski, J., Desjardins, R.L., Tarnocai, C., Monreal, C., Gregorich, E.G., Kirkwood, V., Campbell, C.A., 1998. Possibilities for future carbon sequestration in Canadian agriculture in relation to land use changes. Climatic Change 40, 81–103.

Fearnside, P.M., 1999. Forests and global warming mitigation in Brazil: opportunities in the Brazilian forest sector for responses to global warming under the clean development mechanism. Biomass & Bioenergy 16, 171–189.

Found, W.C., 1971. A Theoretical Approach to Rural Land-use Patterns. Edward Arnold Press, London.

Hall, D.O., 1997. Biomass energy in industrialized countries—a view of the future. Forest Ecology and Management 91, 17–45.

IPCC, I.P.o.C.C, 2001. Climate Change 2001: The Scientific Basis. Cambridge University Press, New York.

Irwin, E.G., Geoghegan, J., 2001. Theory, data, methods: developing spatially explicit economic models of land use change. Agriculture Ecosystems & Environment 85, 7–23.

King, J.A., Bradley, R.I., Harrison, R., Carter, A.D., 2004. Carbon sequestration and saving potential associated with changes to the management of agricultural soils in England. Soil Use and Management 20, 394–402.

Kiss, A., Castro, G., Newcombe, K., 2002. The role of multilateral institutions. Philosophical Transactions of the Royal Society of London Series A—Mathematical Physical and Engineering Sciences 360, 1641–1652.

LGCC, L.G.C.C, 1989. Liping Gazetteer Sichuan Bashu Shushe. Liping, Guizhou.

Li, W.H., 2004. Degradation and restoration of forest ecosystems in China. Forest Ecology and Management 201, 33–41.

Liping Government, 2003. Liping's Operational Regulations on Conversion of Agricultural Land to Forest. Liping Government, Liping.

Liu, Q.M., Reilly, B., 2004. Income transfers of Chinese rural migrants: some empirical evidence from Jinan. Applied Economics 36, 1295–1313.

LSB, L.S.B., 2003. Liping Statistics Yearbook 2003. Liping Statistics Bureau, Guizhou.

Lu, S., Chen, Q., 2001. Opening of piloting agricultural land conversion to forest in Liping. Guizhou Dushi Bao, Guiyang, p. 1.

Menard, S., 2001. Applied Logistic Regression Analysis, second ed. Sage Publication, Thousand Oaks, London, New Delhi.

Mickler, R.A., 2004. Natural resource management to offset greenhouse gas emissions—preface. Environmental Management 33, 431–432.

Ming, X., Zhang, Y., 2000. Alter Peasant's Mode of Cultivation for a Way for Sustainable Development. People's Daily, Changsha, p. 1.

NBS, N.B.o.S.o.P.R.C., 2004. China Statistical Yearbook. China Statistics Press, Beijing.

Olesen, J.E., Bindi, M., 2002. Consequences of climate change for European agricultural productivity, land use and policy. European Journal of Agronomy 16, 239–262.

Robert, M., Saugier, B., 2003. Contribution of terrestrial ecosystems to carbon sequestration. Comptes Rendus Geoscience 335, 577–595.

Russell, S.S., 1986. Remittances from international migration—a review in perspective. World Development 14, 677–696.

SCPRC, S.C.o.t.P.s.R.o.C, 2000. On several policies of furthering experimentation work on returning cultivated land to forestlands

and grasslands. State Council of the People's Republic of China, Beijing.
Secondi, G., 1997. Private monetary transfers in rural China: Are families altruistic? Journal of Development Studies 33, 487–511.
SFA (S.F.A., P.R.C), 2005a. Six Key Forestry Projects: Agricultural Land Conversion to Forest Project [Online]. Available from the Office, State Forestry Adrministration, PR China 〈http://www.forestry.gov.cn/SHTGC/02.htm〉 (verified May 2, 2005).
SFA (S.F.A., P.R.C), 2005b. Six Key Forestry Projects: State Natural Forest Protection [Online]. Available by Office, State Forestry Administration, PR China 〈http://www.forestry.gov.cn/SHTGC/01.htm〉 (verified May 2, 2005).
Silver, W.L., Ostertag, R., Lugo, A.E., 2000. The potential for carbon sequestration through reforestation of abandoned tropical agricultural and pasture lands. Restoration Ecology 8, 394–407.
Sims, P.L., Bradford, J.A., 2001. Carbon dioxide fluxes in a southern plains prairie. Agricultural and Forest Meteorology 109, 117–134.
Skaggs, R.K., 2001. Predicting drip irrigation use and adoption in a desert region. Agricultural Water Management 51, 125–142.
Smith, P., 2004. Carbon sequestration in croplands: the potential in Europe and the global context. European Journal of Agronomy 20, 229–236.
Sperow, M., Eve, M., Paustian, K., 2003. Potential soil C sequestration on US agricultural soils. Climatic Change 57, 319–339.
Stoorvogel, J.J., Antle, J.M., Crissman, C.C., 2004. Trade-off analysis in the Northern Andes to study the dynamics in agricultural land use. Journal of Environmental Management 72, 23–33.
Williams, R.J., Hutley, L.B., Cook, G.D., Russell-Smith, J., Edwards, A., Chen, X.Y., 2004. Assessing the carbon sequestration potential of mesic savannas in the Northern Territory, Australia: approaches, uncertainties and potential impacts of fire. Functional Plant Biology 31, 415–422.
World Bank, 1997. Sharing Rising Incomes: Disparities in China. The World Bank, Washington, DC.
Xu, W., Tan, K.C., 2001. Reform and the process of economic restructuring in rural China: a case study of Yuhang, Zhejiang. Journal of Rural Studies 17, 165–181.
Xu, Z., Bennett, M.T., Tao, R., Xu, J., 2004. China's sloping land conversion program four years on: current situation and pending issues. International Forestry Review 6, 317–326.
Yang, Z., 2001. New and efficient way of agricultural land to forestland conversion: Liping planted about 50 thousand mu of sloping land. Guizhou Daily, Guiyang, p. 1.
Zhang, X.Q., Xu, D.Y., 2003. Potential carbon sequestration in China's forests. Environmental Science & Policy 6, 421–432.
Zhou, S., Yin, Y., Xu, W., Ji, Z., Caldwell, I., Ren, J., 2006. The costs and benefits of reforestation in Liping County, Guizhou Province, China. Journal of Environmental Management, doi:10.1016/j.jenvman.2006.08.014.