SOCIAL-ECOLOGICAL IMPACTS OF CHINA'S PAYMENTS FOR ECOSYSTEM SERVICES PROGRAMS ON LAND USE, MIGRATION AND LIVELIHOODS

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ABSTRACT

QI ZHANG: Social-ecological impacts of China's Payments for Ecosystem Services Programs on land use, migration and livelihoods
(Under the direction of Conghe Song)

Payments for ecosystem services (PES) has emerged as an innovative approach to address the problems in the human-environment nexus. Understanding the ecological and socio-economic impacts of PES programs is essential to the sustainability of environmental goods and services conserved by these programs. The Conversion of Cropland to Forest Program (CCFP) and the Ecological Welfare Forest Program (EWFP) were among the major PES programs initiated in China in the late 1990s. This dissertation draws on data collected from household surveys to investigate human adaptation to the socio-economic and environmental changes in Tiantangzhai Township, Anhui, China, where both CCFP and EWFP were implemented. I found that the PES programs, together with other factors, both directly and indirectly affected cropland abandonment, individual out-migration and rural livelihoods. Proximity of land parcels to the nearest CCFP and EWFP forests increases the likelihood of cropland abandonment. Households receiving higher EWFP payments are associated with higher probabilities of cropland abandonment. I also found that the CCFP and EWFP have different effects on individual's out-migration decisions. The CCFP compensation increases the likelihood of out-migration partly because it not only covers initial migrating costs but also releases farm labor after enrolling their cropland in the program. However, the EWFP compensation has an opposite though far smaller effect on out-migration. Out-migration is also affected by other variables such as individual attributes, household characteristics and community factors. Lastly, CCFP households have a higher and more diversified sources of income than households without CCFP. CCFP households diversify their livelihoods by investing in agriculture (intensifying land use), raising farm animals and using forest resources. In addition, income inequality among CCFP households is greater than

that among nonparticipants. Remittances increase total income inequality for all households regardless whether their participation in the CCFP. Local off-farm income, however, have the opposite effects for the two types of households. A random effect regression analysis suggests EWFP payments significantly increase total income and add to income inequality while CCFP payments make little contribution to income inequality. Overall, these findings provide valuable inputs for policy makers aiming to achieve sustainability for PES programs in the future.

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CHAPTER 1

INTRODUCTION

For the first time in human history, there are more than seven billion people now living on the Earth with over half of them in the cities. The total population of the world is projected to be 9.6 billion by 2050 and 10.9 billion by 2100 (Cohen, 2003; Gerland et al., 2014). The land needed for food production and development, the natural resources needed for economic growth have never been greater. The human inhabitance of the planet Earth has brought in tremendous impacts on the environment, inducing the global climate change and threatening the welfare of future generations (Goudie & Viles, 2013). Thus, there is an urgent need to understand the interactions between human activities and environmental changes so that timely policies can be put in place to make essential ecosystem goods and services sustainable for future generations.

One of the greatest impacts human activities have brought to the Earth surface is land cover and land use change, which has profound impacts on the provision of vital ecosystem goods and services for the society (Foley, 2005; Millennium Ecosystem Assessment, 2005). Land use change is of critical importance in understanding causes and consequences of global processes, such as climate change (Pielke, 2005), biodiversity loss (Pimm & Raven, 2000), tropical deforestation (Achard et al., 2002), and change in water availability (Costa, Botta, & Cardille, 2003). Causes of human-induced land use change range from global markets, national policies at the global scale to landholders' practices at the local scale, such as wood extraction, agricultural extensification, and infrastructure expansion (Lambin et al., 2001; Geist & Lambin, 2002). At the local scale, farm households have been deemed the key decision-makers on land management, which results in the modification of land cover over large areas. However, households often modify land in unsustainable ways and thus get trapped in the deteriorated environment (Barbier, 2010). Households'

behavior in response to the degraded land may cause further environmental changes, influencing the provision of environmental services. The changing land, in turn, can feedback to the human society, influencing humans' behavior in adaptation to the environmental change. Thus, land use change is the key to the problems raised from complex interactions between human and the environment across multiple scales (Verburg, 2014).

To address the adverse problems in the human-environment nexus, Payment for Ecosystem Services (PES) has emerged as an incentive-based approach to conserve the environment through direct investment (S Wunder, Engel, & Pagiola, 2008). Under a PES scheme, a voluntary transaction flows from buyers to providers, with the latter securing the provision of ecosystem services. PES programs often link to land use and target land parcels owned by farm households in rural areas (X. Chen, Lupi, Viña, He, & Liu, 2010). Thus, PES programs are usually designed with goals in both environmental conservation and rural poverty alleviation. Due to the dual goals, the success of environmental policies under PES schemes depends on whether such programs are sustainable in a long run. Therefore, empirical evaluation of PES programs on their ecological and social outcomes is needed to inform policy-makers with regard to the sustainability of PES programs.

China has experienced substantial land cover and land use change over the past decades, which exemplifies the dynamics of human-environment interactions. Due to the rapid growth in economy and population, China has been extracting more natural resources from the environment than it can sustainably provide, which has caused severe environmental degradation. The expansion of agriculture to provide more food and the extraction of timber resources for development needs are perhaps among the most obvious impacts of the economic system on the natural system (Foley, 2005). A half-century policy of forest exploitation immediately following the establishment of the People's Republic of China in 1949 has led to serious consequences to the terrestrial ecosystem, including soil erosion, land degradation, and biodiversity loss (L. Zhang, Tu, & Mol, 2008). In the late 1990s, a series of new forest policies using the PES approach were initiated as a result of the back-to-back natural disasters of historical drought and flooding events of 1997 and 1998 in China, respectively, which caused huge economic and human life losses (Xu, Yin, Li, &

Liu, 2006). The Conversion of Cropland to Forest Program (CCFP), which is the largest PES program, has received great attention in the world due to its large scale and potentially huge impacts (J. Liu, Li, Ouyang, Tam, & Chen, 2008). The CCFP, also known as the "Grain-for-Green" (GFG) program, encourages farmers to convert their cropland on sloping areas and otherwise ecologically sensitive areas to forests or grasslands, and compensates the participating households based on the land areas enrolled (Conghe Song et al., 2014). The ultimate goals of the CCFP are soil and water conservation through forest restoration and poverty alleviation in the rural areas. A second forest program is the Ecological Welfare Forest Program (EWFP), which is a forestry policy for classification-based forest management. The initiation of the EWFP ties to natural reserve, aiming at preserving natural forests for sustainable environmental goods and services as part of the welfare for the public (Dai, Zhao, Shao, Zhou, & Tang, 2009). Under the EWFP, farm households who owned natural forests receive compensation from the government in return for giving up timber harvesting privilege for commercial purposes. Thus, the EWFP is essentially a PES program.

Since the implementation of China's PES programs, studies have been carried out to evaluate these programs' success in sustainable environmental conservation and social welfare improvement in rural areas. Some studies found that these PES programs had positive effects such as income increase, labor constraints relaxation, forest recovery and amelioration of environmental problems (Xu et al., 2006; Uchida, Xu, Xu, & Rozelle, 2007; Bennett, Xie, Hogarth, Peng, & Putzel, 2014). Others, however, found weak evidence on rural livelihood improvement from the PES programs. Weyerhaeuser et al. (2005) found negative impacts of forest protection and rehabilitation programs on livelihoods in Yunnan Province. The failure of the programs was attributed to weak institutions of targeting cropland parcels under the "top-down" regulation of policy implementation in China. Zhang et al. (2008) highlighted that off-farm activities as alternative income sources are important in the sustainability of the forest restoration program in Ningxia Province. However, the increasing opportunities in off-farm job market also threated food security and land tenure security and thus affected the success of the program. Song et al. (2014) evaluated the sustainability of the reforestation program as well as rural livelihoods using a comparative analysis among three sites in China. The results found that although the compensation from the PES programs can provide a safety net to poor

households, the overall improvement of livelihood is limited. Bennett et al. (2014) highlighted trade-offs between searching off-farm jobs and managing reforested areas for rural households participating in the programs. Given mixed results from studies of policy evaluation, the Chinese government still faces challenges of maintaining sustainable provision of ecosystem services from the PES programs and the improvement of rural livelihoods at the same time. The PES programs in China have existed for over ten years, there is still lack of systematic and integrated evaluation of the PES programs in terms of their social and ecological impacts.

The dissertation draws on data collected from household surveys and spatial data obtained from satellite images to investigate impacts of PES programs on human adaptation to environmental changes. The study addresses two broad research questions which are interrelated in the context of human-environment interactions: 1) what are the social-ecological impacts of PES programs? 2) How do these forest programs affect households' behavior in adaptation to environmental changes? With the focus on the impacts of CCFP and EWFP, this study aims at modeling land use change, migration behavior and examining rural livelihoods from a case study in Tiantangzhai Township, Anhui, China. The core of the dissertation consists of three journal paper manuscripts, focusing on cropland abandonment, individual out-migration from rural households and the livelihood contributions from the two PES programs along with other associated factors. The results from these chapters should be of significant value to Chinese forestry policy-makers and those in other developing countries around the world.

CHAPTER 2

IMPACTS OF PAYMENTS FOR ECOSYSTEM SERVICES ON CROPLAND ABANDONMENT

2.1 Introduction

Land-cover and land-use change (LCLUC) has profound impacts on vital ecosystem goods and services across the world (DeFries, Foley, & Asner, 2004; Kareiva, Watts, McDonald, & Boucher, 2007). Land cover has been transformed tremendously by human beings through land use practices (Foley, 2005). Two dominant forms of the transformation are agricultural expansion and deforestation (Geist & Lambin, 2002; Lambin, Geist, & Lepers, 2003). Recently, land use transitions have occurred as new patterns of LCLUC across the world associated with the economic development (Lambin & Meyfroidt, 2011). Under the circumstance of urbanization and economic development, farmers in rural areas migrate to cities to seek better off-farm opportunities. The loss of labor impels rural households to abandon their marginal cropland (T. K. Rudel et al., 2009). As a result, cropland abandonment has occurred as a prominent manifestation of land use transitions under the pathway of economic development.

Cropland abandonment occurs when continued farming of the land ceases to bring sufficient benefits over costs (MacDonald et al., 2000). Cropland abandonment is a ubiquitous phenomenon as a form of land use transitions worldwide. Studies in Europe have found widespread land abandonment at marginal areas due to rural exodus and agricultural intensification (Mather, 2007). Furthermore, over 20 million ha cultivated land were abandoned in European countries, resulted from the socio-economic changes caused by the collapse of the Soviet Union (Lambin & Meyfroidt, 2011). Other countries in the developing world have also experienced cropland abandonment. For instance, farmers in the mountainous regions of Vietnam

have abandoned their cultivation in the uplands with low productivity as a result of agricultural intensification in the lowlands (Meyfroidt & Lambin, 2008).

Cropland abandonment creates a reverse transformation from human-dominated fields to the land surface with less human impact. This reverse process has multiple ecological impacts on the environment. The abandoned land, followed by natural succession to grass or secondary-forests (T. K. Rudel, 2010), offers the potential of increasing carbon storage (Silver, Ostertag, & Lugo, 2000; Kuemmerle et al., 2011), reducing runoff and soil erosion (Jiao et al., 2007; Y. Liu, Fu, Lü, Wang, & Gao, 2012), and restoring of forest ecosystems (Bowen, McAlpine, House, & Smith, 2007; Chazdon, 2008). Cropland abandonment has socioeconomic consequences, such as global food provision and rural labor allocation. Studies observed a remarkable amount of cropland abandonment across the world, making the cultivated land become increasingly scarcer resource for food production to the growing population (Ramankutty, Foley, & Olejniczak, 2002; Lambin & Meyfroidt, 2011). Land abandonment also influences households' behavior in livelihood strategies. In the Nepalese Himalaya, for example, the abandonment of cultivated fields caused food shortage in villages, and forced households to seek opportunities for non-farm jobs via out-migration (Khanal NR and Watanabe T, 2006). Given the effects on both environmental conservation and social development, understanding determinants of cropland abandonment is important in advancing the knowledge of land use transitions.

Cropland abandonment is the manifestation of land use decision at the local scale, where households are deemed the central decision-makers on their land parcels. Unfavorable environmental conditions can impose extra costs of farming, leading to land abandonment at remote areas. Studies have found high risks of cropland abandonment where topographic features are characterized by rough terrain, high elevations, and poor access by households (D Müller, Kuemmerle, Rusu, & Griffiths, 2009; Sikor, Müller, & Stahl, 2009; Dong, Liu, Yan, Tao, & Kuang, 2011). Not only biophysical features determine the abandonment of land parcels by farmers, but socioeconomic characteristics of households can lead to cropland abandonment by influencing households' land-use decision (Benayas, Martins, Nicolau, & Schulz, 2007). For example, a household owning small areas of cropland with a large household size is expected to

be associated with a lower likelihood of cropland abandonment due to the need for food production. However, the involvement of non-agricultural activities, such as off-farm work, raising domestic animals and migration, may reduce farm labor availability, leading to a high probability of cropland abandonment. Demographical properties, such as the household head's age, gender and education, may also be important factors influencing cropland abandonment, although their effects vary (Daniel Müller & Munroe, 2008). For example, higher education increases the chance of getting off-farm jobs, but one with higher education may also be equipped with technology (e.g., irrigation) to expand cropland. The socioeconomic factors on cropland abandonment are sometimes intertwined with political changes, particularly the intervention of environmental policies (Mitsuda & Ito, 2011). Thus, cropland abandonment often coincides with the intervention of environmental policies when policy-makers employed policy instruments, such as area protection and Payment for Ecosystem Services (PES) programs, to trigger and/or accelerate land use transitions (T. K. Rudel et al., 2005; Sierra & Russman, 2006). Recently, PES has emerged as an innovative approach to enhance ecosystem services. However, the relationship between the PES programs and cropland abandonment are not well understood.

China is the largest developing country by the population in the world. Historically, China was constantly under the pressure to produce enough food to feed its large population. A nationwide movement was initiated by the central government in the 1950s to reclaim wasteland to become cropland (Ye, Fang, Ren, Zhang, & Chen, 2009). Since the adoption of reform and open policies in the late 1970s, China's economy has witnessed a double-digit growth for three decades. Such rapid economic growth offered unprecedented opportunities for the rural residents to work in the cities with much better payment than farming. More than two hundred million people migrated from the remote, rural areas to the cities, seeking better economic opportunities in China (Z. Liang, 2016). The rising rural population mobility was inevitably followed by a land-use trend of cropland abandonment in marginal areas, as observed in other countries (Busch, 2006; López, Bocco, Mendoza, Velázquez, & Rogelio Aguirre-Rivera, 2006; Grau & Aide, 2007).

In the late 1990s, the Chinese government initiated a series of forest conservation and restoration programs after a half-century of unsustainable forest exploitation (P. Zhang et al., 2000; C Song & Zhang,

2009). Most of the new forest programs are implemented under the scheme of the Payment for Ecosystem Services (PES). In many cases, PES programs link to land use change, where landowners voluntarily provide environmental benefits through land use management such as preserving existing forests and establishing forests on barren or other non-forest lands (Engel, Pagiola, & Wunder, 2008; Pattanayak, Wunder, & Ferraro, 2010). One of the conservation policies is the Ecological Welfare Forests Program (EWFP), which was implemented with logging bans, aimed at protecting natural forests to stave off ecosystem degradation (Dai et al., 2009). Commercial logging is prohibited for EWFP forests while local residents who own natural forests receive subsidies for giving up timber harvesting privilege. Thus, the EWFP is essentially a PES program.

Among the PES programs, the China's Conversion of Cropland to Forest Program (CCFP) has received great attention due to its large-scale impacts on forest rehabilitation (J. Liu et al., 2008). The CCFP, implemented around 2002, is the world's largest PES program, whereby households who enroll their cropland into the program receive compensation from the central government based on the areas reforested. These croplands are usually located on steep slopes or otherwise in ecologically sensitive areas. Since the implementation of the CCFP, official statistics from the State Forestry Administration have revealed a substantial increase in forest cover. By 2013, over 9.2 million ha of cropland in total have been enrolled into the CCFP (Sate Forestry Administration, 2014). As the first round of the CCFP will end soon, China State Council approved the initiation of the second round CCFP. Policy-makers have planned to convert additional 0.6 million ha cropland to forests (Sate Forestry Administration, 2015).

Accompanied with the implementation of China's PES programs is the prevailing abandonment of cropland in the mountainous areas (Dong et al., 2011; Y. Zhang, Li, & Song, 2014). Given the potential provision of ecosystem services by the abandoned land, the coincidence of cropland abandonment and new forest policies raises the following question: do the PES programs have impacts on cropland abandonment by rural households? However, there is a paucity of study examining the role the new forest policies played in farmers' land-use decision on cropland abandonment. Whether the PES programs have impacts on cropland abandonment remains poorly documented. Cropland abandonment may continue to be the main

land-use practices in mountainous areas, where land parcels are most likely to be targeted and enrolled into the CCFP. Understanding the underlying factors that influence farmers' decision on cropland abandonment can provide critical information to policy-makers for targeting qualified land parcels and designing the payment schemes for the PES programs. Thus, the present study uses a case study in Tiantangzhai Township, Anhui Province, China, to explore the underlying determinants of cropland abandonment under the CCFP and EWFP.

2.2 Methods

2.2.1 Study area

The study area, Tiantangzhai Township, is located in the eastern part of the Dabieshan Mountain in western Anhui Province, China (Fig. 2.1). The region falls in the northern edge of subtropical climate zone, covering an area of 189 km^2, with elevation varying from about 400 to 1,650 meters above sea level. The mean annual temperature is 16.4℃ and the annual total precipitation is 1,350 mm (Conghe Song et al., 2014). The area is remote from major development within a county that is recognized as a county in poverty by the central government. The climate condition makes the area favorable for vegetation growth and thus natural forests dominate the landscape in this region. The township also forms part of the Tianma Nature Reserve with well-developed tourism, protecting the last remaining primary forests in eastern China (Han, Fang, & Huang, 2011). Under the Nature Reserve, natural forests are protected and designated as ecological welfare forests (i.e., EWFP forests) in the middle 1990s. In return, the government compensates the households that own EWFP forests at a rate of 131.25 Yuan/ha/year. Although commercial logging is banned, subsistence use of wood is allowed, such as fuelwood collection.

Tiantangzhai Township is home for over 4,300 households with 753 participating in the CCFP initiated in 2002. Participating households may create one of two types of forests on their croplands: ecological (e.g., sweetgum, maple) or economic (e.g., walnut, pecan) forests. Because the central government required that 80% of the CCFP land must be ecological forests (Uchida, Xu, & Rozelle, 2005),

the main tree species for the CCFP in this area is sweetgum (*Liquidambar styraciflua*) while economic forests are very limited. The CCFP compensation rate in the study area was set by the central government at 3,450 Yuan/ha/year during the initial contract period. The initial contract lasted for 8 years for ecological forests. The central government renewed their initial contracts for another 8 years, but at a lower compensation rate of 1,875 Yuan/ha/year.

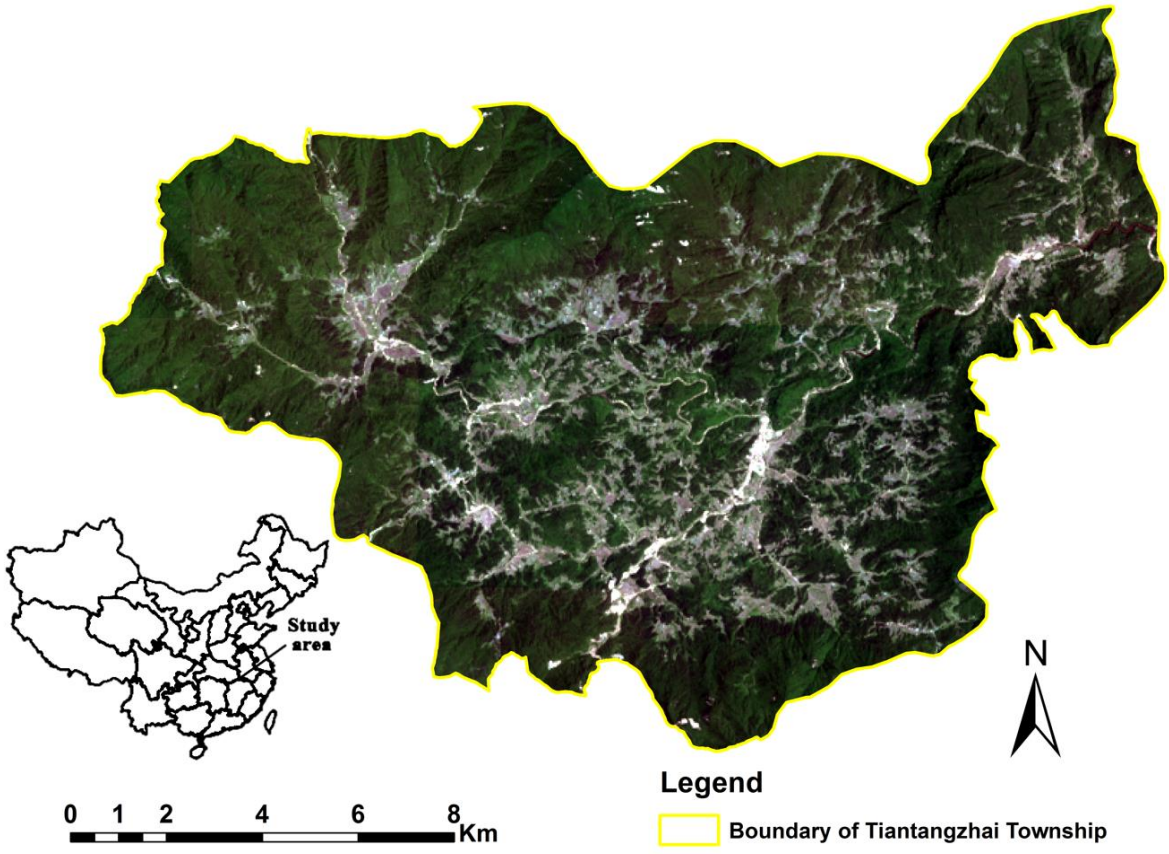

Figure 2.1 Study area: 2013 Landsat OLI image in true color (RGB=432) for Tiantangzhai Township in Anhui, China

Like most rural areas in China, cropland parcels in the Township were primarily collectively controlled by communities (resident groups) with a small proportion allocated to individual households for private management before the rural reform (G. Li, Rozelle, & Brandt, 1998). Land parcels, particularly

those for subsistence grain production, were not allowed to be abandoned according to state regulations. After the Household Responsibility System (HRS), all collective land parcels were allocated to individual households (Mullan, Grosjean, & Kontoleon, 2011). Although the ultimate land owner is the state, farmers enjoy a high degree of usufructuary rights under the current land tenure system. For example, village leaders rarely adjust the holdings of private parcels, and farmers have rights to lease or rent land parcels, to choose which crop to grow, and even to fallow or abandon land parcels. Two primary types of land parcels have been found in this mountainous region: paddy land and dryland. Paddy-land parcels are mainly used for rice, while dryland parcels are for dryland crops such as corn, potatoes and wheat.

2.2.2 Household survey and fieldwork

A survey was conducted with semi-structured questionnaires in the summer of 2013 for 250 households with approximately equal number of households with and without CCFP. In the survey samples, 125 households were randomly selected from each of the two strata: households participating in the CCFP and households not participating. If a household selected was unable to be interviewed due to various reasons (e.g., all household members migrated out or no adequate respondent was found due to mental illness), the nearest neighbor was selected as a substitute in order to maintain the sample size. One of the households did not own any land parcels and thus was not used in this study. Eventually, 138 and 111 households with and without CCFP, respectively, were interviewed. The survey collected household demography, socioeconomic data, and information of PES program participation (i.e., EWFP and CCFP). In addition, detailed information was obtained about each land parcel owned by a household, including land parcel types (paddy land or dryland), parcel areas and the walking distances to the house in minutes. In the survey, households were particularly asked whether the parcel had been abandoned and the year of the abandonment for the abandoned parcels. The nature of land abandonment needed to be differentiated from fallow during the interview. A household may temporarily leave a piece of land in fallow to mitigate soil degradation for future cultivation, while a household decides to abandon a land parcel with little consideration of future farming. This notion was clarified to the respondents since the abandoned land

parcels were of interest. In addition, households were also asked about the abandonment reason for each abandoned parcel. Based on respondents' answers, six major reasons were categorized for cropland abandonment: R1, lack of labor due to migration or aging; R2, crop raiding by wild animals; R3, too far away from the house; R4, not worthwhile for cropping due to high opportunity costs; R5, lack of reliable water supply for crop growth; R6, frequent natural disasters such as flooding, drought, insects, and diseases.

Having parcel information recorded, a fieldwork is carried out to measure geographic coordinates of each land parcel using global positioning system (GPS) units. Geographic coordinates were recorded for the approximate center for each land parcel because of the limited amount of time to delineate the boundary for each land parcel in the field. Overlaying the coordinates with the digital elevation model (DEM), biophysical properties (e.g., elevation, topographic wetness index (TWI), and aspect) of each land parcel are derived. Moreover, the nearest distances of each parcel to the edge of both natural forests and CCFP forest stands classified are also calculated based on satellite images (Q. Zhang, Hakkenberg, & Song, 2016). The natural forest cover is classified based on the 2002 satellite image before the establishment of CCFP forest stands.

2.2.3 Statistical analyses

The temporal trend of cropland abandonment is captured by estimating cumulative probabilities of survived land (i.e., land parcels that had not been abandoned) for each year since 2002. The probability curves (Goel, Khanna, & Kishore, 2010) are depicted for households with and without CCFP. The equity of the curves for the two groups is tested with the log-rank statistic to track the difference of abandonment rates between the two groups. For the abandoned parcels, the percentage of each category of abandonment reasons provided by respondents are tallied for the two types of households in four time periods: Year 03-13, Year 03-07, Year 08-11, and Year 12-13, with the last three periods corresponding to different stages of CCFP implementation.

Random coefficient multilevel models are developed for analyzing hierarchically structured data. The multilevel statistical models are particularly useful to study of land use change, where data are often

nested across various levels (Pan & Bilsborrow, 2005; Y. Zhang et al., 2014). For example, land use decision is influenced by biophysical characteristics at the parcel level and socioeconomic characteristics at the household level and farming activities among different land parcels within the same households are more similar than between households. Thus, a random-coefficient logit model (Guo & Zhao, 2000) is used to examine both fixed effects of parcel/household features and random effects among households on cropland abandonment. The dependent variable of the model is whether the land parcel had been abandoned (=1) or under cultivation (=0) by the time of the survey. In this model, the coefficients of explanatory variables are estimated with a random intercept and fixed slopes. The random coefficient multilevel model is expressed in Equation (2.1).

$$\log\left(\frac{\Pr(Y_{ij}=1)}{1-\Pr(Y_{ij}=1)}\right)=\beta_0+\sum_{p=1}^{P}\beta_p X_{ijp}+\sum_{q=1}^{Q}\gamma_q Z_{jq}+\mu_j+\varepsilon_{ij} \quad (2.1)$$

where $\Pr(Y_{ij}=1)$ is the probability of the abandonment of the i^{th} parcel owned by the j^{th} household. Further, X_{ijp} is the p^{th} predictor describing parcel features and Z_{jq} is the q^{th} predictor of the j^{th} household characteristics that influence land abandonment on parcels. The intercept is captured by the coefficients β_0, while fixed effects at the parcel level and the household level are captured by the parameters β_p and γ_q corresponding to X_{ijp} and Z_{jq}, respectively. Finally, ε_{ij} and μ_j capture the random effects at the parcel level and the household level, respectively.

2.3 Results

2.3.1 Temporal dynamics of cropland abandonment

The households interviewed own 1202 land parcels with a mean area 0.086 ha. The overall abandonment rate of these land parcels is 0.19 (229/1202) at the time of the household survey in 2013 (Table 2.1). Abandoned parcels have a larger mean area than parcels in use for both groups. Parcels owned by CCFP households have a larger mean area than those owned by the other type of households. However,

the abandonment rate of land parcels for CCFP households almost equals that for non-participants at the time of interview.

Table 2.1 Statistical summary of areas for parcels in use and parcels abandoned (n=1202).

Participation	Parcel in Use			Parcel Abandoned		
	Obs.	Mean Area (ha)	Std. Dev.	Obs.	Mean Area (ha)	Std. Dev.
No	450	0.080	0.070	105	0.091	0.066
Yes	523	0.088	0.097	124	0.099	0.086
Total	973	0.084	0.085	229	0.095	0.077

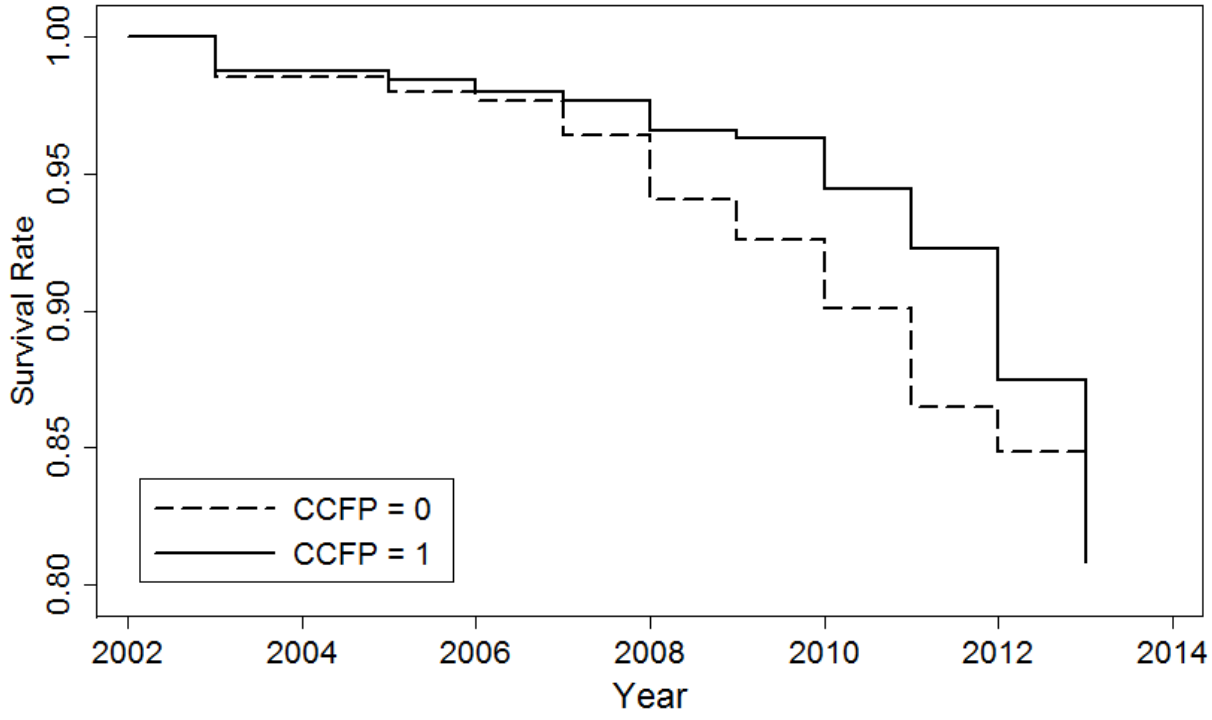

Figure 2.2 Temporal changes of survival rates based on individual cropland parcels for households with and without of the CCFP from 2003 to 2013. The log-rank test of the equality of the two survival functions by the year of 2013: Chi^2=0.03, Pr>Chi^2=0.873. However, the log-rank test reveals significant differences of the two survival rates during 2009-2011 with p-values below 0.01.

The survival rates of individual land parcels show a declining trend for household with and without CCFP during 2003-13 (Fig. 2.2). Once a parcel of cropland is abandoned, it is hard to be put back in use.

Therefore, the survival rate monotonically decreases as more cropland parcels are abandoned. The overall survival rate of land parcels for CCFP households is higher than that of parcels for non-CCFP households before 2013. However, the two trend lines converges by 2013, leading to an insignificant difference between the two types of households. This converging trend suggests an acceleration of cropland abandonment near the time of interview by households that are participating in the CCFP.

2.3.2 Reasons for cropland abandonment

The general patterns of reasons for cropland abandonment provided by respondents are similar for households with and without CCFP during 2003-13, but important differences exist between these two types of households (Fig. 2.3a). For abandoned parcels by CCFP households, lack of labor due to migration or aging (R1) is the most important reason for cropland abandonment, far exceeding all other reasons; high opportunity costs (R4) and lack of reliable water supply (R5) are the second most important reasons for cropland abandonment, while crop raiding by wildlife (R2), long distance to households (R4) and frequent natural disasters (R6) make the least contributions to cropland abandonment. For CCFP households, land parcels that are more susceptible to crop raiding, natural disasters, or far away from the house, might have been enrolled in the CCFP, making them less likely to be the reasons for cropland abandonment. For non-CCFP households, the reasons for cropland abandonment are more diverse. Despite lack of labor (R1) remains the most important reason for cropland abandonment, crop raiding (R2), long distance to the household (R3), high opportunity costs (R4) and lack of reliable water supply (R5) all make significant contributions to cropland abandonment.

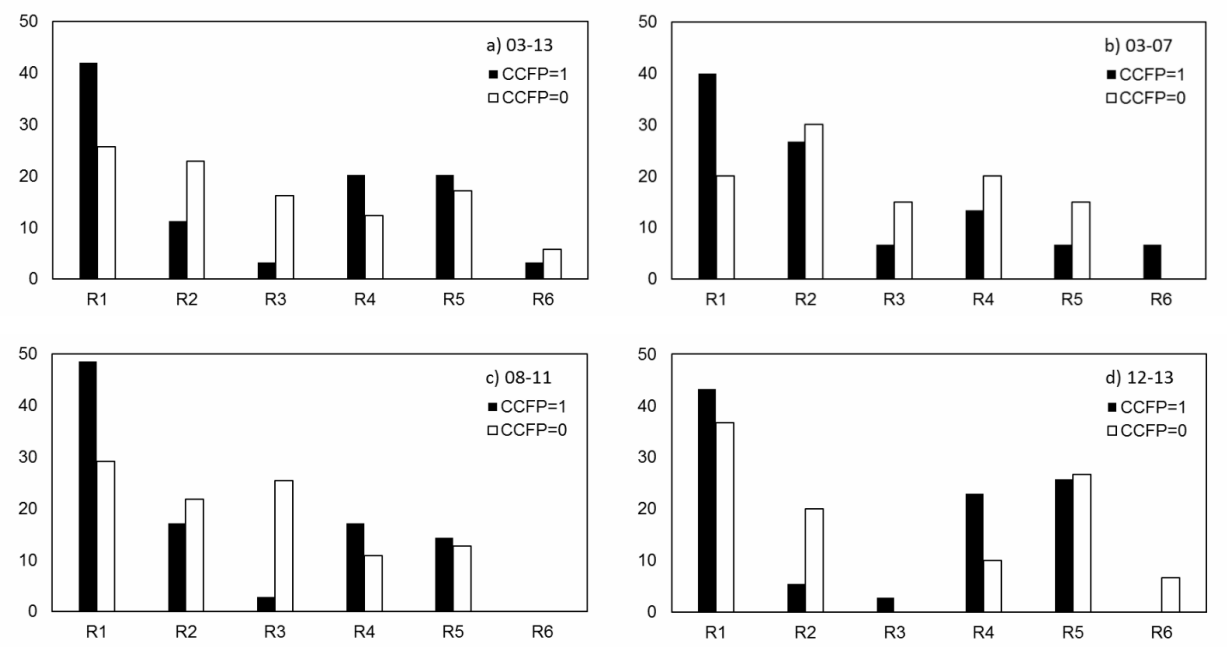

Figure 2.3 Percentage of reasons for cropland abandonment by households with and without CCFP in four time periods: a) the entire time period, b) Year 03-07, c) Year 08-11, and d) Year 12-13.Y-axis is the percentage of the reasons for cropland abandonment provided by respondents. X-axis is the category of responses. R1, lack of labor due to migration or aging; R2, crop raiding by wild animals; R3, too far away from the house; R4, not worthwhile for cropping due to high opportunity cost; R5, lack of reliable water supply for crop growth; R6, frequent natural disasters such as flooding, drought, insects, and disease.

When looking the temporal trend in the reasons for cropland abandonment (Fig. 2.3b, c, and d), the two groups of households show different patterns. During 2003-07, lack of labor is the most important reason for cropland abandonment for CCFP households; crop raiding is the second most important reason, while all other reasons make minor contributions. For non-CCFP households during 2003-07, crop raiding is the most important factor contributing to cropland abandonment, while lack of labor, long walking distance to land parcels, high opportunity costs and lack of water all make important contribution to cropland abandonment. During 2008-11, lack of labor, crop raiding and long walking distance become the top reasons for cropland abandonment for non-CCFP households, while high opportunity costs and lack of reliable water supply remain as non-insignificant secondary reasons. For CCFP households during 2008-11, lack of labor remains as the dominant contributor to cropland abandonment, nearly twice as important compared to non-CCFP households. The biggest difference between the two households is the contribution

of long walking distance, which is nearly as important as lack of labor for non-CCFP households, while making trivial contribution for CCFP households. During the last period of 2012-13, lack of labor, high opportunity costs and lack of reliable water supply make the dominant contributions to cropland abandonment for CCFP households, while other reasons have little effects. Again the reasons for cropland abandonment for non-CCFP households remain diverse, with lack of labor, crop raiding and lack of water as the dominant factors, while high opportunity costs and frequent natural disasters continue to contribute to cropland abandonment.

2.3.3 Statistical modeling of cropland abandonment

At the parcel level, there are significant differences in biophysical properties between abandoned parcels and parcels in use (Table 2.2). Overall, abandoned parcels have significantly higher elevations, lower TWI values, and longer distances to the owners' houses. In addition, dryland parcels account for a significantly lower proportion of abandoned parcels than paddy-land parcels. However, the mean area and the aspect of abandoned parcels do not significantly differ from those of parcels in use. The nearest distances of abandoned parcels to EWFP and CCFP forests are shorter than those of parcels in use.

Statistics of household-level variables are summarized in Table 2.3. The household heads have a mean age of 52 and education of 7 years in 2013. Most of the household heads are male. The average number of non-migrants (i.e., people who live at home and thus are able to provide farm labor) aged 18-60 is 1.79 per household. Households own 0.47 ha of total land on average. About 41 percent of the households suffer from crop raiding by wildlife without effective actions, while 73 percent of the households raise pig(s). The proportion of local off-farm income over the total gross income is 35 percent on average. The average EWFP and CCFP payments are 350 and 170 yuan, respectively. The mean amount of household fuelwood usage is 8,860 kg per year.

Table 2.2 Statistical summary and t-test of mean differences for parcel-level variables between parcels in use and parcels abandoned (n=1202).

Variable	Description	Parcel in Use		Parcel Abandoned	
		Mean	Std. Dev.	Mean	Std. Dev.
Distance to CCFP	Nearest distance to CCFP forest edge (100 m)	3.50	3.24	3.17	2.78
Distance to EWFP***	Nearest distance to EWFP forest edge (100 m)	0.82	0.76	0.62	0.56
Land area	Area of land parcel (ha)	0.08	0.09	0.10	0.08
Land type***	Land type§ (0=paddy land, 1=dryland)	0.48	0.50	0.32	0.47
Walking distance***	Walking distance to the corresponding household (minutes)	9.81	10.02	14.03	12.57
Elevation*	Elevation (100 m)	6.44	0.98	6.57	0.87
TWI***	Topographic Wetness Index	10.07	4.12	9.01	3.13
Aspect	Aspect (0=south-facing, 180=north-facing)	74.69	52.46	79.74	53.85

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

§ "Land type" is a categorical variable and the mean is the proportion of the observations whose choice is "dryland" (=1).

Table 2.3 Statistical summary of household-level variables for households surveyed (N=249).

Variable	Description	Mean	Std. Dev.
CCFP payment	Conversion of Cropland to Forest Program subsidy (1,000 yuan)	0.17	0.24
EWFP payment	Ecological Welfare Forest Program subsidy (1,000 yuan)	0.35	0.41
Age	Age of household head	52.48	9.62
Gender§	Gender of household head (0=male, 1=female)	0.05	0.21
Education	Education of household head (years)	6.95	2.71
Farm labor	Number of non-migrants (i.e., people who live at home, being able to provide farm labor) aged 18-60	1.79	1.09
Total land	Amount of total land owned (ha)	0.47	0.23
Crop raiding§	If suffered crop raiding by wildlife without effective actions (0=no, 1=yes)	0.41	0.49
Raising pigs§	If has pigs (0=no, 1=yes)	0.73	0.45
Local off-farm	Proportion of local off-farm income to the total gross income	0.35	0.37
Fuelwood	Fuelwood usage per year (1,000 kg)	8.86	5.90

§ These three variables are categorical variables and the mean of these variables is the proportion of the observations whose category is "YES" (=1) or "female" (=1).

Results from the random-coefficient multilevel logit model reveal significant fixed effects of parcel features and household characteristics on cropland abandonment (Table. 2.4). Although the parcel area does not have significant effects on cropland abandonment, land types experience different abandonment rates. Dryland parcels are 74% less likely to be abandoned than paddy-land parcels. Parcels located in adverse conditions are more likely to be abandoned. For example, for every additional walking minute the likelihood of abandonment increases by 5%, while an additional unit of TWI decreases the likelihood of abandonment by 8%. TWI is a proximate measure for soil moisture based on the slope and the areas flowing into a given unit area (Sørensen, Zinko, & Seibert, 2006). The larger the TWI value is, the higher the soil moisture might be. However, the elevation and aspect do not have significant effects on cropland abandonment. In addition, the nearest distances of parcels to EWFP and CCFP forests have significant effects on cropland abandonment. Every additional 100m distance to EWFP and CCFP forests decrease the probability of abandonment by 47% and 8%, respectively.

For household characteristics, although attributes of the household head do not have significant effects on cropland abandonment, the larger number of non-migrants aged 18-60 (an indicator of the availability of farm labor) significantly decreases the probability of cropland abandonment. The total amount of land owned by the household and crop raiding do not significantly influence the abandonment of land parcels. However, raising animals (i.e., pigs) and the share of local off-farm income have significant effects on cropland abandonment. Households with pig(s) are less likely to abandon land parcels, while households with a larger proportion of local off-farm income over the total income are more likely to abandon their cropland. In relation to PES programs and forest resources, an additional 1,000 yuan of EWFP payment renders abandonment 101% more likely, while the amount of CCFP payment and fuelwood usage do not have significant effects on cropland abandonment. The intercept variance of the model is 1.33 and the likelihood-ratio test (Chi^2=31.30) shows that the random-coefficient multilevel logit model fits significantly better than an ordinary logistic regression model.

Table 2.4 Fixed effects (odds ratios) and random effect estimation of parcel features and household characteristics on cropland abandonment (number of parcels = 1202, number of households = 249).

Variables	Odds Ratio (*Std. Err.*)	z	P>|z|
Distance to CCFP	0.92 (*0.04*)	-2.04	0.0410*
Distance to EWFP	0.53 (*0.10*)	-3.26	0.0010**
Land area	0.23 (*0.34*)	-1.01	0.3140
Land type	0.26 (*0.06*)	-5.70	0.0000***
Walking distance	1.05 (*0.01*)	4.53	0.0000***
Elevation	1.06 (*0.16*)	0.40	0.6890
TWI	0.92 (*0.03*)	-2.81	0.0050**
Aspect	1.00 (*0.00*)	1.58	0.1150
EWFP payment	2.01 (*0.65*)	2.15	0.0320*
CCFP payment	0.71 (*0.45*)	-0.54	0.5870
Age	0.99 (*0.01*)	-0.63	0.5260
Gender	1.01 (*0.63*)	0.02	0.9870
Education	0.97 (*0.05*)	-0.61	0.5410
Farm labor	0.75 (*0.10*)	-2.05	0.0410*
Total land	1.31 (*0.91*)	0.39	0.6990
Crop raiding	1.31 (*0.33*)	1.06	0.2880
Raising pig	0.50 (*0.15*)	-2.35	0.0190*
Local off-farm	2.36 (*0.85*)	2.37	0.0180*
Fuelwood	1.02 (*0.02*)	0.76	0.4500
Constant	1.10 (*1.69*)	0.06	0.9490
Constant variance	1.33 (*0.41*)		
Intra-class correlation	0.29 (*0.06*)		

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
The log-ratio test shows that the Chi^2 value is 31.30 with p-value 0.000.

2.4 Discussion

Results from the statistical analysis reveal significant effects of PES programs, socioeconomic and geographic factors on cropland abandonment. Although the CCFP payment does not have significant effect, the EWFP payment significantly increases the likelihood of cropland abandonment. This may be because households receive much more compensation from the EWFP in the study area, as the average EWFP payment doubles that from the CCFP for households surveyed (Table 2.3). In addition, households with more EWFP forests live in more remote areas. Therefore, their cropland parcels are more likely far away from home. The EWFP compensation makes it possible for these households to rely on the subsidy, leaving

their cropland abandoned. Previous studies found that the EWFP encouraged household members rely on off-farm activities instead of forest resources (Jiang, Jiang, Liu, Yu, & Wang, 2002).

There is a significant difference of land parcel survival rates between households with and without CCFP during 2009-2011, but the cropland survival trend lines of the two types of households converge by 2013. According to Fig. 2.3d, lack of labor, high opportunity costs and lack of reliable water supply are the primary reasons for cropland abandonment for CCFP households during 2012-13. This implies the increase of opportunity costs for farming as a result of overall economic development in China. The convergence of the cropland abandonment rates between CCFP and non-CCFP households indicates the additionality of forest areas gained from the CCFP. The CCFP in China is a well-known PES program, where households are incentivized or "persuaded" to retire their marginal cropland parcels for forest restoration (Bennett, 2008; S Wunder et al., 2008; Conghe Song et al., 2014). Land parcels that are located on steeper slopes and/or in ecologically-sensitive areas have the priority to be targeted by the local government. Having these poorly-accessible parcels enrolled into the program, participating households are less likely to abandon their remaining land parcels in the years immediately after the CCFP implementation. As time goes on, the increase in forest areas due to the CCFP and EWFP may cause more crop raiding by wildlife, dampening crop yield for the remaining land parcels adjacent to forests (X. Chen, Zhang, Peterson, & Song, 2017). This also explains that the proximity of cropland parcels to EWFP and CCFP forest edges is associated with a high probability of being abandoned (Table 2.4).

In the long term, the CCFP may have influence on cropland abandonment through changing labor availability, which is the primary reason of cropland abandonment (Fig. 2.3). Previous studies found a positive impacts of the CCFP on labor shift from on-farm to off-farm work, particularly for young household members (Uchida, Rozelle, & Xu, 2009). Households who involved in such income-generating activities as off-farm work are less likely to allocate labor back to farming work, their cropland being more likely to be abandoned. This is supported by the findings that more CCFP households thought farming crops was not worthwhile in 2012 and 2013 (see Fig. 2.3d). Furthermore, the CCFP can gradually relax the labor constraints for constrained households (Groom & Palmer, 2012). Participating households enjoy the

ownership of CCFP forests as well as the right of CCFP land management. After the enrollment of their land, CCFP households need to manage the newly-establish trees for the survivorship (Bennett et al., 2014) and thus they cannot spare labor for off-farm work during the early years. When the trees grew up and required fewer management actions, households tended to allocate more labor to off-farm activities. This may explain the convergence of cropland abandonment for the two types of households.

The effects of PES programs on cropland abandonment are examined together with biophysical determinants and household socioeconomic drivers. The results show the importance of topographic conditions (e.g., topographic wetness index, TWI) and geographic accessibility (i.e., the walking distance from the house to land parcels), which is consistent with findings in other areas of the world (D Müller et al., 2009; Lakes, Müller, & Krüger, 2009; Sikor et al., 2009; Daniel Müller, Leitão, & Sikor, 2013). The TWI, which is often included in land cover transition models (Rutherford, Bebi, Edwards, & Zimmermann, 2008), contains information of both water accumulation and slopes. An area with higher TWI is associated with better water availability and a moderate slope, thus a more suitable environmental condition for cultivation, particularly on paddy land with rice farming (Y. Li & Barker, 2004).

The abandonment of land parcels is also affected by socioeconomic characteristics of households, although these effects may be indirectly influenced by the PES programs. A negative relationship is found between the number of non-migrants aged 18-60 (i.e., farm labor) and the likelihood of cropland abandonment, which confirms the importance of labor availability on land use decision by households (Walker, Perz, Caldas, & Silva, 2002). Additionally, raising domestic animals, namely pigs in this case, significantly decreases the risk of abandonment. This might be due to the reason that crops such as corn are needed for pig feeding, as is the common case in Asia (Kim & Dale, 2004). Moreover, a high proportion of local off-farm income over the total gross income renders abandonment more likely. In this region, local off-farm income and remittances from migrants make up the lion's share of total household income (Conghe Song et al., 2014). Thus, households involving in such income-generating activities are more likely to abandon their cropland.

The study on cropland abandonment offers useful information in evaluating the cost-effectiveness of the CCFP, which is essential for the design of such PES programs in the future (Sven Wunder, 2007; Engel et al., 2008). In the CCFP, two interrelated aspects of the cost-effectiveness are the payment scheme and land parcel targeting (Y. Chen, Yang, Sweeney, & Feng, 2010). The Chinese government adopted a two-tier payment scheme for the CCFP: a higher payment for croplands enrolled in the CCFP in the Yangtze River Basin than those in the Yellow River Basin. This is believed to be less cost-effective than a discriminative payment scheme based on opportunity costs (Ferraro, 2008; Y. Chen et al., 2010). Despite the difficulty of estimating opportunity costs, enrolled parcels are likely to have low costs of forgoing cultivation (i.e., opportunity costs) if they possess high risks of being abandoned. Targeting such parcels with less payment can minimize the cost of similar programs in the future. In addition, the abandoned land by households would turn to natural landscape such as grassland or shrubs/forests given sufficient time, potentially providing ecosystem services even without the implementation of environmental policy, albeit at a slower rate (Silver et al., 2000). Actually, scholars have recently reported the prevalence of cropland abandonment in mountainous areas, calling for the need of further consideration of the expansion of the CCFP (X. Li, Tan, & Xin, 2014). Future research may involve the analyses of a time series of data to better capture how the participation of the CCFP, intertwined with other drivers, has affected cropland abandonment through time. Understanding the process of cropland abandonment can provide useful information to the policy makers on designing similar programs in the future.

2.5 Conclusions

The study found that PES programs (i.e., CCFP and EWFP), household socioeconomic characteristics as well as the biophysical properties of the cropland parcels played important roles in cropland abandonment in the study area. Respondents provide more diverse reasons for cropland abandonment for non-CCFP households than CCFP households. The “survival” (i.e., cropland that had not been abandoned) rate of land parcels is higher for CCFP households than that for nonparticipants in the years immediately after the enrollment of CCFP. However, the survival rates for the two types of

households converge at the time of the interview in 2013, suggesting the additionality of the forested areas gained by the CCFP. Although CCFP payment does not have significant effects on cropland abandonment, EWFP payment significantly facilitates cropland abandonment. This may be due to the fact that the average payment from the EWFP doubles that from the CCFP. Biophysical factors that promote cropland abandonment include the proximity of cropland parcels to EWFP and CCFP forests, the poor accessibility and rough terrain conditions, while socioeconomic drivers include the labor unavailability, raising domestic animals and the involvement of off-farm activities. These factors may be indirectly influenced by the PES programs. These findings are valuable for policy makers designing similar PES programs in the future with regard to the cost-effectiveness and land targeting.

CHAPTER 3

IMPACTS OF PAYMENTS FOR ECOSYSTEM SERVICES ON OUT-MIGRATION

3.1 Introduction

Rural out-migration is an on-going process accompanying socio-economic development in the developing world (Stark & Bloom, 1985; Findley, 1987; R E Bilsborrow, McDevitt, Kossoudji, & Fuller, 1987; E. J. Taylor, 1999). China, as the most populous developing country, is no exception. Since the adoption of the Reform and Opening-up Policy in 1978, China's economy has witnessed double-digit growth for three decades, which has led to unprecedented opportunities for residents in the countryside. More than 200 million people have moved from rural areas to cities, seeking better economic opportunities (NBS, 2012; Z. Liang, 2016). The annual population flow on an unprecedented scale substantially alters the demographic and economic landscape via population redistribution (Cai & Wang, 2003; Fan, 2003). Such great mobility also has profound impacts on Chinese society. As a result, the study of rural out-migration in China is of ever growing interest to both migration scholars and policy-makers.

Migration, or population mobility, refers to the movement of people to change their residence from places of origin to places of destination which involves moving across a recognized border (United Nations, 1998; Swanson & Siegel, 2004; Richard E. Bilsborrow, 2016). Migration from rural to urban areas has been a key transformative process of population flows in China. Out-migration has been recognized as a household strategy for poverty reduction in rural China (Du, Park, & Wang, 2005). Understanding rural out-migration in China should not be extrapolated from studies in other countries because of the unique Chinese household registration institution, namely the *hukou* system (Zhiqiang Liu, 2005). The *hukou* system specifies an individual's resident type (agricultural or urban) and location of "permanent" residence.

The *hukou* institution was imposed by the central government in the 1950s as a principal mechanism to keep rural residents from seeking livelihoods in cities, reducing pressures on government budgets to provide infrastructure and welfare for urban residents (Chan & Zhang, 1999). For example, a farmer born in the countryside with an agricultural *hukou* registration was not allowed to reside or work permanently in a big city. However, the Reform and Opening-up Policy adopted by the Chinese government created a huge need for labor in urban areas. Therefore the Chinese government relaxed control over population mobility from rural areas, allowing rural migrants to seek temporary employment in urban areas (Cai & Wang, 2003). Thus, a large number of rural people, typically with low education, migrated to fill labor needs in the cities (Sun & Fan, 2011). These migrants, characterized as the floating population, have come to change jobs easily and frequently from city to city and from year to year, although some return to the original location where their *hukou* is located (Z. Liang & Ma, 2004). Given this complex behavior of out-migration in rural China, empirical studies on the determinants of migration are needed to better understand the causes and mechanism of population redistribution and its implications for socio-economic development.

The dynamics of rural out-migration is closely tied to the dynamics of the natural environment, which is referred to as the migration-environment nexus (Carr, 2005; Laczko, Aghazarm, & Bilsborrow, 2009; Richard E. Bilsborrow & Henry, 2012). Among all the environmental conditions, land use and land management has been recognized as the key linkage between the migration decision-making of rural populations and environmental change (Braimoh, 2004; R. Chen, Ye, Cai, Xing, & Chen, 2014). For example, early rural residents who migrated out from places of origin in response to degraded land may subsequently degrade the land elsewhere in their areas of destination, which may cause further migration in a chain process (Charnley, 1997). The behavior of out-migrants has also been viewed as an adapting strategy by rural farmers coping with high risks of crop failure under adverse and unpredictable environmental conditions (Ellis, 2003; Konseiga, 2007). The migration-environment relationship is thus of crucial importance for regional planning on both the environment and human society.

Payment for Ecosystem Services (PES) has recently been adopted as an innovative approach in environmental policies focusing on the conservation of ecosystem services, particularly when dealing with

land use change (Engel et al., 2008; Pattanayak et al., 2010). In the late 1990s, China adopted the PES approach in the new forest policies in response to the devastation from natural disasters caused primarily by land use change (J. Liu et al., 2008). The largest PES program is the Conversion of Cropland to Forest Program (CCFP), which was implemented in 25 of the 31 provinces, of China starting around 2000, involving 32 million rural households and costing RMB 430 billion yuan (Bennett et al., 2014; Yin, Liu, Zhao, Yao, & Liu, 2014). Under the CCFP, farmers reforest their cropland located on moderately steep slopes or otherwise ecologically-sensitive areas in return for a cash payment from the central government based on the areas reforested. A second PES program, the Ecological Welfare Forest Program (EWFP), is a forest management program for natural forests, which aims to preserve existing forests by prohibiting commercial logging (Dai et al., 2009). Thus the government provides cash compensation to farmers for giving up commercial logging privilege based on the area in natural forests owned by farmers, mostly in mountainous areas. At the same time, the central government abolished all land taxes on these owned forests. To facilitate conservation, when the land use policies of Mao based on collectively owned farmland and land in natural forests were replaced in the 1980s with long-term private ownership, both farmland and forest lands were distributed to the households living on them.

A major challenge to be faced by Chinese policy-makers is the sustainability of the two PES programs. Except for water and soil conservation, the central government also expected these PES programs to provide some poverty alleviation since these croplands are generally located in poor rural areas (Conghe Song et al., 2014). Policy-makers hope that these PES programs would stimulate rural households to allocate more farm labor to non-farm jobs, diversifying their livelihoods. This could also reduce the risk that participating households would convert the withdrawn cropland back to cultivation after government compensation ends. As one of the major livelihood strategies of rural households (Ellis, 2000), migration associated with subsequent remittances back to the origin household can serve as a safety net for the income loss resulting from the reduction in the area cultivated by poor rural households (Du et al., 2005). Despite a number of evaluating impacts of PES programs on rural livelihoods, there is little research on the impacts of programs on out-migration. This is due to the lack of adequate quantitative data sets and complicated by

possible time-lags in the effects of the PES programs on household livelihood strategies. As the CCFP and EWFP have existed since 2000, it is now time to investigate their possible medium-term impacts on rural out-migration, ultimately to better understand their socio-economic consequences and develop appropriate policies.

The present research thus aims to understand the roles played by the Chinese PES programs (i.e., CCFP and EWFP) in rural out-migration using a case study of Tiantangzhai Township, Anhui Province. Since migration decisions of rural farmers may also be affected by various personal and household characteristics and contextual factors, these drivers must also be taken into account to isolate the effects of PES policies on out-migration. The specific objectives of this study thus include: 1) tracking temporal trends in the out-migration of households during the implementation of the PES programs, and 2) developing a statistical estimation model to examine the effects of the PES programs and other factors on out-migration. Since the PES approach is being adopted around the world as a major tool for environmental restoration, the results of this present study should be useful for understanding other PES programs in other countries besides China and therefore provide useful inputs for policy-makers designing similar PES programs in the future.

3.2 Theories on migration

Research on migration dates back to the origins of the field where economists, geographers and sociologists tried modeling human migration in history with macro- or micro-theoretical approaches. From the macro perspective, the migration of populations from place to place is motivated by disparities between areas in wages, employment opportunities, and living conditions (Lewis, 1954; Wolpert, 1965; Todaro, 1969; L. A. Brown & Lawson, 1985). Such disparities are linked to the pull-push theory, which argues that adverse conditions in origins stimulate if not force people to migrate out while better opportunities in destinations attract people to move in (Lee, 1966). The major limitation of these models from a macro-view lies in the lack of consideration of individual characteristics, or migrant selectivity. On the other hand, the microeconomic theory of migration views migration as a personal choice at the individual level. The initial

decision-making of migration by individuals is conceptualized as a function of expected return and expected cost of moving (Sjaastad, 1962; Schwartz, 1976). In these models, key elements affecting the migration decision are individual characteristics relating to human capital, such as age, gender, education, occupation and work experience and skills, and marital status. For example, a person with higher education and work skills expects a higher salary in the destination with better opportunities, while an individual beyond the peak productivity age can expect a lower return. Despite the importance of personal characteristics, these individual-based models ignore the fact that migration decisions are also often affected by household strategies at the household level and household conditions and resources (De Jong & Gardner, 1981; Lauby & Stark, 1988; Root & De Jong, 1991).

The New Economics of Labor Migration (NELM) has proposed to model migration as a strategy of risk diversification at the household level (Stark, 1984; Stark & Bloom, 1985). Based on the theory of the NELM, households are viewed as the central decision-making units deciding whether to allocate one or more workers to migration. The expectation of migration is not only to maximize household welfare through out-migration followed by expected remittances but also to diversify risks that may result from agricultural or market failure (J. E. Taylor & López-Feldman, 2010). In addition, according to Chayanov's theory and the theory of the household life cycle, the allocation of household labor between agriculture and migration depends on household size and structure and land use (Goody, 1958; Chayanov, 1966). Thus, the amount of land and household demography, such as labor availability, directly relate to the migration decision (Alisson Flávio Barbieri, Carr, & Bilsborrow, 2009). The allocation of labor to various purposes on the farm and off has been linked to migration: involvement of adults in the household in on-farm work or local off-farm jobs can decrease the availability of household labor for migration, and vice versa, as they are interrelated, trade-offs. Moreover, remittances by migrants can be used by receiving households to invest in local activities, such as raising animals or agricultural crop intensification, which may mitigate incentives for further out-migration as well as increase household incomes per capita. Finally, social networks from the previous out-migration experience of someone in the household often facilitates migration by reducing the costs of finding work and may also provide a place for the later out-migrant to

live initially (with the previous out-migrant) in the destination location (Richard E Bilsborrow, Oberai, & Standing, 1984; Massey, 1990).

Beyond individual and household factors that may influence migration decisions are community-level factors, which may influence migration behavior as contextual conditions (Richard E Bilsborrow et al., 1984; Findley, 1987; T. Rudel & Roper, 1997). Such contextual factors include labor markets and wage levels, accessibility to transportation, land and other resources, availability of particular kinds of infrastructure (e.g., hospitals, schools), and other socio-economic conditions. Taking into account such areal factors in migration models provides a more comprehensive understanding on the factors that may influence migration decision.

3.3 Study area

The study area is in Tiantangzhai Township, located in a mountainous region in western Anhui Province (Fig. 3.1). The township covers an area of 189 km^2 and lies at an elevation ranging from 402 m to 1,651 m above sea level. Tiantangzhai has a mild climate albeit with rough terrain, suitable for abundant forest cover. The township is remote from the county capital (*Jinzhai County*) and the provincial capital, Hefei, and the county is recognized as a county in poverty by the Chinese government. This township also forms part of the Tianma Nature Reserve in the eastern Dabieshan Mountains, protecting the last remaining primary forests in eastern China. Due to the rich natural resources (including waterfalls, stunning views, and mountain trails), part of the reserve has been developed into an important ecotourism area, providing local residents with business opportunities.

Tiantangzhai Township itself is home for over 4,300 households, distributed in seven administrative villages with varying levels of economic status. The central village in the immediate vicinity of the Tiantangzhai tourism area enjoys better economic opportunities than the other villages, and has a number of hotels and restaurants. Overall social-economic conditions in the township are poor. Thus there is only one junior secondary (middle) school, located in the township center, and students have to go to the county capital for high school, and local farmers survive primarily on subsistence farming (rice, corn, sweet

potatoes) on their own small land parcels. Before the land reforms, land parcels were collectively managed by so-called resident groups, with only small pieces of land allocated to individual households in the same group (G. Li et al., 1998). But under the rural reform policy in the 1980s, all the land was divided among the households in the resident group, which is a cluster of 10 to 40 households. There are currently 165 resident groups in the township. Households within the same resident group sometimes still share cropland and farm together but mostly work their own land under 99 year leases from the government.

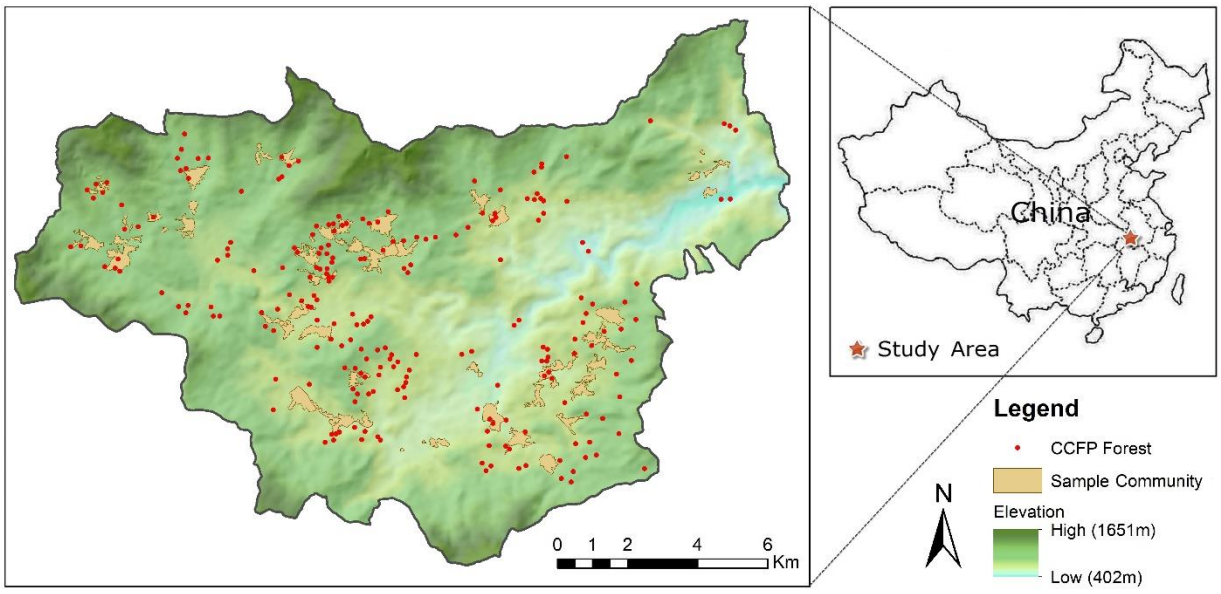

Figure 3.1 Study area: Tiantangzhai Township in Anhui, China

Due to population pressures on the rugged terrain, some of the existing croplands before 2002 were located on slopes with low productivity, leading to soil erosion. The Chinese government therefore initiated the Conversion of Cropland to Forest Program (CCFP) in 2002, aiming at reforesting croplands on steep slopes and otherwise ecologically sensitive areas for soil and water conservation. Among the over 4,300 households in Tiantangzhai Township, about 750 were enrolled in the CCFP by providing them with incentives to retire some of their sloping cropland. Farmers then planted trees on that retired cropland, either *economic trees* (e.g., walnut, pecan, which after a lag produce an income) or *ecological trees* (e.g., sweetgum, maple). Due to the incentive if not perceived as a requirement of the government as well as the

rugged terrain, most planted trees are ecological trees, mainly sweetgum (*Liquidambar styraciflua*). For ecological forests, the payment scheme was the same as that of the Yangtze River Basin: 230 Yuan/mu/year (1 mu =1/15 ha) for the first 8-year contract (2000-2008), which was cut to half (125 Yuan/mu/year) for the second 8-year contract (Conghe Song et al., 2014).

The township is also part of an area where a separate forest conservation policy was implemented. Under the nature reserve, natural forests are designated as ecological welfare forests. The Ecological Welfare Forest Program (EWFP) was hence created by the Chinese government for managing natural forests. Because of the high forest cover in the study area, almost every household owns some natural forests, but the area varies widely. Farmers received 8.75 Yuan/mu/year as compensation for forgoing commercial logging of their natural forests. Although commercial timber harvesting is prohibited, subsistence use of the forest resources is allowed.

During the implementation of these forest policies, as well as before, out-migration has been observed in the study area. The economic compensation and the retirement of cropland may have impacts on increasing or decreasing the pace of out-migration. A previous study found that rural households in the study area often relied on remittances received from out-migrants as well as income from local off-farm work more than income from on-farm activities after 10 years of CCFP implementation (Conghe Song et al., 2014). The present research uses data from a considerably larger sample and a questionnaire that collected more detailed data on livelihoods, as well as for several additional years, so those findings can be accepted or modified here. In any case, the argument is that, following participation in the CCFP program, people may have been even more motivated than before to move away from their origin farms to seek better opportunities. Some household members may have moved within the local area (county), where they are still able to provide farm labor for the origin household when needed, while others migrated out of the county (*Jinzhai County*), mostly to urban areas far from their origin households. Finally, it should be noted that there have been few in-migrants in the township, except for some return-migrants. Thus, overall, the study area is a major migrant-sending region to urban destinations.

3.4 Research questions and hypotheses

Based on the migration theories and understanding of the study area from multiple visits, the study here investigates rural out-migration in Tiantangzhai Township by asking the following research questions: What are the levels of out-migration, and the characteristics of migrants compared to non-migrants? What are the driving factors that influence individuals' out-migration decisions? What are the effects of the PES programs on this out-migration? To answer these questions, the study develops an empirical model of the determinants of out-migration to test hypotheses about various potentially influential factors. It is hypothesized that the migration decision of an individual is affected by personal attributes, household characteristics and contextual factors at the community level.

At the individual level, it is hypothesized that out-migrants tend to be relatively young, single, educated and male as these attributes are more favored by employers in urban areas. However, females who are single may also be associated with a high likelihood of migration since they are less restricted by family matters than those who are married. At the household level, the human capital of the household head is hypothesized to have influence on the migration decisions of other household members, because it is associated with more access to information and awareness of opportunities elsewhere, and higher aspirations for children. Accessibility of the house to the township center and previous migration experience of any household member other than the person in question is hypothesized to positively influence migration as each decreases migration costs. Household size itself may be positively associated with individual out-migration since a large household size is more likely to have surplus labor, controlling for farm size. The amount of land a household has and the areas engaged in cropland cultivation or raising animals are hypothesized to be negatively associated with out-migration since they offer opportunities for work to household members.

In addition to these traditional factors that might influence out-migration, in this study it is particularly interesting to test the hypotheses that the two PES forest policies (i.e., CCFP and EWFP) as exogenous factors affect individual migration, one way or another. Thus the amount of compensation from

either the CCFP or EWFP may be positively related to out-migration by providing financial support. The elevation of the household is also included, though this is likely to have some collinearity with the access variables in this mountainous setting. Finally, at the contextual or community level, accessibility of the community to a hospital and a primary school is hypothesized to be negatively related to migration because it reduces the incentive to migrate to gain easier access to schools or health care. Thus the lack of a close school or health facility (as well as of other community infrastructure) may serve as "push" factors.

3.5 Data sources

The study draws on data collected primarily from a household survey conducted in Tiantangzhai Township in the summer of 2014. A fairly comprehensive questionnaire with 22 sections was designed to obtain socio-economic data at the individual and household level, on demographic characteristics, land available and agricultural activities, household living conditions, participation in PES programs (i.e., EWFP and CCFP), etc. Households participating and not participating in the CCFP program were both sampled and interviewed for the comparison of the two groups, as described above.

Since migration was one of the topics of major interest in the survey, two sections were designed in the questionnaire to capture information relevant to it: a roster of household members and a section on out-migrants of the household. Before the interviews during training, it was necessary to clarify definitions of key terms for interviewers in order to collect consistent information. An *out-migrant* was defined as a person who was a member of the household prior to migration, who had left the household at age 15-59 to live outside the county (*Jinzhai* County) for at least 6 months at some time since 2000 and at the time of interview was still living outside the county. A *non-migrant* was defined as a person who never left the household to live away for at least 6 months and who is currently living in the household at the time of interview. The age range of 15-59 at the time of leaving is the focus of interest in the study as the migration analysis focuses on those involved in the decision-making process (not dependent children), and exclude the elderly. In order to understand why some household members left while others did not in a particular year, the questionnaire obtained the retrospective data (age, gender, education, and marital status) for not

only the *out-migrant* but also a randomly-selected *non-migrant* (when available) in the migrant household pertaining to the time of migration of the household migrant. In survey households with no out-migrant over the period—less than half—data were collected for a randomly selected non-migrant aged 15-59 pertaining to his/her situation five years prior to the survey, or near to the midpoint of migration of the migrants observed. This is about the best that can be done to create an appropriate comparison population of non-migrants, and is an important contribution of the project methodology as it contrasts with the universal practice to date of collecting data for non-migrants only pertaining to the time of the survey. This is evidently not appropriate since the at-risk group of non-migrants not migrating when others did is the population of non-migrants available at the time of migration of the migrants[1].

In addition to the household survey, a survey at the community (i.e., resident group) level was conducted using a structured questionnaire. The resident group leader(s) were interviewed for each resident group sampled in the household survey, to obtain information resident group size (i.e., number of households) and geographic factors such as accessibility to the nearest hospital/clinic and primary school.

3.6 Sampling design

Due to fact that the proportion of households in the CCFP in the study region is low (about 17%), disproportionate random sampling is used in order to generate a sample with roughly similar numbers of households participating in the CCFP and not participating. This is a key part of the project methodology and is not common in field surveys, which overwhelmingly tend to select households with equal probabilities of selection. But that is very inefficient when one is interested in particular kinds of households and data are available in a sampling frame to identify those households—in this case, households with and without CCFP. Such a sampling frame was indeed available, as the county forestry office provided data on the names of all household heads, their resident group, and whether they are receiving or not CCFP. A two-stage sampling strategy is adopted, with the first stage being communities (i.e., resident groups) and the

[1] See Bilsborrow et al. (1984, 1997) and Bilsborrow (2016). This continues to be an issue in the design of migration surveys and the analysis of the determinants of migration based on the survey data.

second stage, households. Based on the availability of human and financial resources and estimated costs of fieldwork, the goal of the household survey was set to interview approximately 500 households, without replacement of absent or refusing households since that all-too-common practice distorts the principle of probability sampling which requires that the a priori probability of selection of each household be known before doing the fieldwork. The selection of households needed to take into account knowledge gained from a prior, smaller survey in the same general study region which found that many households were not available due to the whole household having out-migrated to live elsewhere or the lack of an adequate respondent due to temporary absence (or in a few cases to old-age senility of the remaining adult(s) living in the sampled dwelling). Accordingly, the original goal was to select a sample of about 750 households in order to obtain complete data from a sample of around 500 households, taking into account the expected problems above as well as normal refusals and incomplete responses.

Based on the average number of households in a resident group and the dispersion of resident groups, it is estimated that the number of resident groups to be sampled should be 40, both to reach the total number of households in the sample (750) and to ensure a broad geographic distribution of households in the study area. It is also estimated that a team of five interviewers could, contact about 20 households per day, completing about 13 on average. Therefore, the sampling approach first selected 40 resident groups out of the total 165, and then selected up to 20 households from each sampled resident group.

At the first stage of sampling, resident groups were stratified into five strata according to the proportion of households enrolled in CCFP. By taking into account the stratum size and the mean proportion of CCFP participation, resident groups were randomly selected from each stratum. Given the low CCFP enrollment rate in the Township and the project goal to select about the same numbers of household with and without CCFP, resident groups were oversampled from strata with higher proportions of enrolled households, i.e., with probabilities of selection disproportionate to the stratum proportion enrolled in CCFP (see Table A3.1 in Appendix for details). Thus, the reciprocal of the fractions used to sample households of each of the two types within each resident group is the sampling weight for that type of household in the

sample resident group in the stratum, i.e., the ratio of the total number of resident groups in a stratum to the number sampled resident groups.

At the second sampling stage, a maximum of 20 households from each of the 40 sampled resident groups was selected. For resident groups that had fewer than 20 households, all households were selected. For households with more than 20 households, 10 households were randomly select representing CCFP households and non-CCFP households. If one of the two types of households had fewer than ten households, all were selected, and additional households would be randomly selected from the other group comprising the remaining households to make it a 20 household sample in total. For example, if a resident group has 30 households, with 25 enrolled in CCFP and 5 not enrolled, the 20 household sample size would include all 5 households that were not enrolled in CCFP, and an additional 15 households randomly selected from the 25 CCFP households. Each household sampled in a resident group therefore carries a resident group weight for its type (CCFP or non-CCFP), which depends on both the number of households of its type in its resident group and the number successfully interviewed. The weights are calculated as the ratio of the number of total households in a resident group to the number successfully interviewed, separately for CCFP and non-CCFP households in each resident group (see Table A3.2 in Appendix for details). The final result of this sampling process, and the actual fieldwork, was that the team of interviewers successfully interviewed 481 households, 56% participating in the CCFP, yielding data for 1957 individuals in total.

3.7 Analytical and statistical methods

The temporal trend of out-migration was estimated by calculating the proportion of persons aged 15-59 out-migrating each year of those available at that at-risk age group for out-migrating in sample households each year. The time period was set to 2000-2014 to allow a lag in migration decisions of one year. However, the survey was carried out in the summer of 2014 and hence could only track migration through the first half of 2014. Thus, the out-migrants in the survey could be assumed to cover 50% of the total out-migrants in 2014. The time period also includes two years before actual CCFP implementation, so out-migrants in 2000-2002 were also counted in the temporal analysis, which resulted in a total of 1,236

individuals aged 15-59 at some time in the study period and at risk of out-migration, with nearly half (589) out-migrating at some time in the interval. The reason for including 2000-02 is to show the prevailing level of out-migration right before the implementation of PES policies. The temporal trends of out-migration were compared between 1) households participating in CCFP and those not, and 2) households receiving EWFP payment above the average and those below the average (470 Yuan per household), since virtually all households in the sample received some EWFP payment.

In terms of analyzing the determinants of migration decisions, the theories reviewed briefly above show that individual attributes are likely to be important in decisions of whether to migrate or not. Thus, it is important to compare individual characteristics (i.e., gender, age, education and marital status) between out-migrants and people who did not migrate out for people aged 15-59. For marital status, individuals divorced or widowed (a very small percentage of the total, 3.5%) were combined into the category of single, because they are more like single persons than married ones in not being tied down by a partner. Since the CCFP was implemented starting in 2002 and the aim here is to investigate its effects on migration, individuals in study households aged 15-59 in any years in the time period 2003-2014 are included in the model in those years. The reason of excluding the year of 2002 is that migrants left in 2002 depends on information in 2001, which was prior to the implementation of CCFP. This also allow one year lag of effects on migration from the CCFP. This results in 1,137 individuals from 412 households selected for the descriptive comparison as well as statistical modeling. Persons with various characteristics were also tallied for out-migrants and non-migrants. Age was divided into the following five-year age groups: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, and 55-59, while years of education completed was disaggregated into five levels: 0-4, 5, 6-8, 9-11, 12+, which correspond to not finishing primary school, just finished primary school, junior secondary school, senior secondary school, and completed secondary school or some college education, respectively.

Table 3.1 Description of independent variables for modeling out-migration.

Variable	Description
Individual-level	
Gender	0=male, 1=female
Age	Age in years
Education	Whether finished primary school (0=no, 1=yes)
Marital status[§]	Marital status (0=single, divorced or widowed; 1=married)
Single female	Interaction term of gender and marital status
Household (HH)-level	
CCFP payment	Compensation received from CCFP in past 12 months (1,000 yuan)
EWFP payment	Compensation received from EWFP in past 12 months (1,000 yuan)
Gender of HH head	0=male, 1=female
HH Head's age	Age of household head in years
HH Head's education	Whether household head finished primary school (0=no, 1=yes)
HH Head's marital status	0=single, divorced or widowed, 1=married
Elevation	House elevation above sea level (meters)
Walking distance	Walking distance to nearest paved road measured by time (minutes)
Household size	Number of people living in household
Household wellness	Wellness index of household (score range 3-33)
Cultivated land	Total area of land under cultivation (mu)
Previous migration	Whether any current member who aged 15+ of household has previous out-migration experience (0=no, 1=yes)
Animal sale	Whether household has any income from selling domestic animals in past 12 months (0=no, 1=yes)
Local off-farm work	Whether any household member was engaged in local off-farm employment in past 12 months (0=no, 1=yes)
Use forest resources	Whether household extracted forest resources, such as herbal medicines, in past 12 months (0=no, 1=yes)
Community (RG)-level	
Community size	Number of households in resident group
Distance to school	Distance to nearest primary school measured in walking time (minutes)
Distance to hospital	Distance to nearest hospital or clinic measured in walking time (minutes)

[§] Single individuals (=0) includes those who are single, divorced or widowed at the time of reference; however, divorced and widowed made up a trivial proportion of the total.

The effects of the various hypothesized factors at multiple levels on out-migration is estimated by a multivariate multilevel model. Multilevel models are used for analyzing hierarchically structured data, such as for modeling the determinants of decisions made by individuals within households nested in communities (Goldstein, 1994; J. Zhu, 1998; Yang & Guo, 1999; Raudenbush & Bryk, 2002). An individual's decision about whether or not to migrate depends on not only his/her personal attributes (e.g.,

age, education) and household characteristics (e.g., number of people in the household) but also contextual factors at the community level (e.g., distance to the nearest school). Thus, a multilevel model is appropriate for capturing the nested relationships of individual out-migration decisions being made based on a hierarchy of individual, household, and community factors.

In this study, the dependent variable is whether an individual migrated out (=1) or not (=0) in a given year. As the dependent variable is dichotomous, logistic regression is used for parameter estimation. Independent variables examined at the individual level are personal attributes, viz., gender, age, education and marital status. An interaction term of gender and marital status (i.e., single female) is also included to examine if there is an interaction effect of gender and marital status—to capture if there is an effect beyond the direct effects of gender and marital status.

Variables at the household level include attributes of the household head (i.e., gender, age, education and marital status), size of farm land area, household elevation and walking distance to the nearest paved road, household size, household wellness, and whether any other (current or former) member of the household had migrated away previously. The model also includes variables reflecting household engagement (that is, of any member) in any of several main types of livelihood activities in the 12 months prior to the interview, including whether sold animals, whether engaged in local off-farm work, and whether extracted forest resources. The effects of PES programs are modeled based on the *amount of payment received* by the household from the CCFP and EWFP in the past 12 months.

Potentially relevant variables collected at the resident group or community level include community size and accessibility to facilities such as hospitals and primary schools. The form of the model used is expressed in Equation (3.1).

$$M_{ijk} = f(I_{ijk}, H_{jk}, C_k) \tag{3.1}$$

where M_{ijk} denotes out-migration (yes=1; no=0) for the i^{th} individual in the j^{th} household from the k^{th} community (i.e., resident group); *I* refers to individual attributes; *H* to household characteristics, and *C* to community-level or contextual factors. Note that the *t* subscript for the year is excluded for simplicity in

Equation (3.1). Note also that the model is estimated based on 1,137 individuals aged 15-59 for some years and exposed to the risk of out-migration during 2003-14. Apart from age, which is tracked for each person, and household size, which varies with out-migration and return migration (and occasional deaths), the model implicitly assumes that the characteristics of the individual, household and community as recorded at the time of the survey in 2014 did not change over time, *except* for the key individual and household characteristics specifically obtained in the questionnaire pertaining to the *time of migration*[2]. In fact, it is known that one key variable, total land (in crops, in forest) available to the household rarely changed over time, since the government allocated fixed amounts to households with long-term (99 year) leases, and households, even when members leave including all members, make sure some relative stays behind to continue to lay claim to the land for the household, to retain its *hukou* or legal household registration (Y. Zhu, 2007). The list of independent variables at each level with detailed descriptions is presented in Table 3.1. Note that all data at the individual/household level are weighted in the multivariate model.

3.8 Results and Discussion

3.8.1 Temporal trend

A graph showing the percentage of persons in households with and without CCFP exposed to the risk of out-migration (aged 15-59) who out-migrated in each year shows out-migration to be generally increasing over time during 2000-13 (Fig. 3.2, top panel). Looking at the annual fluctuations for the CCFP households (solid) line, there is a moderate increase immediately after 2002 when the CCFP was first implemented, followed by a second surge in 2010 when the first 8-years of registration was completed, and people could register for a second 8-year participation in CCFP. The larger apparent increase after 10 years of the implementation of the CCFP in 2013 is likely due partly to respondents remembering and reporting out-migration better in the most recent year. The dip in 2008 might be due to the impact of the global economic recession.

[2] If a person migrated more than one, the questionnaire obtained the data pertaining only to the last migration.

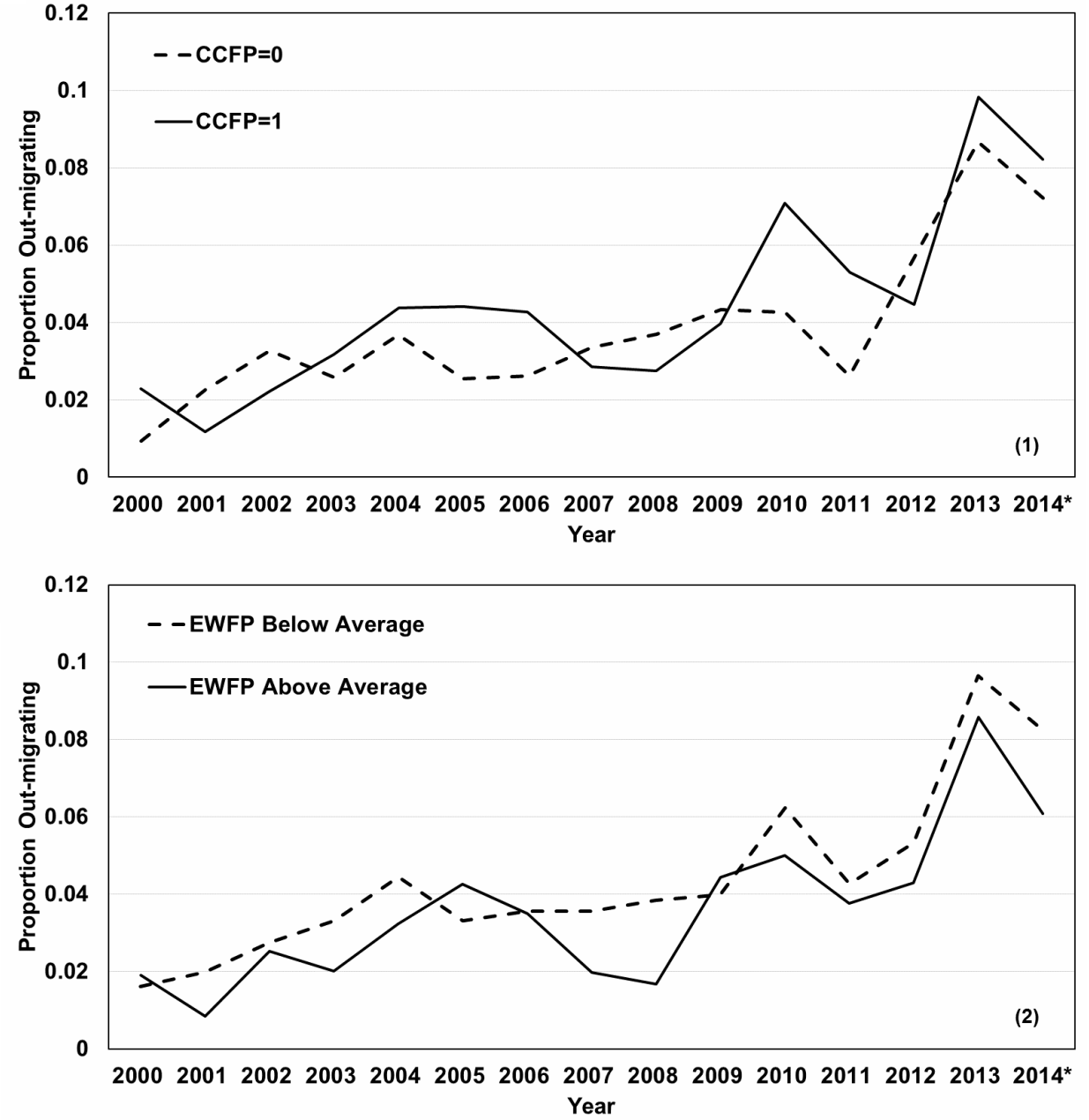

Figure 3.2 Proportion of household members aged 15-59 out-migrating each year during 2000-14 for (panel 1) households with and without CCFP; (panel 2) households receiving EWFP payments above and below the mean. The asterisk for 2014 indicates that data were available only for the first half of 2014 since the survey was carried out in July 2014. The height of the observation for 2014 is annualized to be comparable with other years.

The interpretation now moves on to compare the two lines on the probabilities of out-migration from households with and without the CCFP, still in the top panel. On the one hand, the proportion of out-migrants from CCFP-participating households was overall higher than that from households not participating after 2002. During 2009-10, however, the out-migration rate from CCFP households increased and reached a small peak while the rate from non-CCFP households remained the same. This may be due to households receiving the modest CCFP payment recovering more quickly from the economic recession. However, both groups had a sharp increase in out-migration in 2012-2013, which might be linked to a major rural economic stimulus program[3] of the central government. There was a huge surge in real estate development from the stimulus, attracting rural labor for construction.

The lower panel of figure 3.2 provides a *prima facie* assessment of whether the amount of money received by households from the second PES program, the Ecological Welfare Forest Program (EWFP), has had any evident effect on stimulating or not out-migration. Since all households received EWFP compensation, the comparing analysis examined whether those receiving *more than the average* were more likely to have out-migrants than those receiving less than the average. The two almost parallel lines suggest the difference is small, but that those receiving more were in general *less* likely to have out-migrants, though this was also true prior to the PES program in 2000-2002. Thus the difference in out-migration rates is the opposite to that of CCFP payments. This is probably because households who received more compensation from the EWFP are more satisfied with rural living conditions and thus less likely to send out-migrants. Another key difference between EWFP and CCFP is that EWFP has no impact on freeing farm labor as does the CCFP, by taking cultivable land out of cultivation to reforest it.

[3] The State Council of the People's Republic of China announced the economic stimulus plan on 9 November 2008 (Csanádi, Nie, & Li, 2015).

3.8.2 Descriptive analysis

Of the 1,137 individuals aged 15-59, 516 persons were out-migrants during 2002-14 according to the above definition (Table 3.2). Compared to non-migrants, out-migrants tend to be more male, younger, more educated, and not married (including divorced and widowed). All four of these individual attributes shown in Table 3.2 were very similar for those from CCFP households and non-CCFP households, for both non-migrants and out-migrants. Examining male-female differences of non-migrants and out-migrants, in the lower panel of Table 3.2, however, reveals only small differences in age, with males older than females by 3 years for both out-migrants and non-migrants, and both male and female migrants 15 years younger than their non-migrant counterparts. The gender disaggregation reveals that the education gap between males and females is very small for the more educated migrants (a gap of barely over one-third of a year) compared to the gap for non-migrants of over 2 years. This is an extraordinary difference, and perhaps suggests that there may be much more equality in gender roles among rural out-migrants than among non-migrants. Thus those who migrate are already "different" from those that do not, the latter tending to having more traditional values. Finally, while marital status is similar for non-migrant males and females, it differs for migrant males and females, and in a surprising way: migrant females are more likely to be married than migrant males. Since there are more males than females migrating, this may suggest that the majority of women migrating do so with (or following) their husbands, and that the "surplus" single migrants are mostly males.

The data on the differences between out-migrants and non-migrants in the top panel of Table 3.2 are presented in more detail and schematically in Figure 3.3, showing graphically the extent of the differences. Specifically, out-migrants were more likely to be male while non-migrants were more likely to be female, but the difference is not huge, as it is in many developing countries (Alisson F. Barbieri & Carr, 2005). On the other hand, the differences between migrants and non-migrants for the other three individual attributes are huge, with out-migrants much younger (the age of most being15-34 hence in the first half of the 15-59 study population), while most of the non-migrants are aged 40-59, or in the latter half of the 15-

59 at risk population. As for education, the mode or most common level of the whole adult population is middle school (6-8 years), but with most of the non-migrants having less education than that and few with more education, in contrast to most of the migrants not at that middle level having more rather than less education. A considerable number of rural people quit school before finishing middle school to work on the farm or find jobs to support their families (P. H. Brown & Park, 2002), which occurs throughout rural areas of developing countries. As for marital status, out-migrants have a much higher percentage of single (never married) persons compared to non-migrants, suggesting single individuals who are less tied down to a partner are more likely to migrate than married persons.

Table 3.2 Mean values of individual-level variables for out-migrants and non-migrants aged 15-59 at the time of migration/non-migration, by CCFP participation and by gender.

Variable	Out-Migrants (N=516)		Non-Migrants (N=621)	
CCFP participation	CCFP=1	CCFP=0	CCFP=1	CCFP=0
Gender	0.47	0.41	0.55	0.54
Age	28.6	28.8	43.0	43.5
Education (years)	8.36	8.23	5.43	5.43
Marital status	0.56	0.57	0.85	0.87
N	209	307	278	343
Gender	Male	Female	Male	Female
Age	30.1	27.0	44.9	42.0
Education (years)	8.45	8.08	6.53	4.51
Marital status	0.53	0.62	0.83	0.88
N	290	226	282	339

Gender: percentage of female
Age and Education: in years completed
Marital status: percentage of individuals currently married (not including divorced or widowed)
N: number of individuals

A more comprehensive descriptive statistical analysis of differences between migrants and non-migrants is found in Table 3.3, showing values of means, standard deviations, minimum and maximum values, and whether the differences in means are statistically significant. This is done for not only individual attributes and household characteristics but for community-level factors as well. The top of the table shows the significant differences in individual attributes, with out-migrants to be male, younger, more educated

and single. For example, out-migrants are about 15 years younger on average than non-migrants, which is expected because younger individuals are favored by employers offering jobs in urban areas, while at the same time younger persons are more likely to move and take risks. The percentage female for out-migrants (44%) is significantly lower than that for non-migrants (55%), and the percentage of people married (of both genders together) is much higher for non-migrants, as shown. Nevertheless, the percentage of single females is higher for out-migrants (17%) than non-migrants (6%), which is probably because single women are less tied to house work and caring for a child or the elderly. By comparing the marital status for both genders, it seems that single males are more likely to out-migrate than married ones as well.

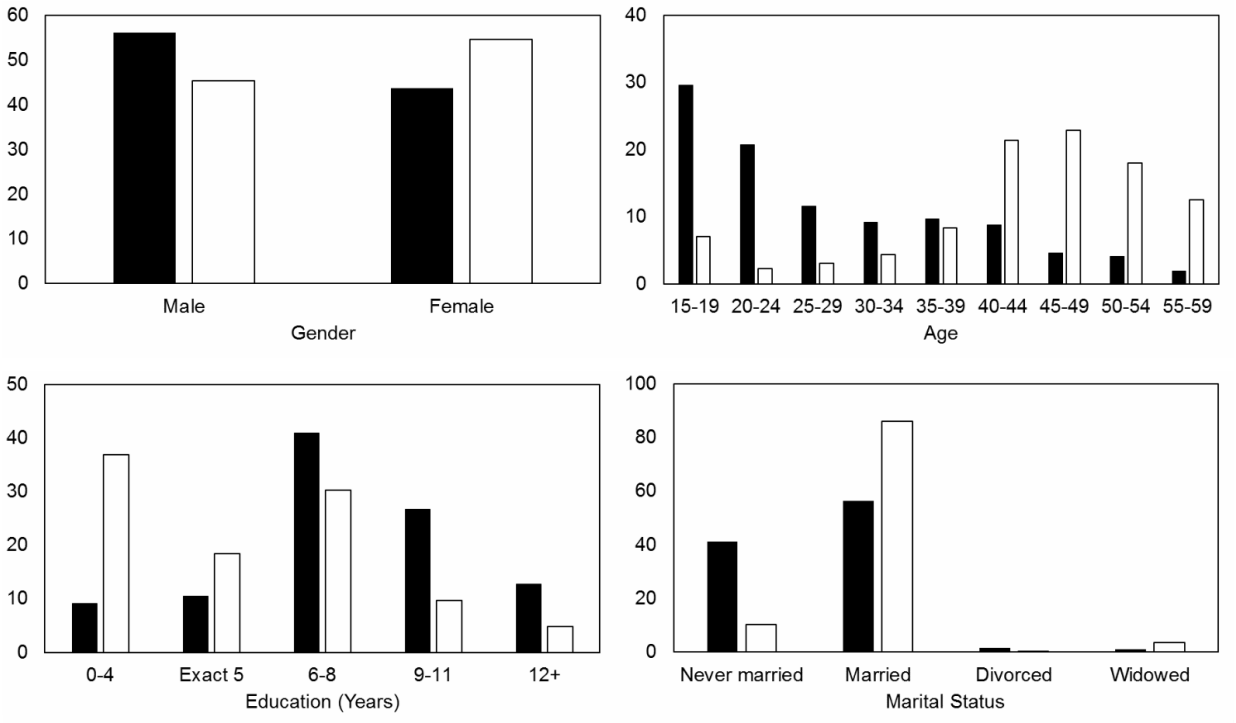

Figure 3.3 Personal attributes of gender, age, education and marital status for non-migrants and out-migrants aged 15-59. The y-axis is the percentage of individuals. Black histogram bars indicate out-migrants, and white bars indicate non-migrants.

Table 3.3 Means, standard deviations, minimum and maximum values of variables for out-migrants and non-migrants aged 15-59 in Tiantangzhai Township (asterisks indicate when differences between migrants and non-migrants are statistically significant).

Variable	Out-Migrants (N=516)				Non-Migrants (N=621)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Individual-level (N=1,137)								
Gender***	0.44	0.50	0	1	0.55	0.50	0	1
Age***	28.7	11.4	15	59	43.3	10.9	15	59
Education***	0.91	0.29	0	1	0.63	0.48	0	1
Marital status***	0.57	0.50	0	1	0.86	0.35	0	1
Single female***	0.17	0.37	0	1	0.06	0.24	0	1
Household-level (N=412)								
CCFP payment†	0.16	0.21	0	1.13	0.14	0.19	0	1.13
EWFP payment**	0.44	0.54	0.02	4.15	0.54	0.68	0.02	4.15
Gender of HH head	0.06	0.23	0	1	0.04	0.19	0	1
HH Head's age***	51.8	9.4	14	81	47.9	8.6	10	79
HH Head's education	0.77	0.42	0	1	0.74	0.44	0	1
HH Head's marital status**	0.88	0.32	0	1	0.94	0.25	0	1
House elevation	666	105	414	974	679	103	413	974
Walking distance	11.0	14.8	1	90	11.7	14.1	1	80
Household size	3.75	1.21	1	8	3.69	1.25	1	8
Household wellness	21.0	5.12	3	33	21.2	4.52	7	32
Cultivated land***	4.44	3.37	0	18	5.13	3.22	0	18
Previous migration***	0.41	0.49	0	1	0.25	0.43	0	1
Animal sale	0.15	0.36	0	1	0.18	0.38	0	1
Local off-farm work***	0.51	0.50	0	1	0.67	0.47	0	1
Use forest resources***	0.55	0.50	0	1	0.65	0.48	0	1
Community-level (N=40)								
Community size	26.2	8.7	9	41	25.8	8.6	9	41
Distance to school	20.1	24.4	2	150	20.1	25.6	2	150
Distance to hospital	19.3	16.0	1	60	18.4	15.6	1	60

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Moving on to the household level variables, men constitute the vast majority of household heads, for both households with and without out-migrants, as anticipated from in traditional, rural China. Heads of out-migration households tend to be older, slightly more educated and less likely to be married than those of non-migration households. Older and more educated household heads may provide better financial and information resources to household members interested in out-migration. Households with out-migrating members are more likely to have a former household member with previous migration experience, which

can lower the cost of migration (helping migrant find housing, food, employment). Households with out-migrants received slightly higher payments from the CCFP on average, but significantly lower payments from the EWFP. The difference in CCFP payments is marginally significant, while the difference in EWFP payment is significant at the 5% level. These "migrant-sending" households are also characterized by having less land in cultivation at the time of out-migration, having fewer people working in local off-farm jobs and extracting less from the forest, all suggesting these households are more likely to have free labor. On the other hand, there appears no significant difference between the two groups of households in walking distance to the nearest paved road, household size, households wellness, and whether they sell animals.

Finally, values of the contextual variables examined are similar for households with out-migrants and non-migrants. Therefore, individual and household attributes appear likely *a priori* to be the primary determinants of out-migration.

3.8.3 Determinants of out-migration: multivariate results

Following the discussion above of the bivariate results showing differences in the characteristics of out-migrants and non-migrants, the model of Equation (3.1) above was used to examine the factors linked to the out-migration decision when all variables are included, through a multivariate multilevel model. Results show significant effects of a number of factors at all three levels—certain personal attributes, household characteristics, and contextual factors (Table 3.4). The interpretation first consider the statistical significance of the effects and the signs, and defer to later a discussion of the right-most column on marginal effects.

Beginning with the results for individual attributes, noting first that males, younger persons (among the at-risk population aged 15-59), those with more education, and married persons are more likely to migrate out from rural areas. The results for gender, age and education are fully anticipated by theory and consistent with most prior studies of migrants in developing countries, including China (J. Zhu, 1998; Yang & Guo, 1999; Sun & Fan, 2011). The results for marital status appear surprising at first, but are not when one considers that it is common in rural areas for women to "marry in" (move into the house of their

husband's family/parents, which is usually where he is still living with his parents when he first gets married). Then, after a time, either the husband or both the husband and wife move away to work in urban areas, whether at the same time or the husband going first. In contrast, when an unmarried son or daughter is living with parents, he/she is somewhat less likely to migrate out, in order to help on the farm (and often ultimately taking over, if male). The exception to this is that single women living with their parents are more likely to migrate away than single men, which is captured in the "single female" interaction variable. While in Chinese tradition it is expected that a single daughter is the one responsible for remaining behind to care for elderly parents, it is apparently nowadays more common in rural China for the (male) son to do so, likely related to the physical advantages of the son in managing a farm. Thus despite the overall negative relationship between out-migration and female gender, a *single* female is 265% more likely to out-migrate, once all the other factors are taken into account. In sum, as in most of rural China, married women are more likely to stay home to take care of any children, particularly up to when they start to go to school at age 5 or 6, while their husbands migrate-out to earn a higher income to support the family through remittances (J. Zhu, 1998).

Moving on to the large number of household variables postulated to possibly affect migration, first, there are several pertaining to the same four attributes of the household head. Thus certain characteristics of the head may affect the likelihood and specification of whether and who migrates away from the house, for the wellbeing of the household and possibly as well of the individual migrant. It turns out that only one of the four attributes of the head is associated with out-migration, with *older* age significantly increasing the probability of out-migration, while gender, education, and marital status of the household head do not have significant effects. It might be anticipated that older heads would be associated with *less* out-migration of other household members (children), who should stay behind to care for them, but in most cases, the older heads in the study population are not so old (mostly 40-65) and in decent health so that is not an issue. In contrast, as the heads move on from their 20's and 30's into their 40's and 50's, their households are likely to become better off due to having more experience in farming and/or off-farm work, and hence more

able to even provide initial travel support and assistance to an out-migrating son or daughter compared to younger heads.

Table 3.4 Results (odds ratios and marginal effects) for determinants of out-migration from the multivariate multilevel model.

Variables[§]	Odds Ratio (*Robust Std. Err.*)	z	P>|z|	Marginal Effect[¶]
Individual-level (N=1,137)				
Gender	0.21 (*0.07*)	-4.87	0.000***	-0.3142
Age	0.85 (*0.01*)	-10.01	0.000***	-0.0332
Education	3.08 (*1.59*)	2.17	0.030*	0.2081
Marital status	3.73 (*2.21*)	2.23	0.026*	0.2414
Single female	3.65 (*2.26*)	2.10	0.036*	0.2855
Household-level (N=412)				
CCFP payment	4.78 (*2.71*)	2.76	0.006**	0.3223
EWFP payment	0.60 (*0.09*)	-3.32	0.001**	-0.1068
Gender of HH head	0.20 (*0.20*)	-1.62	0.105	-0.2440
HH Head's age	1.13 (*0.03*)	5.32	0.000***	0.0251
HH Head's education	1.53 (*0.57*)	1.14	0.256	0.0837
HH Head's marital status	0.32 (*0.29*)	-1.25	0.212	-0.2527
House Elevation	1.00 (*0.00*)	0.42	0.672	0.0003
Walking distance	0.97 (*0.02*)	-1.32	0.186	-0.0056
Household size	1.06 (*0.11*)	0.58	0.560	0.0120
Household wellness	0.99 (*0.03*)	-0.39	0.698	-0.0024
Cultivated land	0.85 (*0.04*)	-3.56	0.000***	-0.0339
Previous migration	3.48 (*0.92*)	4.73	0.000***	0.2676
Animal sale	0.62 (*0.20*)	-1.47	0.142	-0.0939
Local off-farm work	0.25 (*0.12*)	-2.99	0.003**	-0.2991
Use forest resources	1.23 (*0.42*)	0.60	0.548	0.0425
Community-level (N=40)				
Community size	1.01 (*0.02*)	0.46	0.642	0.0018
Distance to school	1.01 (*0.00*)	1.72	0.086†	0.0017
Distance to hospital	1.02 (*0.01*)	2.52	0.012*	0.0035
Intercept	0.33 (*1.26*)	-0.29	0.772	-
Intercept variance	0.40 (*0.26*)			

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The log pseudo-likelihood is -3629.2 and the Wald Chi^2 is 1752.8 with p-value 0.000.

§ All data used in the model are weighted.

¶ Marginal effects are the effects on probabilities of out-migration when the other variables are at their means.

Among the other household variables, a number do *not* have statistically significant effects, including household elevation, household size, walking distance to the nearest paved road (further discussed below) and household wellness. In many other developing countries where household sizes are often large, one observes a positive relation with out-migration, as it provides a way for the household to diversify its income sources, on the one hand, and when landholdings are minimal, may alleviate food consumption deficiencies (L. A. Brown & Lawson, 1985; Braimoh, 2004; Richard E. Bilsborrow, Barbieri, & Pan, 2004; Alisson Flávio Barbieri et al., 2009). The lack of an effect in China is likely due to family sizes being so small. In contrast, when the household has a former member migrating out significantly increases the likelihood (by 2.5 times) of another member out-migrating. This is because prior migrants can offer assistance and information, which can lower the costs of migration for subsequent prospective out-migrants, as hypothesized (Massey, 1990; Alisson Flávio Barbieri et al., 2009).

In terms of the livelihood variables, households with larger areas of land in cultivation or a household member engaged in local off-farm work are much less likely to send an out migrant, as these livelihood activities require labor. In contrast, using forest resources or selling animals does not have significant effects, doubtless because in China these are not significant sources of income, and rather serve as minor supplements.

Moving on to the two key policy variables in this study, reflecting the PES programs, both CCFP and EWFP payments have significant effects on individual out-migration, but surprisingly *their effects are opposite*. For households in the CCFP, the compensation for enrolling land has a positive effects on out-migration. The mechanism of the CCFP effects involves not only the modest cash compensation but mainly the effects of land use change, from cultivation to reforestation, which has numerous direct and indirect impacts on rural households. First, the subsidy provides poor households with a little financial support, which could be used to cover the initial costs of out-migration, such as transportation and labor market searching (Curran & Rivero-Fuentes, 2003). Second, and clearly the dominant effect (see below), the reduction in cultivated cropland can free up farm labor for other activities, including out-migration (Uchida et al., 2009; Groom & Palmer, 2012). Indeed, unless land- and labor-intensifying technological change is

adopted on the remaining farmland the household has, the decline in the cropped area reduces the household's demand for labor[4]. Like most rural areas in China, farmers in Tiantanzhai Township used to be constrained to remain on their land due to insecure land tenure (Mullan et al., 2011), but this is no longer the case as they tend to have 99 year leases to the land.

The EWFP, on the other hand, statistically has an opposite albeit far smaller effect on out-migration from rural households, compared to the CCFP. This may be attributed partly to the fact that the mean payment of the EWFP (about 470 yuan/year) almost triples the mean CCFP payment (about 150 yuan/year) in the township (Table 3.3). Although the compensation *rate* is low (8.75 Yuan/mu/year), the mean *area* of EWFP forests (47 mu) owned by households is far larger than that of CCFP land (1.14 mu). Local forest station records indicate that the maximum amount of EWFP compensation in the study region is more than 10,000 yuan. Such amounts, even the mean of 470 yuan provide meaningful support for a rural household, making additional income from out-migrant remittances much less needed than in those households receiving less EWFP compensation even if they receive CCFP compensation, given how small the latter tends to be. Note that the EWFP program has no effect at all on freeing-up farm labor, as EWFP does not involve cropland as CCFP does. Households receiving the higher amounts of EWFP compensation due to having more forested lands are located higher up in the mountains, and hence farther from roads, contributing to the lack of the expected (positive) effects of two other household variables found to be statistically insignificant above—house elevation and walking distance to the nearest paved road.

Finally, the available community or contextual factors were examine to see what structural factors may condition out-migration of people from the 40 rural resident groups, apart from their individual and household characteristics. Although no differences in community mean characteristics were observed between households with out-migrants and those without out-migrants, in this multivariate study there are interesting significant contextual effects of distance to school (at the 10% level) and hospital (at nearly the 1% level). Due to the lack of educational facilities in the villages and their distance, children usually have

[4] For discussions of land and/or labor intensifying technological change, see, for example, (Boserup, 1965) and (Richard E. Bilsborrow & Geores, 1992, 1994).

to walk far for primary schooling and even move out of their resident groups to the township center for secondary education (to Tiantangzhai), and of course much farther for higher education. Similarly to educational facilities, the lack of or distance to hospital or clinic facilities seems to also have some effect on "pushing" people to move, though this and the education variables may also proxy for the search for better living conditions in general, as other community-level variables were not available. Nevertheless, very similar effects of access to health and education facilities were found in a very different context, the Ecuadorian Amazon (Alisson Flávio Barbieri et al., 2009).

3.8.4 Interpreting the marginal effects

Following up on the discussion of the results for the variables above—statistically significant and not significant—in the right-hand column of Table 3.4, the marginal effects of each independent variable are provided on changing the probability of out-migration, computed at their mean values, in effect keeping all the other independent variables at their mean levels. Thus, for example, among the individual attributes, a woman has about 31% chance less of migrating away than a man in this sample of rural households in China. Someone older than the overall mean age of the at-risk population (around age 35) by 5 years will have about 16% less likelihood of out-migrating. In terms of marital status, a married individual is associated with a 24% higher chance of migrating than a single person, except that a single woman has a 28% greater chance of migrating than a married individual whether male or female. Someone with a completed primary school education or higher (i.e., greater than 5 years in Tiantangzhai) has about a 21% higher chance of out-migrating than one with education less than or equal to 5 years. In the whole Tiantangzhai Township, there is only one middle school, which is in the township center. The lack of a high school stimulates people to move out of the township if they seek more education than middle school. However, they may still remain in the county unless they seek more than a high school education.

Among the statistically significant household variables, if a household has someone who has migrated out before, then the likelihood of someone else out-migrating is 27% higher than it would have been, other things equal. If the age of the household head is 5 years older than the overall mean age of heads,

the household has about a 13% more chance of sending an out-migrant when it has an eligible person. However, having additional 1 mu cultivated land above the mean is associated with a 3% less chance of sending an out-migrant. The small marginal effect of cultivated land (-0.03), albeit significant, may be due to the small land plots cultivated by households in Tiantangzhai. In addition, a household involved in local off-farm work is associated with a 30% smaller chance of having household member out-migrate. It is notable that one of the biggest effects on out-migration is participation in the CCFP program, viz., receiving the small payment for shifting a small amount of farmland back into forest land. An additional 1,000 yuan above the mean CCFP payment of 150 increases the likelihood of out-migration by over 32%, controlling for all other factors. On the other hand, the EWFP program, which has the opposite effects, has about one third the effect (albeit statistically marginal) on out-migration as one additional 1,000 yuan above the mean EWFP total payment of 470 decreases the chance by 11%, other factors being equal.

Finally, for the contextual or resident group effects, it can be seen that their effects, even when significant, are very small in comparison with the effects of the key individual and household factors described above. For example, an additional five minutes walking time above the mean of 20 minutes to the nearest primary school and above the mean of 19 minutes to the nearest hospital is associates with an increase in the probability of out-migration of only 8% and 17%, respectively, controlling other factors.

3.9 Conclusions

Rural out-migration is the key form of migration and a major contributor to the transformation and modernization of the economy in China. This out-migration also likely contributes to poverty reduction among rural households in many areas of China as in most developing countries around the world. But demonstrating this in the case of the study households is beyond the scope of this paper, though it definitely should be examined as there has been little published work on this topic for China.

Over the course of many centuries of civilization, population growth and expanding the occupation of the land area of China has involved vast clearing of forests and other ecological changes, accelerating in the last century. The extensive deforestation led to increasing flooding, loss of life, and major erosion and

soil degradation, pushing policy-makers to develop large-scale, innovative policies to stimulate reforestation, including the use of PES programs to encourage farmers to reforest croplands and protect remaining forests. A secondary intended impact of China's PES programs is to reduce rural poverty by inducing changes in livelihoods and rural out-migration, to the extent it is followed by important remittances to origin area households. While this study does not examine the issue of remittances directly, it can be presumed that they increase with higher out-migration. The present study conducted a multilevel statistical analysis to model the determinants of out-migration from farm households in one region of China where households have been participating in two PES policy initiatives: the Conversion of Cropland to Forest Program (CCFP) and the Ecological Welfare Forest Program (EFWP).

One important conclusion from these results arises from the finding that CCFP payments are associated with increased out-migration. The main mechanism for this is likely that the CCFP program reduces the area in cropland which reduces the demand for farm labor, which then has other induced effects on rural livelihood strategies, including increased out-migration. These effects (others such as whether off-farm employment rises) are of paramount interest in not only the appraisal of the full effects of the CCFP on rural households and their poverty, but also in the study of human-environment interactions more broadly (Engel et al., 2008; Raymond et al., 2013). These induced effects have not been investigated in prior studies of these PES programs in China (and little studied in other countries as well), but should be to develop a full understanding of the impacts of the PES programs. It is the rural farmers who ultimately make the decisions about land use, who may or may not participate in the PES programs, and who may or may not alter their livelihoods in response—i.e., by out-migration, by changing crops and/or adopting more land-intensive agricultural technologies, and/or by reallocating (remaining, in the case of out-migration) household labor to other uses, such as off-farm work. If the overall consequences of the PES programs are not positive for the participating farm households, whatever their positive effects on re-greening the landscape—they will tend to be non-sustainable: once the subsidies are ended, farmers will be likely to revert to previous behaviors, cutting down forests to expand their cultivated area and also to sell trees commercially (if the EWFP program ends). Studying the factors that affect individual out-migration as a

household livelihood strategy is thus essential to understanding the sustainability or not of such programs on reforestation, where they have been observed to have clear success in China (Uchida et al., 2005; Grosjean & Kontoleon, 2009; Démurger & Wan, 2012). Understanding the relationship between PES programs and out-migration thus is important for environmental policy-makers, as well as for those concerned with rural poverty, inequality and development in general in China.

The factors affecting out-migration from rural households were examined in the study region of central China, drawing on migration theories and experience in the rural China study region. To summarize the main findings, apart from those for the PES variables, the analysis found that the principal factors at the individual level were gender (males somewhat more likely to out-migrate) followed by education; at the household level, the main factors were cultivated land area, involvement of the household in the local labor market, and previous migration experience. The contextual factors available had weaker effects, but greater distance to the nearest primary school or hospital was linked to more out-migration. This suggests policy instruments to expand the provision of schools and health facilities (perhaps small clinics short of full hospitals) in the local area (and/or improve access through improved roads or transportation). For the households high up on the mountain, poor accessibility to schools and hospitals appears to act as "push" factors that adds to the factors that stimulate rural households to send household members away to seek better opportunities.

In the migration model, the inclusion of the PES payment variables directly reflects policy instruments, so the results here should also be useful for the design of future incentive programs. On the one hand, compensation from the CCFP gave the farmers incentives to both improve the environment and adjust their livelihoods. As farm households increasingly adopt out-migration as a response or otherwise alter their livelihoods, there is less likelihood that they will turn reforested land back to cropland. On the other hand, the larger amounts of EWFP payments makes it easier for the more isolated households (with more land in forests) to continue their existing ways of life, reducing incentives for farmers to change or diversify their livelihoods, but only as long as the payments continue. Is that the policy goal? It could be, as a *permanent* subsidy to those living in the mountains, in exchange for their provision of the ecosystem

services provided by their forests, as well as to reduce their poverty. If the goal is to encourage those farmers to diversify their sources of livelihood, or even migrate away from the mountainous rural area, then other policies are desirable. But in the absence of other new policies, if the EWFP payments cease, these farmers would likely need to rely more on farmland (clearing steeply sloped land to increase their area cultivated) and/or engage in commercial logging, selling trees as a source of household income, degrading the ecosystem services the forests provide.

CHAPTER 4

IMPACTS OF PAYMENTS FOR ECOSYSTEM SERVICES ON RURAL LIVELIHOODS

4.1 Introduction

Rural poverty ties closely to environmental degradation (Leonard, 1989; Reardon & Vosti, 1995; Barbier, 2000; Angelsen et al., 2014). In developing countries, for example, rural farmers unsustainably use farmland by using practices that degrade land by leading to soil erosion and nutrient depletion. On the one hand, some may escape the degraded environment by searching for and finding alternative livelihood activities (Richard E. Bilsborrow, 1987; Richard E Bilsborrow, 1992), but other farmers continue to deplete the natural resources that their livelihoods depend on, until they are forced to abandon the land and migrate or perish. In the latter circumstances, the rural poor who deteriorate the environment are trapped in poverty, which is the case in many rural areas of developing countries (Azariadis & Stachurski, 2005; Dasgupta, Deichmann, Meisner, & Wheeler, 2005; Barbier, 2010).

To address the adverse nexus between rural poverty and environmental degradation, payments for ecosystem services (PES) have been widely adopted by policy designers as an innovative approach for environmental conservation. The PES approach provides economic incentives to potential ecosystem service providers in order to secure the provision or maintenance of ecosystem services (Weyerhaeuser et al., 2005; S Wunder et al., 2008). The implementation of PES programs often relates to land use and targets land parcels used by rural households, sometimes in remote areas (X. Chen et al., 2010). Thus, the government acts on behalf of the public by offering payments to rural farmers for environmental conservation. Though the underlying idea of PES is straightforward, putting such programs into practice faces a plethora of challenges (Pattanayak et al., 2010). PES programs are usually designed with dual goals,

first, conserving key ecosystem services, and second, stimulating rural households to change their livelihoods to be more sustainable in the long-run (J. Li, Feldman, Li, & Daily, 2011). The success of PES programs thus depends on whether rural farmers shift or diversify their livelihoods to be more sustainable (Kelly & Huo, 2013). Thus, empirical evidence is needed to evaluate socio-economic outcomes of PES programs.

In the late 1990s, China adopted a series of new forest policies using the PES approach in response to the back-to-back natural disasters of drought and flooding (P. Zhang et al., 2000). These forest policies were initiated with ambitious goals for soil and water conservation (J. Liu et al., 2008). Among all the forest polices, the Conversion of Cropland to Forest Program (CCFP) is regarded as the largest forest restoration program. In the CCFP, participating households convert croplands on steep slopes or otherwise ecologically sensitive areas to forests or grassland and receive compensation from the central government. Since most land parcels are targeted in rural areas, the implementation of the program also intend to alleviate poverty for rural households (Conghe Song et al., 2014). By 2014, the central government has invested about 300 billion Chinese Yuan on CCFP, involving 32 million households (Sate Forestry Administration, 2015; Rodgríguez et al., 2016). In addition to the CCFP, China also adopted new forestry strategies of forest management. One of the policy tools is the Ecological Welfare Forests Program (EWFP), which was initiated with classification-based forest management (Dai et al., 2009). The purpose of the EWFP is to preserve natural forests for sustainable environmental goods and services as part of the welfare for the public in general. In the EWFP, commercial logging is prohibited but households owning EWFP forests can receive payment by giving up timber harvesting privilege. Despite the logging ban, subsistence use of natural forests such as fuelwood collection is permitted for local residents. Thus, the EWFP is essentially a PES program.

The PES programs have brought direct or indirect impact to rural livelihoods. The CCFP alters land use for participating households and releases labor from farming activities. Meanwhile, the EWFP restricts the use of natural forests, stimulating people to rely on other activities than traditional timber harvesting. Moreover, the compensation of the programs serves a financial incentive for rural households to adjust their

income structure. By shifting or diversifying rural livelihoods, farmers may be able to generate income from off-farm activities while minimize risks of falling back to the old livelihood strategy, where a household can be devastated by a single crop failure (Ellis, 2000; Groom & Palmer, 2012).

Since the implementation of the new forest policies, evaluating the socio-economic impact of such PES programs have been attracting great interests (Uchida et al., 2009; J. Li et al., 2011; Y. Liang, Li, Feldman, & Daily, 2012; Kelly & Huo, 2013; Conghe Song et al., 2014; Zhen Liu & Lan, 2015). Some studies found that the CCFP has positive effects on rural livelihoods in terms of income growth and labor shifting (Uchida et al., 2009; Yao, Guo, & Huo, 2009; Kelly & Huo, 2013). For example, the CCFP payments can relax liquidity constraints and thus increase off-farm employment for participating households (Uchida et al., 2009). Other scholars, however, found weak or no evidence of significant effects by the CCFP as households in the program have not necessarily shifted labor from on-farm to off-farm (J. Li et al., 2011; Y. Liang et al., 2012). In some areas, the forest restoration program had also revealed some negative impacts on rural livelihoods and some participating farmers considered their livelihoods worse off (Weyerhaeuser et al., 2005; Wang & Maclaren, 2012). By comparing among three sites, Song et al. (2014) suggested that CCFP compensation can provide a safety net for the rural poor whose livelihoods depends primarily on agriculture and forests. In addition, Li et al. (2011) found that income inequality among CCFP households is lower than that among nonparticipants. Focusing on livelihood diversification, Liu and Lan (2015) suggested that the CCFP increases the extent to which households diversify their livelihoods.

Given mixed results from previous studies, there still exist gaps in understanding the underlying process of rural livelihood changes under the PES programs. This is partially because that changing rural livelihood is a long term process and it needs time for such programs to manifest their effects. Furthermore, the mechanisms of effects vary among different PES programs. This paper aims to narrow the knowledge gap by analyzing rural households' income structure under the PES programs in China. Since 2000, the SLCP and the EWFP have existed for over ten years. It is time to assess their long-term effect on rural livelihoods.

The overall goal of the study is to analyze income levels and structures of rural households following implementation of PES programs (i.e., the CCFP and EWFP). While the study focuses on impacts of the CCFP, the EWFP is also considered as an external factor potentially affecting rural livelihoods. The specific objectives are two-fold. First, the study explores income levels and its decomposition among different sources of income for households with and without CCFP. Then livelihood diversification and the income structures are compared between households with and without CCFP among low-, medium- and high-income households. Second, the study examines income inequality and take one step further by examining how the underlying factors such as human capital contribute to it. The results should provide useful information on the process of rural livelihood change under the PES programs.

4.2 Materials and methods

4.2.1 Study area

The study area, Tiantangzhai Township, is located in a mountainous region in western Anhui Province, China. The area extends over 189 km^2 with elevations ranging from 300-1700m above sea level. The dominant land cover of the township is natural forest, thus the area forms part of the Tianma National Nature Reserve. Natural forests within the reserve are designated as Ecological Welfare Forests and protected from commercial logging by local residents. Due to the beautiful natural scenery, part of the nature reserve has been developed as a tourist attraction.

The township consists of seven administrative villages, comprising over 4,300 households. Households within the same village constitute resident groups. A resident group is generally comprised of 10 to 40 households, who live close to each other and mostly even farmed together on collective farms before the 1980s. With the implementation of the rural household responsibility system in China in the early 1980s, cropland parcels were distributed to each household in the same resident group. Most land parcels in Anhui are small, on sloping terrain and have poor soils. Therefore, the farmers can hardly make ends meet by merely farming.

To generate more income, households are also usually involved in other activities. Some households raise domestic animals such as pigs and ducks or chickens, or extract forest resources, especially *Gastrodia Elata*. *Gastrodia Elata* is a cash crop fungus, which involves high (seed) costs and yields good income. Other households, however, allocate their labor to off-farm activities, either in the local area (both in agriculture as laborers on other farms, or in non-agricultural work) or far away in cities via out-migration. A few households also start local non-farm businesses, such as hotels and convenience stores. In addition, most households receive governmental subsidies in agriculture mainly to partly compensate their costs of farming, and to encourage them to remain on farms. Households also receive elderly subsidies for any household member above age sixty.

In Tiantanzhai Township, the CCFP and the EWFP subsidy payments had been implemented for over ten years by the time of the survey in 2014. The CCFP was initiated in 2002, and about 750 households were enrolled in this program in 2014, almost all joining in the early years. Under the CCFP, households receive 230 yuan per mu (1 mu = 1/15 ha) of cropland converted to forest per year for the first 8-year period, and 125 yuan/mu/year for a second 8-year period following the end of the initial contract period, usually in 2010 (Conghe Song et al., 2014).

The other PES program, EWFP, is associated with the establishment of the nature reserve in the middle 1990s. Due to the mountainous topography, almost all rural households own some natural forest. The establishment of the nature reserve automatically qualifies all natural forests within the reserve to be ecological welfare forest, automatically enrolling the land owners in the EWFP. Households with EWFP forests are compensated at a rate of 8.75 yuan/mu/year for giving up commercial logging and thereby preserving the forest. Because the area of natural forests owned by households varies widely, the amount of compensation received by households from the EWFP area also has wide variation.

4.2.2 Data acquisition, entry and preparation

4.2.2.1 Household survey

This study uses data from a rural household survey in Tiantangzhai Township implemented during the summer of 2014. A disproportionate stratified sampling approach is adopted to select both communities (resident groups) and households within the communities participating and not participating in the CCFP. The goal is to oversample households with CCFP so as to have a final sample with approximately similar numbers of households receiving and not receiving the CCFP subsidy. The survey eventually results in 481 successfully interviewed households with virtually complete data on all items, 271 participating in the CCFP and 210 not participating. Sampled households carried sample weights, so that they represent the household population over the entire study area (see Chapter 3).

Data were collected using structured questionnaires administered by trained university student interviewers. The questionnaire was designed to obtain information on incomes from all known usual sources of rural livelihoods, notably from farm activities (growing crops and raising animals), extracting resources from the forest, business income, income from local off-farm work (agricultural and non-agricultural), income from remittances from out-migrants and others, and income from government subsidies of various types, apart from PES subsidies, as well as miscellaneous income such as bank interest, renting house rooms or receiving gifts. Questions used to capture the incomes and costs of these sources are provided in Appendix Table A4.1.

4.2.2.2 Data estimation and imputation

Analyzing rural livelihoods involves income estimation from multiple activities. Crops harvested and animals owned are not only for sale but also for consumption by the households themselves. Thus, values of self-consumed crops and animals must be estimated to estimate total income from these activities. In this study, the values of the production of crops and animals are estimated by multiplying their quantities by the corresponding unit prices in local markets. Total agricultural income is the sum of incomes from the

sale of crops/animals and the values of items produced for self-consumption (including of crops for animal consumption) (see Appendix Table A4.2).

Missing responses are virtually inevitable during household surveys. Data imputation methods are then needed to complete nonresponses for statistical analysis, to avoid deleting entire households (Brick & Kalton, 1996). In this study, missing values mainly existed for estimating incomes and costs of extracting forest resources, income from remittances, and income from governmental subsidies. In the section on forest resources, two households had missing values for total income and costs of planting *Gastrodia Elata*. The total income of *Gastrodia Elata* was imputed as the mean income of other households in the same resident group, and the costs were estimated as half of that total income, as this was the approximate relationship for households with complete data. For remittances, four households indicated that they received remittances but did provide an amount. These four missing data cases were imputed as the median for remittances of all households receiving remittances in the sample (see Appendix Table A4.3).

Missing data from governmental subsidies were imputed for three types of subsidies (see Appendix Table A4.4). The elderly subsidy was received when the household had a member aged 60 years or older, with the amount of being 660 Yuan/year for each qualified person. The other two types of subsidies (comprehensive and agriculture) were imputed as the means of other households receiving the same subsidy in the same village (i.e., the village mean). An agricultural (or comprehensive) subsidy is paid by the government to any household planting crops. The value of total government subsidies is the sum of all of these subsidies.

4.2.3 Income levels and sources

Before carrying out the analyses of income inequality and livelihood diversification, it is necessary to identify income sources for rural households, which income sources are divided into nine categories: income from raising crops (referred to as the variable, crops) and animals (animals); PES payments (PES); income from extracting forest resources (forest); local non-farm businesses profit (business); local off-farm wage income (Off-farm); remittances from out-migration (remittances); other government subsidies

(subsidies); and other miscellaneous sources of income (other). PES payments is the sum of compensation from both the CCFP and the EWFP, while government subsidies excludes all PES payments. Total income from each sources are then tallied, and summed to get the total for the household, and compare values between households with and without CCFP.

To capture the extent to which rural households diversify their livelihoods, a two-dimension indicator known as the inverse Herfindahl-Hirschman Index (HHI) is used. The index not only considers the number of income sources but also takes into account the share of each source in total income (Zhen Liu & Lan, 2015). This index has been asserted to be an indicator of livelihood diversification suitable for conditions in rural China (Ellis, 2000; Zhao & Barry, 2013). The general equation of the HHI is:

$$HHI = \frac{1}{[sy_1^2 + sy_2^2 + \cdots + sy_n^2]}, \qquad 1 \leq HHI \leq n \tag{4.1}$$

where sy_i (for $i=1, 2, \ldots, n$) is the income share of the i^{th} source and $n = 9$ in this case. The larger the HHI value is, the greater the extent to which a household diversifies its income sources. When total income is evenly distributed to all the income sources, the HHI value reaches the maximum. When there is only one source, HHI = 1, indicating the least diversified income sources.

Households at different income levels may tend to adopt different strategies in livelihood diversification. For example, a rich household may be engaged in a single but lucrative income generation activity, while a poor household may have to engage in many activities to survive, or to minimize risks of single activity since it has little or no capita or savings to fall back on. Thus households are divided based on total income into low-, medium- and high-income levels, with nearly equal numbers of households in each group. First, all households are ranked from the lowest total income to the highest. Then the first 1/3 is designated as the low-income group and the last 1/3 as the high-income group. Finally, the remaining households in the middle form the medium-income group. After the classification, the income shares from different resources are tallied for each group for households with and without CCFP. Among all livelihoods, growing crops is a major activities used to maintain living standards of rural households. To further examine

the impacts of PES programs, the study compares the statistics of land cultivation and costs on farm between households with and without CCFP.

4.2.4 Income inequality and income generation

4.2.4.1 Gini coefficient

The Gini coefficient has been widely used for a long time as an indicator of inequality (Gini, 1912), especially with respect to assets (i.e., land) and income distribution (Leibbrandt, Woolard, & Woolard, 2000). The Gini coefficient can be linked to the Lorenz curve for a geometrical interpretation. First, households are categorized from the lowest to the highest income; then, the Lorenz curve is plotted as the cumulative proportion of income on the vertical or y-axis against the cumulative proportion of households on the horizontal or x-axis. When all households have the same identical income (i.e., even distribution of income), the Lorenz curve appears as a straight line, which is the Line of (Complete) Equality (Gastwirth, 1972). At the other extreme, when one household holds all income and all others have no income, the plotted Lorenz curve is the horizontal axis out to the last person when it shoots up to the Line of Perfect Inequality. The Gini coefficient is the ratio of the area between the Lorenz curve and the Line of Equality, and is hence 0 for perfect equality of incomes and 1.0 when one household has all the income. The Gini coefficient is estimated from the following equation:

$$G = 1 - \sum_{i=1}^{n} (X_i - X_{i-1})(Y_i + Y_{i-1}) \tag{4.2}$$

where n is the number of households, X_i is the cumulated proportion of households, and Y_i is the cumulated proportion of income, for $i = 1, 2, \ldots, n$, with $X_0=0$, $X_1=1$, $Y_0=0$ and $Y_1=1$.

The expression of the Gini coefficient can also be captured by the contribution of multiple components of income (i.e., income sources) to total income inequality. The basic equation for the Gini coefficient based on its components can be written as:

$$G = \sum_{k=1}^{K} S_k R_k G_k \tag{4.3}$$

where S_k is the share of source k income in total income, R_k is the correlation between source k income and total income, and G_k is the inequality of income from source k. While S_k and G_k are positive and less than one, the R_k value falls between negative one and plus one. A negative value of R_k denotes that source k income has a negative correlation with the rank of total income. The larger the product of the three components, the greater the contribution the income source k makes to total income inequality. The equations for these three components can be written as:

$$S_k = \frac{\mu_k}{\mu} \tag{4.4}$$

$$R_k = \frac{cov[Y_k, F(Y)]}{cov[Y_k, F(Y_k)]} \tag{4.5}$$

$$G_k = \frac{2cov[Y_k, F(Y_k)]}{\mu_k} \tag{4.6}$$

where Y and Y_k are total income and source k income, respectively, while μ and μ_k are the means for total income and income from source k, respectively . The *cov* denotes the covariance function and $F(Y)$ denotes the cumulative distribution of total income (Y) or source k income $F(Y_k)$. For example, $F(Y)=f(y_1),\ldots,f(y_n)$ where $f(y_i)$ is the rank of y_i divided by the number of observations (Stark, Taylor, & Yitzhaki, 1986).

In the expression of the Gini coefficient, the concentration coefficient or the "pseudo-Gini" coefficient also plays an important role in revealing the inequality of source k income. The "pseudo-Gini" coefficient (C_k) is the product of R_k and G_k. It mimics the Gini coefficient calculation but re-orders source k income according to the rank of total income (Raffinetti, Siletti, & Achille Vernizzi, 2016). When C_k is greater than G, income from source k expands total income inequality. When C_k is smaller than G, income from source k lower total income inequality. The expression for the pseudo-Gini coefficient can be written as:

$$C_k = R_k G_k = \frac{2cov[Y_k, F(Y)]}{\mu_k} \quad (4.7)$$

Based on the total Gini equation, one may also derive marginal effects of each income source and examine the sensitivity of the overall Gini to a small change in each income source. Suppose there is an exogenous increase in income from source *j* by a certain factor σ_j, the marginal change and its percentage change from income source *j* can be written as, respectively:

$$\frac{\partial G}{\partial \sigma_j} = S_j(R_j G_j - G) \quad (4.8)$$

$$\frac{\partial G}{\partial \sigma_j}(\frac{1}{G}) = \frac{S_j R_j G_j}{G} - S_j \quad (4.9)$$

When the correlation between income from source *j* and total income (i.e., *Rj*) is negative or zero, the marginal change is negative, which will lessen total income inequality. When it is positive, the marginal change is positive, expanding total income inequality.

4.2.4.2 Determinants of income generation and inequality

Underlying factors such as assets and human capital can play critical roles in income generation for rural households and thus contribute to income inequality among households. In this study, a regression-based approach (G. H. Wan, 2002; G. Wan & Zhou, 2005) was used to explore the contributions of various income driving factors to the overall Gini coefficient. Before the actual decomposition, an income generation function should be developed. Based on the theoretical framework and empirical understanding, the study proposes that the income of rural households depends on human capital, labor availability, accessibility to market, physical capital (e.g., land and other assets) and exogenous political-economic factors (i.e., PES programs).

In the model specification, the dependent variable is the natural logarithm of total net income. The determining variables in the model include the highest education among household members, age and age square of the member with the highest education, household size, number of household labor allocated to

farming, number of household labor allocated to off-farm labor, whether has out-migrant since 2003, an index of household assets (Wellness score), walking distance to the nearest paved road in minutes (Access to road), and the total amount of cropland (paddy rice) under cultivation. To analyze the effects of PES programs, the model also includes variables relevant to forest policies, which are EWFP forest areas (EWFP) and CCFP reforested area (CCFP). In many cases, a household member may engage in both farming activities and off-farm work and thus can be regarded as both farm labor and wage earner. During the survey, the interviewers asked the main activity of household members and how many months did household members (aged 12+) involve in off-farm work in the past 12 months. A household member whose main activity is off-farm work for 6+ months is considered as off-farm labor, while a household member whose main activity is farm work with involvement in off-farm work less than 6 months is considered as farm labor. The household wellness score is an indicator based on the condition of the household's dwelling on multiple dimensions, such as main fuel use, household durable assets, sanitary facility, etc.. The index for each household is the sum of its highest score for each category (see Appendix Table A4.5). The interpretation of independent variables with their means and standard deviations is listed in Table 4.5 (in the section of Results and Discussion).

The function is estimated using a mixed effects model, which allows for random effects of the intercept to control for unmeasured differences across resident groups. The model specification can be written as:

$$\ln y_{ij} = \beta_0 + \sum_{p=1}^{P} \beta_p x_{ijp} + \mu_j + \varepsilon_{ij} \qquad (4.10)$$

where $\ln y_{ij}$ is the natural logarithm of total income for the i^{th} household in the j^{th} resident group, and x_{ijp} is the p^{th} predictor for that household. Fixed effects of the intercept and of the independent variables are captured by β_0 and β_p, respectively, with β_p corresponding to x_{ijp}. Random effects at the household level and the resident group level are captured by ε_{ij} and μ_j, respectively.

Given the income generation function, the procedure of decomposition is conducted to derive the contribution of independent variables to the overall Gini (G. H. Wan, 2002; Shorrocks, 2013). First, replace all x_q's (for $q = 1, 2, \ldots, P$) with sample mean $\bar{x}_q$ and predict total income. Let the predicted income be Y_q. Then, let $G(Y_q)$ be the Gini coefficient of Y_q, which can be considered as the contribution of all other independent variables expect one, X_q. Thus, the difference between the Gini of the original income Y and the Gini of the predicted income Y_q, written as $C_q = G(Y) - G(Y_q)$, can be attributed to the effect of the omitted variable, X_q. This effect is referred to as the first round effect of X_q, while the procedure can be extended to as many rounds as the number of all independent variables. For example, at the second round, two variables X_q and X_r are replaced by their means. The second round effect of X_q can be calculated as $C_q = G(Y_r) - G(Y_{qr})$, for $r = 1, 2, \ldots, P$ and $r \neq q$. Within each round, more than one Gini contributing values can be obtained for a certain variable. All values for that variable within the same round are averaged and the mean of the average effects of all rounds is the final effect for that variable.

4.3 Results and Discussion

4.3.1 Income levels and sources

After over ten years of PES implementation, local off-farm income and remittances from out-migrants are generally the two principal sources of income for rural households in Tiantangzhai Township (Fig. 4.1). This suggests that most households have shifted their livelihoods to non-farm activities and rely primarily on local off-farm work and out-migration. However, PES payments account for the least amount of income of all sources. Households participating in the CCFP also have only very slightly higher incomes from local off-farm work and remittances from out-migrants than households not participating. In addition, CCFP households have much higher income from crops, animals, and forest resources, indicating that households who enrolled land in the program also have higher outputs from these activities. Contrary to what was expected, CCFP households received *less* income from business than non-CCFP households,

suggesting the small PES subsidies did not lead to more entrepreneurial activity. Both types of households received similar modest amounts of governmental subsidies (excluding PES subsidies).

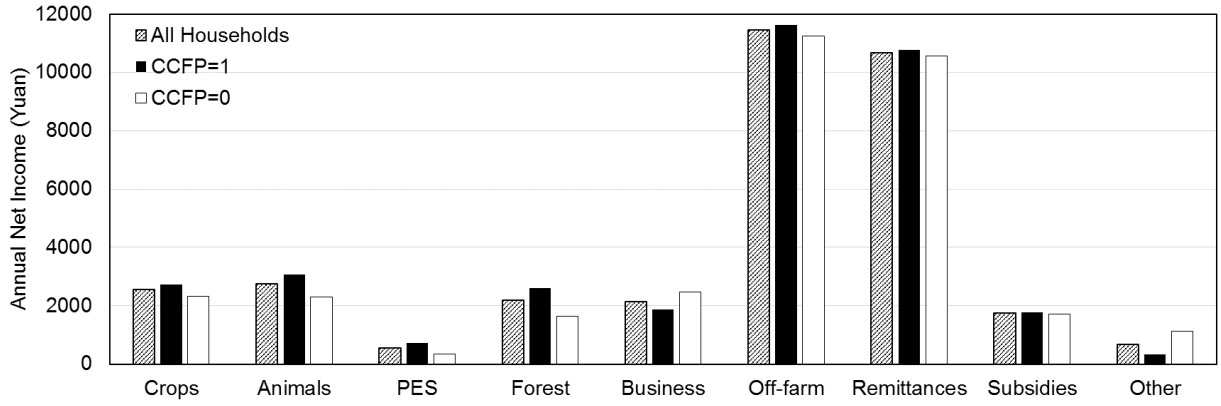

Figure 4.1 Annual income of different sources for rural households (all households), households participating in the CCFP (CCFP=1) and households not participating (CCFP=0). The x-axis denotes the income source.

Table 4.1 Statistics on per capita income from different sources for households with and without CCFP (asterisks indicate when differences in means are statistically significant).

	Variables	CCFP=1 (N=271)		CCFP=0 (N=210)		Difference in Means
		Mean	Std. Dev.	Mean	Std. Dev.	
Per capita source income (unit: 1,000 yuan)						
1	Crops	1.11	1.23	0.92	1.01	0.19†
2	Animals	1.28	2.65	0.87	1.77	0.41*
3	PES payments	0.32	0.35	0.14	0.19	0.18***
4	Forest resources	0.97	2.44	0.63	1.35	0.34†
5	Local non-farm business	0.63	2.73	0.85	4.78	-0.22
6	Local off-farm work	3.75	6.95	3.80	5.50	-0.05
7	Remittances	4.88	11.58	4.67	9.55	0.21
8	Subsidies	0.80	1.73	0.73	1.44	0.07
9	Other income	0.13	0.60	0.34	2.91	-0.21
	TOTAL	13.87	14.26	12.95	12.43	0.91
Livelihoods diversification						
	HHI	2.43	0.99	2.24	0.94	0.19*

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Moving on to per capita income, households participating in the CCFP have a higher per capita income on average than those not participating (Table 4.1). In addition, the value of livelihood diversification index, which is HHI in Equation (4.1), for households with CCFP is significantly higher than that for households without CCFP. Specifically, mean income from crop, animals, forest resources and PES by CCFP households is significantly larger than income from the same sources of nonparticipants. Moreover, households with CCFP receive more remittances and governmental subsidies than nonparticipants, although the differences in means are not significant. However, local non-farm business profit, off-farm income and other income for CCFP households are slightly lower than those for nonparticipants, but the differences are not significant.

In terms of the share of source income, income structure shows different patterns among low-, medium- and high-income groups between households with and without CCFP (Fig. 4.2). Generally, income levels of low-income group are more similar than the other two groups for both households with and without the CCFP. For the low-income group, CCFP households have higher proportions of income from animals, forest, crops and businesses but lower proportions of income from remittances, local off-farm work and governmental subsidies than nonparticipants. This suggests that poor households who are participating in the CCFP receives more PES compensation and are more likely to invest in activities of raising animals or extracting forest resources, which is mainly *Gastrodia Elata*. One possible explanation is that poor households lack the skills and/or capital to enter into non-farm activities (Barrett, Bezuneh, & Aboud, 2001; Zhen Liu & Lan, 2015). Thus poor households enrolled in the CCFP would be trapped into using even scarcer land to cultivate after enrollment, unless the find alternative sources of income or intensify agricultural activities somehow to increase income per unit of land, which increases the diversification of their income sources (Reardon, Berdegué, Barrett, & Stamoulis, 2007). This suggests that CCFP households with low incomes tend to be risk-averse and seek to maximize security by diversifying livelihoods.

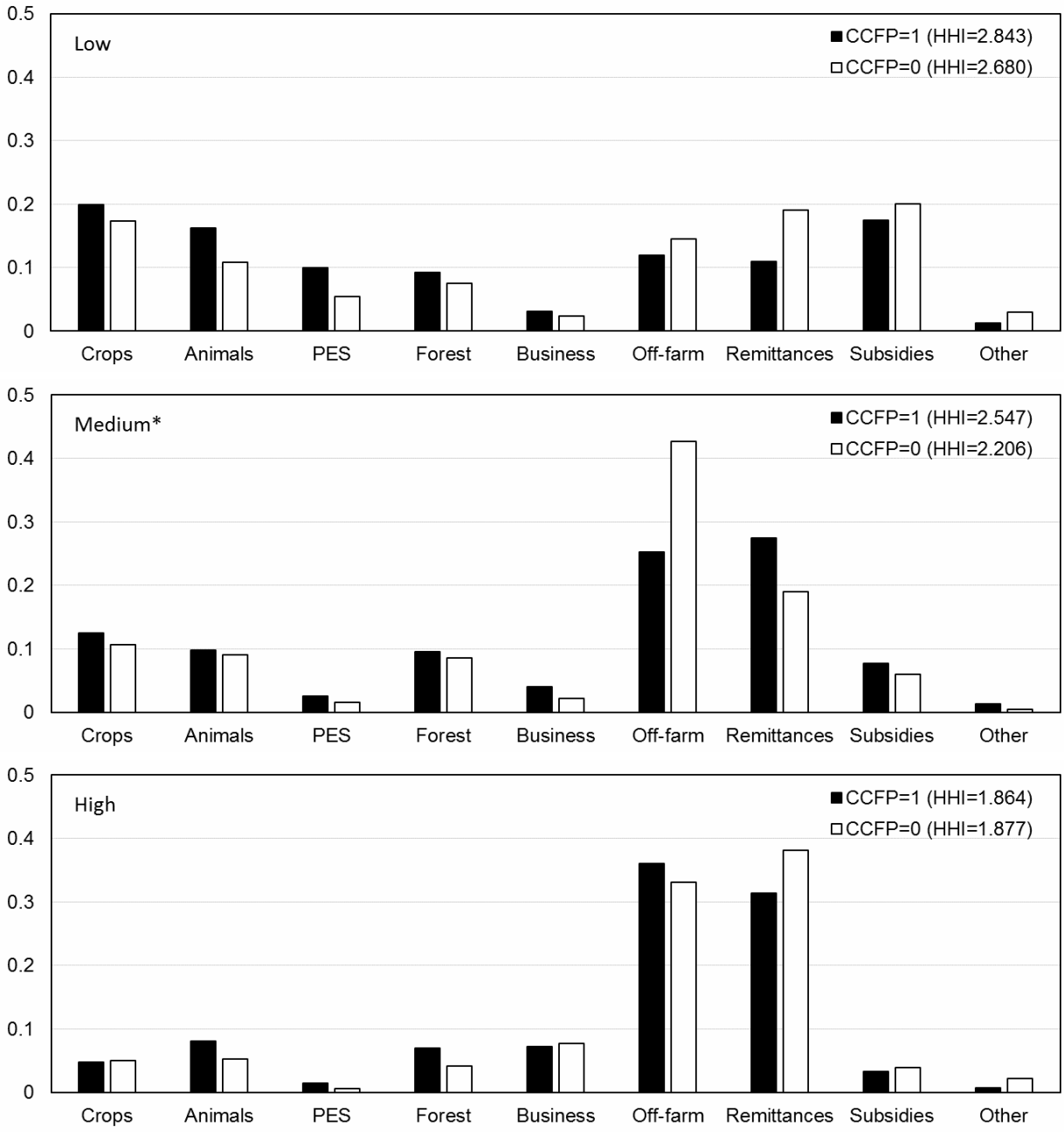

Figure 4.2 Distribution of sources of income of households with and without CCFP, for low-, medium- and high-income groups. The X-axis denotes the income source and the y-axis the share of income. The asterisk indicates that the sources of household income are statistically significantly different at the 5% level (only for medium income households).

For the medium-income group, both types of households have the greatest income shares from local off-farm work and remittances from out-migration. Households participating in the CCFP have a larger share of remittance but a lower share of local off-farm income than nonparticipants. This indicates that

medium-income households in the CCFP are more likely to rely on remittances from out-migration, while nonparticipants at the medium level depend more on finding local off-farm jobs. This may be partly due to the release of farm labor, and partly due to that the CCFP compensation may be able to cover the initial costs of out-migrating-out for households at the medium-income level (see Chapter 3). Except for local off-farm income, income shares from the other sources for CCFP households are all higher than those by nonparticipants. In addition, the livelihood diversification index for households with CCFP is significantly higher than that for households without CCFP.

Table 4.2 Statistics on farm costs, animal and forest resources for households participating in CCFP and not participating (asterisks indicate when differences in means are statistically significant).

Variables	CCFP=1			CCFP=0			Difference in Means
	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	
Paddy land planted (mu)	2.8	2.7	271	2.5	2.5	210	0.31
Dryland planted (mu)	1.5	1.5	271	1.2	1.2	210	0.27*
Land planted (mu)	4.3	3.5	271	3.7	3.0	210	0.58†
Land rent in§ (%)	9.4	19.7	235	7.8	19.4	180	1.63
Land leased or abandoned§ (%)	35.1	35.9	257	39.3	37.7	201	-4.19
Farm costs per mu (1,000 yuan)	2.5	2.2	235	3.0	2.7	180	-0.55*
Share in farm costs (%)							
Fertilizer	49.3	25.3	231	47.3	25.4	172	2.01
Pesticide/Herbicide	6.5	13.5	231	4.0	6.2	172	2.42*
Crop seeds	20.6	18.7	231	18.0	15.7	172	2.56
Hiring labor	22.0	27.9	231	28.1	29.5	172	-6.09*

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

§ These two variables are the percentages of land rent in, leased or abandoned in total land owned by households.

For households with high income, off-farm income and remittances are still among the top sources of income for households with and without CCFP. However, CCFP households have a higher proportion of off-farm income but a lower proportion of remittances than nonparticipants, albeit slightly for both income sources. Among the rest of income sources, households with CCFP are more likely to invest in animals and forest resources than households not participating in the program. Since households with high

income rely primarily on major activities (i.e., local off-farm work and out-migration with remittances), the extent to which high-income households diversify their income sources is much lower than low- and medium-income households according to the values of HHI.

Statistical analysis of agricultural activities shows that households participating in the CCFP cultivate more land, particularly dryland, but have significantly lower farm costs than households not participating in the program (Table 4.2). Although households receiving CCFP payments have enrolled some of land parcels into the program, they are associated with a higher likelihood of renting land (especially dryland) in from other households and a lower likelihood of cropland abandonment or leasing land to other households. Previous studies suggested that CCFP compensation is negatively associated with the abandonment of land parcels, as the remaining land parcels after the enrollment are mostly in good quality (see Chapter 2). By decomposing farm costs, CCFP households have more investments on fertilizer, pesticide, herbicide, and crop seeds but lower costs in hiring labor than nonparticipants. Having their sloping land enrolled into the CCFP, participating households cultivate on land in good quality and thus can lower costs in hiring farm labor, but they also tend to intensify agriculture by fertilizing and using pesticide or herbicide. Overall, although having labor shifted to off-farm income-generating activities, CCFP also keep cultivating on the rest of cropland after the land enrollment into the program. Contributions of different sources of income to income inequality.

4.3.2 Contributions of different sources of income and income inequality

The overall Gini coefficient (G) for all rural households in the sample in Tiantangzhai Township is 0.4522, with the Gini coefficient for households participating in the CCFP (0.4615) slightly higher than that for non-participants (0.4379), indicating greater inequality among households in the CCFP (Fig. 4.3) although they have a higher mean income. This result of comparing Gini coefficients between households with and without CCFP is different from results in other study areas (J. Li et al., 2011), and may be attributed to the income structure pattern of households in the study area. In Tiantangzhai, the PES programs have existed for over ten years and local off-farm work and out-migration have become major activities for rural

households. Similar to a previous study (Conghe Song et al., 2014), income from local off-farm jobs and remittances from out-migrants make up the lion's share of total income for most households. Thus, off-farm income and remittances from out-migrants also tend to make the greatest contribution to total income inequality.

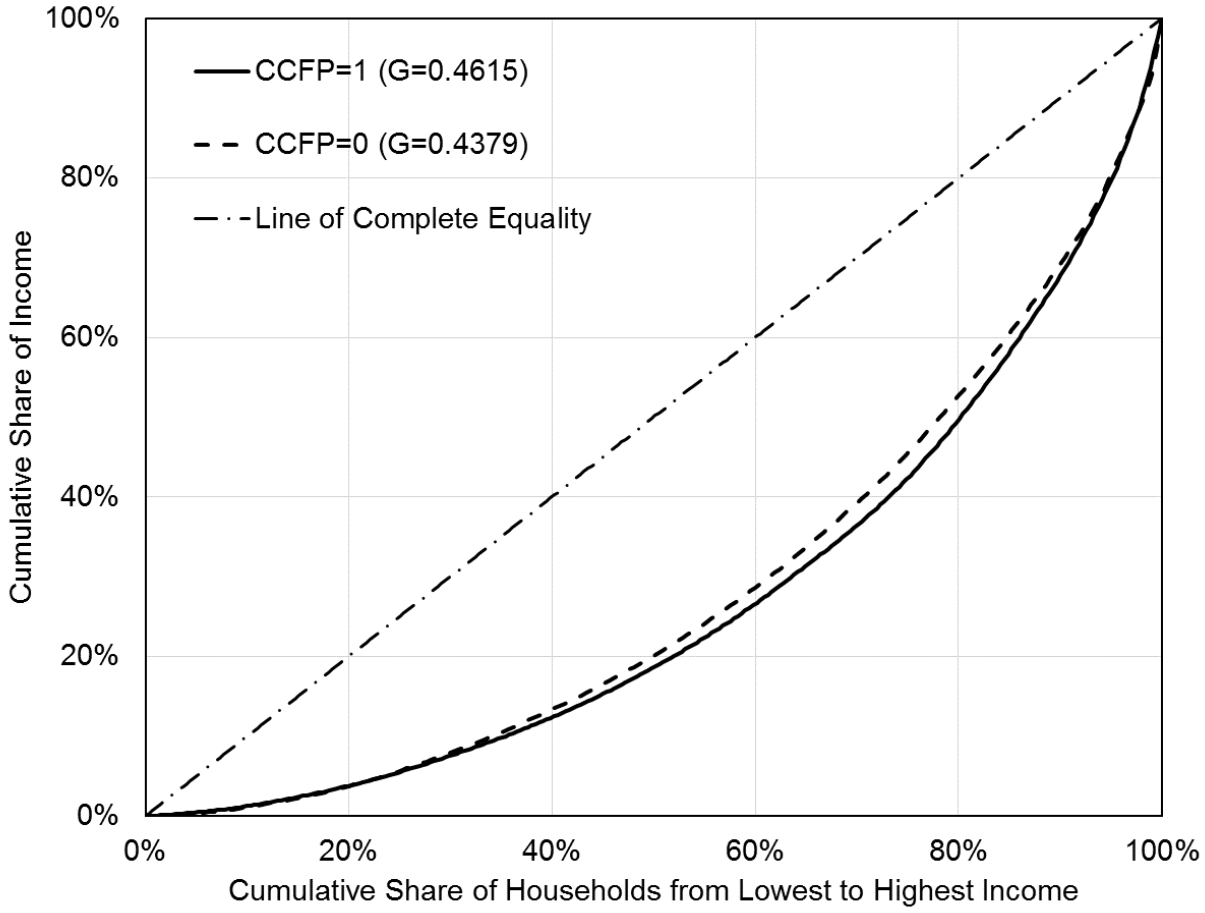

Figure 4.3 Lorenz Curves and Gini coefficients of total net income for households with and without CCFP.

Measures of inequality attributed to different income sources are provided in Table 4.3. For CCFP households, off-farm income and remittances from migrants make the greatest contributions to total income (33% and 30%, respectively) as shown by S_k, and also to income inequality as measured by sg_k (42% and 38%, respectively). In addition, the pseudo-Gini coefficients (C_k) of local non-farm business profit, local

off-farm earnings, and remittances from migrants for CCFP households are greater than *G*, indicating income from these activities worsens total income inequality. Receiving remittances is directly linked to sending out-migrants by households. Poor households without migrants cannot even support the initial costs of migration, while households with remittance-sending migrants can use money to invest in additional income-generating activities (see Chapter 3) or to improving existing activities. Thus, poor households who enrolled land parcels in the program may be more likely to be trapped in traditional agriculture and fail to shift labor to non-farm income-generating activities, such as to out-migration or local off-farm work, unless they already had out-migrants before CCFP enrollment. In general, it is evident from the results that households with income from not only crops and animals but also other sources such as PES, forest resources, and other sources lessens total income inequality, as their pseudo-Gini coefficients are lower than *G*.

For households without CCFP, the largest income shares are also from local off-farm income (33%) and remittances (31%), which makes substantial contribution to total income inequality (33% and 39%, respectively). In addition, local non-farm business income makes substantial contribution to total income inequality (12%). The C_k of local non-farm business income, remittances and other income for nonparticipants are greater than *G*, worsening total income inequality. In contrast to CCFP households, local off-farm income by nonparticipants has a slightly lower value of C_k than G and thus slightly decreases total income inequality. The payment from PES programs make the least contribution to the overall inequality for both types of households, which is due to the small proportion of the payment in total income. In addition, the C_k of PES payment for nonparticipant is negative, suggesting a negative correlation between PES payment and total income. For the households not participating CCFP, their PES payments are all from the EWFP, which varies widely among households in Tiantangzhai according to the forest lands they have. Households who receive more EWFP payment may be more satisfied with their living conditions higher in the mountains, and thus less likely to engage in new income-generating activities.

Table 4.3 Measures of inequality attributed to different income sources for households with and without CCFP.

Income	S_k	R_k	G_k	C_k	$S_kR_kG_k$	sg_k
CCFP = 1						
Crops	0.0770	0.2643	0.4949	0.1308	0.0101	2.2%
Animals	0.0866	0.3536	0.7205	0.2548	0.0221	4.8%
PES	0.0206	0.1183	0.4171	0.0493	0.0010	0.2%
Forest resources	0.0736	0.4415	0.7919	0.3496	0.0257	5.6%
Business	0.0528	0.5406	0.9452	0.5110	0.0270	5.8%
Off-farm work	0.3271	0.7562	0.7777	0.5881	0.1924	41.7%
Remittances	0.3030	0.7250	0.7997	0.5797	0.1757	38.1%
Subsidies	0.0500	0.1762	0.5357	0.0944	0.0047	1.0%
Other	0.0093	0.3178	0.9597	0.3050	0.0028	0.6%
TOTAL	1.0000	1.0000	0.4615	0.4615	0.4615	100.0%
CCFP = 0						
Crops	0.0692	0.2448	0.4930	0.1207	0.0084	1.9%
Animals	0.0683	0.3748	0.7625	0.2858	0.0195	4.5%
PES	0.0100	-0.0942	0.5049	-0.0476	-0.0005	-0.1%
Forest resources	0.0485	0.1743	0.7936	0.1383	0.0067	1.5%
Business	0.0731	0.7818	0.9542	0.7460	0.0546	12.5%
Off-farm work	0.3334	0.6216	0.6914	0.4298	0.1433	32.7%
Remittances	0.3130	0.7118	0.7704	0.5484	0.1716	39.2%
Subsidies	0.0507	0.1968	0.5852	0.1152	0.0058	1.3%
Other	0.0336	0.8614	0.9821	0.8459	0.0285	6.5%
TOTAL	1.0000	1.0000	0.4379	0.4379	0.4379	100.0%

S_k – share in total income
R_k – Gini correlation with total income rankings
G_k – Gini when consider all households, including those with zero income
C_k – pseudo-Gini coefficient, $C_k = R_kG_k$
$S_kR_kG_k$ – contribution to Gini coefficient of total income
sg_k – percentage of contribution of source *k* income to Gini coefficient of total income

The income sources show different marginal effects on the total Gini coefficients for households with and without CCFP (Table 4.4). For both groups, some income sources have positive effects on the total Gini coefficient while others have negative effects on the total Gini coefficients. For CCFP households, increases in local off-farm work and remittances have the biggest effects on increasing the inequality in total income, while increases in income from agriculture (crops and animals) and subsidies most decrease total income inequality, followed by smaller effects of the PES payments and use of forest resources. For

example, a one percent increase in off-farm income results in an increase in the total Gini by 9%, while a one percent increase in crop income decreases the total Gini by 5.5%.

Table 4.4 Marginal effects of income sources for households with and without CCFP

Income	CCFP = 1		CCFP = 0	
	amf	rmf	amf	rmf
Crops	-0.0255	-5.5%	-0.0220	-5.0%
Animals	-0.0179	-3.9%	-0.0104	-2.4%
PES	-0.0085	-1.8%	-0.0049	-1.1%
Forest resources	-0.0082	-1.8%	-0.0145	-3.3%
Business	0.0026	0.6%	0.0225	5.1%
Off-farm work	0.0414	9.0%	-0.0027	-0.6%
Remittances	0.0358	7.8%	0.0346	7.9%
Subsidies	-0.0183	-4.0%	-0.0164	-3.7%
Other	-0.0015	-0.3%	0.0137	3.1%

amf – absolute change of the total Gini coefficient with 1% increase of source *k* income
rmf – relative change of the total Gini coefficient with 1% increase of source *k* income

For households without CCFP, remittances followed by local non-farm business income have the largest marginal effects on increasing the total Gini, while other sources have negative marginal effects, led by agricultural incomes, subsidies and extraction of forest resources. Note that contrary to CCFP households, local off-farm work slightly reduces (improves) income inequality of non-CCFP households: a one percent increase in local off-farm income decreases the total Gini by 0.6%. The marginal effect of all PES payments on improving income equality for nonparticipants is -1.1%, which is slightly smaller than that for CCFP households (-1.8%).

4.3.3 Determinants of household income and income inequality

Means and standard deviations of independent variables used in the mixed effects model on the determinants of total household income of sample households are provided in Table 4.5. The mean value of the highest education of household members across all households is 9.0 years, corresponding to high school education. These household members with the highest education have a mean age of 35. Mean

household size is a small 2.8, with mean farm labor 1.2 persons, and mean off-farm labor 0.4 persons (aged 12+). A substantial proportion (70%) of the households have sent out a migrant since 2003, following CCFP implementation. This along with very low fertility in China accounts for the low mean household size. The mean wellness index is 20 and mean walking distance to the nearest paved road is a brisk 12 minute walk. The mean area of paddy land under cultivation by rural households is 2.7 mu. Rural households own 48 mu in EWFP forests on average, or about 3 hectares, which is much larger than the mean area of CCFP forest land (1.14 mu). These mean values are useful in interpreting the estimation of coefficients in the model, which the discussion now moves onto.

Table 4.5 Interpretation of independent variables with means and standard deviation.

Variable	Interpretation	Mean	Std. Dev.
CCFP	CCFP forest are (mu)	1.14	1.53
EWFP	EWFP forest area (mu)	47.7	59.0
Edu	Highest education of household member (years)	9.2	3.0
Age	Age of member with highest education	35.0	16.7
HH size	Number of people currently living in the house	2.8	1.3
Farm labor	Number of farm workers[§]	1.2	0.9
Off-farm labor	Number of off-farm workers[¶]	0.4	0.6
Out-migration	Whether has out-migrant(s) since 2003 (0/1)	0.7	0.5
Wellness	Wellness score (3-33)	20.1	5.4
Access to road	Walking distance from household to nearest paved road (mins)	12.0	15.6
Land	Total amount of paddy land under cultivation (mu)	2.7	2.6

[§] Farm labor is defined as household members (aged 12+) whose main reported activity is farm work in the past 12 months (with involvement in off-farm work less than 6 months).
[¶] Off-farm labor is defined as household members (aged 12+) whose main activity is off-farm work for 6+ months in the past 12 months.

Table 4.6 provides the effects of the underlying factors on the determinants of total household income as well as of their effects on total income inequality (the two columns on the right). Results from the mixed-effects model show significant effects of most hypothesized variables on income. Among variables with effects statistically significant (at the 10% level or better), the number of off-farm workers (off-farm labor) and having had an out-migration since 2003 have the greatest positive effects on total

household income, with coefficients of 0.39 and 0.27, respectively. This suggests that labor availability for off-farm work and out-migration is important in generating income (off-farm income or remittances), which is also consistent with results from the study of income level sources above. The highest education of any household member has significant effects, indicating the importance of human capital in income generation. Noting the mean highest education (high school), people have to move out of the township for even for this level of education because the highest educational facility in the study area township is only middle school.

Table 4.6 Factors determining the generation of income and the contribution of factors to total income inequality.

Variables	Coefficient (*Robust Std. Err.*)	z	P>|z|	Gini	Gini %
CCFP	0.047 (*0.037*)	1.27	0.2050	0.0088	2.0
EWFP	0.001 (*0.001*)	1.97	0.0490*	0.0107	2.4
Education	0.049 (*0.022*)	2.19	0.0280*	0.0247	5.5
Age	-0.024 (*0.011*)	-2.18	0.0290*	0.0423	9.4
Age^2	0.000 (*0.000*)	1.70	0.0880†	-	-
HH size	0.060 (*0.043*)	1.37	0.1690	0.0195	4.3
Farm labor	0.120 (*0.079*)	1.52	0.1290	0.0154	3.4
Off-farm labor	0.392 (*0.085*)	4.60	0.0000***	0.0594	13.1
Out-migration	0.268 (*0.111*)	2.41	0.0160*	0.0136	3.0
Wellness	0.050 (*0.009*)	5.73	0.0000***	0.0661	14.6
Access to road	0.007 (*0.004*)	1.56	0.1180	0.0090	2.0
Land	0.028 (*0.020*)	1.36	0.1720	0.0097	2.2
Constant	8.154 (*0.274*)	29.74	0.0000***	-	-
All variables				0.2827	62.5

† $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
The log pseudo-likelihood is -4628 and the Wald Chi^2 is 595 with p-value 0.000.
Gini – contribution to the total Gini, which is 0.4522 for all rural households
Gini % – the share of contribution to the total Gini

Notice that the age of the person in the household with the highest education has *negative* effects (coefficient -0.024) on income generation. Noting that the mean value of age is 35, this means that when there is someone younger than that, it is expected that he/she will tend to have more education and that this tends to contribute to generating more income for households. In addition, the generation of total income is significantly positively associated with household assets (Wellness) with coefficient 0.05, which could

reflect that some of the assets constituting the score contribute to some income-generating activity, notably farm tools and transportation equipment, but also possibly certain electrical appliances and communications equipment (see items C4-C7 in Appendix Table A4.4). Household size does not have a significant effect, once the positive effects of working members (farm and off-farm laborers) is taken into account. It was hypothesized that access to the nearest paved road (the shorter the distance) should have a positive effect on income by making it easier to take produce to market to sell or to go to off-farm work, so that farther distance from the road should lead to *lower* income, but the effect is positive and not significant. Finally, regarding the effects of PES programs on household incomes, the area of EWFP forests owned by households significantly increases total income, suggesting the potential of EWFP in bettering off rural household incomes. However, a larger positive effect of CCFP participation is statistically insignificant, likely due to the very small amounts of land (available to be) enrolled in CCFP in contrast to the large amounts in EWFP.

Based on the regression-based determinants of total household income, the contribution of each of the factors to total income inequality can now be determined (right columns of Table 4.6). All variables together explain 62% of total income inequality (.28 of .45). Since the contribution to income inequality relies on the estimation of coefficients of variables, the following interpretation will focus on the variables with significant effects on income generation. The wellness score of household is the factor that explains the most inequality (15%), reflecting the effects of previous income on accumulation of assets, and the persistence of inequality over time in households since wellness scores tend to change slowly over time, in contrast to income itself. This is followed by the number of persons involved in off-farm labor, which explains 13% of total income inequality. This is expected as the allocation of off-farm labor (for 6+ months) produces off-farm income, which as seen above is one of the two principal determinants of household income, and thus in contributing to inequality among households. Thus households with off-farm income tend to have significantly higher incomes than those without off-farm workers. In addition, the highest education of a household member and the youth of this member also make substantial contributions to total

income inequality, with mean Gini shares of 6% and 9%, suggesting the importance of a young adult in the household embodying human capital.

Farm labor and out-migration, however, make little contribution to total income inequality, with a mean Gini share of only 3.4% and 3.0%, respectively. These two factors, together with their corresponding income sources, reflect that most rural households have shifted from farm activities to non-farm activities and out-migration to generate most of their income, and that, while the former is a major factor contributing to inequality (linked more with the wellness score as well), out-migration generates income via remittances without increasing inequality among households. Apparently both poor and non-poor households are equal-opportunity senders of out-migrants. This also suggests that, at least in the case of this township, out-migration is to be encouraged. Thus a substantial proportion of all rural households (about 70%, poor as well as rich) have sent out at least one out-migrants since 2003, which often has led to crucial amounts of remittances being received. This call for further research, on the extent to which poorer households send out migrants as often as the less-poor, or whether it is the poor households who tend to receive the most remittances, as they need them more.

Finally, regarding PES programs, the EWFP and CCFP areas owned by households both lead to PES payments that contribute to income inequality albeit in a small way, with Gini shares of only 2.4 and 2.0%, respectively. In Tiantangzhai, the amount of the EWFP payment depends only on the area of natural forests owned by the rural household. The maximum amount received in the study area in the sample was 4,600 yuan/year with a few receiving nothing and the mean being 470 yuan/year in the household sample (corresponding to a mean size of 47 mu, noted earlier). In addition, mean payment received from the EWFP is triple that from the CCFP. Thus, the EWFP has more explanatory power than the CCFP in explaining income inequality.

Despite the statistically significant coefficients, limitations exist in the regression-based procedure. First, while the model explains over 60% of the difference in total income inequality across households, this leaves much unexplained. However, this is totally the norm in explaining individual or household

behavior from household survey data, the rest being left to unobservable factors (G. H. Wan, 2002; G. Wan, 2004) and possibly errors in reported data, including income data provided by respondents

4.4 Conclusions

In the late 1990s, China initiated a series of forest policies to convert croplands back to forests and to conserve existing forests, called respectively the Conversion of Cropland to Forest Program (CCFP) and the Ecological Welfare Forest Program (EWFP). Evaluating how the payments for ecosystem services programs impact rural livelihoods is essential for assessing the sustainability of the environmental conservation programs which have had such beneficial effects on reforestation, as confirmed in satellite imagery (Q. Zhang et al., 2016). In this paper, the study uses data from a detailed household survey to analyze the income levels and structures of rural households receiving PES payments in a rural area Tiantangzhai Township, Anhui Province, China. The study first examines income levels and their sources or distribution among various livelihood activities, followed by a study of the inequality in household incomes in general, and differences in livelihood diversification of households participating in the CCFP and those not, with EWFP as an exogenous factor.

In the analysis of sources of livelihood diversification, CCFP households are found to have both slightly higher per capita incomes and more diversified sources of income than households not participating. This suggests that receiving the CCFP subsidy indeed has led to some positive responses of households in adopting new livelihood activities in response to having less land available for raising crops. In general, low-income households rely more on income from crops, livestock, forest resources and subsidies than middle and higher income households, and thus have more diversified income sources than the other two groups, reflecting their search for income from whatever source possible. Medium- and high-income households, on the other hand, rely mostly on two things, wages from off-farm work and remittances from out-migrants, and thus have less diversified income sources However, the fact that the bulk of rural farm household incomes come from precisely those two sources for most of these households probably reduces pressures on them to seek other sources of income as much,

In addition, and consistent with the expectations as one possible response to reducing their *area* in crops, CCFP households tend to engage in more agricultural intensification than non-CCFP households, as indicated by the slightly higher expenses on agricultural inputs (fertilizer, pesticides, herbicides, and seeds—see Table 4.2), as they cultivate more land with higher inputs.

Results from the study of income inequality reveal that total income inequality among CCFP households is greater than that among non-participants. Local off-farm income and remittances from out-migration are the greatest contributors to income inequality as they make up the lion's share of total household income for the majority of farm households. Remittances from out-migrants, however, have little effect on increasing income inequality whereas local off-farm worker incomes do have big effects on increasing inequality overall, and for households with CCFP, although it decreases income inequality for non-participants. PES compensation decreases income inequality of households with and without CCFP, albeit with a trivial contribution.

Results from the multivariate statistical analysis of the determinants of income inequality demonstrate the important roles played by human capital, household assets and especially labor availability and its allocation to off-farm work in income generation and inequality. Out-migration followed by receiving remittances is the other major factor explaining rural household income, and hence has been the major survival strategy of farm households in the region, and perhaps throughout rural China. In relation to the two types of PES programs examined, only EWFP payments have statistically significant positive effects on income and also contribute a bit more (2.4% vs. 2.0% for CCFP) to income inequality. This is probably due to that EWFP payments being on average three times larger per household than CCFP payments in the study area.

CHAPTER 5

CONCLUSIONS

The process of human interaction with the natural environment is complex (Moran & Elinor, 1999; Liu et al., 2007). Land cover and land use change is a result of the interactions (Lambin et al., 2001). Human alters land surface conditions in the process of pursuing a better livelihood via various socio-economic activities. Due to the rapid growth of population, global land-cover/land-use changes have seriously compromised the goods and services that the welfare of the society depends on. In order to sustain key ecosystem services, Payments for Ecosystem Services (PES) has recently emerged as an innovative approach for environmental restoration and conservation (Wunder, Engel, & Pagiola, 2008). PES often aims at preservation of certain land use by rural households (Chen, Lupi, Viña, He, & Liu, 2010). Under PES programs, the provision of environmental services are secured through direct compensation of the service providers. The long-term success of PES programs depends on the sustainability in environmental conservation and social welfare improvement (Ferraro, 2008). Therefore, evaluating the socio-ecological impacts of PES programs is of great importance.

In the late 1990s, China adopted the PES approach in its new forest policy for environmental conservation and protection (Liu, Li, Ouyang, Tam, & Chen, 2008). One of the largest programs is the Conversion of Cropland to Forest Program (CCFP). Under the CCFP, rural households convert their cropland on steep slopes (or otherwise ecologically-sensitive areas) to forests, and receive payments from the central government in return. Another PES program is the Ecological Welfare Forests Program (EWFP). Under the EWFP, rural households give up their privilege in commercial logging of natural forests in exchange for government compensation. These PES programs have existed for over ten years. An

integrative evaluation of social-ecological outcomes of these programs can provide valuable information on program sustainability to policy makers and scholars.

To investigate the impacts of China's PES programs in the new forest policy, this dissertation uses a case from Tiantangzhai Township in Anhui, China to examine land use decisions by rural households, individual behavior of migration and rural livelihoods. Results show that both EWFP and CCFP, together with other influential factors, have played important roles in cropland abandonment, individual out-migration, and rural livelihood, but their influencing mechanisms are different.

The implementation of CCFP involves the enrollment of cropland by rural households, which frees farm labor from land cultivation. Thus CCFP households with labor surplus are able to adopt alternative livelihoods such as out-migration (Chapter 3). This is also supported by the evidence that local-off farm work and remittances from out-migrants make up the lion's share of total income for most households, and households with CCFP receive more income from these two sources than households without CCFP (Chapter 4). As households allocate more labor to lucrative activities (e.g., out-migration with expected remittances), they are less likely to engage in agricultural activities of farming land, leaving cropland abandoned. Although modeling results do not find significant effects from the CCFP payments (mainly because of the small amount of payments), this reforestation program can indirectly influence the land use decisions by households through labor allocation. Evidence includes that the probability of cropland abandonment is significantly and positively associated with farm labor availability, i.e., household members aged 18-60 (Chapter 2).

Regarding ecological impacts of the CCFP, households with CCFP have an overall lower rate of cropland abandonment during 2001-2013 than households without CCFP. This is due to that households with CCFP have enrolled poor quality land into the program and thus were less likely to abandonment the remaining land, especially at the early stage of CCFP implementation (2003-2007). However, an increasing trend of cropland abandonment is observed for both types of households during 2012-13 period, suggesting increasing opportunity costs of land cultivation in a long run as households gradually allocate farm labor to lucrative activities. Moreover, land parcels in proximity to CCFP forests (and natural forests as well) have

higher risks of being abandoned. These abandoned cropland near forest edges will eventually become forested due to natural regeneration, enhancing the effective areas of the CCFP. The increase of reforested area may also trigger negative feedback to rural households' livelihoods via crop raiding by wildlife, potentially facilitating cropland abandonment.

In terms of socio-economic impacts of the CCFP, households enrolled in CCFP have higher per capita income with more diversified income sources than households without CCFP. Although households have enrolled some of their land parcels into the CCFP, they have larger shares of income from crops, animals and forest resources, particularly for the low- and medium-income households. For low- and medium-income households, CCFP households tend to diversify their income sources than nonparticipants. For high-income households, however, both types of households rely on fewer but higher yield activities such as local off-farm work and receiving remittances from out-migrants, which leads to less diversified livelihoods. Additionally, households with CCFP tend to intensify agriculture as they have higher inputs on fertilizer, herbicide and pesticide. However, households without CCFP have a higher cost share in hiring labor, which is likely due to the fact that their land parcels have poor accessibility and thus are labor-demanding. After over ten years of CCFP implementation, the inequality of total income among CCFP-participating households is greater than that among nonparticipants. Off-farm income and remittances from out-migration make the greatest contribution to total income inequality for households with CCFP. The overall income in the township is low, and most households can hardly make ends meet by relying solely on land cultivation. The CCFP payments only provide a safety net for poor households and thus are insufficient to stimulate them to adopt livelihood alternatives. Thus, these poor households that fail to shift their farm labor to other income-generating activities are trapped in poverty of land cultivation. For households with relatively higher income, however, the CCFP serves as incentive of shifting livelihoods by freeing farm labor from land cultivation. The decomposition of income inequality to driving factors reveals that the direct compensation from the CCFP only explained 2% of total income inequality.

Different from the CCFP, the EWFP does not lead to the retirement of cropland parcels. Thus the social-ecological impacts of the EWFP mainly results from the preserved natural forests and the

governmental subsidies as financial support. The EWFP can enhance ecosystem services via conservation of natural forest through direct or indirect impacts on cropland abandonment by rural households. Studies have suggested that the township has experienced a substantial increase of forest cover during 2002-13, which can be mainly attributed to the EWFP (Zhang, Hakkenberg, & Song, 2016). The growth of natural forests potentially accelerates the abandonment rate of land parcels in proximity to the edge of EWFP forests (Chapter 2). In addition, EWFP payments also increase the likelihood of cropland abandonment. Although the compensation rate of EWFP is much smaller than that by the CCFP, the mean total amount of EWFP payments is three times that of CCFP payment, as rural households in this area generally own a larger area of natural forest. Results of income inequality indicate that the EWFP payments are primarily undertaken by households with low income (Chapter 4). These poor households tend to be satisfied by the amount of subsidies, and thus are less likely to involve in land cultivation. Moreover, households receiving higher amounts of EWFP subsidies are demotivated to adopt alternative livelihoods, such as out-migration, albeit with far smaller effects than CCFP subsidies (Chapter 3).

The findings of the present study have valuable inputs for policy-makers in creating similar PES programs in the future in China or other developing countries. Previous study on policy evaluation often focused on effects of a single PES program (e.g., CCFP) but rarely considered direct or indirect impacts from multiple programs. This dissertation investigates simultaneously social-ecological outcomes of the CCFP and the EWFP in China, and found both reinforcing effects and offsetting effects from the two programs. For instance, the CCFP and EWFP both induce the abandonment of cropland parcels in proximity to forest land via changing water availability and increasing crop raiding by wild animals (Chapter 2), while the compensation from the two programs have opposite effects on adopting alternative livelihoods such as out-migration (Chapter 3). The different influencing mechanisms of the two policies on rural livelihoods suggest policy-makers should have comprehensive evaluation before expanding current programs or creating similar programs in the future.

The CCFP converts labor demanding cropland to nearly care-free forest land, thus frees farm labor for other activities, but the EWFP demotivates them to involve in alternative livelihoods. However, poor

households with CCFP and large amounts of EWFP payment also stick to cropland cultivation through agricultural intensification, leading to diversified livelihoods (Chapter 4). In terms of the CCFP, future reforestation policies (CCFP-like programs) should targets cropland parcels with higher risks of abandonment but preserve those with low abandoning risks. This implementing strategy can not only stimulate households to allocate farm labor to non-farm activities but also secure diversified livelihoods for poor households. Moreover, the land-targeting mechanism is useful for designing discriminative payment scheme and thus can improve the cost-effectiveness of the program when implemented. The current programs have been implemented in a flat compensation rate, which is probably due to the difficulty in measuring opportunity costs of forgoing land cultivation. The modeling of cropland abandonment attempts to offer an alternative approach to estimate the extent to which a household value land parcels. As households shift their income structure from agriculture to non-agricultural activities, the abandoned land parcels being targeted can maximize the effectiveness of environmental conservation meanwhile minimize the costs in policy implementation.

The examination of determinants on cropland abandonment, individual out-migration and income generation find that both the CCFP and the EWFP have direct and indirect effects on rural households' livelihood options. Since both programs provide subsidies based exclusively on the forested areas (CCFP for plantation forest and EWFP for natural forest), the payment rate is key to the cost of these PES programs. For the CCFP, although the payment rate decreased to half after the renewal of the initial eight-year contract, rural households are willing to pursue the new income structure with non-farm activities, even when the program ends (Song et al., 2014). This indicates that households enrolled in the CCFP have successfully adopted alternative livelihoods, a greater indicator for the sustainability of the ecosystem services provision by CCFP forests. Moreover, the CCFP payment contributes little to income difference among households (Chapter 4), which is indeed a favorable outcome from the point of view of environmental policy-makers because the program has *not* introduced much inequality to rural household income.

The principal ecological goal of the EWFP is natural forest preservation. If the policy-makers target extremely poor households, the program may also achieve the secondary goal of rural poverty alleviation.

However, once the program ends and the subsidy ceases, poor households would be trapped in poverty again due to lack of resources or skills to adopt alternative livelihoods (Chapter 4). These households thus may turn back to old life style and engage in deforestation activities, undermining the effort of environmental conservation by the PES program. In addition to the forest policy, human capital and physical capital of rural households have also played important roles in pursuing non-farm livelihoods and income generation. Thus, the implementation of the conservation programs should be coordinated with other development policies (e.g., education, infrastructure, and job training) in order to create sustainable development.

APPENDIX

Table A3.1 Stratification and sampling of resident groups at first stage (community level).

Stratum	# of resident groups	Mean of CCFP proportion	Standard deviation	# of resident groups sampled	Sample fraction	Stratum weight
I: 0.8-1.0	10	0.903	0.296	10	10/10	1
II: 0.5-0.79	13	0.620	0.485	9	9/13	1.44
III: 0.3-0.49	18	0.406	0.491	7	7/18	2.57
IV: 0.01-0.29	38	0.144	0.352	10	10/38	3.8
V: 0-0	86	0	-	4	4/86	21.5
Total	165	-	-	40	-	-

Table A3.2 Sampling households with and without CCFP participation at the second stage.

RG ID	# of HH	CCFP %	# of HHs interviewed	# of HH1	# of HH2	# of HH1 interviewed	# of HH2 interviewed	HH1 weight	HH2 weight
RG Stratum I: 0.8-1									
26	26	0.85	13	22	4	11	2	22/11	4/2
28	29	0.86	13	25	4	10	3	25/10	4/3
27	31	0.96	16	30	1	15	1	30/15	1/1
29	27	0.89	16	24	3	13	3	24/13	3/3
30	28	0.96	16	27	1	15	1	27/15	1/1
31	13	0.92	11	12	1	10	1	12/10	1/1
54	19	0.84	15	18	3	12	3	18/12	3/3
53	19	0.89	15	17	2	14	1	17/14	2/1
52	11	0.82	8	9	2	8	0	9/8	-
165	30	0.80	10	24	6	10	0	24/10	-
RG Stratum II: 0.5-0.79									
25	13	0.62	11	8	5	7	4	8/7	5/4
24	24	0.54	10	13	11	8	2	13/8	11/2
51	34	0.59	10	20	14	7	3	20/7	14/3
78	17	0.71	11	12	5	10	1	12/10	5/1
127	9	0.56	4	5	4	3	1	5/3	4/1
128	15	0.73	9	11	4	5	4	11/5	4/4
148	24	0.58	11	14	10	8	3	14/8	10/3
147	11	0.55	6	6	5	6	0	6/6	-
149	20	0.75	12	15	5	12	0	15/12	-
RG Stratum III: 0.3-0.49									
23	23	0.43	13	10	13	7	6	10/7	13/6
16	41	0.32	14	13	28	8	6	13/8	28/6
20	19	0.42	11	8	11	5	6	8/5	11/6
18	34	0.35	13	12	22	8	5	12/8	22/5
49	16	0.38	6	6	10	4	2	6/4	10/2
76	36	0.44	13	16	20	11	2	16/11	20/2
143	36	0.31	14	11	25	8	6	11/8	25/6
RG Stratum IV: 0.01-0.29									
46	23	0.26	9	6	17	4	5	6/4	17/5
45	31	0.19	14	6	25	5	9	6/5	25/9
71	35	0.17	12	6	29	3	9	6/3	29/9
68	26	0.076	9	2	24	2	7	2/2	24/7
107	42	0.17	13	7	35	3	10	7/3	35/10
108	35	0.20	12	7	28	4	8	7/4	28/8
139	31	0.16	13	5	26	2	11	5/2	26/11
138	17	0.18	15	3	14	3	12	3/3	12/12
141	29	0.28	16	8	21	3	13	8/3	21/13
140	38	0.18	17	7	31	6	11	7/6	31/11
RG Stratum V: 0-0									
163	26	0.0	13	0	26	-	13	-	26/13
131	31	0.0	12	0	31	-	12	-	31/12
81	34	0.0	14	0	34	-	14	-	34/14
9	15	0.0	11	0	15	-	11	-	15/11
Total			481			270	211		

RG: resident group; HH: households; HH1: households with CCFP; HH2: households without CCFP

Table A4.1 Questions used to compute net income from different sources

Source	Code and question
Crops	(*For each crop, in the past 12 months*)
	E3: How much did you harvest?
	E4: How much was sold?
	E5: What was the unit price?
	E6: What was the total value of sales?
	(*For all crops, in the past 12 months*)
	G4a: What were the costs of materials (e.g., fertilizer, pesticides, etc.) and hiring labor?
Animals	(*For each type of animals*)
	F3: How many of this type of animals do you currently have?
	F4: How many were sold in the past 12 months?
	F5: How much did you earn from selling them in the past 12 months?
	F6: How much did you earn from selling animal products in the past 12 months?
	(*For all animals, in the past 12 months*)
	G4b: What are the costs involved in raising animals (e.g., animal feed)?
PES	J3: How much compensation did you receive from the CCFP in the past 12 months?
	L3: How much compensation did you receive from the EWFP in the past 12 months?
Forest	(*For each type of forest resources, in the past 12 months*)
	M11: How much did you earn from extracting the forest resource?
	M12: What were the costs involved in producing, extracting and selling the forest resource?
Business[§]	(*For each business, in the past 12 months*)
	N7: What were the total gross revenue in a usual month?
	N8: How much was the estimated monthly costs (e.g., rent, utilities, repairs)?
Off-farm	(*For each type of work of each person, in the past 12 months*)
	O8: What was the total earning from this job by this person?
Remittances	Q10e: How much money altogether has your household received from the out-migrant in the past 12 months?
	Q10g: (If received goods) What was the estimated value of the major goods the out-migrant sent/brought to the household in the past 12 months?
	S5: (If received money or goods from anyone who was not a household member) What was the estimated total money sent by other persons?
	S6: What was the estimated total value of goods sent by other persons?
Subsidies	(*For each type of government subsidy, in the past 12 month*)
	T3: How much governmental subsidies did your household receive?
Other	T4: How much other income did you earn in the past 12 months? Could you specify the income source? (For example: social gifts, rental income from properties or animals, income from interest on savings account or investments)

[§] The annual income and cost for business(es) were estimated by multiplying monthly revenue and monthly costs by 12.

Table A4.2 Unit prices for estimating values of self-consumed crops and animals

Code	Crops	Unit price (Yuan/kg)	Code	Animals	Unit price (Yuan per unit)
100	Rice	2.3	200	Cattle	4500
101	Wheat	1.8	202	Pigs	1000
102	Oil seeds	4	203	Goats/Sheep	750
103	Corn	2.4	205	Chicken	750
104	Sweet potatoes	1.8			
105	Beans	3			
106	Peanuts	2			

Table A4.3 Data imputation for incomes and costs from extracting forest resources and remittance

Code	Source	Income	Cost	Household ID
M404	Gastrodia Elata	3000	1500	565
M404	Gastrodia Elata	5000	2500	667
Q10c	Remittance	20000	-	302
Q10c	Remittance	20000	-	343
Q10c	Remittance	20000	-	385
Q10c	Remittance	20000	-	404

Table A4.4 Data imputation for governmental subsidies.

Subsidy	Qualification	Imputation	# of households
Elderly	If has household member aged 60+	660 yuan per person	17
Comprehensive & agriculture	If plant crops	village mean	39

Table A4.5 The questionnaire of household wellness indictors (score).

	Category	Item	points
C1	What type of house do you have?	Three story concrete	5
		Two story concrete with indoor bathroom	4
		Two story concrete without indoor bathroom	3
		Single story Brick House	2
		Adobe house	1
		No house	0
C2	What kind of fuel do you use?	Coal, gas or electricity only, no fuelwood	5
		Primarily coal, gas & electricity, some fuelwood	4
		Half coal, gas & electricity, half fuelwood	3
		Primarily fuelwood, some coal, gas & electricity	2
		Fuelwood only	1
		Rice, wheat or corn stalks only	0
C3	What kind of water and sanitation facilities do you have?	Piped water and flush toilet	5
		Piped water and outdoor latrine	4
		Pressure well and outdoor latrine	3
		Natural Spring and outdoor latrine	2
		Open water and outdoor latrine	1
		Harvest rain and outdoor latrine	0
C4	What kind of the electrical appliances do you have?	A/C	5
		Solar panel	4
		Refrigerator	3
		Washing/Dry machine	2
		Electric cooking pot/microwave	1
		None	0
C5	What communications and entertainment equipment do you have?	Computer	5
		Cell phone	4
		Fixed line phone	3
		TV/Stereo	2
		Radio	1
		None	0
C6	What farming tools and equipment do you have?	Tractor/Transporting tractor (>2000 Yuan)	5
		Thrasher machine/Other small process machine	4
		Electric pump	3
		Ox	2
		Hoes, other farming tools	1
		None	0
C7	What do you use for transportation?	Sedan or minivan	5
		Mini-truck	4
		Motor cycle/Motorized tricycle	3
		Electric bike	2
		Bike or human-powered tricycle	1
		None	0

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