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Effects of payment for ecosystem services and agricultural subsidy programs on rural household land use decisions in China: Synergy or trade-off?

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ABSTRACT

While agri-environmental policies that target different problems are often simultaneously implemented at the same place, little attention has been paid to the interactions of the policies, either in policy design or evaluation. The goal of this study is to understand the potential interactions (synergies or trade-offs) between an agricultural subsidy program and two payments for ecosystem services (PES) programs, namely the Conversion of Cropland to Forest Program (CCFP) and the Ecological Welfare Forest Program (EWFP), and their effects on household land use decisions. Data collected from 481 rural households in Anhui, China are used for the exploration. The Sustainable Livelihoods Framework is used to identify factors that may affect household land use decisions, i.e., whether to expand, stabilize, or shrink the cropland area, and further to identify whether to abandon or rent out land if the shrinkage decision is made. The results show that: (1) most rural households (58%) in the study area reduce cultivated land, and mostly via cropland abandonment, while only 16% of the interviewed households expand land area; (2) the most important factors determining cropland expansion include farm tools and transportation equipment, while the number of parcels and financial support are the dominant factors that stimulate households to adopt abandoning over renting-out decisions when deciding to shrink cropland; (3) EWFP payment has a significant direct impact on cropland management, while no significant influences are observed from the other two programs; (4) there exist complex trade-offs among the three government programs with similar or conflicting aims, which highlights the need to take policy interactions into account when designing new agri-environmental policies.

1. Introduction

Agricultural lands, which constitute 38% of the earth's ice-free land surface, are the most important components of global land use (Foley et al., 2011). They provide essential goods, such as food, fiber, timber, biofuels, and services, upon which human livelihoods and well-being depend (Foley et al., 2005; Wang et al., 2018). In most countries, the basic management unit of agricultural land (especially cropland) is the farm household (Cao et al., 2017; Lengoiboni et al., 2011). These households make decisions on how to use the cropland, including whether to cultivate or fallow each land parcel, what crops to grow, how much fertilizers and pesticides to use, and whether to adopt new technologies. The way households use cropland affects not only the food availability and livelihood stability of farm households but also the food security of a nation (van Wijk, 2014). More importantly, the environmental consequences of land use decisions made by rural households often reach far beyond the farm boundaries (Nguyen et al., 2017), including soil erosion and degradation, surface and groundwater contamination, and biodiversity loss, which are all well documented (Parker et al., 2008; Sierra et al., 2017). Agri-environmental policies that target farm households are becoming increasingly popular and important tools for environmental management (Baylis et al., 2008; Farley and Costanza, 2010; Hayes et al., 2017). However, these policies have often been found ineffective and sometimes even have unintended negative outcomes (Malawska et al., 2014). Better understanding the underlying factors that influence household land use decisions and the mechanisms of household responses to policies would, therefore, provide useful information for designing more effective policies.

The present study examines contemporary household land use decision-making in a rural region of China. The country has a history of

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land cultivation for over 8000 years (Bryan et al., 2018). The current agricultural population is 0.59 billion (National Bureau of Statistics (NBS, 2017). The 1978 Reform and Opening-up Policy promoted the implementation of the Household Responsibility System (HRS) that redistributed croplands from communes to households in 1981 [1]. The HRS increased agricultural productivity to a great extent (Miao et al., 2016; Bryan et al., 2018). Despite its remarkable achievements in economic growth since the late 1970s, China continues to face several major challenges, particularly involving environmental sustainability, food security, and rural poverty. Recognizing the challenges, the Chinese government has made great effort by introducing a series of environmental conservation and agricultural development programs. For example, to restore the degraded forest ecosystem, China launched some of the world's largest Payments for Ecosystem Services (PES) programs. The Ecological Welfare Forest Program (EWFP) and the Conversion of Cropland to Forest Program (CCFP) are among these PES programs. The EWFP (1998–2020) protects natural forests by prohibiting commercial logging and compensates rural households who give up their privilege in commercial timber harvesting from the forests they own (State Forestry Administration (SFA, 2001). The CCFP (1999–2020) aims at soil and water conservation through converting croplands on steep slopes or other ecologically sensitive areas into forest or grassland by compensating farmers based on the cropland areas converted (China State Council, 2002; State Forestry Administration (SFA, 1999).

While urbanization has consumed a large amount of cropland (D'Amour et al., 2016), the CCFP further converted a total of 27 million ha of cropland into forest and grassland by the end of the first round of policy implementation in 2013 (State Forestry Administration (SFA, 2013), which triggered great concerns about food security and social stability (Liu et al., 2014). To mitigate the grave concern about national food self-sufficiency due to cropland loss, China made a historical change in its agricultural policy in 2004, shifting from taxing farm households to subsidizing agricultural production via agricultural subsidy programs (ASP) (Huang et al., 2013). Four major types of subsidies, i.e., *direct grain subsidy*, *high-quality seed subsidy*, *comprehensive input subsidy*, and *machinery subsidy*, are provided to farm households to stimulate agricultural production and productivity (Huang and Yang, 2017).

Given that a substantial amount of public resources has been dedicated to the ASP, it is expected to influence the land use decisions of farm households in rural areas, which has inspired many policy evaluation studies. Yu and Jensen (2010, 2014) and Yi et al. (2015) found that the program increased grain yield and grain production areas, whereas Gale et al. (2005) argued that the agricultural subsidies and tax elimination played minor roles in the grain production increase in 2005. Huang et al. (2011) also indicated that the agricultural subsidies are insufficient to affect the sown area or fertilizer use decisions. It was also found that agricultural subsidies have an indirect impact on cropland use through reducing farmer's out-migration, thereby increasing labor inputs in grain production (Meng, 2012). Regarding the PES programs, Zhang et al. (2018d) suggested that CCFP participation and EWFP payment may indirectly induce additional cropland abandonment. Wang (2013) and Chao et al. (2017) found that the enrollment in CCFP enhances agricultural intensification as households adopt improved inputs and management practices on their remaining cropland.

As described above, the existing literature on the relationship between the policies and household land use decisions focused on grain production, including the changes in the grain sown area, agricultural inputs and outputs. There has been little household-level research that seeks to understand how households change *cropland area in use* after policy implementation, which is the focus of this study. Before the farming season begins, households decide whether to maintain the current farm area in use, expand it by renting in additional land, or downscale by renting out or abandoning some of their marginal cropland parcels. We first examine whether the household cropland use decision is one of expansion, stabilization, or shrinkage, then further analyze whether renting out land or abandonment is favored when the shrinkage decision is made [2]. A motivation for analyzing this set of land use decisions comes from the facts that farmers currently have a more diversified set of available livelihood choices (Anderson and Leiserson, 1980; Gray et al., 2008) and are becoming less dependent on cropland (Burnham and Ma, 2017). As a result, cropland abandonment and transfers among households have increased at an accelerated rate (Zhang et al., 2018a). However, there are still households holding positive attitudes towards farming and are even seeking to expand their cropland area. Understanding the factors that influence a household's decision regarding cropland expansion, stabilization, or shrinkage is thus useful for understanding the patterns of land use as well as livelihood decision-making in rural China. This understanding should also be useful for rural areas in other developing countries as well.

This study is particularly interested in the three agri-environmental policies, which are CCFP, EWFP, and ASP. Although all of them have now existed for more than 14 years, most studies evaluated their impacts on household behaviors within the first 5 years of policy implementation, regarding their immediate or short-term effects (Liu et al., 2008; Rodríguez et al., 2016). Considering changes in the payment schemes, socioeconomic environment and the complexity of human behavior, the effects of these policies may have changed over time at different implementation stages. For example, the compensation rate for CCFP has been reduced by half in the second 8-year contract period (China State Council, 2007), which may not be able to cover the opportunity costs of giving up farming. As the Chinese government has placed an increasing emphasis on agricultural development, the total investment in agricultural subsidies climbed from less than 20 billion yuan in 2004 to approximately 160 billion yuan in 2014 (Huang and Yang, 2017) [3]. Moreover, reforms are being made to improve the agricultural subsidy programs, such as expanding the subsidies, and changing the recipients of subsidies from cropland use right owners to the actual cultivators (Ministry of Agriculture and Rural Affairs of China, 2015). Therefore, it is essential to re-examine their effects on rural households with a longer time perspective to provide updated information for the policy-makers.

At present, multiple agri-environmental policies with similar or different aims are often implemented in parallel (Liu et al., 2014; Long, 2014), such as the PES programs and ASP. Many existing policy studies, however, largely focused on the analysis of one policy in isolation (Kern et al., 2017; Uchida et al., 2009; Yi et al., 2015). Less attention has been paid to the interactions of different policies, either in policy design or evaluation. Up till now, there has been no quantitative investigation of the interactive effects of the PES and ASP on household land use

[1] According to the Rural Land Contracting Law of China, implemented in 2003 and revised in 2017, cropland officially remains under the control of the state or collective ownership but is managed by households via land contracts, which grant each farm household a secure right to use the contracted land for 30 years, renewable for an additional 30 years. Since the cropland use right is long-term and potentially permanent, the land parcels contracted by each household are referred to as owned land in this study.

[2] In many other countries, cropland is bought and sold in markets as commodities, so farm land sizes are determined mainly via this market mechanism rather than by renting in or renting out parcels, though the latter is also surprisingly common as well for short run purposes between neighbors (as in China) as well as for longer term land use. However, according to the current Land Management Law in China, the direct transfer (sale) of contracted cropland from one farmer to another is not legal, though there is a growing demand for this now in China. Currently, however, farmers can only rent in/out cropland use rights.

[3] In 2014, the year our household survey was conducted, 1 US $ = 6.2 yuan.

decision. In this study, we attempt to introduce the concepts of agri-environmental policy synergies or trade-offs among the three programs. The synergies are defined as the situations when multiple policies reinforce rather than undermine each other, while trade-offs arise when the implementation of one policy undermines the effectiveness of another. Data from a household survey in a rural mountainous area of Anhui Province, China, are used to quantitatively measure the effects in a real-world context. The study area is especially suitable for investigating the interactions of these policies, since both PES programs and the ASP were implemented in the study area simultaneously. This study can thus provide information for designing more cost-effective policies, through combining ones that enhance the desired effects while avoiding ones that counteract each other. In addition, we develop and apply a statistical methodology that could be adapted for use in other contexts where it is crucial to evaluate the *overall* effects of multiple agri-environmental policies implemented simultaneously.

2. Theoretical framework

2.1. The sustainable livelihoods framework

The development of the empirical model and the identification of explanatory variables are based on the Sustainable Livelihoods Framework (SLF). Developed in the 1990s (Carney, 1998; DFID, 1999; Ellis, 2000a), the SLF has been widely used in explaining household behaviors concerned with livelihoods, including diversification of economic activities (e.g., Ellis, 2000b; Vasco Pérez et al., 2015; Wu et al., 2017), transitions in livelihood activities over time (Bhandari, 2012), migration (Gray, 2009), and resilience and adaptive capacity (Thulstrup, 2015). The recent research has also drawn on the SLF to study agricultural land use, such as forest clearing (Babigumira et al., 2014), crop diversification (Nguyen et al., 2017), terrace building and the conversion of sloping cropland to forest or grassland (Tang et al., 2013). Nevertheless, to our knowledge, the SLF has not been applied to examine household decisions about cropland use.

The SLF (Carney, 1998; DFID, 1999; Ellis, 2000a) brings in a wide range of factors that may affect human livelihood strategies (McLennan and Garvin, 2012). Potential factors include individual and household characteristics, household assets, public policies, and other contextual factors, which can be organized in an integrated way to provide a comprehensive understanding of household livelihood decisions and associated livelihood outcomes.

According to the SLF (Fig. 1), households have varying degrees of access to a collection of assets, which can be broadly classified into five forms of capital, i.e., human, social, physical, natural and financial, which represent both the endowments and constraints of rural households that shape their livelihoods. In addition, households respond to government policies and the vulnerability context (e.g., shocks, trends, and seasonality). These are the main factors expected to affect household adoption of livelihood strategies, such as land use decisions, which lead to distinct livelihood outcomes, such as increased incomes, reduced poverty and decreased vulnerability. As shown in Fig. 1, the SLF also involves feedbacks from livelihood assets to livelihood outcomes. Positive feedbacks enhance the accumulation of assets while negative feedbacks erode them (DFID, 1999). The longer the period of time, the more these feedbacks reinforce or offset the individual effect of a particular policy. As discussed below, we interviewed households (in 2014) that are affected by CCFP, EWFP, and ASP for more than 10 years.

The rationale for adapting our theoretical model based on the SLF framework is as follows: (1) it is human-centered, focusing on the analysis of human livelihood strategies and livelihood outcomes, which are consistent with the scope of this study, i.e., the determinants of land use decision-making at the household level; (2) it establishes linkages between the five-dimensions of assets and household livelihood choices, which enable us to explore how heterogeneities in household access to the various types of capital may affect the land use decision; (3) it integrates the political and institutional context needed to evaluate the policies of interest; and (4) it was originally developed for analyzing household behaviors in a rural agricultural context. Therefore, the SLF framework is used to guide the identification of factors affecting household land use decisions and, hence, the specification of the empirical model.

2.2. Dependent variables

The outcome of interest in this study is the cropland use decision made by each household. Households almost always own multiple cropland parcels in the study area and may rent in additional parcels from neighbors or rent out and/or abandon some of their parcels. We first focus on whether a household is expanding, maintaining or reducing its cultivating cropland area. Consequently, the three following household land use decisions can be identified: (1) *expansion*: land rented in > land rented out + land abandoned; (2) *stabilization*: land rent in = land rented out + land abandoned; and (3) *shrinkage*: land rented in < land rented out + land abandoned. Then, a second decision is how to shrink the cropland area in use if the shrinkage decision is made, which involves either (1) net *renting out*: land rented out > land abandoned; or (2) net *abandonment*: land rented out < = land abandoned.

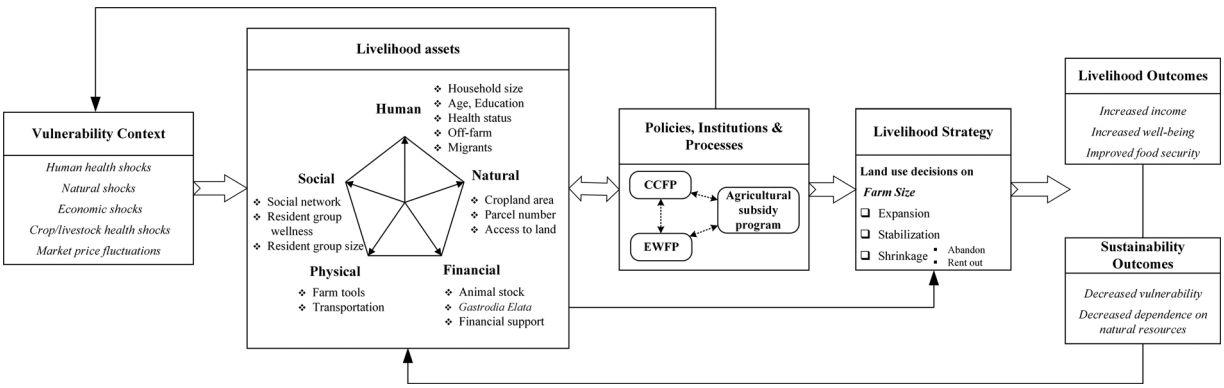

Fig. 1. Household land use decision making process based on the Sustainable Livelihoods Framework.
Adapted from DFID (1999) and McLennan and Garvin (2012).

2.3. Explanatory variables and hypotheses

The selection of potential explanatory variables affecting household land use decisions is guided by the SLF, the literature on household decision-making and land allocation, and our knowledge of the study area. We aggregate variables into six categories, including the policy context and the five dimensions of livelihood assets (i.e., human, natural, physical, financial, and social).

Policy context: Government policies and programs may play crucial roles in household land use decision-making. In this context, we are interested in three policies, two PES programs (EWFP and CCFP) and the ASP. The EWFP was initiated near the end of the 1990s as a policy tool for forest management (State Forestry Administration (SFA, 2001; Dai et al., 2009; Song et al., 2018). Households forfeiting logging privileges on their forestland could receive EWFP compensation based on the area of forests they own. Evidently, the effects of EWFP on household cropland used are not direct but rather indirect, via the additional household income. If the payment fails to compensate the net income lost from foregone logging, there is likely to be some inclination for households to allocate their labor time to some other economic activities to keep the household income from declining. Thus, the cropland area could increase or decrease, depending on the amount of compensation from the EWFP and the subsequent household responses, such as finding local off-farm jobs or out-migration, renting in more cropland from neighbors, or purchasing additional farm inputs/tools or transport equipment. These responses would increase the household income.

The CCFP was launched by the Chinese central government in 1999 with the main goal of soil and water conservation and a secondary goal of poverty alleviation (State Forestry Administration (SFA, 1999; Song et al., 2014). Rural households participating in the CCFP receive compensation (deposited in their bank account at the end of each calendar year) based on the area of qualified croplands converted into forests (or grassland for areas not suitable for forests). Converting sloping cropland to forests reduces the cropland area, thus releases some household labor from farming. Therefore, additional land use change may happen over time after participation in the CCFP. First, CCFP households may keep the remaining cropland constant, *but* intensify its use with more labor inputs per unit land area [4] (stabilization). Second, these households may seek to expand the cropland area by renting in land from neighbors (expansion), offsetting the area lost from the CCFP. Last, they may also do neither of the above, but shift the released labor to other activities, notably local off-farm work or out-migration. In any case, with the progression of time, these feedbacks may lead to expansion, stabilization or (further) reduction of cropland in use by 2014, when the household survey for this study was conducted.

In addition to the EWFP and CCFP, most households in the study area receive agricultural subsidies from the central and local governments through the ASP. The agricultural subsidies are provided to both stimulate grain production to improve food security in China and raise farmers' income for rural poverty reduction. These subsidies make fertilizers, pesticides, high-quality grain seeds, and farm machinery more affordable to farmers (Yi et al., 2015), and hence raise the productivity of cropland. Farmers could benefit not only by increasing these inputs via the ASP to increase cropland productivity, but also by renting in more land, if available, to increase grain production. The relationship between the ASP and farm practices is therefore more straightforward than that of the other policies, as it motivates increased crop production either with cropland stabilization or expansion. The ASP should lead to less cropland abandonment. However, farmers may use the agricultural subsidies they receive for other purposes as well, such as to finance out-migration, seek off-farm work, or just increase their consumption to improve their life quality.

In addition to the direct effects above, we explore three plausible interactions among the three policies: (1) the CCFP participation and the EWFP payment; (2) the CCFP participation and the agricultural subsidies; and (3) the EWFP payment and the agricultural subsidies. We hypothesize that CCFP and EWFP, with similar environmental goals, have synergistic effects on household land use, most likely stimulating cropland shrinkage. The CCFP and the ASP, which have conflicting aims, may have trade-off effects on cropland use. Finally, the EWFP and the ASP, both of which increase household incomes, may interact affecting land-use decisions.

Human capital: refers to the quantity and quality of household human resources that they use to achieve their livelihood objectives (DFID, 1999) through a variety of options. Human capital manifest in household size, household age-sex composition, the stage of the household lifecycle, or dependency ratio (i.e., ratio of consumers to workers), and household member education. The relationship between demographic factors and household land use decisions has been studied, both theoretically (e.g., Chayanov, 1966; Walker and Homma, 1996) and empirically (Barbieri et al., 2005; Entwisle et al., 1998; Gray et al., 2008; Liu et al., 2005), via the consumption needs of household members and agricultural production, depending on the labor available for farming (VanWey et al., 2007). For example, households are less likely to expand cropland beyond that needed for subsistence production in the early stage of the lifecycle due to the lack of labor (Chayanov, 1966). However, cropland expansion may occur as children grow up, and then decline at later stages when children leave the house to form their own households. Similarly, consumption needs rise and fall with the number and age of household members. In addition to being used as a proxy for the household lifecycle, age may also represent farm experience.

Among the other human capital variables, the education of household members is a key indicator of labor quality, reflecting the knowledge and skills needed to take advantage of livelihood opportunities. Health status constitutes another important dimension of labor quality. Here, health status is measured from reported expenditures on medicines and health care in the previous 12 months. We assume that those who spend more generally have more health problems, though it is true that sometimes the poorest do not spend money for health care even when they are ill since they cannot afford it, and they just cope with minor illnesses without medical treatments. In addition to farming, households engage in local off-farm work and send members to migrant labor markets, both of which are important aspects of livelihood strategy. Remittance from migrants is often a major source of income for rural households (Zhang, 2017). The local off-farm employment and out-migration evidently affect the labor availability to the farm, and thus tend to decrease the cultivated cropland area. Therefore, the household size, mean age of the household's adults, household head's education, medical expenditures, number of adults engaged in local off-farm work, and whether the household has any out-migrants are selected as the indicators of human capital, which have potential effects on cropland use decisions.

Natural capital: refers to natural resources from which certain livelihood goods (e.g., crops, timber) are derived (DFID, 1999). The total cropland area in *mu* (area unit used in rural China, 1 mu = 1/15 ha) and the number of parcels owned by a household denote the quantity of natural resources available. Irrigation access, slope and soil quality represent the quality of natural capital (e.g., Pan and Bilsborrow, 2005; Gray and Bilsborrow, 2014; Nguyen et al., 2017). The (mean) distance to the cropland parcels measures the accessibility to natural capital (Babigumira et al., 2014). Distance tends to be better captured by minutes walking—which is more closely related to the farmer's behavior—than the Euclidean distance from the household to the cropland parcels in meters. The ownership status of cropland also affects its

[4] Intensification of agriculture has long been studied by economists and agricultural scientists and may involve increasing applications of labor per unit of land and/or increased applications of other inputs, such as fertilizer, pesticides, etc., which may or may not be a response to increasing population pressures (see, e.g., Boserup, 1965; Bilsborrow and Carr, 2001).

access, as sharecroppers and partial owners have less control over land and usually benefit less from agricultural input in crop production. Such households invest less on natural resource maintenance and are more likely to exit farming (Bhandari, 2012). In this study, the area of cropland owned, number of parcels, and mean travel time from the home to the cropland parcels (minutes walking) are selected to represent natural capital.

Physical capital: comprises the productive assets and infrastructure that can be used to generate household income. The ownership of farm tools, such as shovels, hoes, plows, pumps and threshers, enhances a household's capacity to grain production, thus contributing to the management of larger and/or more cropland parcels. Having transportation means, such as a tractor or other vehicle (truck, car or even motorcycle), makes it easier both to deliver agricultural supplies and to transport agricultural products to the market (Omamo, 1998). Thus, access to more or better infrastructure may stimulate cropland expansion. On the other hand, proximity to the town center makes off-farm employment more accessible, which may lead to cropland shrinkage. Here, two indices, i.e., *farm tools* and *transportation equipment* (see Appendix A), are used to measure physical capital. Each of the two factors is scored on a 6-point scale ranging from low access to infrastructure equipment (score 0) to high access (score 5).

Financial capital: denotes the financial resources (savings and access to credit) that households can use to diversify livelihood strategies, which affects land use (DFID, 1999). Better access to financial capital enables a household to directly rent land in or indirectly stimulates more investments in farm equipment, employment of farm labor, and/or usage of fertilizers and pesticides, potentially leading to expanding the cropland area. Prior studies have found positive linkages between animal husbandry and cropland use in China, as animals provide manure and draft power (such as oxen) (Alary et al., 2011)—both important for crop production. Hence, animal keeping may reduce farm exit, as found by Bhandari (2012) in a rural agricultural area of Nepal. On the other hand, households that raise animals usually use more land to produce food for them (especially larger animals, such as cows and pigs). In addition, animal stock can be considered as a form of financial capital, as it provides a stock of wealth that can be sold for cash when needed.

Many rural households in Tiantangzhai are also involved in cultivating *Gastrodia Elata* (GE) (a Chinese medicinal fungus) as a cash crop. GE can be the major source of agricultural income, but growing GE is labor intensive, thus reducing labor availability for grain production. Although income from local off-farm work is another important source of income, it is highly correlated with the number of off-farm workers, which is already included in our model above under human capital. Finally, financial support (e.g., remittances, cash and goods) from previous household members who out-migrated and/or other relatives is part of the household income and may affect land use, either positively—to the extent it is used to increase land productivity via the purchase of inputs such as fertilizers or invested in farm tools or transportation equipment (already controlled for in the model)—or negatively, to the extent that receiving remittances reduces the necessity to farm. Therefore, animal stock, GE cultivation, and financial support are used as measures of financial capital.

Social capital: refers to the ability of households to enhance livelihoods through social networks (e.g., kinship, friendship, neighbor ties) and membership in social organizations or other groups (e.g., ethnic, caste, racial) (Njuki et al., 2008). First, rural village residents often enjoy close kinship and neighborhood bonds, and mutual support systems arise out of generations of living close to each other and enduring the vicissitudes of natural or anthropogenic hardships. Thus, households with high social connectedness may have more social resources to draw upon for various support, such as switching to higher-value crops, expanding the cropland area by renting in land, or shifting household labor from farming to off-farm work. Here, social connectedness is measured as the sum of money sent and received as social gifts [5] relative to estimated total household income during the past 12 months; a larger amount of money used as social gifts implies a higher degree of social connectedness. Second, households in the same social organization have higher levels of trust, mutual acquaintances and recognition, which may also facilitate collective actions and generate communal benefits (Klerkx and Proctor, 2013). Additionally, households with membership in the same formalized groups are often expected to follow the same sets of rules, norms and sanctions (DFID, 1999), and thus may exhibit similar land use behaviors, in contrast to households in different ethnic, or other groups (Bhandari, 2012; Carr, 2005; Gray et al., 2008; Lu et al., 2010). In the present study, all households belong to the same Han ethnic group, so only two resident group level variables are used, i.e., resident group size and resident group wellness. The wellness of the resident group is computed as the *mean wellness index* of all households that live in the group, based on seven factors, including house type and construction, water and sanitation facilities, ownership of electrical appliances, communications and entertainment equipment, types of fuel used for energy, farm tools, and means of transportation (Song et al., 2018). The last two indicators were excluded to calculate the mean wellness index because they are already included in physical capital above at the household level (see Appendix A). Each factor is scored on a 6-point scale, with the wellness index being the sum of the highest scores from each category.

3. Materials and methods

3.1. Study area and context

This study draws on data collected from a household survey conducted in Tiantangzhai Township, Jinzhai County, Anhui Province, China (Fig. 1), which covers an area of 189 km^2 (latitudes 31°8′ N ~ 31°17′ N, longitudes 115°38′ E ~ 115°54′ E). Elevations in this mountainous area range from 363 m to 1729 m above sea level. Tiantangzhai has a subtropical monsoon climate with a mean annual temperature of 16.4 °C and a mean annual precipitation of 1350 mm. The township is heavily forested (72% of the total land area in 2013) with a modest area in cropland (14%) (Zhang et al., 2018c; Chen et al., 2018). The primary crops are rice, corn, and sweet potato, produced primarily for domestic consumption and animal feed. Farmers also grow tea, walnuts and fruit from trees on dryland as cash crops. Household livelihoods in Tiantangzhai have also been heavily dependent on forests, with 83% of the households in the study area relying on fuelwood as their main source of fuel (Song et al., 2018). It is worth noting that, in recent years, many households shifted from traditional crops to *Gastrodia Elata* (GE) cultivation, reaching nearly half the households in the study area at the time of the survey in 2014. GE is a type of fungus in East Asia that grows on certain species of freshly cut trees in a semi-shaded environment, which can be used as a valuable ingredient in traditional Chinese medicine. Although the initial cost is high due to the high cost of seeds, growing GE can yield high incomes due to its high market price. In addition to crop and GE cultivation, many households are also involved in other livelihood activities, such as animal husbandry, local off-farm work. Households also send members to migrant labor markets, expecting remittances, which, along with local off-farm income, often accounts for the lion's share of household income (Song et al., 2014).

[5] In China, it is a custom that when a household has a big life changing event, such as a birth, marriage, graduation, purchase of a new house, death, etc., friends and relatives come to share the happiness or sadness, and bring or send money as a social gift, much of which is used in community or kinship celebrations or mourning. The amount received varies widely in different parts of China and depends on the wealth and social status of both the sender and the recipient as well as the closeness of their relationship. Hence, the money sent and received as social gifts is a good indicator of social capital.

Table 1
Explanatory variables based on sustainable livelihoods framework.

Variable category and variable name		Description
Policy context	CCFP participation	Whether participates in CCFP (1 = yes, 0 = no)
	EWFP payment	Subsidy from EWFP
	Agricultural subsidies	Subsidies from the agricultural subsidy program
Human capital	Household size	Number of household members
	Mean age of adults	Age of adult household members
	Head's education	Education of household head
	Medical expense	Proxy for health status, measured by household annual expenditures on medicines and health care in past 12 months
	Off-farm labor	Number of household members working in local off-farm labor market
	Household out migrants	Whether household has former member(s) working in non-local labor market
Natural capital	Cropland owned	Area of cropland owned (mu)
	Number of parcels	Number of cropland parcels owned
	Travel time to parcels	Average walking distance from household residence to cropland parcels owned, measured in minutes walking
Physical capital	Farm tools	Score of level of farm tools and equipment owned (see Appendix A, category 6)
	Transportation equipment	Score of level of transportation equipment owned (see Appendix A, category 7)
Financial capital	Animal stock	Value of animals owned by the household
	If cultivates GE	Whether a household engages in *Gastrodia Elata* cultivation
	Financial support	Amount of money received by household from migrants/relatives/friends
Social capital	Social connectedness	Sum of money sent and received as social gifts / total annual income
	Resident group size	Number of households in the resident group a household belongs to
	Resident group wellness	Average wellness index of the households in the resident group (see Appendix A)

Due partially to the harsh biophysical conditions and poor infrastructure, an estimated 31% of the rural residents in Tiantangzhai still live under the national poverty line (Tiantangzhai Township Government, 2016). To alleviate poverty as well as reduce the reliance on natural resources, two national PES programs have been implemented in the study area. Nearly all households in rural areas of the township have some natural forests, and thus are enrolled in the EWFP program. The EWFP compensation for households was 8.75 yuan/mu/year (which equals to about US $21/ha/year). Given the large areas of natural forest that households own in this mountainous township, households received 592 yuan/year (~US $95) on average. In contrast, only 17.5% of households in Tiantangzhai participated in CCFP. The CCFP compensation for households in Tiantangzhai was 230 yuan/mu/year during the first eight-year contract period, starting in 2002. The compensation was reduced to 125 yuan/mu/year when the policy was renewed for an additional 8 years in 2007. The mean subsidy received by CCFP participants was 173 yuan/year in 2014. Finally, 87% of the sampled households cultivate cropland and produce grain (mostly rice), and thus receive some agricultural subsidies, though the money received varies widely. The mean agricultural subsidies received by the sampled households was 696 yuan in 2014. The subsidies from the EWFP, CCFP, and ASP programs accounted for 8%, 2%, and 10% of annual household agricultural net income on average, respectively.

3.2. Household survey

The dataset used to analyze rural household land use decision-making is from a two-year household survey (2014–2015) in Tiantangzhai township, Anhui province, in central China. The survey was conducted using a 22-page questionnaire covering many topics, including land cultivation and agri-environmental program participation. In particular, the questionnaire contains detailed information on: (1) household demographics; (2) land area, including area of cropland owned, cultivated, rented in, rented out, and abandoned; (3) types of crops and the amounts harvested and sold; (4) investments in crop production, including fertilizer, pesticides, herbicides, seeds and hired labor; (5) cost of inputs and value of outputs from other agricultural production activities, such as animal husbandry and *Gastrodia Elata* cultivation; (6) labor allocation to on-farm and off-farm activities; (7) participation in and subsidies obtained from CCFP, EWFP and ASP; (8) household income from all sources and household expenditures; and (9) accessibilities to each cropland parcel, the nearest main road, and the township center, measured in the estimated time most people require to get there, by walking, motor cycle, bus, etc.

For administering the household survey, five college students were recruited from Anhui Agricultural University and trained as enumerators. We adopted a disproportionate stratified random sampling technique to select the households for interview. All resident groups within the township were first separated into 5 strata based on the percent of households participating in the CCFP. We oversampled the strata with higher proportions of households participating in the CCFP because only 17.5% of the households in the Township were enrolled in the CCFP. After the resident groups were selected, we randomly selected up to 20 households for interview with a goal of equal number of households in and out of the CCFP. If a sampled resident group has fewer than 20 households, all households were selected. If a resident group has less than 10 households in (out of) the CCFP, all these households will be selected, and the remaining household would be selected from the other type of households to make up a total of 20 selected households. This allowed us to select a scientific, representative sample comprising approximately half CCFP participants and half nonparticipants although each selected households may have a different representative weight, which can be taken care of in the statistical analysis (see Song et al., 2018 for details). The survey team eventually completed interviews on 481 sample households from 40 resident groups in 7 administrative villages. Of the households interviewed, 40 had no cropland or have missing values on key data and thus are excluded from this study, which resulted in a total of 441 households for the analysis.

3.3. Statistical models

Based on the Sustainable Livelihoods Framework and the literature, we constructed statistical models to investigate the determinants of household land use decisions. The dependent and explanatory variables specified by the conceptual model are described in Table 1.

Since the dependent variable in this study has three mutually exclusive responses (*stabilization, expansion* and *shrinkage*), we use standard multinomial logistic (MNL) regression (Agresti, 1996) to model household land use choices. Specifically, we construct and estimate two models. In the first (Model 1), we use the full sample and set the outcome of stabilization (Y = 1) as the reference response to estimate the log-odds of expansion (Y = 2) or shrinkage (Y = 3). In the second model (Model 2), we select a subsample of all households (sample size = 256) with cropland shrinkage and set the reference outcome to the choice of renting-out cropland (for renting-out, Y = 30; for abandonment Y = 31). The equations for Model 1 and Model 2 can be

written as in the following forms:

$$\text{logit}(Y_i') = \log\left(\frac{P_{Y_i=2\ or\ Y_i=3}}{P_{Y_i=1}}\right) = \alpha + \sum \beta_k x_{ik} + \varepsilon_i \quad (1)$$

$$\text{logit}(Y_i') = \log\left(\frac{P_{Y_i=31}}{P_{Y_i=30}}\right) = \alpha + \sum \beta_k x_{ik} + \varepsilon_i \quad (2)$$

where i is the subscript for the i^{th} household, x_k represents the k^{th} explanatory variable; α is the intercept; β_k is the coefficient for the k^{th} variable, measuring the effect of x_k; and ε is the error term. In the model here, we have classified the explanatory factors into six groups of explanatory variables, i.e., *human capital*, *natural capital, physical capital*, *financial capital*, *social capital*, and the *policy context,* comprising a total of 23 variables.

We also investigate various possible interaction effects, including between each pair of policies, by introducing interaction terms (Jaccard, 2001) into Model 1 and Model 2, separately. The two models with interaction terms are referred to here as Model 3 and Model 4. A general equation for Model 3 and 4 can be written as follows:

$$\text{logit}(Y_i') = \alpha + \sum \beta_k x_{ik} + \gamma x_{i1}x_{i2} + \delta x_{i2}x_{i3} + \theta x_{i3}x_{i1} + \varepsilon_i \quad (3)$$

where x_1, x_2 and x_3 represent the explanatory variables of CCFP participation, EWFP payment and agricultural subsidies, respectively.

To assist the interpretation of the possible interactions among these policies, we convert the predicted logit(Y_i') to its predicted conditional probability as (Liao, 1994):

$$P_{Y_i=j} = \frac{\alpha_j + \sum_{k=1}^{K} \beta_{jk} x_{ik} + \gamma_j x_{i1}x_{i2} + \delta_j x_{i2}x_{i3} + \theta_j x_{i3}x_{i1} + \varepsilon_{ij}}{1 + \sum_{j=2}^{3} e^{\alpha_j + \sum_{k=1}^{K} \beta_{jk} x_{ik} + \gamma_j x_{i1}x_{i2} + \delta_j x_{i2}x_{i3} + \theta_j x_{i3}x_{i1} + \varepsilon_{ij}}} \ (j = 2, 3) \quad (4)$$

As some income and expenditure variables are strongly right-skewed (i.e., GE income, animal stock, remittances, medical expenses), a natural logarithmic transformation is used prior to model estimation to reduce the effects of skewed outlier values. To make it easier for interpreting the interaction effects, all continuous variables are converted into z-scores with a mean of 0 and standard deviation of 1. Finally, the multicollinearity of all the explanatory variables together is examined using variance inflation factors (VIF) (Appendix B). The VIF values range between 1.09 and 2.66, suggesting acceptable multicollinearity.

4. Results

4.1. Descriptive statistics

Table 2 provides the descriptive statistics on the land use of the sample households in Tiantangzhai township. Unlike the large farms in the United States and Europe, China has a longstanding tradition of small-scale farming, with a typical farming household in China managing only 8.4 mu (which equals to 0.56 ha) of cropland (Yan et al., 2016). In this mountainous study area, the cropland is much smaller than the national average. Households own the usufruct right for only 5.7 mu (0.38 ha) of cropland on average, with more cropland abandoned (1.1 mu/household) and rented out (0.8 mu/household) than rented in (0.5 mu/household). Thus, the most common decision of households in 2014—and consistent with widespread out-migration from rural areas of China in recent decades—was to shrink the land area in use (58%), followed by stabilization (26%). Only 16% of the sampled households increased cropland cultivated areas through expansion.

Households making the expansion decision had less cropland (5.1 mu) than those who maintain or reduce cropland before the expansion, as expected. The average amount of land rented in by them is relatively high, at 2.6 mu/household, among the sampled households. The shrinkage decision is divided into two subcategories, with more households abandoning cropland (36%) than renting it out (22%). Households who adopt abandonment have the largest initial cropland area (6.1 mu), and the mean abandoned land is also larger compared with the remaining land, at 2.6 mu. Those who favor the renting out decision rent out 3.3 mu/household of cropland on average. Accordingly, the expansion households have the largest total cropland in use on average (7.3 mu/household), followed by the stabilization households (5.5 mu/household), while those abandoning (3.3 mu ha/household) or renting out land (2.0 mu/household) cultivate the smallest areas of cropland. The wide dispersion of the outcome variables indicates substantial differences in the areas cropped in 2014, which is mostly not due to differences in original "ownership" (see discussion in section 5.2 below), but rather to land transfer and abandonment, as investigated in this paper. It also suggests that many households in the study area no longer see crop production as their major source of livelihood, which is consistent with what was found in another rural area of China in Yunnan Province (Frayer et al., 2014), as well as in many other developing countries (Barrett et al., 2001; Vasco Pérez et al., 2015; Wunder et al., 2014).

Table 3 provides descriptive statistics of the explanatory variables for households engaging in each land use outcome decision. As our sampling method aimed to collect data on similar numbers of CCFP participants and nonparticipants, in the end, the participants constituted 56% of the sampled households. Households who make the expansion decision (in the twelve-month reference period in 2013–2014) have a higher rate of participation in CCFP (61%) than those abandoning (56%) or renting out (51%). This suggests that CCFP participants tend to rent in some cropland from neighbor households after they enrolled some of their own parcels in the CCFP to replace some of the land set aside for reforestation. However, compared to the mean land enrolled in the CCFP program of 2.0 mu, the difference in the areas rented in turns out to be trivial (0.5 mu for participants and 0.4 mu for nonparticipants), so the net effect of the CCFP is not seriously compromised (up to 2014) by subsequent changes in the household livelihoods from possible feedback effects (in Fig. 1). On

Table 2
Descriptive statistics of dependent variables by land use decisions (Unit: mu[a]).

Land Use	Full sample (n = 441)		Stabilization (n_1 = 114)		Expansion (n_2 = 71)		Shrinkage (n_3 = 256)			
							Renting-out (m_1 = 98)		Abandonment (m_2 = 158)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cropland owned	5.7	2.7	5.5	3.0	5.1	2.7	5.7	2.6	6.1	2.6
Cropland rented in	0.5	1.2	0.0	0.3	2.6	1.9	0.1	0.4	0.1	0.4
Cropland rented out	0.8	1.6	0.0	0.3	0.1	0.4	3.3	1.7	0.2	0.5
Cropland abandoned	1.1	1.6	0.0	0.1	0.3	0.6	0.5	0.8	2.6	1.8
Total cropland in use[b]	4.3	3.3	5.5	3.0	7.3	3.4	2.0	2.2	3.3	2.7

[a] Mu is an area unit used in rural China, 1 mu = 1/15 ha.
[b] Total cropland in use = Cropland owned + Cropland rented in - Cropland rented out - Cropland abandoned.

Table 3
Descriptive statistics of explanatory variables.

Variables		Unit	Full sample		Expansion		Stabilization		Shrinkage (n_3 = 256)			
			(n = 441)		(n_1 = 71)		(n_2 = 114)		Renting out (m_1 = 98)		Abandonment (m_2 = 158)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Policy context	CCFP participation	%	56.5	49.6	60.6	49.2	59.6	49.3	51.0	50.2	55.7	49.8
	EWFP payment	Yuan	592.4	667.4	543.6	564.9	665.2	719.4	473.8	537.9	635.4	734.3
	Agricultural subsidies	Yuan	695.8	1340.1	630.2	487.4	796.0	1049.7	765.4	2437.4	609.8	666.1
Human capital	Household size	Persons	2.9	1.3	3.1	1.2	3.2	1.4	2.6	1.1	2.8	1.4
	Mean age of adults	Years	52.6	10.3	52.4	9.9	52.1	8.9	52.8	10.9	53.0	11.1
	Head's education	Years	5.9	3.0	5.7	2.9	5.8	2.9	6.7	3.5	5.6	2.8
	Medical expense	1,000 Yuan	4.1	7.0	2.7	3.6	4.8	7.2	5.0	8.9	3.6	6.6
	Off-farm labor	Persons	0.5	0.7	0.3	0.6	0.5	0.7	0.7	0.7	0.4	0.7
	(Number of off-farm labor / Number of adults)	%	20.4	28.3	10.5	19.7	18.5	25.0	33.7	33.4	17.9	27.9
	Household out migrants	%	66.2	47.4	60.6	49.2	64.0	48.2	69.4	46.3	68.4	46.7
Natural capital	Cropland owned	Mu	5.7	2.7	5.1	2.6	5.5	3.0	5.7	2.6	6.0	2.6
	Number of parcels	Count	3.5	1.8	4.6	2.0	3.5	1.6	2.1	1.5	3.7	1.6
	Travel time to parcels	minutes	11.1	8.2	10.5	7.7	10.2	7.3	11.7	8.2	11.6	8.9
Physical capital	Farm tools	Index	2.5	1.6	3.2	1.6	2.6	1.7	1.9	1.5	2.3	1.5
	Transportation equipment	Index	2.5	1.4	2.4	1.3	2.6	1.3	2.6	1.5	2.6	1.4
Financial capital	Animal stock	1,000 Yuan	4.5	8.8	7.5	10.7	4.8	8.3	1.9	2.4	4.6	10.2
	If cultivates GE	%	57.6	49.5	66.2	47.6	72.8	44.7	35.7	48.2	56.3	49.8
	Financial support	1,000 Yuan	10.0	20.3	5.2	11.7	12.4	27.6	9.6	15.2	10.7	19.6
Social capital	Social connectedness	%	47.0	79.4	32.5	42.7	39.4	48.4	54.7	107.8	54.2	88.1
	Resident group size	Households	26.1	8.6	26.5	8.9	26.2	8.8	27.9	7.4	24.6	8.9
	Resident group wellness	Index	20.2	2.1	20.0	2.1	20.2	2.1	20.6	2.0	20.1	2.2

average, the households received slightly higher payments from the ASP (696 yuan) than from the EWFP (592 yuan). These figures may be compared with the much smaller mean payment received by households from the CCFP (173 yuan). Households with stable farm size received the most from the ASP, while households with abandoned croplands benefited the least.

Regarding human capital, sample households overall have a mean size of only 2.9 members (rural households are small in China, due to both low fertility since the one-child policy was initiated in 1982 and much out-migration), a mean age of 52.6 for adult members (due also to the out-migration), and a mean education of 5.9 years for adults. On average, 18% of household members are involved in local off-farm work, and 66% of households have sent one or more members to out-migration labor markets—an extraordinarily high proportion of rural household members—reflecting the massive rural population displacement occurring in China for the past four decades and accompanying the unprecedented urbanization and economic expansion. Reported annual expenditures on medicines and health care averaged 4100 yuan per household, or 12% of the annual household income. The comparison among the three types of households shows that those with cropland expansion or stabilization have larger household sizes than those with cropland shrinkage, which is consistent with Chayanov's (1966) finding that larger households tend to have higher consumption needs for food and enough labor to maintain or expand farming activities. It is also noticeable that households renting out cropland tend to have the highest education (6.7 years), which is likely linked to their more frequent involvement in off-farm work, where more education is helpful. Households that expand their cropland tend to spend the least on medical care, which may imply they are among the lowest income households and cannot afford to spend more. As expected, households who were expanding their cropland had the lowest local off-farm participation (11%) and the likelihood of having an out-migrant household member (but the percentage was still at 61%). For the two types of shrinkage households, those renting out land engaged much more in local off-farm work than those abandoning land (34% vs. 18%) and were slightly more likely to have an out-migrant household member. Overall, those reducing cropland were more likely to have an out-migrant, while those expanding were the least likely.

For natural capital, households had a mean cropland area of 5.7 mu, a mean number of parcels of 3.5, and mean travel time to cropland parcels of 11.1 min. Households that *expand* cropland have the smallest cropland area but the largest parcel number, indicating that their owned croplands are highly fragmented. While both the renting-out and abandoning households have larger cropland areas, the parcel size of the former is much larger than the latter, making it easier to find renters. Households that *expand* or *stabilize* cropland have slightly easier access to their cropland parcels than those that *shrink* their cropland.

In terms of physical capital, the household's access to productive assets show large variations, but the mean indices of both farm tools and transportation infrastructure (see Appendix A) owned by households were both 2.5. As expected, those who *expand* cropland tend to possess the most farm tools, including tractors, which enhances production efficiency. In terms of transportation equipment, however, households engaging in land expansion have slightly poorer transportation assets than the other households.

In addition to crop production, households in Tiantangzhai also participate in two other agricultural activities that may produce significant farm income, i.e., GE cultivation and animal husbandry, which are classified here under financial capital, for reasons explained earlier. On average, 58% of households are involved in GE cultivation, and the mean value of animal stock is a modest 4500 yuan. As Tiantangzhai is a poor agricultural area, many households are dependent on remittances from out-migrant workers. The average remittance received was 10,000 yuan/household in 2014. Among all the household types, those with stable farm size were the most likely to be involved in GE cultivation (73%). Meanwhile, households expanding cropland tend to have the highest animal stock (valued at 7500 yuan/household on average). This suggests that some of the expanded land is used for growing crops to feed animals. For GE, its cultivation is labor demanding, limiting farmers from renting in more cropland. Given the high input costs for seed, the net income earned from GE is not as high as the households that can afford to reduce cropland. Households with stable cropland receive the highest remittances from out-migrants and/or support from other relatives, which releases pressures on them to engage in seeking more land, raising animals or cultivating GE. Meanwhile, households that reduced their cropland receive the median amounts of financial

Table 4
Multinomial logistic regressions with dependent variables: main effects.

Variables		Model 1 (Base = Stabilization)						Model 2 (Base = Renting out)		
		Expansion			Shrinkage			Abandonment		
		Odds Ratio	S.E.	P > |z|	Odds Ratio	S.E.	P > |z|	Odds Ratio	S.E.	P > |z|
Policy context	CCFP participation	1.724	0.793	0.236	0.995	0.346	0.988	0.942	0.443	0.899
	EWFP payment	0.665	0.163	**0.095***	0.677	0.126	**0.037****	0.919	0.197	0.695
	Agricultural subsidies	0.740	0.204	0.276	0.784	0.163	0.242	0.784	0.157	0.224
Human capital	Household size	0.623	0.159	**0.064***	0.579	0.133	**0.018****	1.478	0.520	0.267
	Mean age of adults	0.754	0.232	0.359	1.230	0.299	0.395	0.887	0.221	0.630
	Head's education	1.089	0.314	0.768	0.656	0.138	**0.045****	0.563	0.132	**0.014****
	Medical expense	0.802	0.173	0.305	0.733	0.145	0.115	0.609	0.158	**0.056***
	Off-farm labor	0.303	0.137	**0.008*****	0.890	0.206	0.615	0.654	0.209	0.185
	Household out migrants	1.193	0.649	0.745	2.704	1.110	**0.015****	0.315	0.177	**0.039****
Natural capital	Cropland owned	0.583	0.207	0.129	2.345	0.567	**0.000*****	0.635	0.165	**0.080***
	Number of parcels	1.259	0.327	0.376	0.491	0.120	**0.004*****	12.887	5.284	**0.000*****
	Travel time to parcels	0.805	0.277	0.528	1.209	0.245	0.349	0.737	0.182	0.216
Physical capital	Farm tools	2.074	0.726	**0.037****	1.115	0.247	0.622	0.854	0.228	0.556
	Transportation equipment	2.083	0.585	**0.009*****	1.653	0.378	**0.028****	1.382	0.390	0.251
Financial capital	Animal stock	1.064	0.343	0.846	0.779	0.161	0.228	0.663	0.155	**0.078***
	If cultivates GE	0.379	0.258	0.154	0.366	0.192	**0.055***	1.687	0.855	0.302
	Financial support	0.883	0.235	0.639	1.056	0.230	0.804	1.985	0.584	**0.020****
Social capital	Social connectedness	1.240	0.309	0.389	1.463	0.299	**0.063***	1.157	0.307	0.582
	Resident group size	0.545	0.181	**0.067***	0.655	0.129	**0.032****	1.432	0.354	0.147
	Resident group wellness	0.679	0.212	0.214	1.125	0.211	0.531	0.597	0.157	**0.050***
Constant		0.480	0.284	0.214	2.859	1.409	**0.033****	6.146	4.071	**0.006*****
Model summary		Wald Chi^2 = 99.30, p < 0.001 Log pseudo likelihood = -2800.15 Pseudo R^2 = 0.289						Wald Chi^2 = 88.54, p < 0.001 Log pseudo likelihood = -804.91 Pseudo R^2 = 0.474		

***p < 0.01, **p < 0.05, *p < 0.10.

support, as they apparently tend to depend more on local off-farm work.

Finally, regarding social capital, the money received and spent in social activities accounts for a high share (47%) of total household income on average (a heavy burden for many households when they are net payers, and a benefit when they receive). Those reducing their cropland area (regardless of renting out or abandoning cropland) had larger proportions of money involved in social networks, which may provide them better access to off farm opportunities. As expected, households who rent out land tend to live in larger resident groups, which is probably because larger communities make it easier to find renters, which is consistent with those abandoning living in smaller resident groups. Finally, those renting out land also live in slightly better-off resident groups, as reflected in their mean wellness levels, but the difference is small.

4.2. Determinants of land use decisions

Table 4 provides the statistical significance and parameter estimates of variables predicting land use decisions from both models. Model 1 assesses the land use decision of expansion, stabilization or shrinkage for all sample households, while Model 2 evaluates cropland renting-out versus abandonment for households reducing cropland. The results are interpreted relative to the reference categories. The Wald Chi^2 and differences in the **log** pseudo likelihood from the two models suggest both regressions fit the data well overall. The odds ratios are presented to show the main effects, with values greater than one interpreted as showing a positive effect on the dependent variable compared to the reference option, and conversely for values lower than 1.0.

4.2.1. Policy context effects

For the *policy context*, only the size of the EWFP payment has significant effect on the decision to expand or shrink cropland. Households receiving one standard deviation (1.0 SD) larger than the mean EWFP payment are approximately 33% less likely to expand the cropland area (p < 0.10), as well as being 32% less likely to shrink cropland use (p < 0.05), indicating that the EWFP payment stimulates households to adopt the stabilization decision. Households living in higher elevations and more isolated areas have more forestland and, therefore, receive larger EWFP payment. These households also have less access to other livelihood options (e.g., local off-farm work), and tend to be poorer. Therefore, the EWFP payment can be viewed as an important livelihood source that helps them stabilize their income, despite giving up their logging privileges to conserve forests. It should be noted that although EWFP restricted natural capital to some extent, fuelwood collection by rural households in the study area is allowed by the local government as it is a fundamental livelihood, particularly for poorer household living at higher elevations (Song et al., 2018).

In contrast, neither CCFP participation nor the agricultural subsidies appear to exert significant effects on any of the land use decisions examined here. Thus, while there does appear to be some indication of CCFP households expanding their land to partly replenish land withdrawn from use, this effect is small and not statistically significant (see Section 2.3). Therefore, rather than replacing the land given up for CCFP, in the intermediate decade since participating in CCFP, many households have altered their livelihoods towards more intensified use of the remaining cropland, engaging in off-farm work, or even out-migration. With respect to the agricultural subsidies, the lack of significant effects may attribute to the failure of the program in identifying the actual cultivators. Up till 2014 when the survey was conducted, subsidies were still being given to the land owners, instead of the farmers engaged in grain production, thus it is unlikely to affect their cropland use decisions. This is in agreement with Huang et al. (2011) based on a national survey dataset. Another reason may be that the effects of the agricultural subsidies have been, after a decade, mostly counteracted by the other possible uses of the compensation, such as changes in livelihoods and/or improving consumption expenditures (especially in these low-income households), but examining this is beyond the scope of this paper.

4.2.2. Human capital

Household size has significantly negative associations for both cropland expansion and shrinkage, indicating larger households are more likely to *stabilize* land use. The effects of the mean age of adults are not significant in both models, but households with more educated adults are less likely to shrink cropland and tend to rent land out rather than abandon it if shrinkage is adopted. This may reflect that more education is associated with higher consumption aspirations, which, in turn, raises the household's awareness of the economic value of cropland. Households with higher medical expenditures tend to stabilize cropland but those who do reduce it rent land out rather than abandon it, perhaps due to the rent received helping to cover medical costs. There is a much stronger and negative relationship between local off-farm labor and cropland expansion, i.e., households are 70% less likely to expand their land area if the number of household members engaging in off-farm labor increases by 1.0 SD (approximately 1 person) ($p < 0.01$). Meanwhile, having an out-migrant has a strong positive association with cropland shrinkage, with the likelihood for households with an out-migrant household member reducing cropland being approximately 1.7 times larger than those without an out-migrant in the household ($p < 0.05$). Moreover, households having out-migrants are very likely to rent land out instead of abandoning it when they cultivate less land ($p < 0.05$).

4.2.3. Natural capital

Cropland area is considered a form of natural capital that should have a direct relationship with household land use. As expected, we find statistically significant, strong effects of cropland area and number of parcels in both models, although the directions and magnitude vary greatly. Cropland area and number of parcels have opposite effects in land use decision making. First, households possessing a 1.0 SD larger cropland area (0.18 ha) are 1.3 times more likely to *reduce* cropland in use, since they have more land available. Meanwhile, those with 1.0 SD more parcels (approximately 2 parcels) are 50% less likely to reduce cropland, other things being equal. For households that reduce the cropped area, those with more parcels are strongly inclined to abandon them—likely due to it being too much trouble to manage dispersed parcels. This is consistent with what was found by Yan et al. (2016) in another mountainous area in Chongqing, China. In addition, the number of parcels is related to elevation, as households living in higher elevations tend to have fewer but larger parcels with lower soil fertility than those living at lower elevations. Thus, they are likely to abandon parcels rather than rent them out when reducing cropland. Households living farther from roads in smaller resident groups with lower population density have more difficulty renting out parcels. Finally, the mean travel time to parcels, somewhat surprisingly, is not significantly associated with land use decision, perhaps due to few plots being very far from houses.

4.2.4. Physical capital

As expected, households that possess more farm tools (e.g., hoes and shovels, a small tractor, thresher, water pumps) have a higher probability of expanding their farm size (odds ratio = 2.1, $p < 0.05$), but it has no effect on shrinkage vs. stabilization or abandonment vs. renting out. Similarly, having transportation equipment increases the likelihood of *both* expansion (odds ratio = 2.1, $p < 0.01$) and shrinkage (odds ratio = 1.7, $p < 0.05$), but the expansion association is stronger. The ownership of transportation tools (e.g., car or truck, or motorized bicycle vs. nothing) not only greatly enhances accessibility to local markets, thus making it easier to sell agricultural products (hence the expansion effect), but also makes it easier to find local off-farm work (which can explain the shrinkage effect). Furthermore, some households obtain extra income by renting out farm tools and especially transportation services to neighboring households, transferring physical capital into financial capital or social capital.

4.2.5. Financial capital

Three variables are examined here. First, GE cultivation has a marginally significant effect on the shrinkage decision, i.e., households with GE are 63% less likely to reduce the cropland area than those without, suggesting that its capacity to generate high net farm incomes is an important factor that allows farm households to continue to focus on farming as their major livelihood. Households raising more domestic animals also tend to have more stable land use, and when they reduce it, it is via renting land out rather than abandoning it. Households who reduce cropland, due perhaps to the effects of financial support providing substantial contributions to household income, tend to abandon cropland rather than seek renters.

4.2.6. Social capital

Finally, we find that some dimensions of social capital also appear to have significant influences on household land use, though the indicators present mixed effects. First, households with greater social connectedness (i.e., more money involved annually in social activities with relatives and neighbors, as implied by social gifts) are more likely to *reduce* the farm area in use. This is in line with our hypothesis that households spending more money on social connections are more likely to learn about (more lucrative) off farm-work opportunities, which can lead to off-farm work and reduce the amount of cropland in use. In addition, the resident group size is negatively associated with *both* expansion and shrinkage, indicating that households in larger resident groups tend to *stabilize* land use. This may be because larger resident groups are generally located in lower elevations with more productive cropland parcels and easier access to irrigation, education and health services, and markets, which may contribute to stabilization. It is also plausible that larger resident groups that would have lived in the area for more generations will be more socially stable. Finally, resident group wellness does not affect expansion or reduction decisions but does have a significant effect in Model 2. Particularly, households in the well-off resident groups tend to have more social resources for members to draw upon, which makes it easier for them to rent land out, since there are neighbors that are more able to afford to rent land.

4.3. Interaction effects

Possible interaction effects among the three agri-environmental policies that have similar (CCFP vs. EWFP) or conflicting aims (both PES vs. ASP) on household land use decisions should be of considerable interest to policy-makers. Of the 441 sample households, 56% participated in CCFP, 100% in EWFP, and 87% received agricultural subsidies. At the outset, we should first mention that we investigated the possibility of a three-way interaction (CCFP × EWFP × ASP) and found it had no significant effects on any of the land use decisions. Then, all possible two-way interactions (i.e., CCFP × EWFP, CCFP × ASP, and EWFP × ASP) were examined. Entering these interacting terms significantly ($p < 0.001$) improves the overall model fit (Table 5), which demonstrates the likelihood of some significant interactions among the policies. In particular, we observe significant interacting effects between the amounts of the EWFP payment and the agricultural subsidies on the decisions of both expansion (renting in land) and shrinkage (renting out land or abandoning it) (Model 3). The results together suggest an overall interactive effect away from stabilization, and a

Table 5
Multinomial logistic regressions with dependent variables: interaction effects.

Variables		Model 3 (Base = Stabilization)						Model 4 (Base = Renting out)		
		Expansion			Shrinkage			Abandonment		
		Odds Ratio	S.E.	P > |z|	Odds Ratio	S.E.	P > |z|	Odds Ratio	S.E.	P > |z|
Interaction	[CCFP = 1] * EWFP payment	1.158	0.503	0.735	1.051	0.348	0.881	2.888	1.243	**0.014****
	[CCFP = 1] * Agricultural subsidies	0.917	0.425	0.852	0.848	0.313	0.656	1.182	0.455	0.663
	EWFP payment * Agricultural subsidies	2.145	0.681	**0.016****	1.598	0.379	**0.048****	0.940	0.185	0.755
Policy context	CCFP participation	1.821	0.856	0.202	1.014	0.359	0.969	1.188	0.563	0.717
	EWFP payment	0.537	0.161	**0.038****	0.600	0.132	**0.020****	0.739	0.189	0.238
	Agricultural subsidies	0.740	0.222	0.315	0.755	0.179	0.236	0.769	0.202	0.318
Human capital	Household size	0.609	0.157	**0.054***	0.572	0.135	**0.018****	1.455	0.522	0.296
	Mean age of adults	0.839	0.260	0.572	1.337	0.325	0.233	0.900	0.225	0.673
	Head's education	1.127	0.316	0.670	0.660	0.138	**0.046****	0.555	0.135	**0.015****
	Medical expense	0.873	0.186	0.524	0.773	0.149	0.180	0.640	0.179	0.111
	Off-farm labor	0.307	0.141	**0.010****	0.918	0.212	0.712	0.630	0.204	0.154
	Household out migrants	1.226	0.684	0.715	2.881	1.217	**0.012****	0.358	0.207	**0.075***
Natural capital	Cropland owned	0.579	0.203	0.119	2.339	0.557	**0.000*****	0.633	0.167	**0.084***
	Number of parcels	1.343	0.373	0.288	0.496	0.120	**0.004*****	12.094	4.894	**0.000*****
	Travel time to parcels	0.856	0.293	0.650	1.251	0.248	0.258	0.736	0.187	0.229
Physical capital	Farm tools	2.106	0.753	**0.037****	1.111	0.258	0.651	0.849	0.242	0.566
	Transportation equipment	2.379	0.734	**0.005*****	1.806	0.432	0.013	1.370	0.377	0.253
Financial capital	Animal stock	1.043	0.327	0.892	0.793	0.166	0.267	0.669	0.165	0.103
	If cultivates GE	0.363	0.259	0.155	0.330	0.179	0.041	1.673	0.851	0.312
	Financial support	0.902	0.232	0.689	1.065	0.238	0.779	1.990	0.585	**0.019****
Social capital	Social connectedness	1.221	0.318	0.443	1.408	0.291	**0.097***	1.134	0.299	0.634
	Resident group size	0.508	0.168	**0.041****	0.613	0.127	**0.018****	1.502	0.394	0.122
	Resident group wellness	0.596	0.192	0.108	1.070	0.204	0.722	0.643	0.174	0.103
Constant		0.470	0.284	0.211	3.006	1.519	**0.029****	5.342	3.552	**0.012****
Model summary		Wald Chi^2 = 95.83, p < 0.001 Log pseudo likelihood = -2754.03 Pseudo R^2 = 0.301						Wald Chi^2 = 91.05, p < 0.001 Log pseudo likelihood = -781.63 Pseudo R^2 = 0.490		

***p < 0.01, **p < 0.05, *p < 0.10.

slight dominance of expansion over shrinkage of the area in which crops are planted from the interaction effect (both the regression coefficient and the significance levels point in this direction). Bearing in mind the lack of effects of the agricultural subsidies and the effects of higher EWFP payment being strongly linked with *stabilization*, as observed in Table 4, this indicates a more complex, and likely nonlinear relationship overall of the EWFP payment on the area of cropland. Overall, there is little change in the *main* effects of either policy variable or any other explanatory variable, regarding the sign, size and significance level, when the interaction terms are included in the model (compare Table 5 with Table 4).

Farmers receiving the agricultural subsidies are slightly more likely to increase their land area used for growing crops if they already have large areas of forest, for which they are also receiving payment that could facilitate paying for land to rent. This positive synergy with EWFP appears greatest for those households receiving the highest EWFP payment, who tend to be living in the highest altitudes with the most forestland. This could be because more cash—the double subsidies putting them above some threshold—makes it more feasible for them to invest in farm tools to increase the productivity of farmland and/or transportation equipment to facilitate taking products to market.

Although there is no effect of CCFP × EWFP on cropland area and no effects of CCFP in Table 4, there now appears a powerful interactive effect on the decision to abandon cropland vs. rent it out (Model 4, in Table 5). This suggests that the compensation received from the EWFP increases the incentive to abandon cropland rather than rent it out for those enrolled in CCFP. Thus, households at higher elevations with more forestland, and therefore receiving higher EWFP payment are more likely to *abandon* land than rent it out. Given their isolation and greater difficulty in finding nearby neighbors to rent out their relatively poor cropland, they are more likely to just abandon it. Finally, the third pairwise interaction between CCFP and the agricultural subsidies is not statistically significant in either model, and thus is not discussed further (Fig. 2).

4.3.1. Graphical illustration of the interaction between the EWFP and ASP

When the interaction effects are significant, they add to the *total* effects of the variables involved. To assist the interpretation of the complex interactions, we calculate and graph the predicted conditional probabilities of each land use choice based on Eq. (4) (Figs. 3 and 4). The values of the dependent variables are predicted by changing the value of the EWFP payment from low (-2.0 SD) to medium (mean) to high (+2.0 SD), while the agricultural subsidies vary continuously from low to high, and CCFP participation varies from 0 to 1, holding all other variables in the model at their means.

We analyze the interaction between EWFP and ASP payments by plotting the predicted probabilities of land use at different values of the agricultural subsidies according to the level of EWFP payment received, i.e., low, medium, and high (Fig. 3). This takes into account that the EWFP payment stratifies households by the amount of forestland they have, which, in turn, is linked to altitude, distance from the nearest paved road and town, and probably poverty as well. The figure shows that the EWFP and the ASP have trade-off effects on cropland use, controlling for other variables. As shown in Fig. 3, the increase in the

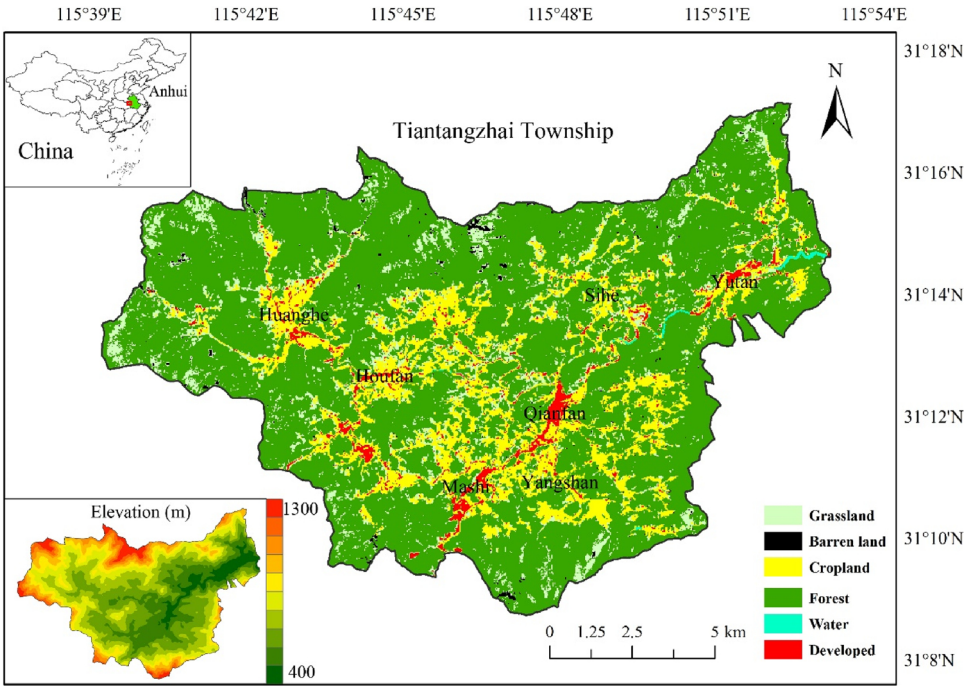

Fig. 2. Location of the study area with land-use/land-cover and elevation distribution.

EWFP payment from low to high reverses the relationship between ASP and the expanding probability from negative to positive (see slopes in Fig. 3a), while it alters the relationship between the ASP and the stabilization probability from positive to negative (Fig. 3c).

For shrinkage, there are more complicated nonlinear interactions (Fig. 3b). If we look at the effects of the ASP at average levels of EWFP, shrinkage appears in the cropped area for those simultaneously receiving both payments, which becomes stronger at higher levels of EWFP and agricultural subsidies (Fig. 3b). This shows that the overall positive association of the agricultural subsidies with cropped area is nonlinear but towards shrinkage, contrary to expectations. However, this effect varies with the level of EWFP; for those with low EWFP payment, we observe a negative relationship (trade-off) between the probability of cropland expansion and the size of the agricultural subsidies, but a strong positive association with stabilization (Fig. 3a, c). Interestingly, we find an inverse U-shaped (concave from below) relationship for households with low EWFP payment when making the decision to reduce the cropland area in use (Fig. 3b), so households with both low EWFP and low agricultural subsidies are the least likely to reduce the cropped area (Fig. 3a, b), but tend to stabilize cropland use when larger agricultural subsidies are provided (Fig. 3b, c).

Overall, expansion is not very sensitive to the size of the agricultural subsidies, as indicated by the fairly horizontal slopes in Fig. 3a, indicating little effect of the ASP on expansion or reducing the cropland used. In contrast, for high EWFP households, the probabilities of both expansion and shrinkage are higher with larger agricultural subsidies, while the stabilization tendency *decreases* significantly. These households are most likely to stabilize the cropped area with low agricultural subsidies but reduce the cropland use with a higher subsidy, amounting to a significant trade-off in the *a priori* expected effects, with the

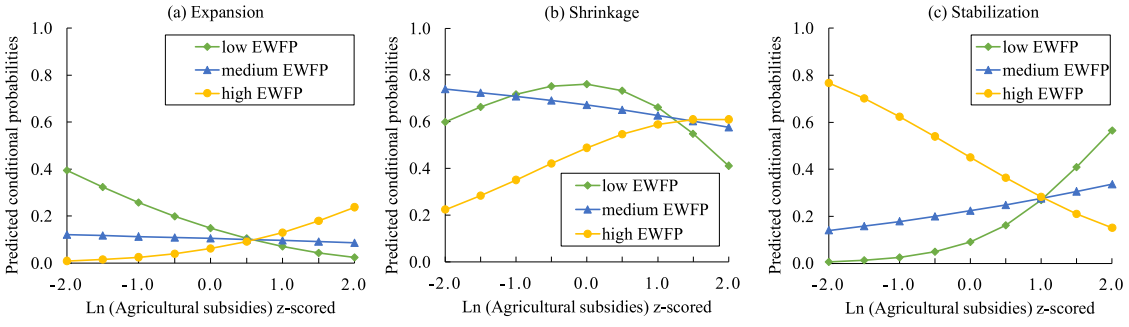

Fig. 3. Interaction between EWFP payment and agricultural subsidies.
The EWFP payment and agricultural subsidies have been converted to z-scores, the values of -2, 0, and +2 can be used to represent for "low", "average", and "high" level, respectively. Same as below.

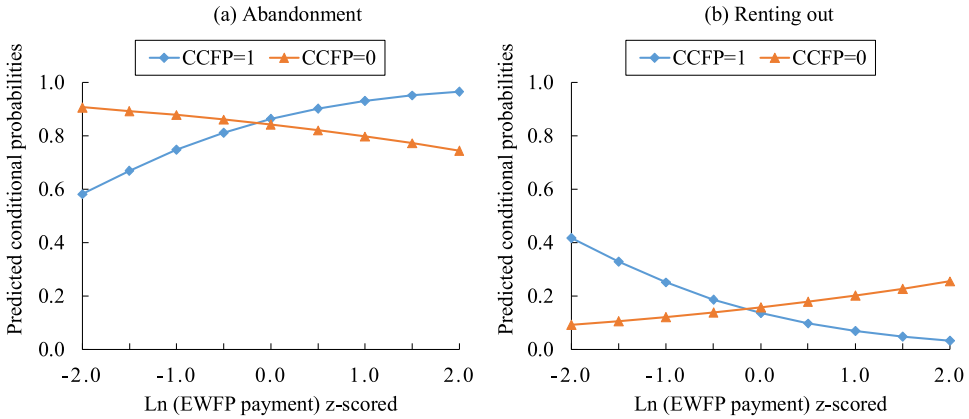

Fig. 4. Interaction between CCFP and EWFP.

(negative) effect of the EWFP payment dominating the (positive) effect of the agricultural subsidies overall. The tendency to reduce cropland overall is a desirable effect of the policy, as those receiving the highest "double subsidies" tend to be the poorest and have the lowest quality of cropland, living farther up the mountainsides (Fig. 3b).

4.3.2. Graphical illustration of the interaction between the CCFP and EWFP

We next analyze the interaction between the CCFP and EWFP on the decision of abandonment vs. renting out by comparing the predicted probabilities of cropland use at various EWFP payment values with respect to CCFP participation and nonparticipation. It is notable that participation in CCFP reverses the slight negative effect of the EWFP payment on abandonment by changing the slope slightly upward (Fig. 4a), demonstrating that CCFP and EWFP have trade-offs on the decision of abandonment vs. renting out. Specifically, for CCFP participants, a higher EWFP payment is linked to an even higher intention to abandon parcels rather than renting them out, although they have already withdrawn land from crop use earlier upon enrolling in CCFP. In contrast, non-CCFP participants show opposite trends, being slightly less likely to abandon and more likely to rent out with higher EWFP subsidies. The reason may be that nonparticipants have marginal parcels that they seek to rent out to generate additional income rather than abandon them. The higher the EWFP subsidy, the more isolated and poorer the households are, and thus they have greater intentions to rent out marginal croplands.

5. Discussion and policy implications

5.1. Policy interactions: synergies, trade-offs, and total effects

In this study, we adapt the Sustainable Livelihoods Framework to develop an empirical model to explore the synergies and trade-offs between three agri-environmental policies which *a priori* have similar goals (i.e., CCFP and EWFP) or conflicting ones (CCFP/ EWFP vs. the agricultural subsidy program) on household cropland use decisions.

First, regarding the synergistic interaction between the two PES programs, we hypothesized that, by the time of the survey in 2014, the CCFP and the EWFP may have positive synergies on land use, to the degree that the farmer uses (some of, at least) the EWFP subsidy as well as the current CCFP payment to rent in farmland, to partially replenish the cropped area given up for the original land enrollment in CCFP. Thus, over the 12–14 year period since the farmers initially made the decision to participate (or not) in the CCFP program, most have become more engaged in off-farm economic activities—off-farm agricultural work (for neighbors), non-agricultural work in the local area, or sending migrants who usually send sizable remittances back (Uchida et al., 2009; Zhang et al., 2018b). By the time we observe the households in 2014, there are no significant cropland replacement effects from CCFP, and instead, there are strong effects towards stabilization of land use linked to the much larger EWFP subsidy payments (Table 5). Indeed, Zhang et al. (2018d) found that CCFP households were less likely to abandon cropland in the years immediately after enrollment in CCFP. Once the interaction effects are considered, these two PES programs exhibit a strong statistically significant *trade-off* on the decision of *how* to reduce land use in those cases when that is the decision. Thus, with no EWFP subsidy, the CCFP encourages some households to rent out cropland (for the income) almost as much others abandon it, but as the EWFP subsidy rises, abandonment becomes ubiquitous. Since the payments from both programs provide income, overall, participants are less inclined to rent land out than non-CCFP participants.

We also find statistically significant interacting effects of the EWFP payment and the agricultural subsidies on the cropland expansion and reduction decisions. The individual effects of agricultural subsidies are insignificant, while the larger the EWFP payment, the more likely the decision will be to stabilize cropland area (Table 4). Introducing the interactive effects (Table 5) considerably reduces the tendency towards stabilization (making it curvilinear), reverses the effects of the EWFP on expansion, and leads to more complex relationships, as is evident in Fig. 3, and as discussed above.

Methodologically, this study seeks to illustrate the value of statistical analysis of multiple policies together to examine the degrees of synergies and trade-offs. Surprisingly, we find that policies with similar as well as different objectives can both lead to significant trade-offs on land use decisions. Thus, government policy decision-makers need to be more careful when introducing more than one policy in the same location (relevant to the same households). Since even a single policy may have contradictory short-run and longer-run effects, the implementation of more policies in parallel leads to even greater uncertainty. On the other hand, policies may have positive synergies, which should be leveraged. For example, the two PES programs (CCFP and EWFP) have initial reinforcing effects on protecting forests and forest regeneration but have trade-off effects on cropland abandonment versus renting-out. Although the abandonment of cropland may facilitate ecological recovery, it gives rise to insecurity of food production for the needs of the growing population, which is of central priority for China's development policies. Hence, at both national and local-levels,

it is important to conduct integrated analyses of existing policies before introducing new ones, taking their synergies and trade-offs into account. In our study area, the local government should determine what the most important policy goal is, i.e., environment conservation, poverty reduction or grain production. Then, all existing and future policies need to be better designed to promote synergies and avoid trade-offs towards achieving that goal *with priority*. Once that is planned, policies can be considered to achieve a second policy goal but taking care from the outset that achieving it does not seriously compromise (through trade-offs) the achievement of the primary goal. If it does, then ways should be sought to reconfigure or apply it to minimize the contradictory effect. However, if the policies instead generate synergies, then all may proceed.

While our findings provide rich empirical evidence on household land use decision-making in a rural agricultural setting that should be useful for a more efficient design of agri-environmental policies, a few limitations of the approach and results must be acknowledged here. First, the Sustainable Livelihoods Framework (Fig. 1) recognizes that several contextual factors as well as other policies may mediate household access to alternative livelihoods, which will affect livelihood decisions associated with the policies under consideration (DFID, 1999). Moreover, the SLF shows that there may be important feedback mechanisms (as observed in this case study) that affect the longer-term outcomes. Important mediation and feedback mechanisms are undoubtedly not captured by this current model, but we are exploring to develop an agent-based model to better capture the complexity of the household decision-making process in the study area.

5.2. The importance of more effective use of abandoned cropland

Although deforestation for land cultivation is still a main trend in some countries where PES projects are implemented (Porras et al., 2013; Wimberly et al., 2017), the abandonment of agricultural land in marginal areas has received increasing attention by scholars and policy-makers. The phenomenon of cropland abandonment in our study area is not the exception from many others worldwide (Mather, 2001; Meyfroidt and Lambin, 2008; Prishchepov et al., 2013). When related to agri-environmental policies, the farm households' decision to abandon cropland is critical for understanding land use and livelihood changes, given its potential for ecological restoration and threats to food security.

Empirical evidence from our study area suggests that households are more likely to reduce the amount of cropland to cultivate over time by abandoning it, instead of renting out cropland to others. This land use trend is observed not only in the study area but in many rural areas of China (Liu et al., 2014) and is likely to become even more pronounced in the future as more rural households shift their primary livelihood activities to off-farm work or migrate to urban areas. For mountainous areas such as Tiantangzhai, a reason for abandonment is that cropland parcels located on mountain slopes are less productive due to poor soils and rainfall retention capacity than at lower elevations. To make more effective use of the abandoned croplands, governments could expand existing or develop new incentive-based programs to convert abandoned croplands to forest, such as by expanding the CCFP to provide seedlings for ecological forest trees or "economic" trees, e.g., fruit or nut bearing trees, which produce income after a few years. At the same, one thing policy-makers concern is the sustainability of the PES programs, which could be hampered by the reversion of reforested areas to cropland by rural farmers after the payments end. More broadly, the growing abandonment of parcels in areas with productive croplands can be attributed to the lack of efficient land transfer markets. The abandoned cropland can be leveraged in land transfer market, where land in good quality can be secured for food production. In China, households have not been allowed to buy or sell land, whose ultimate owner is the state. Land users could not even transfer cropland use rights until the new land transfer and circulation policy was initiated after our survey was completed in 2014 (Miao et al., 2016; Ministry of Agriculture and Rural Affairs of China, 2014). Nevertheless, guidelines on how cropland use rights can be formally transferred remain to be established, not to mention the establishment of private ownership and real land transfer markets (Xie and Jiang, 2016). Functioning real land ownership and transfer markets would facilitate the transformation of natural capital to financial capital and vice versa, with the person receiving the financial capital then invested with the capacity to create new agricultural or non-agricultural activities, to stimulate employment and increase production. Governments could create incentives for such investment rather than just leaving the funds to be used to finance moves to urban areas, as has been occurring overwhelmingly. Overall, policy makers need to consider new policies to make better use of the abandoned croplands to contribute to rural poverty alleviation, environment restoration, and/or food security in China. This may be a concern in many other developing countries as people continue to migrate to urban areas in search of better livelihoods.

6. Conclusions

This paper studies the interactive effects of multiple agri-environmental policies on household cropland use decisions in a rural area of central China, where the three government programs, i.e., the CCFP, the EWFP and the ASP were implemented simultaneously. Fifty-eight percent of the households in the study area shrink cropland area in use (22% via renting out and 36% via abandonment), while those who stabilize or expand land use only constitute 26% and 16%, respectively. Factors influencing household cropland use decisions are complex, including the ownership and access to various livelihood assets (such as human, natural, physical, financial, and social) and the policy context. The results from the statistical model suggest that EWFP payment tend to enhance cropland stabilization as the payment appears to increase household incomes and lower inclinations to migrate away or seek off-farm work, while CCFP and agricultural subsidies do not exert significant direct effects on any of the land use decisions. It is worth noting that we found complex but intriguing synergies and trade-offs among the three government policies. Households receiving both high EWFP and agricultural subsidies tend to reduce their farm size, offsetting the original goal of the agricultural subsidy program to encourage grain production and, hence, use of cropland, which confirms our hypothesis that policies with conflicting goals may involve trade-offs. However, the two PES programs exhibit a strong statistically significant *trade-off* effect (instead of *synergy,* as we hypothesized) on the household's decision between abandonment versus renting-out. However, by the time of the interview in 2014—a medium to long-term period of 10–14 years following policy implementation—households had adapted to the initial stimuli of the policies, rendering the assessment of effects more difficult in this study [6]. These findings can be highly valuable for policy-makers to design more efficient agri-environmental policies, i.e., to avoid trade-offs that reduce the effectiveness of policies and to build on synergies to achieve environmental or development goals. However, to do this, clear policy priorities must be set first, rather than just establishing several different policies each aimed at achieving one goal but failing to consider wasteful trade-offs.

Acknowledgements

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[6] Collecting baseline data on a representative sample of households prior to or at the onset of policies is also crucial for evaluating their impacts. Then, a survey a few years later can assess the main short-run impacts, before they are followed by human adaptations and adjustments as well as the effects of unrelated changes over time in the society and economy, confounding the assessment of the effects of policies per se.

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Appendix A

Table A1

Table A1
Questionnaire for evaluating level of household assets (index computed based on summing highest points corresponding to house entry in each category).

	Category	Item	Points
1	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
2	What kind of fuel do you use?	Coal, gas or electricity only, no fuelwood	5
		Primarily coal, gas & electricity, some fuelwood	4
		About half coal, gas & electricity, half fuelwood	3
		Primarily fuelwood, some coal, gas & electricity	2
		Fuelwood only	1
		Rice, wheat or corn stalks only	0
3	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
4	What kind of the electrical appliances do you have?	A/C in house	5
		Solar panel	4
		Refrigerator	3
		Washing/Dry machine	2
		Electric cooking pot/microwave	1
		None	0
5	What communications and entertainment equipment do you have?	Computer	5
		Cell phone	4
		Fixed line phone	3
		TV/Stereo	2
		Radio	1
		None	0
6	What farm 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 farm tools	1
		None	0
7	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

Appendix B

Table B1

Table B1
Collinearity Statistics.

Variables		Stabilization vs. Expansion vs. Shrinkage	Abandonment vs. Renting out
Interaction	[CCFP = 1] * EWFP	2.46	2.53
	[CCFP = 1] * Agricultural subsidies	2.66	2.60
	EWFP * Agricultural subsidies	1.07	1.12
Policy context	CCFP participation	1.09	1.12
	EWFP payment	2.46	2.41
	Agricultural subsidies	2.66	2.64
Human capital	Household size	1.58	1.67
	Mean age of adults	1.42	1.47
	Head's education	1.14	1.29
	Medical expense	1.10	1.18
	Off-farm labor	1.44	1.54
	Household out migrants	1.17	1.36
Natural capital	Cropland owned	1.30	1.41
	Number of parcels	1.37	1.58
	Travel time to parcels	1.09	1.16
Physical capital	Farm tools	1.25	1.21
	Transportation equipment	1.49	1.79
Financial capital	If cultivates GE	1.28	1.33
	Animal stock	1.26	1.41
	Remittance received	1.26	1.32
Social capital	Social connectedness	1.13	1.18
	Resident group size	1.20	1.23
	Resident group wellness	1.13	1.18
Mean VIF		1.48	1.55

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