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Why Do Farmers Abandon Their Farmland in the Loess Hilly and Gully Region? A Case Study in Guyuan, Western China

XUE Zhichao[1], ZHEN Lin[2,3,*], YAN Huimin[2,3], HU Yunfeng[2,3]

1. School of International Economics and Management, Beijing Technology and Business University, Beijing 100048, China;
2. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;
3. University of Chinese Academy of Sciences, Beijing 100049, China

Abstract: Exploring the driving mechanism and factors influencing farmers' decisions regarding farmland abandonment is fundamental for the targeted control of land abandonment and the adjustment of land management policies, especially for ecologically fragile areas. This study used Guyuan, a typical hilly and gully region, as a study area and employed the framework of a participatory assessment workshop, key informant interviews, and questionnaires to obtain data from stakeholders at multiple levels. The descriptive statistical analyses were carried out from social, economic, and natural aspects to explore the factors affecting farmers' decisions to abandon farmland in the hilly and gully regions. By combining multiple levels of stakeholders and multiple sources of data, the multi-spatial-temporal analysis effectively allowed us to conduct a comprehensive and thorough exploration of the potential factors affecting farmers' land abandonment decisions using this framework. The results revealed important aspects of the main social, economic and environmental factors. (1) Among the social factors, the influence of neighbours is the most influential, owing to the herd mentality of farmers and the negative impact of abandoned farmland on surrounding farmland. Additional factors are declining employment opportunities and grain subsidies. (2) The main economic factors affecting farmers' abandonment of farming are land productivity, farming costs, and grain price. (3) The main environmental factors include road accessibility, slope and terrain relief, and farmers living in hilly and mountainous areas are more sensitive. This research provides comprehensive knowledge about the trade-offs associated with land abandonment and local stakeholders in the Loess hilly and gully region of China, a reference for finding possible pathways to halt the negative impacts, and a solid foundation for the statistical and spatial model building to simulate the abandonment scale, spatial-temporal evolutionary process, and the risk of abandonment for political reference.

Key words: Loess hilly and gully region; farmland abandonment; the willingness of farmer; multi-level participatory analysis

1 Introduction

Farmland abandonment has significant consequences for ecosystem recovery and biodiversity, sustainable rural development, and food security (Díaz et al., 2011; Katayama et al., 2021). The estimated global area of farmland abandonment was 4.72 million km^2 in 2000, which reflected an increasing trend (Paudel et al., 2020), especially for remote, mountainous, economically unproductive farm areas (Liang et al., 2020). Farmland abandonment occurs when human control over farmland is given up, and the land is left to nature. While it has mainly occurred in developed countries, it is also happening in some developing countries.

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First author: XUE Zhichao, E-mail: zhichao.xue@btbu.edu.cn
***Corresponding author:** ZHEN Lin, E-mail: zhenl@igsnrr.ac.cn

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The consequences and impacts of farmland abandonment vary among different regions (Perpiña et al., 2021). Some studies have indicated that farm labour decline and farmland abandonment are the natural consequences when agricultural skills and technologies are enhanced (Yan et al., 2016); and land abandonment improves soil conditions, natural reforestation, and carbon sequestration (Houghton et al., 1999; Ramankutty et al., 2010; Robledano-Aymerich et al., 2014). Others have reported that the land abandonment decreased food production, increased the probability of wildfires (Li and Li, 2017; Sil et al., 2019), and induced the loss of traditional farming practices (Xue and Zhen, 2018). Studies in Europe (Fischer et al., 2012), Japan (Katoh et al., 2009), and Mexico (García-Frapolli et al., 2007) have found that the maintenance of traditional agricultural production and landscapes is conducive to the protection of endangered species.

With respect to remote regions, where agriculture is the primary industry and ecosystems are fragile, the trends of farmland abandonment result in a direct decline in grain acreage, which may lead to a considerable reduction in local food production, and potentially threaten regional food security and ecosystem balance (Feng et al., 2005; Li and Li, 2017). The Loess Plateau of China is one of the most severely eroded areas globally. With highly erodible soils, extensive land fragmentation, and deep slopes, farmland abandonment in the Loess Plateau is increasing. Although there is some uncertainty in the ecological dimension due to the possible benefits from the natural recovery of local ecosystems, farmland abandonment is potentially affecting the local food security and employment (Shi and Shao, 2000; Xue and Zhen, 2018). The scientific community and local governments have emphasized the need for thorough studies on the drivers and consequences of farmland abandonment, and possible strategies for mitigating it.

The factors influencing farmland abandonment are complex and vary regionally. They generally include natural and social factors, such as land fragmentation, the local agricultural development level, labour force characteristics, etc. (Baumann et al., 2011; Osawa et al., 2016). The complexities and regional differences in the influencing factors require a specific and targeted research and analysis on the forces driving abandonment in a given study area to further evaluate the regional risk of abandonment or a spatial pattern simulation (Li and Li, 2017). Farmers are the principal actors in land-use decisions based on diverse natural and social conditions. To explore the relationship between household characters and farmland abandonment, an increasing amount of research on the analysis of drivers of farmland abandonment has arisen in recent years.

However, existing research has two main knowledge gaps. 1) One aspect is the limited spatial scale. Studies have focused mainly on a single scale, such as the country, province, or village level. However, given the complexity of natural conditions, differences among different regions or different kinds of sub-landforms exist, even within one administrative region (Li and Li, 2017; Xue and Zhen, 2018). For instance, a study on rural household farmland abandonment based on survey data from 27 provinces (cities) in China and 8031 rural households revealed that the regional differences in off-farm labourers, which induced the land abandonment, are significant. There is a greater need for specific analyses on comprehensive farmland abandonment evaluation or policy recommendations (Xu et al., 2019). 2) Another aspect is the limited temporal scale. Most research is conducted through field surveys in one or two time periods (Hua et al., 2016). Some of them require the farmers to recall past conditions and extend them in the temporal scale; however, the accuracy of this approach is unclear and likely decreases with the increasing length of the timescale from the research timeframe. Some literature review work has obtained various results on land abandonment in a given period, but included different regions (Yan et al., 2016). However, the land-use strategies of farmers in a specific region were also changed and affected by sweeping changes in the social-economic-environmental conditions spanning several years or more.

Guyuan is located in the typical Loess hilly and gully region and is facing severe agricultural land abandonment. This study adopts a multi-level stakeholder analysis framework and uses multiple sources of data to carry out a multi-spatial-temporal scale assessment within this research background, and then the drivers of agricultural land abandonment are further explored. The aim is to provide support and references for developing a regional sustainable land management strategy by comprehensive factor analysis from the farmers' perspectives. This study has two specific objectives:

(1) To promote a combined multi-spatial and multi-temporal analysis to realize a comprehensive understanding of the driving mechanisms of farmland abandonment by farmers;

(2) To explore the social, economic, and natural factors of farmers' abandonment behaviour in Guyuan in order to support land-use management decisions.

2 Materials and methods

2.1 Study area

2.1.1 General information

Guyuan is located on the northwestern edge of the Loess Plateau in China and belongs to the Ningxia Hui Autonomous Region (Fig. 1). It lies in the east longitude range of 105°19'E to 106°57'E and the north latitude range of 35°14'N to 36°31'N (Guyuan Bureau of Statistics, 2019b). Guyuan has a land area of 1.05×10^4 km^2, of which the farmland is around 8900 km^2, accounting for 84.7% of the total area. About 41.64% of the total area in Guyuan has a slope greater than 15° (Xue and Zhen, 2018). Due to the

hydraulic impact and cutting of rivers, this area has formed typical hilly, gully, and fragmented geographical characteristics. Since these geographic conditions are inferior for living and farming, the Chinese government launched a series of ecological restoration projects. For instance, the sloping land conversion program (SLCP) was implemented in 2001 to convert cropland or barren land on steep slopes into grasslands and forests. With the promotion of SLCP in this area, the forested area in Guyuan has increased from 12.8% to 22.2%, and the grassland coverage rate has increased from 35% to 73% (Guyuan Bureau of Forestry, 2015). The implementation of ecological restoration projects and the increasing grassland and forest land areas may have potential benefits for precipitation. The annual average rainfall in Guyuan has slightly increased in recent years, reaching 538.16 mm in 2018, which represented an increase of 9.3% compared with the 492.2 mm in 2015 (DCRES-CAS, http://www.resdc.cn/).

The annual GDP of Guyuan in 2018 reached 30.32 billion yuan, of which the added value of the primary industry reached 5.8 billion yuan, an increase of 4.0% from 2017 (Guyuan Bureau of Statistics, 2019a). By the end of 2018, the total population of permanent residents in Guyuan was 1.2 million, among which the rural population was 771100, accounting for 62.07% of the total (Guyuan Bureau of Statistics, 2019a). The major crops in Guyuan are winter wheat in rotation with summer maize and potato. These crops account for 48.0% of the total cultivated area, but the production of local crops is limited. The average production levels of wheat, maize, and potato in Guyuan are 2388.06 kg ha^{-1}, 5074.63 kg ha^{-1}, and 3731.34 kg ha^{-1}, respectively (Guyuan Bureau of Statistics, 2019a), accounting for 44%, 83%, and 94% of the average production at the national level, respectively (National Bureau of Statistics, 2019). The income of local rural residents is lower than the national mean level. In 2018, rural residents' per capita disposable income was 9556.7 yuan, which was 81.63% of the average autonomous region level of 11708 yuan and 73.14% of the national average level of 13066 yuan (Guyuan Bureau of Statistics, 2019a).

Farmland abandonment has arisen as one of the severe land-use problems in Guyuan. The specific area of abandoned farmland is hard to determine from remote sensing images or statistical data; however, as estimated by local

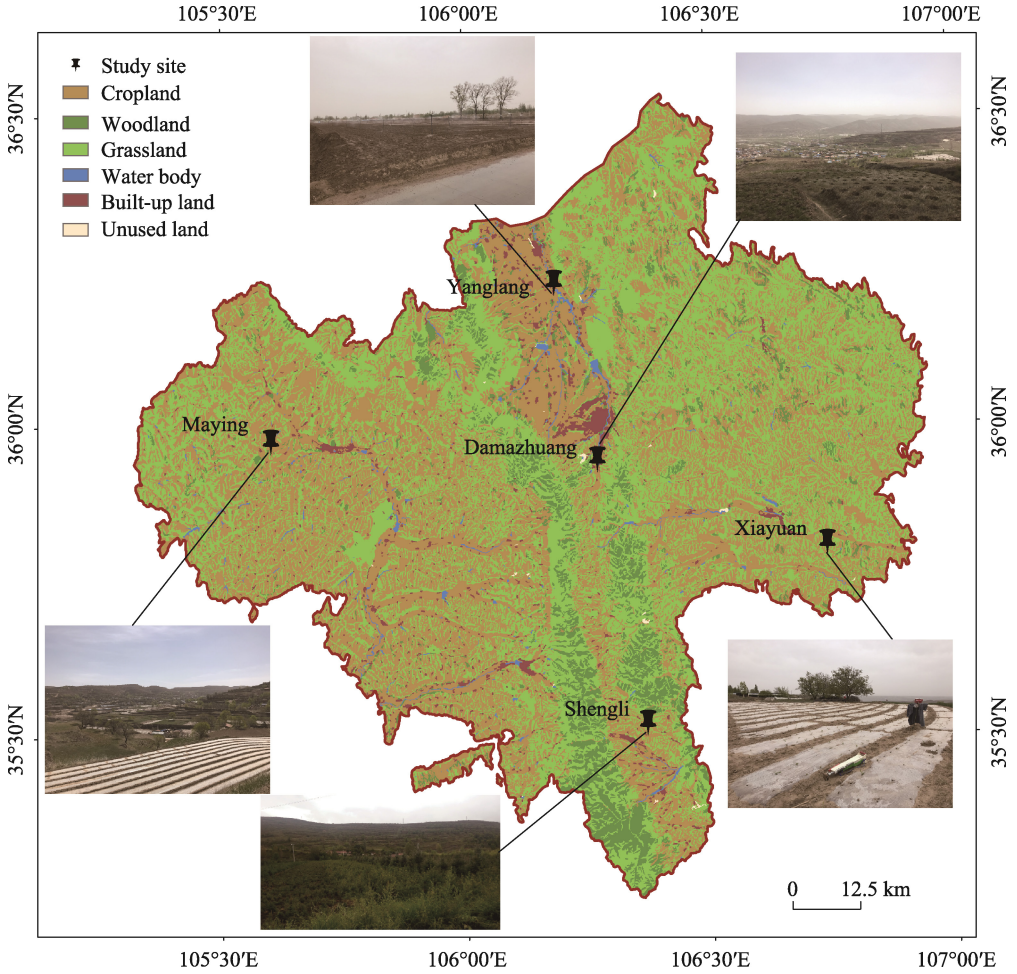

Fig. 1 Location, land cover, and natural features of Guyuan and the representative study sites

experts, about one-fourth of the farmland has already been abandoned so far, and its trends are increasing severely (Xue and Zhen, 2018). From the implementation of the SLCP in 2000 until 2015, Guyuan has increased the area of forest and grassland by 3.11×10^5 ha, of which 1.42×10^5 ha was provided by the conversion of abandoned farmland and wasteland (Guyuan Bureau of Forestry, 2015), which contributed to the release of land abandonment. However, the regions of that project are limited to steep slope areas, and farmers' participation is voluntary; thus, as the promotion of the project progresses, the benefits of abandonment release are decreasing. For instance, in Damazhuang Village, the abandoned farmland has been reduced from around 50% to 15% after SCLP, and the remaining area was mainly abandoned due to drought or difficult accessibility. In Maying Village, 10% of the farmland is abandoned, mostly steep slope land; however, the residents of the village have refused to participate in the SLCP, which has increased the trend of farmland abandonment with no means of control.

2.1.2 Representative field survey sites

There are four kinds of representative landforms in the hilly and gully regions of Guyuan: valley plain, hills, tableland and stony mountain. These regions are remote villages with no convenient access to cities. We chose one village with each kind of typical landform as the representative study sites, as well as a typical peri-urban village to reflect the impact of urban development (Table 1). Yanglang Village is located in the valley in the northern part of Guyuan, and it has relatively good irrigation and farmland conditions. No more than 1% of its farmland has been abandoned due to the difficulty of constructing irrigation infrastructure. Maying Village is in the plateau hills region of western Guyuan, with a broad range of steep slopes and undeveloped infrastructure. Xiayuan Village is located in west Guyuan, with tableland and hills, and around half of the farmland is located in the tableland with suitable grades and good conditions for machine working. Shengli Village is a stony mountain village with limited farmland, and it is located in the southern part of Guyuan within the Liupan Mountain area. Damazhuang Village is a typical peri-urban village, located in the central region of Guyuan, about 8 km from the town and with convenient transportation, leading to a loss of farm labour in the area.

Table 1 Detailed information of the representative villages in Guyuan

Village	Feature	Slope [1]	Farmland abandonment situation	Main livelihood
Yanglang	Valley plain	99.6% with slopes <5°	85.0% of farmland is irrigated; abandonment is rare and primarily due to drought	Mainly work in town
Maying	Plateau hills	72.6% with slopes >25°	10.0% of farmland is abandoned; abandonment is increasing due to accessibility challenges	Mainly farming, part-time jobs in town
Xiayuan	Tableland and hills	64.6% with slopes <15°	Before SLCP, 20.0% farmland abandonment; After SLCP, 14.3% farmland abandonment; Farmers mainly living and farming on the tableland, but abandoning the steep areas and faraway hill land	Mostly farming and livestock breeding, with part-time jobs in town
Shengli	Stony mountains	65.8% with slopes >15°	Before SLCP, 13.3% farmland abandonment; After SLCP, no farmland abandonment (replaced by tree nurseries and the forest economy)	Mainly work in town
Damazhuang	Peri-urban village	62.4% with slopes <5°	Before SLCP, 50.0% farmland abandonment; After SLCP, 15.0% farmland abandonment	Mainly work in town (convenient transportation)

Note: [1] Statistical data from questionnaires. The rate means the percentage of cultivated areas with the indicated slope condition. SLCP: Sloping Land Conversion Program.

2.2 Methodology

We conducted participatory assessment workshops at the Guyuan level, key informant interviews (KIIs) at the village level, and questionnaire surveys at the individual level to gather information on the differences at multiple spatial levels. At the temporal level, besides the household questionnaire surveys conducted in 2016 in the representative villages, we also collected continuous household survey data from fixed peasant households from 2010 to 2016 as a supplement for the temporal dimension. Using this data, we analyzed the factors influencing the abandonment behaviour of households in representative Loess hilly and gully regions in Guyuan, Western China. Potential factors were designated from three aspects, namely, social factors, economic factors, and natural factors. We classified the results of the three dimensions and found the key factors.

2.2.1 Participatory assessment workshop at the Guyuan level

A participatory assessment workshop was conducted in May 2017 in Guyuan. We invited five government officers working in the agricultural and natural resources department in the Guyuan local government and five experts from local universities who were familiar with the study site to participate in the assessment workshop. The professional background and general information of each participant can be found in Appendix I. The topics of this workshop were the farmland abandonment conditions in Guyuan so far, an assessment of the possible impacts, the possible reasons for abandonment, and the selection of representative villages

for further quantitative questionnaire surveys.

2.2.2 Key informant interviews at the village level

KIIs were conducted in five representative villages selected through the participatory assessment workshop. When choosing the key informants, we balanced the village managers and representative farmers and their work and living experiences. Finally, we decided on one representative farmer and two village managers (the village cadre). We conducted a semi-structured interview with each informant, which lasted around 1.5 h each. The interview content included the farmland abandonment conditions in the village and the possible drivers of abandonment, the likely trends and reasons for farmland usage in the village, and the suitable sample size for the village questionnaires to achieve excellent and objective representation.

Through the KIIs, we could understand the background of each village and the particular geographical and cultural features of each village. The KIIs at the village level helped us to achieve a good understanding of the results of drivers obtained from household questionnaires and served as the fundamental explanation for the drivers. Thus, the implementation of the KIIs contributed to bridging the gap between the perspectives of the experts at the Guyuan level and the household farmers at the individual level.

2.2.3 Questionnaires at the household level

Questionnaire surveys were conducted from 2 to 9 May 2017 through face-to-face interviews. The questionnarie mainly contained two parts: basic information, and the decision to abandon the land and the reason. The basic information included gender, age, main occupations, education levels of household members, annual household income, and farmland area and production. The willingness for land abandonment part consisted of multiple-choice questions of the factors impacting the household's decision on land abandonment and the possible thresholds influencing the decision. We conducted a descriptive statistical analysis for each factor of the three dimensions to determine their impacts.

Four PhD candidates in relevant research fields conducted the questionnaire surveys to ensure the quality of the questionnaires, and we also organized training sessions for our research group. To improve efficiency, we sought assistance from the key informants in each village for guiding the tour. We ultimately collected 202 valid questionnaires in Guyuan, with 49, 33, 37, 40, and 43 in Yanglang Village, Maying Village, Xiayuan Village, Shengli Village, and Damazhuang Village, respectively.

2.2.4 Time series of the household survey

The time series of household sample data was in the range of 2011 to 2016. These data were obtained from household survey data compiled and conducted by the Ningxia Hui Antonymous Region survey Team of the National Bureau of Statistics (2012–2017). With the continuous-time series and large-scale sample survey data, this survey can be used as a reference for scientific research and government strategizing. It includes the household survey and agricultural survey analysis reports, and sample survey data. It mainly includes the labour transfer statistical data, grain production, household subsidies, consumption for agricultural production, etc. The basic household information, employment condition, and consumption data were all obtained through the household questionnaire surveys. The grain area and production were obtained through sample surveys in representative villages. The availability of regular time series data from 2011 to 2016 could contribute to the survey gap in the temporal dimension. Based on these first-hand data, we could conduct further analysis on the driving factors and changes from temporal dimension.

3 Results

3.1 Classification of the factors affecting land abandonment

Through the workshop with the experts, the drivers of land abandonment were classified into the three dimensions of social factors, economic factors, and natural factors. Social factors include employment opportunities, grain subsidies, and neighbours' decision-making. Financial (economic) elements include the output of cropland, price of grain, and farming costs. Natural factors include two components. One component is natural disasters, which are represented by droughts and rat infestations. The other component is the land condition, which is more important in the hilly and gully regions, and thus has been refined into three subfactors of road, slope, and topographic relief. The road factor here is focused on the accessibility of the farmland. In the remote villages of Guyuan, with a high percentage of steep slopes and challenging topography, some farmlands are not easy to access. The road conditions here can be artificially described as three types. The first type is the common condition, where at least concrete pavement leads to the farmland, so some cultivating machines can move into the farmland. The second type is the poor condition, where dirt roads lead to the farmland, so farmers and livestock can still access the land and do the farming. The third type is the severely bad condition. Such farmlands are always located in steep slope areas, and there is no way to access the farmland directly. Farmers can carry out farming activities, but machines and irrigation instruments are difficult to use in these conditions.

3.2 Social factors affecting land abandonment

Among the social factors, neighbours' decision-making had the most significant contribution for farmers' willingness to abandon farmland. About 32% of the farmers said that if more than 25% of their neighbours chose to abandon their farmland, they might do the same. One possible reason for this high percentage is the herd mentality of farmers. Even though some farmers did not know the real reasons why

their neighbours gave up their land, they were convinced that there must be a rational reason and that following their neighbors' lead should be the right way. Another important reason is that farmers believed that an increase in the abandoned farmland around their plot would possibly increase the levels of wild animals and plants, which would threaten or destroy their cropland and restrain the cultivation. Thus, they could not farm as usual and would be forced to give up their land. Some villagers living in relatively flat areas pointed out that if their neighbours gave up their land, they would like to rent those areas and conduct farming at a larger scale to get more benefits. This kind of rural land transfer would mitigate the condition of land abandonment (Xue and Zhen, 2018). The next main impact factor was employment opportunities. About 22% of farmers acknowledged that as long as there were suitable job opportunities in the vicinity of the village or county or beyond, they would like to get a job and might give up on planting on some farmland since they could not balance both simultaneously. In the past several years, farmers have witnessed increasing income from off-farm employment, with an annual increase of around 51.8% in Guyuan (Xue and Zhen, 2018). The number of farmers choosing to work off-farm increased from 360 in 2010 to 479 in 2016 among the surveyed households, and it also showed an increasing trend (Ningxia Hui Antonymous Region Survey Team of National Bureau of Statistics, 2012, 2017).

The preferable work location was outside the village but within the county, and the proportion of off-farm jobs within the county increased compared to all off-farm job locations, from 28% in 2010 to 50% in 2016 (Ningxia Hui Antonymous Region Survey Team of National Bureau of Statistics, 2012, 2017). This trend was shown by an inclination of the farmers to start working off-farm at a closer location to balance the energy needed to also work on the farm. The least impactful factor was grain subsidies. The household grain subsidy income in Guyuan was around 188.81 yuan in 2010 and accounted for 6.63% of the annual household income. The average grain subsidy in Guyuan increased from 188.81 yuan in 2010 to 365.76 yuan in 2016. However, the average yearly household income also increased from 2848.62 yuan in 2010 to 10679.83 yuan in 2016. Thus, the proportion of subsidies in terms of total household income was reduced from 6.63% to 3.42% (Ningxia Hui Antonymous Region Survey Team of National Bureau of Statistics, 2012, 2017). As a result, on average, only 5% of farmers expressed the desire to give up planting their land if the grain subsidy policy was abolished (Fig. 2).

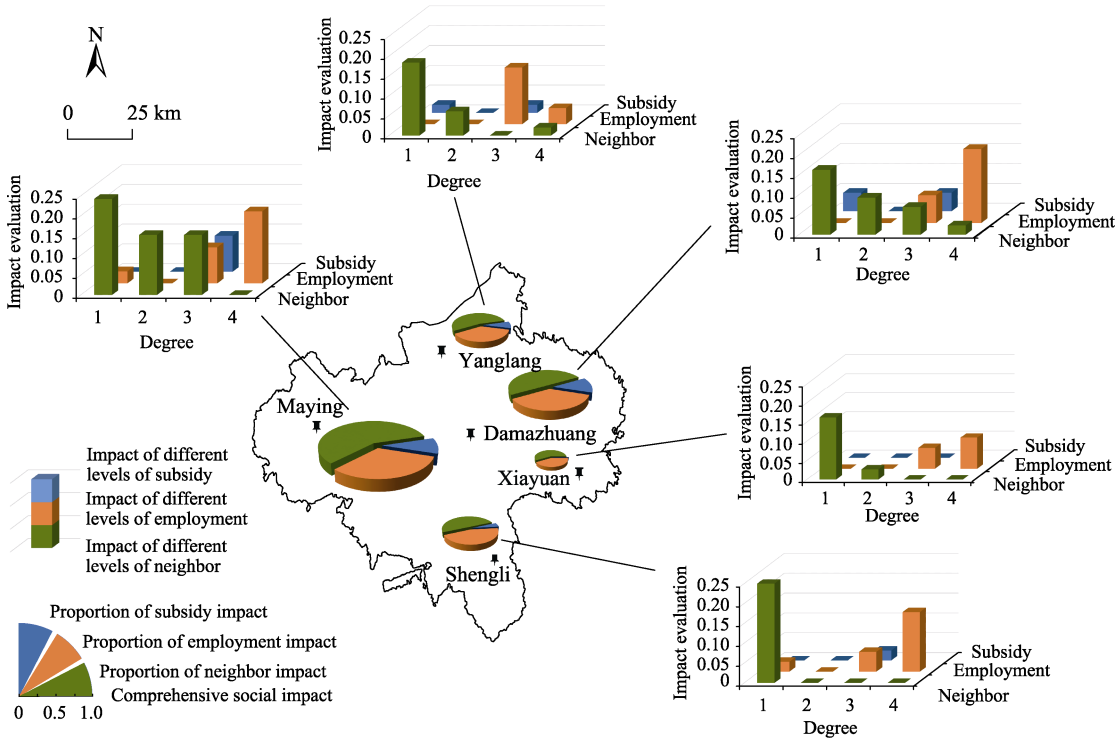

Fig. 2 Social factors affecting farmers' decisions to abandon farmland

Note: The numbers 1, 2, 3, and 4 for each dimension indicate different degrees. In neighborhood impact dimension, 1: All, 2: Majority (75%), 3: Half (50%), 4: Minority (25%). In employment dimension, 1: Village, 2: County, 3: Town, 4: Any kinds. In subsidy dimension, 1: 10 yuan, 2: 15 yuan, 3: None.

From the perspective of different representative villages, the influences of social factors were diverse. They were mainly related to the other behaviours of farmer households caused by the various landforms and locational environments of the cropland. In Maying Village, the neighbours' decision-making had the most significant impact (55%). The

reason is that this village is located in the hilly mountainous areas, where village roads are underdeveloped, and the information communication and transportation are relatively inaccessible. Farmers make decisions primarily through discussions among the neighboring villagers. For instance, according to the KIIs results for village managers, the policy of the SLCP was promoted in the village. However, while more than 88% of the land in Maying Village met the requirements of the program, the entire village chose not to participate in it because of the influence of a certain proportion of conservative villagers so that a large amount of sloping farmland is still preserved. The site least affected by social factors was Xiayuan Village. around half of the land in Xiayuan Village is tableland, where machines can be used for high-efficiency farming. Therefore, the farmers have extra time to work and receive education in the town at the same time. According to the statistics from the questionnaires, the average level of education of adults at junior high school or above in Xiayuan Village was 48.6%; therefore, the land use decisions there are more objective and less affected by neighbourhoods, subsidies, and new employment opportunities.

3.3 Economic factors affecting land abandonment

Among economic factors, the impact of cropland production on farmers' farmland abandonment willingness was relatively significant (Fig. 3). About 31% of farmers believed that when the output of cropland falls below the input, they may give up farming, while the remaining 69% of farmers still held the view that cropland is the fundamental guarantee for their livelihoods; so regardless of the harvest level, it would be better to keep farming than give it up completely. The second-largest impact factor in the economic dimension was farming cost. According to the household survey, household expenses for agricultural production were increasing slightly, as the average household cost increased from 785.3 yuan in 2010 to 874.1 yuan in 2016, for an increasing rate of 11.3%. But combined with the rapid growth of household agricultural income, the proportion of agricultural expenditure to income decreased from 66.5% in 2010 to 35.3% in 2016. Thus, the farming cost is an impact factor for farmland abandonment, but the threat is not very severe. About 27% of farmers believed that when the farming cost far exceeds their tolerance, for instance, more than two times the present cost, they may choose to abandon farming. Finally, the least prominent factor in the economic dimension was the price of grain. About 25% of farmers believed that if the cost of grain becomes too low, they may give up planting, but some farmers stressed that they would choose other crop types and continue cultivating.

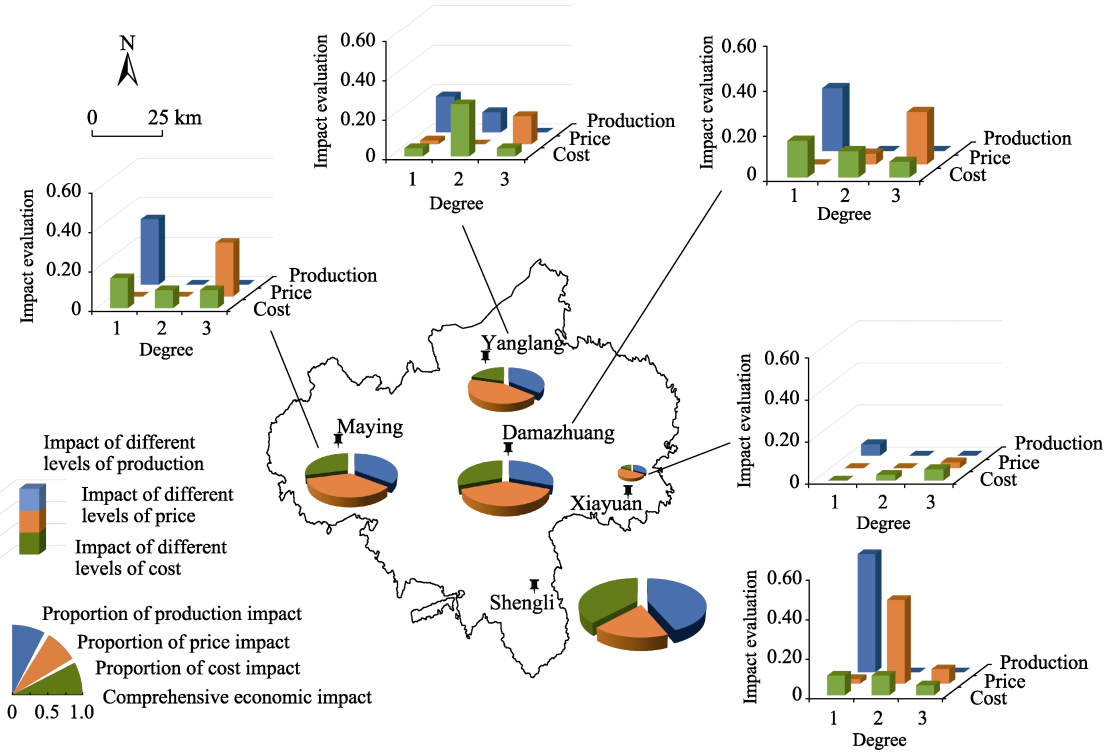

Fig. 3 Economic factors affecting farmers' decisions to abandon farmland

Note: The numbers 1, 2, and 3 for each dimension indicate different degrees. In cost dimension, 1: 1–2 times, 2: 3–5 times, 3: ≥6 times. In price dimension, 1: 2.00 yuan kg^{-1}, 2: 1.60 yuan kg^{-1}, 3: 1.20 yuan kg^{-1}. In production dimension, 1: <5970 kg ha^{-1}, 2: 5970–11940 kg ha^{-1}, 3: >11940 kg ha^{-1}.

The village most strongly affected by multiple economic factors was Shengli Village (with an average affected proportion of 46%), followed by Maying Village (31%), Damazhuang Village (30%), and Yanglang Village (27%);

while the impact on Xiayuan Village was the smallest (5%). Despite all of the economic factors affecting Xiayuan Village, the farmers stressed that planting would not restrain their off-farm work outside the village, and the villagers were inclined to plant organic vegetables and food in their plots to improve their quality of life. Therefore, the economic benefits of cropland do not generally affect the decision-making of land abandonment.

3.4 Natural factors affecting land abandonment

3.4.1 Land conditions affecting land abandonment

The average degree of the impact of land conditions on farmers' choices of farmland abandonment decreased in the order of roads (on average, 36% of farmers in Guyuan were affected by the road factor) = slope (on average, 36% would be affected by slope factor) > topographic relief (on average, 26% would be affected by the topographic relief factor). Shengli Village was the most sensitive for land condition factors, as 53%, 63%, and 53% of the surveyed farmers would choose to give up farming with land conditions of tremendous topographic relief (e.g., the need to cross the mountain), no available path, and slopes above 25°, respectively. The second most strongly affected village was Maying Village. Nearly half of the farmers thought that the road (45%) and slope (48%) would affect their decision-making. Only four and eight households in Yanglang Village expressed the impact of topographic relief and slope, respectively, while five and three households in Xiayuan Village also indicated the effect of topographic relief and slope, respectively.

3.4.2 Natural disasters affecting land abandonment

In general, natural disasters had little impact on farmers' abandonment behaviour (Table 2). Only 34 households (around 17% of surveyed households) and ten households (approximately 5% of surveyed households), respectively, believed that only after droughts and rat infestations occurred for more than five years would they consider giving up their farming.

Table 2 Impacts of natural hazards on farmers' willingness to abandon farmland

Village	Drought		Rat infestation	
	Households	Proportion (%)	Households	Proportion (%)
Yanglang	5	10	1	2
Maying	8	24	3	9
Damazhuang	6	14	3	7
Shengli	13	33	1	3
Xiayuan	2	5	2	5
Guyuan	34	17	10	5

On the one hand, due to the frequent occurrence of drought, farmers are well prepared and can resist drought. For example, in Xiayuan Village, where around 5% of farmers can be affected by drought, the Village Committee organizes the farmers to purchase grain insurance in order to collectively protect the land revenue; thus, the negative impacts of drought are still decreasing. On the other hand, even if there has been a continuous drought for many years, farmers still expect that there will be no drought in the next year. So, while they would likely choose to reduce the number of sowings or change the type of seeding, they generally would not quickly abandon farming due to natural disasters. Drought turned out to have a relatively high impact on Shengli Village (33%). Due to the small amount of land owned by farmers in Shengli, the effect of years of drought would be more likely to change the farmers' way of making a living, for instance, the cultivation of nurseries. According to the KIIs, although there is no statistical data which reflect rat infestations, rat infestations have decreased during these years due to the SLCP and other ecological recovery projects. Thus, rat infestations may affect farmers' choices less at present.

3.5 Comprehensive analysis of the three aspects of farmland abandonment factors

The results from Xiayuan and Yanglang villages indicated a less affected ratio for the farmland abandonment issue (Fig. 4). The effect of the land condition is reduced because the farmland in these villages has flat terrain and is located in high-accessibility areas. As a result, more than 61% of farmers believed that none of the land condition factors of the plots would lead to the choice of abandonment.

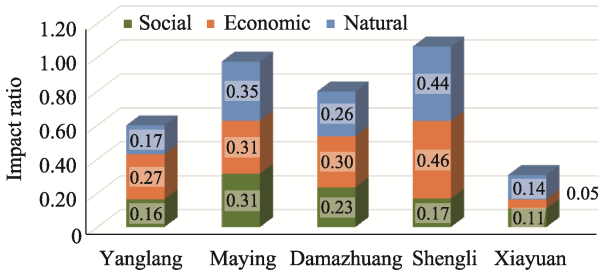

Fig. 4 The three aspects of farmland abandonment factors in five villages

The most easily influenced to abandon their farmland are the villagers in Shengli and Maying villages, especially while facing natural factors. Shengli Village and Maying Village are located in the rocky mountainous area and hilly mountainous area, respectively. More than 75% of the cropland is sloping land. Therefore, in the cultivation of land in these two villages, the inconvenience of roads and the steepness of the cropland were influential to local farmers, and hence, these villages were the most sensitive group. According to the analysis of KIIs, after implementing the SLCP in Shengli Village, the preserved cropland was limited and the per-capita cropland area was only about 0.1 ha person^{-1}. As a result, the income from cropland is not the

main source of household income anymore. In recent years, the introduction of planting nurseries has produced good economic benefits, further reducing farmers' dependence on cropland. Therefore, the harmful economic effects brought by the existing limited and inefficient cropland led to the most significant impact on farmland use choices in Shengli Village.

4 Discussion

4.1 Three aspects affecting farmland abandonment in the Loess hilly and gully region

The most important social factor is the neighbours' decision-making. As we gathered from the testimony of farmers, the possible reasons are the herd mentality and adverse effects on their land of farmland abandonment around their land. Some studies point out that when neighbours abandon their farmland, other farmers will probably take it over and work it together with their original farmlands to reach specific scale effects. We also collected information from a limited number of farmers in relatively flat areas of Guyuan who held this view. However, according to the hilly and gully landform and relatively poor education in this region, although transportation is developing, the access and information on off-village or off-farm are still far from ideal (Zhang et al., 2008), especially for the older generation, which is the leading group that is still working on farms.

Employment opportunities with more income has become a key factor for land abandonment. On the one hand, with the attractive effect of employment opportunities, fewer young people in rural areas want to stay in farming, further promoting farmland abandonment. A study in Jiangxi Province stressed the increasing opportunity costs of farming labour, locations of farms far from the villages and towns, and farmers with more land but lower net income as the main reasons for farmland abandonment (Xie et al., 2014). On the other hand, the implementation and introduction of the SLCP and a coordinated labour transfer policy have led farmers in Guyuan to gradually become inclined to work off-farm. Some studies have addressed the decline of agricultural labour might be the direct cause of land abandonment (Li and Li, 2017). As we found in this research, the number of farmers choosing to work off-farm is increasing. This observation seems to agree with the authority's expectation to reduce the reliance of farmers on their land and to improve the transfer of labour toward nonfarming activities to ultimately improve their income, although this approach may not always work in other sites in China. In addition, some research has also pointed out that the agricultural labour force is shrinking and ageing.

Farmland abandonment is particularly problematic in mountainous and semiarid areas, where the low productivity and land degradation occurs along with soil or climate conditions that are unfavourable for agriculture. In Europe, land abandonment represents one of the major land cover and land use changes since the 19th century, and land abandonment has mainly happened in mountainous areas and semiarid environments (Lasanta et al., 2017; Dolton-Thornton, 2021). In our research, the villages located in the rocky and hilly mountainous areas also show significant effects of land condition on farmland abandonment.

4.2 Analysis of factors affecting farmland abandonment

Agricultural land abandonment is a prominent global land-use change phenomenon. Farmland abandonment has received research attention since the early 1990s, but most of the research has been published only in the last decade, especially for Asian countries (Subedi et al., 2021). Land use activities are integral to the interrelated environmental, economic, and institutional systems, and farmland abandonment results from multiple driving forces. Within the same landform unit, different villages, different types of rural households, and different plots were found to have additional risks and extents of farmland abandonment (Li and Li, 2017). Research in other regions for different periods would have different kinds of classifications and views of the driving factors. For instance, Castillo combined the many factors that drove agricultural land abandonment into three groups, related to biophysical, agricultural socio-economical, and demographic and geographic factors, to model agricultural land abandonment in the EU (Perpiña et al., 2021). Meyfroidt's research characterized the socio-economic determinants of farmland abandonment to reveal the trade-offs associated with abandoned cropland in European Russia, western Siberia, Ukraine and Kazakhstan—the region where the vast majority of post-Soviet farmland abandonment took place (Meyfroidt et al., 2016). The most focused factors were found to include labour conditions, land conditions, and economic conditions mainly extracted from the social, natural, and economic dimensions. In our research with the participatory experts' workshop, we ultimately defined three possible dimensions according to the local constraints, refined each dimension into several indicators, summed up the features of farmers' willingness for each dimension, compared different characteristics among five different villages, and, finally, examined the other impacts of each driving factor. This kind of refined research could potentially contribute to better local, sustainable land management strategies.

4.3 Limitations and the way forward

Our study has some limitations. The household survey data of our research in 2017 and of the Ningxia Hui Antonymous Region Survey Team of the National Bureau of Statistics did not use the same kinds of household sample groups. Although we only employed the statistical data to draw background information, this approach is somewhat insufficient or not as good as using the same household sample group to conduct continuous surveys. Furthermore, the thresholds for

each factor can help policymakers to develop land-use strategies, but in this research, they were not explicitly extracted; so this aspect needs further analysis and research in the future.

5 Conclusions

We comprehensively explored the potential factors affecting farmers' land abandonment choices by combining multiple levels of stakeholders and multiple sources of data to carry out a multi-spatial-temporal scale assessment. We analyzed the mechanisms potentially involved in the abandonment behaviour of households in the Loess hilly and gully regions in Guyuan, China. We classified the factors influencing land abandonment into three dimensions, the social, economic, and natural dimensions. Among the affecting social factors, the influence of neighbourhoods turned out to be the most significant, while the subsidy for grain was the least influential. In the economic dimension, land production, farming cost, and grain price of the current year affected farmers' choices to a similar degree. Still, this dimension's influence varied according to the landform conditions of different villages. The main natural factors included road accessibility, slope, and terrain relief, and farmers living in hilly and mountain areas were more sensitive to biological factors.

The study provides comprehensive knowledge about the trade-offs associated with land abandonment and local stakeholders in the Loess hilly and gully region of China, and provides the reference for possible pathways to halt the negative impacts. In addition, based on the current analysis of the mechanism of farmland abandonment and the identification of regional impact factors, it is possible to construct a statistical and spatial simulation model for the prediction and evaluation of the abandonment scale, temporal and spatial evolution process, and the risk of land abandonment. These spatial simulations and predictions have attracted less attention so far, but would be useful for political reference.

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References

Baumann M, Kuemmerle T, Elbakidze M, et al. 2011. Patterns and drivers of post-socialist farmland abandonment in Western Ukraine. *Land Use Policy*, 28(3): 552–562.

Díaz G I, Nahuelhual L, Echeverría C, et al. 2011. Drivers of land abandonment in Southern Chile and implications for landscape planning. *Landscape and Urban Planning*, 99(3–4): 207–217.

Dolton-Thornton N. 2021. Viewpoint: How should policy respond to land abandonment in Europe? *Land Use Policy*, 102: 105269. DOI: 10.1016/ j.landusepol.2020.105269.

Feng Z M, Yang Y Z, Zhang Y Q, et al. 2005. Grain-for-green policy and its impacts on grain supply in West China. *Land Use Policy*, 22(4): 301–312.

Fischer J, Hartel T, Kuemmerle T. 2012. Conservation policy in traditional farming landscapes. *Conservation Letters*, 5(3): 167–175.

García-Frapolli E, Ayala-Orozco B, Bonilla-Moheno M, et al. 2007. Biodiversity conservation, traditional agriculture and ecotourism: Land cover/land use change projections for a natural protected area in the northeastern Yucatan Peninsula, Mexico. *Landscape and Urban Planning*, 83(2–3): 137–153.

Guyuan Bureau of Forestry. 2015. Report on Sloping Land Conversion Programme implementation in Guyuan. Guyuan, China: Guyuan Bureau of Forestry. (in Chinese)

Guyuan Bureau of Statistics. 2019a. 2019 Statistical communiqu for national economic and social development in Guyuan. Guyuan, China: Guyuan Bureau of Statistics. (in Chinese)

Guyuan Bureau of Statistics. 2019b. Physical geography of Guyuan. Guyuan, China: Guyuan Bureau of Statistics. (in Chinese)

Houghton R A, Hackler J L, Lawrence K T. 1999. The US carbon budget: Contributions from land-use change. *Science*, 285(5427): 574–578.

Hua X B, Yan J Z, Li H L, et al. 2016. Wildlife damage and cultivated land abandonment: Findings from the mountainous areas of Chongqing, China. *Crop Protection*, 84: 141–149.

Katoh K, Sakai S, Takahashi T. 2009. Factors maintaining species diversity in satoyama, a traditional agricultural landscape of Japan. *Biological Conservation*, 142(9): 1930–1936.

Katayama N, Mashiko M, Koshida C, et al. 2021. Effects of rice-field abandonment rates on bird communities in mixed farmland-woodland landscapes in Japan. *Agriculture, Ecosystems & Environment*, 319: 107539. DOI: 10.1016/j.agee.2021.107539.

Lasanta T, Arnáez J, Pascual N, et al. 2017. Space-time process and drivers of land abandonment in Europe. *Catena*, 149: 810–823.

Li S F, Li X B. 2017. Global understanding of farmland abandonment: A review and prospects. *Journal of Geographical Sciences*, 27(9): 1123–1150.

Liang X, Li Y, Zhou Y. 2020. Study on the abandonment of sloping farmland in Fengjie County, Three Gorges Reservoir Area, a mountainous area in China. *Land Use Policy*, 97: 104760. DOI: 10.1016/ j.landusepol.2020.104760.

Meyfroidt P, Schierhorn F, Prishchepov A V, et al. 2016. Drivers, constraints and trade-offs associated with recultivating abandoned cropland in Russia, Ukraine and Kazakhstan. *Global Environmental Change*, 37: 1–15.

National Bureau of Statistics. 2019. Announcement of the National Bureau of Statistics on grain output in 2018. Beijing, China: National Bureau of Statistics. (in Chinese)

Ningxia Hui Antonymous Region Survey Team of National Bureau of Statistics. 2012. The survey data of Ningxia Hui Autonomous Region, Ningxia Hui Autonomous Region. Beijing, China: China Statistic Press. (in Chinese)

Ningxia Hui Antonymous Region Survey Team of National Bureau of Statistics. 2017. The survey data of Ningxia Hui Autonomous Region, Ningxia Hui Autonomous Region. Beijing, China: China Statistic Press. (in Chinese)

Osawa T, Kohyama K, Mitsuhashi H. 2016. Multiple factors drive regional agricultural abandonment. *Science of the Total Environment*, 542: 478–483.

Paudel B, Wu X, Zhang Y, et al. 2020. Farmland abandonment and its determinants in the different ecological villages of the Koshi River Basin, central Himalayas: Synergy of high-resolution remote sensing and social surveys. *Environmental Research*, 188: 109711. DOI: 10.1016/j. envres.2020.109711.

Perpiña C C, Jacobs-Crisioni C, Diogo V, et al. 2021. Modelling agricultural land abandonment in a fine spatial resolution multi-level land-use model: An application for the EU. *Environmental Modelling & Software*, 136: 104946. DOI: 10.1016/j.envsoft.2020.104946.

Ramankutty N, Heller E, Rhemtulla J. 2010. Prevailing myths about agri-

cultural abandonment and forest regrowth in the United States. *Annals of the Association of American Geographers*, 100(3): 502–512.

Robledano-Aymerich F, Romero-Díaz A, Belmonte-Serrato F, et al. 2014. Ecogeomorphological consequences of land abandonment in semiarid-semiarid Mediterranean areas: Integrated assessment of physical evolution and biodiversity. *Agriculture*, *Ecosystem & Environment*, 197: 222–242.

Shi H, Shao M G. 2000. Soil and water loss from the Loess Plateau in China. *Journal of Arid Environments*, 45(1): 9–20.

Sil Â, Fernandes P M, Rodrigues A P, et al. 2019. Farmland abandonment decreases the fire regulation capacity and the fire protection ecosystem service in mountain landscapes. *Ecosystem Services*, 36: 100908. DOI: 10.1016/j.ecoser.2019.100908.

Subedi Y R, Kristiansen P, Cacho O. 2021. Drivers and consequences of agricultural land abandonment and its reutilisation pathways: A systematic review. *Environmental Development*, 42: 100681. DOI: 10.1016/j.envd ev. 2021.100681.

Xie H, Wang P, Yao G. 2014. Exploring the dynamic mechanisms of farmland abandonment based on a spatially explicit economic model for environmental sustainability: A case study in Jiangxi Province, China. *Sustainability*, 6(3): 1260–1282.

Xu D, Deng X, Guo S, et al. 2019. Labor migration and farmland abandonment in rural China: Empirical results and policy implications. *Journal of Environmental Management*, 232: 738–750.

Xue Z C, Zhen L. 2018. Impact of rural land transfer on land use functions in Western China's Guyuan based on a multi-level stakeholder assessment framework. *Sustainability*, 10(5): 1376. DOI: 10.3390/su10051376.

Yan J Z, Yang Z Y, Li Z H, et al. 2016. Drivers of cropland abandonment in mountainous areas: A household decision model on farming scale in Southwest China. *Land Use Policy*, 57: 459–469.

Zhang L, Tu Q, Mol A P J. 2008. Payment for environmental services: The Sloping Land Conversion Program in Ningxia Autonomous Region of China. *China & World Economy*, (2): 16. DOI: 10.1111/j.1749-124X.2008.00107.x.

黄土丘陵沟壑区农民为何选择撂荒？以宁夏固原为例

薛智超[1]，甄　霖[2,3]，闫慧敏[2,3]，胡云峰[2,3]

1. 北京工商大学国际经管学院，北京 100048；
2. 中国科学院地理科学与资源研究所，北京 100101；
3. 中国科学院大学，北京 100049

摘　要：探索影响农户撂荒的因素，是针对性地开展生态脆弱地区土地管理政策调整的基础。本研究选取黄土丘陵沟壑区不同地貌类型的典型村落为研究对象，采用参与式评估框架、关键人物访谈、问卷调查等方法，从多利益相关者角度开展调研，并结合长时序农户调研统计数据，从多时空维度对影响农民撂荒决策的潜在因素进行了探讨。结果表明：（1）在社会维度中，对撂荒决策影响最大的因素是邻居的影响，这是偏远地区农民的从众心理和撂荒地对周边农田可能带来的负面影响综合作用的结果。（2）经济维度的影响因素主要是土地生产力、种植成本和粮食价格等。（3）自然环境因素主要包括道路可达性、坡度和地形起伏等，其中丘陵山区农户对自然环境因素的影响更为敏感。本研究描绘了黄土丘陵沟壑地区耕地撂荒与区域利益相关者交互响应的综合画像，为探索遏制撂荒可能带来的负面影响的路径提供了参考，并为进一步开展撂荒行为的空间变化模拟与管理决策支持奠定了基础。

关键词：黄土丘陵沟壑区；撂荒；农户意愿；多利益相关者参与