RESEARCH ARTICLE

WILEY

Examining pathways linking rural labour outflows to the abandonment of arable land in China

Lili Chen[1,2,3] | Michael E. Meadows[4,5] | Ye Liu[1,2,3] | Yanliu Lin[6]

[1]School of Geography and Planning, Sun Yat-Sen University, Guangzhou, China

[2]Guangdong Key Laboratory for Urbanization and Geo-Simulation, Sun Yat-Sen University, Guangzhou, China

[3]Guangdong Provincial Engineering Research Center for Public Security and Disaster, Guangzhou, China

[4]Department of Environmental and Geographical Science, University of Cape Town, Rondebosch, South Africa

[5]School of Geographic Sciences, East China Normal University, Shanghai, China

[6]Department of Human Geography and Planning, Utrecht University, Utrecht, The Netherlands

Correspondence
Ye Liu, School of Geography and Planning, Sun Yat-sen University, Guangzhou, 510275, China.
Email: liuye25@mail.sysu.edu.cn

Abstract

Against the backdrop of increasing rural labour outflow in China, the marginalisation of agriculture and arable land abandonment has become prevalent. Previous studies have examined the linkages between rural labour outflow and arable land at the national scale but have largely ignored regional differences. Moreover, mechanisms linking rural labour outflow to abandonment have not been analysed systematically. This study uses 2016 China Labour-force Dynamics Survey data (CLDS) and structural equation models (SEMs) to examine the means by which rural labour outflows affect arable land abandonment regionally. The analysis focuses on the mediating role and the moderating role of land tenure approval (LTA), nonagricultural income (NAI), agricultural mechanisation (AMC), and agricultural production efficiency (APE). There are three major findings. Firstly, in the main grain-producing areas (MGPA), part-time labour outflow alone is positively associated with arable land abandonment, while in the main grain-consuming areas (MGCA), only off-farm labour is directly related; there is no significant relationship between labour outflow and arable land abandonment in grain production and marketing balance areas (GPMBA). Secondly, part-time labour does not necessarily lead to reduced levels of mechanisation, although lower APE emerges as an important factor in promoting arable land abandonment. Thirdly, the relationships between off-farm labour/part-time labour and arable land abandonment are moderated by LTA in both MGPA and GPMBA, while the moderation effect exists only in the case of part-time labour in MGCA and GPMBA. We conclude that policies and measures in relation to agriculture and abandonment should be formulated differently for different regions.

KEYWORDS
agricultural mechanisation, agricultural production efficiency, arable land abandonment, nonagricultural income, rural labour outflows

1 | INTRODUCTION

Arable land abandonment (ALA) has emerged as one of the most critical challenges to agriculture and food security, particularly in the context of the COVID-19 pandemic (Gray & Bilsborrow, 2014; He et al., 2020; Maharjan et al., 2020). Many countries have begun to restrict the export of grain and other agricultural products, and agricultural and food markets in some countries are facing disruptions because of shifts in food demand (Laborde et al., 2020). Although China maintained food self-sufficiency, stability, and order during the spread of the coronavirus disease, there is a growing concern about the relationship between the population and arable land. The total area of arable land in China decreased by 960 km² from 2000 to 2015, and the abandonment of arable land rate in mountainous

counties exceeded 14.32% (Li, Li, et al., 2018). Coupled with overall arable land scarcity in China, soil quality is often poor, and more than 70% of fields produce only low to medium yields.[1] Moreover, the Second National Land Survey records a reduction in the arable land area of China for seven consecutive years between 2009 and 2016.[2] Reserve arable land is also seriously deficient[3] and further highlights the scarcity of suitable land for agriculture in the country. ALA therefore threatens food security, agricultural development, and the health of the social-economy. Worse still, the statistics show that the number of individuals engaged in farming in rural China decreased from 283 million in 1978 to 194 million in 2019, with an increased tendency for the young to be employed in nonagricultural work while the old are left to plough the fields. The new rural generation appears to be less willing to participate in agricultural production, while the older generation is physically less well equipped to work on the land (Li & Li, 2016). Accordingly, given the expanding scale of rural labour outflow in China, agriculture is likely to become increasingly marginalised, and ALA may further accelerate the process of farmland abandonment (Xu, Deng, Guo, & Liu, 2019; Yan et al., 2016). The problem has aroused the attention of both the Chinese government and researchers in an attempt to understand its root causes and find solutions to slow down the pace of abandonment (Liu et al., 2016; Qin & Liao, 2016; Xu, Deng, Huang, et al., 2019). Farmland abandonment is common in both developed and developing countries and regions, including parts of Europe (Baumann et al., 2011; Dolton-Thornton, 2021; Price et al., 2015; San Roman Sanz et al., 2013; Zavalloni et al., 2021), Southeast Asia (Fox et al., 2009), Brazil (Castro et al., 2019), and Ecuador (Caulfield et al., 2019). A number of organisations, including the Institute for European Environmental Policy (IEEP), the European Union (EU), and the United Nations Educational, Scientific and Cultural Organisation (UNESCO), have taken measures to avoid further farmland abandonment (Levers et al., 2018). The phenomenon continues to occur, however, and there is an urgent need to explore driving factors and find ways to reduce farmland abandonment.

If the labour force has low agricultural production efficiency (APE) and wages are lower than in the nonagricultural sector, then such labour is likely to be absorbed by the modern industrial sector (Ranis & Fei, 1961). Since agriculture is characterised by low productivity and high costs such that, given the low market price of food production, farming alone is not enough to improve peasants' quality of life and may be insufficient to support even basic livelihoods (Hussain et al., 2016). In response, rural labour migration between rural and urban areas, or between rural areas, in seasonal and circular ways (moving back and forth, to the same or different areas) is very common in developing countries (Almeida & Bravo-Ureta, 2019; Yan et al., 2014). Rural labourers tend to increasingly diversify their livelihoods by exploring nonagricultural income (NAI) opportunities, which have become an important source of rural households' income (Shirai et al., 2017). A study showed that NAI contributed up to 60% of total rural household income in Indonesia and Vietnam (Haggbla et al., 2009). The theory of new economics of labour migration views that migration and remittances can improve rural livelihoods through relaxing production constraints, diversifying income sources, and providing financial capital for investment (Taylor, 1999). However, as the availability of rural labour declines, arable land, especially that of poor quality and low productivity, is abandoned first (Dolton-Thornton, 2021). In fact, both rural labour outflows and agricultural production are important livelihood strategies in rural areas of developing countries (He et al., 2020; Scoones, 2009). Rural migration plays a key role in ALA since it is both an essential component of changes to farming practices and livelihood strategies, as well as a major driving force of change in other dimensions. Migration is especially prominent in developing countries because the (seasonal) labour movement from rural villages to urban centres has brought significant changes in agricultural production. However, the relationship between rural labour outflows and farmland abandonment under the influence of both natural conditions and social-economic conditions is complex and variable, and the question as to how rural labour outflows affect farmland abandonment has not been systematically considered so far.

Most existing studies related to ALA are focused on mountainous areas where land quality is usually low or very low (Hatna & Bakker, 2011; San Roman Sanz et al., 2013; Wang, Zhang, et al., 2019; Yan et al., 2016). Following labour outflow, failure to improve APE exerts a negative impact on productivity, and many rural households may not be able to utilise arable land regardless of its quality. It is therefore important to explore the nature of the problem in areas other than the mountains. Although a few studies have tested the relationship between labour outflows and farmland abandonment using micro-empirical analyses at the national scale (Xu, Deng, Guo, & Liu, 2019; Xu, Deng, Huang, et al., 2019), they tend to neglect differentiation among different regions, which may lead to the application of ineffective or inappropriate policies. Several studies have shown that the spatial distribution of ALA and rural labour outflows is uneven (Qi et al., 2019; Song & Zhang, 2019). Regional differences due to variations in farm labour demand and arable land resource availability (Maharjan et al., 2020; Xu, Deng, Guo, & Liu, 2019) may further affect the response of rural households to labour outflow. At the macroscale, however, such differences may be eliminated (Song & Zhang, 2019). It is, therefore, necessary to explicitly consider spatial heterogeneity if the impact of rural labour outflows on ALA is to be evaluated.

Pathways linking rural labour outflows to ALA are poorly understood, and agricultural production elements and efficiency in particular warrant further investigation. Agricultural machinery is one of the three major elements of agricultural production, and APE may directly affect households' arable land behaviour (Qian & Hong, 2016). Several studies have examined the influence of migration on rural household agricultural machinery use and established that different types of outflowing labour may affect the application of agricultural techniques to varying degrees (Gilles et al., 2013; Qin & Liao, 2016). Another long-standing contention is that remittances generated from labour outflow have altered the availability of capital resources for the purchase of production materials affecting agricultural production (Chiodi et al., 2012; Gray & Bilsborrow, 2014; Pan et al., 2018). Moreover, the

ownership, use, and exchange of farmland have far-reaching implications for APE, and there is a large and growing body of literature on the impacts of land tenure security on farmland investments and agricultural productivity (Jin & Jayne, 2013; Mwesigye et al., 2017). The situation in China is unique due to the existence of a farmland property rights system whereby rural households are not allowed to sell their farmland and have only farmland usage rights rather than sole ownership. The mechanisms by which labour outflow affects ALA remain unclear.

Due to variations in the nature of farm work and type of arable land, the rate of labour outflow may vary in response to the changes in market and institutional environment (Xu, Deng, Huang, et al., 2019). Any analysis of ALA needs to consider the differential effects of different types of labour outflow and also take account of the combined effects of natural conditions and socio-economic factors (Li & Li, 2016). For example, it has been shown that the attributes of householders (e.g., age, education level, political status, income structure, and the number of labourers) and their village environment (e.g., terrain, availability of public facilities, and location) are critical factors (Kizos et al., 2009; Ustaoglu & Collier, 2018), and it is, therefore, important to consider these diverse elements to gain a deeper understanding of the drivers of ALA.

As a developing country with massive rural–urban migration, China offers a highly informative lens through which we can explore mechanisms by which labour outflow influences ALA. The unique land system offers valuable insights regarding complex pathways by which rural labour outflow affects ALA. Moreover, while China has many diverse geographical regions, spatially variable agricultural resource conditions, and different levels of economic development, little research has investigated the difference in the impact of rural labour outflow on farmland abandonment in different regions. Arable land and rural labour are the foundation of grain production, and regional differences in production capacity are closely related to the flow intensity of rural labour, whose influence on ALA in regions with different levels of grain production capacity may be greatly different. Therefore, taking account of the spatial patterns of grain production capacity in China, this research aims to examine the impact of labour outflow on the abandonment of arable land in different regions of rural China using data from 2016 China Labour-force Dynamics Survey (CLDS). The study particularly focuses on the various underlying processes linking rural labour outflows to ALA, namely, the rise in NAI, increased level of mechanisation, and increased level of agricultural efficiency. This research contributes to the body of knowledge on reducing abandoned arable land in China in two ways. Firstly, the analysis goes beyond earlier studies by integrating rural households' NAI, agricultural mechanisation (AMC), APE, and LTA into a framework when exploring mechanisms by which labour outflow affects ALA. In so doing, the study unravels the moderation effects of LTA and NAI and the mediation effects of AMC and APE in the relationship between rural labour outflows and ALA. Secondly, the study provides a comprehensive comparative analysis of regional differences in the impact of rural labour outflows on ALA.

2 | THEORETICAL FRAMEWORK: THE MECHANISMS BY WHICH LABOUR OUTFLOW AFFECTS ALA

Rural to urban migration may increase rural household incomes (Che, 2016; Nguyen et al., 2019) but at the same time may change land-use behaviours and farm management and production efficiency (Liu et al., 2016; Nguyen et al., 2019; Xiao & Zhao, 2018), such that the effects of rural labour outflows on ALA are complex and not clearly understood (Baumann et al., 2011; Li & Li, 2016; Ustaoglu & Collier, 2018). To understand these effects, it is important to identify the outflows of two types of rural laborers, including (i) *off-farm labourers* who receive a stable income from nonagricultural employment and who do not receive any income from farming (ii) *part-time labourers*, who receive income from both nonagricultural employment and farming activities.

It has often been assumed that off-farm labour outflow promotes ALA because it leads to labour scarcity in agricultural production and the remaining labour being unable to meet the original production demands such that peasants choose to abandon all or part of their arable land (Liu et al., 2016; Xu, Deng, Guo, & Liu, 2019). In such cases, off-farm earnings may be higher and become the main source of household income, thereby allowing agricultural production to be reduced and promoting agricultural marginalisation (Almeida & Bravo-Ureta, 2019; Wang et al., 2014). However, some scholars oppose this view, suggesting that the external income from nonagricultural sources may have a positive influence on the farm and help to maintain arable land production (Pan et al., 2018; Xu et al., 2017). In such instances, NAI can be used to subsidise rural livelihoods and increase agricultural inputs, such as fertiliser, pesticide, and agricultural machinery (Caulfield et al., 2019; Chiodi et al., 2012; Gray & Bilsborrow, 2014; Jokinen, 2018; Liu et al., 2016), which eventually improves agricultural productivity and may therefore reduce ALA. Moreover, the middle-aged and older adults are the mainstay of agricultural production in the countryside due to limited opportunities in the urban labour market (Xia & He, 2017), and most off-farm labourers are young rural-urban migrants who have no experience of agricultural production. In such instances, off-farm labour outflow may not actually result in more arable land being abandoned. Since rural households in China are typically just small parcels of arable land with low scales of production (Chen & Zhai, 2015), off-farm labour may simply comprise individuals surplus to production requirements such that their migration may have no effect on agricultural production. In the meantime, other studies have shown that labour outflow may stimulate the application of new agricultural technologies and the development of new agricultural production methods, thereby not only offsetting the reduction of farming labour and ageing farming labour but also improving overall agricultural efficiency (Caulfield et al., 2019). Meanwhile, LTA reinforces land contractual management rights and makes it possible for the landowner to lease the land to other peasants (Luo et al., 2017; Xiao & Zhao, 2018; Su et al., 2020). This form of labour migration is likely to reduce ALA.

The deployment of part-time labour may also support arable land production and constrain or reduce abandonment through remittances improving agricultural input, such as the introduction of mechanisation and fertiliser use, leading to improvements in APE (Chiodi et al., 2012; Pan et al., 2018). Meanwhile, nonagricultural employment for part-time labourers may be relatively unstable and low income-earning, so that there may be a reluctance to give up the arable land (Su et al., 2017). Additionally, LTA may also promote part-time labour to transfer their arable land instead of abandoning it. On the contrary, however, other studies hold that part-time labour is not only the main form of nonagricultural employment but also the mainstay of agricultural production in rural households but that it may lower APE (Liu et al., 2016; Xu, Deng, Guo, & Liu, 2019). In the meantime, because of lower NAI and unstable nonagricultural employment, the deployment of part-time labour may not be able to increase agricultural input sufficiently to offset production deficiencies arise from an ageing farm labour force, thereby promoting ALA (Han et al., 2019). Other studies have shown that the greater the number of part-time labourers in a rural household, the higher the NAI earned, thereby increasing the tendency to leave rural areas and abandon or transfer the arable land (Shao et al., 2015; Xiao & Zhao, 2018). Moreover, there are higher "opportunity costs" for part-time labour participating in agriculture, particularly for those located far away from rural areas (Xiao & Zhao, 2018), which may therefore favour ALA. On balance, therefore, studies appear to support the view that part-time labour outflow promotes ALA.

Based on the above, it may be expected that the effect of off-farm and part-time labour on ALA depends on changes in AMC and APE and that off-farm labour is more likely to improve AMC and APE, while part-time labour is more likely to reduce AMC and APE. LTA and NAI may also play a moderating role in this process. While such additional income can be invested in agricultural production (Caulfield et al., 2019; Zhang et al., 2020), several studies show that such additional funds may be used to renovate or construct houses and purchase other durable consumer goods (Taylor & Lopez-Feldman, 2010; Wang et al., 2014). Regarding regional differences, because agricultural production is the main source of total household income in the main grain-producing areas (MGPA) in China, their heavy reliance on arable land suggests that in these regions any NAI is more likely to be invested in agricultural production. On the other hand, in the major grain consuming areas, any NAI is less likely to be reinvested in production, gradually leading to the marginalisation of the agriculture sector (Lu et al., 2020; Wang et al., 2013a). In the case of LTA, improvement in investments such as agricultural machinery is apparent (Luo et al., 2017).

Accordingly, we propose the following hypotheses:

H1a. Off-farm labour hinders ALA, and this hindering effects vary by region.

H1b. Part-time labour promotes ALA, and this promoting effects vary by region.

H2a. Off-farm labour hinders ALA through increasing AMC and APE among rural households.

H2b. Part-time labour promotes ALA through decreasing AMC and APE among rural households.

H3. The higher the ratio of NAI to total income for rural households with off-farm labour or part-time labour, the less likely they are to abandon their arable land.

H4. Regardless of regional differences, LTA moderates the effects of off-farm and part-time labour on ALA.

The above theoretical framework and research hypotheses can be illustrated as follows (Figure 1):

3 | MATERIALS AND METHODOLOGY

3.1 | Study area and data source

The study area includes 29 provinces of China which, according to anticipated spatial differences in regard to agricultural production (Cheng et al., 2015; Lu et al., 2020), is divided into three regions, including MGPA, MGCA, and GPMBA (Figure 2). MGPA includes 13 provinces: Hebei, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Anhui, Jiangxi, Shangdong, Henan, Hubei, Hunan, and Sichuan. MGCA includes nine provinces: Shanxi, Ningxia, Gansu, Yunnan, Guizhou, Chongqing, Guangxi,b Shaanxi, and Xinjiang. GPMBA includes seven provinces: Beijing, Shanghai, Guangdong, Zhejiang, Fujian, Tianjing, and Hainan. MGPA in China have relatively abundant arable land resources and farming labour, and its agricultural production machinery is the highest in China (Ma et al., 2015). Environmental conditions are more suitable for growing grain crops. However, there has been a serious loss of farming labour in recent years, which may lead to a decline in agricultural production and hinder the development of the region, albeit agriculture is the main source of households' income and peasants do not easily give up agricultural production (Lu et al., 2020).
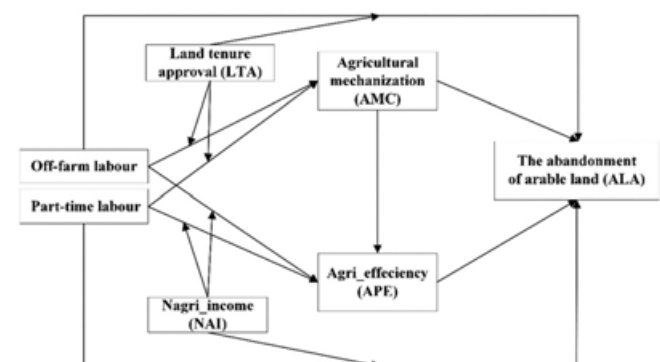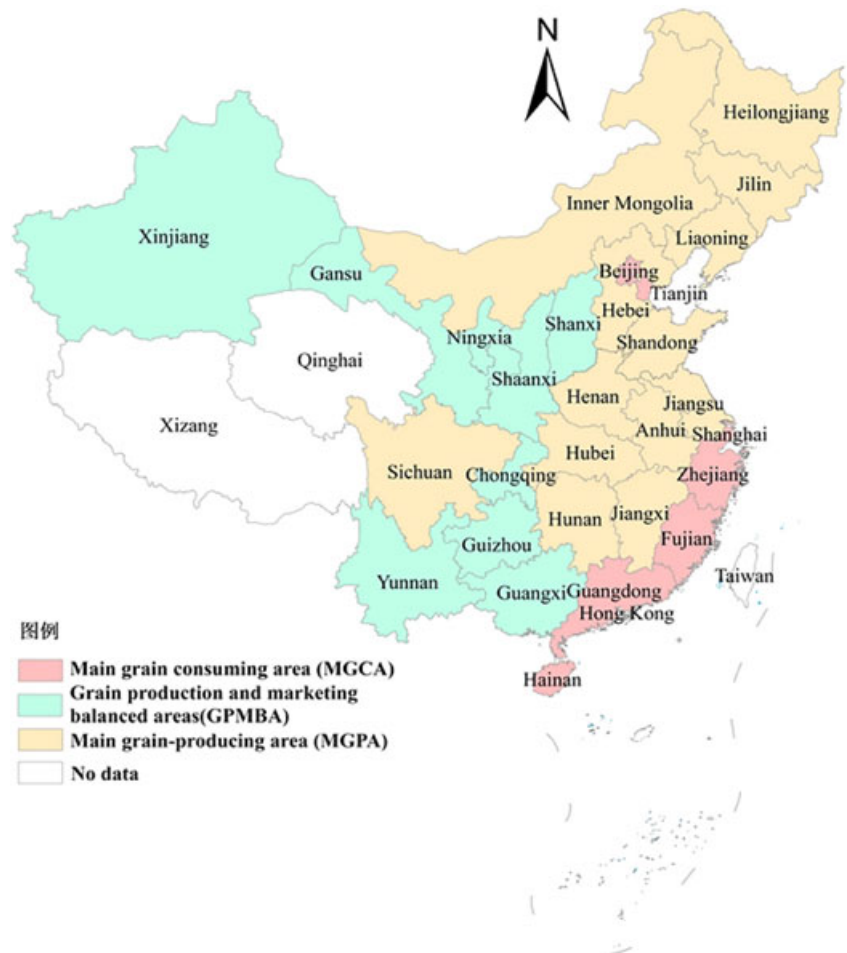

FIGURE 1 Theoretical framework

FIGURE 2 Main grain-producing areas (MGPA), main grain consuming areas (MGCA), and grain production and marketing balance areas (GPMBA) in China

The area of arable land is small and the loss of production is relatively high in MGCA, and rural households' NAI is proportionately high, and they are clearly becoming less dependent on farmland. In such cases, demands for farm labour are lower and many households are more likely to abandon their arable land as the labour force migrates to the urban areas (Wang et al., 2013). Most of the provinces in GPMBA are located in western China which is characterised by arid and/or mountainous environments, so the level of agricultural technical efficiency is relatively low (Ma et al., 2015), and the per capita income in households is the lowest. The arable land in this region may be able to meet people's food demands, but more and more agricultural labourers prefer nonagricultural work with higher income. On the one hand, peasants will not give up farmland easily, because the total income in households is low, and arable land can provide the most basic guarantee for life; on the other hand, they may also give up farming because of poor farming conditions and lower agricultural output. Therefore, there may be significant differences in the effect of rural labour outflow on ALA among the three regions.

The study adopts data from the 2016 wave of CLDS (http://css. sysu.edu.cn/Data for details), which is a large-scale survey conducted by the Center for Social Science Survey of Sun Yat-sen University. A multistage, cluster, stratified, Probability Proportional to Size (PPS) sampling technique was utilised to sample respondents. At the first stage of sampling, 29 provincial administrative divisions (hereafter, provinces) were divided into eight strata based on the province's population size.[4] The second stage of sampling involved the random selection of 160 primary sampling units (such as urban districts, counties, or county-level cities) across the 29 provinces. The third stage of sampling involved the random selection of 400 sampling units (villages and communities) from the selected districts and counties. At the fourth stage, an average of 35 households was randomly selected from the sampled villages and communities. In this study, samples included all household members aged between 15 and 64, as well as those over 65 if still working. It excludes household members who are unable to work due to disability, pregnancy, and studying in schools. Following basic screening and processing, the resultant subsample contains 5,369 households, 222 villages, and 9,328 individuals (outflowing rural labour). We further divided respondents into three groups according to where they lived: MGPA (2,781 rural households), MGCA (1,312 rural households), and GPMBA (1,276 rural households).

Key variables at the individual, household, and the village level were presented as follows:

1. **ALA**. The ratio of each household's abandoned arable land to the total area of family-run arable land.

2. **Rural labour mobility**. The ratio of number of off-farm labourers and part-time labourers to the number of all labourers in each rural household. These two types of labour are distinguished based on their occupation and employment status. Specifically, respondents were asked to classify their employment status either as "full nonagricultural employment," "part-time nonagricultural employment" or as "temporary nonagricultural employment." Off-farm labourers refer to those who are engaged in full nonagricultural employment, and part-time labourers refer to those who are engaged in part-time nonagricultural employment and temporary nonagricultural employment.

3. **Mediators**. There are two mediators. One is mechanised agriculture in a rural household (AMC), and respondents were asked to classify their households' AMC method as "mechanised" or "traditional farming." The other is APE, which is calculated based on the agricultural input and output of arable land by using the Stochastic Frontier Production Function (SFPF) (Lin et al., 2017). Household's agricultural production function is set as follows:

$$
\begin{aligned}
\ln Y_i = {} & \alpha_0 + \beta_L \ln L_i + \beta_A \ln A_i + \beta_M \ln M_i \\
& + \beta_{LA} \ln L_i \ln A_i + \beta_{LM} \ln L_i \ln M_i + \beta_{AM} \ln A_i \ln M_i \\
& + 0.5 \beta_{LL} (\ln L_i)^2 + 0.5 \beta_{AA} (\ln A_i)^2 + 0.5 \beta_{MM} (\ln M_i)^2 + v_i - u_i
\end{aligned}
\tag{1}
$$

where Y_i is the agricultural output (mainly the output of arable land) of the i-th rural household; α_0 is the constant term; L_i, A_i, and M_i represent the input of farming labour, the input of arable land, and the input of capital of the i-th rural household, respectively; the vector β represents the corresponding coefficients of primary terms, interaction terms, and quare terms; $v_i - u_i$ is the mixed error, v_i represents the random error, and $v_i \sim$ iid N $(0, \sigma_u^2)$; u_i is nonnegative, which is independent of v_i and assumed to obey an independent truncated normal distribution N (m_i, σ_u^2).

4. **Moderators**. Two moderators were identified, namely, the ratio of non-agricultural income to total household income (NAI) and whether land certification has been obtained (LTA).

5. **Control variables**. The attributes of respondents, their households, and villages.

3.2 | Structural equation models (SEM)

Structural equation modelling (SEM) can provide consistency and comprehensive explanations of the actual phenomena for a series of complex relationships (Hayes, 2017; Wen & Ye, 2014). In our study, SEMs were used to examine the relationship among variables.

The statistical analysis was carried out in three steps. First, we applied SEMs to examine the mediating role of AMC and APE in the relationship between rural labour outflows and ALA. Secondly, we assessed whether the direct effect of rural labour outflows on ALA was moderated by NAI and LTA. Thirdly, we examined whether indirect effects (mediating effects) were moderated by NAI and LTA. We

then made a comparison between three areas in terms of relationships between rural labour outflow, mediators, and ALA. All statistical analyses were conducted in STATA 14.0.

4 | RESULTS AND ANALYSIS

4.1 | Descriptive statistics

The major features of the sampled households are shown in Table 1. The percentage of abandoned area is (ALA) exceeds 7.0%, which indicates ALA was still increasing at the time of the survey, since the percentage is greater than that of 2014 (6.2%) and 2015 (5.11%) recorded in previous studies (Xu, Deng, Guo, & Liu, 2019; Yan et al., 2016). Regionally, the area of land abandoned (11.55%) is highest in MGCA, followed by GMBPA, with MGPA having the lowest. For the core independent variables, the average proportion of off-farm labour and part-time labour is almost 40.0% and 10.0%, respectively, and except that more off-farm labour in MGCA is greater than 50%, the difference between regions is not large. The proportion of off-farm labour is significantly greater than that of part-time labour. In regard to the mediators, almost half of the sampled households have adopted mechanised farming in MGPA while the proportion is lowest in MGCA (31.5%). Approximately half of all sampled rural households had obtained certificates of land transfer approval by the end of 2015. For moderators, the average NAI accounts for more than 60% of total household income in MGCA, while the proportion is lowest in GMBPA. All independent variables pass the multicollinearity test and there is no significant linear correlation.

4.2 | Total effects of labour outflow on ALA in different regions

Based on SEMs, the total effects of labour outflow on ALA are presented in Table 2. The dependent variable is the ratio of abandoned arable land of all sampled rural households in Model_0 where samples from GPMBA are set as the control group, and the result shows that the core independent variables are positively related to the dependent variable, and the coefficients of off-farm labour and part-time labour are significant at the 1% level, indicating that the more off-farm labour and part-time labour a rural household owns, the higher ratio of abandoned arable land. This suggests that hypothesis H1b is supported while H1a is rejected. Meanwhile, the result also indicates that, when other variables are left unchanged, off-farm labour and part-time labour increase by 1%, and the average ratio of abandoned arable land increases by 0.315% and 0.366%, respectively. Moreover, the results show that the average ratio of abandoned arable land in GMPA is lower than that of GPMBA, suggesting that most rural households in GMPA rely more strongly on agricultural income and do not easily give up farming, although this would require further verification.

Therefore, Model_1 to Model_3 compare the impacts of labour outflow on ALA in different areas. Firstly, Model_1 shows that

TABLE 1 Descriptive statistics of variables

Variables		All samples (N = 5,369) Mean	Std. Dev.	MGPA (N = 2,781) Mean	Std. Dev.	MGCA (N = 1,312) Mean	Std. Dev.	GMBPA (N = 1,276) Mean	Std. Dev.
Dependent variable	ALA	0.074	0.241	0.053	0.204	0.115	0.302	0.079	0.239
Core independent variables	Off-farm	0.393	0.350	0.364	0.344	0.535	0.334	0.311	0.338
	Part-time	0.084	0.195	0.081	0.197	0.063	0.167	0.111	0.213
Mediators	AMC	0.470	0.499	0.531	0.499	0.315	0.465	0.496	0.500
	APE	0.346	0.473	0.440	0.494	0.096	0.292	0.399	0.487
Moderators	LTA	0.506	0.500	0.588	0.492	0.245	0.431	0.595	0.491
	NAI	0.452	0.823	0.458	0.453	0.608	0.449	0.376	0.438
Control variables at the household level	Age/year	54.681	12.171	55.108	11.971	55.573	13.095	52.845	11.422
	Education (years of education of household head/year)	7.251	3.390	7.175	3.410	7.470	3.362	7.192	3.368
	Political (whether the household head is a party member)	0.086	0.280	0.087	0.282	0.086	0.280	0.082	0.274
	Elders (number of elderly people over 64 years old/person)	0.582	0.781	0.592	0.794	0.602	0.778	0.541	0.756
	Children (number of children under 15 years old/person)	0.768	0.976	0.705	0.913	0.816	1.102	0.856	0.962
	Total_incm (total income/RMB, yuan)	41290.740	68514.150	37043.870	49252.460	61546.380	110266.000	29805.490	37460.400
	Agri_incm (agricultural income/RMB, yuan)	9626.198	24778.400	11386.510	26865.710	4901.753	20727.320	10637.610	23219.920
	H_labour (the number of labourers/person)	2.223	9.339	2.975	12.681	0.537	1.519	2.315	3.245
Control variables at the household level	C_dist (distance to the nearest county/km)	27.661	26.343	28.793	25.575	16.766	13.935	36.333	33.051
	D_dist (distance to the nearest town/km)	8.963	9.527	10.612	11.696	6.310	3.555	8.100	7.560
	Terrain of the village (plains as the reference group)								
	Hills	0.279	0.448	0.296	0.457	0.379	0.485	0.139	0.346
	Mountains	0.261	0.439	0.219	0.414	0.150	0.357	0.466	0.499
	The level of harmony (low and medium as the reference group)								
	RH (relatively high)	0.514	0.500	0.478	0.500	0.607	0.489	0.497	0.500
	VH (very high)	0.204	0.403	0.285	0.452	0.070	0.255	0.166	0.372

(Continues)

TABLE 1 (Continued)

Variables		All samples (N = 5,369)		MGPA (N = 2,781)		MGCA (N = 1,312)		GMBPA (N = 1,276)	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	KinderG (whether the village has kindergartens)	0.523	0.500	0.472	0.499	0.566	0.496	0.589	0.492
	PrimaryS (whether the village has primary schools)	0.612	0.487	0.502	0.500	0.603	0.489	0.861	0.346
	JuniorS (whether the village has junior high schools)	0.166	0.372	0.162	0.369	0.139	0.346	0.203	0.402
	Sport (whether the village has sport and fitness facilities)	0.617	0.486	0.519	0.500	0.886	0.318	0.555	0.497
	Square (whether the village has public squares or parks)	0.342	0.475	0.293	0.455	0.452	0.498	0.337	0.473
	Hospital (whether the village has hospitals and clinics)	0.818	0.386	0.845	0.362	0.786	0.410	0.791	0.407
	Outw_servi (whether the village provides outworking services)	0.132	0.338	0.100	0.300	0.104	0.305	0.229	0.420
	Irrigati_servi (whether the village provides irrigation services)	0.412	0.492	0.462	0.499	0.455	0.498	0.261	0.439
	Pest_servi (whether the village provides pest-control services)	0.374	0.484	0.349	0.477	0.441	0.497	0.360	0.480
Regions									
	MGPA	0.517	0.500						
	MGCA	0.244	0.429						
	GMBPA	0.239	0.426						

Abbreviations: ALA, arable land abandonment; AMC, agricultural mechanisation; APE, agricultural production efficiency; GPMBA, grain production and marketing balance areas; LTA, land tenure approval; NAI, nonagricultural income; MGCA, main grain consuming areas; MGPA, main grain-producing areas.

TABLE 2 The total effects of labour outflow on arable land abandonment in different regions

Models (regions) Variables	Model_0 (all sample members)		Model_1 (MGPA)		Model_2 (MGCA)		Model_3 (GPMBA)	
	Estimates	S.E	Estimates	S.E	Estimates	S.E	Estimates	S.E
Off_farm	0.315***	(0.075)	0.120	(0.106)	0.276**	(0.271)	0.020	(0.014)
Part_time	0.366 ***	(0.078)	0.395***	(0.089)	0.169	(0.255)	−0.009	(0.012)
MGPA	−0.245***	(0.054)						
MGCA	−0.014	(0.068)						
Control variables	Controlled							
Observations	5,369		2,781		1,312		1,276	

Note: all control variables are added to all models.
GPMBA, grain production and marketing balanced areas; MGCA, main grain consuming areas; MGPA, main grain-producing areas. *,**,*** are statistically significant at 10%, 5% and 1% level, respectively.

part-time labour is positively associated with ALA, while for off-farm labour the relationship is not significant in MGPA, which also shows that when the proportion of part-time labour increases by 1%, the mean ratio of abandoned arable land increases by 0.395%. Since there are many households and co-operatives with large-scale arable land, the development of the market for farmland transfer[5] is relatively well established in MGPA, meaning that off-farm labour can transfer the land and migrate to the urban areas for work, and off-farm labour is not significantly related to ALA. Secondly, in contrast, according to Model_2, the correlation between part-time labour and abandonment is not significant, while off-farm labour is positively associated with ALA in MGCA, which also shows that when off-farm labour increases by 1%, the mean ratio of abandoned arable land increases by 0.276%. This arises because a relatively developed economy with lower agricultural benefits promotes land abandonment following labour outflow. While the arable land area per capita in MGCA is smaller than that in MGPA, households with part-time labour could manage the arable land by themselves even if they suffer from the reduction in the labour force. Thirdly, Model_3 results show that ALA does not appear to be affected by rural labour outflows in GPMBA. Since economic development is relatively weak, and most households rely on agriculture to maintain a self-sufficient life, this situation prevents rural households from easily giving up agriculture.

4.3 | Mechanisms by which labour outflow affects ALA

Tables 3–4 and Figure 3 show the results of the mechanisms based on SEMs. The goodness-of-fit indicators (e.g., AIC and −2log likelihood) reveal acceptable goodness of fit for the SEMs.

4.3.1 | Mediating effects of AMC and APE

The direction and strength of impacts of rural labour outflows on AMC vary between the three areas. Firstly, the effect of off-farm labour is significantly negative in MGPA (-0.145, $p < 0.01$) and positive in GPMBA (0.061, $p < 0.1$), although in MGCA there is no apparent influence. Meanwhile, a significant negative effect of part-time labour on AMC is observed in MGPA (-0.188, $p < 0.01$) and GPMBA (-0.116, $p < 0.01$), whereas the influence is positive in MGCA (0.158, $p < 0.01$). Secondly, there is no apparent influence of off-farm labour on APE, while part-time labour is significantly associated with reduced APE in all three areas. This finding indicates off-farm labour does not necessarily lower AMC and may even play a positive role in promoting AMC, while part-time labour appears to lower APE.

The mediating effects of AMC and APE were further explored and the results are shown in Table 4. Regardless of regional differences, there are no significant mediating effects of AMC and APE on the connection between off-farm labour on ALA. In contrast, the relationships are statistically significant in the case of part-time labour, indicating that AMC and APE have mediating effects. Interestingly, although the overall effect is not statistically significant, part-time labour does seem to promote ALA indirectly through AMC and APE, while the indirect effect is negative in the case of MGCA, which further suggests that part-time labour could suppress ALA by promoting production efficiencies in this area.

Taking the above in combination with the results presented in Tables 2 and 3, it can be concluded that off-farm labour for the most part has a direct influence on ALA in China, while part-time labour also acts indirectly through AMC and APE, albeit with differences between regions. Importantly, these findings indicate that, for part-time labour, APE is an important factor leading to ALA. Overall, these findings lead us to reject **Hypothesis 2a**, that off-farm labour constraints ALA through increasing AMC and APE in rural households, and that **Hypothesis 2b** is partly accepted, namely, part-time labour promotes ALA because it results in decreased levels of mechanisation and production efficiency.

4.3.2 | The moderating effects of LTA and NAI

These moderating effects are illustrated graphically in Figure 3.

TABLE 3 The relationship among rural labour outflows, AMC, AEP, and ALA

Samples	All sample members			MGPA			MGCA			GPMBA		
	AMC	APE	ALA	AMC	APE	ALA	AMC	APE	ALA	AMC	APE	ALA
Off-farm	-0.037*	-0.094	0.291***	-0.145***	-0.130	0.015	0.111	0.062	0.309**	0.061*	0.028	0.041
	(0.022)	(0.051)	(0.075)	(0.029)	(0.087)	(0.130)	(0.071)	(0.104)	(0.337)	(0.033)	(0.030)	(0.033)
Part-time	-0.152***	-0.464***	0.264***	-0.188***	-0.515***	0.343***	0.158***	-0.255***	0.165	-0.116***	-0.208***	-0.066
	(0.018)	(0.042)	(0.075)	(0.019)	(0.065)	(0.116)	(0.040)	(0.083)	(0.253)	(0.036)	(0.031)	(0.041)
AMC		0.273***	-0.076*		0.287***	-0.082		0.135***	-0.243**		0.181***	-0.163**
		(0.028)	(0.043)		(0.042)	(0.059)		(0.048)	(0.120)		(0.069)	(0.078)
APE			-0.149***			-0.057*			-0.259**			-0.166***
			(0.027)			(0.034)			(0.106)			(0.035)
MGPA	0.005	0.100***	-0.231***									
	(0.017)	(0.036)	(0.052)									
MGCA	-0.090***	-0.144***	-0.039									
	(0.022)	(0.044)	(0.066)									
Observations	5,369			2,781			1,312			1,276		

Notes: ALA, arable land abandonment; AMC, agricultural mechanisation; APE, agricultural production efficiency; GPMBA, grain production and marketing balanced areas; MGCA, main grain consuming areas; MGPA, main grain-producing areas. *, **, *** are statistically significant at 10%, 5% and 1% level, respectively.

TABLE 4 The mediating effects of labour outflow on arable land abandonment in different areas: AMC and APE as mediators

Pathways	Indirect effects			
	All outflowing labour	MGPA	MGCA	GPMBA
Off-farm → AMC →ALA	0.003	0.012	−0.027	−0.010
	(0.001)	(0.018)	(0.036)	(0.043)
Off-farm → APE → ALA	0.014	0.007	−0.016	−0.005
	(0.006)	(0.006)	(0.013)	(0.007)
Off-farm → AMC → APE →ALA	0.002	0.002	−0.004	−0.002
	(0.001)	(0.007)	(0.001)	(0.008)
Part-time → AMC → ALA	0.012***	0.015***	−0.038**	0.019**
	(0.006)	(0.012)	(0.015)	(0.009)
Part-time → APE → ALA	0.069***	0.029***	0.066***	0.035***
	(0.016)	(0.019)	(0.021)	(0.053)
Part-time → AMC → APE → ALA	0.006***	0.003***	−0.006**	0.004*
	(0.002)	(0.001)	(0.005)	(0.003)

Abbreviations: ALA, arable land abandonment; AMC, agricultural mechanisation; APE, agricultural production efficiency; GPMBA, grain production and marketing balanced areas; MGCA, main grain consuming areas; MGPA, main grain-producing areas.
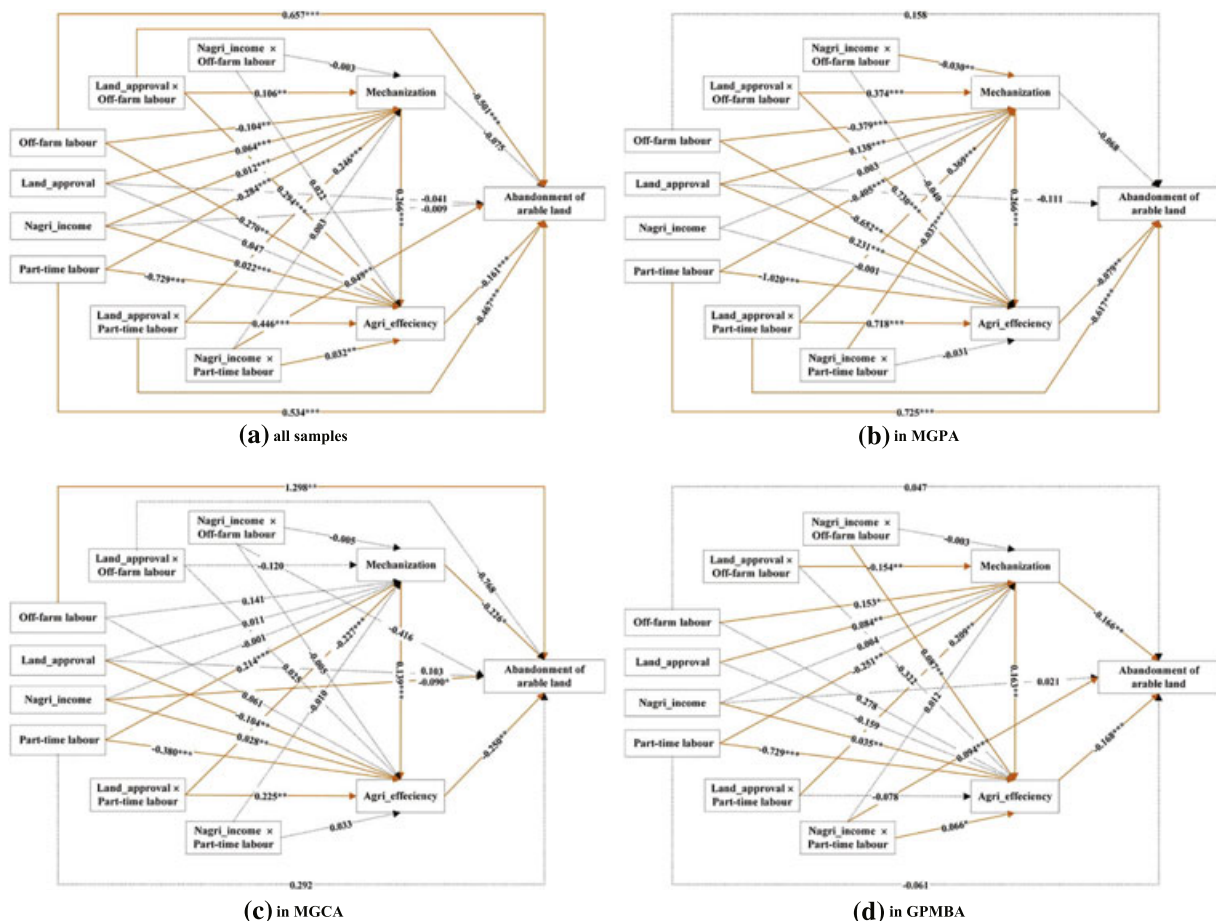
FIGURE 3 The moderating effect of land tenure approval (LTA) and nonagricultural income (NAI) in the relationship between rural labour outflow and ALA

Taking the entire sample set, both direct effects and indirect effects of rural labour outflow on ALA are shown to be moderated by LTA; LTA not only suppresses the direct effects in both off-farm labour (−0.501, $p < 0.01$) and part-time labour (−0.467, $p < 0.01$) but also lowers indirect effects by reducing the negative impact of off-farm labour (0.294, $p < 0.01$) and part-time labour (0.446, $p < 0.01$) on APE.

In MGPA, the direct moderation effect of LTA is observed only in the case of part-time labour (−0.671, $p < 0.01$), suggesting that LTA can alleviate the direct effects of part-time labour on ALA. LTA also appears to weaken the indirect effects of all labour outflows by reducing the negative impact of rural labour on APE, while NAI reinforces the indirect effects by enhancing the negative impact of rural labour on the degree of mechanisation. These findings indicate that LTA promotes production efficiency that, in turn, further reduces ALA. NAI lowers the effect of outflowing labour in reducing AMC, while AMC is not significantly related to ALA, which implies that NAI does not increase investment in agriculture but rather stimulates the outflowing labour to transfer their arable land.

In MGCA, LTA moderates only indirect effects by weakening both the positive impact of part-time labour on AMC (−0.227, $p < 0.01$) and the negative impact on APE (0.225, $p < 0.01$). It is speculated that LTA promotes arable land transfer and adjusting the scale of farm management, that is, despite the fact that some part-time labour when transferring out of their arable land leads to decreased AMC, in other cases, this leads to improved APE. NAI, however, appears to have no moderating effects in this area.

Finally, in GPMBA, NAI acts as an indirect moderator and promotes the effect of part-time labour on ALA (0.094, $p < 0.01$) while also reinforcing the positive effect of off-farm labour on APE (0.087, $p < 0.01$) and weakening the negative impact of part-time labour on APE (0.066, $p < 0.01$). This finding indicates that NAI can lead to improved APE when the labour forces migrate. Moreover, LTA moderates the indirect effect by weakening the impacts of off-farm labour (−0.154, $p < 0.01$) and part-time labour (0.209, $p < 0.01$) on AMC, possibly because LTA promotes the arable land transfer.

Based on the above, these findings partly confirm **Hypothesis 3** because the moderation effect of NAI only exists in the case of part-time labour from the perspective of the whole of China; specifically, this effect only exists in GPMBA, and the higher NAI for rural households with part-time labour, the less likely they are to abandon their arable land indirectly by improving APE but the more likely abandoning arable land directly. The results also partly confirm **Hypothesis 4** because, in MGCA, LTA does not moderate the relationship between off-farm labour and ALA.

5 | DISCUSSION AND POLICY IMPLICATIONS

Most previous research investigating the causes of ALA at the household level have focused on mountainous areas with low quality (He et al., 2020; Wang, Zhang, et al., 2019; Yan et al., 2016). A few studies have examined this issues on a national scale regarding farming households as a unified whole and consider them characterised by rational behaviour aimed at maximising their interests (Cao et al., 2008; Caulfield et al., 2019; Wang et al., 2020), and those focus only on the relationship between labour outflows and farmland abandonment while ignoring regional differences (Cao et al., 2008; Che, 2016; Luo et al., 2017; Xu, Deng, Huang, et al., 2019). In fact, the effect of rural labour outflows on ALA is not only influenced by regional factors, but also likely to be affected by human and social resources, such as agricultural machinery and agricultural means of production (Caulfield et al., 2019). Therefore, in placing labour outflows, agricultural production, the land system, and ALA in a theoretical framework, this study enhances our understanding of the effects of rural labour outflow on households' agricultural production input and livelihood strategies. In the meantime, the investigation of the difference among regions of the effect of rural labour outflows on ALA confirms that it is extremely important to formulate different agricultural policies according to livelihood strategies of rural households responding to the different types of labour outflow in different regions.

Inconsistencies in findings of previous studies may be related to specific regional characteristics and features of labour types. Based on the research findings in this study, not all types of outflowing rural labour have a significant impact on ALA depending on the area concerned. For example, off-farm labour does not promote ALA and part-time labour is in MGPA, while the opposite situation prevails in MGCA while neither are related to abandonment in GPMBA. Specifically, the impacts of rural labour outflows on ALA are not always direct but mediated and moderated by indirect relationships within a specific area. Part-time labour may promote ALA when mediated by reduced AMC and APE in MGPA. For farming households in MGPA, the per capita arable land area is relatively high, and part-time labour needs to find ways to balance agricultural production and non-agricultural work, which constrains both their time and effort for agricultural production and reduces the use of agricultural machinery, leading to the reduction of APE, which also explains that part-time labour is negatively associated with APE in our findings. Despite the fact that off-farm labour is associated also with APE, the relationship is moderated by LTA, which markedly weakens the negative effect of off-farm labour on APE and leads to a situation whereby off-farm labour no longer has an impact on ALA. As observed here, LTA also weakens the relationship between part-time labour and ALA, and while it cannot offset the negative impact of part-time labour on APE, it confirms the positive impact of LTA in GMPA. This result is inconsistent with conclusions of Luo and Zhang in highlighting the impact of LTA impacts on agricultural production (Luo & Zhang, 2020). Although the current proportion of rural households with LTA has been as high as 96% (the data in the study come from 2016 when the proportion of LTA was only about 50%) , LTA remains incomplete and not all households are appraised of the benefits of confirming land rights. Moreover, after the expiration of the first round of land contractual management rights, rural households may lose this sense of security, so new policies and strategies should be developed to deal with incomplete property rights on collective land.

In MGCA, however, NAI is the main source of income for rural households which have only limited arable land, and the total income in this area is markedly higher than other regions (Table 1). Here, off-farm labour is less reliant on agricultural production, thereby favouring ALA directly, and the situation would be influenced if the farmland transfer market is improved. More importantly, since it is found that farmland transfer plays an important role in preventing farmland abandonment (Shao et al., 2016; Wang, Qiu, & Yu, 2019), while according to the statistical data on the village level in our study showing the status of transferring out of the land of households who do not live in the village all the year-round, 62.82% and 54.27% of households have transferred out of their land in MGPA and GPMBA, respectively, while only 40.90% have transferred out of their land in MGCA. Therefore, it may be inferred that low levels of farmland transfer have promoted the positive relationship between off-farm labour and ALA in MGCA, and this may underly inconsistencies in the findings relating to the impact of off-farm labour on ALA between regions. Meanwhile, this also indicates that efforts to improve farmland transfer may be the key to reducing ALA arising from off-farm labour in MGCA. Since it is known that the outsourcing of agricultural services can promote farmland transfer and reduce ALA (Luo et al., 2019), local governments need to publicise and streamline farmland transfer processes. Accordingly, the farmland market must be considered in future investigations of the impacts of rural labour outflows on ALA, and promoting an efficient market is a key to reducing ALA.

Although part-time labour is shown to have significantly reduced AMC and further promoted ALA in MGPA and GPMBA, interventions to promote AMC in MGCA may reduce abandonment, suggesting that part-time labour does not necessarily lead to lower AMC. Moreover, if part-time labour adopts AMC, this can to a certain extent make up for the loss of APE caused by insufficient labour (time and energy) input. However, our findings regarding part-time labour show that APE was eventually reduced and this further promoted ALA. It is suggested that this may be because the use of agricultural machinery applications is still limited. Land fragmentation and restrictive terrain conditions lead to increased costs, constraining the application of mechanical farming despite a degree of AMC promotion by part-time labour in MGCA. Therefore, AMC appears to have offset the effects of labour shortage only to a limited degree (Belton & Filipski, 2019; Zheng & Xu, 2016). This study suggests that it may be more effective to promote and develop small-scale agricultural machinery supported by maintenance service providers, especially in hilly mountainous areas or some districts where arable land is usually scattered and disconnected, such as MGCA and GPMBA. Accordingly, it is important to formulate tailored policies for outsourcing services for mechanical tilling, such as organising mechanical farming services with the village as a cooperative, and providing incentives for groups that provide mechanical farming services in each village.

As noted above, the results show that part-time labour may affect ALA through increasing or decreasing AMC and reducing APE. While the overall effect of part-time labour on ALA is not significant in MGCA and GPMBA, it is still possible for indirect effects to be important influences (Preacher & Hayes, 2008) in what has been referred to

as the "masking effect" (Wen & Ye, 2014). The indirect effects of APE are opposite to the total effects, which weakens the positive correlation between part-time labour and ALA and highlights that, as is the case in MGPA, reduced APE due to part-time labour also emerges as an important factor in promoting ALA in MGCA and GPMBA. Therefore, initiatives that favour the transformation of labour from part-time to off-farm should be considered, a suggestion that may be relevant to the formulation of agricultural land protection policies in developing countries where migrant labour is common (Caulfield et al., 2019; Miluka et al., 2010; Zeng et al., 2020). Rural labour outflow is an inevitable consequence of promoting larger-scale farmland management and realising agricultural modernization, and thus the key is to maintain or even improve APE when accelerating the transformation of labour from part-time to off-farm. The key to maintaining APE lies in the improvement of the agricultural knowledge and skills of rural labour through education and vocational training. The role of rural elites as crucial actors in the transformational development of relatively successful villages and stimulating rural innovation is known to be important (Kalantaridis et al., 2019; Li, Fan, & Liu, 2019) such that the quality of the labour force, as well as the number of workers remaining on the land, needs to be considered as part of any policy framework. Moreover, we suggest that NAI can encourage peasants to increase their level of investment in agriculture and further reduce abandoned arable land in GPMBA, although in MGPA, NAI appears to favour rural labour outflow with the effect of reducing the level of input to agriculture.

From a research perspective, we argue that it is important to identify and distinguish direct and indirect relationships between rural labour outflow, arable land management, and agricultural production. While this study explores the pathways of rural labour outflow effects on ALA and highlights some policy implications related to regional differences, agricultural production factors, and rural attraction, a number of limitations are evident. Firstly, the estimated effects of rural labour outflow on AMC may not be sufficiently accurate due to the fact that AMC is measured here using a binary variable while a continuous variable may be more appropriate to describe the level of AMC. Secondly, the impact of rural labour outflow on APE depends on both quantity and quality of farm labour remaining on the land, and although the latter was not explicitly included in our research framework, it must certainly be considered in developing future agricultural policy. Finally, arable land transfer emerges as an important factor influencing ALA but, due to data limitations, was omitted from the study. Despite these limitations, our research on the mechanisms by which labour outflow affects ALA provides an important perspective and identifies a number of valuable policy implications.

6 | CONCLUSIONS

This paper constructs SEMs for different types of rural labour regarding ALA. In so doing, we reveal the mechanisms by which labour outflow affects ALA, with a particular focus on the mediating role of AMC and APE and the moderating role of NAI and LTA. Using the rich

dataset from 2016 CLDS, an empirical study is conducted to investigate the behavioural mechanism of ALA in the Chinese context by considering outflowing labour types and regional differences to verify the accuracy of these hypotheses.

The results show that rural labour outflow as a whole in China has a significant positive correlation with ALA and that there are significant differences in the impact mechanism between different types of outflowing labour. Firstly, both off-farm labour and part-time labour are significantly related to ALA. Empirical analysis suggests that if the proportion of off-farm labour and part-time labour increases by 1%, the average ratio of abandoned arable land increases by 0.315% and 0.366%, respectively. This emphasises that rural labour outflow may promote ALA and that the effect of part-time labour nationally is stronger. Secondly, based on the analysis of mediating effects, off-farm labour appears to act only directly, while part-time labour promotes ALA both directly and indirectly, and more importantly, increased levels of part-time labour do not necessarily lead to less AMC while lower APE emerges as an important factor in part-time labour promoting ALA. Thirdly, our analysis of moderating effects shows that LTA can directly constrain the influence of off-farm labour and part-time labour on ALA by favouring APE improvements. A similar moderation effect for NAI is only observed in the case of part-time labour.

Not only are the impacts of different rural labour outflow on ALA substantially different, but there are contrasting impacts of rural labour outflow on ALA between regions. In MGPA, part-time labour plays a significant role and is associated with increased levels of ALA, although the impact is not significant in the case of off-farm labour. In contrast, in MGCA, off-farm labour appears to promote ALA, while the effect is not significant for part-time labour. Meanwhile, there is no significant correlation between the two types of labour and ALA in GPMBA. However, while the total effect of labour outflow on arable land is not significant in some regions, the mediating effects of AMC and APE are significant in the case of part-time labour regardless of regional difference, and there are no significant mediating effects of AMC and APE on the connection between off-farm labour on ALA. The relationships are, however, statistically significant in the case of part-time labour. In respect of moderating effects, LTA appears to suppress both the direct and indirect negative effects of part-time labour by improving APE although, in MGPA, NAI enhances the negative effects on AMC and further promotes ALA in this area. Meanwhile, in GPMBA, NAI is shown to reduce ALA in the case of both part-time and off-farm labour by improving APE, while NAI appears to have no influence on the relationship between rural labour outflows and ALA in MGCA.

These findings indicate two means of reducing the impact of rural labour outflows on ALA, namely, (a) reducing the direct effects of off-farm labour in the MGCA and part-time labour in MGPA and (b) alleviating indirect effects, mainly associated with the influence of part-time labour in MGPA. Both can be achieved by local authorities and village collectives promoting knowledge of arable land management and heightening awareness of conservation measures. Moreover, not all types of outflowing rural labour abandon their arable land directly. Off-farm labour appears to act only directly, while part-time labour appears to act more along the lines of the classic "rational

peasant" that adjusts farming decisions according to agricultural production conditions. Lower APE is an important factor underlying the observation that part-time labour results in more ALA, and therefore, improving APE is key to alleviating ALA. Meanwhile, the identification of regional contrasts in terms of labour outflow impacts should be an important element of policy formulation in other situations where labour outflow is a prominent element of the agricultural economy. Application and adaptation of our research framework and methodology to other developing country settings may be useful in identifying the effects of different types of outflowing labour, in understanding the complex pathways among factors promoting ALA and in highlighting regional differences towards the goal of improving agricultural policy to ensure food security and sustainable development.

DATA AVAILABILITY STATEMENT

ORCID

Ye Liu https://orcid.org/0000-0003-2511-5413
Yanliu Lin https://orcid.org/0000-0001-7015-1443

ENDNOTES

[1] Data are derived from the results of China's quality grade update evaluation of 2016. (http://g.mnrgov.cn/201712/t20171226_1711147.html).

[2] Aarable land area in China decreased by 464,000 ha from 135.385 million ha in the second National Land Survey data at the end of 2009 to 134.921 million ha at the end of 2016. The data are from the Land and Resources Bulletin of people's Republic of China over the years.

[3] From the survey results of national reserve arable land resources in China (http://www.mnr.gov.cn/dt/zb/2016/gd/).

[4] There are a total of eight strata: eastern-region provinces with a large population (excluding Guangdong), eastern-region provinces with a small population, central-region provinces with a large population, central-region provinces with a small population, western-region provinces with a large population, western-region provinces with a small population, the Pearl River Delta in Guangdong, and the rest of Guangdong.

[5] Farmland transfer: Under the Household Contract Responsibility System of China (HCRS), village collectives own farmlands; and farming households contract farmland from collectives and receive the land contract and management rights. Farmland transfer refers to the transfer of the management rights.

REFERENCES

Almeida, A. N., & Bravo-Ureta, B. E. (2019). Agricultural productivity, shadow wages and off-farm labor decisions in Nicaragua. *Economic Systems*, 43, 99–110. https://doi.org/10.1016/j.ecosys.2018.09.002

Baumann, M., Kuemmerle, T., Elbakidze, M., Ozdogan, M., Radeloff, V. C., Keuler, N. S., Prishchepov, A. V., Kruhlov, I., & Hostert, P. (2011). Patterns and drivers of post-socialist farmland abandonment in Western Ukraine. *Land Use Policy*, 28, 552–562. https://doi.org/10.1016/j.landusepol.2010.11.003

Belton, B., & Filipski, M. (2019). Rural transformation in central Myanmar: By how much, and for whom? *Journal of Rural Studies*, 67, 166–176. https://doi.org/10.1016/j.jrurstud.2019.02.012

Cao, Z. H., Hao, J. M., & Liang, L. T. (2008). Economic analysis and strategy research on farmland abandonment. *Journal of Agrotechnical*, *3*, 43–46.

Castro, P., Pedroso, R., Lautenbach, S., Baez Villanueva, O. M., & Vicens, R. (2019). Spatial patterns of farmland abandonment in Rio de Janeiro state. In *Strategies and Tools for a Sustainable Rural Rio de Janeiro* (pp. 69–85). Springer International Publishing. https://doi.org/10.1007/978-3-319-89644-1_6

Caulfield, M., Bouniol, J., Fonte, S. J., & Kessler, A. (2019). How rural out-migrations drive changes to farm and land management: A case study from the rural Andes. *Land Use Policy*, *81*, 594–603. https://doi.org/10.1016/j.landusepol.2018.11.030

Che, Y. (2016). Off-farm employments and land rental behaviour: Evidence from rural China. *China Agricultural Economic Review*, *8*, 37–54. https://doi.org/10.1108/CAER-09-2014-0086

Chen, F., & Zhai, W. J. (2015). Land transfer incentive and welfare effect research from the perspective of farmers behaviour. *Economic Research Journal*, *50*, 163–177.

Cheng, M. W., Huang, T. T., & Liu, Y. J. (2015). The influence of rural labour outflow on food production from the evidence of China. *China Rural Survey*, *6*, 15–21.

Chiodi, V., Jaimovich, E., & Montes-Rojas, G. (2012). Migration, remittances and capital accumulation: Evidence from Rural Mexico. *Journal of Development Studies*, *48*, 1139–1155. https://doi.org/10.1080/00220388.2012.688817

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

Fox, J., Fujita, Y., Ngidang, D., Peluso, N., Potter, L., Sakuntaladewi, N., Sturgeon, J., & Thomas, D. (2009). Policies, political-economy, and swidden in Southeast Asia. *Human Ecology*, *37*, 305–322. https://doi.org/10.1007/s10745-009-9240-7

Gilles, J. L., Thomas, J. L., Valdivia, C., & Yucra, E. S. (2013). Laggards or leaders: Conservers of traditional agricultural knowledge in Bolivia. *Rural Sociology*, *78*, 51–74. https://doi.org/10.1111/ruso.12001

Gray, C. L., & Bilsborrow, R. E. (2014). Consequences of out-migration for land use in rural Ecuador. *Land Use Policy*, *36*, 182–191. https://doi.org/10.1016/j.landusepol.2013.07.006

Haggbla, S., Hazell, P., & Reardon, T. (2009). *Transforming the Rural Non-farm Economy: Opportunities and Threats in the Developing World*. Issue Briefs (Vol. 92) (pp. 289–290). Johns Hopkins University Press.

Han, J. B., Liu, S. Y., Zhang, S. F., & Liu, Y. F. (2019). Influence of aging of agricultural labor force on large- scale management of land. *Resources Science*, *41*, 2284–2295. https://doi.org/10.18402/resci.2019.12.12

Hatna, E., & Bakker, M. M. (2011). Abandonment and expansion of arable land in Europe. *Ecosystems*, *14*, 720–731. https://doi.org/10.1007/s10021-011-9441-y

Hayes, A. F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. Guilford Publications.

He, Y. F., Xie, H. L., & Peng, C. Z. (2020). Analyzing the behavioural mechanism of farmland abandonment in the hilly mountainous areas in China from the perspective of farming household diversity. *Land Use Policy*, *99*, 104826. https://doi.org/10.1016/j.landusepol.2020.104826

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Security*, *8*, 921–937. https://doi.org/10.1007/s12571-016-0607-5

Jin, S. Q., & Jayne, T. S. (2013). Land rental markets in Kenya: Implications for efficiency, equity, household income, and poverty. *Land Economics*, *89*, 246–271. https://doi.org/10.3368/le.89.2.246

Jokinen, J. C. (2018). Migration-related land use dynamics in increasingly hybrid peri-urban space: Insights from two agricultural communities in Bolivia. *Population and Environment*, *40*, 136–157. https://doi.org/10.1007/s11111-018-0305-7

Kalantaridis, C., Bika, Z., & Millard, D. (2019). Migration, meaning(s) of place and implications for rural innovation policy. *Regional Studies*, *53*, 1657–1668. https://doi.org/10.1080/00343404.2019.1597971

Kizos, T., Dalaka, A., & Petanidou, T. (2009). Farmers' attitudes and landscape change: Evidence from the abandonment of terraced cultivations on Lesvos, Greece. *Agriculture and Human Values*, *27*, 199–212. https://doi.org/10.1007/s10460-009-9206-9

Laborde, D., Martin, W., Swinnen, J., & Vos, R. (2020). COVID-19 risks to global food security. *Science*, *369*, 500–502. https://doi.org/10.1126/science.abc4765

Levers, C., Schneider, M., Prishchepov, A. V., Estel, S., & Kuemmerle, T. (2018). Spatial variation in determinants of agricultural land abandonment in Europe. *Science Total Environment*, *644*, 95–111. https://doi.org/10.1016/j.scitotenv.2018.06.326

Li, S. F., & Li, X. B. (2016). Progress and prospect on farmland abandonment. *Acta Geographica Sinica*, *71*, 370–389.

Li, S. F., Li, X. B., Sun, L. X., Cao, G. Y., Fischer, G., & Tramberend, S. (2018). An estimation of the extent of cropland abandonment in mountainous regions of China. *Land Degradation & Development*, *29*, 1327–1342. https://doi.org/10.1002/ldr.2924

Li, Y. R., Fan, P. C., & Liu, Y. S. (2019). What makes better village development in traditional agricultural areas of China? Evidence from long-term observation of typical villages. *Habitat International*, *83*, 111–124.

Lin, W. S., Wang, Z. G., & Wang, M. Y. (2017). Land registration and certification, production factor allocation and agricultural production efficiency: An analysis based on China labor-force dynamics survey. *Chinese Rural Economy*, *7*, 64–82.

Liu, G. S., Wang, H. M., Cheng, Y. X., Zheng, B., & Lu, Z. L. (2016). The impact of rural out-migration on arable land use intensity: Evidence from mountain areas in Guangdong, China. *Land Use Policy*, *59*, 569–579. https://doi.org/10.1016/j.landusepol.2016.10.005

Lu, X. H., Ke, N., & Kuang, B. (2020). Regional differences and influencing factors of China's grain production capacity. *China Land Science*, *34*, 53–62.

Luo, B. L., Wan, Y. L., Hong, W. J., & Zhong, W. J. (2019). Fragmentation, service outsourcing and farmland abandonment—An empirical analysis based on questionnaires from 2704 households in 9 provinces. *Economic Review Journal*, *7*, 63–73.

Luo, B. L., & Zhang, L. (2020). Does rural land registration and certification promote the development of agricultural factor markets? *China Economic Studies*, *5*, 17–31.

Luo, M. Z., Liu, K., & Zhu, W. J. (2017). Does confirmation of land rights reduce farmland abandonment?—The empirical analysis based on PSM from the questionnaire survey of rural households in Sichuan, Henan, and Shanxi. *Journal of Agrotechnical Economics*, *2*, 15–27.

Ma, L. J., Wang, Y. P., & Wu, J. (2015). Analysis on spatial disequilibrium and convergence of technical efficiency of grain production in China. *Journal of Agrotechnical Economics*, *4*, 4–12.

Maharjan, A., Kochhar, I., Chitale, V. S., Hussain, A., & Gioli, G. (2020). Understanding rural outmigration and agricultural land use change in the Gandaki Basin, Nepal. *Applied Geography*, *124*.

Miluka, J., Carletto, G., Davis, B., & Zezza, A. (2010). The vanishing farms? The impact of international migration on Albanian family farming. *Journal of Development Studies*, *46*, 140–161. https://doi.org/10.1080/00220380903197978

Mwesigye, F., Matsumoto, T., & Otsuka, K. (2017). Population pressure, rural-to-rural migration and evolution of land tenure institutions: The case of Uganda. *Land Use Policy*, *65*, 1–14. https://doi.org/10.1016/j.landusepol.2017.03.020

Nguyen, D. L., Grote, U., & Nguyen, T. T. (2019). Migration, crop production and non-farm labor diversification in rural Vietnam. *Economic Analysis and Policy*, *63*, 175–187. https://doi.org/10.1016/j.eap.2019.06.003

Pan, Z. H., Xu, W., Huang, Z. Y., & Wang, G. X. (2018). The effects of labour migration on rural household production in inland China: Do

landform conditions matter? *Population, Space and Place*, 24. https://doi.org/10.1002/psp.2086

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40, 879–891. https://doi.org/10.3758/brm.40.3.879

Price, B., Kienast, F., Seidl, I., Ginzler, C., Verburg, P. H., & Bolliger, J. (2015). Future landscapes of Switzerland: Risk areas for urbanisation and land abandonment. *Applied Geography*, 57, 32–41. https://doi.org/10.1016/j.apgeog.2014.12.009

Qi, W., Deng, Y., & Fu, B. J. (2019). Rural attraction: The spatial pattern and driving factors of China's rural in-migration. *Journal of Rural Studies*. https://doi.org/10.1016/j.jrurstud.2019.03.008

Qian, L., & Hong, M. Y. (2016). Non-agricultural employment, land transfer and changes in agricultural production efficiency: An empirical analysis based on CFPS. *Chinese Rural Economy*, 12, 2–16.

Qin, H., & Liao, T. F. (2016). Labor out-migration and agricultural change in rural China: A systematic review and meta-analysis. *Journal of Rural Studies*, 47, 533–541. https://doi.org/10.1016/j.jrurstud.2016.06.020

Ranis, G., & Fei, J. C. (1961). A theory of economic development. *American Economic Review*, 51, 533–565.

San Roman Sanz, A., Fernandez, C., Mouillot, F., Ferrat, L., Istria, D., & Pasqualini, V. (2013). Long-term Forest dynamics and land-use abandonment in the Mediterranean Mountains, Corsica, France. *Ecology and Society*, 18(2), 38. https://doi.org/10.5751/ES-05556-180238

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies*, 36, 171–196. https://doi.org/10.1080/03066150902820503

Shao, J. A., Zhang, S. C., & Li, X. B. (2015). Farmland marginalization in the mountainous areas: Characteristics, influencing factors and policy implications. *Journal of Geographical Sciences*, 25, 701–722. https://doi.org/10.1007/s11442-015-1197-4

Shao, J. A., Zhang, S. C., & Li, X. B. (2016). Effectiveness of farmland transfer in alleviating farmland abandonment in mountain regions. *Journal of Geographical Sciences*, 26, 203–218. https://doi.org/10.1007/s11442-016-1263-6

Shirai, Y., Fox, J., Leisz, S. J., Fukui, H., & Rambo, A. T. (2017). The influence of local non-farm employment on rural household structure in Northeast Thailand. *Journal of Rural Studies*, 54, 52–59. https://doi.org/10.1016/j.jrurstud.2017.06.003

Song, W., & Zhang, Y. (2019). Farmland abandonment research progress: Influencing factors and simulation model. *Journal of Resources and Ecology*, 10, 345–352. https://doi.org/10.5814/j.issn.1674-764x.2019.04.001

Su, B. Z., Li, Y. H., Li, L. Q., & Wang, Y. (2017). How does nonfarm employment stability influence farmers' farmland transfer decisions? Implications for China's land use policy. *Land Use Policy*, 74, 66–72. https://doi.org/10.1016/j.landusepol.2017.09.053

Taylor, J. E. (1999). The new economics of labour migration and the role of remittances in the migration process. *International Migration*, 37, 63–88. https://doi.org/10.1111/1468-2435.00066

Taylor, J. E., & Lopez-Feldman, A. (2010). Does migration make rural households more productive? Evidence from Mexico. *Journal of Development Studies*, 46, 68–90. https://doi.org/10.1080/00220380903198463

Ustaoglu, E., & Collier, M. J. (2018). Farmland abandonment in Europe: An overview of drivers, consequences, and assessment of the sustainability implications. *Environmental Reviews*, 26, 396–416. https://doi.org/10.1139/er-2018-0001

Wang, C. C., Zhang, Y. Q., Yang, Y. S., Yang, Q. C., & Hong, J. (2019). What is driving the abandonment of villages in the mountains of Southeast China? *Land Degradation & Development*, 30, 1183–1192. https://doi.org/10.1002/ldr.3303

Wang, C. G., Rada, N., Qin, L. J., & Pan, S. W. (2014). Impacts of migration on household production choices: Evidence from China. *Journal of Development Studies*, 50, 413–425. https://doi.org/10.1080/00220388.2013.866221

Wang, Q., Qiu, J. J., & Yu, J. (2019). Does rural resettlement accelerate farmland abandonment in mountainous areas: A case study of 1578 households in Southern Shaanxi. *Journal of Natural Resources*, 34, 1376–1390. https://doi.org/10.31497/zrzyxb.20190703

Wang, Y., Li, X., Xin, L., & Tan, M. (2020). Farmland marginalization and its drivers in mountainous areas of China. *Science of Total Environment*, 719, 135132. https://doi.org/10.1016/j.scitotenv.2019.135132

Wang, Y. M., Yao, X. G., & Zhou, H. M. (2013a). Rural labour outflow, regional difference and grain production. *Management World*, 11, 67–76.

Wen, Z. L., & Ye, B. J. (2014). Analyses of mediating effects: The development of methods and models. *Advances in Psychological Science*, 22, 731–745. https://doi.org/10.3724/SP.J.1042.2014.00731

Xia, Z. Z., & He, X. F. (2017). Half-work and half-tillage and China's progressive urbanization model. *Social Sciences in China*, 12, 117–137.

Xiao, W., & Zhao, G. C. (2018). Agricultural land and rural-urban migration in China: A new pattern. *Land Use Policy*, 74, 142–150. https://doi.org/10.1016/j.landusepol.2017.05.013

Xu, D. D., Deng, X., Guo, S. L., & Liu, S. Q. (2019). Labor migration and farmland abandonment in rural China: Empirical results and policy implications. *Journal of Environmental Management*, 232, 738–750. https://doi.org/10.1016/j.jenvman.2018.11.136

Xu, D. D., Deng, X., Huang, K., Liu, Y., Yong, Z. L., & Liu, S. Q. (2019). Relationships between labor migration and cropland abandonment in rural China from the perspective of village types. *Land Use Policy*, 88, 104164. https://doi.org/10.1016/j.landusepol.2019.104164

Xu, Q., Liu, J., & Qian, Y. F. (2017). Labor mobility, farmland confirmation and farmland transfer. *Journal of Agrotechnical*, 5, 4–16.

Yan, J. Z., Yang, Z. Y., Li, Z. H., Li, X. B., Xin, L. J., & Sun, L. X. (2016). Drivers of cropland abandonment in mountainous areas: A household decision model on farming scale in Southwest China. *Land Use Policy*, 57, 459–469. https://doi.org/10.1016/j.landusepol.2016.06.014

Yan, X. H., Bauer, S., & Huo, X. X. (2014). Farm size, land reallocation, and labour migration in rural China. *Population, Space and Place*, 20, 303–315. https://doi.org/10.1002/psp.1831

Zavalloni, M., D'Alberto, R., Raggi, M., & Viaggi, D. (2021). Farmland abandonment, public goods and the CAP in a marginal area of Italy. *Land Use Policy*, 107, 104365. https://doi.org/10.1016/j.landusepol.2019.104365

Zeng, J. X., Gao, L. L., Wang, B., & Long, W. J. (2020). Who are the Chinese professional farmers? A comparative analysis of the characteristics of the Chinese and foreign agricultural labourers. *Issues in Agricultural Economy*, 7, 130–142.

Zhang, Y. N., Long, H. L., Li, Y. R., Ge, D. Z., & Tu, S. S. (2020). How does off-farm work affect chemical fertilizer application? Evidence from China's mountainous and plain areas. *Land Use Policy*, 99, 104848. https://doi.org/10.1016/j.landusepol.2020.104848

Zheng, X. Y., & Xu, Z. G. (2016). Endowment restriction, factor substitution and induced technological innovation: A case research on the grain producing mechanization in China. *China Economic Quarterly*, 16, 45–66.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.