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Research Progress on Farmers' Livelihood Transformation and Its Ecological Effects—A Review

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Abstract: Farmers' livelihoods and their impacts on the ecosystem are important indicators of human-land relationships. Appropriate livelihood strategies for farmers can meet the needs of human well-being and promote the sustainable use of natural resources, thereby maintaining the health and stability of natural ecosystems. Scholars have carried out a great deal of research on the changes in farmers' livelihoods, as well as the driving mechanisms and ecological effects, but there are still many controversial issues about the ecological effects of farmers' livelihood transformation. On the basis of collecting and sorting out the relevant literature, this paper analyzes the previous research results on the transformation mechanism and ecological effects of farmers' livelihoods, and further explores the coupling relationship. Through the analysis and summary, we find that the choice of farmers' livelihoods is affected by natural factors, subjective willingness and social policies. The transformation of farmers' livelihood changes the ways of production, consumption and resource utilization, which in turn profoundly affects the evolutionary process of the natural ecosystems. This paper establishes a research framework for the livelihood transformation mechanism of farmers and its ecological effect, and finally summarizes two directions that need to be studied further in the future: (1) Exploring the interactions between the driving factors of farmers' livelihood transformation; and (2) Exploring a win-win sustainable mechanism for farmers' livelihood needs and natural resource utilization.

Key words: farmers' livelihood transformation; transformation characteristics; driving mechanism; ecological effect

1 Introduction

A livelihood strategy determines the way that human activities act on the natural environment, thus driving the direction of the evolution of human-land systems (Wang et al., 2012; Fu, 2018). In the natural and socio-economic systems, the interrelationship between human livelihoods and ecosystems is one of the core scientific issues of sustainable development today (Wang et al., 2019).

Farmers are one of the most basic socio-economic units and behavioral decision-makers, and they are the most basic actors of sustainable behavior in rural areas. Thus, their livelihood behavior determines the use of resources, and the efficiency of that usage has a profound impact on the ecological environment (Zhang and Zhao, 2015). Against the background of the continuous improvement of market conditions, the implementation of regulatory policies, and the development of urbanization, the types of employment and production methods of farmers in China have undergone significant changes. According to the data from the "2020 China Household Survey Yearbook", the proportion of wage income in the income of rural residents in China is generally on the rise, accounting for 41.1% in 2019. At the same time, the proportion of operating income is generally declining, accounting for 36.0% in 2019. In addition, among the oper-

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ating incomes of the primary industries, the incomes of agriculture and forestry generally showed an overall downward trend, while the incomes of animal husbandry and fishery showed an upward trend. In summary, the transformation of farmers' livelihood has become the most prominent economic and social phenomenon in the rural areas of China (Hao et al., 2013). The relationship between the transformation of farmers' livelihood and the evolution of regional ecosystems is an important entry point for understanding the relationship between man and land in the new era, which has become an important basis for ecosystem management.

Farmers' livelihoods and their impact on the ecological environment have become hot topics in academic research (Bhandari, 2013; Komarek et al., 2014). When farmers are highly dependent on local natural resources for their livelihood, they will reclaim land or overgraze, leading to ecological problems such as soil erosion, grassland degradation and land desertification. When the sources of income and livelihoods are diversified, farmers' dependence on land resources decreases, which in turn promotes natural vegetation restoration and "forest transformation" (Wang et al., 2011; Li et al., 2016). In addition, as farmers' livelihoods and sources of income change, their production and consumption behaviors will change, as does the way they occupy and use natural resources (Cheng et al., 2015). However, there are complex intercoordinations and dynamics in the impact of farmers' livelihood transformation, and the results of the impact also have many uncertainties. Clarifying the impact of farmers' livelihood transformation on the ecosystem can provide an important basis for formulating and implementing ecological protection policies. By summarizing the existing research on these issues, this paper refines and establishes the research framework for the study of the ecological effects of farmers' livelihood transformation, clarifies the key scientific issues and links involved, analyzes the research progress from the two aspects of farmers' livelihood transformation mechanisms and ecological effects, and finally proposes the key directions of future research.

2 Research framework of farmers' livelihood transformation and its ecological effects

There are many factors involved in the transformation of farmers' livelihood, and different viewpoints have been put forward in domestic and foreign studies. It is generally believed that the transformation of farmers' livelihood is the result of the combined effect of farmers' subjective willingness and objective promotion, the most direct driving force is the income of farmers, and the willingness of the farmers themselves is also affected by both natural and social capital (Jiao and Guo, 2020). The choice of farmers' livelihood strategies depends on the amount of livelihood capital and the expected value of the benefits. Farmers with more capital have more options, and the pursuit of income will directly drive farmers to seek more reasonable livelihood strategies. Human activities such as urbanization, rural transformation and the implementation of some major ecological projects have restricted farmers' use of agricultural resources, resulting in a decrease in the stock of natural capital such as cultivated land owned by farmers, and thus causing farmers in the original areas to change their land use strategies and seek alternative sources of income (Cui et al., 2018; Qian, 2020). In addition, harsh natural conditions such as climate change and disasters will lead to the decline or loss of land productivity. In order to survive, farmers have to change their livelihood strategies by engaging in non-agricultural work to achieve a higher income. Positive factors such as ecological compensation and ecological poverty alleviation will increase farmers' willingness to change their livelihoods, while negative factors such as natural disasters will make farmers passively adjust their livelihoods. Farmers with large amounts of natural capital and physical capital stock tend to choose pure agricultural livelihood strategies, while farmers with more financial capital, social capital and human capital tend to choose combined agricultural-part-time, part-time and non-agricultural livelihood strategies (Wang and Fang, 2021). Farmers' agricultural activities are essentially a process of using natural resources, so as farmers change their livelihood strategies, the way they use natural resources also changes. Therefore, shifts in the livelihood strategies affect how natural resources are used, which in turn affects regional ecosystem structure and function (Li et al., 2021).

In this paper, the Chinese literature on the transformation of farmers' livelihood was found using CNKI, and the relevant literature on the transformation of farmers' livelihood abroad was obtained through the Sci-direct, Web of Science and Springer Link databases. The query keywords included farmers' livelihoods, farmers' livelihood transformation, livelihood transformation, and the ecological effects of farmers' livelihood transformation. According to the publication time and correlation, the available Chinese literature and English literature were determined. The data and citation sources of the articles also include relevant government annual reports. According to the framework of the article regarding the characteristics of farmers' livelihoods, the driving mechanisms of farmers' livelihood transformation, livelihood transformation and land use, livelihood transformation and natural resource utilization, and livelihood transformation and ecosystem changes, this paper uses the method of combining summary analysis and comparative analysis to comprehensively organize and analyze the literature content, and finally the literature and information from the data obtained are analyzed and summarized.

The ecological effect of farmers' livelihood transfor-

mation involves two important propositions of the transformation mechanisms and ecological effects, "driving factors, livelihood transformation, natural resource utilization and ecosystem evolution" constitutes a complete chain of research, and the coupling relationships and interactions between these four components constitute the key scientific issues to be resolved in the study of the ecological effects of farmers' livelihood transformation. The coupling relationships between the driving factors and farmers' livelihood transformation are mainly reflected in the research on the farmers' livelihood transformation mechanism, and the previous studies mainly describe the characteristics and driving factors of farmers' livelihoods in different regions and different periods. The coupling relationships among the transformation of farmers' livelihood, the utilization of natural resources and the evolution of ecosystems are mainly reflected in the studies on the ecological effects of farmers' livelihoods, and the existing studies mainly focus on the impacts of livelihood transformation on regional natural resource utilization, production and consumption patterns, land cover changes and ecosystem evolution. Based on the driving factors of farmers' livelihoods, livelihood transformation, natural resource utilization and ecosystem evolution, there are also trade-offs, synergies, positive and negative feedbacks and other interactions. Previous studies have focused on the changes in farmers' livelihoods and the responses of family income and the ecological environment under the implementation of ecological policies, but there is a lack of in-depth analysis of its microscopic mechanism (Fig. 1).

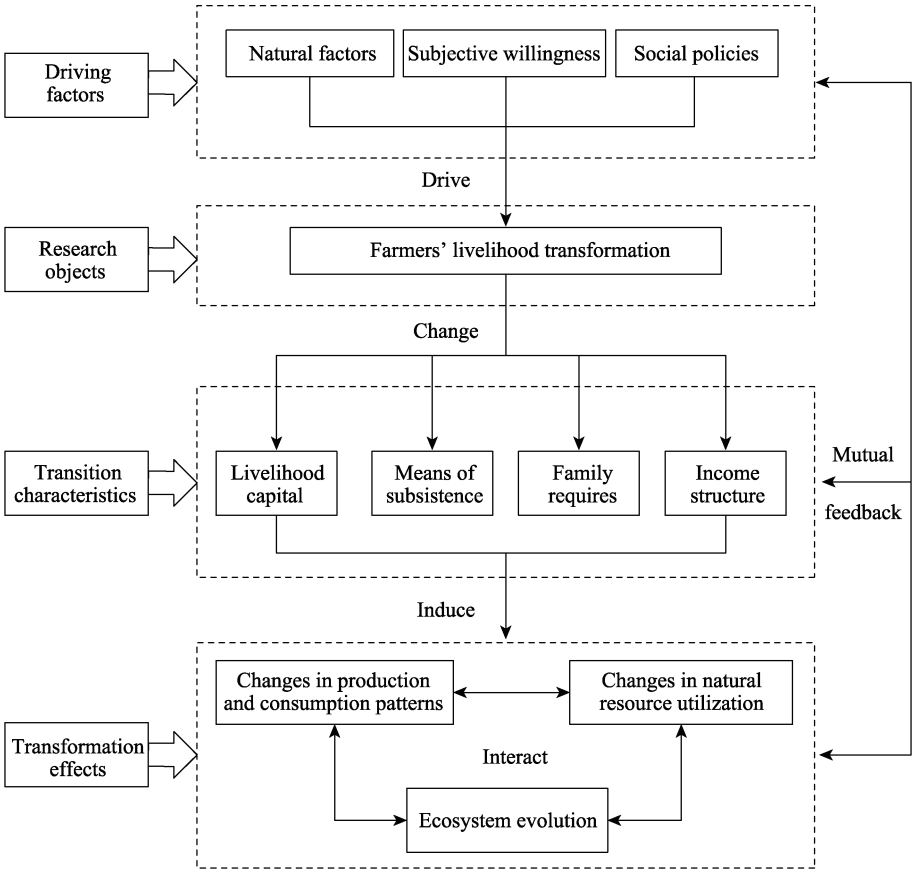

Fig. 1 Framework of the basic scientific problems of farmers' livelihood transformation

3 Transformation mechanism of farmers' livelihood

3.1 The main features of the transformation of farmers' livelihood

Research on farmers' livelihoods has gone through a process of qualitative description, taxonomic research and quantitative description. Studies have found that the transformation of farmers' livelihood is in line with the family life cycle theory, showing different livelihood characteristics according to the stages of young families, middle-aged families and elderly families (Barbieri et al., 2005). Domestic and foreign scholars have conducted a large number of studies on the classification of farmers' livelihood types, but the bases and criteria for classification show great differences between studies (Cheng et al., 2015; Wu, 2015; Wang et al., 2016). In addition to considering the two aspects of non-agricultural employment and agriculture, some scholars

have considered the actual situation of farmers' employment, studied the planting industry and breeding industry separately, and made a more detailed classification of farmers' livelihood in the farming-pastoral ecotone (Meng et al., 2013; Dao, 2014; Yang and Xu, 2016). By summarizing the relevant research results, we found that the main characteristics of farmers' livelihood strategies are related to regional differences, the diversity of means and needs, and differences in the conditions of the farmers themselves (Viswanathan and Shivakoti, 2008; Biswas and Mallick, 2021; Hernández- Núñez et al., 2022).

Farmers' livelihood choices are closely related to the level of regional economic and social development (Su and Yin, 2020). Studies have found that in poor and underdeveloped regions, farmers' livelihood transitions are more intense and the livelihood types are more diversified. Livelihood changes are relatively stable in relatively developed regions, and the livelihood types tend to be more business-oriented (Chen et al., 2017; Zhang and Wang, 2020). Farmers in the eastern, central and western regions of China are more inclined to choose the livelihood strategies of labor-oriented, partial agriculture-oriented and part-time agriculture-oriented than those in the northeastern region. Compared with the plain areas, the hilly areas show a significantly reduced probability of farmers choosing the livelihood strategies of migrant-led or part-time farming. In addition, the higher the level of infrastructure, the more likely it is that farmers will choose the agricultural-part-life strategy (Geng et al., 2021).

In addition to the results on the transformation of farmers' livelihood, the diversification of livelihood means and needs cannot be ignored. Farmers' livelihood means can be divided into two types, namely pure agricultural livelihood and non-agricultural livelihood. Pure agricultural livelihood means that the income of farmers is mainly based on agricultural production, including planting, breeding, etc. Non-agricultural livelihoods include non-agricultural self-management, migrant workers, etc. (Wang and Wu, 2014). It is worth noting that agricultural production is changing from human production in the traditional sense to mechanized production, and the methods are diversified. It is no longer limited to traditional food production, and the planting area of cash crops has tended to increase. Wang et al. found that the overall adjustment direction of in the livelihood model of ethnic minority farmers in poor mountainous areas is "grain crop production - partial grain crop production - partial economic crop production - pure economic crop production" (Wang and Wu, 2014). With the development of more agricultural production technology options and the implementation of ecological protection policies, farmers' livelihoods will show higher diversity (Diao et al., 2019; Asfaw et al., 2021; Ayana et al., 2021).

In terms of farmers' subjective willingness, low-investment and high-income means of livelihood are often sought after by the majority of farmers (Higgins et al., 2021; Sunam et al., 2021). Farmers always prefer low-cost and high-income means of livelihood. According to the diversity of livelihood activities, Wang et al. divided farmers into four types: enterprising type, professional type, potential type and survival type. Each type of farmer has different needs for livelihood. Enterprising farmers have more energy to engage in a variety of livelihood activities, and their income structure is more average. Professional farmers are mainly engaged in business production, such as vegetable planting, animal husbandry, slaughtering and the sale of livelihood activities. Potential farmers have a higher level of diversification although their livelihood assets are low. Survival farmers are the group with the lowest livelihood assets in the village, and their index of livelihood diversification is slightly higher than that of professional farmers (Wang and Fang, 2021). This study found that the diversity of farmers' livelihood can improve the diversity of income, but it has no direct correlation with high income. Therefore, while meeting the diversification of farmers' livelihoods, figuring out how to improve the income source of farmers is an important proposition for the transformation of farmers' livelihood. In addition, under the dual pattern of rural revitalization and ecological civilization construction, the pursuit of ecological environment-friendly livelihoods is also an important part of the farmers' needs (Yang et al., 2019).

The transformation of farmers' livelihood has the characteristics of being endogenous and exogenous. Its manifestation and content are closely related to the farmers' family conditions, regional development level, livelihood diversity and subjective will. On the basis of existing research, exploring the profound relationships between farmers' livelihood transformation characteristics and driving factors will be an important part of future research.

3.2 Driving mechanisms for the transformation of farmers' livelihood

With the continuous improvement of China's urbanization development and the agricultural product market environment, farmers are no longer limited to self-sufficiency, and a large number of rural laborers have migrated to the cities. The traditional agricultural production methods have undergone significant changes (Hao et al., 2013; He et al., 2013; Meng et al., 2013; Tang, 2015).

The choice of farmers' livelihood is the result of the combination of internal and external factors. When the benefits obtained are greater than the livelihood capital or do not meet expectations, farmers will adjust their livelihood strategies according to their own situation, and change the means of livelihood to meet their needs (Murungweni et al., 2014; Mumuni and Oladele, 2016; Snyder et al., 2020). The internal factors that affect the livelihood choices are closely related to the natural and social capital owned by the farmers themselves and their expectations for life. The external factors are derived from the changes in natural conditions

and the implementation of social policies. At the same time, internal factors and external factors will also affect each other, and jointly determine the livelihood choices of farmers (Stringer et al., 2020; Campbell, 2021; Quandt, 2021). Through household surveys and socio-economic data analysis, Wei (2019) and He (2015) found that tourism impact research based on the perspective of sustainable livelihoods was of great significance for exploring the improvement of farmers' livelihoods, reducing the vulnerability of farmers' livelihoods and promoting the sustainable development of rural tourism destination human-land systems. Ge (2014) found that the return of farmland in the poverty-stricken areas around Beijing had a significant promoting effect on farmers' livelihood transformation through the investigation of farmers' livelihoods and land use in the region, and there was a coupling process of mutual influence between returning farmland and farmers' livelihood transformation. By studying the selection of livelihood patterns by the migrant farmers in loess hilly area, Li (2016) found that in order to improve their living conditions and achieve their own survival and development goals, farmers will inevitably spontaneously choose the livelihood model that maximizes their benefits. Combined with the analysis of relevant research results, the causes of farmers' livelihood changes can be divided into positive factors and negative factors. Positive conditions such as ecological compensation and ecological poverty alleviation can improve farmers' income, in which case the farmers will take the initiative to choose the appropriate means of livelihood. Negative conditions such as natural disasters and land degradation will lead farmers to passively make livelihood changes. In summary, the internal factors affecting the transformation of farmers mainly come from the subjective willingness of farmers, including the level of livelihood income and the purpose of livelihood, while the external factors include natural factors such as land resources, climate conditions, ecological compensation, ecological restoration and social policies (Makate et al., 2016; Binam et al., 2017; Mabon et al., 2021).

Livelihood capital is an important concept regarding farmers' livelihood transformation. Some scholars and research institutions consider subsistence capital to be both tangible and intangible assets on which livelihood strategies are formed, including human capital, natural capital, physical capital, financial capital and social capital (He et al., 2013; Antwi-Agyei et al., 2014; Hishe et al., 2019; Persson et al., 2021). Livelihood capital determines the choice of the farmers' livelihood mode and possible action strategies, so the accurate quantification of farmers' livelihood capital can discriminate the future development trends of farmers from the source (Yan et al., 2010), which also provides a new perspective for the quantitative study of farmers' livelihoods. The driving factors of farmers' livelihood choices can be summarized as interest demand driven, natural condition driven, and social policy driven. Human capital, natural capital, social capital, financial capital, ideas and other livelihood capital determine the optimal balance between pure agricultural livelihood and non-agricultural livelihood (Joseph et al., 2013; Manlosa et al., 2019; Eadie et al., 2020). Identifying the driving factors of farmers' livelihood changes is the basis of constructing the livelihood transformation mechanism. The problem of farmers' livelihood transformation requires multi-level research in sociology, economics, ecology and other disciplines (Ranam and Moniruzzaman, 2021).

The livelihood characteristics of farmers include regional differences, diversity of means, needs, and differences in the farmers' own conditions (Kubitza et al., 2018; Fadairo et al., 2020). The mechanisms of livelihood transformation can be considered from both macro and micro perspectives. The macro-mechanism includes internal factors and external factors. Internal factors include farmers' natural, social capital stock and expectations for life, while external factors mainly refer to the changes in natural conditions and the implementation of social policies. The micro-mechanism believes that the driving force of livelihood transformation comes from the livelihood capital, and livelihood capital includes human capital, natural capital, material capital, financial capital and social capital. Overall, the factors driving farmers' livelihood choices can be summarized as interest demand driven, natural condition driven and social policy driven (Dendir and Simane, 2019; Naudiyal et al., 2019; Deng et al., 2020; Escarcha et al., 2020; Bacon et al., 2021) (Table 1). Farmers' livelihood transformation has the characteristics of being endogenous and exogenous, and its manifestations and contents are closely related to farmers' family conditions, regional development level, livelihood diversity and subjective willingness. Based on the existing research, exploring the profound relationships between the characteristics of farmers' livelihood transformations and driving factors will be an important part of future research. In addition, the choice of farmers' livelihoods is affected by subjective and objective factors and other multi-level factors. The existing research has studied the classification of the factors affecting the transformation of farmers' livelihood from different angles. However, there is still a lack of suitable research methods, specific micro-mechanisms and application examples. Therefore, in the future, it will be necessary to strengthen the construction of research on the mechanisms and methods of farmers' livelihood transformation, and strengthen the research on the characteristics of farmers' livelihoods and the mechanisms and relationships of livelihood transformation.

4 Ecological effect of farmers' livelihood transformation

4.1 The impact of livelihood transformation on farmers' land use

The abandonment of land from agricultural production is the

Table 1 Summary of farmers' livelihood characteristics and transformation mechanisms

Content	Connotation
Livelihood characteristics	Diversity: Farmers, expectations and needs, livelihood types...; Differences: Economic society, geographical space...
Livelihood types	Pure agriculture, partial agriculture, concurrent agriculture (business, service...), non-agricultural type...
Macro factors	Farmers: Subjective willingness, family cycle...; Natural factors: Climate change, natural disasters...; Social policy: Returning farmland to forest, ecological compensation, ecological migration...
Micro factors	Natural capital: Land multifunctionality, land productivity, water resources, climate conditions...
	Physical capital: Storage facilities, agricultural machinery facilities, irrigation infrastructure, transport facilities...
	Human capital: Technical training, education, innovative thinking, working population...
	Social capital: Relations with neighbors, labor networks, bank connections, traffic convenience...
	Financial capital: Agricultural income, non-agricultural income, access to bank credit, investment ratio...
Evaluation	Index: Livelihood diversity index, livelihood vulnerability index, livelihood change index...
	Methods: Data survey of farmers, multivariate analysis of variance, cluster analysis, fuzzy comprehensive evaluation method...
	Indicators: Transformation costs, farmer income, farmer well-being, sustainability...
Research significance	Ensuring food security and ecological security, maintaining livelihood sustainability, improving farmers' well-being, developing the rural economy...

most intuitive manifestation of the decline in farmers' dependence on natural resources (Castella et al., 2013; Oestreicher et al., 2014). With the diversification of farmers' livelihoods and income diversification, the role of agricultural production in the increases in a farmers' income declines. Under labor constraints, farmers will reduce the scale of land operations and tend to abandon all or part of their land (Li et al., 2014b; Hao et al., 2015b; Shao et al., 2015; Yang et al., 2016; Li et al., 2017a). The abandonment of land from agricultural production means the transformation of artificial ecosystems to natural ecosystems, which facilitates ecosystem restoration (Yan et al., 2016; Zhang et al., 2016; Li et al., 2017b; Zhao et al., 2017). However, some studies have found that abandoning land management does not necessarily promote ecological restoration. Some soil and water conservation measures adopted in traditional agriculture (such as terraces) can protect the slope from degradation (Temudo et al., 2014; Zhang et al., 2019). When farmers abandon or extensively use the land, they neglect the construction and management of infrastructure, resulting in land degradation and soil erosion (Koulouri et al., 2007). Non-agricultural workers' associations reduce farmers' investment in land conservation and land improvement, which are not conducive to ecosystem restoration (Morera and Gladwin, 2006). Other studies have suggested that while abandoning poor-quality land, farmers concentrate their labor and capital on better-quality land, which on the one hand will better utilize land productivity, but on the other hand, it also facilitates vegetation restoration on the poorer-quality land (Hao et al., 2015a; Hao et al., 2017). Wang et al. believed that the change in farmers' livelihoods resulted in the contraction of the winter wheat planting area in Hebei Plain, saving a great deal of irrigation water resources (Wang et al., 2013; Wang et al., 2018).

Existing studies have shown that land reclamation does not necessarily promote land ecological restoration. On the contrary, the rational use of land is conducive to soil and water conservation and ecosystem stability. However, the existing studies only focus on the results of land use under the transformation of farmers' livelihood, but there is a lack of horizontal and vertical comparative studies, and the spatio-temporal scale effect of land use change is rarely taken into account (Oumer et al., 2013). Therefore, future research should focus on combing the impacts of livelihood transformation on the way farmers use land under different temporal, spatial and geographical conditions (Méndez-Lemus et al., 2017).

4.2 The impact of livelihood transition on farmers' consumption patterns

As the most important economic activity subject and the most basic decision-making unit in rural areas, the production and consumption strategies adopted by farmers determine the use of natural resources and utilization efficiency, as well as the intervention methods and intensity of the ecological environment. For example, farmers are no longer engaged in agricultural production after fully participating in non-farm employment, while the consumer products are mainly from the market. By comparison, the impacts of such farmers on local ecosystems and natural resources will be reduced (Li, 2008b; Hou et al., 2015; Zhao et al., 2016). He et al. (2016b) found that non-agricultural employment can significantly reduce the per capita fuelwood consumption of farmers by reducing the proportion of the agricultural labor force and increasing the level of non-agricultural wages. Non-agricultural employment and agricultural specialization constitute the main driving force of fuelwood substitution (Wang and Yang, 2012; Duan et al., 2016). Some scholars have introduced the ecological footprint theory and evaluation method into their evaluations of the impacts of farmers' consumption on the ecosystem. For example, Jia et al. (2016) found that the per capita ecological

footprint of farmers decreased after immigration, indicating that the pressure on resources and the environment from the farmers' livelihood activities had decreased. With the continuous improvement of market conditions, farmers' production is no longer limited to their own consumption demand, and farmers' production and consumption have become two completely different decision-making processes. Therefore, in the context of livelihood transformation, it is necessary to coordinate these two processes of production and consumption as a whole to measure the impact of farmers on the ecological environment (Mohammed et al., 2020).

The transformation of farmers' livelihood will change their consumption structure and level, which in turn will have either a favorable or negative impact on the natural ecological system. Normally, pure agricultural production causes greater damage to the ecosystem than non-agricultural production. However, driven by the market, assessing the impact of farmers on the ecological environment needs to fully consider the direct role of farmers' production and living activities, and distinguish between the overlapping effects of different livelihood types (Cramb et al., 2009).

4.3 The impact of farmers' livelihood transition on ecosystem evolution

The transformation of farmers' livelihood changes the structure and function of regional ecosystems through the combined effects of production and consumption, resulting in uncertain evolutionary directions of the ecosystems (Zhang and Zhao, 2015; Fu et al., 2018). Farmers' production and operation activities directly affect the land, and eventually manifest as vegetation changes throughout the region. The production behavior dominated by reclaiming wasteland and expanding the scale of aquaculture, as well as the energy consumption behavior dominated by salary, materials and straw are the main factors contributing to ecological degradation in ecologically fragile areas (Jia et al., 2016). Human activities (e.g., labor transfer, land use, ecological protection policies) may have had greater impacts on vegetation and ecosystem services than climate factors in recent periods (Lu et al., 2015; Li et al., 2016; Tong et al., 2016). Li et al. (2015) and Li and Tan (2018) suggested that population and agricultural labor migration had a significant role in promoting vegetation cover. Li (2008a) summarized the effects of grazing, grazing prohibition and farmland reclamation on the service functions of grassland ecosystems from five aspects: primary material production function, carbon sink function, windbreak and sand fixation, material cycle and biodiversity maintenance. Since the Reform and Opening up, a large amount of rural labor and the population in China have been transferred to cities, and the phenomenon of non-agriculturalization of the farmers' livelihood has been prominent. Livelihood de-farming has contributed to ecosystem recovery and "forest transformation" by reducing famine and deforestation by farmers, and reducing damage to the land cover (Li and Zhao, 2011; He et al., 2016a). Studies have also found that the land use patterns of farmers and herdsmen have led to a shift in landscape patterns and boundaries in agro-pastoral ecotones (Liu et al., 2011). Therefore, scholars generally believe that changing farmers' livelihoods, promoting livelihood diversification and non-agriculturalization are effective ways to achieve sustainable ecosystem management (Wang and Yang, 2011; Cheng et al., 2015; Fouladbash and Currie, 2015).

Different livelihood types have varying impacts on the ecosystem by changing the production and consumption patterns of farmers. However, most of the existing studies consider the ecological effects from the results of livelihood transformation, and there is a lack of micro-mechanism and scenario simulation research. In the future, the economic effects, spatial analysis and model simulation can be combined to explore the impact of livelihood transformation on ecosystem evolution (Gutiérrez Rodríguez et al., 2016; Yuan et al., 2017; Shao et al., 2018).

At present, for the vast majority of domestic and foreign farmers, the transformation direction is from pure farming to non-agricultural, and the way of livelihood is being gradually diversified, from traditional farming to diversified. With the gradual transformation of farmers' livelihood, their consumption and production methods for energy, commodities, food and other necessities are also changing. Farmers' demand for daily necessities and other products tends to be refined and processed, and production methods are no longer limited to traditional natural conditions and human labor, but are now more dependent on the improvement of quantity and quality brought about by modern science and technology. The changes in the farmers' consumption mode and production mode further cause changes in natural resource utilization and the ecosystem, which produces an ecosystem effect. The effect of farmers' livelihood transformation on ecosystems is also affected by regional natural conditions, social and ecological policies and other factors. The final result may be either improvement or deterioration, and its nature is either reversible or irreversible with great uncertainty. At the same time, it will also feedback on the sustainable use of natural resources by human beings. Therefore, it is of great significance to evaluate the comprehensive effects of the ecological environment and natural resources caused by farmers' livelihood transformation on farmers' livelihood, natural resources utilization and ecological environmental sustainability. The ecological effects of farmers' livelihood transformation can be analyzed from the aspects of the farmers, landscape and regional scale. Researchers can use the land multifunctional index, landscape multifunctionality, biodiversity index and other related index methods to characterize the direction and trend of ecosystem changes in a certain farmers' livelihood transformation area (Guo et al., 2014; Fang et al., 2020; Defe and Matsa, 2021) (Table 2).

Table 2 Summary of ecological effects of farmers' livelihood transformation

Content	Connotation
Changes in consumption patterns	Energy: Firewood into electricity; Commodities: Primary products into secondary products; Food: Agricultural by-products into deep processing products
Changes in mode of production	Land use: Intensification, specialization, diversification or abandonment, desertification...; Application of science and technology: Making full use of pesticide and fertilizer technology, large-scale mechanization technology and transgenic agricultural technology
Changes in natural resource utilization	Impact on the utilization of regional water resources, land resources, animal resources and plant resources…
Ecosystem changes	Improving, maintaining or reducing the multi-functionality, resistance and resilience of the ecosystem
Final ecological effect	Sustainable or extensive use of natural resources; Improvement or destruction of the ecological environment
Evaluation methods	Farmer scale: Land multifunctional index, land use/land cover change index…; Landscape scale: Landscape multi-functionality, landscape fragmentation…; Regional scale: Vegetation coverage, biodiversity index…

5 Discussion and prospects

5.1 Discussion

Farmers' livelihood is an important means for farmers to make a living. Under the combined effect of internal and external factors, farmers will change their existing livelihood types according to the income level of agricultural production, and then change the farmers' livelihood. Farmers' agricultural production activities are the main and direct driving factors for the structural and functional changes of natural ecosystems. On this basis, the transformation of livelihood strategies will inevitably lead to corresponding changes in the production and consumption patterns, and ultimately lead to the evolution of ecosystems in the direction of adaptation or degradation. The main scientific problems of farmers' livelihood transformation and ecological effects include the driving factors, transformation mechanisms, resource utilization and ecosystem changes, which have feedback and coupling effects (Mumuni and Oladele, 2016; Shuklar et al., 2019; Mohammeed et al., 2020) (Fig. 2). At present, the research methods on farmers' livelihood diversification, livelihood transformation and ecological effects of transformation mainly include questionnaire surveys and regression analysis, which can accurately identify the direct and indirect driving factors of farmers' livelihood changes, but research on the micro-mechanisms of farmers' livelihood transformation and the coupling relationships with ecosystem changes is still lacking. In the process of farmers' transformation, socio-economic changes, as well as changes in the use of natural resources and the farmers' consumption patterns usually occur. Among these changes, there are key driving factors for livelihood transformation, which are also the results of livelihood transformation and have dramatic interactions. Therefore, one focus of future research will be to clarify the man-land relationship under the transformation of farmers from the coupling mechanism of social policy-farmer itself-ecological process, which will make this research complex, dynamic and uncertain. Future research can comprehensively consider the driving factors and ecological effects of farmers' livelihood transformation from the perspectives of landscape ecology and ecological economics, explore their coupling relationships, and analyze the internal and mutual trade-offs or synergies of factors such as farmers' livelihood capital, family structure and social policy. To clarify the interactions among driving factors, livelihood transformation, natural resource utilization and ecosystem change, it is urgent to carry out systematic and comprehensive research and put forward appropriate quantitative, simulation and prediction models and a general framework system, which can provide a sufficient scientific basis for formulating agricultural and rural policies and guiding farmers in choosing the type of livelihood utilization that maximizes their own income and ecological environmental benefits (Li et al., 2014a; Fadairo et al., 2020; Bonye et al., 2021).

5.2 Prospects

The transformation mechanism of farmers involves the cumulative effect of natural capital, human capital, social capital and financial capital (Wang and Fang, 2021), the evolutionary effect of the ecological environment (Zhao, 2017), and the promotion effect of the policy system (Cui et al., 2018; Qian, 2020). From these three aspects, we can summarize the three basic lines of livelihood transformation as follows: the transformation mechanism based on the main conditions of farmers, the transformation mechanism based on the characteristics of land change, and the transformation mechanism driven by the policy system. The active transformation of farmers is usually carried out in pursuit of higher income. Land transfer is accompanied by the transformation of pure agricultural livelihoods to part-time-agricultural and non-agricultural livelihoods. Policy system promotion mainly occurs in remote and underdeveloped poor areas. Constructing a complete mechanism for farmers' livelihood transformation can integrate farmers' willingness, livelihood capital and objective driving force, which will help to provide a comprehensive understanding of the rural social economy and the ecological environment. How the

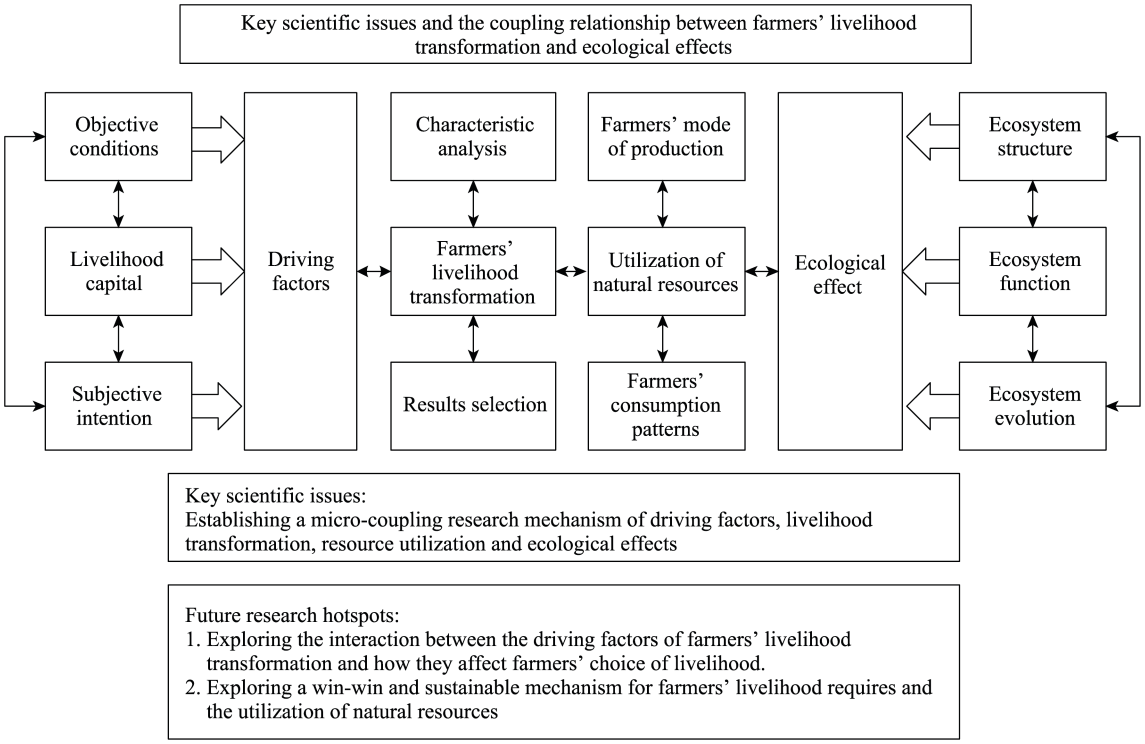

Fig. 2 Key scientific issues and their coupling relationships between the livelihood transformation of farmers and ecological effects

livelihood capital affects the willingness of farmers, how to formulate policies for guiding farmers to carry out the correct livelihood transformation, and how to realize the reasonable coupling between the evolution of the natural ecological system and the choice of livelihood are the key problems in the establishment of the transformation mechanism. The ultimate goals of studying the livelihood transformation mechanism of farmers are to integrate the key factors affecting the livelihood transformation of farmers, initially establish the livelihood transformation mechanism, and realize the bidirectional sustainability of farmers' livelihood and natural resource utilization.

The relationship between farmers' livelihood transformation and regional ecosystem evolution is a hot topic in current academic research, which will also provide an important basis for regional ecosystem management and ecological protection policy. Limited by the quantification and spatialization of farmers' livelihoods, most studies have carried out large-scale studies and preliminarily revealed the role of livelihood transformation in ecosystem evolution, but the mechanism and process of its impact require further study. Future research on the mechanism of farmers' transformation and its ecological effects can focus on the main line of "farmers' livelihood, production and consumption, land use and vegetation change" from the two micro scales of farmers and plots. Farmers' livelihood types with planting, breeding and non-agricultural employment as the main means of livelihood, and livelihood capital composition and changes will become the focus of future research. In the future, the main research route will focus on calculating the degree of farmers' occupation of natural resources from the two aspects of production and consumption, exploring the microscopic mechanism of regional vegetation change, breaking through the coupling mechanism and key links between farmers' livelihood strategies, resource utilization methods and vegetation restoration, comprehensively explaining the role and mechanism of farmers' livelihood transformation on regional ecosystem change, and putting forward policy suggestions for the "win-win" of ecosystem protection and the sustainable livelihood of farmers.

6 Conclusions

Farmers' livelihood has inherent characteristics and development laws, and its transformation is a complex dynamic process, which is affected by many factors. Different socio-economic and geographical conditions create different types of farmers and livelihoods, which provides the innate conditions and important characteristics of farmers to choose their livelihoods. Farmers' livelihood transformation is the process by which farmers make choices for different livelihood types. The mechanism that affects the decision-making process can be considered from both macro and micro levels. The macro level includes internal factors and external factors. Farmers' subjective willingness to pursue income is the starting point of livelihood transformation. The natural condition base and social policy drive

are important external conditions for farmers to carry out livelihood transformation. The micro-mechanism of farmers' livelihood transformation can be explained by livelihood capital, which includes natural capital, physical capital, human capital and social capital. The proportions of different types of livelihood capital owned by farmers and their interactions ultimately affect the farmers' choice of livelihood. The impact of livelihood transformation on ecosystems is affected by changes in farmers' consumption patterns and production modes. After the changes in the farmers' consumption mode and production mode, the first change is the structure and degree of the use of natural resources such as salary, water resources and land resources, which leads to either the sustainable use of natural resources or destructive overexploitation, which then affects the multifunctionality, resistance and resilience of the ecosystem, and ultimately makes the ecological environment either better or worse.

The general direction of farmers' livelihood transformation is from a pure agricultural type to a non-agricultural type. In the process of transformation, there are many ways for farmers to maintain their livelihood, such as tourism, work and business. Whether the relationship between farmers and livelihoods is good or not can be evaluated by the livelihood diversity index, livelihood vulnerability index and livelihood change index. Farmer survey analysis, cluster analysis and multivariate analysis of variance can be used to analyze the causes and results. The connotation of indicators can make full use of land productivity, land transfer degree, market demand, value expectation, farmers' innovation ability, farmers' transformation cost, etc. The ecological effects caused by farmers' livelihood transformation can be evaluated from the farmers' own scale, landscape scale or regional scale. On the scale of farmers, we mainly focus on land use change, using the land multifunctional index and land use / land cover change index to evaluate it. At the landscape scale, we mainly focus on the multi-functionality and the integrity of the landscape, which can be evaluated by landscape multifunctionality and the landscape fragmentation index. At the regional level, we mainly focus on the impact of the transformation of farmers' livelihood on vegetation coverage and biodiversity, which can be characterized by the vegetation coverage and biodiversity index.

The transformation of farmers' livelihooditsitsits is related to food security, ecological security and livelihood sustainability. Appropriate livelihoods can significantly improve the farmers' well-being, protect biodiversity and realize rural economic development. The characteristics, transformation mechanisms and ecological effects of a farmers' livelihood jointly constitute a complete organic chain regarding the farmers' livelihood choices. Studies on the mechanisms of farmers' transformation and their ecological effects have important reference significance for guiding ecological protection and rural revitalization.

References

Antwi-Agyei P, Stringer L C, Dougill A J. 2014. Livelihood adaptations to climate variability: Insights from farming households in Ghana. *Regional Environmental Change*, 14(4): 1615–1626.

Asfaw A, Bantider A, Simane B, et al. 2021. Smallholder farmers' livelihood vulnerability to climate change-induced hazards: Agroecology-based comparative analysis in Northcentral Ethiopia (Woleka Sub-basin). *Heliyon*, 7(4): e06761. DOI: 10.1016/j.heliyon.2021. e06761.

Ayana G F, Megento T L, Kussa F G. 2021. The extent of livelihood diversification on the determinants of livelihood diversification in Assosa Wereda, Western Ethiopia. *GeoJournal*, 2021. DOI: 10.1007/s10708-021-10379-5.

Bacon C M, Sundstrom W A, Stewart I T, et al. 2021. Towards smallholder food and water security: Climate variability in the context of multiple livelihood hazards in Nicaragua. *World Development*, 143: 105468. DOI: 10.1016/j.worlddev.2021.105468.

Barbieri A F, Bilsborrow R E, Pan W K. 2005. Farm household lifecycles and land use in the Ecuadorian Amazon. *Population and Environment*, 27(1): 1–27.

Bhandari P B. 2013. Rural livelihood change? Household capital, community resources and livelihood transition. *Journal of Rural Studies*, 32: 126–136.

Binam J N, Place F, Djalal A A, et al. 2017. Effects of local institutions on the adoption of agroforestry innovations: Evidence of farmer managed natural regeneration and its implications for rural livelihoods in the Sahel. *Agricultural and Food Economics*, 5(1): 2. DOI: 10.1186/s40100-017-0072-2.

Biswas B, Mallick B. 2021. Livelihood diversification as key to long-term non-migration: Evidence from coastal Bangladesh. *Environment, Development and Sustainability*, 23(6): 8924–8948.

Bonye S Z, Aasoglenang T A, Yiridomoh G Y. 2021. Urbanization, agricultural land use change and livelihood adaptation strategies in peri-urban Wa, Ghana. *SN Social Sciences*, 1: 9. DOI: 10.1007/s43545-020-00017-1.

Campbell D. 2021. Environmental change and the livelihood resilience of coffee farmers in Jamaica: A case study of the Cedar Valley farming region. *Journal of Rural Studies*, 81: 220–234.

Castella J C, Lestrelin G, Hett C, et al. 2013. Effects of landscape segregation on livelihood vulnerability: Moving from extensive shifting cultivation to rotational agriculture and natural forests in Northern Laos. *Human Ecology*, 41(1): 63–76.

Chen F, Yan J Z, Li H L. 2017. Understanding household livelihood strategies in rural Chongqing: A livelihood activity perspective. *Journal of Southwest University* (*Natural Sciences*), 39(11): 113–119. (in Chinese)

Cheng W S, Qiao H Q, Han G J. 2015. Safety and quality of farmers' livelihood are the core of China's rural problems. *Journal of Lanzhou University* (*Natural Sciences*), 51(5): 699–704. (in Chinese)

Cramb R A, Colfer C J P, Dressler W, et al. 2009. Swidden transformations and rural livelihoods in Southeast Asia. *Human Ecology*, 37(3): 323–346.

Cui J N, Wang J, Zhang X H. 2018. Study on the willingness to livelihood transformation and intergenerational differences of Tibetan migrants in Qinghai Province. *Journal of Southwest Minzu University* (*Humanities and Social Science*), 39(9): 16–21. (in Chinese)

Dao R N. 2014. Relationship between livelihood assets and livelihood strategies of rural households of farming-pastoral area: A case study on four counties in the Eastern Inner Mongolia. *China Population, Resources and Environment*, 24(5): 274–278. (in Chinese)

Defe R, Matsa M. 2021. The contribution of climate smart interventions to enhance sustainable livelihoods in Chiredzi District. *Climate Risk Management*, 33: 100338. DOI: 10.1016/j.crm.2021.100338.

Dendir Z, Simane B. 2019. Livelihood vulnerability to climate variability and change in different agroecological zones of Gurage Administrative Zone, Ethiopia. *Progress in Disaster Science*, 3: 100035. DOI: 10.1016/j.pdisas.2019.100035.

Deng Q Q, Li E L, Zhang P Y. 2020. Livelihood sustainability and dynamic mechanisms of rural households out of poverty: An empirical analysis of Hua County, Henan Province, China. *Habitat International*, 99: 102160. DOI: 10.1016/j.habitatint.2020.102160.

Diao X S, Magalhaes E, Silver J. 2019. Cities and rural transformation: A spatial analysis of rural livelihoods in Ghana. *World Development*, 121: 141–157.

Duan W, Ma B, Qin Q, et al. 2016. Study on farmers' ecological protection behavior research based on livelihood capital. *Ecological Economy*, 32(8): 180–185. (in Chinese)

Eadie P, Atienza M E, Tan-Mullins M. 2020. Livelihood and vulnerability in the wake of Typhoon Yolanda: Lessons of community and resilience. *Natural Hazards*, 103(1): 211–230.

Escarcha J F, Lassa J A, Palacpac E P, et al. 2020. Livelihoods transformation and climate change adaptation: The case of smallholder water buffalo farmers in the Philippines. *Environmental Development*, 33: 100468. DOI: 10.1016/j.envdev.2019.100468.

Fadairo O, Williams P A, Nalwanga F S. 2020. Perceived livelihood impacts and adaptation of vegetable farmers to climate variability and change in selected sites from Ghana, Uganda and Nigeria. *Environment, Development and Sustainability*, 22(7): 6831–6849.

Fang Y P, Zhu R, Zhang C J, et al. 2020. Cascading adaptation of rural livelihood to changing environment: Conceptual framework and experiment from the Koshi River Basin. *Advances in Climate Change Research*, 11(2): 141–157.

Fouladbash L, Currie W S. 2015. Agroforestry in Liberia: Household practices, perceptions and livelihood benefits. *Agroforestry Systems*, 89(2): 247–266.

Fu B J. 2018. Thoughts on the recent development of physical geography. *Progress in Geography*, 37(1): 1–7. (in Chinese)

Ge Z C. 2014. Research on the coupling relationship between land use change and the farmer's livelihoods in poor areas of returning farmland to forest around Beijing and Tianjin: A case study of Laishui County. Diss., Baoding, China: Hebei Agricultural University. (in Chinese)

Geng Y X, Liu X H, Rao P X. 2021. Study on the impact of rural livelihood capital and regional heterogeneity on livelihood strategies—Based on an empirical analysis of CFPS data. *Forestry Economics*, 43(5): 17–31. (in Chinese)

Guo S L, Liu S Q, Peng L, et al. 2014. The impact of severe natural disasters on the livelihoods of farmers in mountainous areas: A case study of Qingping Township, Mianzhu City. *Natural Hazards*, 73(3): 1679– 1696.

Gutiérrez Rodríguez L, Hogarth N J, Zhou W, et al. 2016. China's conversion of cropland to forest program: A systematic review of the environmental and socioeconomic effects. *Environmental Evidence*, *BioMed Central*, 5(1): 1–22.

Hao H G, Li X B, Tan M H, et al. 2015a. Agricultural land use intensity and its determinants: A case study in Taibus Banner, Inner Mongolia, China. *Frontiers of Earth Science*, 9(2): 308–318.

Hao H G, Li X B, Xin L J. 2017. Impacts of non-farm employment of rural laborers on agricultural land use: Theoretical analysis and its policy implications. *Journal of Resources and Ecology*, 8(6): 595–604.

Hao H G, Li X B, Zhang H Y, et al. 2013. Driving factors and the implications of work choices of rural laborers in ecologically vulnerable areas in North China. *China Population*, *Resources and Environment*, 11(4): 357–366.

Hao H G, Li X B, Zhang H Y, et al. 2015b. Driving effect of labor opportunity cost on farmland marginalization. *Journal of Arid Land Resources and Environment*, 29(3): 50–56. (in Chinese)

He A L. 2015. Impacts of rural tourism on farmer's livelihoods in North slope of Qinling mountains: Based on sustainable livelihoods analysis perspective. Diss., Xi'an, China: Northwest University. (in Chinese)

He R W, Liu S Q, Chen G J, et al. 2013. Research progress and trends on sustainable livelihoods of Chinese farmers. *Progress in Geography*, 32 (4): 657–670. (in Chinese)

He W F, Yan J Z, Zhou H, et al. 2016a. The micro-mechanism of forest transition: A case study in the mountainous areas of Chongqing. *Journal of Natural Resources*, 31(1): 102–113. (in Chinese)

He W F, Yan J Z, Zhou H, et al. 2016b. The factors influencing rural household firewood consumption: A theoretical model and empirical research of a typical area in Chongqing Municipality. *Acta Ecologica Sinica*, 36(5): 1369–1379. (in Chinese)

Hernández-Núñez H E, Gutiérrez-Montes I, Bernal-Núñez A P, et al. 2022. Cacao cultivation as a livelihood strategy: Contributions to the well-being of Colombian rural households. *Agriculture and Human Values*, 39: 201–216.

Higgins D, Arslan A, Winters P. 2021. What role can small-scale irrigation play in promoting inclusive rural transformation? Evidence from smallholder rice farmers in the Philippines. *Agricultural Water Management*, 243: 106437. DOI: 10.1016/j.agwat.2020.106437.

Hishe S, Lyimo J, Bewket W. 2019. Impacts of soil and water conservation intervention on rural livelihoods in the Middle Suluh Valley, Tigray Region, northern Ethiopia. *Environment, Development and Sustainability*, 21(6): 2641–2665.

Hou C X, Zhao X Y, Wen Y, et al. 2015. Spatial disparities and the reasons about the impact of the peasant household consumption on environment: Based on the survey data of Zhangye City in 2010. *Acta Ecologica Sinica*, 35(6): 2013–2019. (in Chinese)

Jia G P, Zhu Z L, Wang X T, et al. 2016. Research on the changes of migrant's livelihood strategies and their ecological effects: A case study of Hongsipu District in Ningxia Province. *Research of Agricultural Modernization*, 37(3): 505–513. (in Chinese)

Jiao N, Guo Q Y. 2020. Identification of farmers' livelihood strategies and their dynamic transformation. *Journal of South China Agricultural University* (*Social Science*), 19(2): 37–50. (in Chinese)

Joseph V, Thornton A, Pearson S, et al. 2013. Occupational transitions in three coastal villages in Central Java, Indonesia, in the context of sea level rise: A case study. *Natural Hazards*, 69(1): 675–694.

Komarek A M, Shi X, Heerink N. 2014. Household-level effects of China's sloping land conversion program under price and policy shifts. *Land Use Policy*, 40: 36–44.

Koulouri M, Giourga C. 2007. Land abandonment and slope gradient as key factors of soil erosion in Mediterranean terraced lands. *Catena*, 69(3): 274–281.

Kubitza C, Krishna V V, Alamsyah Z, et al. 2018. The economics behind an ecological crisis: Livelihood effects of oil palm expansion in Sumatra, Indonesia. *Human Ecology*, 46(1): 107–116.

Li G, Fang C, Qiu D, et al. 2014a. Impact of farmer households' livelihood assets on their options of economic compensation patterns for cultivated land protection. *Journal of Geographical Sciences*, 24(2): 331–348.

Li S J, Li X B, Tan M H. 2015. Effects of rural-urban migration on vegetation greenness in fragile areas: A case study of Inner Mongolia in China. *Acta Geographica Sinica*, 70(10): 1622–1631. (in Chinese)

Li S J, Sun Z G, Tan M H, et al. 2016. Effects of rural-urban migration on vegetation greenness in fragile areas: A case study of Inner Mongolia in China. *Journal of Geographical Sciences*, 26(3): 313–324.

Li S F, Li X B, Xin L J, et al. 2017a. Extent and distribution of cropland abandonment in Chinese mountainous areas. *Resource Science*, 39(10): 1801–1811. (in Chinese)

Li W, Tan M H. 2018. Spatial recombination of population in the mountains of southwest China and its impact on vegetation: A case study along rivers. *Acta Ecologica Sinica*, 38(24): 8879–8887. (in Chinese)

Li W H. 2008a. Theory, method and application of ecosystem service function value evaluation. Beijing, China: China Renmin University Press. (in Chinese)

Li W H. 2016. A research on interest-driven choice of livelihood patterns of migrated farmers in the Loess Hilly region. Diss., Xi'an, China: Northwest University. (in Chinese)

Li X B. 2008b. Theoretical hypotheses about agricultural land use changes and the relevant propositions about environmental impacts. *Advances in Earth Science*, 23 (11): 1123–1129. (in Chinese)

Li X B, Zhao Y L. 2011. Forest transition, agricultural land marginalization and ecological restoration. *China Population*, *Resources and Environment*, 21(10): 91–95. (in Chinese)

Li Y B, Luo G J, Huang J. 2017b. Spatial-temporal evolution, mechanism and vegetation restoration of abandoned farmland in the Maolan National Nature Reserve. *Carsologica Sinica*, 36 (4): 447–453. (in Chinese)

Li Z, Yi J, Li W Y. 2021. A review of studies on sustainable livelihood of farmers based on the utilization of natural resources. *Land and Resources Information*, (5): 31–38. (in Chinese)

Li Z H, Yan J Z, Hua X B, et al. 2014b. Factors influencing the cultivated land abandonment of households of different types:A case study of 12 typical villages in Chongqing Municipality. *Geographical Research*, 33 (4): 721–734. (in Chinese)

Liu J H, Gao J X, Lv S H, et al. 2011. Shifting farming-pastoral ecotone in China under climate and land use changes. *Journal of Arid Environments*, 75(3): 298–308.

Lu C X, Yu F Q, Liu X J, et al. 2015. Responses of ecosystems to ecological compensation in a key ecological function area of the Loess Plateau. *Journal of Resources and Ecology*, 6(6): 369–374.

Mabon L, Nguyen S T, Pham T T, et al. 2021. Elaborating a people-centered approach to understanding sustainable livelihoods under climate and environmental change: Thang Binh District, Quang Nam Province, Vietnam. *Sustainability Science*, 16(1): 221–238.

Makate C, Wang R C, Makate M, et al. 2016. Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. *SpringerPlus*, 5(1): 1135. DOI: 10.1186/s40064-016-2802-4.

Manlosa A O, Hanspach J, Schultner J, et al. 2019. Livelihood strategies, capital assets, and food security in rural Southwest Ethiopia. *Food Security*, 11(1): 167–181.

Méndez-Lemus Y, Vieyra A, Poncela L. 2017. Periurbanization, agricultural livelihoods and Ejidatarioś social capital: Lessons from a periphery municipality in Michoacán, Mexico. *Procedia Engineering*, 198: 428–443.

Meng J J, Ai M R L, Liu Y, et al. 2013. Study on relationship between livelihood capital and livelihood strategy of farming and grazing households: A case of Uxin Banner in Ordos. *Acta Scientiarum Naturalium Universitatis Pekinensis*, 49(2): 321–328. (in Chinese)

Mohammed I, Kosa A, Juhar N. 2020. Economic linkage between urban development and livelihood of peri-urban farming communities in Ethiopia (policies and practices). *Agricultural and Food Economics*, 8: 21. DOI: 10.1186/s40100-020-00164-2.

Morera M C, Gladwin C H. 2006. Does off-farm work discourage soil conservation? Incentives and disincentives throughout two Honduran hillside communities. *Human Ecology*, 34(3): 355–378.

Mumuni E, Oladele O I. 2016. Access to livelihood capitals and pro pensity for entrepreneurship amongst rice farmers in Ghana. *Agric ulture & Food Security*, *BioMed Central*, 5: 1. DOI: 10.1186/s40066-015-0049-x.

Murungweni C, Wijk M T, Giller K E, et al. 2014. Adaptive livelihood strategies employed by farmers to close the food gap in semi-arid south eastern Zimbabwe. *Food Security*, 6(3): 313–326.

Naudiyal N, Arunachalam K, Kumar U. 2019. The future of mountain agriculture amidst continual farm-exit, livelihood diversification and outmigration in the Central Himalayan villages. *Journal of Mountain Science*, 16(4): 755–768.

Oestreicher J S, Farella N, Paquet S, et al. 2014. Livelihood activities and land-use at a riparian frontier of the Brazilian Amazon: Quantitative characterization and qualitative insights into the influence of knowledge, values, and beliefs. *Human Ecology*, 42(4): 521–540.

Oumer A M, Hjortsø C N, Neergaard A. 2013. Understanding the relationship between livelihood strategy and soil management: Empirical insights from the central Highlands of Ethiopia. *Food Security*, 5(2): 143–156.

Persson J, Ford S, Keophoxay A, et al. 2021. Large differences in livelihood responses and outcomes to increased conservation enforcement in a protected area. *Human Ecology*, 49(5): 597–616.

Qian P. 2020. Livelihood driving mechanism and ecological effect of land use change in immigrant areas: A case study of Hongsibao District, Ningxia. Diss., Yinchuan, China: Ningxia University. (in Chinese)

Quandt A. 2021. Coping with drought: Narratives from smallholder farmers in semi-arid Kenya. *International Journal of Disaster Risk Reduction*, 57: 102168. DOI: 10.1016/j.ijdrr.2021.102168.

Rana M M P, Moniruzzaman M. 2021. Transformative adaptation in agriculture: A case of agroforestation in Bangladesh. *Environmental Challenges*, 2: 100026. DOI: 10.1016/j.envc.2021.100026.

Shao J A, Huang Z L, Deng H. 2018. Characteristics of nonpoint source pollution load from crop farming in the context of livelihood diversification. *Journal of Geographical Sciences*, 28(4): 459–476.

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(6): 701–722.

Shuklar R, Agarwal A, Gornott C, et al. 2019. Farmer typology to understand differentiated climate change adaptation in Himalaya. *Scientific Reports*, 9(1): 1–12.

Snyder K A, Sulle E, Massay D A, et al. 2020. "Modern" farming and the transformation of livelihoods in rural Tanzania. *Agriculture and Human Values*, 37(1): 33–46.

Stringer L C, Fraser E D G, Harris D, et al. 2020. Adaptation and development pathways for different types of farmers. *Environmental Science & Policy*, 104: 174–189.

Su F, Yin Y J. 2020. Optimal livelihood strategy for different poverty groups among farmers: A case study of the Qin-Ba Mountain area in South-Shaanxi, China. *Journal of Mountain Science*, 17(5): 1206–1220.

Sunam R, Barney K, McCarthy J F. 2021. Transnational labour migration and livelihoods in rural Asia: Tracing patterns of agrarian and forest change. *Geoforum*, 118: 1–13.

Tang Q. 2015. Research progress and future key trends of sustainable livelihoods. *Advances in Earth Science*, 30(7): 823–833. (in Chinese)

Temudo M P, Abrantes M. 2014. The cashew frontier in Guinea-Bissau, west Africa: Changing landscapes and livelihoods. *Human Ecology*, 42(2): 217–230.

Tong L M, Zeng B, Wang X. 2016. Spatiotemporal variation of NDVI and its influence factors in different ecological districts, Shanxi Province. *Research of Soil and Water Conservation*, 23(3): 71–76. (in Chinese)

Viswanathan P K, Shivakoti G P. 2008. Adoption of rubber-integrated farm-livelihood systems: Contrasting empirical evidence from the Indian context. *Journal of Forest Research*, 13(1): 1–14.

Wang C C, Yang Y S. 2011. Review of research on mountainous ecological

restoration based on farmer household livelihood evolution. *Journal of Natural Resources*, 26(2): 344–352. (in Chinese)

Wang C C, Yang Y S. 2012. An overview of farmers' livelihood strategy change and its effect on land use/cover change in developing countries. *Progress in Geography*, 31(6): 792–798. (in Chinese)

Wang C C, Yang Y S, Zhang Y Q. 2011. Economic development, rural livelihoods, and ecological restoration: Evidence from China. *AMBIO*, 40(1): 78–87.

Wang C C, Yang Y S, Zhang Y Q. 2012. Rural household livelihood change, fuelwood substitution, and hilly ecosystem restoration: Evidence from China. *Renewable and Sustainable Energy Reviews*, 16(5): 2475–2482.

Wang C C, Zhang Y Q, Yang Y S, et al. 2016. Assessment of sustainable livelihoods of different farmers in hilly red soil erosion areas of southern China. *Ecological Indicators*, 64: 123–131.

Wang H, Fang Y G. 2021. Livelihood transformation and sustainability of rural households in mountainous areas: A case study of Yaozhan Town in Weichang County of Hebei Province. *Economic Geography*, 41(3): 152–160. (in Chinese)

Wang J, Wu H T. 2014. Relationship between the participation of ethnic minority farmers in mountainous areas and their livelihood strategies: A case study of southwest Yunnan. *Guizhou Ethnic Studies*, 35(7): 126–129. (in Chinese)

Wang J B, Zhao J, Li C H, et al. 2019. The spatial-temporal patterns of the impact of human activities on vegetation coverage in China from 2001 to 2015. *Acta Geographica Sinica*, 74(3): 504–519. (in Chinese)

Wang X, Li X B, Xin L J. 2013. Impact of the shrinking winter wheat sowing area on agricultural water consumption in the Hebei Plain. *Acta Geographica Sinica*, 68(5): 694–707. (in Chinese)

Wang X, Li X B, Xin L J, et al. 2018. Driving factors on winter wheat abandonment by farmers in North China Plain and its policy implication. *Transactions of the Chinese Society of Agricultural Engineering*, 34(9): 248–257. (in Chinese)

Wei Y B. 2019. Analysis on the influencing factors and effects of rural tourism construction on farmers' livelihood transformation: Based on the Mayangxi ecological tourism area in Changtai County. Diss., Fuzhou, China: Fujian Agriculture and Forestry University. (in Chinese)

Wu Y. 2015. Study on farmers livelihood capital impact on the livelihood strategies. *Journal of South China Agricultural University* (*Social Science Edition*), 14(2): 57–66. (in Chinese)

Yan F C, Jiao J Y, Cao B T, et al. 2016. Soil anti-erodibility of abandoned lands during different succession stages of plant community in hilly-gullied region of the Loess Plateau: Take Fangta small watershed as an example. *Chinese Journal of Applied Ecology*, 27(1): 64–72. (in Chinese)

Yan J Z, Wu Y Y, Zhang Y L, et al. 2010. Livelihood diversification of farmers and nomads of eastern transect in Tibetan Plateau. *Journal of Geographical Sciences*, 20(5): 757–770.

Yang L, Liu M C, Min Q W, et al. 2019. Review of eco-environmental effect of farmers' livelihood strategy transformation. *Acta Ecologica Sinica*, 39(21): 8172–8182. (in Chinese)

Yang Y, Xu Y. 2016. Farmers' livelihood and land use in the farming-pastoral transitional zone: A case study of Kerqinzuoyihouqi, Inner Mongolia. *Journal of China Agricultural University*, 21(12): 114–123. (in Chinese)

Yuan C C, Liu L M, Ye J W, et al. 2017. Assessing the effects of rural livelihood transition on non-point source pollution: A coupled ABM-IECM model. *Environmental Science and Pollution Research International*, 24(14): 12899–12917.

Zhang B L, Jia R C, Liu G B, et al. 2016. Remote sensor analysis of vegetation restoration in Green-for-Grain project areas of Inner Mongolia. *Environmental Science & Technology*, 39(1): 187–193. (in Chinese)

Zhang B L, Sun P L, Jiang G H, et al. 2019. Rural land use transition of mountainous areas and policy implications for land consolidation in China. *Journal of Geographical Sciences*, 29(10): 1713–1730.

Zhang F F, Zhao X Y. 2015. A review of ecological effect of peasant's livelihood transformation in China. *Acta Ecologica Sinica*, 35(10): 3157–3164. (in Chinese)

Zhang J Y, Wang L C. 2020. Analysis on small peasant household revitalization from the perspective of the rural revitalization strategy. *Human Geography*, 35(6): 66–75. (in Chinese)

Zhao A Z, Zhang A B, Liu H X, et al. 2017. Spatiotemporal variation of vegetation coverage before and after implementation of Grain for Green Project in the Loess Plateau. *Journal of Natural Resources*, 32(3): 449-460. (in Chinese)

Zhao X Y. 2017. Sustainable livelihoods research from the perspective of geography: The present status, questions and priority areas. *Geographical Research*, 36(10): 1859–1872. (in Chinese)

Zhao Y L, Zhang M, Li X B, et al. 2016. Farmland marginalization and policy implications in mountainous areas: A case study of Renhuai City, Guizhou. *Journal of Resources and Ecology*, 7(1): 61–67.

农户生计转型及其生态效应研究进展

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摘　要：农户生计及其对生态系统的影响是反映人地关系的重要表征。合理恰当的农户生计策略既能满足人类福祉需求，也能促进自然资源的可持续利用，进而维持自然生态系统的健康稳定。学术界围绕农户生计变化、驱动机制及其生态效应等方面开展了大量研究，但关于农户生计转型的生态效应还存在较多争议问题。本文在搜集梳理相关文献基础上，辨析了农户生计的转型机制及生态效应的已有研究成果，并进一步探究了两者之间的耦合关系，发现农户生计的选择受到自然因素、主观意愿和社会政策三方面影响，而农户生计的转型改变了生产、消费、资源利用方式，进而影响着自然生态系统演化过程。文章建立了农户生计转型机制及其生态效应研究框架，最后提出了未来需要深入研究的方向：（1）探究农户生计转型驱动因子之间的相互作用及其对农户生计选择产生影响；（2）结合农户生计转型的驱动因子和生态效应，提出农户生计需求和自然资源利用的双向可持续策略。

关键词：农户生计转型；转型特征；驱动机制；生态效应