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Farmers' preferences for sustainable farmland construction — Insights from a discrete choice experiment in China

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ABSTRACT

Sustainable farmland construction (SFC) is a priority development strategy used to address the integrated goals of "efficiency output, resource conservation, and environmental friendliness" in agricultural systems. Introducing farmer participation to optimize SFC institutions can improve farmland construction efficiency and address limited construction funding. This study analyzed farmer preferences for participating in SFC through a discrete choice experiment survey of farmers in the project area. This study also evaluated farmers' willingness to pay for different SFC schemes. The findings indicate that farmers prefer constructing mechanized production roads (MPR), leveling farmland and transforming the contiguous farmland (LF and CF), integrated irrigation and fertilizer facilities (IIFF), and moderate improvement in ecological protection facilities. On the basis of the heterogeneity of the farmer preferences, they can be classified as benefits-driven and ecology-driven. In addition, factors such as age, educational level, risk proneness, land transfer, and cultivated land quality can influence the classification of farmer preferences. Farmers' willingness to pay for MPR, LF and CF, ED, IIFF, and moderate improvement in ecological facilities has reached 50–80 % of construction costs, essentially bridging the investment gap under the SF standards set by the central government. Based on the aforementioned, SFC schemes should be designed to consider farmers' needs and regional development requirements. Allocating SF construction costs according to farmers' willingness to pay for various facilities, formulating diverse investment ratios, and forming a coherent government-farmer cooperation mode are recommended. This study introduces policy tools to establish a farmers' participation mechanism in farmland construction, offering valuable insights into institutional reforms in land consolidation projects across other developing countries.

1. Introduction

To achieve the United Nations Sustainable Development Goals, agricultural production systems face increased demands, including continually enhancing land productivity, promoting environmentally friendly production practices, and improving farmland ecology (FAO, 2022). Farmland construction is recognized as a priority strategy to bolster agricultural production efficiency and optimize resource utilization, with initiatives being implemented globally (Hao et al., 2023; Li et al., 2023). High-standard farmland (HSF) construction represents a distinctive land consolidation system in China. By 2020, 53 million ha of HSF had been constructed, resulting in a 10 %–20 % grain yield increase and cost-effectiveness of 7.5 thousand Chinese yuan (CNY) per ha. However, during this period, the construction objectives focused on

Abbreviations: SFC, Sustainable Farmland Construction; SF, Sustainable Farmland; HSF, High-standard Farmland; CNY, Chinese Yuan; CE, Choice Experiments; LF or CF, Level Farmland or Construct Contiguous Farmland; LF and CF, Level Farmland and Construct Contiguous Farmland; MPR, Mechanized Production Road; ED, Ecological Ditches; IIFF, Integrated Irrigation and Fertilizer Facilities.

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enhancing grain production capacity, with insufficient awareness regarding the sustainability of the production modes and the importance of farmland ecological preservation (MARA, 2021b). The issue is pervasive in land consolidation projects undertaken in developing nations (Do et al., 2023; Nguyen and Warr, 2020). Consequently, the latest farmland construction planning advocates for a sustainable farmland (SF) system, aiming for "efficient output, resource conservation, and environmental friendliness" (Yin et al., 2022; Zhou and Cao, 2020). SF requires constructing and renovating ecological infrastructures that align with sustainable production practices. SFC aims to further enhance comprehensive production capacity and quality benefits on grain, promote the transformation of agricultural production modes, improve the service functions of farmland ecosystem, and increase farmers' income (Wang, 2022).

A management institution is a crucial assurance for conducting farmland construction, with developed countries adopting modes wherein stakeholders collaboratively participate in formulating construction schemes and sharing costs (Jiang et al., 2022; Krupowicz et al., 2020). By contrast, China predominantly relies on government leadership, using a "top-down" management mode. The mode is limited by the lack of stakeholder participation, resulting in the failure of the construction infrastructures to align with actual needs and the dual challenges of idle and insufficient supply of infrastructures for agricultural production. Moreover, SFC requires an investment of 60–90 thousand CNY per ha, which poses a great financial burden to the government (CPPC, The National Committee of the Chinese People's Political Consultative Conferenc, 2021). Hence, there is an urgent need to optimize and innovate management institutions by integrating stakeholders' participation in construction. Farmers inherently benefit from the effectiveness of governance as a direct stakeholder in farmland utilization and management. Farmers should be vital in formulating farmland construction schemes and sharing costs. This study addresses the dilemma implemented in farmland construction by involving farmers' participation, thus overcoming the obstacles to agricultural sustainability transformation.

Shanxi and Shaanxi have issued the 2021–2030 Farmland Construction Plan, which proposes increasing construction standards and per-ha investment, broadening funding channels, and guiding diverse parties to participate in farmland construction. Meanwhile, the green farmland construction project in the Yellow River Basin was implemented in 2023. The region, designated as a project area, will establish green and climate-resilient agricultural production bases to enhance the agricultural system's sustainability (EPHQD, Ecological Protection and High Qulity Development in the Yellow River Basin, 2023). Research on farmers' preferences for participating in SFC can clarify the current status and demands of farmland development, and calculating the payment levels for farmers provides precise references for formulating stakeholder investment mechanisms.

Research related to farmland construction focuses on the relationship between farmland water conservancy facilities and production (Bhavsar et al., 2023), the entities investing in facility construction (Jie, 2022; Simango et al., 2021), and farmers' participation and investment willingness (Akrofi et al., 2019). Theoretical analysis methods such as Planned Behavior Theory, Symbiosis Theory, and Public Goods Theory are widely used in such studies (Li et al., 2021; Yin et al., 2022). Empirical analysis commonly adopts sampling surveys to establish econometric models, with structural equation models and binary discrete choice models being frequently used. Recently, choice experiments (CE) have been used in farmers' behavioral preferences, focusing on farmers' participation in innovative production technology (Aravindakshan et al., 2021; Schaafsma et al., 2019), ecological compensation (Nong et al., 2021; Ureta et al., 2021), ecosystem improvement (Wang et al., 2021), and policy design (Caputo and Lusk, 2022). Existing research provides essential insights into logical frameworks, theories, and analytical methods for this study. However, farmland construction is often project-based, with construction activities integrating multiple categories of facilities. Previous studies focused on a single infrastructure, limiting their practical contributions. Regarding research on farmers' participation in farmland construction, the emphasis is on exploring willingness rather than payment levels. This study examines farmers' needs and payment levels for all infrastructures related to SF, providing a more systematic and operationally robust basis for developing a participation mechanism. In terms of research methods, traditional willingness surveys lack a measure of payment levels under specific farmland construction standards. By contrast, CE can more accurately examine farmers' preferences and quantify the willingness.

This study aimed to understand the construction preference and the payment level of farmers who participate in SF and the variation of preference in relation to individual characteristics and farmland conditions. In a discrete choice experiment, we elicited farmers' preferences for a program that combines infrastructure and ecology improvement on farmland, supported by a conditional payment to avoid the arbitrary selection of farmers. First, this study discusses farmers' preferences, clarifying the development needs of farmland construction to provide a reasonable reference for regional SFC schemes. Second, it explores the heterogeneity of farmers' preferences, elucidating the intrinsic relationship between farmers' endowments and preferences to provide guidance for formulating differentiated participation pathways for farmers. Finally, it accurately measures the payment level of farmers, quantifies the intensity of farmers' willingness, and provides a more targeted basis for a cost-sharing mechanism. Overall, this study is of significant importance in optimizing farmland construction management institutions and improving construction efficiency by clarifying how farmers participate in farmland construction in terms of pathways, schemes, and standards.

The remainder of this paper is structured as follows. Section 2 presents the material and methods of this paper, including the selection of the study area, the establishment of the research framework based on a literature review, the proposal of the research hypotheses, the design of the choice experiment, and the descriptions of the data collection and econometric models. Section 3 provides the results of this study, and Section 4 discusses the findings and policy implications. The conclusions and limitations are provided in Section 5.

2. Material and methods

This section delineates the rationale behind the selection of the research area, constructs a comprehensive theoretical framework for this study, and proposes corresponding hypotheses. In addition, it explores the experimental design and data collection, presenting the methods utilized, such as the mixed logit model and latent class model.

2.1. Study area

This study was conducted in a major area of agricultural production at Shanxi and Shaanxi provinces (Fig. 1), which is in the Yellow River Basin in China. Shanxi and Shaanxi provinces, representative of the Loess Plateau region, constitute 4 % of the national cultivated land and contribute 5 % to the national grain production, playing a crucial role in ensuring food security (CNBS, National Bureau of Statistics of China, 2023). As of 2020, 2.05 million ha of HSF in the region has been successfully constructed, significantly improving production conditions. However, because of inconsistent construction standards and low investments, the HSF varies. Moreover, the completed HSF only represents approximately 30 % of the region's total cultivated land, with most of the farmland still facing issues such as a weak infrastructure, inadequate infrastructure support, declining production efficiency, and severe soil erosion in regions. There needs to be proper protective measures for farmland, and previous construction projects showed insufficient attention to farmland ecology, making them incompatible with sustainable agricultural production modes. To address current challenges in farmland construction and bottlenecks in agricultural sustainability,

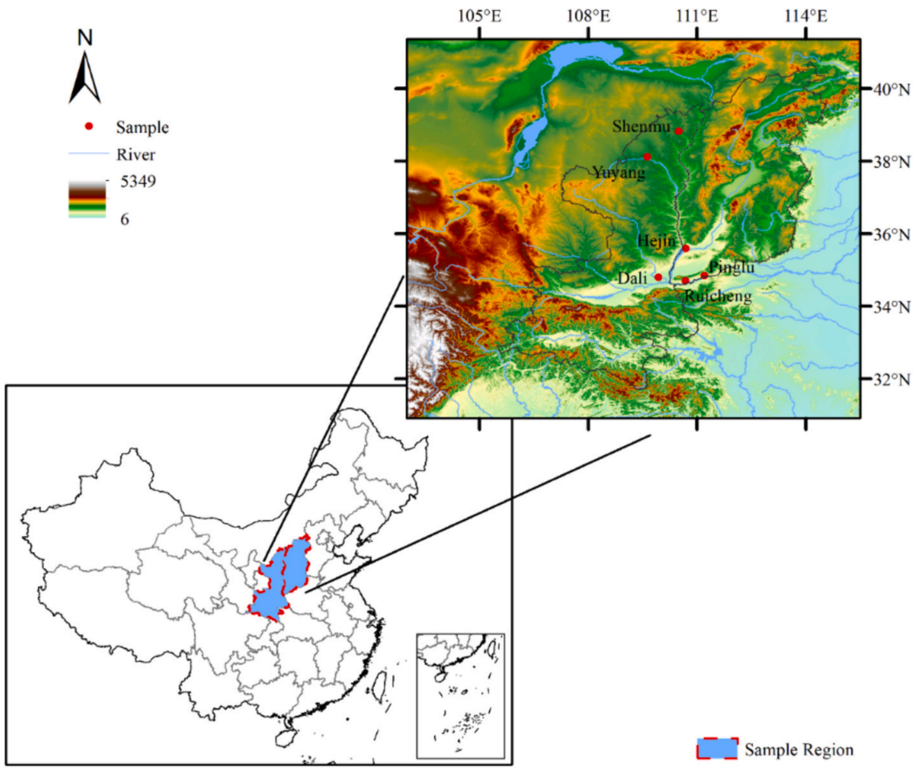

Fig. 1. Study area.

Shanxi and Shaanxi have taken the lead in establishing demonstration zones for sustainable farmland. Meanwhile, policies pertaining to these demonstration zones propose the exploration of a management system that can ensure the long-term development of SFC. This study's inception effectively responds to practical demands.

2.2. Theoretical framework and hypothesis

The core of SFC lies in enhancing farmland infrastructures and ecology, falling under the category of public goods provision. Public goods are characterized by non-excludability and non-rivalrous consumption. However, most public goods do not fully meet these criteria, existing as "quasi-public goods." Farmland, irrigation facilities, field roads, and ecological facilities, for instance, be classified as quasi-public goods (Wang and Liu, 2019; Wang et al., 2021). The usage of these infrastructures is confined to specific regions and limited to farmers within regions. To maximize benefits, farmers can invest in and construct quasi-public goods. The framework theoretically supports the farmer's participation mechanism for SFC.

On the basis of assumption of rational actors in neoclassical economics, farmers, as decision-makers, choose action schemes that maximize their utility within constraints. In selecting specific farmland construction alternatives, farmers exhibit different preferences according to the actual needs of farming, which is a decision made after weighing expected benefits and costs. The direct effect of farmland construction on increasing grain yield and its positive impact on changing production modes to enhance resource utilization efficiency have been verified in academia and recognized by farmers (Li et al., 2023; Li et al., 2024). Flat and large-area farmland and field roads provide necessary conditions for mechanized farming, which is an essential measure to improve production efficiency and save labor (Hao et al., 2024). In addition, IIFF can achieve a 20–30 % reduction in water and fertilizer. Consequently, the following hypothesis is proposed:

Hypothesis 1. Farmers prefer field production roads, land leveling and contiguous transformation, and IIFF.

Previous studies have found differences in farmers' attitudes toward participating in activities related to ecological improvement. The promotion of farmland's ecological enhancement has significantly affected agriculture. Farmers' awareness of ecological conservation has been heightened. Some farmers believe that improving farmland's ecology can enhance their living and production environment and demonstrate a sense of social responsibility (Maleksaeidi and Keshavarz, 2019; Tama et al., 2021). The long-term benefits of such improvements will positively affect future generations. However, some farmers may not be actively involved in such activities because of the solid positive externalities of farmland ecological improvement, from which they cannot directly benefit economically (Yin et al., 2022). The following hypothesis is proposed:

Hypothesis 2. Farmers exhibit differences in their choices regarding ecological conservation facilities.

Farmers exhibit diverse preferences, primarily influenced by the constraints that they encounter, rather than being attributed to their "irrationality" or "bounded rationality." These constraints depend on various factors. Household income not only determines whether farmers engage in infrastructure construction but also dictates the level and manner of their participation (Khan et al., 2022). Farmers' age reflects their physical condition and farming experience, impacting their decision-making in infrastructure construction (Villamayor-Tomas et al., 2019). The educational level of individuals correlates with their comprehension knowledge of infrastructures in production (Li et al., 2023). Higher educational levels generally enhance farmers' willingness to participate in agricultural activities. However, higher education levels may also lead decision-makers to engage in non-agricultural activities, potentially reducing their inclination toward infrastructure construction. Participation in SFC is an investment behavior influenced by farmers' risk propensity, aversion to risk, and ability to identify risks (Aravindakshan et al., 2021). Land is a crucial input in agricultural production, that affects farmers' decision-making and willingness (Fig. 2). According to behavioral economics theory, individuals'

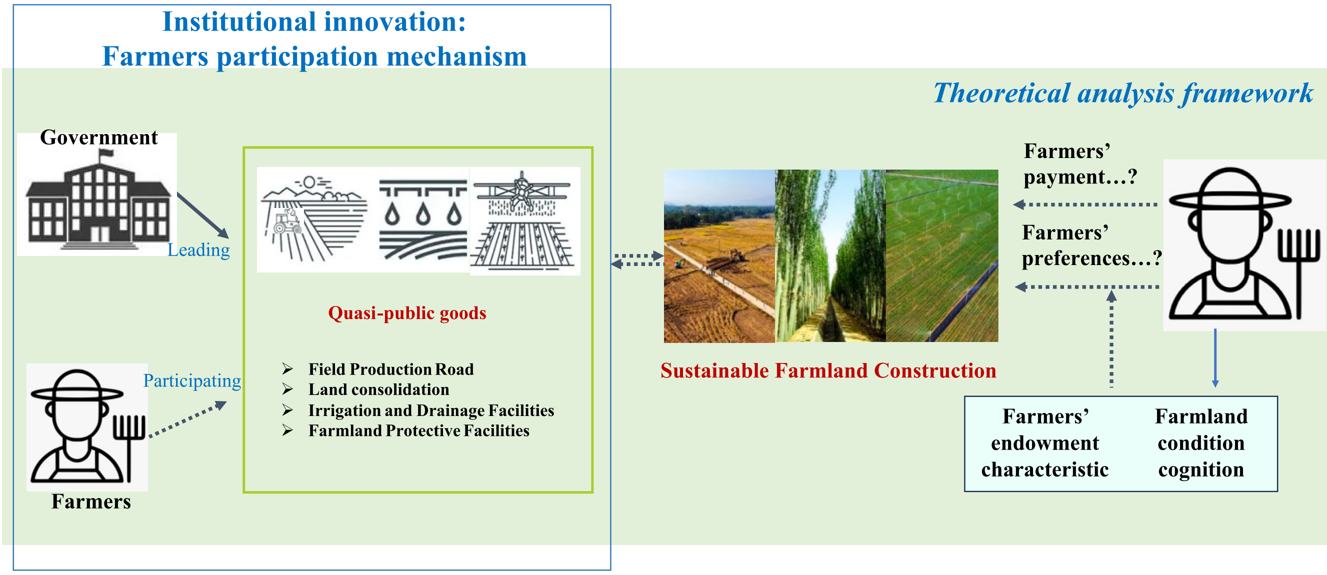

Fig. 2. Theoretical framework.

preferences and willingness are affected by their awareness of relevant factors (Luu, 2020). Farmers' willingness to participate in farmland construction also depends on their cognition of relevant facilities. Thus, a hypothesis is proposed:

Hypothesis 3. The heterogeneity of farmers' preference is influenced by their endowments and perception of farmland conditions.

2.3. Choice experimental design and data collection

2.3.1. Attributes and level configuration

The selection and design of assessment attributes and their levels are crucial for the successful implementation of CE. Therefore, this study follows the principles of selecting attributes based on infrastructure construction categories under SF standards. It ensures that the chosen attributes are intuitive and easy for farmers to compare in different choice sets. In addition, it guarantees that the attributes are relevant to SF policies and reflect the attributes of urgently needed construction categories. To design the assessment attributes and level values, the research team conducted preliminary investigations scientifically and rationally before the questionnaire design. In June to July 2021, on-site surveys of the status of farmland construction in Shanxi and Shaanxi were conducted, and interviews were conducted with local agricultural management departments, village committees, and farmers to understand the needs for farmland construction. From September 2021 to September 2022, team members visited the Yellow River Basin in batches, conducting field surveys on the current state of farmland and infrastructure construction in multiple project areas and non-project areas on SFC. Building on the preliminary survey, the basic status of farmland construction was identified. The research team designed the experimental booklet and CE questionnaire through literature review and focus group interviews. Subsequently, in July 2022, the research team conducted a simulation experiment and in-depth interviews with 44 farmers. Experimental attributes and survey data were adjusted and quantitatively analyzed, ultimately finalizing four construction evaluation attributes and one monetary attribute for SF, as shown in Table 1.

A method combining stratified and random sampling was used in the field survey, following the hierarchy of 'county-township-natural village-farmer.' Considering factors such as each county's economic development, population proportion, and transportation conditions, three townships were selected from each county, with three to five natural villages chosen from each township. A random sample of 10–15 households was surveyed in each natural village, totaling 608 farmers.

Table 1
Attributes and level descriptions.

Attributes	Attribute levels		
Field production road	Maintaining status quo	To construct the mechanized production road (MPR)	
Land consolidation	Maintaining status quo	To level the farmland or construct the contiguous farmland (LF or CF)	To level the farmland and construct the contiguous farmland (LF and CF)
Irrigation facility	Maintaining status quo	To construct ecological ditches (ED)	To construct integrated irrigation and fertilization facilities (IIFF)
Ecological facility improvement on Farmland[a]	Maintaining status quo	Moderately improved	Highly improved
Costs per household (CNY/0.0667ha)	0	400 600	1000

[a] Biological habitat, ecological corridor, protective forest.

The survey included a dual evaluation by farmers and researchers on the questionnaire understanding and completion attitude of participating households in the experiment. After excluding 35 invalid questionnaires, the final dataset comprised 573 valid questionnaires (308 from Shanxi, 265 from Shaanxi), with 4620 valid observations in Shanxi and 3975 in Shaanxi.

2.3.1.1. Field production road. Field roads are crucial agricultural, infrastructures that significantly increase the mechanization rate and promote modern agricultural production (Gebresilasse, 2023; Shamdasani, 2021). "Field production road" generally refers to machine plowing roads and production roads. Through on-site investigations, substantial variations were observed in the current configuration of field production roads. Overall, 70 % of surveyed farmland in the region requires construction or improvement of field production road. It is noteworthy that farmland engaged in large-scale cultivation has mostly optimized field road, meeting the demands of mechanized operations. In the new round of HSF construction planning, it is proposed to rationally scheme and construct field road networks, prioritizing the transformation and utilization of existing roads. The plan stipulates that field roads in plain areas should be short, straight, and smooth, and those in mountainous and hilly areas should follow the terrain. It also emphasizes the construction of bridges and culverts, meeting the requirements for agricultural production such as machinery operations and transport of agricultural inputs. Given the configuration and construction standards of field production roads, this study sets two levels for this attribute: “Maintaining the status quo” and “MPR.”

2.3.1.2. Land consolidation. Land consolidation generally involves two types of activities: LF and CF. LF ensures the thickness of the arable layer through measures such as backfilling with topsoil and excavating elevated areas to fill low-lying areas, improving field drainage and cultivation conditions. The core of CF is to reorganize and adjust scattered, fragmented, small plots of farmland to create contiguous, orderly, and large plots, facilitating more efficient and intensive farmland management, enabling large-scale farming, and promoting mechanized production. Land consolidation aims to enhance land utilization and ensure sustainable resource utilization (Hao et al., 2023). Simultaneously, it aims to improve the ecological environment of the farmland, reduce soil erosion, and prevent land degradation. The study area urgently needs land consolidation, considering varied demands across different regions. This study sets three levels for the land consolidation attribute: “Maintaining status quo”, “LF or CF”, “LF and CF.”

2.3.1.3. Irrigation facility. Water conservancy facilities are a crucial guarantee for agricultural production. Traditional irrigation and drainage facilities, mostly open ditches, result in large water volumes, leading to low irrigation water utilization rates. In addition, high water pressure in open ditches causes uneven irrigation and issues such as fertilizer loss (Zhu et al., 2023). Open ditches neglect their ecological functions, causing damage to the habitat and landscape for channel organisms and a significant decline in biodiversity. Farmland construction emphasizes coordinating irrigation zone productivity and the ecological environment in the new era. There is a greater focus on strengthening the construction of on-farm irrigation and drainage facilities, promoting efficient water-saving irrigation, increasing effective irrigated areas, and improving water use efficiency (Xiong et al., 2023). Ecological ditches and IIFF are widely promoted and used. Ecological ditches primarily enhance channel water conveyance efficiency, reduce slope erosion, and create an environment that supports biological survival and growth, fostering biodiversity. IIFF, including drip and spray irrigation, are water-saving irrigation systems that allow precise water and fertilizer application based on crop needs. These facilities are crucial for improving irrigation water use efficiency and fertilizer utilization rates. This study defines the irrigation facility attribute using three levels: “Maintaining status quo”, “ED”, “IIFF”.

2.3.1.4. Ecological facility improvement on farmland. Biological habitats, ecological corridors, and protective forests enhance farmland ecology. Their functions include improving microclimates, mitigating, and defending against natural agricultural disasters, creating environments conducive to crop and field biological growth, and enhancing farmland ecological services. Farmland ecological improvement projects have strong public benefits, but agricultural producers may not fully recognize these benefits. This study investigates farmers’ support level for farmland ecological improvement actions. Simultaneously, it focuses on discussing facility construction needs under SF standards. The attribute is set as “Maintaining status quo” “Moderately improved” “Highly improved.”

2.3.1.5. Costs per household. In this study, the term “monetary attribute” refers to the amount that households are willing to pay when selecting a specific attribute combination from the choice sets. To determine the specific amounts for the monetary attribute, the contingent valuation method was primarily used during the presurvey to investigate the respondents’ willingness to pay for the SFC. The most frequently occurring amounts of 400, 600, and 1000 CNY per household were selected as the monetary attribute.

2.3.2. Orthogonal experiment and questionnaire design

The questionnaire design involves an orthogonal experiment to create intuitive alternatives with different levels of attribute combinations. These alternatives are then grouped into choice sets, which are further combined to form experimental questionnaires. In this study, each CE questionnaire provides respondents with five choice sets (i.e., each respondent completes five independent CEs) and each choice set includes three alternatives. Fig. 3 illustrates a choice set, where “alternative 3” represents no intervention, and “alternative 1” and “alternative 2” represent different degrees of intervention.

Table 1 outlines the attributes and levels for SFC. Representative choice sets need to be selected with 216 possible alternatives (2 * 3 * 3 * 3 * 4 = 216) and 23,220 potential choice sets ($C_{216}^{2} = 23{,}220$). This study used an orthogonal experimental design and obtained 10 alternatives and 45 choice sets after eliminating unreasonable options. Furthermore, an expert panel was organized to examine the rationality of each choice set. Adjustments were made to the choice sets with dominant strategies, resulting in the final selection of 15 choice sets divided into 3 versions. One version of the questionnaire was randomly selected for questioning.

2.4. Methodology

By assuming that farmers have different choices for SFC schemes to achieve their utility maximization, we adopt a random utility model, specifically the mixed logit model, which is an extension of the standard conditional logit model (McFadden, 1974). This model accommodates unobservable preference heterogeneity among respondents by allowing coefficients to vary across decision-makers. In addition, the model avoids assuming independence of irrelevant alternatives.

On the basis of the random utility model, the utility a farmer *i* derives from alternative *j* is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \tag{1}$$

where V_{ij} represents the utility of farmers i participating in the experiment, based on observable characteristics, in choosing alternative j and ε_{ij} is a random error term. Step 1: The mixed logit choice probability of choosing alternative j is given by

$$P_{ij} = \int \frac{exp(X_{ij}\beta_j)}{\sum_{j=1}^{J} exp(X_{ij}\beta_j)} f\left(\beta_j|\theta\right) d\beta_j, \tag{2}$$

where X_{ij} is the experimental attribute variable for farmers i choosing alternative j, as shown in Table 1. β_j is the corresponding estimated coefficient, and $f\left(\beta_j|\theta\right)$ is the probability density function for β_j, assumed to follow a certain distribution (Train, 2009), such as normal, uniform, and triangular distributions. In this study, we assume a normal distribution for $f\left(\beta_j|\theta\right)$, with θ being the vector of estimated parameters for this density function, such as the mean and variance in the case of a normal distribution. In the mixed logit model, β_j is a random variable, that can be expressed as follows:

$$\beta_j = \beta_k + \overline{\omega}_k, \tag{3}$$

where β_k is the coefficient for the random utility variable, assumed to be a fixed value, and $\overline{\omega}_k$ is the random disturbance term. β_k and $\overline{\omega}_k$ can be considered the mean and variance of this normal distribution. Therefore, the observable utility function V_{ij} can be expressed in a simple linear form:

$$V_{ij} = (\beta_k + \overline{\omega}_k)X_{ij} + \varepsilon_{ij}. \tag{4}$$

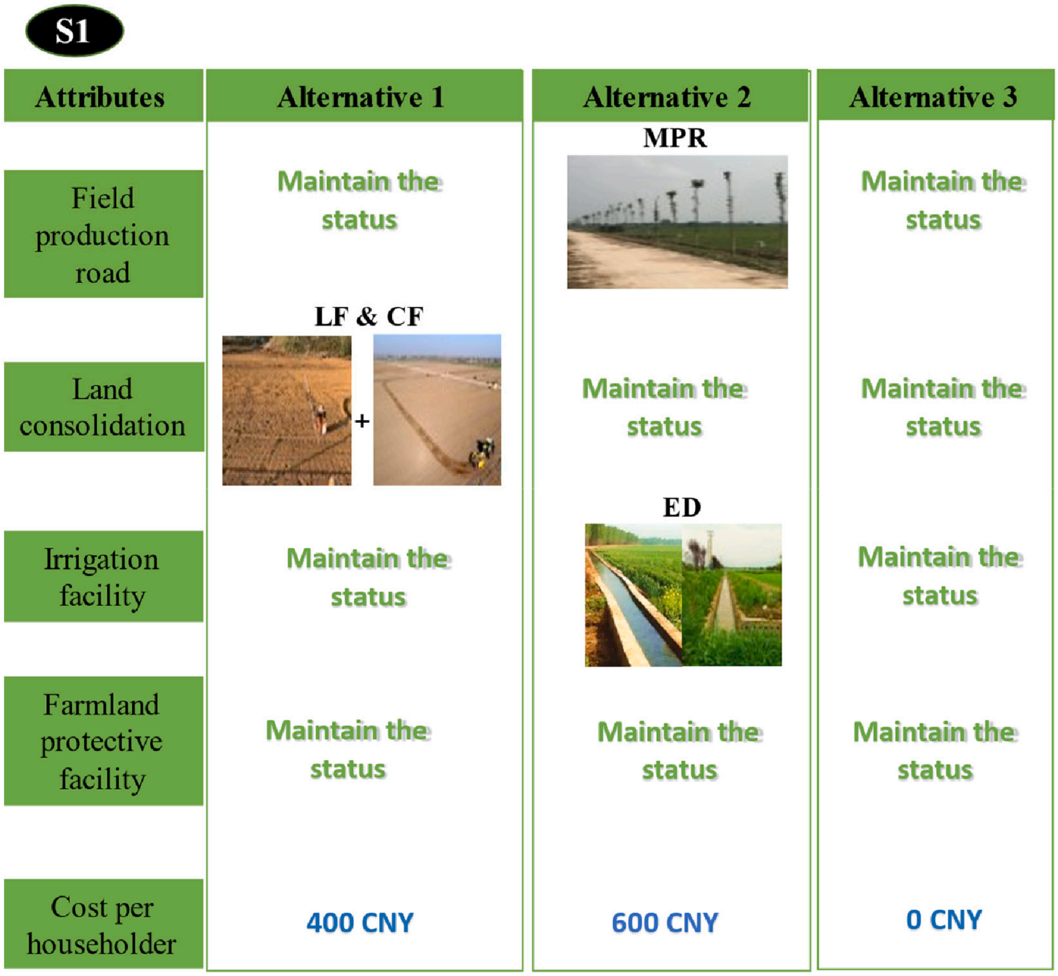

Fig. 3. Choice set example.

Step 2: To examine the impact of heterogeneity among farmers on their choice preferences, this study introduces a latent class model. The respondents' choice preferences are divided into different classes $c(c - 1, \ldots, C)$ to capture preference heterogeneity, with preference coefficients a_c for class c. Preferences within the same class of farmers are homogeneous, but preferences among farmers from different classes are heterogeneous. This model can uncover some patterns in the heterogeneity of farmers' preferences. By assuming that respondent n belongs to class c, the probability of choosing option j^* from choice set t (out of T choice sets) is as follows (Colombo et al., 2009; Greene and Hensher, 2003):

$$prob(i, j^*, t|c) = \prod_{t=1}^{T} \frac{e^{\alpha_c x_{ij^*t}}}{\sum_{j=1}^{J} e^{\alpha_c x_{ijt}}}, \tag{5}$$

The models are estimated by maximum simulated likelihood using 1000 Halton draws (Hole, 2007). We estimate uncorrelated coefficients using dummy coding (Hensher et al., 2005).

Step 3: Willingness to payment (WTP) on SFC by farmers

The WTP estimate, which is the ratio between the coefficient for each attribute and the price coefficient. The marginal WTP for attribute x is as follows:

$$\widehat{wtp} = -\frac{\widehat{\beta_x}}{\widehat{\beta_p}}, \tag{6}$$

The standard approach in Eq. (6), which is also referred to as a WTP in preference space, is obtained from procedures based on the mixed logit model (Train and Weeks, 2005).

3. Results

This section presents the key findings of this study. It begins with the descriptive statistics of the samples, followed by base model results illustrating farmers' preferences for SFC. Moreover, it explores the heterogeneity in farmer preferences using latent class model. Furthermore, the Willingness to Pay (WTP) of farmers' participation in SFC is estimated.

3.1. Descriptive statistics

In the empirical analysis of the mixed logit model, two types of variables are included: the CE attribute and socioeconomic information of participating households. The information encompasses individual characteristics, household features, and perceptions of current farmland conditions, as shown in Table 2.

In the survey sample, 80 % are male, with an average age of 55 years or above and an average education duration of approximately 8.8 years. In studies examining farmers' decision-making regarding participation in agricultural activities, most participants are male (Fischer and Wollni, 2018; Kragt et al., 2023; Zemo and Termansen, 2018; Zhang and Paudel, 2019). It is attributed to males serving as the primary labor force in households, affording them a more profound understanding on agricultural production and associated tasks. Field surveys corroborated that some female participants faced challenges in assessing infrastructure development needs. By contrast, male participants displayed a more systematic grasp of rational construction schemes and cost

Table 2
Descriptive statistics.

Variable	Definition	Shanxi				Shaanxi			
		Max	Min	Mean	SD	Max	Min	Mean	SD
Gender	Male = 1, Female = 0	1	0	0.838	0.369	1	0	0.868	0.339
Age	Age of Respondents	79	31	58.653	9.929	79	30	57.325	10.960
Educational level	Educational Experience for Respondents (Year)	16	0	9.141	2.527	15	0	8.445	2.761
Occupation	Part-time farmer = 1, Professional Farmer = 0	1	0	0.201	0.401	1	0	0.362	0.481
Risk proneness	1–6 Risk propensity increases gradually	6	1	2.516	2.006	6	1	2.298	1.855
Number of labors	Average number of labors per household	5	1	3. 41	1.831	6	1	3.84	2.418
Land transfer	Yes = 1, No = 0	1	0	0.396	0.489	1	0	0.551	0.497
Household income (CNY/a)	Annual household Net income (10 thousand CNY)	15	1.7	6.091	2.427	10	0.035	0.835	1.250
Cultivated land quality satisfaction	Strongly dissatisfied (1)–Strongly satisfied (5)	5	1	4.052	0.938	5	1	4.011	0.813
Degree of well-equipped on farmland infrastructure[a]	Strongly unequipped (1)–Strongly well-equipped (5)	5	1	3.055	1.041	5	1	3.192	0.863

[a] Ditches, roads, water, electricity.

considerations, facilitating more comprehensive and logical decision-making. The aging population and lower educational attainment among rural laborers are acknowledged realities in China, consistent with findings from similar research. Approximately 80 % of the Shanxi region's sample comprises professional farmers, while it is around 60 % in Shaanxi. By 2022, China's rural population is approximately 1.05 billion, accounting for 75 % of the total population, with roughly 800 million engaged in agricultural cultivation (CNBS, National Bureau of Statistics of China, 2023). Therefore, the high proportion of professional farmers observed aligns with the reality in China. There is a significant disparity in participating households' average annual household income, with Shanxi averaging approximately 60 thousand CNY/a and Shaanxi at 10 thousand CNY/a. In 2022, rural residents' per capita disposable income was 18 thousand CNY per annum, with an average household size ranging from three to five individuals (CNBS, National Bureau of Statistics of China, 2023). Therefore, the average household income level in the surveyed area is generally consistent with the national average. The risk propensity of the respondents indicates a predominantly risk-averse orientation. There is a notable difference in land transfer, with 55 % of households in Shaanxi engaging in land transfer compared with approximately 40 % in Shanxi. Land transfer policies are actively promoted to expand agricultural operations and increase land productivity through centralized production. It also reflects that the farmers can exercise their land use rights and contracting rights flexibly according to their needs, enabling them to expand or relinquish agricultural operations more dynamically (MARA, 2021a). In addition, the current farmland conditions are similar in the two regions, and respondents perceive land quality and facility adequacy at an average to above-average level.

3.2. Estimations of the basic model

In the mixed logit model, the significance and direction of the coefficient signify farmers' preferences for attributes within the SFC scheme. Positive coefficients denote a preference for such infrastructure construction among farmers, whereas negative coefficients suggest a

Table 3
Mixed logit results (model 1).

Variable	Shanxi				Shaanxi			
	Coef. Mean		S.D. Mean		Coef. Mean		S.D. Mean	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
MPR	0.978**	0.461	1.852***	0.250	0.568	0.401	2.097***	0.233
LF or CF	−0.114	0.487	2.414***	0.503	0.336	0.389	1.659***	0.409
LF and CF	1.004**	0.453	1.146***	0.358	0.846**	0.411	1.289***	0.282
ED	0.609	0.348	3.226***	0.488	0.516	0.289	2.381***	0.407
IIFF	1.609***	0.463	−3.002***	0.706	1.103***	0.365	2.23***	0.524
Moderately improved	0.742***	0.381	0.848**	0.454	0.504**	0.366	1.816***	0.531
Highly Improved	−0.268*	0.364	2.499***	0.465	−0.525*	0.259	1.438***	0.334
Costs per household	−0.002**	0.001			−0.002***	0.001		
asc	−7.21***	2.127			−6.275***	1.503		
asc_Gender	0.610	0.499			1.592	0.532		
asc_Age	0.018	0.022			0.051	0.017		
asc_Educational level	0.231***	0.078			0.186**	0.043		
asc_Occupation	0.295	0.462			−0.041	0.312		
asc_Risk proneness	−0.479**	0.212			−0.465**	0.210		
asc_Number of labors	0.040	0.231			0.36	0.190		
asc_Income	0.027	0.072			−0.011	0.094		
asc_Land transfer	0.837***	0.199			0.237**	0.181		
asc_Cultivated land quality satisfaction	0.411	0.381			0.329	0.323		
asc_Degree of well-equipped on farmland	−0.365**	0.167			−0.328	0.151		
Log likelihood	−680.851				−817.053			
Pseudo R^2	0.22				0.24			
Prob > chi^2	0.000				0.000			
$chi^2(12)$	200.060				212.970			

Note: costs per household 0 was used to model the third option (no participation), no improvements were used for the other attributes (maintaining status quo)
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

lack of preference for farmers (Haider, 2007; Jia and Zhao, 2021). The regression results are presented in Table 3.

For Shanxi, the result indicates heterogeneity of farmers' preferences for "MPR," "LF and CF," "IIFF," "moderately improved," and "highly improved" variables. In contrast, it suggests that farmers exhibit heterogeneity for "LF and CF," "IIFF," "moderately improved," and "highly improved" variables in Shaanxi.

The results confirm the validity of Hypothesis 1. When the farmers' preferences for each attribute variable are analyzed, the following patterns are evident:

Production road preference: The coefficient for the preference toward MPR in Shanxi is significantly positive. Compared with maintaining the status quo, engaging in MPR enhances the participation utility for farmers.

Land consolidation preference: The coefficient for the preference toward the combination of LF and CF transformation is significantly positive in both regions, and LF or CF alone is insignificant. It implies a pronounced demand among farmers for the combined transformation of LF and CF improvements.

Irrigation facility preference: The coefficient for the preference toward IIFF is significantly positive in both regions. Conversely, the improvement of ED is not significant, indicating a substantial demand among farmers for IIFF. The efficacy of ED primarily lies in environmental optimization and in mitigating non-point source pollution. However, its impact on enhancing resource utilization efficiency and output is less significant than that of IIFF's (Hadizadeh et al., 2018).

Farmland protection facility preference: The coefficient for the moderately improved attribute is significantly positive, and the coefficient for the highly improved attribute is significantly negative in both regions. It suggests that farmers prefer farmland protection facilities in the order of moderately improved, maintaining the status quo, and highly improved.

The estimated results for **costs per household** in both regions are significantly negative. This implies that participating farmers tend to contribute by paying lower expenses for SFC, to achieve improvements in agricultural production conditions.

In addition, the estimated results of the farmer characteristics suggest that individuals with higher levels of education, currently involved in land transfer activities and confronting inadequate infrastructure exhibit enthusiasm for participating in SFC. The influence of educational level has been widely validated in studies on farmer participation in agricultural activities (Wąs et al., 2021; Zulfiqar et al., 2021). Consequently, it is evident that the attributes of SFC significantly influence farmers' preferences and exhibit heterogeneity. Furthermore, attribute variables are crucial factors influencing farmers' participation compared with farmer characteristic variables.

3.3. Estimations of the latent class model

The latent class model can further identify respondents' preference heterogeneity and can categorize households with similar preferences into the same class. On the basis of the mixed logit model results, the findings in the Shanxi and Shaanxi provinces were broadly consistent, allowing a joint modeling approach to analyze farmer preference heterogeneity. The optimal classification structure for the latent class model must be determined in advance, typically based on the AIC and BIC criteria. By calculating, it was found that when farmers were divided into two classes, the AIC and BIC achieved the minimum estimates.

Class 1 farmers account for 57.6 % of the total respondents, and Class 2 farmers account for 42.4 % (Table 4). The average probability of the two classes of farmers has a small gap, with percentages of 49.6 % and 41.2 %, respectively. The participation rates of both classes of farmers in this study are relatively high, and there are no instances of meager participation rates or resistance to participation compared with similar studies (Permadi et al., 2017; Schulz et al., 2014).

Farmers' preferences for SFC schemes vary by class. MPR, LF, CF, and IIFF significantly positively affect participation for Class 1 farmers, and highly improved and costs per household negatively impact their participation. For Class 2 farmers, ED, IIFF, and moderately improved significantly positively affect participation, and costs per household have a negative effect. It indicates that Class 1 farmers prefer infrastructures that enhance agricultural efficiency and benefits, while Class 2 farmers are more concerned regarding resource-saving facilities and farmland ecological construction. These results confirm the validity of Hypothesis 2.

The latent class model also estimated the impact of the farmer characteristic variables on farmer participation in SFC schemes. The results indicate that compared with Class 2 farmers, older age, lower educational level, risk-averse individuals, engagement in land transfer activities, and better-cultivated land quality make farmers more likely to be classified into Class 1. This result supports Hypothesis 3.

Table 4
Latent class model results (model 2).

	Class 1		Class 2	
	Coef.	S.E.	Coef.	S.E.
MPR	0.343**	0.637	0.365	0.315
LF or CF	0.070	0.785	−0.016	0.260
LF and CF	0.481**	0.714	0.230	0.286
ED	−0.497	0.562	0.966*	0.149
IIFF	0.916**	0.401	1.092**	0.390
Moderately improved	−0.724	0.730	0.413**	0.293
Highly improved	−0.802*	0.413	−0.451	0.171
Costs per household	−0.001**	0.001	−0.002***	0.000
asc	−2.524***	0.741	1.491***	0.481
Gender	−0.636	0.334		
Age	0.027**	0.013		
Educational level	0.165**	0.042		
Occupation	0.165	0.272		
Risk proneness	−0.103**	0.157		
Number of labors	−0.085	0.164		
Income	0.004	0.039		
Land transfer	0.231**	0.250		
Cultivated land quality satisfaction	0.393***	0.135		
Degree of well-equipped on farmland	−0.173	0.121		
cons	3.727***	1.119		
Percentage of various categories of farmers	0.576 0.484		0.424 0.496	
Log likelihood	−817.053			
AIC	2698.956			
BIC	2888.529			

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

3.4. WTP estimates

This study calculates payment levels based on specific attributes. Farmers' payment levels for MPR, LF and CF, ED, IIFF, and moderately improved are 353, 431, 339, 847, and 99 CNY/ha, respectively

Table 5
WTP results.

	WTP	95 % confidence interval	
MPR	353.294**	49.420	657.168
LF or CF	201.059*	−124.061	526.179
LF and CF	431.198**	121.356	741.040
ED	339.05**	61.852	616.247
IIFF	847.221**	494.776	1199.665
Moderately improved	99.08**	34.912	563.248
Highly improved	−58.36***	−307.049	190.329

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

(Table 5). This result reflects high willingness among farmers to participate in SFC. However, related research has shown a discrepancy between farmers' willingness and behavior in participating in public goods supply and environmental governance (ElHaffar et al., 2020; Li et al., 2021). This requires achieving benefit goals through social networks and long-term trust norms (Le Coent et al., 2021). In other words, farmers' investment mechanisms rely on formal institutional arrangements and informal community institutions to achieve cost-sharing among farmers, encourage cooperative behavior, and constrain opportunistic behavior.

4. Discussions and implications

SFC is a strategic measure aligned with the objectives of modern agricultural development, playing a crucial role in leading the sustainable transformation of agricultural systems. Studies have indicated a disconnect between previous farmland construction schemes and actual needs, with high rates of redundant post construction modifications limiting the enhancement of diverse benefits in "production, ecology, and livelihood" (Bao and Feng, 2021b; Zheng et al., 2023). In addition, the effective supply of farmland construction has been consistently constrained by difficulties in financing. Even with the latest standards, which have raised the investment to 45 thousand CNY/ha in many areas, it still falls short of meeting the expectations for SF (Shuai et al., 2023). Hence, farmers' willingness to participate in farmland construction should be prioritized in SF management to maximize the expected efficiency of farmland improvement. Insufficient construction funds and limited facility supplies can be better resolved by attracting stakeholders. Using the CE and considering specific alternatives of SFC, this study delves into farmers' preference and the sources of their heterogeneity. In this study, farmers' participation levels are quantified based on SF benefit goals and a regional farmer participation institution encompassing the "pre-construction scheme" and "construction investment" is proposed. The findings can help in the formulation of policies for other stakeholders participating in farmland construction and can guide the government for future decision making.

4.1. Preference for farmer participation in SF

On the basis of the facility attribute analysis, farmers exhibit a more urgent demand for the MPR in Shanxi. Through the survey, it is evident that agricultural authorities prioritize mechanized operations to enhance productivity, with widespread coverage and a rich variety of machinery provided by agricultural machinery cooperatives. It may contribute to increased awareness among farmers regarding the benefits of MPR. Concerning land consolidation, farmers in both regions show a significant demand for dual treatment involving LF and CF. In reality, most areas in the Yellow River Basin exhibit fragmented farmland patterns, and the topography of the hills and mountains leads to widespread uneven land, hindering convenience in agricultural production (Liang et al., 2021; Lu et al., 2022; Zhou et al., 2022). Regarding irrigation facility, both regions exhibit a significant preference among farmers for IIFF compared with ED construction. It may be because ED's primary functions focus on ecological benefits such as preventing soil erosion and agricultural non-point source pollution, while providing limited assistance in enhancing production income. IIFFs, known for their water-saving and fertilization effects that lead to increased yield and quality, have gained widespread recognition (Chen et al., 2022; Zhou et al., 2020; Zhuang et al., 2019). Operating entities engaged in large-scale planting have already begun independently adopting such facilities (Cai and Du, 2016; Lang et al., 2021). Farmers face difficulties in independent transformation due to small planting areas, scattered plots, and limited capital endowment. Under the unified management of SFC by the government, farmers have found new opportunities to use IIFF. Farmers' preferences for ecological protection facility are ranked as moderate improvement, maintaining the status quo, and high-level improvement. Such facilities are more public-spirited, benefiting farmers mainly through improved environmental perception and the demonstration of social responsibility (Chen et al., 2022; Xia and Yang, 2022). This indicates that although farmers are ecologically aware, they are unwilling to invest too much. The payment level results indicate that participating farmers tend to engage in SFC by paying lower costs to achieve environmental improvement and increased social welfare, aligning with theoretical expectations.

In summary, LF and CF, IIFF, and MPR urgently need improvement projects. There is still inconsistent awareness of certain facilities in different regions. The promotion of SF-related construction content should be led by local governments, aiming to enhance farmers' awareness from various perspectives such as facility usage methods and cost-benefit. It is also suggested to establish differentiated construction schemes in policy formulation to meet regional needs. Meanwhile, the government should consistently guide farmers to understand the importance of improving farmland ecosystem services. However, intervening to increase farmers' payments for ecological improvement projects is inappropriate. Because stallholder farmers remain financially vulnerable, there is limited space to expand their payment levels, which contradicts social moral standards. The key focus in enhancing farmers' ecological awareness is to enable them to adopt more sustainable production practices, integrating environmental protection consciousness into all their agricultural activities and emphasizing changes in farmland ecology. The government must allocate and use farmers' inputs more reasonably, transforming their contributions into dedicated funds for specific facility construction. Meanwhile, establishing a funding management system involving farmers in cooperative supervision would encourage their active participation, promoting farmland construction efficiency.

4.2. Whether preference would vary with the external and internal aspects of farmers

Clearing the heterogeneity of farmers' preferences is beneficial for providing participation schemes that better match their endowment characteristics. In this experimental result, farmers are divided into two classes. The first class of farmers predominantly participates in high-cost, high-return infrastructure construction. Strengthening their environmental responsibility and ecological awareness is needed. It requires the government to learn from international experiences and conduct various activities related to agricultural ecological protection through diverse channels, including case studies and practical initiatives. The second class of farmers prefers resource-saving and environmentally friendly facilities. However, the construction of IIFF must correspond to flat and large-scale farmland. Further investigation into the current farmland situation is needed to avoid insufficient understanding of synergistic effects on various facility construction and application, and results in an unreasonable construction scheme.

This study found from the characteristic variables of the two classes of farmers that those older, those with higher educational level, risk-averse individuals, those engaged in land transfer, and those with better-cultivated land quality are more willing to participate in benefit-driven facility construction. With the aging trend in agricultural production becoming increasingly apparent, they solely rely on agricultural income, prompting a stronger desire to increase production profits and a heightened focus on related facilities (J et al., 2021). It also reflects that older farmers show less enthusiasm for ecological facility improvements, a result supported by related studies (Feyisa, 2020; Gao et al., 2020; Jia and Zhao, 2021; Ruzzante et al., 2021). As the educational level of farmers increases, their comprehension of the significance of SFC also increases (Schaafsma et al., 2019). They gain more advantages in agricultural production and management, fostering a clearer assessment of the benefits and returns of diverse facilities (Aravindakshan et al., 2021). However, it should not be ignored that the relatively low proportion of farmers with high school education or above in this survey might also influence the estimation results. Behavioral economics provides insights into how risk preferences shape individual behavior in uncertain environments. Risk-averse farmers are more inclined to participate in benefit-driven facility construction. This indicates that the acceptance of such facilities has reached a high level, as farmers perceive SFC as a risk-sharing activity related to the long-term government-led farmland construction and the beneficial outcomes that farmers recognize. They trust government actions and are more willing to improve farmland conditions under cost-sharing. It also supports the government in establishing a more comprehensive SFC mechanism to further enhance its management role. Farmers engaging in land transfer experience positive utility when participating in benefit-driven facility construction. Farmers in a leasing status typically are more concerned regarding farmland conditions (Zhang and Paudel, 2019). For tenants, the focus is enhancing facility levels to meet agricultural production needs. Landlords also anticipate improving farmland conditions under cost-sharing, aiming for future higher rental prices and longer contract durations while ensuring the sustained efficient use of the land. Land transfer is an effective pathway to promote large-scale operation, necessitating the government to clarify ownership responsibilities and determine participation channels of SFC based on different producers. The participation mechanisms for farmers and industrial organizations (large grower, family farm, cooperative, and agribusiness) should be established according to the nature of their managed land, land transfer area, and contract duration. Cultivated land quality and infrastructure conditions are fundamental aspects for understanding the requirements of farmland improvement. On the basis of the field surveys, farmers with better-quality cultivated land generally believe that the most effective way to increase food yield is by equipping more advanced infrastructures. However, they do not perceive infrastructure construction as helpful in improving cultivated land quality. It emphasizes the importance for the government to focus on promoting and advocating the indirect and long-term benefits of SFC. Overall, the determination of SFC schemes should not only respect regional production demand differences but also prioritize farmers' preferences and intentions. Tailored information interventions should be provided to farmers of different classes based on farmland investigations, aiming to achieve optimal construction scheme formulation.

4.3. How do the payment levels for farmers contribute to SF?

Farmers exhibit a high willingness to pay for various types of facilities. This study referred to the estimated costs of previous farmland construction projects in the study area and the budgets of the Green Farmland Construction Project in the Yellow River Basin. Depending on the difficulty of renovation in different regions, the construction costs are as follows: LF and CF: 200–800 CNY/0.067 ha, MPR: 200–500 CNY/0.067 ha, IIFF: 400–1000 CNY/0.067 ha, ED: 100–400 CNY/0.067 ha, moderate improvement of farmland ecology: 50–100 CNY/0.067 ha, and high improvement of farmland ecology: 200–500 CNY/0.067 ha. Farmers' contributions to various facilities have reached 50–80 % of the highest costs, reflecting their high enthusiasm for participating in SFC. In recent years, Shaanxi has consistently increased investment in farmland construction projects (China Xinhua News, 2023), especially focusing on irrigation facilities through various subsidies, establishing large scale of water-saving facilities, and creating multiple national water-saving irrigation demonstration areas (Shaanxi Government, 2022). The realization of the benefits helps farmers better understand the significance of SFC, promoting their proactive attitude towards participation. Currently, the government's investment standard for farmland construction projects is 22,500 CNY/ha, and the demand for SFC ranges from 67,500 to 90,000 CNY/ha. This study has identified the infrastructures suitable for farmer participation in SF and has further determined the specific payment levels for these infrastructures. However, farmers are one of the stakeholders in farmland construction, and cost-sharing in public goods construction should further consider the proportions borne by the government, farmers, and other stakeholders.

For the allocation of fund from farmers, it can be stipulated that government investment in SFC is contingent upon farmers providing matched fund. This mode aims to diversify fund sources while enhancing farmer participation and efficacy. Relying solely on government investment may foster dependency among farmers, potentially leading to instances of free-rider and the tragedy of the commons (Galioto and Musotti, 2023; Githinji et al., 2023). Conversely, expecting farmers to fully finance farmland construction could impose financial burdens beyond their means, diminishing their perceived value of the endeavor and reducing their willingness to development SF. Consequently, a single fund mode is not sustainable. The fund framework should incorporate government investment as the primary source and matched contributions from farmers. Implementing a farmer-led "build first, subsidize later" mode may prove effective in the project operation. This mode capitalizes on initial fund raised by various avenues, including rural collective economic organizations, farmer labor, in-kind contributions, and community fundraising. Such a strategy ensures that rural social capital is optimally utilized for agricultural and rural development, enhancing overall fund efficiency. After the successful acceptance of SFC, the government can provide incentives or subsidies as rewards. Policy formulation related to special standards of farmers investment should be based on regional situation, ensuring farmers' contributions are fully allocated to their preferred construction schemes.

4.4. How to recognize and strengthen the role of farmers in farmland construction?

Farmland, a fundamental element of agricultural production, plays a crucial role in continuously enhancing production capacity. Since the founding of the People's Republic of China, farmland construction has been closely linked to the nation's economic development, reflecting the transformative processes and stage characteristics of agricultural and rural development, and farmland construction. Farmland construction has yet to yield ideal results despite undergoing various developmental stages compared with developed countries such as Japan, North America, and Australia (Yang et al., 2022). The main reasons for this discrepancy lie in existing issues in management, primarily manifested in unreasonable schemes that fail to align with the actual demands of agricultural production (Junjie et al., 2022; Zheng et al., 2023). Insufficient investments have led to low construction standards, falling short of the expected quality goals (Bao and Feng, 2021a). The fundamental constraint stems from the government's dominance in farmland construction, lacking substantial participation from involved parties. Thus, on the basis of the farmers' perspective, this study conducted an exploratory experiment on their involvement in SFC. The findings provide insights into guiding farmers in understanding the essence of SFC, motivating their active participation, and formulating mechanisms for their involvement in SFC. Relevant policy implications are summarized based on the results (as shown in Fig. 4).

This study innovatively addresses investment limitations in farmland construction, explores the genuine needs of producers, and establishes a participatory mechanism for SFC, considering the current state of farmland and farmers' preferences. At the institutional level, it reconciles the substantial financial pressure on the central government with inadequate realization of farmers' inherent responsibilities, balancing between farmers' demands and construction funding requirements. It provides a precise implementation scheme for the new farmland construction strategy and offers valuable insights for devising management mechanisms in other countries undergoing farmland consolidation. In addition, it contributes a novel perspective and serves as a reference for related research in the field.

5. Conclusions

SFC is a priority strategy aligned with the integrated goals of output

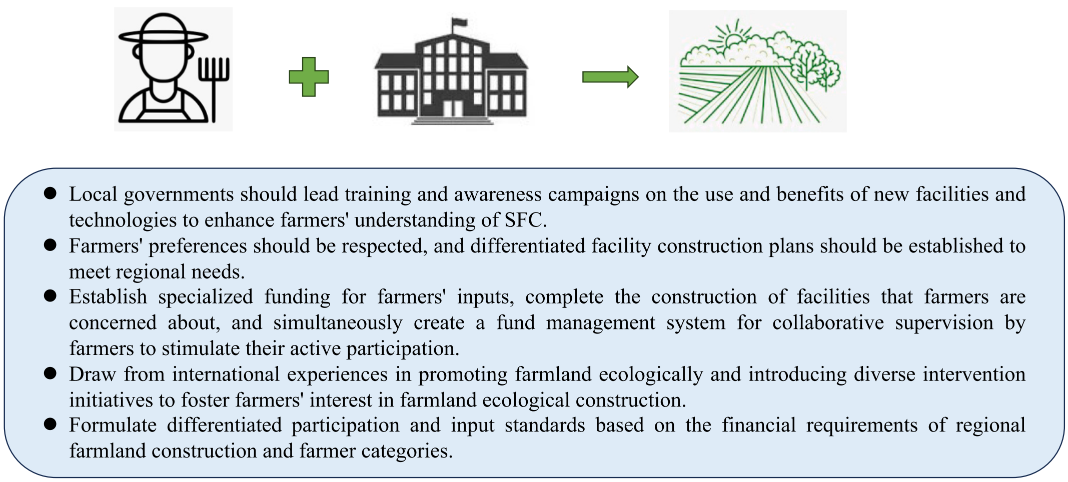

Fig. 4. Policy implications extend.

efficiency, resource conservation, and environmental friendliness. To address challenges such as low investment standards and poor construction outcomes resulting from the need for more stakeholders' participation in farmland construction, this study focuses on optimizing and innovating farmland construction institutions by integrating farmers' participation. First, on the basis of the SFC framework, this study identifies farmers' preferences and clarifies their infrastructure demand. Second, further exploration of farmer preference heterogeneity clarifies the characteristics of heterogeneous farmer classes. Finally, the farmer's willingness to pay is measured based on SFC attributes. Overall, the findings indicate a strong demand from farmers for LF and CF, IIFF, and MPR, and enthusiasm for ecological facility construction remains to be enhanced. Respondents' age, educational level, land transfer status, risk propensity, and current land conditions influence farmers' participation utility and preferences. Farmers' payment levels for MPR, LF and CF, ED, IIFF, and moderately improved in ecological protection facilities have reached 50–80 % of construction costs. Therefore, formulating SFC schemes should be tailored to local conditions. It is imperative to ask local governments to take the lead in promoting the benefits of various infrastructures and providing relevant technical training, thereby enhancing farmers' acknowledgment of SFC elements. Moreover, in strengthening actions to enhance farmers' ecological consciousness, introducing diverse intervention initiatives to foster farmers' interest in farmland ecological construction is essential. Furthermore, at the central government level of governance, formulating mechanisms for farmers' investment should thoroughly address their requirements and establish special funds. Overall, this study validates the effectiveness of determining SFC schemes based on farmers' preferences and successfully provides a regional plan for project demonstration areas. The payment level of farmers has been clarified, providing a reliable theoretical basis for cost-sharing on SFC. Notably, the study expands the research ideas and methods for stakeholders' participation in agricultural activities. The conclusions and policy implications can serve as experiential references for promoting the effectiveness of land consolidation and optimizing the management institutions of other agricultural projects in developing countries.

This study establishes a set of policy tools for farmer participation mechanisms in farmland construction but has certain limitations. First, this study involves two provinces, and the results demonstrate regional differences. Therefore, the research findings need to adequately represent the reality of farmland and farmers' preferences in other regions. Future studies should broaden the selection of study locations to understand the construction foundations in different areas and refine farmer participation institutions while recognizing variations. Second, the study only investigates farmers' investment levels. Given the numerous stakeholders in farmland construction, the construction of investment mechanisms should involve more participants. Exploring standards for the involvement of other stakeholders is a future research direction.

CRediT authorship contribution statement

Yanshu Yin: Writing – original draft, Validation, Software, Formal analysis, Data curation, Conceptualization. **Yingnan Zhang:** Software, Methodology, Data curation. **Wenjing Duan:** Writing – review & editing, Validation, Methodology. **Ke Xu:** Writing – review & editing, Validation, Investigation. **Zihong Yang:** Writing – review & editing, Validation. **Boyang Shi:** Writing – review & editing, Validation. **Zhizhen Yao:** Writing – review & editing, Validation. **Changbin Yin:** Supervision, Project administration, Methodology, Conceptualization. **Thomas Dogot:** Writing – review & editing, Validation, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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