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Farmers' Perception of Shelter Forests and the Influencing Factors in Windy Desert Areas of the Hexi Corridor, China

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Abstract: Shelter forest systems in the sandy areas mainly comprise farmland shelter forests (FSF) and windbreak and sand-fixing forests (WSF). Through a questionnaire survey of farmers in the oasis–desert transition zone of the windy desert areas of the Hexi Corridor in China, a perception assessment model of farmers' perception of the status quo and ecosystem service function of shelter forests was constructed, and the willingness of farmers to pay for shelter forest construction and protection was measured. Influencing factors for the farmers' perception of shelter forests were analyzed by a multiple regression analysis. The results showed problems with pests and diseases all present in FSF and WSF, the destruction of farmland in FSF, and water scarcity in WSF. Farmers evaluated the ecological role of shelter forests as the most obvious in windbreak and sand fixation; intermediate in the four ecological roles of leisure and recreation, agricultural production, a sense of locality, and climate regulation; and the smallest in soil improvement. Nearly 95% of farmers are willing to donate funds to shelter forest construction and protection, and the average amount the farmers were willing to pay was CNY 54.30 per year. Willingness to pay, annual household income, gender, environmental experience, age, and interview area have significant effects on farmers' perception of shelter forests. Finally, in this paper, we recommend increasing motivation through government financial support and training for farmers to address pests and diseases, water security, and the destruction of farmland in shelter forests to ensure healthy and sustainable growth.

Keywords: shelter forest; farmers' perception; evaluation model; influencing factor; forest environmental management

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1. Introduction

Shelter forests in sandy areas primarily include farmland shelter forests (FSF) and windbreak and sand-fixing forests (WSF), playing a crucial role in ecological services such as soil and water conservation, water nourishment, wind protection, sand fixation, farmland protection, and climate regulation and supporting human production and livelihoods [1–5]. The Hexi Corridor, an essential part of the northern sand control belt of China's Three North Protective Forest Project, has made significant strides in restoring degraded forests and vegetation areas [6–8]. Since 2020, this project has entered the sixth phase of the third stage [9]. With China's forest rights reform, there is a shift from state-owned to private forests [10]. In this transition, the attitudes of farmers, as stakeholders in shelter forests, play a critical role in the health and sustainability of these forests.

The international community also has made significant efforts towards forest development, including subsidies and support to farmers for afforestation. The European Commission adopted the new EU Forest Strategy 2030 [11] as a flagship initiative of the European Green Deal [12]. The new EU Forest Strategy 2030 aims to develop a vision and concrete actions to increase the quantity and quality of EU forests and strengthen their protection, recovery, and resilience. From an agricultural perspective, the new CAP proposed by the Common European Agricultural Policy (post-2020) emphasizes the need to pay more attention to environmental and sustainability issues [13]. Indeed, this new reform has nine specific objectives aimed at improving the environmental, social, territorial, and health aspects related to agricultural sustainability and not only the productive and economic aspects of the previous reform [14]. The U.S. Forest Land Management Planning Protocol aims to ensure that forest plans meet current state forest planning and management needs, including the provision of sustainable benefits, services, and uses (including recreation); the conduct of forest restoration and protection; watershed protection and wildlife conservation; and sound natural resource management under changing conditions [15]. The near-natural management approach characterized by the creation of mixed forests in Germany's forest restoration program has addressed problems such as forest pests and forest stand degradation. Thus, countries around the world, including China, have made efforts in forest restoration, and these initiatives are worth studying and learning from around the world.

The health and stability of shelter forests are prerequisites for their effective protective functions. Historically and currently, shelter forests have been used on farmland to protect crops and property from harsh weather conditions [4,5]. Consequently, farmers play a primary role as both builders and users of shelter forests [16]. However, due to various factors such as drought [17,18], shelter forests often face decline, including dieback, low growth rates, mortality, and sparse regeneration [19]. Within the constraints of non-intervention in natural conditions, governments and farmers seek management approaches or policies to address these issues and ensure the healthy growth of shelter forests. As the management shifts from state to private forests, there is a growing argument for increased farmer activism [20]. Therefore, understanding farmers' attitudes towards forests is crucial.

Farmers' perceptions of shelter forests are influenced not only by individual characteristics but also by social and governmental policies. Duesberg noted that the majority of afforestation in Ireland is carried out by private landowners, particularly farmers, with the government encouraging afforestation through subsidies [16]. Additionally, age affects personal satisfaction with silviculture and welfare for future generations [21]. The benefits of tree planting can also lead to positive attitudes toward reforestation [22]. Furthermore, reforestation subsidies can increase farmers' incentives to reforest [23,24]. These factors collectively shape farmers' positive attitudes towards forests. However, some farmers are reluctant to plant trees, believing that the land should be used for agricultural production, emphasizing the importance of food production [25]. Some farmers derive low satisfaction from woodland management and are therefore reluctant to establish woodland areas [26]. Additionally, the acquisition of large tracts of land by corporations for forest plantations has led some small farmers to sell their land and move to urban centers [27]. Other farmers contract out unused or unsuitable land for crop cultivation for tree planting [28]. Moreover, using non-public forest land for ecological purposes reduces management protection and investment by farmers [29]. Therefore, farmers' perceptions of forests encompass both positive and negative attitudes.

In China, shelter forests have shown signs of degradation as they mature [30]. This degradation may be attributed to the lack of direct involvement from certain public groups, leading to misperceptions about the forests' condition. Therefore, there is a need for a quantitative or qualitative understanding of farmers' perceptions of forests. On one hand, for ecological services, studies have shown that residents believe the ecological value of shelter forests is primarily reflected in soil retention, water conservation, climate regulation, and increased biodiversity [31]. On the other hand, research indicates that

the effectiveness of farmland shelter forests in absorbing carbon dioxide and improving the climate environment is well recognized among farmers [32]. However, these studies are still not comprehensive, as they do not consider other functions, such as cultural values. There is also a lack of harmonized surveys based on farmers' understanding of the current status of shelter forest growth. From another perspective, by examining the willingness of farmers to invest in the construction and protection of shelter forests, we can gain a deeper understanding of their motivations and attitudes toward environmental conservation. This is because people's willingness to pay for forest bathing also reflects the tourism and economic value of forests [33]. The extent to which residents perceive ecosystem services greatly influences their maximum willingness to pay [31]. From the perspective of the sustainable development of shelter forests, our previous study revealed that farmers generally hold a positive attitude towards ecological compensation and the management and control of pests and diseases in farmland shelter forests [9]. Also, forest farmers could timely take control measures that can reduce the economic loss caused by forest biological disasters (FBDs) [34]. Such measures can enhance farmers' enthusiasm and contribute to the healthy development of forests.

Despite the extensive research available on farmers' attitudes and forest management, including our previous studies, the literature often focuses on the public or farmers' attitudes toward forest management and the benefits forests provide. However, there is a significant gap in addressing the sustainability of protected forests. The Hexi Corridor shelter forest is a key zone in the northern sand control belt of the Three North Protective Forest, and the current status of the shelter forest needs to be investigated from a farmer's perspective. To bridge this gap, our study introduces two assessment indicators for farmers' perceptions of shelter forests. Factors characterizing the current status include growing conditions, pests and diseases, livestock destruction, water security, completeness, and the destruction of farmland. Characteristics that characterize ecological service functions include windbreaks and sand fixation, climate regulation, agricultural production, leisure and recreation, a sense of locality, and soil improvement. These indicators encompass the current status and ecological functions of shelter forests at the primary level and multiple secondary indicators under this primary level. Using the perception scores derived from these indicators, we analyze the factors influencing farmers' understanding of shelter forests, incorporating demographic and environmental characteristics. Additionally, we assess farmers' willingness to pay for the construction and protection of shelter forests.

Understanding farmers' perceptions of current shelter forest development is crucial. Our assessment model not only measures farmers' comprehension of shelter forests but also provides insights into the development of these forests. We used this research design to explore the following concepts: ① What are farmers' perceptions of shelter forests based on current status and ecological service functions? ② What are the factors that influence farmers' perceptions of shelter forests? ③ Design a future management plan for shelter forests in sandy areas. We should not view farmers merely as self-interested parties but as key managers of sustainable forest development. This perspective will offer valuable guidance for managing forests in windy desert regions and similar areas worldwide.

2. Materials and Methods

2.1. Study Area

The study area was Hexi Corridor in Gansu, located in northwestern Gansu province, China (92°–107° E, 36°–43° N) (Figure 1). The terrain is high in the south and low in the north of the area, thanks to the Qilian Mountains in the south and the desert and Gobi in the north. This causes the three major rivers to flow from south to north. The climate of the region is a typical temperate continental arid climate, with rainfall gradually decreasing from east to west. The soils are mainly brown and gray desert soils [9]. The Badain Jaran Desert (39° N–41° N and 100° E–104° E) spans approximately 50,000 km^2, and the Tengger Desert has a total area of 36,000 km^2 [35]. The Hexi Corridor is a commercial grain base in northwest China and a key corridor to West Asia and Europe and is also an important

part of the Silk Road [36]. As a result of the desert in the northern part of the corridor, since 1978, China's Three-North Shelter Forest Project has been planting *Populus* L., *Elaeagnus angustifolia* L., *Haloxylon ammodendron*, and *Tamarix ramosissima* trees along the northern wind–sand line in the region to counteract the damage caused by the wind and sand to farmland and residential areas. However, due to the constraints of the natural conditions and human activities in the area, species within the area's protection system, such as mature *Populus* L. and *Haloxylon ammodendron* trees, often degrade and die due to drought and lack of water, and the ecological environment still required constant attention [37].

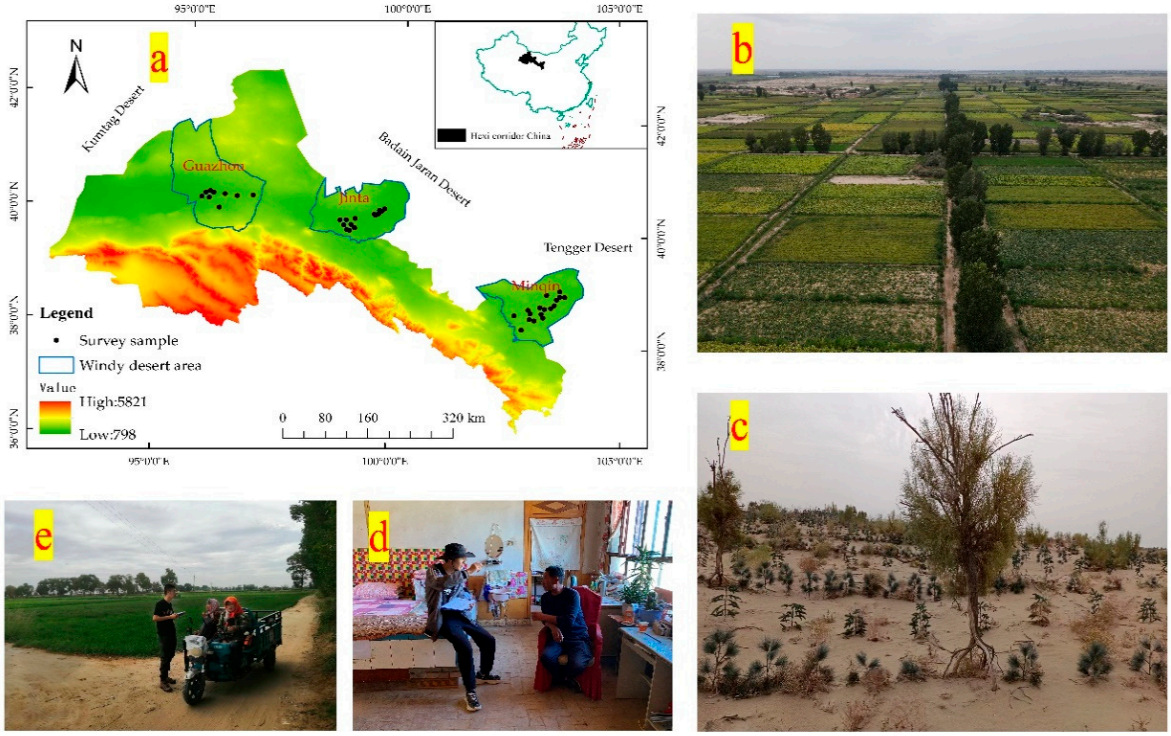


Figure 1. A map of the study area. (**a**): The geographic location of the study area. (**b**): Farmland shelter forest. (**c**): Windbreak and sand fixation forest. (**d**,**e**): Interviewing farmers.

Minqin County is located at the eastern end of the corridor and is surrounded on the east, west, and north by the two major deserts—the Tengger and the Badanjirin—which make up 90% of the district and feature serious wind and sand hazards. Wind erosion is the main cause of oasis desertification in the region [38], along with, of course, water scarcity and agricultural activities [39]. Premier Wen Jiabao of the State Council visited Minqin in 2007 and proposed that "Minqin must not become the second Lop Nor", providing a warning regarding the deterioration of the ecological environment in the Shiyang River Basin of the Hexi Corridor. This is because Lop Nor used to serve as an oasis lake and a gathering place for agricultural activities but has now disappeared due to the fragile natural resources and irrational human activities [40]. Therefore, from the past to the present, Minqin has been building shelter forests to counteract wind and sand hazards and protect the oasis ecosystem.

Jinta County is located in the north of the middle end of the Hexi Corridor in the middle and lower reaches of the Hei River at the edge of the Batangilin Desert [41]. The eastern and northern part of Jinta County is the Badanjilin Desert, with the desertification area accounting for 64%, and there are more than 410 wind and sand sources in the county, including 18 key wind and sand sources. The average annual precipitation is only 60 mm, while the average annual evaporation is as high as 2500 mm, so the perennial drought and water shortage, along with the wind and sand, result in the ecological environment being very fragile. Sandstorms have increased from 3–5 times a year in the 1980s to 20–24 times a

year at present. Wind and sand disasters can be serious, and the creation of a protection system is the basis of resisting wind and sand hazards and improving the habitat. Jinta County is also in the economic radiation zone of the cities of Zhangye, Jiuquan, and Jiayuguan. Bearing east and west and even south and north, Jinta oasis forms a security barrier for the Jiuquan satellite launch center and provides important support for national border construction [9].

Guazhou County is located at the western end of the Hexi Corridor in the middle and lower reaches of the Shule River. Guazhou County is a typical arid desert area with sparse precipitation and an arid climate. In the county, there are 41 wind and sand sources distributed on the 250 km wind and sand line, and nearly 85% of the land area is desertified land. With more than 75 days of windy weather of force 7 or higher each year, this area is known as the "-world wind bank- " [9]. Due to the windy environment, shelter forests have been planted in the Guazhou area, mainly of *Xinjiang poplar* and *Haloxylon ammodendron*, to resist the effects of wind and sand and protect people's production and life.

2.2. Data Source

The data for this study came from in-depth interviews conducted from August to September 2022, following a pre-study in 2021 of farmers in Minqin, Jinta, and Guazhou counties, where the corridor is heavily impacted by desertification. Statistics and maps were used to pre-select several locations in towns and villages close to the desert, and a questionnaire survey was conducted in a random sample of 1–4 villages in the selected towns. Participatory Rural Appraisal (PRA) was used to ask farmers for their answers to the relevant indicators through face-to-face interviews. Some questions need to be translated into easy-to-understand words to communicate with farmers; for example, your opinion on the leisure and recreation role of shelter forests can be transformed into the question of whether you usually rest or play cards under the shelter forests so that farmers can understand what we mean. A total of 713 questionnaires were distributed, and 650 valid questionnaires were returned, with a validity rate of 91.2%. Each farmer was interviewed for about 15–25 min, and photographs were taken to record the interviews. The interviews were conducted at the farmers' homes or on the farmland, as some of the farmers were working in the fields at the time. The farmers in the study were predominantly male, with ages ranging from 40 to more than 60 years old. The distribution of towns/villages in the sample area is Minqin: 10/22, Jinta: 7/16, and Guazhou: 10/26. The demographic characteristics of the research sample are listed in Table 1, and the questionnaire information can be found in Appendix A.

Table 1. Demographic characteristics of the survey sample.

Variable	Category	N	%
Gender	Male	497	76.5
	Female	153	23.5
Age group	0–40	48	7.4
	41–60	427	65.7
	61–75	175	26.9
Education level	Primary school and below	183	28.2
	Junior high school	299	46.0
	High school and above	168	25.8
Annual household income	≤CNY 20,000 (≤USD 2787)	49	7.5
	CNY 20,001–40,000 (USD_ 2787–5575)	301	46.3
	CNY 40,001–60,000 (USD_ 5575–8362)	218	33.6
	>CNY 60,000 (>USD 8362)	82	12.6

The questionnaire designed in this paper involved interventional research in humans, and the wishes of the respondents were fully respected and informed during the interview process. It was approved by the Ethics Committee of the College of Earth and Environmental Sciences of Lanzhou University, approval number 20240826.

2.3. Methods

2.3.1. Research Framework and Indicators

Human perception or understanding of an environmental issue generally includes several main aspects. For example, the perception of water resources encompasses the source of the water, the quality of the water, and the use and sustainability of the water [42]. In turn, factors affecting perception include multiple aspects, such as individual characteristics, gender and age, and social experience characteristics, such as participation in environmental construction. When applied to the perceptions of shelter forests, we considered three types of perception, i.e., perceptions of the current state of development, perception of the ecosystem service functions, and how farmers' perception of shelter forests may influence the willingness to pay for shelter forest construction and protection.

We set six main questions on the current development status of the shelter forest regarding growth conditions, pests and diseases, destruction of trees by livestock, water security, completeness, and destruction of farmland. Two or three choices were set for each question based on the actual feedback from farmers. Completeness expresses the degree of completeness of a shelter tree species, not just a single species. Destruction of farmland reflects the competition between shelter forests and crops for nutrients and water. Similarly, we set six questions about the ecosystem service functions of shelter forests, i.e., windbreaks and sand fixation, climate regulation, agricultural production, leisure and recreation, sense of locality, and soil improvement. Leisure and recreation expresses the degree to which the farmers use the shelter forest for leisure and recreation, e.g., sitting under the trees to cool off in the shade. Sense of locality expresses the humanistic significance of the shelter forest as a native species in the local area. Considering the differences in perceptions between regions, the method of comparing means in R version 4.3.3 was used to study farmers' perceptions of the status and ecosystem functions of shelter forests between regions.

We used the conditional value method, which involves evaluating the value of a certain environmental object, investigating and inquiring about peoples' willingness to pay for the protection of a certain resource or the improvement of environmental benefits and then obtaining the value of this environmental object [43,44]. We included only the willingness to pay and not the willingness to be compensated to examine farmers' willingness to donate to shelter forest construction and protection and allowed respondents to choose the payment interval and specific amount. Before setting the payment interval, we fully understood the income and willingness of the farmers. Because the income of farmers in the sandy area is limited and too high of an amount will make farmers resent this behavior, we chose to set the interval based on CNY 100, including an unwillingness to pay, 1–10, 11–50, 51–100, and more than 100. The purpose of this approach was to determine the farmers' motivation to construct and protect forests based on the actual situation rather than a compensatory measure with a financial purpose. For the influencing factors of perception, we mainly incorporated demographic factors, environmental characteristics, and respondents' social experiences. The specific perception indicators and impact factors are presented through a framework diagram in Figure 2.

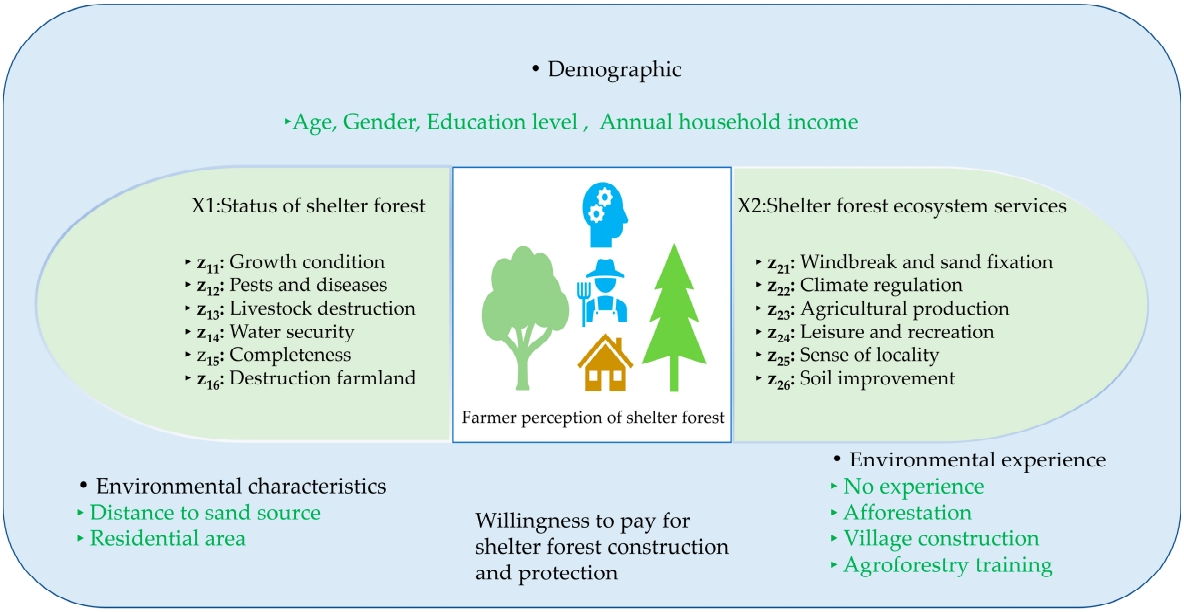


Figure 2. Framework for the research ideas.

2.3.2. Perception Assessment Model

As shown in Figure 2, during the questionnaire design stage, we designed two level 1 indicators to assess farmers' perception of shelter forests, namely, "perception of the current status of shelter forest X1", and "perception of the ecosystem service function of shelter forest X2". Each level 1 indicator contained multiple level 2 indicators (z_{11}~z_{16}, z_{21}~z_{26}) and was scored on a scale of 1—3. Synthesizing the purpose of this study, the perception assessment model was constructed as follows:

$$Y = \sum_{i=1}^{2} X_i \times W_i \qquad (1 < Y_i < 3) \tag{1}$$

where Y is the score for the respondent's perception of shelter forests; X_i is the score of the respondent on the two primary indicator questions; and W_j is the weight, which takes the value of 1/2 because there are two primary indicators.

$$X_i = \frac{1}{6} \sum_{m=1}^{6} z_{im} \tag{2}$$

where $z_{im} \in [1, 3]$, (i = 1, 2), and (m = 1, 2, ... 6). The m-th option of the question was selected, with values ranging from 1 to 3.

2.3.3. Farmers' Willingness to Pay for Shelter Forest Construction and Protection

Willingness to pay consists of two components: the psychological willingness to pay, which is universal, and the financial willingness to pay exactly how much and the upper limit of the willingness to pay in various situations. We presented the respondents with a choice of price ranges that they were willing to pay for shelter forest construction and protection and asked them to choose the most appropriate option and the specific amount. We used the maximum amount the farmers were willing to pay to calculate the amount of money that each farmer would pay for shelter forest construction and protection, which was calculated as follows:

$$E = \sum_{i=1} a_i P_i \tag{3}$$

where E represents the willingness to pay WTP, which is the maximum amount that the farmer is willing to pay for shelter forest construction and protection; a_i is the value range

chosen by the respondent; and P_i is the probability corresponding to the respondent's choice of the relevant value range.

2.3.4. Analysis of the Factors Affecting Farmers' Perception of Shelter Forest

In univariate linear regression analysis, one main influencing factor is used as the independent variable to explain the change of the dependent variable. In the study of real problems, the change of the dependent variable is often affected by several important factors, so it is necessary to use two or more influencing factors as independent variables to explain the change in the dependent variable, which is known as multiple regression analysis [45]. The influencing factors of farmers' perception of shelter forests include several aspects, such as gender, age, education, and willingness to pay, so we used these eight variables as independent variables to examine their effects on perception scores. Most importantly, the effect of the interaction of the independent variables on the perception scores was also considered in this process [46]. We designed four hypotheses about the interaction variables in this study. All the interaction term analyses were performed in R version 4.3.3, with the multiple regressions fitted using the lm function and graphical presentation of the interaction terms achieved using ggplot2 and the effects function from the effects package. The four hypotheses about the factors affecting farmers' perception of shelter forests in this study were as follows.

Hypothesis 1. *The effect of willingness to pay on the perception scores is influenced by annual household income and education level, i.e., the higher the annual household income or the higher the education level, the higher the willingness to pay and the higher the perception scores.*

Hypothesis 2. *The effect of age on perception scores was influenced by environmental experience and education level, i.e., the richer the environmental experience, the older the age, or the higher the education level, the younger the age.*

Hypothesis 3. *The effect of the interview area on the perception score is influenced by environmental experience and distance to sand sources, i.e., there are differences in environmental experience and distance to sand sources among respondents from different regions, which further affect the perception scores.*

Hypothesis 4. *The effect of gender on the perception scores is influenced by environmental experiences, i.e., males may have more environmental experiences than females, further impacting the perception scores because males are more likely to be on the farm while females are at home taking care of the family.*

3. Results

3.1. Farmers' Perception of Shelter Forests

3.1.1. Farmers' Perception of the Status and Ecosystem Services of Shelter Forest

Six aspects of the survey report, namely growth, completeness, pests and diseases, livestock damage, water security, and the destruction of farmland, were used to evaluate the farmers' perception of the status of shelter forests (Figure 3a).

The results show that 46%, 33%, and 21% of the farmers thought that the current growth condition of the local shelter forest was good, average, and poor, respectively. Furthermore, the main reasons farmers cited for the poor growth were aging trees and a lack of water.

- Completeness: A total of 74% and 26% of the farmers thought that the shelter forest system was complete and patchy, respectively. The perceived patchiness of some farmers was mainly due to the homogeneity of the tree species in the area as well as the decline and death of certain species due to poor drought resistance.
- Livestock destruction: The proportion of farmers who thought that the shelter forests were not damaged/were damaged by livestock was 79% and 21%, respectively. Ac-

cording to the interviewees, with the national policy of returning farmland to forests and the implementation of the closed grazing policy, the local area is dominated by the captive breeding of livestock, so livestock rarely destroys the forest areas.

- Water supply: A total of 28% and 72% of the farmers thought that the shelter forest had guaranteed water/did not have guaranteed water, respectively. Through farmers' reflections and field inspections, the reason why there was no guarantee of water supply in the windbreak sand-fixing forest area (WSF) was that part of it comes from natural precipitation in addition to regular irrigation by local villages and forestry and grassland departments.
- Pests and diseases: A total of 22%, 51%, and 27% of the farmers thought that the pests and diseases in the shelter forests were at the level of no pests and disease, minor pests and disease, and serious pests and disease, respectively. Respondents reported that in farmland shelter forests (FSF), the main problems are rotten bark, brown spots, rust, aphids, and asphodel, while in windbreak sand-fixing forests (WSF), the main problems are dead branches, powdery mildew, and rodent infestation.
- Destruction of farmland: The proportion of farmers who thought that the shelter forests were competing with agricultural land for nutrients and water was 10%, 72%, and 18% for no competition, minor competition, and serious competition, respectively. Serious impacts are mainly found in the shelter forests adjacent to agricultural land (FSF).

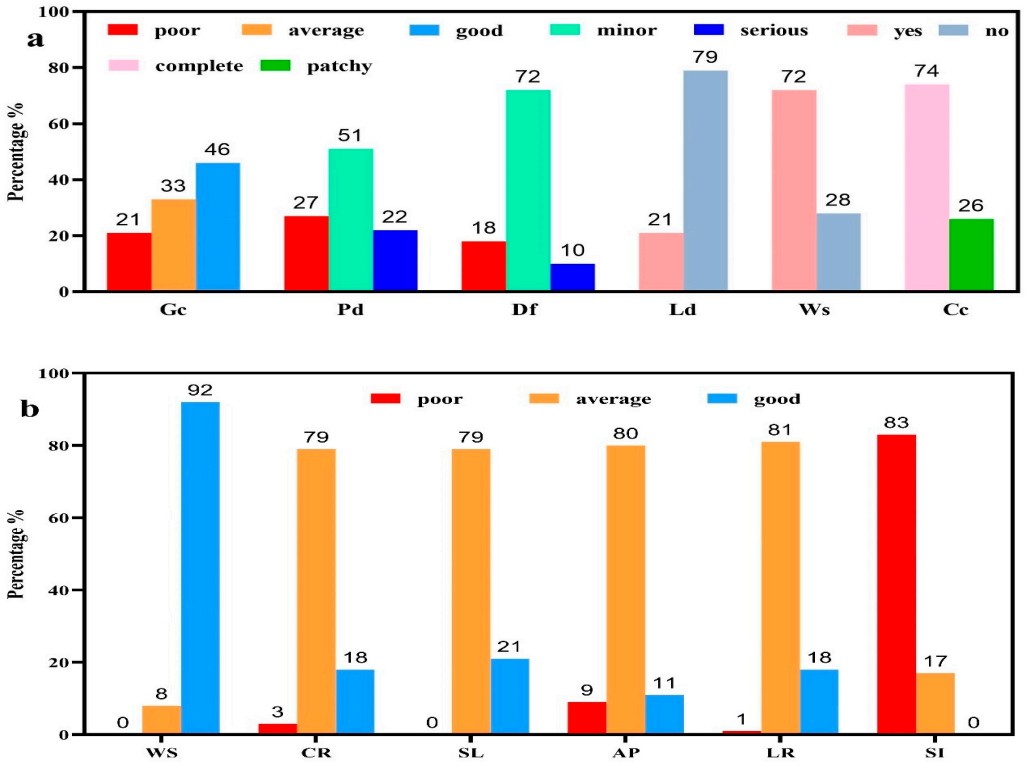


Figure 3. Farmers' perception of the shelter forest. Note: (**a**) status, (**b**) ecosystem service, Gc: growth condition, Pd: peats and diseases, Df: destruction farmland, Ld: livestock destruction, Ws: water security, Cc: completeness condition; WS: windbreak and sand fixation, CR: climate regulation, SL: sense of locality, AP: agricultural production, LR: leisure and recreation, SI: soil improvement.

We further derived from the role of farmers in ecosystem services of shelter forests that windbreak and sand fixing was the most obvious. The four ecological roles of leisure and recreation, agricultural production, a sense of locality, and climate regulation were generally in the middle, and soil improvement was the least important (Figure 3b). This shows, firstly, that shelter forests have played an important role in local wind and sand

hazards mitigation and microclimate regulation. Secondly, the local people have developed a deep connection with the shelter forest, and shelter forests have become an important part of the local community. In addition, shelter forests play a major role in protecting farmland from hazards and maintaining agricultural production, and people can also enjoy leisure activities in the forest areas. Finally, it is possible that the forests compete with farmland for nutrients, resulting in damage to the land, and therefore the effect on soil improvement is not obvious.

3.1.2. Regional Divergence in Farmers' Perception of Shelter Forests

Farmers' perception of the status of shelter forests in the three counties shows that (Figure 4) regarding the growth condition, Guazhou has a larger number of shelter forests in good condition than Minqin and Jinta, with Jinta's proportion of shelter forests in good condition being the second largest and the shelter forest in Minqin mainly concentrated at the average level as a whole. There is little difference between the three counties in terms of the proportion of shelter forests in poor condition. In terms of pests and disease, all three counties predominantly report an average level of pests and disease. In terms of the destruction of farmland, all three counties report an average level of destruction of farmland. In terms of livestock destruction, all three counties report that no destruction by livestock is more common than livestock destruction. In terms of water security, all three counties report that water security is an issue. In terms of shelter forest completeness, all three counties report a higher number of complete shelter forests rather than patchy. Overall, there is no significant difference in the status of the shelter forest in the three counties.

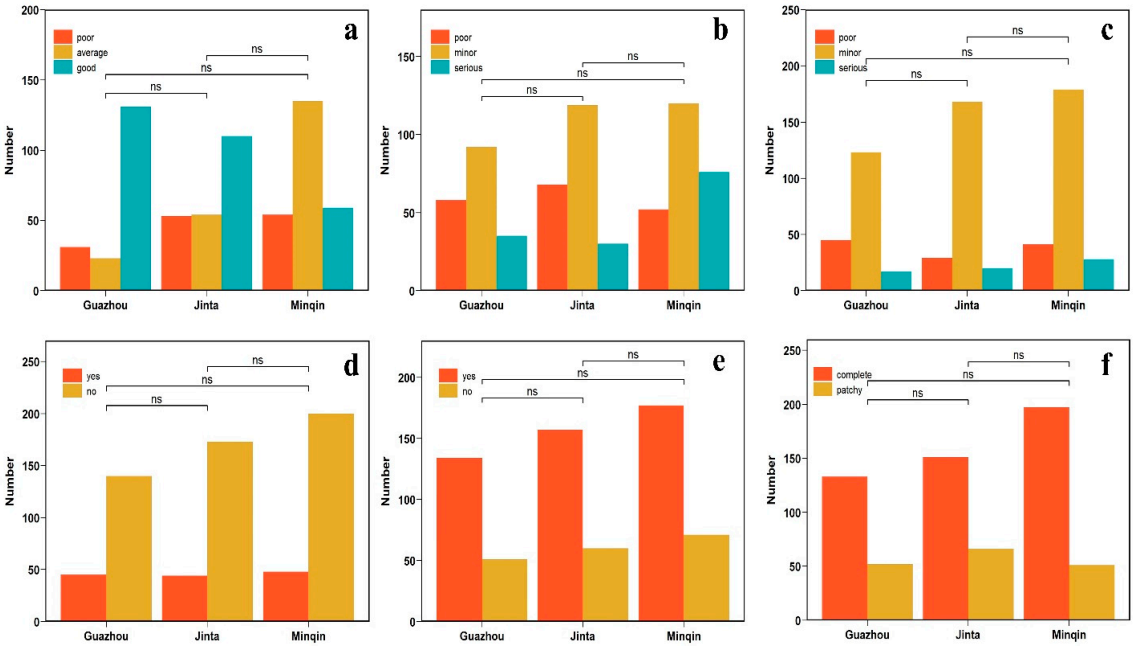


Figure 4. Regional divergence in farmers' perception of shelter forest status. Note: (**a**): growth condition, (**b**): peats and diseases, (**c**): destruction farmland, (**d**): livestock destruction, (**e**): water security, (**f**): completeness condition, ns: no significant.

The ecosystem service roles of the shelter forests in the three counties can be expressed as the most obvious role of windbreak and sand fixation, with climate regulation, a sense of locality, agricultural production, and leisure and recreation basically in the middle, and the lowest role of soil improvement. There is no significant difference in the ecosystem service role of shelter forests in the three counties (Figure 5).

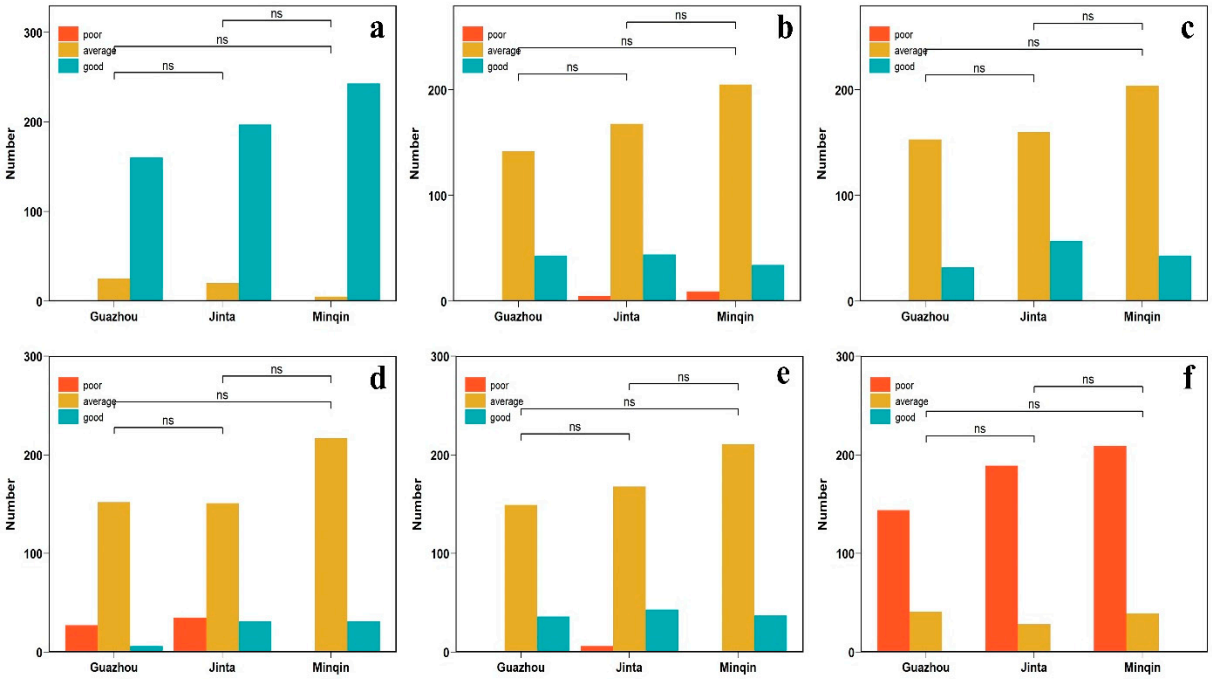


Figure 5. Regional divergence in farmers' perception of shelter forest ecosystem service. Note: (**a**): windbreak and sand fixation, (**b**): climate regulation, (**c**): sense of locality, (**d**): agricultural production, (**e**): leisure and recreation, (**f**): soil improvement, ns: no significant.

3.2. Farmers' Willingness to Pay for Shelter Forest Construction and Protection

The WTP value of farmers for shelter forest construction and protection was calculated to be CNY 54.30 through the mean estimation method (Table 2). The total regional WTP was CNY 35,295. Guazhou had the highest WTP value, Minqin was in the middle, and Jinta was the lowest.

Table 2. Statistics for willingness to pay (WTP) intervals and specific amounts /CNY.

Area	No	1–10	11–50	51–100	>100	Total	Average
Minqin	12 (4.84)	50 (20.16)	86 (34.68)	67 (27.02)	33 (13.30)	12,871	51.90
Jinta	9 (4.15)	40 (18.43)	87 (40.09)	69 (31.80)	12 (5.53)	10,400	47.93
Guazhou	12 (6.50)	38 (20.54)	46 (24.86)	46 (24.86)	43 (23.24)	12,024	65.00
Total	33 (5.07)	128 (19.70)	219 (33.70)	182 (28)	88 (13.53)	35,295	54.30

Note: Frequency in parentheses, quantity outside parentheses. The two rightmost columns are the total and average payments calculated through Equation (3).

The frequency statistics for WTP showed that 5.07% were unwilling to pay and 94.93% were willing to pay. Most respondents indicated that they were willing to pay an amount of CNY 11–50 or 51–100 per year. The reasons for the reluctance to pay by some farmers were further understood to include two aspects: the problem of low household income or the belief that the cost of shelter forest construction and protection should be borne by the government.

3.3. Factors Influencing Farmers' Perception of Shelter Forest

The analysis of the interaction factors affecting farmers' perception of shelter forests showed that willingness to pay, annual household income, gender, environmental experience, age, and interview location all had a significant effect on farmers' perception of shelter forests at $p < 0.05$ (Table 3). Further interaction effects indicated that annual household income and education level significantly influenced the perception score in interaction with

a willingness to pay (Table 3). That is, as annual household income increases, willingness to pay and perception scores also increase, but this trend begins to decline after the WTP value exceeds 100 as annual household income increases (Figure 6a). The effect of education level on willingness to pay and perception scores shows an upward trend, and after a willingness to pay of about 25, this trend begins to decline as the effect of education level increases the impact (Figure 6b).

Table 3. Interaction factors influencing farmers' perception of shelter forests.

Variable	Estimate	SE	*t*	*p*
WTP	4.855×10^{-3}	3.383×10^{-4}	14.353	***
AHI	6.970×10^{-2}	8.506×10^{-3}	8.195	***
WTP: AHI	-6.638×10^{-4}	8.812×10^{-5}	−7.533	***
WTP	3.798×10^{-3}	1.971×10^{-4}	19.270	***
EL	5.532×10^{-3}	6.508×10^{-3}	0.850	0.396
WTP: EL	-2.130×10^{-4}	9.054×10^{-5}	−2.352	*
Gender	0.129	0.059	2.187	*
EE	0.103	0.029	3.500	***
Gender: EE	−0.038	0.023	−1.668	0.958
Age	0.018	0.001	26.384	***
EL	−0.022	0.018	−1.226	0.221
Age: EL	0.000	0.000	1.270	0.205
Age	0.022	0.001	29.484	***
EE	0.088	0.016	5.348	***
Age: EE	−0.002	0.000	−5.069	***
IA	0.051	0.036	1.410	0.159
DS	0.033	0.036	0.902	0.367
IA: DS	−0.018	0.017	−1.065	0.287
IA	−0.111	0.030	−3.718	***
EE	−0.034	0.023	−1.464	0.144
IA: EE	0.051	0.016	4.302	***

Note: WTP: willingness to pay, AHI: annual household income, EL: education level, EE: environmental experience, IA: interviewed area, DS: distance to sand source. ***: $p < 0.001$, *: $p < 0.05$.

The impact of environmental experience on the interviewed areas and perception scores showed different performances, with agroforestry training and village construction showing an increasing trend as the interviewed areas moved westward, while no experience and afforestation showed a decreasing trend as the interviewed areas moved westward (Figure 6c). The effect of environmental experience on age and perception scores shows a shift from predominantly agroforestry training before age 56 to no experience after age 56, with the effect of having experience in afforestation and village construction in a more neutral trend (Figure 6d).

The results of the interaction effects found that the effect of gender on perception was not moderated by environmental experience; the effect of age on perception was not moderated by education level; and the effect of interview location on perception was not moderated by distance to the sand source (Table 3). The results of the interactions argue against hypothesis 4 as well as the interactions of age with education level in hypothesis 2 and interview location with distance to sand source in hypothesis 3.

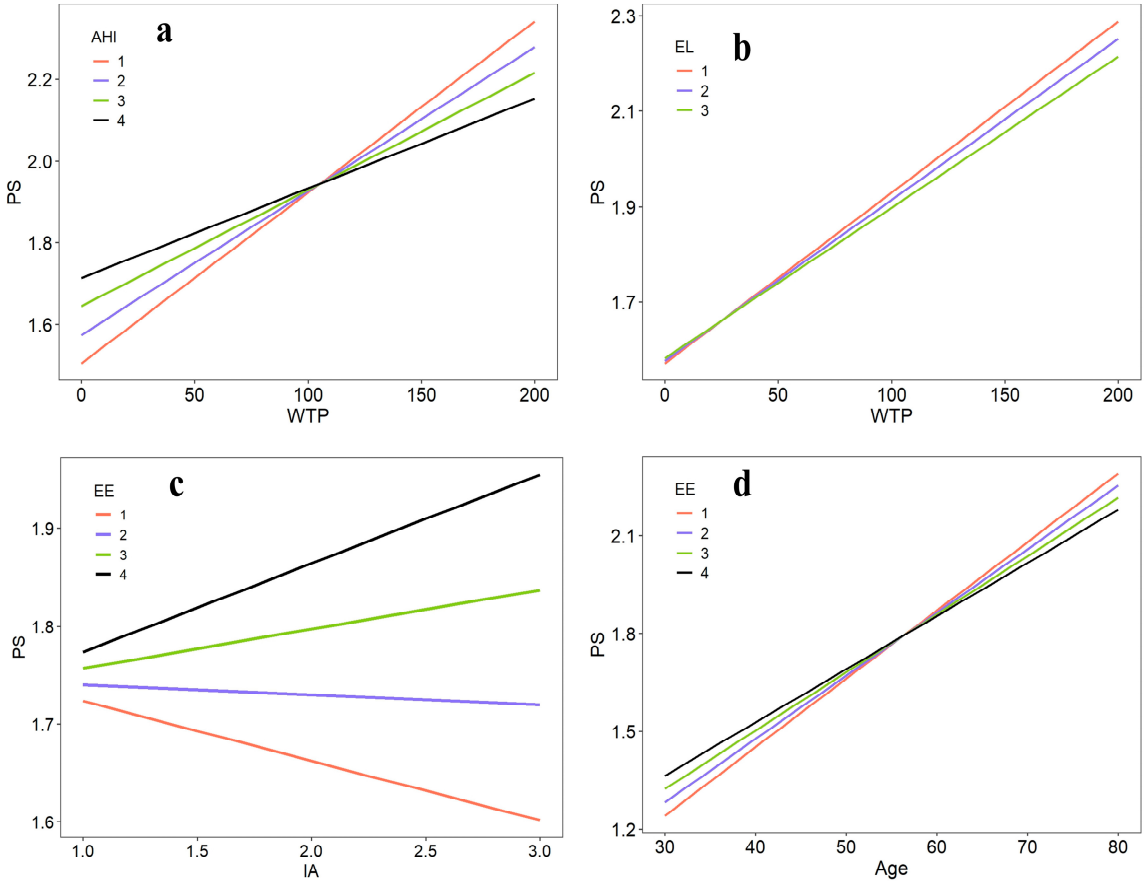


Figure 6. Interaction factors influencing farmers' perception of shelter forest. Note: WTP: willingness to pay, PS: perception score, AHI: annual household income, EL: education level, EE: environmental experience, IA: interviewed area. (**a**) is the perception score moderated by willingness to pay and annual household income; (**b**) is the perception score moderated by willingness to pay and education level; (**c**) is the perception score moderated by interviewed area and environmental experience; (**d**) is the perception score moderated by age and environmental experience; A larger number on the horizontal axis of c indicates that the interviewed area is farther west. The 1, 2, 3, and 4 in the legend (**c**,**d**) represents no experience, afforestation, village construction, and agroforestry training.

4. Discussion

Farmers' perception of the current status of shelter forests was dominated by the presence of pests and diseases, the destruction of farmland, water scarcity, and livestock damage leading to tree degradation. This is related to the arid as well as water-scarce environment of the windy desert areas, although a large proportion of local ecological inputs (tree planting, water use, etc.) are used to maintain the shelter forests in a good state of growth. Current research suggests that natural events such as droughts, temperature extremes, and pests and diseases play a key role in forest ecosystem dynamics [47]. On the one hand, the dieback and mortality of shelter forests usually involve a variety of interacting factors, ranging from drought to pests and diseases [48]. On the other hand, some shelter forests have not been subject to silvicultural measures after afforestation, resulting in weeds competing with seedlings or saplings for water and nutrients and the growth of seedlings and saplings being restricted or even resulting in death [48,49]. In addition, native species and zonal apex vegetation types are often not considered in the selection of tree species, along with the constraints of stand conditions [50,51], which have also led to the decline of shelter forests.

Farmers' perception of the ecosystem service functions of shelter forests was dominated by windbreak and sand fixation and also climate regulation. Other researchers have

also noted that shelter forests are generally recognized as preventing wind erosion and fixing dune movement [52]. Caborn also found that shelter forests play an important role in climate regulation. Secondly, the farmers also thought that shelter forests benefited their sense of locality and also leisure and recreation [53]. As Nijnik and Mather found in their research on the Scottish public's preferences for woodland development, woodlands play an important role in the integration of the aesthetic, ecological, and socio-economic components of landscape management [54]. Similar studies have demonstrated that exposure to forests promotes people's physical and mental health [55]. Finally, farmers are also concerned about the benefits of shelter forests for agricultural production through the protection of farmland. The benefits of arable farmers can be even more important, as crops can be irreplaceably destroyed by a single extreme weather event [56]. However, the farmers perceived that the soil improvement of shelter forests was of the lowest importance, which may be related to the fact that since the Hexi Corridor is located in an arid and semi-arid zone, where the scarcity of water resources is a major limiting factor, the competition for water between agriculture and forestry inevitably causes some damage to the soil. Contrary to our study, in the Tarim Basin of Xinjiang, farmers perceived better soil retention effects of shelter forests [31], and regional heterogeneity may have influenced the effectiveness of shelter forests.

We calculated the WTP value of farmers for shelter forest construction and protection through the mean estimation method. Other related studies have also explored residents' willingness to pay for forests through the contingent valuation method [57]. Both studies found that the respondents were willing to provide a certain amount of money for forest protection. In this study, we found that farmers' willingness to pay a certain amount of money for shelter forest construction and protection was closely related to the ecosystem service function of shelter forests, such as shelter forests protecting habitats and agricultural production, as mentioned above. In addition, we also found that some farmers were reluctant to pay for two main reasons: low family income and the belief that the cost of construction and protection of shelter forests should be borne by the government. Therefore, the government is still on forestry policy to strengthen the financial input in the windy desert areas, which is a more hostile environment. Furthermore, reduced investment in forest management and protection may also increase the incidence of forest fires and pests [58]. Farmers' willingness to pay for shelter forest construction and protection not only helps to alleviate the government's financial pressure but also reveals the farmers' motivation to participate in forestation. According to this study with an average payment of CNY 54.30 per person to support the construction and protection of shelter forests, according to the standard of about CNY 2000 for afforestation of 666 square meters in China's sandy areas, the amount of payment for 36 people can fund its completion. Our calculation of WTP only examines the willingness of farmers to contribute to the construction and protection of shelter forests, focusing on the perception of shelter forests and the factors influencing them. We will aim to conduct further in-depth research on WTP and willingness to accept (WTA) in the future.

Influencing factors that contributed to the farmers' perception of shelter forests were willingness to pay, annual household income, gender, environmental experience, age, and interviewed area. Other researchers have found that residents' willingness to pay for the conservation of ecotourism resources was significantly influenced by income and education [59]. In this study, the influence of environmental experience on the interviewed areas with cognitive scores in agroforestry training and village construction westward (Minqin—Jinta—Guazhou) is related to the fact that the further west area, similar to Guazhou silviculture, has a longer history and that farmers rely on the training and then silvicultural experience in addition to the migration policy, which led to the development of the rural construction in the west; afforestation has resulted in a better and healthier level of shelter forests [60]. Regardless of age, education level, and environmental experience, there is a need to train farmers in agroforestry from the field of forestry policy and to provide better guidance on afforestation to solve the problem of the declining quality of shelter

forests, which is resulting in a low survival rate for seedlings and a weakening of the ability of the shelter forests to resist wind and drought [61].

The Hexi Corridor is in an arid desert area with frequent wind and sand disasters, and the construction of shelter forests is an important measure to ensure local economic and social development. It will be necessary to address issues such as pests and diseases and the destruction of farmland, which are the key to the sustainable growth of shelter forests. Hence, we have provided some suggestions about future shelter forest management plans in windy and desert areas (Figure 7). We suggest the planting of shrubs to act as windbreak forests near the desert and trees to form farmland shelter belts near the residential areas. It will be necessary to control the pests and diseases reported by farmers through the use of fertilizers and pesticides and to coordinate the relationship between forest and farmland to ensure the ecological use of water to cope with soil improvement.

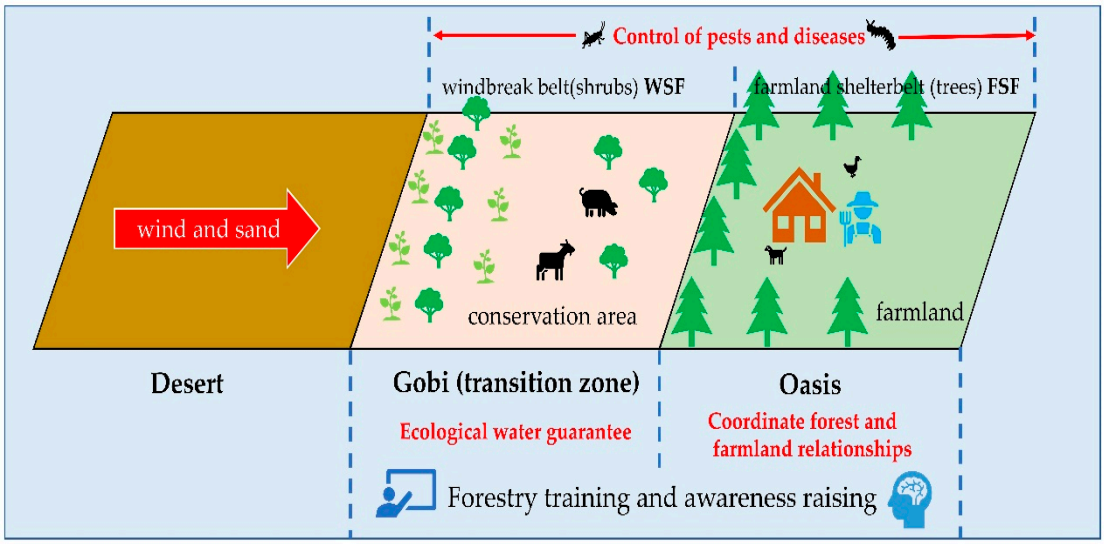


Figure 7. Environmental management planning for shelter forests in windy desert areas.

Because of the changes in forests caused by climate change and taking Europe as a reference, the European Union's forest strategy has repeatedly referred to sustainable management practices [62] so that the degradation of forests, pests and diseases, or modes of adjustment are all cross-referenced with China's management of protected forests, such as the active management of pests and diseases, guaranteeing the water security of forests and adjusting the contradiction between land and human beings. Similarly, the European Common Agricultural Plan is a good source of inspiration for focusing on rural development, for example, by encouraging farmers to actively participate in the management and construction of forests, as is the case in China, and through which agricultural subsidies can be obtained, mainly to address environmental issues. Given the international emphasis on reducing deforestation and forest degradation, increasing forest restoration through afforestation and reforestation and improving forest management will be of great importance [63]. The results of this study will have wider significance for the continued growth of shelter forest systems in sandy and windy areas.

5. Conclusions

According to the results of the study, farmers' perceptions of the current status of shelter forests in windy desert areas of the Hexi Corridor were highlighted in terms of pests and diseases, the destruction of farmland, and water security. Farmers believe that shelter forests provide important ecosystem service functions, but their role in soil improvement is not high. Therefore, pests and diseases need to be addressed through fertilizers or pesticides for both farmland shelter forest areas and windbreak forest areas. In addition, there is a need to regulate the competition between forests and farmland in the farmland

shelter forest area, for example, by appropriately reducing farming on the side near the trees, as well as a need to address the issue of water security in the windbreak forest area. Improving the relationship between forests and farmland through the above measures will ensure the healthy development of shelter forests and soil.

A high percentage of farmers are willing to pay a certain amount of money for the construction and protection of shelter forests. Willingness to pay, annual household income, gender, experience in environmental protection, age, and interviewed area all affect farmers' perception of shelter forests. Therefore, the government and society should pay more attention to farmers' perception of shelter forests. For example, when governments organize training courses on agroforestry techniques or financial support, farmers should be encouraged to actively participate in the construction and protection of shelter forests to improve their perception level further.

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Appendix A. Questionnaire

Shelter forest survey No:
Purpose: Healthy and sustainable growth of shelter forest
Survey location:_Survey time:
Name:___Age:____Gender:__
Picture number: Family population:
1 Education level: (1): primary school and below (2): junior high school
(3): high school and above
2 Annual household income:
(1): ≤20,000; (2): 20,001–40,000; (3): 40,001–60,000; (4): >60,000 (CNY)
3 Distance to sand source:
(1): less than 1 km (2): 1–5 km; (3): more than 5 km
4 Environmental experience:
(1): no (2): afforestation (3): village construction (4): agroforestry training
5 Willingness to pay for shelter forest construction and protection (CNY)
(1): none; (2): 0–10; (3):11–50; (4):51–100; (5): >100 Specific amounts:
Shelter forest perception (please select your answer by marking)
6 Growth condition: poor: 1 average: 2 good: 3
7 Pests and diseases: no: 3 minor: 2 serious: 1
8 Destruction of farmland: no: 3 minor: 2 serious: 1
9 Completeness: complete: 1 patchy: 0
10 Water supply: yes: 1 no: 0
11 Livestock destruction: yes: 0 no: 1
12 Windbreak and sand fixation: poor: 1 average: 2 good: 3
13 Climate regulation poor: 1 average: 2 good: 3

14 Sense of locality: poor: 1 average: 2 good: 3
15 Agricultural production: poor: 1 average: 2 good: 3
16 Leisure and recreation: poor: 1 average: 2 good: 3
17 Soil improvement poor: 1 average: 2 good: 3
Note: The number indicates the corresponding score; if you can't understand the question, please refer to the explanation below or inquiry us.
Growth condition: shelter forest growing good or poor
Pests and diseases: express whether there are pests and diseases in shelter forest
Destruction of farmland: express whether shelter forest growth is affecting crops
Completeness: express whether varieties of shelter forest are single or abundant
Water supply: express whether shelter forests have an abundant water supply
Livestock destruction: express whether shelter forests have livestock destruction
Windbreak and sand fixation: express shelter forest protection against wind and sand
Climate regulation: express shelter forests make the climate better
Sense of locality: express the local importance of the shelter forest
Agricultural production: express shelter forest protects crops from harm and increases production
Leisure and recreation: play cards and enjoy the cool under the shelter forest
Soil improvement: the quality of the soil becomes better after the planting of shelter forest

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