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# Public Preferences for the Design of a Farmland Retirement Project: Using Choice Experiments in Urban and Rural Areas of Wuwei, China

Liuyang Yao <sup>1</sup> , Minjuan Zhao <sup>1,\*</sup>, Yu Cai <sup>1</sup> and Zhaowei Yin <sup>2</sup>

<sup>1</sup> College of Economics & Management, Northwest A&F University, 3 Taicheng Road, Yangling 712100, China; yaoliuyang@gmail.com (L.Y.); caiyu1785@nwfau.edu.cn (Y.C.)

<sup>2</sup> Department of Research & Development, Haudi Investigation Design & Consulting Company, Xi'an 710000, China; joweiii@163.com

\* Correspondence: minjuan.zhao@nwsuaf.edu.cn; Tel.: +86-298-708-1398

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**Abstract:** This paper presents an application of a choice experiment measuring public preferences for a farmland retirement project (FRP) in the Gansu environmental degraded region of China. The project helps improve China's long-term food security, and information on public preferences can be used to cost-effectively design such policies. FRP is conceptualized with four attributes relating to public preferences: Areas enrolled in the program, duration of the contract, priority zone for conservation, and vegetation type for planting. The analysis employs a mixed logit model, allowing for preference heterogeneity, and explores the differences between the willingness to pay of urban and rural residents. Results identify substantial benefits for FRP, and these benefits are closely linked to the program design. Results also show that the willingness to pay for a longer period of the program of urban residents is significantly higher than that of rural residents. Finally, this study proposes policy recommendations that the number of areas and years of the current FRP in the study area can be increased moderately, but not excessively, to further benefit local residents.

**Keywords:** land retirement; choice experiments; willingness to pay; preference heterogeneity

## 1. Introduction

Since 2003, China has achieved “twelve years of consecutive growth (2003–2015)” in grain output to feed one fifth of the world's population on 7% of the world's arable land, basically realizing its food self-sufficiency [1]. However, with food production increasing year by year, on the one hand, it has paid the painful ecological costs, such as the aggravating non-point source pollution, the declining quality of arable land, and the over-exploitation of groundwater [1,2]; on the other hand, it has resulted in such socio-economic losses as the rising inventory cost of the grain stockpiling program, the declining comparative advantage of agricultural products, and the distorted prices in agriculture economy [3]. These challenging issues mean that it is vital that China finds new ways to achieve sustainable grain production, while solving the associated ecological and socio-economic problems. Against this background, in 2016, the Chinese government tentatively started the farmland retirement project, sometimes called set-aside or fallow, for the protection of land quality and the promotion of sustainable agriculture development, by subsidizing environmentally benign land uses [4].

As an effective way to reduce the pressure on the environment, ensure the sustainable utilization of agricultural resources, regulate the market of agricultural products, and enhance the competitiveness of the agricultural sector [5], the farmland retirement project has long been implemented in developed countries. The Soil Bank Program, carried out by the U.S. government between 1956 and early 1970s, and the Conservation Reserve Program, implemented since 1985, played significant roles in reducing

soil erosion, stabilizing land prices, and reducing agricultural overproduction [6,7]. The EU also launched its five-year volunteer set-aside program in 1988, followed by the MacSharry Common Agricultural Policy reforms in 1992, to make it mandatory for farmers to retire a percentage of their land each year [8]. The reforms helped regulate the grain market and protect the environment until it was canceled in 2008 and replaced by a new voluntary retirement program. The Japanese government carried out the Rice Paddy Set-aside Program in 1970, which aimed both to protect farmers' income and maintain domestic rice prices through policy measures, such as land retirement, price subsidies, and import tariffs [9]. Different countries implemented their land retirement policies through subsidies which helped maintain both a stable agricultural market and an improvement of agro-ecological conditions, so as to ensure the sustainable utilization of land resources.

In 2016, China's central government appropriated 686 billion RMB conservation funds to 1.16 million mu (15 mu = 1 ha) of arable land (0.07% of China's total grain cultivation area) for the implementation of pilot farmland retirement projects (FRP) [4]. Three regions, including groundwater funnel areas in Hebei and Heilongjiang provinces, heavy metal-contaminated areas in Hunan province, and areas with serious environmental degradation in Guizhou, Yunnan, and Gansu provinces, were designed to retire a certain quantity of arable land for difference ecological restoration purposes. In 2017, the subsidy for the project was expanded to 1.06 billion RMB with 2.00 million mu of arable land (0.12% of China's total grain cultivation area) involved [10]. In order to ensure that the FRP could be promoted smoothly and the benefits outweigh the costs of the project, it is necessary for the policymakers to take public preferences into consideration. Moreover, studies have shown that potential social benefits arising from land preservation and conservation practices are often associated with a set of attributes that characterize the project design [11–22]. For China, the FRP is still at a pilot stage and details concerning the design of the project are still in progress. While the benefits of the FRP will depend upon the details of how the project is designed, a lack of public preferences will hinder the development of policies that help maximize social benefits for a given conservation budget.

To overcome the above limitations, this research aims to estimate the public's ex-ante preferences for the FRP design for the first time, and identify which of the design attributes will be valued the greatest. Choice experiments (CE) have been employed for the estimation of China's FRP benefits which possess different dimensions of values. By incorporating the benefit-related attributes of the FRP design, such as area, location, duration, and restoration measures in a hypothetical setting, public preferences can be elicited using their trade-offs of these FRP attributes against the corresponding payment. A better understanding of public preferences for the design of FRP will demonstrate whether the benefits will justify the investment and secure public support in making farmland retirement policies. In this paper, the CE survey was conducted in Wuwei, Gansu province, for eliciting public preferences from both rural and urban areas, and the mixed logit model was considered for urban and rural residents separately, to reflect preference heterogeneity.

Previous studies provide evidence that choice experiments can be used to facilitate the design of farmland protection policies [11–22]. Several applications of these CE studies, using a willingness to accept (WTA) approach, have investigated farmers' preference for particular features of the European Union countries' agri-environmental subsidy schemes [13–16]. Other CE studies, on the contrary, using a willingness to pay (WTP) approach, were able to examine the multiple environmental and social benefits delivered by farmland protection policies [17–22]. The CE implemented in our study, using a WTP approach, contributes to the literature by providing some of the first Chinese evidence on a specific farmland protection policy (i.e., FRP). Especially, to avoid biased parameter estimates in the calculation of benefits [23,24], mixed logit models and coefficient simulations have been used to account explicitly for the preferences' differences between urban and rural households, which have been found in contingent valuation studies [25,26], but have not been adequately addressed in previous CE studies (e.g., [21,22]).

The remaining parts of our paper are organized as follows: Section 2 introduces the study area; Section 3 illustrates questionnaire design and the survey implementation; In Section 4, we present

the theoretical model used for data analysis; Section 5 gives the results and discussion of the model estimation; and Section 6 concludes the paper and discusses the policy implications of our study.

## 2. Study Area

The study area, Wuwei, lies in the east of the Shiyang River Basin (SRB), which exhibits an arid, temperate continental climate (Figure 1). The annual precipitation goes from 50 mm to 600 mm, decreasing from south to north, together with a much higher evaporation ranging from 700 mm to 2600 mm, increasing from south to north. Wuwei is not only the central city of the SRB, but also an important node of the transportation network of the Silk Road Economic Belt. Wuwei has been a major source of the country's sandstorms, and 39% of its area covered by the Tengger Desert, the Badain Jaran Desert, and the vast Gobi Desertland [27,28]. At the same time, the population density in Wuwei is 375 persons/km<sup>2</sup>, which is the highest of China's inland basins [29]. Unsustainable depletion of water and soil resources for satisfying the demand on agriculture has resulted in serious ecological crises, such as groundwater decline, land degradation, and a loss of biodiversity [30]. Fragile ecosystems and intensive human activities all contribute to the increasing pressure on natural resources and constraints on agricultural development. In order to secure future agricultural development, it is of importance to encourage farmers to retire their arable land from grain production to the provision of conservation services.

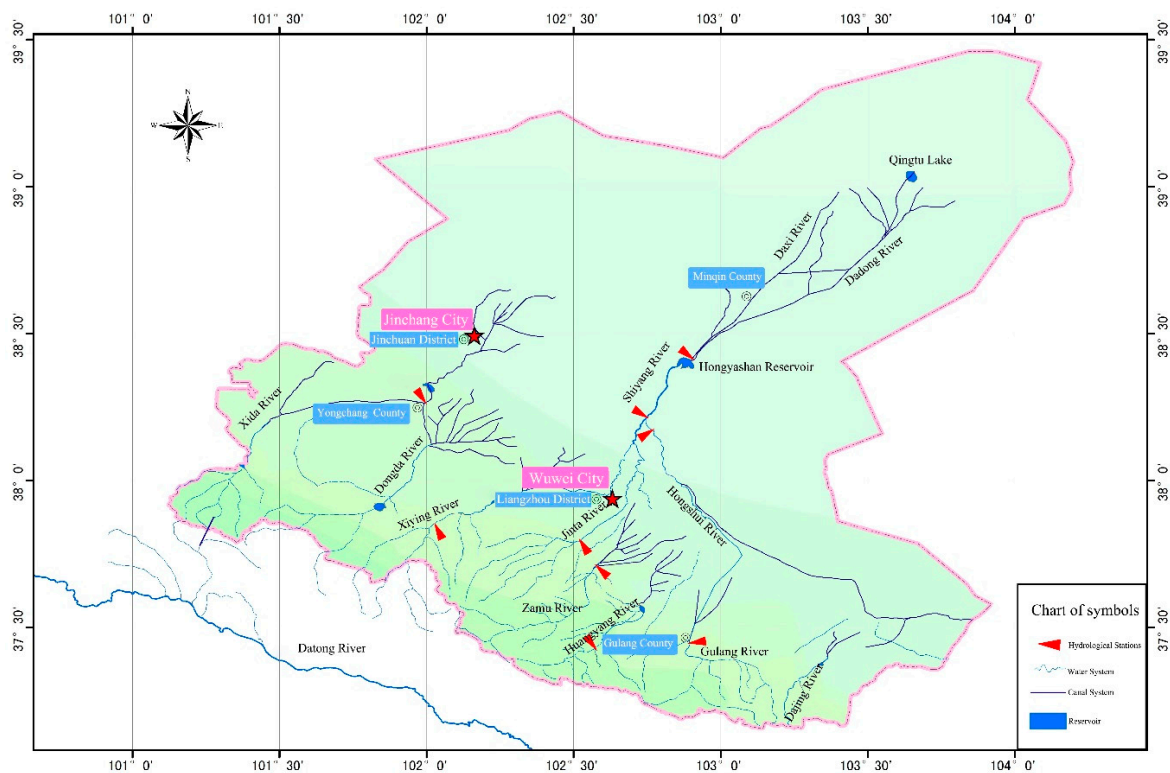


Figure 1. Map of the study site, Wuwei.

Wuwei is one of the cities where the pilot FRP has been implemented, with 10,000 mu of arable land being subsidized for 3 years' retirement [31]. During the retirement period, windbreak and sand-fixing plants will be planted to conserve water and protect plough layer, and an annual subsidy of 800 RMB per mu of the retired area will be provided to support farmers' incomes. Meanwhile, intensive agricultural activities will also be modified, to reduce the negative impact on the environment and to improve soil and water quality. Compiling information on public preferences for the pilot FRP, as well as for the further design of the project, will help to enhance the effectiveness of policy design.


















### 3. Questionnaire Development and Survey Implementation

A well-designed and pretested questionnaire has been used to collect public preferences for the current study. The first part of the questionnaire was a set of warm-up questions which collected respondents' opinions on the current ecological conditions and possible land conservation benefits in Wuwei. The second part was a color-printed information booklet to assist respondents to better understand the core CE tasks in the third part. The information booklet provided full instructions on (1) an introduction to the geographic location and ecological condition of Wuwei, (2) a description of the impacts of FRP on environmental quality (Appendix A), and (3) a detailed explanation of the attributes and their levels (Table 1 and Appendix B) used for characterizing a specific design of the FRP. This information was made possible to maximize the link between FRP and individual wellbeing by the combination of words (consisting of description, cheap talking, and survey protocols) and graphics (including maps, illustrations, photos, and icons). The last part included respondents' self-rated response qualities and their socio-demographic characteristics. Additional aspects of survey design and implementation are summarized in the following sections.

#### 3.1. Attributes and Levels for Valuation

To conduct choice experiments, a systematic process for attributes selection was conducted by combining the findings from earlier studies [13–15,17,22], and with the collaboration of economists, soil scientists, Shiyang River Basin Authority, policymakers from the agricultural department of Wuwei, and members of the stakeholder groups. Our context-specific FRP attributes that are being considered for the project design in Wuwei city include: Area enrolled in the program, duration of the retirement, priority zone for conservation, vegetation type for planting, and annual payment for the FRP per household (Table 1).

**Table 1.** Attributes and levels for choice experiment design.

Attributes	Levels			
<b>Area</b> Total area retired in Wuwei municipality				
	10,000 mu	20,000 mu	50,000 mu	
<b>Priority zone</b> Priority zone for selecting retired areas				
	Sandstorm Reduction	Wildlife Conservation	Surface Water Protection	Groundwater
<b>Duration</b> The retires years of the arable land				
	3 year	5 year	10 year	
<b>Vegetation type</b> Use Priority after the land's retirement				
	Grassland	Shrubbery Land	Woodland	
<b>Payment</b> The inevitable costs per household per year				
	50 yuan	100 yuan	150 yuan	200 yuan











Attributes' levels within the CE have been grounded in the tendency of FRP policies and identified by our expert consultations and field studies. The payment vehicle used in this study is the inevitable increase of household's expenditure every year. Combining level values from both non-monetary attributes (i.e., FRP attributes) and payment attributes, a specific retirement project with its associated cost can be developed. By the use of CE, we can model how respondents trade off different characteristics of an FRP. The estimation results derived from these trade-offs will be used to identify the public preferences for FRP attributes, as well as each attribute's different levels, which can consequently help the Wuwei government to formulate the corresponding details of the FRP.

### 3.2. Experimental Design

Experimental design in CE is the process of generating hypothetical choice sets through a combination of attributes' levels, in order to identify the independent influences of the design attributes [32]. How to determine the structure of the choice sets and allocate the attributes' levels to different choice sets is the key to the experimental design [32–34]. The choice sets generated by the experimental design will largely affect the results of experimental votes, as well as the corresponding benefits for estimation [33]. A “good” experimental design should be able to explain most of the observed variance between the attributes and produce the smallest possible random error [34].

With reference to the standard procedure [35], our experimental design allowed respondents to choose their preferred one from the following four options: (1) Two hypothetical FRP designs to be implemented in Wuwei city, labeled as Option 1 and Option 2; (2) two opt out options, including “I support farmland retirement in general, but my household would/could not pay for either Option 1 or Option 2” and “I would not vote for either Option 1 or Option 2”. Based on our experience of previous CE surveys and a pre-survey in the study area, we found that some respondents believed it was right to vote for ecological restoration options because of the social pressure. However, they were not actually willing to pay the corresponding fees, which caused the payment percentage that we obtained to be more than the percentage that respondents would actually pay. To this end, our choice sets included two opt out options, and the “support but not willing to pay” option was used to avoid the appearance of “fake” payments [17]. During the model estimation process, the two opt out options have been merged. Figure 2 provides an example of the choice questions used in our questionnaire.

#### YOU WILL BE ASKED TO VOTE: EXAMPLE QUESTION

Attribute	Option 1	Option 2
<b>Retired area</b> (10 mu roughly equals one football pitch)	 10,000 mu	 50,000 mu
<b>Priority zone</b>	 Sandstorm Reduction	 Wildlife Conservation
<b>Duration</b>	 3 year	 5 year
<b>Vegetation type</b>	 Woodland	 Grassland
<b>Household Payment</b>	 100 yuan	 150 yuan

Please vote for one of the following four options:

- I would vote for "Option 1", and pay 100 yuan per year.
- I would vote for "Option 2", and pay 150 yuan per year.
- I support farmland retirement in general, but my household would/could not pay for either Option 1 or Option 2.
- I would not vote for either Option 1 or Option 2.

Figure 2. Sample choice experiment question.



It can be seen from Table 1 that the full experimental design has the number of possible choice sets of  $(3^3 \times 4^2)^2 = 186,624$  from the combination of attributes' levels for two FRP options. Due to the large number of choice sets generated by the full factorial design, it is impractical to complete the full sets within a limited budget. Therefore, there is a necessity to optimize the generation as well as the grouping of choice sets using a fractional experiment design. Orthogonal design is the earliest and most widely used factorial experimental design method [32]. However, a growing number of researchers are beginning to question the assumption of the orthogonal design, in which all between-attribute correlations are zero [36–39]. The appearance of optimal design, also called efficient design, has accelerated the development of factorial experimental design by the use of new algorithms to meet the criteria of a good design [34,36]. In particular, the optimal design can account for prior information of the parameters to be estimated, which significantly reduces the asymptotic standard errors of the estimated parameters, and as a result can produce designs that are more efficient than orthogonal design [38,39].

The prior information obtained in this case study came from two aspects [40]: First, the author referred to the economic valuation studies of farmland conservation practices in China [21,22,25,26]; second, a small-scale pilot study was conducted at the place of investigation, generating evidences for such priors. In this paper, 48 choice sets (see an example in Figure 2) were created and simultaneously divided into 12 blocks by optimal design with the help of “Ngene 1.1.1” software. The 48 choice sets were found to have no dominant or redundant alternatives, with D error 0.0013 and A error 0.0210, which reflected the quality of our experimental design. Thus, the questionnaires used in our survey included 12 versions, each of which had 4 choice tasks for each respondent to vote from independently.

### 3.3. Survey and Data Collection

The data used in this article was collected from urban and rural areas of all three districts of Wuwei in the SRB: Liangzhou District, Minqin County, and Gulang County. In the process of collecting data, face-to-face interviews were done by 12 well-trained graduate students from our research team in August 2016. Assistance from our research team was proved to be necessary during our pilot studies because the sample included less educated rural residents who could fail to understand the complicated CE questionnaire. Interviewers could provide clarifications to the respondents and the eligible participants would receive a gift from our interviewers as an incentive. A stratified random sampling procedure was applied, based on the distribution of the population in urban and rural areas. In the urban areas of each district, six to eight street communities were stratified considering their house price, and using the proportional allocation technique, 15 to 20 households were randomly selected from each street community. In the rural areas of each district, four to six townships were stratified considering their geographic distance to the district's central place, two to four villages were randomly selected from each township, and using the proportional allocation technique, 10 to 20 households were randomly selected from each village.

As many as 850 households, 360 from the urban region and 490 from the rural region, were selected. A total of 799 completed surveys were obtained because the other 71 households failed or rejected to be involved in our investigation. Of the received 779 questionnaires, 36 protest responses (“Government-should-pay attitude” or “be skeptical of the settings of choice tasks”) were eliminated from the analysis. In addition, identified by respondents' self-evaluation (e.g., representativeness of whole family, understanding of the choice tasks, conscientious of responding), investigators' observation (e.g., understanding of the choice tasks, cooperation during the survey, using sufficient time to fulfill the questionnaire), another 44 responses were also excluded. Thus, the remaining 699 questionnaires (82.23% of the total selected) were available for further estimation. Descriptive statistics of the socioeconomic characteristics of the received 779 samples and valid 699 samples are shown in Table 2, which also includes the voting characteristics of these respondents.

Due to the low response rate in rural areas (86.7%), we were unable to exactly match the ratio of urban to rural households in Wuwei (41.9% urban to 58.1% rural). The urban-rural ratio of the received

779 samples was 45.4% to 54.6%. The comparisons between the values of 779 samples and 699 samples indicated that there was no evidence of systematic drop out according to the socio-demographic variables and the percentage of opt out options that had been chosen in the 779 samples was higher than that of the 699 samples, which was because the dropped-out samples included a large proportion of protest zeros. Based on these results, we continue the discussion primarily in terms of descriptive statistics for the valid 699 samples.

**Table 2.** Socioeconomic and choice characteristics of respondents.

Variables	N = 779			N = 699		
	Urban	Rural	All	Urban	Rural	All
Number of respondents	354	425	779	319	380	699
Observations	1416	1700	3116	1276	1520	2796
Male	62.11%	69.98%	66.40%	62.38%	69.74%	66.38%
Age	37.05	49.25	43.71	37.01	47.26	42.58
Years of residence	33.94	45.66	40.34	33.30	45.52	39.94
Stay in Wuwei	78.80%	84.25%	81.77%	78.68%	85.00%	82.12%
Years of education	12.46	8.32	10.20	12.49	8.39	10.26
Household size	2.43	4.44	3.52	2.45	4.46	3.54
Household's annual income	51,358	39,967	45,143.4	51,640	39,716	45,158
Option 1 has been chosen	43.13%	40.47%	41.68%	45.4%	42.6%	43.8%
Option 2 has been chosen	39.38%	38.58%	38.94%	41.5%	40.7%	41.1%
Support FRP without pay	15.51%	14.28%	14.84%	12.1%	13.5%	12.9%
Neither options	1.98%	6.67%	4.54%	0.9%	3.2%	2.2%

The proportion of male samples was higher than that of women because interviews were mostly conducted at the respondents' homes, and families often recommended heads of their households to fill out our questionnaires. The average age of the study population was 42.58 years, and their average residence time in Wuwei was 39.94 years, which was 93.8% of their average age. Of these respondents, 82.1% indicated that they would continue to live in Wuwei for the next 10 years. This means that the selected respondents were familiar with the ecological conditions in Wuwei and would take its long-term development into account. The average education level of urban respondents (roughly high school) is higher than that of rural respondents (roughly junior high school), and this was also true in terms of the family income, while the average number of persons per household in the former is less than that of the latter. These characteristics coincided with the socioeconomic conditions of China's urban and rural areas and the corresponding statistical data [27].

A total of 84.94% respondents have chosen one of the two FRP options (Option 1 or Option 2), indicating that most of the residents in Wuwei were willing to pay for the FRP options. There was no significant difference between the proportion choosing Option 1 (43.8%) and that choosing option 2 (41.1%) as the preferred option, which implied that the results generated using the unlabeled design of FRP alternatives were valid and will not result in alternative specific constant terms that vary according to FRP options. In addition, 15.1% of the respondents supported land retirement but were not willing to pay, well above 2.2% of the "vote for either options" option, which indicated that our experimental design could avoid the yea-saying bias by adding the "support but not willing to pay" option. Although the voting proportions of the urban and the rural sub-samples were similar, further tests for the differences in preferences between urban and rural residents should be conducted, considering their different experience with land resources and socioeconomic characteristics.

#### 4. Econometric Specification: Mixed Logit Model

The CE is based on the random utility theory and represents the utility ( $U_{ni}$ ) of an individual  $n$  under a given ecological alternative  $i$  as [41]:

$$U_{ni} = V_{ni}(\beta_n) + \varepsilon_{ni} = \delta(ASC) + \alpha_n(\mathbf{X}_i) + \gamma_n(-P_i) + \varepsilon_{ni} \quad (1)$$

where  $V_{ni}(\beta_n)$  is the observable representative utility based on the parameter  $\beta_n$ , and  $\varepsilon_{ni}$  is the unobservable random part with a probability density function denoted as  $f(\varepsilon)$ .

The representative utility is usually linear [41,42] and consists of three parts: ASC is the alternative specific constant, with a value of 1 when there is a FRP and 0 otherwise indicating the average utility with the presence of FRP; the vector  $X_i$  is the value of the FRP attributes in alternative  $i$ ;  $P_i$  is the inevitable expenditure (i.e., willingness to pay, WTP) in order to achieve the defined FRP alternative  $i$ ; and  $\beta_n = (\delta, \alpha_n, \gamma_n)$  is a parameter vector which reflects the degree of individual  $n$ 's preference for each attributes. The researcher cannot observe  $\beta_n$ , but can make assumptions about the distribution of  $\beta_n$  over the population, that is,  $f(\beta)$ . The distribution of  $\varepsilon_{ni}$ ,  $f(\varepsilon)$ , reflects the influence of the irrational part. When  $f(\varepsilon)$  is a Gumbel distribution, the probability that an individual  $n$  chooses option  $i$  in all  $J$  alternatives can be expressed as:

$$P_{ni} = \text{Prob}(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall j \neq i) = \frac{e^{V_{ni}(\beta_n)}}{\sum_J e^{V_{nj}(\beta_n)}} = \int \left( \frac{e^{V_{ni}(\beta)}}{\sum_J e^{V_{nj}(\beta)}} \right) f(\beta) d\beta \quad (2)$$

If  $\beta_n = \beta$  (that is to say, all the respondents have symmetric taste parameters, and thus  $f(\beta) = 1$ ),  $P_{ni}$  degenerates into the logit probability, and the corresponding discrete choice model is called the multinomial logit model. If  $f(\beta)$  is a continuous probability density function (such as a normal distribution),  $P_{ni}$  can be regarded as a weighted average of the logit probability based on the weight  $f(\beta)$ , and the corresponding model is called the mixed logit model. The mixed logit model is different from other forms of logit models, since the value of  $\beta$  is not a constant but a distribution, which can deal with the variability of people's tastes. Because the mixed logit model can incorporate the random taste variation, the results of model estimation are more robust [41,42] and can reflect the distribution of FRP's benefits within the population, which will deepen the policymakers' understanding of public preferences.

In this paper, all FRP attributes have been considered as categorical variables. This is due to the fact that certain areas and durations are the prerequisites for formulating the retirement project (Appendix B): If the area for retirement is 0, there is no point in discussing the duration, priority zone or vegetation type of the project; similarly, if the duration is 0, it also makes no sense to discuss area, priority zone, or vegetation type. This shows that the choices made by respondents should also be based on a certain area and duration as preconditions. Moreover, when treated as continuous variables, area and duration attributes are constrained to have constant marginal influences on the utility. In contrast, the categorical variables do not need such a limit. Especially when there are fewer levels for an attribute (for example, both area and duration only have three levels), being specified as categorical variables will produce more reliable estimates. For the specification of our four categorical variables, this paper uses the dummy coded method. Considering the ongoing pilot FRP in Wuwei, nine dummy variables have been generated with reference categories of 10,000 mu, sandstorm reduction, 3 years, and grassland, respectively. Thus, the nine FRP dummy variables used for the estimation include: Area 20,000 mu, 50,000 mu; priority zone wildlife, surface water, groundwater; duration 5 years, 10 years; and vegetation type shrubbery, woodland. As a consequence, the parameter estimation for  $\delta$  in Equation (1) will be the marginal utilities of the reference FRP, which is defined by the four un-coded reference categories.

Moreover, all parameters for FRP variables ( $\alpha_n$ ) have been set as normal distributions with mean  $\mu$  and standard deviation  $\sigma_n$ . The parameter for payment attribute,  $\gamma_n$  is specified as a random parameter as well, with a bounded triangular distribution which ensures the negative marginal utility of expenditure [42]. The coefficient on the reference FRP,  $\delta$ , is specified to be fixed to measure the symmetric preference for the reference project to which all other categories will be compared. As literatures have indicated that there are significant differences in the willingness to pay for the protection of farmland between China's urban and rural residents using the contingent valuation method [25,26], this study estimates the utility functions for urban and rural residents separately.



## 5. Estimation Results and Discussion

### 5.1. Model Estimation Results

Table 3 presents the results of Mixed Logit models with 2000 Halton draws accounting for correlations among the four survey responses from each individual (panel data). A likelihood-ratio test indicates that both models are joint significant at the 1% level. Moreover, there are significant influences from the reference FRP and the payment. The result validates that the public has a positive preference for the FRP, and the increase in the payment decreases the probability of an option being chosen, which is in line with the theoretical expectation.

**Table 3.** Mixed logit results: Urban and rural choice experiments.

Parameter Type	Attributes	Urban	Rural
Fixed parameter	Base scenario	−3.345 *** (0.293)	−5.277 *** (0.341)
Random parameters' means ( $\hat{\mu}_n$ )	20,000 mu	1.230 *** (0.271)	1.595 *** (0.269)
	50,000 mu	0.909 *** (0.168)	1.256 *** (0.157)
	Surface water	−1.374 *** (0.215)	−0.223 (0.164)
	Groundwater	−1.614 *** (0.213)	−1.308 *** (0.181)
	Wildlife	−2.947 *** (0.300)	−1.765 *** (0.222)
	5 years	5.101 *** (1.077)	2.250 *** (0.472)
	10 years	1.750 *** (0.188)	−0.522 *** (0.137)
	Shrubbery land	0.094 (0.143)	−0.953 *** (0.172)
	Woodland	1.962 *** (0.217)	−0.044 (0.133)
	Payment	0.025 *** (0.002)	0.035 *** (0.003)
	Random parameters' distributions ( $\hat{\sigma}_n$ )	20,000 mu	0.533 (0.775)
50,000 mu		0.546 (0.445)	0.005 (0.282)
Surface water		0.054 (0.508)	0.007 (0.280)
Groundwater		0.110 (0.500)	1.042 *** (0.283)
Wildlife		0.018 (0.531)	0.929 *** (0.354)
5 years		5.024 *** (1.074)	1.492 *** (0.729)
10 years		0.604 (0.377)	0.004 (0.588)
Shrubbery		0.058 (0.358)	0.539 (0.447)
Woodland		1.567 *** (0.296)	0.095 (0.565)
Payment		0.025 *** (0.002)	0.035 *** (0.003)
Respondents (N = observations)			319 (N = 1276)
Log Likelihood Function ( $\chi^2$ d.f = 20)		−911.043 (977.179 ***)	−1056.875 (1221.637 ***)
McFadden Pseudo R <sup>2</sup>		0.349	0.366

Notes: asterisks \*, \*\*, \*\*\* denote significant level of 0.10, 0.05, and 0.01 respectively; values in the brackets are standard errors of the estimated parameters.

The estimated location parameters of nine FRP dummies ( $\mu$ ) are the average changes of utility in comparison with the utility of the four reference categories. For both rural and urban residents, an expansion of the area enrolled in the program, from 10,000 mu to 20,000 mu or 50,000 mu, has a positive influence (1.230 or 0.909 for urban households and 1.595 or 1.256 for rural households) on the utility; extending the duration of the retirement from 3 to 5 years will also significantly increase the utility (5.101 for urban households and 2.250 for rural households). Urban residents' average preference for 10 years (1.750) is significantly more than the reference category 3 years; for sandstorm reduction is significantly higher than other levels of the priority zone (−1.374, −1.614, and −2.947 for surface water, groundwater and wildlife, respectively); and for grassland has no significant difference with shrubbery land, but lower than woodland (1.962). For rural residents, their average preference for 10 years (−0.522) is significantly lower than the reference category 3 years; for sandstorm reduction is statistically the same with surface water, but higher than other levels (−1.308 and −1.765 for groundwater and wildlife, respectively); and for grassland is the same with woodland, but higher than shrubbery land (−0.953).

Both urban and rural residents agree that increasing the area enrolled in the project to 20,000 mu and the period to 5 years are the optimal design of the project. The public's average rankings of different attributes' levels reveal a certain pattern in the perceived importance as area and duration increase: Public preferences first increase and then decrease with the expanding scale of land retirement.

These results strengthen findings confirmed by other studies that long-term land retirement becomes less preferred as it reduces the flexibility of the project [15,43] and self-rehabilitation of the soil [44]; and soften conclusions that a greater magnitude of the estimated parameter is associated with a larger protected area [17,45]. Our results are also associated with the stage of China's FRP. Due to the current land retirement policy still being in the pilot phase, long period (for 10 years) and excessive area (for 50,000 mu) of the set-aside may lead to a decrease in cultivated land and raise problems such as food supply, as well as farmers' livelihood security.

Both urban and rural residents agree that the primary environmental threat to the basin comes from *sandstorm*, while *wildlife conservation* is of the least importance. This is because Wuwei, as one of the most serious desertified areas in the country, is seriously endangered by sandstorms. At the same time, its population of wildlife is relatively low, yet has not been given enough attention by local residents. In the aspect of vegetation type for planting, urban residents have a significantly higher preference for *woodland*, while rural residents' preference for *woodland* is statistically the same with *grassland*. The possible reason is that *woodland* has the highest landscape and carbon storage value and thus favored by urban residents. In addition to taking the landscape and carbon storage value into consideration, our surveyed rural residents had concerns that planting trees may damage the soil's physical properties for crop production after expiring the FRP. *Surface water* and *grassland*, which are essential for development for irrigated agriculture and sheep farming, have also been favored by rural residents.

The estimated standard deviations of random parameters reflect the distribution of individual preferences for each variable in local households. The insignificant standard deviations mean that the corresponding preferences do not vary in the population. For example, the estimated parameters of 50,000 mu, *surface water*, 10 years, and *Shrubbery* have insignificant standard deviations, implying that urban and rural residents have systematic preferences for those variables. While significant standard deviations mean that residents' preferences for FRP dummies follow a normal distribution, and thus can be used to calculate the population proportion processing positive or negative preferences. The most division in support among urban households is the preference for 5 years, with a mean of 5.101 and standard deviation of 5.024, which indicate that 84.5% of respondents' utilities (right-sided area of the normal distribution) would be increased, while the other 15.50% of respondents' utilities would be decreased; and among the rural households is the preference for 20,000 mu, with a mean of 1.595 and standard deviation of 1.400, which indicate that 87.3% of respondents' utilities (right-sided area of the normal distribution) would be increased, while the other 12.7% of respondents' utilities would be decreased. These results reflect the advantages of using the mixed logit model, which relaxes the assumption of "independent from irrelevant alternatives" with respect to the multinomial logit model [41], and help us get a deeper understanding of public preferences by revealing the unevenly distributed benefits both within, and between, urban and rural residents.

## 5.2. Welfare Analysis

The respondents' willingness to pay (WTP) for the design of FRP schemes, which refers to the marginal rate of substitutions of the FRP dummy variables against the payment attributes in Equation (1), can be expressed as  $\alpha_n/\gamma_n$ . Because  $\alpha_n$  and  $\gamma_n$  in the mixed logit model specified in this paper are both random parameters, the ratio distribution of  $\alpha_n/\gamma_n$  is unknown, and the implicit price cannot be directly derived from the two random variables. Our study calculates the empirical distribution of implicit prices through a simulation method [42–47], using the estimated mean matrix and covariance matrix from mixed logit models. Table 4 illustrates the estimated implicit prices for both rural and urban residents separately, along with their differences. The 5th and 95th percentiles of the implicit prices' empirical distributions are also shown in Table 4, which corresponds to the critical values for a 90% confidence interval.

**Table 4.** Implicit prices and their differences for urban and rural choice experiments.

Attributes	Urban		Rural		Difference (Urban–Rural)	
	WTP	CI (5%, 95%)	WTP	CI (5%, 95%)	WTP	CI (5%, 95%)
Base scenario	185.22	(160.35, 215.53)	212.21	(188.99, 238.99)	−26.99	(−63.88, 11.04)
20,000 mu	67.48	(45.33, 90.44)	64.02	(46.12, 81.74)	3.46	(−25.30, 33.06)
50,000 mu	49.60	(36.60, 62.63)	50.22	(41.21, 59.48)	−0.62	(−16.90, 15.59)
Surface water	−76.33	(−99.75, −55.33)	−8.91	(−19.28, 1.70)	−67.42	(−93.29, −43.84)
Groundwater	−89.16	(−110.32, −70.03)	−52.54	(−65.85, −39.94)	−36.62	(−61.60, −12.75)
Wildlife	−162.68	(−193.33, −136.55)	−70.72	(−87.23, −56.42)	−91.96	(−125.87, −61.21)
5 years	283.16	(191.04, 375.12)	89.90	(62.21, 117.01)	193.26	(99.06, 289.01)
10 years	96.20	(81.34, 113.12)	−21.04	(−31.54, −11.33)	117.24	(99.25, 137.46)
Shrubbery land	4.94	(−8.46, 18.52)	−38.57	(−50.94, −26.56)	43.50	(25.73, 61.57)
Woodland	108.35	(87.29, 130.55)	−1.62	(−10.76, 7.31)	109.97	(87.40, 134.20)

The implicit prices can be considered as the average annual benefits each household derived from the implementation of FRP. In the case of the ongoing pilot FRP (10,000 mu and 3 years) in Wuwei, if *sandstorm reduction* and *grassland* are also designed as the package for conservation—the reference FRP, urban residents are willing to pay 189.63 RMB per year, accounting for 0.37% of urban households' annual income; rural residents are respectively willing to pay 211.33 RMB per year, accounting for 0.53% of rural households' annual income. The average WTP for the reference FRP of rural residents is higher than that of urban residents, but the difference is not significant. The ratio of WTP value to income estimated in our study is comparable to what people would be willing to pay for other farmland protection policies in other parts of China, and was around 1% [21,22,25,26]. According to the Statistical Yearbook of Wuwei [27], the total number of households in urban and rural areas were 0.22 million and 0.31 million, respectively. Therefore, the annual total WTP for the reference FRP amounts to 105.94 million RMB, with a 90% confidence interval of (93.33, 120.84) million RMB.

The implicit prices of 20,000 mu and 50,000 mu of urban residents are the same with rural residents. However, urban residents' WTPs for longer retirement years (from 3 years to other levels) of duration are particularly larger than rural residents, which are 202.41 RMB and 120.42 RMB for 5 years and 10 years, respectively. These findings indicate that longer contract periods are generally preferred by urban residents compared to rural residents. The possible reason is that the change of social benefits caused by FRP is not evenly distributed between urban and rural samples. Rural residents are more likely to take the risks caused by land retirement than urban residents [48]. Urban residents have higher WTPs for levels of vegetation type attribute, but lower WTPs for levels of priority zone attribute than that of the urban residents. When deciding the use of arable land, food production should be front of mind for farmers whose acceptance of retiring land to shrubbery or tree covers is lower than urban residents, and thus a lower WTP for priority zone attribute. Meanwhile, rural residents' production and daily activities are more likely to be affected by environmental conditions, thus a higher WTP for priority zone attribute is observed.

Implicit prices can also be used to determine which factors are most valued by the public and to help policymakers assign more resources to those factors in designing the FRP. For the urban residents in Wuwei, a combination of 20,000 mu enrolled area, 5 years contract length, *sandstorm reduction* as the priority zoo, and *woodland* as the vegetation type would be the preferred FRP, while for the rural residents the combination would be 20,000 mu enrolled area, 5 years contract length, *sandstorm reduction* or *surface water* protection as the priority zoo, and *woodland* or *grassland* as the vegetation type. Therefore, for Wuwei, the optimal combination of policy design should be the one preferred by urban households, which would also be preferred by rural households at the same time. At this point, the annual WTP for the preferred FRP can be calculated by adding the implicit prices of attributes' corresponding levels and the reference FRP, which are 644.21 RMB and 364.51 RMB for urban and rural residents, respectively. As a result, the annual benefits of the preferred design of the FRP amount to 253.96 million RMB, about 2.72 times that of the reference project.

## 6. Conclusions and Policy Implications

This study has analyzed the benefits of China's pilot FRP through the conduction of choice experiments in urban and rural areas of Wuwei. The public's multi-dimensional preferences for the design of the project has been investigated for the first time to inform policymakers about which dimension of the project can be designed. The results reveal that, on average, social benefits will be improved due to the implementation of the FRP and the public's WTP is closely linked to the area enrolled in the project, duration of the contract, priority zone for conservation, and vegetation type for planting. Moreover, significant preference variations are found among residents and differences in WTP estimates between urban and rural residents are particularly large for longer retirement years. Results can be used to forecast social benefits derived from the FRP and thus to provide the basis for delivering the most beneficial FRP policies.

The most important implication to draw from our study is that the current scale of China's FEP could potentially be broadened to properly improve public benefits. Considering that the current FRP in environmental degradation area of Wuwei is a three-year, 10,000 mu contract, the duration can be moderately increased to five years by extending or renewing the contract, and consideration should be given to expanding the subsidized area in Wuwei from 10,000 mu to 20,000 mu to further increase the social benefits. However, if policymakers increase the duration from 5 years to 10 years, and the retired area from 20,000 mu to 50,000 mu, there will be a decline in social benefits. Therefore, the implementation of the FRP needs to balance the improvement of ecological condition and the development of agricultural production, as well as avoid blindly expanding the duration and areas of the FRP. In addition, although the FRP in Gansu province is aimed at the practice of ecological restoration, it is still necessary to design the retirement project in conjunction with the particular context of local ecological conditions. In the case of Wuwei, public preferences for *woodland* and *sandstorm reduction* are significantly higher than other levels of the priority zone and vegetation type attributes, respectively. This means that, by considering the demand for sandstorm reduction and the need for landscape aesthetics and carbon storage, a more beneficial land retirement project in Wuwei will be formulated.

The results in our study also indicate that public preferences varied between urban and rural residents. In general, urban residents are likely to receive more benefits from a longer period of the project, as well as retiring the farmland to *shrubbery land* and *woodland*, but have lower WTPs for improvements in *surface water*, *groundwater*, and *wildlife* than rural residents in Wuwei. The significant differences between urban and rural residents' WTPs for land protection policies, which can also be found in other stated preference studies [25,26], are tied to China's urban-rural disparity from the perspective of livelihood sources and quality of life. Further studies should also provide evidence-informed guidance on whether and how WTP differences are affected by attitudinal and socioeconomic factors. Despite these differences, the combination of 20,000 mu enrolled area, 5 years contract length, *sandstorm reduction* as the priority zoo, and *woodland* as the vegetation type is perceived the most beneficial policy design for both urban and rural residents. Accordingly, our study offers avenues for maximizing the joint benefits of urban and rural residents in Wuwei. The annual benefits of adding the preferred attributes' levels amount to 253.96 million RMB, which can be used to cost-effectively promote the implementation of FRP.

In conclusion, the analysis of public preferences for FRP in this paper has not only reflected the importance of sustainable management of land resources to the public, but also provided a basis for potential policy improvement. The information provided here suggests a possibility of using the CE approach for investigating public preferences for land retirement policies in China, and serves as proof of concept for other countries considering ecological restoration through agricultural policies. However, the results derived from our paper are a site-specific study in Gansu province where reducing ecosystem degradation is the key policy objective, and we cannot simply transfer the results of our preference analysis to other policy sites with different retirement objectives. For example, the main objective of the FRP implemented in Hebei province is to reduce the use of groundwater, while the



main purpose of the FRP implemented in Hunan province is to treat heavy metal polluted areas. Further research is still needed to help policymakers be more knowledgeable about public preferences in different policy sites. In addition, landowners' participation in the FRP is the key to achieving policy objectives, thus the study of their willingness to participate will also provide relevant insights. Research on the supply side will increase the probability of delivering the FRP, hence reducing implementation costs. These and other issues all need to be improved in further studies.

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## Appendix A

### What is Farmland Retirement Project?

The city of Wuwei is an ecologically fragile area, facing the threat of the water resources scarcity, land desertification, vegetation degradation and sandstorm hazards. **Farmland retirement, is a way in which the taxpayer subsidizes the conservation of arable land by the replantation of plants that can break wind and fix sand, conserve water, and protect plough layer. At the same time, agricultural activities will be reduced to improve local ecological conditions.**

In Wuwei, farmland retirement can alleviate land desertification on the edge of the desert, reduce land salinization of the irrigation areas, prevent the decline of groundwater level, lower the risk of surface water pollution, and increase the living spaces for wild animals.





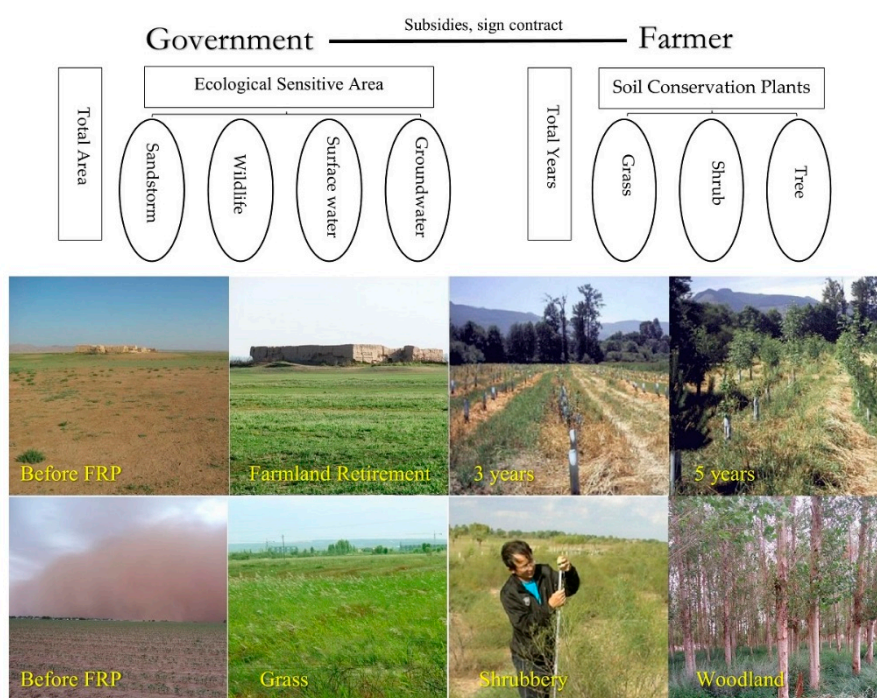
## Appendix B

### How to Implement Farmland Retirement?

**Government formulates plans**, including **area**, such as 10,000 million mu, 20,000 mu or 50,000 mu; and **priority zone**, such as, sandstorm reduction, wildlife conservation, surface water protection and groundwater protection.

**Farmers participate farmland retirement plans voluntarily**, carrying out 3 years, 5 years or 10 years' **duration of the retirement**; and **planting vegetation** such as grasses like alfalfa and stipa capillata, shrubs like hedysarum mongolicum and Artemisia annua or trees like tamarisk, and populus.

**Sign the contract**. During the contract period, farmers will be subsidized and their arable land will be replaced with windbreak and sand-fixing plants, water-conservation plants or tillage-protected plants to improve local ecological conditions. Farmers can decide how to use of arable land after expiring the contract. Subsidies of the contract come from the increased cost of living in each urban and rural household.



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