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Factors Influencing Farmer Willingness to Fallow Winter Wheat and Ecological Compensation Standards in a Groundwater Funnel Area in Hengshui, Hebei Province, China

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Abstract: Land use/land cover change will have a certain impact on the regional ecological environment. This study uses the questionnaire survey method, an opportunity cost method and a logistic model to evaluate the suitability of an ecological compensation standard for a winter-wheat-fallow cropping system in a groundwater funnel area in Hebei. The main factors affecting farmers' willingness to fallow fields provide a theoretical basis for scientifically and rationally developing a rotation policy in the groundwater funnel area. The results indicate the following: (1) nearly 87% of the surveyed farmers would accept a winter-wheat-fallow policy, whereas 13% would not; (2) farmer educational level, the total number of participants in the agricultural labor force, dependency rate, farmers' attitudes toward a winter wheat-fallow policy in the groundwater funnel area and the farmer level of trust in government policy have significant positive effects farmer intention to fallow, whereas the number of days of participation in farming, the cultivated land quality and the per capita area of cultivated land have a significant negative effect on farmers' fallowing intentions; (3) considering only the impact of winter wheat on groundwater, the proposed compensation standard for farmers who accept the policy is 0.00095 $/hm^2; (4) some policy implications are put forward to improve the effectiveness of the winter wheat fallowing policy in the groundwater funnel.

Keywords: land use; land fallow; farmers' willingness; compensation standard; winter wheat-fallow; logistic model; China

1. Introduction

Land use/ land cover change will have a certain impact on the regional ecological environment [1]. At the Fifth Plenary Session of the 18th CPC (Communist Party of China) Central Committee in 2015, Chinese president Xi Jinping introduced the "CPC Central Committee Three-year Plan for National Economic and Social Development". He noted that China's cultivated land development and utilization intensity are excessive [1]: after long-term development in some areas, soil fertility has been seriously depleted, soil and water loss [2] are ongoing, groundwater has been over-exploited, and soil degradation and non-point source pollution have become prominent challenges restricting sustainable agricultural development. The North China Plain is one of the regions with a water resource shortage and is a typical sensitive groundwater zone [3]. However, the main water supply source for this region is groundwater, and the natural factors of climate and precipitation on the North China Plain have a great impact on groundwater resources [4]. At present, the water resources in northern China are heavily utilized, and groundwater exploitation in this area accounts for 69.81% of the total water consumption. The North China Plain is the largest grain-producing area in the country, accounting for 78.82% of the total yield [5]. In recent years, the North China Plain grain yield has increased each year; simultaneously, however, the North China Plain is also facing multiple resources and environmental challenges. Food production has created soil erosion, groundwater overexploitation, soil degradation and other issues, which have become a constraint to the North China Plain agricultural sustainable development of the outstanding contradictions [6]. In northern China, farmers use unrestricted amounts of groundwater for irrigation, causing annual groundwater declines. Furthermore, winter wheat is considered the most water-consuming agricultural product in northern China, thus leading to serious over-exploitation of groundwater [7]. Groundwater over-exploitation has a series of negative consequences including environmental change [8,9], decreased groundwater, seawater intrusion and land subsidence [10]. Groundwater requires a long time for restoration. Because of the over-exploitation of groundwater in Hebei, Beijing and other places in the past 30 years, the already shallow groundwater levels have generally decreased by 0.02–0.04 km, in Hebei Province, the groundwater level dropped significantly, reaching an average groundwater depth of 0.01857 km. The groundwater depth was 0.10723 and 0.1014 km in Hengshui Jing County, and Zaoqiang, respectively. Thus, groundwater management on the North China Plain should address the issue of over-exploitation [11]. Appropriate seasonal fallowing is beneficial for the recovery of groundwater. In the "13th Five-year Plan", the state proposed to explore the implementation of a rotation and fallow system. During the severe drought and water shortage in Hebei Province, a seasonal fallow was implemented for many years in the HeiLonggang groundwater funnel area (ChangZhou, Heng Shui, Xingtai, etc.). Winter wheat grown with irrigation water must be allowed to fallow to reduce the groundwater burden, which requires a change in the planting pattern; in addition, during the fallow period, only those crops that consume less water, such as spring maize, summer maize, potatoes and drought-resistant Zadou barren grains, should be planted [12] to reduce the amount of groundwater used. Ecological compensation [13] refers to the preservation and restoration of ecosystems, ecological function or ecological value, in a certain ecological function area; this compensation is provided for a special population of farmers who abandon production in some areas to bring economic losses. Ecological compensation is often referred to as Payments for Ecosystem/Environmental Services (PES) in foreign literature. Fallow farming ecological compensation is payment given to farmers who, in accordance with the requirements of the government, allow all or part of their cultivated land to fallow and take appropriate protective measures. The government uses economic means to provide a remedy for the loss of its interests [14,15]. Several factors influence winter-wheat fallow, including farmer personal characteristics, family and production and management characteristics, cultivated land state, and farmer response to the national policy system. Discussing these factors and the ecological compensation standards is of great theoretical and practical value for China to scientifically and reasonably implement rotation and fallow systems in the groundwater funnel area.

Many studies have evaluated farmer willingness to fallow. Reimer et al. [16] analyzed the reasons for the large differences in the farmer participation rate in Environmental Quality Incentive Program (EQIP) projects in 50 states in the United States. They found that the individual characteristics of farmers, farm size, the sale of agricultural products and environmental expenditure by the federal government affected farmer willingness to participate in agricultural environmental policy in western Ireland; a preference calibration model was used to analyze the economic effects of a grassroots agricultural environmental policy. It was found that producers were very sensitive to market or policy incentives and that the appropriate economic subsidies could not only effectively promote the supply of farmland ecological environment but also significantly improve the level of family welfare [17]. J.H. Sitterley et al. studied factors affecting farmland fallow rates on an Ohio farm [18]. Lohr and Park used survey data from counties in Illinois and Michigan to construct a two-step probability model to analyze the factors that affected the willingness of the farmers to fallow, assuming that the respondents were willing to participate in the fallow [19]. Joseph C. Cooper et al. (1998) used survey data on farmer willingness to build a discrete selection model and a stochastic utility model. They used these models to calculate the ratio of farmers willing to maintain the US "protection and reserve plan" contract and corresponding subsidy standards [20]. Wang et al. [21] used a multi-level logit model to analyze the influencing factors in a cropping system and calculated the opportunity costs in Cangzhou County. ZUO Zhe-yu [22] used a contingent valuation method to study farmer willingness to pay for water-saving irrigation in groundwater over-exploitation areas in Hebei. Li Fen [23] used a questionnaire and a multivariate logistic method to analyze the main factors that affect ecological compensation and the willingness of peasant households to fallow in the Poyang Lake area and also proposed relevant policy suggestions. Han Peng et al. [24] evaluated an ecological compensation policy formulation that was targeted at fragile ecological zones and based on the logistic method to analyze farmers' willingness to accept compensation.

There are also several studies on opportunity cost. "Opportunity cost" was first proposed by Friedrich von W, a famous American economist and Austrian scholar, in his book "Natural Value". At present, many methods are used to determine ecological compensation standards, including the opportunity cost method, the willingness survey method, the ecosystem service function value method, and economic model method. Among these methods, the opportunity cost method is the most widely used to determine ecological compensation standards both domestically and internationally [25,26]. Yong Xinqin [27] used this method to determine the compensation standard for paddy field and dryland protection in Zhangjia Village, Mao Town, Tongshan County [28]. Yuan Peng used a hyperbolic model of the technical efficiency and municipal sample data to analyze the opportunity cost of China's industrial environmental control. Hu Zhentong collected data on 470 herdsmen in Inner Mongolia and used the opportunity cost method to estimate the standard of grazing ban and develop policy recommendations [29]. Additionally, ecological compensation projects in the US, such as The United States Conservation Reserve Program (CRP) and EQIP [30], and in Colombia, Costa Rica, Nicaragua and other countries predominantly apply the opportunity cost method to develop ecological compensation standards [31,32].

The above literature is widely available, and existing literature mainly focuses on the reasons for groundwater overexploitation on the North China Plain. However, extant research does not have sufficient depth, such as information about the factors influencing farmers' willingness to implement winter-wheat fallow in a groundwater funnel area, the rationality of compensation standards, and the effect of the implementation of the policy of compensation for fallowing. The Chinese government has introduced a number of relevant policy measures, such as the "Notice of Hebei Province People's Government on the printing and distributing a pilot program for comprehensive treatment of the overexploitation of groundwater in Hebei (2015)" and the "Hebei Provincial Department of Agriculture, Hebei Provincial Department of Finance issuance of 2015 annual groundwater overdraft comprehensive management of Hebei notice of a pilot program for agricultural planting structure and agronomic water-savings-related project implementation"; the purpose of these policies is to guide farmers to change their planting habits, with the goal of "a decrease in the area sown with winter wheat that proves to be a practical strategy to reverse groundwater overexploitation and to promote groundwater storage" in order to slow the overexploitation of groundwater. The present study aims to examine this policy based on a case study of Hengshui, Hebei Province; a questionnaire was used to elucidate factors such as the willingness of farmers to implement winter-wheat fallow, the input and output of agricultural products and farmers' responses to the fallowing policy system. The responses were used to analyze the influencing factors of seasonal fallow and the willingness of farmers to implement this practice. The opportunity cost method was used to analyze the efficacy of a subsidy of 0.00092 $/hm^2$, which is prescribed by government [33].

The main contributions of this paper are as follows. First, it analyzes the factors influencing farmers' willingness via a logistic model, the results of which can provide a theoretical basis for the development of a reasonable fallowing system for cultivated land in China. Second, it uses data collected directly from individual farmer households, which increases the robustness of the results.

2. Methods and Data Sources

2.1. Study Area

The study area, Hengshui City, is approximately 8815 km^2 in size and is located in the southeastern part of Hebei Province, between longitude 115°10′–116°34′ and latitude 37°03′–38°23′ north. Hengshui City is located on the Hebei alluvial plain, and the terrain slopes from the southwest to the northeast. The soil is dominated by light soil, with sandy soil or clay, and the area is within a continental monsoon climate zone, which is a warm semi-arid type. In the research area, agricultural water consumption accounted for 90.08% of the total local groundwater consumption [5]. The study area was mainly planted with winter wheat, summer corn, and spring corn. The local agriculture focuses on two crops per year, such as winter wheat/summer maize or winter wheat/spring maize, in the non-fallowed areas. The region is a deep-groundwater overexploitation area; due to the shortage of surface water replenishment, a reduction in winter wheat acreage is necessary. Hence, to address Hengshui's situation, a policy to adjust planting patterns and to promote winter wheat water-saving and sustainable production was introduced by the government in 2015. At present, the fallow area is mainly planted with a single-cropping system, such as spring maize, summer maize, peanuts, cotton, or various cereals to achieve a "decrease in area sown with winter wheat as a practical strategy to reverse groundwater overexploitation and to promote groundwater storage." Increasing the yield potential, which is dependent on rain and temperature in the autumn, will help to minimize the impact of fallowing on food security.

2.2. Methods

Willingness to fallow was recorded as willing/unwilling and is therefore a binary variable. Accordingly, a binary logistic regression model was used to analyze the factors influencing farmers' willingness to practice winter wheat fallowing in non-fallowed areas. The opportunity cost method was used to calculate the compensation standard for winter wheat farmland.

2.2.1. Logistic Models

The dependent variable involved is the willingness of the farmer to fallow, which is a binary discrete variable, and does not conform to the statistical significance of the normal distribution and cannot be estimated by the least squares method. Therefore, it does not meet the general linear regression constraints and cannot directly use multiple linear regression.

The factors that affect farmers' willingness to fallow include a wide variety of options that combine to indicate willingness to fallow or unwillingness to fallow. The measurement model established as an explanatory variable with such a decision result is called a binary selection model. Since the explanatory variable of the binary discrete selection model is nonlinear, it needs to be transformed into a utility model for evaluation. The logistic model is a binary discrete selection model with logical distribution as the probability distribution of random error terms, thus it is suitable for the analysis of the selection behavior according to the utility maximization principle. It is the most ideal and the most widely used model to analyze the individual decision-making behavior [34–37].

This paper then uses a binary logistic model to analyze the influencing factors of farmers' willingness to implement winter wheat fallow. Farmers who live in Hengshui exhibited two main types of willingness with respect to accepting compensation for winter wheat fallow: unwillingness defined as 0, or willingness defined as 1. Pi is the probability of willingness to fallow, and $1 - P_i$ is the probability of non-willingness to fallow. The logistic model was constructed as follows:

$$\log\left(\frac{P_i}{1-P_i}\right) = b_0 + b_1x_1 + b_2x_2 + \cdots + b_nx_n + \varepsilon \quad (1)$$

where b_0 is a fixed intercept; x_1, x_2, x_n and b_1, b_2, b_n respectively represent the explanatory variables and coefficients; and ε is a random disturbance term wherein the effect is random with respect to the influence of y. The internal impact factor is random and independent, the effect of x on y is determined, and x is independent of random items that do not affect each other.

According to a government-issued document in 2015, the pilot program involved 44,400 hm^2 in Hengshui City, but the current fallowing target by country was not reached. Thus, farmer willingness was set as the explanatory variable, with willingness coded as "1" and unwillingness coded as "0." Explanatory variables were categorized into four categories: farmer personal characteristics, family and production and management characteristics, cultivated land state, and farmer response to the national policy system. Description of these variables and variable assignments is provided in Table 1.

Table 1. Descriptions of the influencing factors.

Level-One Variable	Level-Two Variable	Variable Definition	Expected Direction of Action
Farmer personal characteristics	Age	Under 30 years old = 1; 30–40 years old = 2; 40–50 years old = 3; over 50 years old = 4	+
	Gender	Male = 0; Female = 1	+
	Education level	Primary school or below = 1; junior middle school = 2; high school or secondary school = 3; college or higher = 4	+
Family, production and management characteristics	Number of days involved in farming	Time engaged in farming	–
	The total number of agricultural labor force	Number of people engaged in agricultural production	–
	Farmers' occupation	Pure agricultural farmers = 0; farmers with concurrent business = 1	+
	Dependency ratio	The number of farm laborers divided by the total population	+
	Use of machinery	Yes = 1; No = 2	?
Cultivated land state	Cultivated land quality	One and two farmland area divided by the total farmland area	–
	Per capita area of cultivated land	The total land area divided by the total household population	–
Farmer response to the national policy system	Attitude of farmers toward winter wheat fallow in the underground funnel area	Non-supportive = 1; moderate attitude = 2; supportive attitude = 3	+
	Farmers' level of trust in government policy	No trust = 1; not much trust = 2; more trust = 3; much trust = 4	+

Note: Cultivated land quality is divided into four classes: class one involves to yields of winter wheat from good land that were greater than 0.00083 kg/hm^2; class two involves yields from relatively good land of 0.00074–0.00083 kg/hm^2; class three involves yields from relatively poor land of 0.00064–0.00074 kg/hm^2; and class four involves yields from poor land of less than 0.00064 kg/hm^2.

2.2.2. Opportunity Cost Method

In the study area, the economic bottom line for accepting the fallowing policy was that the ecological compensation was sufficient to compensate for economic losses due to the abandonment of winter wheat planting. Without considering the cost or with an assumption that the direct cost is zero [38], when the ecological compensation is greater or equal to the opportunity cost, farmers become willing to implement winter wheat fallow.

(1) The opportunity cost method was used to determine the compensation standard for winter wheat-fallow as follows:

$$C = \alpha_1 - \alpha_2 \quad (2)$$

where C is the opportunity cost of winter wheat, α_1 is the net income of the plots before fallowing the farmland, and α_2 is the net income after fallowing the farmland. When $\alpha_1 < \alpha_2$, rational farmers choose to participate in letting winter wheat fields lie fallow, which indicate that farmers who participate in ecological compensation can benefit; when $\alpha_1 = \alpha_2$, most of the farmers choose to continue to participate in letting winter wheat fields lie fallow, indicating that farmers who fallow their farmland were not affected. When $\alpha_1 > \alpha_2$, rational farmers may be reluctant to participate in fallowing farmland, indicating that farmer participation in fallowing farmland was impaired. When the net gain of spring maize planting was similar to the net gain of summer maize, the opportunity cost was equal to the net income from winter wheat; when spring corn was not equal to summer maize, the opportunity cost was equal to the difference between a double-cropping and single-cropping system.

(2) Net income of crops:

$$\alpha = P \times Y - \alpha_1 - \alpha_2 - \alpha_3 - \alpha_4 - \alpha_5 - \alpha_6 \quad (3)$$

where P is the sale price of agricultural products ($/kg), Y is the crop yield (kg/hm^2), α_1 is the seed input cost (kg/hm^2), α_2 is the cost of pesticide inputs (kg/hm^2), α_3 is the seed irrigation input cost (kg/hm^2), α_4 is the cost of fertilizer inputs (kg/hm^2), α_5 is the mechanical input cost (kg/hm^2), and α_6 is the labor input cost ($/days).

(3) Labor input costs:

$$\alpha_6 = \mu \times k \quad (4)$$

where α_6 is total labor input (days), μ is the shadow wages of the labor force, and k is the unit labor input (days/hm^2).

(4) The shadow wages of the labor force:

$$\mu = \varepsilon \times \frac{T}{\alpha_6} \quad (5)$$

where T is the total agricultural income ($), α_6 is the total labor input (days), and ε is the elastic coefficient of labor input. The Cobb-Douglas production function was created by mathematician Cobb and economist Paul Douglas to study the relationship between input and output [39,40]. It was used to estimate the model as follows:

$$\ln T = d_0 + d_1 \times \ln L + d_2 \ln \alpha_6 + d_3 \ln I + \sum (d_4 \times \theta) + \varepsilon \quad (6)$$

where d_0 is a constant term; L is the land area; α_6 is the total labor input (days); $\ln L$ is the capital input; d_0, d_1, d_2 and d_3 are the elastic coefficients; refers to external factor such as farming condition, climate factors and force characteristics; d_4 is the influence corresponding coefficient of total agricultural income; and ε is a residual term.

2.3. Data Sources

All of the data in this study come from a farmer survey questionnaire distributed in Hengshui, Hebei Province between July and mid-August 2016. The sample selection of farmers was obtained through stratified sampling and random sampling. According to the principle of uniform distribution, a total of 26 households were randomly selected from each of the eight districts (three cities and five counties). The entire research process included the pre-research and formal research. To assess the reliability of the data, we conducted our own household research and research objectives without government officials. The site selection method identified villages that are heavily irrigated by groundwater with an underground funnel and selected parts of the fallow areas and undeveloped areas. The specific research area included Jing County with Wangqian Temple and Beiliuzhi Town, in which a total of 26 questionnaires were obtained from two villages; Shenzhen City of Datun Township, Yuke Township and Gaoguzhuang Town, in which a total of 27 questionnaires were obtained from five villages; Anping County of Daziwen Township, in which a total of 27 questionnaires were obtained from four villages; Wuyi County of Heyan Town, Dengjiazhuang, in which a total of 23 questionnaires were obtained from five villages; Jizhou City of Guandaoli Township, Xiaozhai Township and Zhaochuan Town, in which a total of 32 questionnaires were obtained from six villages; Zaoqiang County of Tanglin Township, Xiao Zhang Zhen and Zaoqiang County, in which a total of 31 questionnaires were obtained from eight villages; Peach District of Hengshui City, in which a total of 10 questionnaires were obtained; and North Township, Zhou Wozhen and Sun Village of Wuqiang County, in which a total of 36 questionnaires were obtained from eight villages (see Figure 1). A total of 212 questionnaires were collected, of which there were 198 valid questionnaires, accounting for 93.4%. The main contents of the questionnaire include the characteristics of household decision-making, family and production and management characteristics, cultivated land status and farmer response to the national policy system, etc.

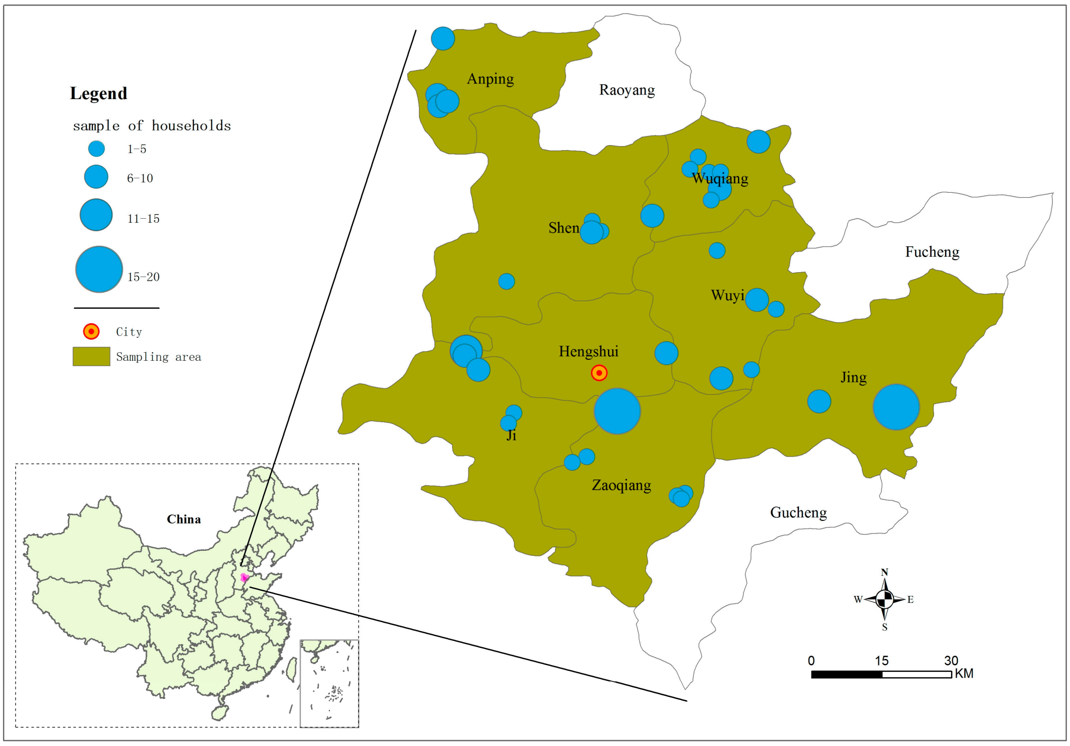

Figure 1. Distribution of survey samples.

3. Results and Analysis

3.1. Farmers' Willingness to Implement Winter Wheat Fallowing and Descriptive Statistical Analysis of Each Influencing Factor

In general, the responses toward fallowing were positive. More than 87% (172) of respondents indicated that they were willing to fallow, while 13% (26) were not (see details in Figure 2).

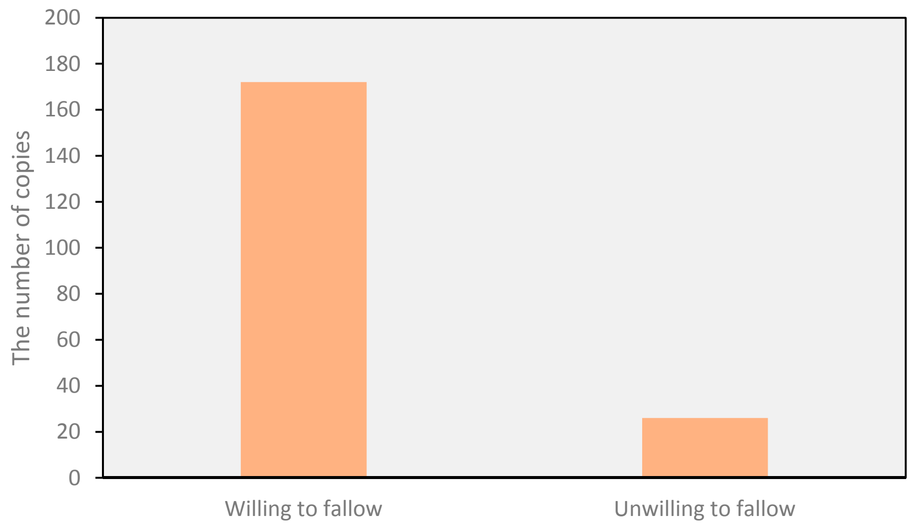

Figure 2. Farmer willingness to fallow winter wheat.

A small proportion of the farmers were reluctant to accept ecological compensation to fallow. We found that there were two main reasons for this. First, ecological compensation is lower than the income from planting winter wheat. Second, farmers rely on arable land and believe that planting winter wheat guarantees their livelihoods.

Combined with the existing references and the questionnaire content, the factors influencing willingness to fallow were divided into four groups: a farmer's personal characteristics [41,42], family and production and management characteristics [43–45], cultivated land status [16,46], and farmer response to the national policy system [43,46]. The descriptive statistical analysis of the relevant variables is shown in Table 2.

Figure 3 shows the frequency of observed values that influence the farmers' willingness or unwillingness to fallow, including the proportion of education level, the attitude of farmers toward winter wheat fallow in the underground funnel area, and the farmer degree of trust in government policy. The level of education of farmers who willing to fallow is higher than the level of education of those unwilling to fallow; also, the number of farmers who are willing to fallow is higher than the number who are not willing to fallow in the groundwater funnel area. At the same time, it is not difficult to see that farmers who are willing to fallow exhibit a higher degree of trust in government policy than those who are not willing to fallow. From Figure 3, we conclude that education level, attitude of farmers toward winter wheat fallow in the underground funnel area, and farmer degree of trust in government policy have an obviously positive impact on the willingness to follow.

Table 2. Descriptive statistical analysis.

Level-One Variable	Level-Two Variable		Frequency (Percentage)	Minimum Value	Maximum Value	Mean	Standard Deviation	Variance
Farmer personal characteristics	Age	Under 30 years old 30–40 years old 40–50 years old Over 50 years old	0 (0%) 4 (3.7%) 9 (8.33%) 95 (87.96%)	2	4	3.84	0.46	0.21
	Gender	Male Female	85 (78.7%) 23 (213%)	1	2	1.21	0.41	0.17
	Education level	Primary school or below Junior middle school High school or secondary school College or higher	18 (16.67%) 42 (38.89%) 38 (35.19%) 10 (9.26%)	1	4	2.37	0.87	0.76
Family, production and management characteristics	Number of days involved in farming	50 or less 50–150 150–250 250 or more	6 (5.56%) 37 (34.26%) 42 (38.89%) 23 (21.3%)	3.4	6.58	5.01	0.69	0.48
	The total number of agricultural labor force	One Two More than three	22 (20.37%) 54 (50%) 32 (29.63%)	1	8	2.38	1.25	1.56
	Farmers' occupation	Pure agricultural farmers Farmers with Concurrent business	28 (25.93%) 80 (74.07%)	0	1	0.74	0.44	0.19
	Dependency ratio	20% or less 20–50% Above 50%	44 (40.74%) 7 (6.48%) 57 (52.78%)	0	0.83	0.37	0.33	0.11
Cultivated land status	Use of machinery	Yes No	104 (96.3%) 4 (3.7%)	1	2	1.04	0.19	0.04
	Cultivated land quality	25% or less 25–50% Above 50%	3 (2.78%) 14 (12.96%) 91 (84.26%)	0	1	0.73	0.24	0.06
	Per capita area of cultivated land	Less than 1 acre 1–2 acres More than 2 acres	5 (4.63%) 38 (35.19%) 65 (60.19%)	0.63	7.8	2.32	1.25	1.57

Table 2. *Cont.*

Level-One Variable	Level-Two Variable		Frequency (Percentage)	Minimum Value	Maximum Value	Mean	Standard Deviation	Variance
Farmer response to the national policy system	Attitude of farmers toward winter wheat fallow in the underground funnel area	Non-supportive attitude Moderate attitude Supportive attitude	12 (11.11%) 84 (77.78%) 12 (11.11%)	1	3	2.67	0.67	0.45
	Farmers' level of trust in government policy	No trust Not much trust More trust Much Trust	6 (5.56%) 19 (17.59%) 11 (10.19%) 72 (66.67%)	1	4	3.38	0.96	0.93

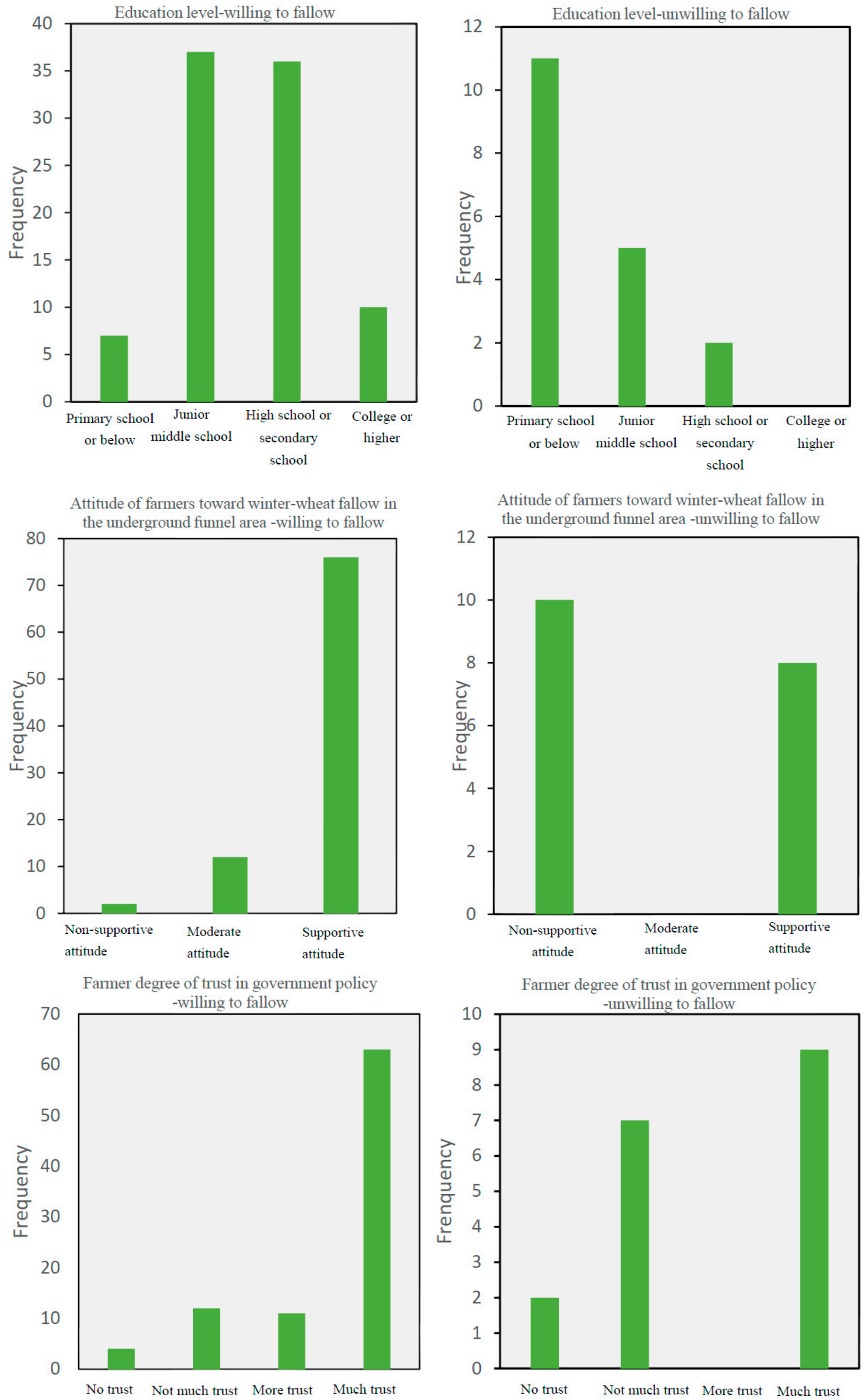

Figure 3. Observation of frequencies of some factors influencing farmers' willingness or unwillingness to fallow.

3.2. Logistic Regression Analysis of the Factors Influencing Farmland Winter Wheat Fallowing

According to the previous selection of indicators, Eviews 7.2 software (Quantitative Micro Software Co., Irvine, CA, USA) was used to analyze the data, providing statistical results on winter wheat fallow influencing factors, as shown in Table 3 below.

Table 3. Regression results.

	Influencing Factors	Coefficient	Std. Error	*z*-Statistic	Prob.
Farmer personal characteristics	Age	−4.199	33.647	−0.125	0.901
	Gender	0.880	1.243	0.708	0.479
	Education level	5.012	2.272	2.206	0.027 **
Family and production and management characteristics	Number of days involved in farming	−6.484	2.831	−2.291	0.022 **
	Total number of agricultural laborers	1.243	0.722	1.721	0.085 *
	Farmer occupation	0.767	1.810	0.424	0.672
	Dependency ratio	3.868	2.075	1.864	0.062 *
	Machinery use	−0.854	2.006	−0.426	0.670
Cultivated land state	Cultivated land quality	−8.446	4.424	−1.909	0.056 *
	Per capita area of cultivated land	−1.606	0.963	−1.668	0.095 *
Farmer response to the national policy system	Attitude of farmers toward winter wheat fallow in the underground funnel area	1.202	0.681	1.764	0.078 *
	Farmer degree of trust in government policy	1.566	0.840	1.864	0.062 *
McFadden R-squared = 0.692					
Prob (LR statistic) = 0.000					
LR statistic = 67.741					
Total obs = 108					

* $p < 0.05$; ** $p < 0.01$.

(1) Farmer personal characteristics

As shown in Table 3, among the personal characteristics of the farmers, education level has a significant positive impact on fallow implementation; this result is consistent with Gao J, et al. (2014) [47]. This association is primarily due to two reasons: (1) farmers who have a higher education level understand the hazards of a groundwater funnel and recognize that it is harmful to their production and livelihood, and thus are more willing to fallow; (2) a higher education level in farmers indicates higher skill levels for engaging in non-farming endeavors, thus these farmers may have more opportunities to engage in non-agricultural work and less dependence on arable land; thus, farmers with a higher education level were more willing to fallow. The survey results show that among the farmers surveyed, there were 18 (13%) did not want to fallow, of which 61% were illiterate, 28% had only a primary education, and 11% had only a junior high school-level education. Thus, farmer educational level has a crucial influence on willingness to fallow.

(2) Family, production and management characteristics

As shown in Table 3, among the family, production and management characteristics, days engaged in farming has a negative effect on willingness to fallow, indicating that with greater time spent farming, farmers are less willing to fallow. It is possible that farmers who spend little time in farming do so because they have other jobs. In such a scenario, farmers may be more willing to let the lands lie fallow. The total number of household agricultural laborers and the willingness of farm households to fallow shown a significant negative correlation. This may be because, when the total number of family agricultural laborers is greater, farmers are heavily dependent on arable land, resulting in very few farmers who are willing to fallow. The dependency ratio and willingness to fallow were significantly correlated. This finding indicates that willingness to fallow increased as the dependency ratio increased. This can be attributed to the fact that when the dependency ratio was greater, the pressure to produce income was greater, as a meager agricultural income is not sufficient to support additional expenses. Therefore, these farmers support fallowing to provide them with more time to engage in non-agricultural work.

(3) Influence of cultivated land characteristics

As shown in Table 3, the quality of arable land had a negative effect on the attitude towards fallowing. This result is consistent with Li Z et al. (2015) [48]. This finding indicates that when the quality of farmland is higher, farmers are more reluctant to fallow. In other words, the higher the quality of arable land, the higher the yield, and the greater the income, which leads to farmers being unwilling to fallow. The farmland area per person also has a negative effect on the fallowing willingness. This finding indicates that when the farmland area per person was greater, the farmer was less willing to fallow. The reason for this is that when the farmland area per person is greater, farmers can carry out large-scale mechanized production, thus reducing the production costs and increasing the net income of agricultural products. As a result, planting winter wheat can generate a certain profit, and farmers are therefore less willing to fallow.

(4) The impact of farmers' response to the national policy system

As shown in Table 3, the attitude of farmers towards the winter wheat-fallow policy had a significant positive effect on willingness to fallow farmland in the groundwater funnel. The more farmers supported the fallowing policy in the groundwater funnel, the more they were willing to fallow. Farmers' confidence in the implementation of policies by the government had a positive and significant effect on the willingness to fallow. Farmers' trust in the government is an important precondition for accepting a fall cultivation policy; farmers' confidence in the implementation of the policy directly stimulated the enthusiasm of farmers and increased the willingness of farmers to fallow.

3.3. Winter Wheat Opportunity Cost Analysis

Using data from 198 questionnaires, according to the Cobb-Douglas production function, Eviews7 was used to apply an ordinary least squares (OLS) regression. The explained variable was the total agricultural income; the explanatory variables were the cultivated land area of crops, the days of labor input, the proportion of capital input, the proportion of high-quality arable land, the proportion of males in agriculture, the age of farm decision-makers, and the educational level of farm decision-makers. The regression results are shown in Table 4 below.

Table 4. Regression results.

Variable	Coefficient	Std. Error	t-Statistic	*p* Value
C	3.550	0.404	8.784	0.000
Cultivated area	0.484	0.076	6.328	0.000 ***
Number of days worked	0.017	0.038	0.457	0.648
Capital input	0.531	0.052	10.296	0.000 ***
High-quality cultivated land proportion	0.490	0.116	4.208	0.000 ***
Proportion of men in the agricultural labor force	−0.134	0.115	−1.163	0.247
Age of farm decision-makers	0.010	0.045	0.232	0.816
Education level of farm decision-makers	−0.054	0.031	−1.769	0.078 *
Included observations: 198				
R-squared = 0.822				
Prob(F-statistic) = 0.000				

* $p < 0.05$; *** $p < 0.0001$.

According to Table 4, the results indicate that there is a significant correlation with factors such as the cultivated land area of crops, capital inputs, the proportion of men working as agricultural laborers and the education level of farms' decision-makers. In the estimation model, R_2 = 0.822 and the F test was very high; these findings indicate that the fitting degree of the model was better, and the credibility was higher. The elastic coefficient of total labor input was 0.017185 (0.02), and we determined that the average wage of the agricultural labor force was 4.565 $/day in 2015 in Hengshui City. According to this study, planting spring and summer maize on the same plots involved basically the same input and output, and the net income was basically equal. Therefore, with the average shadow-wage included in (2), we could calculate the net income from winter wheat. The general compensation standard adopts the mean as the standard of ecological compensation [49]. Thus, the opportunity cost of farmers fallowing winter wheat farmland was 0.00095 $/hm^2.

4. Conclusions and Discussion

4.1. Conclusions

In this paper, a logistic model was used to analyze the influencing factors of winter wheat fallow in the Hengshui area, the opportunity cost method was used to calculate the net income of farmers' planted crops, and the compensation standard of winter wheat fallow was obtained. The main results are summarized follow.

First, based on the questionnaire data, nearly 87% of the surveyed households were willing to accept the winter wheat-fallow-policy, while 13% were not. In recent years, as the groundwater level has declined, the cost of irrigation has increased. Thus, farmers are generally willing to fallow winter wheat.

Second, the logistic regression analysis showed that education level, total number of household agricultural laborers, dependency ratio, farmer attitudes toward fallowing winter wheat in the groundwater funnel area, and farmer confidence in the government policy all had a significant positive effect on the willingness of farmers to fallow; on the other hand, workdays in farming, farmland quality, and farmland area per person had significant negative effects on the willingness of farmers to fallow.

Finally, the study found that the net income from summer corn was the same as the net income from spring maize planted in the same place; therefore, the ecological compensation standard was equal to the net income from winter wheat. Calculating the opportunity cost of planting winter wheat indicates that the ecological compensation standard of winter-wheat fallow is 0.00095 $\$/hm^2$ in the Hengshui area.

4.2. Policy Implication

(1) The results revealed compensation standards of 0.00095 $\$/hm^2$; however, Wang, X. [16] found a reference value of 0.00064 $\$/hm^2$ in a survey of Cangxian winter wheat. This difference may be related to agricultural prices at the time of the investigation. Therefore, ecological compensation should not be a "one size fits all" value; rather, it should address local conditions to develop compensation standards that are appropriate. Before the government selects a pilot program, we should investigate the local conditions for the development of fallow policy and compensation standards. Furthermore, the compensation standard should be based on the annual fluctuations in food prices to allow reasonable adjustments.

(2) The government should promote the transfer of surplus labor by developing a green industry in the groundwater funnel area and introducing technical guidance and training, thus improving the yield of other crops.

(3) The marketing of the Policy for Fallowing Cultivated Land should be strengthened using television, radio, lectures and other media to improve farmer awareness of the fall cultivation policy and to enhance farmers' awareness of groundwater resources protection. Farmers should actively cooperate with the implementation of groundwater protection policy to ensure the sustainable development of groundwater on the North China Plain.

(4) A fallow compensation system should be further strengthened, and the policy-guarantee system should be optimized: financial support should be increased, and the introduction of advanced technology and technical guidance to increase the yields of other crops through technical training and by promoting the transfer of surplus labor is of importance for fallow programs to be carried out effectively.

(5) To reduce the pressure on the groundwater by relying on groundwater irrigation in winter wheat areas, the two-year system should be changed to a one-year system, which can be achieved through a "decrease in the area sown with winter wheat, which proves to be a practical strategy to reverse groundwater overexploitation and to promote groundwater storage"; the yield potential, which is dependent on rain and temperature in the autumn, will also guide farmers to transform planting habits.

(6) Weed problems should be dealt with. When fields are not planted, weeds grow, leading to problems such as the additional consumption of water. Therefore, the government should strengthen the scientific and rational management of cultivated land, including regular weeding of fallow land.

4.3. Discussion

In this study, the ecological compensation standard for winter-wheat fallow was estimated to be 0.0009 $\$/hm^2$; however, this value was determined with insufficient scientific basis. Farmer questionnaire data were used to calculate the opportunity cost of winter-wheat fallow and estimate an ecological compensation standard for the fallowing policy in the Hengshui area. The compensation standard proposed in this paper is very different from that proposed by Wang X. This result indicates that ecological compensation standards cannot be "one size fits all" and should be determined based on research. This study has some limitations. First, the net income from winter wheat in Hengshui 2016–2017 is the opportunity cost. The scope of the case area should be expanded in the future, and surveys should be conducted. Second, because of limited funds, the sample size was small. Third, this study did not take into account national policy variables and other factors. Further work is necessary to obtain more robust winter-wheat fallow compensation standards in areas of groundwater overexploitation.

Based on the above conclusions, it is surmised that the change of farmers' livelihood has a direct impact on farmers' decision-making behaviors [50].This study argues that when implementing of ecological compensation policy [51], we should fully consider the farmers' own assets and improve the livelihood capital of farmers. According to the needs of farmers, we must formulate ecological compensation measures and solve the long-term livelihood problems of farmers. Only in this way can we better the effective implementation of an ecological compensation policy [52,53].

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