# Non-Market Valuation of Straw Returning to Farmland: Residents' Awareness and Willingness to Pay in Heilongjiang Province, China

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**Abstract.** The awareness and willingness to pay (WTP) of 1,669 households in Heilongjiang Province were investigated using the Contingent Valuation Method (CVM). The results showed that 91.00% of the surveyed residents responded positively to monetary contribution or voluntary labor. The proportion of rural residents choosing "monetary contribution," "voluntary labor," and "monetary contribution and voluntary labor" was 14.16%, 60.06%, and 25.78%, respectively; for urban residents, these proportions were 20.36%, 46.73%, and 32.91%, respectively. The findings indicate that straw return has high non-market value. While residents have a high level of awareness and willingness to pay, the actual proportion of payment remains relatively low. Age, education level, and average annual household income were identified as significant factors affecting WTP. The estimated non-market value of straw in Heilongjiang Province reached 5.045 billion yuan in 2022, which is equivalent to 1.36% of provincial agricultural output, or approximately 1,532.09 yuan per ton, providing a quantitative basis for optimizing national black soil conservation policies and straw returning compensation standards.

**Keywords:** straw, returning to field, Contingent Valuation Method, non-market valuation, willingness to pay, black soil conservation

## 1 Introduction

China's black soil region is central to national grain security, but intensive cultivation has reduced soil organic matter and erosion resistance [1-3]. Straw returning can restore soil quality and reduce fertilizer dependence [4,5], yet collection costs, insufficient equipment and incentives, and the public nature of many benefits constrain adoption. Quantifying residents' WTP can therefore support compensation and black-soil conservation policy.

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Previous work covers farmland amendments [6], straw feed [7], fuel [8], environmental effects [9], waste management and straw-return payment decisions [10-12], and no-till machinery [13]. However, the regional non-market value of straw returning remains insufficiently quantified.

Using Heilongjiang Province as a case, this study compares rural and urban residents' awareness, payment preferences, and WTP; identifies significant socioeconomic determinants; and estimates the aggregate and per-ton non-market value of straw returning.

## 2 Materials and Methods

### 2.1 Methods and Model Selection

Contingent valuation elicits economic choices in hypothetical markets and is widely used to estimate non-market environmental and public-service values [14-19].

Because willingness to participate is binary, a logistic regression model was used to estimate the relationship between WTP and household characteristics. The model is shown below:

$$P_i = \frac{\exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)}{1 + \exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)} \tag{1}$$

$P_i$where P is the probability of willingness; $\beta_0$ is the intercept; $x_i$ denotes the explanatory variables; and $\beta_i$ denotes the corresponding coefficients.

Logistic regression was selected because its coefficients are interpretable for a common binary outcome and it avoids the computational burden of the probability model and the rare-event emphasis of the complementary log-log model.

### 2.2 Area Overview

Heilongjiang covers 473,000 $km^2$ and contained approximately 9.369 million urban and 4.782 million rural households in 2022 [20]. Based on major crop yields and grain-straw ratios [21], annual straw production was approximately 88 million tons.

### 2.3 Questionnaire Design and Sample Selections

The questionnaire covered study background; household socioeconomic characteristics; awareness of land, pollution, soil-fertility, yield, and cost benefits; and WTP through cash, voluntary labor, or both.

Twelve cash intervals and nine labor-day intervals were provided. Data were used to compare awareness and payment preferences, estimate logistic models, and calculate regional non-market value.

Trained investigators conducted one-to-one online and offline interviews from July to September 2022. PPS assumptions of 95% confidence, P=50%, d=5%, and DEFF=4 produced a minimum sample of 1,537.

All 1,669 questionnaires were returned; 1,634 were valid (97.90%), exceeding the required sample.

# 3 Results and Discussion

## 3.1 Analysis of Sample Socio-Economic Characteristics

The valid sample comprised 783 rural and 851 urban respondents. Men accounted for 77.11%, 68.85% had completed high school or higher education, and mean household size was 3.71. Average annual household income was 61,700 yuan for rural and 76,700 yuan for urban households. Respondents represented diverse occupations, and the distributions broadly matched Heilongjiang's socioeconomic structure.

## 3.2 Analysis on the Cognitive Value of Straw Returning

Awareness was assessed for reduced land occupation and pollution, improved soil structure and fertility, and increased yield or reduced production cost.

For every benefit, more than 65% of rural and urban respondents selected agree or completely agree. Agreement exceeded 80% for reduced pollution and improved soil structure and fertility, indicating strong recognition of the non-market benefits of straw returning.

## 3.3 Correlation Analysis Between WTP and Socio-Economic Characteristics

Overall, 91.00% were willing to contribute money, labor, or both. Logistic regression used willingness as the dependent variable and eight socioeconomic and awareness indicators as explanatory variables. Age, education, and annual household income significantly affected WTP (Table 1).

**Table 1.** Correlation analysis between socio-economic characteristics and WTP using binary Logistic regression estimation results.

| Variables | Number | Coefficient/β | Standard error | Wald | df | Significance | Exp(β) |
|---|---|---|---|---|---|---|---|
| Household registration | X1 | -0.010 | 0.196 | 0.003 | 1 | 0.958 | 0.990 |
| Gender | X2 | 0.249 | 0.221 | 1.268 | 1 | 0.260 | 1.283 |
| Age** | X3 | 0.761 | 0.383 | 3.953 | 1 | 0.047 | 2.141 |
| Location | X4 | 0.389 | 0.280 | 1.929 | 1 | 0.165 | 1.476 |
| Education** | X5 | 1.124 | 0.483 | 5.410 | 1 | 0.020 | 3.077 |
| Occupations | X6 | 0.398 | 0.286 | 1.934 | 1 | 0.164 | 1.489 |
| Household labor force | X7 | -0.485 | 0.636 | 0.582 | 1 | 0.446 | 0.616 |
| Average annual household income *** | X8 | -0.770 | 0.283 | 7.425 | 1 | 0.006 | 0.463 |
| Constant | C | 1.488 | 0.397 | 14.033 | 1 | 0.000 | 4.426 |

Note: * * * indicates correlation at a 1% level, and * * indicates correlation at a 5% level.

### 3.4 Statistical Analysis of Payment Methods and WTP Payment Interval Frequency

Rural respondents mainly preferred voluntary labor (60.06%), whereas urban respondents showed a more balanced distribution. Cash-only participation was 14.16% for rural and 20.36% for urban households; combined payment was 25.78% and 32.91%, respectively, as shown in Figure 1(a).

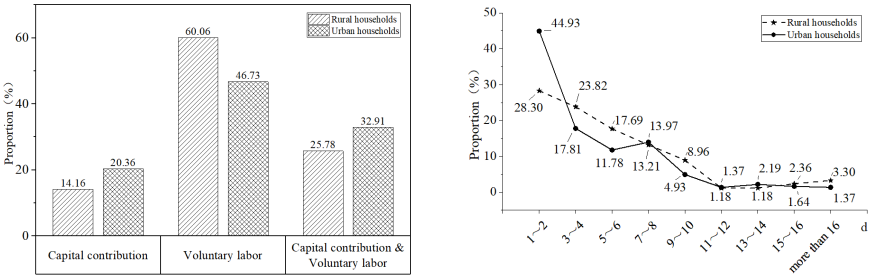



**Fig. 1.** Residents' payment preferences: (a) proportions of different payment methods; (b) frequency distribution of voluntary-labor intervals.

More than 70% of cash-paying respondents accepted less than 200 yuan annually. Willingness generally declined as the proposed amount increased, although urban respondents more often accepted amounts above 400 yuan, as shown in Figure 1(b).

For labor-based and combined payment, willingness decreased as required labor days increased. Labor contributions were converted using daily disposable income so that payment modes could be compared monetarily.

### 3.5 Correlation Analysis Between Payment Methods and Socio-Economic Characteristics

A second logistic model compared cash with voluntary labor after excluding unwilling respondents and the combined-payment group. Residence, occupation, and annual household income were evaluated as determinants.

Residence, occupation, and income significantly affected payment mode. Urban and higher-income respondents were less likely to choose voluntary labor, supporting flexible programs that allow cash or labor participation.

### 3.6 WTP and Non-Market Value Quantitative Accounting

Mean cash-only WTP was 152.50 yuan per rural household and 173.74 yuan per urban household. Mean voluntary labor was 5.45 and 4.53 days; converted annual WTP was 277.17 and 413.66 yuan (Table 2).

**Table 2.** Different payment methods for straw returning and utilization of WTP.

| Categories | Average WTP yuan/(household/year) for investment payment | Average number of days of compulsory labor payment/(days) | Average WTP converted from voluntary labor contribution yuan/(household/year) | Average WTP under investment and obligation labor payment yuan/(household/year) |
|---|---|---|---|---|
| Rural residents | 152.50 | 5.45 | 277.17 | 415.08 |
| Urban residents | 173.74 | 4.53 | 434.79 | 635.93 |

The non-market value of straw is calculated as follows:

$$V_n = \frac{V_t}{S_y \cdot R} \tag{2}$$

where V*n* is non-market value per ton, S*y* is annual straw quantity, and R is the capitalization rate derived from the safe interest rate and regional risk adjustment [19].

The estimated non-market value in 2022 was 5.045 billion yuan, equal to 1.36% of provincial agricultural output or approximately 1,532.09 yuan per ton.

### 3.7 Broader Policy Implications and Scalability to National Context

The estimated value provides a benchmark for compensation and can be replicated elsewhere with local income, cropping systems, and treatment capacity. The gap between 91% stated participation and lower cash payment shows that policy must combine compensation with machinery, collection, storage, and flexible cash-or-labor channels.

## 4 Conclusions

Residents strongly recognized the benefits of straw returning, and 91.00% were willing to participate. Age, education, and income affected WTP, while residence, occupation, and income shaped payment mode. Rural households preferred labor; urban households used more cash and combined payment.

The estimated non-market value was 5.045 billion yuan, or approximately 1,532.09 yuan per ton, providing a quantitative basis for black-soil conservation and compensation policy.

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## Competing Interests

The authors declare no competing interests.

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