The willingness to accept for agriculture sustainability: A choice experiment study in the Hani Terraces

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Abstract
Modern intensive agriculture is in conflict with the functioning of ecosystems, including excessive use of pesticide, removal of "water recharge" forest and destruction of traditional rural landscape. Since government’s support policy has enormous implications for the sustainability of agricultural practices, it's important to understand how the farmers would prefer public support to be allocated. Considering the deterioration of farmland ecosystems, a choice experiment was conducted concerning farmers’ WTA (Willingness to Accept) for sustainable development of the Hani Terraces in China. We applied a random sampling strategy to study the preferences of farmers (n=224). The experimental design consisted of four attributes (pesticide, afforestation, landscape and subsidy) that varied on between three and four attribute levels. Two conditional logit models were used to obtain marginal values of traits.

Keyword: Agricultural Sustainability, Hani Terraces, Choice modeling, Willingness to Accept

1. Introduction
The Hani Terraces are located in south-western China, and they are quite famous for spectacular terraces in the Ailao Mountain area. The Hani Terraces have an area of 70,000 ha, and in some places there are more than 3,000 terraces. Over the past 1,300 years, the Hani and Yi people have constructed their villages above the terraces just below the mountain top forests.

The Hani and Yi inhabitants have created an integrated farming system, and developed a perfect irrigation system which brings water from the forested mountaintops to the terraces. The Hani Terraces were named as National Wetland Park and World Heritage Site, however, the overall terraced system’s key physical attributes, terraces, forests and villages are under threat and the traditional farming system is no longer robust.

1.1 Pesticide Risk
In the traditional breeding system of the terraces, ducks fertilize the rice plants and devour pests, while cattle and pigs contributed to base fertilizer. However, nowadays, as farmers attempt to meet growing food demand and are faced with strong pest pressure, they increasingly rely on synthetic pesticides. Farmers frequently misuse and overuse pesticides which have raised concerns about negative effects on both people and environment. In the absence of observable benefits to environment protection, and without efficient governmental control mechanisms, rice production in the Hani Terraces has changed into an environmentally unfriendly state over the past 20 years.

1.2 Water Shortage
The mountain top forests play a significant role in capturing and sustaining the water needed for the terraces irrigation. Currently, more and more villages develop forestry commodity economy for the provision of timber and food. They cut down the ancient ‘water recharge’ forest,
such as tag alder (*Alnus cremastogyne* Burk.), then plant trees like eucalyptus (*Eucalyptus robusta* Smith), cedar (*Taxodiaceae*) and walnut (*Juglans*). The dense forest used to have high resilience against climate change, however, now the terraces are experiencing water shortage.

**1.3 Landscape Vulnerability**

The traditional local houses have walls built adobe bricks under a thatched roof which looks like a ‘mushroom’ shape. Mushroom is one of the Hani Terraces’ most famous attractions. However, in the last two decades, ongoing urbanization trend has contributed to the increasing modern buildings, which result to the replacement of adobe and thatched roofs to concrete bricks and tiles. The overall image of villages in the landscape has been changed, and now, at least 80% of the houses in the villages are mainly of extraneous architectures. Farmers prefer modern domestic spaces, causing a problem of sustaining traditional houses.

**1.4 What do the farmers want?**

The current common aim of the Hani Terraces is to integrate the farmers’ socio-economic goals with the ecological and landscape goals. Relevant issues here concern include how to protect the traditional architecture and forest, and how to accelerate the implementation of pesticide reduction strategies. To achieve the goal of effective management, decision makers need to understand the tradeoff between farmers’ preferences for the protection of the terraced system and the loss of comfort and economic.

In relation to management purpose, an efficient incentive should be set equal to the marginal damage. While suggesting the need to increase the input of farmers’ preferences in planning the terraces development, there is an absence of information on what the farmers really want. So understanding farmers' willingness-to-accept (WTA) for protection of the terraced system would provide key information for policy makers to introduce subsidy. Therefore, the availability of an economic estimate of the farmers’ loss of comfort and economic could be pivotal, allowing us to identify the optimal subsidy.

**2. Goal and research questions**

Our aim is to reveal how the farmers value the considered characteristics of the Hani Terraces, and based on this information draw up efficient subsidy measures. For that purpose, we estimated farmers' marginal WTA for different attributes of the Hani Terraces.

Traditionally, most valuation studies are of the CVM variety that invites respondents to express a WTA in order to derive a value for a single attribute, while such approach does not provide information about the relative importance of different attributes and the potential tradeoffs inherent in decision-making (Lawson and Manning, 2001). However, CE-type studies can estimate the preferences of individuals by forcing them to make trade-offs – not only between attribute and money – but also between different attributes. We conducted a choice experiment (CE) to explore the farmers’ preferences among the conservation priorities of the Hani Terraces. A set of hypothetical the terraces’ profiles was created, and farmers were asked to choose their most preferred alternatives.

The attributes used to create the profiles were pesticide, afforesting, landscape, and subsidy. The CE survey took place in Yuanyang county, we calculated the willingness-to-accept (WTA) of farmers for improvements in the environment and landscape of the terraces. In addition, we examined how the welfare effects differ between farmers using information on respondents' socio-economic characteristics.
3. Survey design

The questionnaire focused on three parts. In the first part, we asked respondents their perception of pesticide. This part also included questions about the function of forest, and had the respondents ever personally experienced any of water scarcity? And there are other questions related to farmers' desire for modern construction, which reflected respondents' attitude to culture protection. Then, the questionnaire described the actual current the Hani Terraces’ situation and development risks.

The second and most important part of the questionnaire contained the CE exercise. Before the CE questions, we told the farmers that an improvement of terrace system is possible by implementing a 10-year management project, and that the government was about to do this. Policy options included: 1) reducing pesticide application on fields which would decrease the agricultural products' quantity; 2) afforesting to improve the soil water environment in forest which would reduce farmers’ forestry income; 3) supporting traditional building materials and techniques which would batter farmers’ aspirations for spaces; 4) subsidy to make up for farmers’ loss if they pursue protection goals. Farmers were therefore asked to view the various choice sets related to management alternatives of the terraces.

The third part asked questions in order to obtain a detailed image of the individual socio-demographic conditions, including age, education, and income.

3.1 Choice experiment

Choice Experiment (CE) is a valuation method that infers people's preferences for a set of alternatives, described by a set of relevant attributes (Louviere et al., 2010). Based on the attributes represented, the respondents are asked to decide which of the options they would choose. Relating respondents’ choices to attribute levels allows for development of a conditional logit (CL) model to understand the influence of different attributes.

3.1.1 Choice experiment: attributes and attribute levels

The initial step to develop a choice experiment is to identify relevant attributes and to decide on attribute levels. In our study, the selection of attributes and attribute levels for the choice experiment was informed by previous research in the region. The final design included the attributes pesticide, afforestation, landscape, and subsidy.

The attribute “pesticide” was formalized in terms of pesticide consumption. The attribute “afforestation” was expressed in terms of the acreage of tag alder. The attribute “landscape” was formalized by using the percentage of traditional building mushroom. To facilitate the comprehension of trade-offs between attributes, during the CE questions, respondents were provided with a card summarizing their possible future range of variation.

Special attention was given to the selection of the payment vehicle (see Table 1). Bids were selected on the basis of the average agricultural subsidies, the compensation of Conversion of Farmland to Forests and the travel subsidies from the local Tourist Administration, which are set at about 50 Yuan per month per household.
Table 1 List of the attributes used in the CE value application and corresponding values

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide (pesticide consumption)</td>
<td>decrease by 20%</td>
<td>decrease by 30%</td>
<td>decrease by 40%</td>
<td>-</td>
</tr>
<tr>
<td>Afforestation (the acreage of tag alder)</td>
<td>increase by 5%</td>
<td>increase by 10%</td>
<td>increase by 15%</td>
<td>-</td>
</tr>
<tr>
<td>Landscape (percentage of traditional buildings)</td>
<td>increase by 5%</td>
<td>increase by 10%</td>
<td>increase by 15%</td>
<td>-</td>
</tr>
<tr>
<td>Subsidy (Yuan/household per month)</td>
<td>20</td>
<td>50</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

3.1.2 Choice experiment: experimental design

The experimental design of a choice experiment entails the systematic allocation of attributes and attributes levels to choice situations. In our study, the number of attributes and levels gave rise to 108 possible profiles (3*3*3*4=108). To develop the profiles in the questionnaire, we applied a fractional fractional design (by R AlgDesign package). An efficient design aimed at minimizing standard errors of choice model parameter estimates, and the procedure of fractional fractional design reduced the number of profiles to a level of 36 alternatives, but this number was still too large a task for a respondent to complete. To reach a more manageable level of alternatives, we made copy of the fractional fractional design in R, so there were two designs of 36 alternatives.

Then, we added two groups of random numbers to each design in R. Next, each design was sorted on the basis of its corresponding random number. We signed the alternatives to 36 choice sets in this order, finally we checked the dominating alternatives and eliminated 12 choice sets, and thus 24 sets were used.

Each choice set consisted of two signed alternatives and a status quo alternative in which the levels of attributes refers to present situation. The 24 choice sets were randomly grouped into eight subsets of three choice sets, so resulting in eight versions of the questionnaires. Thus, each respondent faced a choice experiment evaluating three choice sets and in each set they decided whether to keep the status quo or to choose an alternative scenario. Table 2 shows one example of choice sets. All combinations were asked in roughly equal frequencies.

Table 2 One example of choice sets

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Option A</th>
<th>Option B</th>
<th>Option C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide (pesticide consumption)</td>
<td>decrease by 30%</td>
<td>decrease by 30%</td>
<td></td>
</tr>
<tr>
<td>Afforestation (the acreage of tag alder)</td>
<td>increase by 5%</td>
<td>increase by 10%</td>
<td></td>
</tr>
<tr>
<td>Landscape (percentage of traditional buildings)</td>
<td>increase by 10%</td>
<td>increase by 15%</td>
<td>Current situation</td>
</tr>
<tr>
<td>Subsidy (Yuan/household per month)</td>
<td>80</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Study sites and sampling

The process started in cooperation with local translators by preparing a questionnaire for a small scale pilot study during two days with sixteen farmers in September 2014. Based on the pre-test, we improved the final design of questionnaire.

The final survey was conducted in April 2015. The terraces are mainly spread in Yuanyang County, so we conducted the final survey in four villages of this county. For the sampling, we used random sampling in the survey villages so that individuals (over 18 years) were asked for their
willingness to take part to the survey. The entire questionnaire took approximately 15 min for the respondent to complete, and field staff in each village included a local translator who expressed the core concepts in detail to respondents, because some respondents have difficulties in understanding mandarin. The total number of respondents was 224 and 179 respondents returned questionnaire in a completed form.

4. Data and Model

4.1 Some basic statistics of the questionnaire

Among the total 179 valid answers, the share of female respondents is 36.3%, and the average respondent is 40.9 years old. Table 3 shows the survey statistics and the socio-demographics of the sample. The average household size is 5.6, and in each household at average 2 persons are younger than 18. The average household income is roughly 51,300 Yuan/year, and only 20% of their revenue from agriculture business. Only 26.8% of the respondents have completed primary school.

Out of the respondents, only 11.7% of the farmers were concerned about pesticide risks, and most respondents knew very little about hazards of pesticide contamination. 85.5% of the sample population considered forests for water security important. 82.7% of the population believed that modern building is more beautiful and comfortable than mushroom.

<table>
<thead>
<tr>
<th>Statistical information</th>
<th>Mean or percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>36.3%</td>
</tr>
<tr>
<td>Age</td>
<td>40.9</td>
</tr>
<tr>
<td>Household size</td>
<td>5.6</td>
</tr>
<tr>
<td>Number of persons under 18 in each household</td>
<td>2</td>
</tr>
<tr>
<td>complete primary school</td>
<td>26.8%</td>
</tr>
<tr>
<td>yearly household income (in RMB)</td>
<td>51,300</td>
</tr>
<tr>
<td>agricultural income in household income</td>
<td>20%</td>
</tr>
<tr>
<td>concerned about pesticide risks</td>
<td>11.7%</td>
</tr>
<tr>
<td>Well known about the forest’s role of saving water and drought defying</td>
<td>85.5%</td>
</tr>
<tr>
<td>Believe that modern building is more beautiful and comfortable than mushroom</td>
<td>82.7%</td>
</tr>
</tbody>
</table>

4.2 Model

4.2.1 Conditional logit model

Data obtained from the questionnaires was analyzed using conditional logit model (CL). The CL is the typical model used in CE studies, which obtain a general idea of the effect of attributes on the choice. In this model, the utility function of each respondent contains a deterministic component that consists of attributes that influence respondent's utility and a random component that is unobservable for researchers (Lancaster, 1966; Adamowicz et al., 1994; Boxall et al., 1996). The deterministic term is usually assumed to be linear in parameters, which implies that all respondents have the same preference structure for the attributes (Artti Juutinen, et al., 2011). Socioeconomic variables can be included as interactions with attributes. The total utility \( U \) of alternative \( i \) for an individual \( n \) is represented by:
where $x_{ik}$ is the $k$ attribute value of the alternative $i$; $\beta_{ik}$ is the utility coefficient for $k$ attribute of the alternative $i$; $ASC_i$ is alternative specific constant for option $i$; and $\epsilon_{ni}$ is the random component in the utility function.

Assuming a type I extreme value distribution for $\epsilon_{ni}$, the choice probability on the alternative $i$ is defined as $p_{ni}$:

$$p_{ni} = \frac{\exp \left( \sum_k \beta_{ik} x_{ik} \right)}{\sum_{j \in C} \exp \left( \sum_k \beta_{jk} x_{jk} \right)}$$

where $j$ is another option; $C$ denotes respondent's complete choice set.

### 4.2.2 Welfare measures

The results of the CE survey can be used to estimate marginal WTA. Marginal WTA are the marginal rates of substitution (MRS) between the attributes in question and the subsidy attribute, which represents the WTA for a 1% increase in the quantity of the attribute under analysis (Colombo et al., 2009). For a sufficiently small change in attribute, the mean WTA for improvement will be approximately equal to the marginal WTA. The marginal WTA for a single attribute can be estimated as the ratio of the coefficient for that attribute to the negative of the coefficient for the subsidy attribute (Rolfe et al., 2000):

$$\text{Marginal WTA} = -\left( \frac{\beta_{\text{attribute}}}{\beta_s} \right)$$

where $\beta_s$ is the marginal utility of subsidy attribute.

### 5. Empirical findings

Two conditional logit models were executed by using the collected data with R 3.1.1.

#### 5.1 Model 1

Model 1 is a basic specification that demonstrates the effect of each attribute can have on the respondents' preferences for alternative scenarios. Formally, we have:

$$V_i = ASC_i + \beta_1 \times \text{Pesticide} + \beta_2 \times \text{Afforestation} + \beta_3 \times \text{Landscape} + \beta_4 \times \text{Subsidy}$$

Utility is determined by the levels of four attributes (Pesticide, Afforestation, Landscape, and Subsidy). Hence, the model provides an estimate of the importance of the choice attributes’ change in the probability that one of these options will be chosen. As an alternative specific constant, $ASC_i$ captures the deviation from the status quo option (Morrison, et al., 2002).

The coefficients for all attributes in model 1 have the expected signs and are significant. The coefficient on Subsidy is significantly positive, because the more money farmers can receive, the more likely they are to improve the terraces’ situation ($\beta_4 = 0.024$). On the contrary, the parameter estimate for Pesticide is negative, underlining that farmers prefer yield stability ($\beta_1 = -1.042$). The Afforestation parameter estimate is significantly negative ($\beta_2 = -0.234$), demonstrating that an improvement of this attribute will decrease the utility of respondents. The negative signs of the coefficient for Landscape ($\beta_3 = -0.450$) illustrates that some respondents assign no utility to mushroom.

#### 5.2 Model 2

In order to better understand how preference varies across individual characteristics, the
attributes were interacted with demographic variables in model 2. We added two additional variables (Income, Age) in the function:

\[ V_2 = \text{ASC} + \beta_1 \times \text{Pesticide} + \beta_2 \times \text{Landscape} + \beta_3 \times \text{Afforestation} + \beta_4 \times \text{Subsidy} \]

\[ + \beta_{p1} \times \text{Pesticide} \times \text{Income} + \beta_{l1} \times \text{Landscape} \times \text{Income} + \beta_{al} \times \text{Afforestation} \times \text{Income} \]

\[ + \beta_{pa} \times \text{Pesticide} \times \text{Age} + \beta_{la} \times \text{Landscape} \times \text{Age} + \beta_{aa} \times \text{Afforestation} \times \text{Age} \]

The effects of interaction of the Pesticide attribute with Income and Age are statistically significant, meaning that individual utility is sensitive to the respondent's level of income and age. The interaction between Pesticide and Income is positive, supporting the hypothesis that respondents with more income would choose the environmentally-friendly farming practices. The modeling result illustrated a negative relationship between respondents' Age and Pesticide, which mean that older farmers are reluctant to change their current farming practices.

Similarly, the coefficient of the interaction between Landscape and Income is significant and negative, indicating richer respondents would be less likely to choose traditional architecture. The coefficient of Age is positive, as older respondents would more prefer the mushroom.

The parameter estimates for Afforestation \times Income and Afforestation \times Age are not significant, implying that the estimated preference for Afforestation is not associated to Income or Age. The estimation results of the two models are in Table 4.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficients</td>
<td>p-value</td>
</tr>
<tr>
<td>Subsidy</td>
<td>0.024</td>
<td>0.000</td>
</tr>
<tr>
<td>Pesticide</td>
<td>-1.042</td>
<td>0.001</td>
</tr>
<tr>
<td>Afforestation</td>
<td>-0.234</td>
<td>0.011</td>
</tr>
<tr>
<td>Landscape</td>
<td>-0.450</td>
<td>0.000</td>
</tr>
<tr>
<td>Pesticide \times Income</td>
<td>0.077</td>
<td>0.089</td>
</tr>
<tr>
<td>Afforestation \times Income</td>
<td>0.013</td>
<td>0.490</td>
</tr>
<tr>
<td>Landscape \times Income</td>
<td>-0.235</td>
<td>0.000</td>
</tr>
<tr>
<td>Pesticide \times Age</td>
<td>-0.031</td>
<td>0.094</td>
</tr>
<tr>
<td>Afforestation \times Age</td>
<td>0.007</td>
<td>0.330</td>
</tr>
<tr>
<td>Landscape \times Age</td>
<td>0.049</td>
<td>0.004</td>
</tr>
</tbody>
</table>

5.3 Welfare analysis
The marginal WTA for a certain attribute is the negative ratio of the attribute coefficient and the coefficient for the Subsidy attribute. According to the coefficients above, without covariates, farmers were willing to accept 43.42 Yuan per household per month for an improvement in the attribute Pesticide. Farmers were also willing to accept 9.8 Yuan per household per month for an improvement in the attribute Afforestation. The WTA for Landscape of farmers was estimated to be 18.8 Yuan as stimulus in the experiment.

6. Conclusions
This article tested the farmers’ preferences for terraces protection, which would provide a range of agri-environmental and countryside benefits for public. The policymakers need to address the relation between sustainable agricultural practices and traditional landscape preservation and WTA estimates, and were required to account the appropriate substitution rate
between different targets. The valuation is based on a survey undertaken in Yuanyang County, using the CE method.

The implicit price results of this study demonstrate that the most difficult attribute for the Hani Terraces protection is Pesticide, followed by Landscape, and an improvement in the Afforestation attribute was rated lowest. The probability of choosing the improved protection option varies with some socioeconomic variables. The respondents with higher income are more likely to reduce usage of pesticide and less likely to protect traditional buildings. The younger respondents are more inclined to environmentally friendly farming practices and modern buildings.

Reference