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Original Research

Consumer's WTPe for Grass-fed Meat and Its Implications in Sustaining Grassland for Degrading Karst Region of Guizhou, China

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Abstract

The Guizhou province in southern China is a typical karst region that is highly affected by environmental degradation and needs to implement sustainable ecological restoration programs. This paper first conducted a willingness to pay extra (WTP_e) survey for provisioning services of grassland based on consumers' preference to grass-fed cattle or lamb production process to check public concerns over rural grassland and the potential of compensation foundation collection. Results show that: 1) the WTP_e for grass-fed beef production was RMB 16.51±4.81/kg, or for grass-fed lamb was RMB 34.24±7.37/kg which was not trivial to land use decision making; 2) as much as 83.6% of urban citizens acknowledge their preference for grass-fed meat production than high-energy-diet meat and 55.7% even declare they would shift their eating habit from traditional meat of pork to grass-fed meat like beef or lamb; 3) respondents with middle income and moderately educated level showed dramatically higher WTP_e for grass-fed beef than did other groups. 4) the maximum total consumer's WTP_e for grass-fed meat production was predicted to RMB 10.38 x 10^9 per year in the target province which equals to a capacity in sustaining 1.15 x 10^6 ha grassland in condition of 900 RMB per 1000 m^2. This amount doubled current compensation per capital given by the government. This WTP_e with intention to sustain grassland for meat production process has the capacity to transfer food safety demand of urban consumers to a guidance for rural land use behavior via their economic action. Through this mechanism, a control switch for ecological restoration can be built through the market to avoid overproduction or insufficient production of grass-fed meat.

Key words: ecosystem services, karst grassland, contingent valuation, environmental degradation, willingness to pay

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Introduction

Compared to cropland, grassland has been reported to exhibit more environmentally friendly characteristics. For example, it was a less densely utilized land use system [1-2]; it has semi-natural succession yet cropland does not [3]. It has reduced negative environmental impacts and higher valued ecosystem services than cropland has in terms of better soil and water conservation [4], aesthetic value, *etc.* [5-6]. It also provides provisioning services mainly in terms of animal meat, which has better per capita value than traditional crops for local poverty farmers as well as for the local environment. Therefore, semi-natural grassland construction has been widely recommended as one of the important restoration strategies in karst regions where intensive land use was found to be a decisive factor that historically caused heavy environmental degradation in the fragile karst area of southern China [7-8]. To reduce the environmental pressure and to halt the serious spreading tendency of ecosystem degradation, the Chinese government and decision-makers have compensated local farmers or enterprises for grassland construction and to encourage them to withdraw from cropland in some karst regions since the last decade of the 20th century [2].

Yet, the area of grassland in southern China has never been recognizably changed [9], although many restoration programs have been launched to encourage semi-natural grassland construction and sustainable maintenance [10]. An important obstacle is that in southern China, including major karst regions, people traditionally eat pork rather than grass-fed meat [11-13]. For example, in 2015, total production of pork in Guizhou province was 1.61 million tons which was nearly 10 times of beef of 168 thousand tons, and approximately 40 times of lamb of 42 thousand tons respectively [14]. Thus, the small size of the grass-fed meat market is hard to enlarge unless public preference changes. In fact, the feedback between grass-fed meat consumers and producers needs to be better activated [15]. The current situation has led to the information mismatch and then imposed the negative expectation of producers on the economic value of semi-natural grassland [16-19]. Consequently, poverty producers in the ecological degrading region of southern China are far more sensitive to giving up their inefficiently managed cropland for grass-fed meat production because crops could be their daily food at least in case they could not earn enough money for living.

Recently, public concerns over food safety have kept changing consumer's preference for grassland based products under the context of rapid development of the industrialization and urbanization process. This is mainly due to two reasons [14-15]. On one hand, a high-energy diet in the animal-feeding industry system has significantly increased the productivity of pork products at the expense of food safety including issues of overusing agrochemicals like fertilizers, pesticides [20], food additives, antibiotics, or issues of transgenic [21-25]. On the other hand, grass-fed meat (mainly in terms of beef and lamb) has many positive safety attributes in terms of less fatty [26], less pollutants [27], and beneficial nutrient components including omega-3 fatty acids [28], conjugated linoleic acid isomers, and enhanced antioxidant components such as glutathione and superoxide dismutase [29].

Summarily, positive characteristics of grass-fed meat might have the potential to recover the linkage broken in the industrialization process between rural land use change and urban meat consumption. As declaimed by FAO, "food safety encompasses value chains from farm to plate" [30], an intensive food safety crisis could serve as catalyst for rural land use change [21]. Up to date, it has been reported that 60% of the sampled rural families have reduced the expectation on the product output from family gardens, including animal-feeding and vegetable plantation for their own safety when they realized the dangerous characteristics of agrochemical over-input [21]. The public seems to gradually believe that grassland based meat production provides a healthier procedure for animal feeding than factory farming, because it allows more physical practice to animals and requires fewer chemical inputs during the feeding period [31-32]. If the linkage between rural and urban becomes closer and valuable, the degrading rural ecosystem can be restored and sustained via the sustainable maintenance of grassland ecosystems with the concerns or support from urban citizens.

But there is little chance to change diets for swine because they lack enzymes to digest fiber in grasses [13]. Therefore, to what extent urban consumers in karst cities prefer to pay for the grass-fed products is a decisive signal for land use change in degrading karst region yet remain unknown.

Contingent valuation method (CVM) is a widely used and powerful tool to measure public preference in terms of willingness to pay (WTP) for hypothetical positive actions toward environmental goods or services via a stated preference survey [14] due to its flexibility in valuation process. In developed regions and countries like North America, Scottish, Italy, Spain, etc. [33-36], grassland was regarded as a renewable resource of high value to sustain by consumers in cities for their aesthetic value and non-use value [33]. Studies in Europe showed that urban citizens displayed their willingness to pay (WTP) not only for the conservation of grassland landscapes [3], but also for reducing grazing intensity in the context of integrated restoration management [33]. The citizens even showed high WTP for reconverting croplands into semi-natural grassland [34].

In developing countries, low WTP for environmental conservation has been regarded as a major puzzle for grassland conservation and utilization due to income shortage [35-37], and different social perceptions [38]. Before 2006, urban residents in China were reported indifferent about the overgrazing behavior of herders [37]. But after, the low WTP puzzle seems to change.

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In 2007, it was firstly found in China that urban consumers in 3 cities Ansai, Xi-an and national capital Beijing, have WTP for cropland-to-grassland conversion at RMB 343, 388, and 883 per capita per year [39], respectively. In 2016, it was reported that herder families' concern for environmental changes and response to degrading sites had changed greatly for the better [40].

However, studies on consumers' preferences or willingness to pay for products from grasslands are scarce [3]. Actually, the contingent valuation method has seldom been used for valuing grassland systems at consumers' end [5]. This paper tries to measure the degree of consumers' preference towards the grassland based production environment which can be a checkpoint to indicate the echo of the market for both policy-makers and rural farmers when land use decisions need to be made. To target specifically on the preference for grassland based feeding process, a new concept of willingness to pay extra (WTP_e) for grass-fed meat has been used in this paper. To compare with the traditional way of WTP measurement, the WTP for general ecosystem services of grassland has also been surveyed.

Research Progress in Grassland Ecosystem Services

Mechanism Between Grass-fed Meat Purchase Incentive and Grassland Sustainability

With the industrialization development, modern industry systems have increased productivity for human society. Meanwhile it raised the food pollution issue during the production process in terms of chemical pollution including toxin heavy metals which resulted in poisoning consequences, and pathogens pollution that caused foodborne diseases even fatal illness [41]. Furthermore, it was reported that for the past 30 years, other food crises in terms of antibiotics, hormones, pesticide and agrochemicals have made food safety a more important public issue for consumers than hygiene standards and food poisoning [42]. Especially since the bovine spongiform encephalopathy issues raised, some consumers naturally choose to face the consequences of food safety problems and adjust their preference, attitude and behavior towards food products [42].

All these food safety concerns make a strong dynamic for consumers to change their eating habits [43-47], or to pay more attention to the production process globally [48-49]. It is necessary to make a framework to state the rationale of consumer purchase incentive and sustainable ecosystem services of grassland.

Due to less agrochemical input and better taste, meat products from grass-fed or grazed process are well accepted as desired, especially with food safety attributes compared to meat produced from the industry system. In this context, products with desirable value and reasonable prices may create purchase incentives for consumers. Through the meat exchange and market information releasing, consumers' preference of semi-wild animal rearing or the grass-fed meat indirectly encourage sustainable management or conservation practice for grassland or grazing ecosystem to provide sustainable ecosystem services and qualified environment for meat production. Details of the purchasing incentive analysis framework are shown in Fig. 1.

Fig. 1. addresses the purchase incentive of consumers towards grass-fed meat that is raised in semi-natural grassland. Semi-wild way of animal rearing is considered as a good way of production with fine environment to produce grass-fed meat with batter taste and safer attributes compared to confined rearing animal meat produced from concentrate fodder-fed. Which commonly constitute a desired meat product quality. Given a reasonable price was set, the desired value can drive consumers to raise the purchase incentive to buy the grass-fed products with extra willingness to pay for. With this possibility, a policy tool can be applied to set the WTP_e aside and allow it to devote directly to sustain

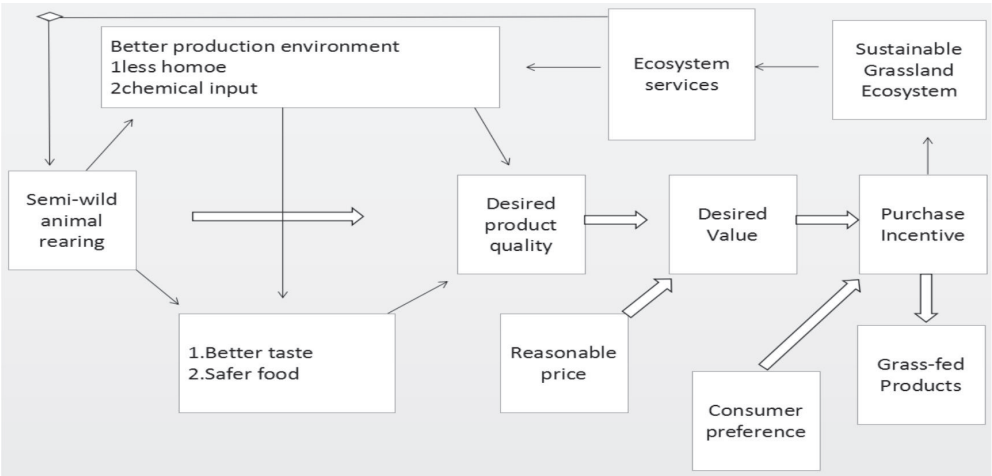

Fig. 1. Purchase incentive framework and rationale for sustainable grassland maintenance.

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a better grassland ecosystem services in rural regions. In return, the better condition of grassland could further supply grass-fed products in a sustainable way.

Survey and Questionnaire

The survey was implemented from March to December 2015 with 314 respondents older than 18 years old. Considering China's unemployment rate of 4.04% in 2015 and in order to save time, the majority of this survey was implemented during break time on working days of full time occupation sites including government offices, enterprises in central business districts, and on the street during the weekend. The main members of the survey groups were 10 faculties and master students of Guizhou Normal University. Finally, the accepted respondents turned out to be more male than female.

In-depth interviews were conducted within 20% of the surveyed respondents at random for further information about their perception, reasoning, decision-making and demographic behind the WTP_e.

Four layers of information were collected using brief and simple questions. Firstly, a perception layer consisted of three answers related to food safety and ecosystem services including provisioning, supporting, regulation and cultural services. Secondly, a preference layer was formed of three questions about WTP_e for grass-fed beef and lamb and WTP for 10 listed items on ecosystem services that were accepted in our pre-survey. Thirdly, information was collected about the possibility of individual actions towards supporting grassland and its ecosystem services. Finally, respondents' demographics were collected, including gender, age, income, education and residence.

WTP_e was measured using the question: 'Assuming the current cattle price is 40RMB/500g for beef, or RMB 50/ 500g for lamb, how much will you specifically pay for the grass-fed way of meat production'. To match the accountable standard, WTP_e was adjusted to RMB per kg. However, WTP for ES has no concrete measurement unit, it can only be presented according to respondents' annual income.

The verification process was carried out with a different set of questions (all questions see the appendix table A) which commonly asked the respondents' grass-fed preference from different angles to assess the seriousness level of the respondents.

Rationale for WTP_e (Willingness to Pay Extra) and WTP

Contingent valuation method surveys the monetary value of environmental goods or services, or both, represented by means of contingent statement in a hypothetical market/scenarios. In this assumed condition of CVM, the demand for a preferred goods with conservation attribute could be measured by the total amount from other goods or benefits that one is willing to give up for the benefits gained through the conservation practice. Questions normally were asked by way of dichotomous choice (DC) in terms of "Yes" or "No", while prices were surveyed in open-ended format (OE) allowing respondents to state their maximum WTP, or by card experiment (CE) which incorporates assumed choices for WTP written in cards.

WTP_e for grass-fed production. In relation to the environmental-friendly products, traditional WTP measured via contingent valuation method (CVM) or choice experiment (CE) normally asked for the overall price of interested public goods or private goods with new environmental attributes. Then, through comparison between products with or without those environmental attributes, the prices of the public goods or environmental attributes can be elicited. However, the costs embedded in the surveyed WTP of products vary a lot due to the impacts from complicated external factors which make the embedded value of environmental attributes sometimes elicited inaccurately.

To solve this problem, we tried the direct survey approach for the grassland demand from consumers and named it as WTP extra (or WTP_e) to mark the surveyed extra part of willingness to pay. Thus, regardless of costs, a direct linkage between urban consumer and rural producers hopefully could be built and reflect the consumer's preference towards artificial grassland ecosystems that would be realized in the market.

Traditional WTP:

$$v_t(P, Q, y) = v_t(WTP, Q_i, y_i) = v_t[(P_0+P_g), \left| Q_0 \pm \Delta Q_i \right|, y_i] = \text{utility of meat + utility of grass-fed attribute}$$

Where, $v_t(P, Q, y_i)$ is the utility function for grass-fed meat priced at "p" and sold at a quantity "q" for a person with income "y"; $v_t(WTP, Q_i, y_i)$ is the utility function for grass-fed meat priced at "WTP" and sold at a quantity "Q_i" for a person with income "y_i". P_0 and Q_0 denote the current price and quantity of current industry-based meat, Pg is price for grass-fed attribute, ΔQ_i means Q_i-Q_0; vt (WTP, Q_i, y_i) is the utility function of non-grass-fed meat priced at "WTP" and sold at a quantity "Q_i" for a person with income "y_i".

The major problem of traditional WTP is the difficulty to extract the price for the utility of the grass-fed attribute. However, only the part of the market price has relation with land use type decisions in the rural area.

WTP extra (WTP_e):

$$v_e(\Delta P', Q_i', y_i') = v_t(WTP_e, Qi', y_i') = \text{utility of grass-fed attribute of meat product}$$

$v_e(WTP_e, Q_i', y_i')$ is the utility function of grass-fed attribute priced at "WTP_e" and sold at a quantity of "Q_i'" for a person with income "y_i'".

Since the assumed traditional WTP shares the same focus zone and target population with our WTP, some variables such as total consumption size of meat

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and personal income of respondents in Guizhou province, are relatively stable. We therefore consider that Q_i equals to Q_i', and y_i equals to y_i'. Then, v_e ($\Delta P'$, Q_i', y_i') = v_t (WTP_e, Q_i, y_i) = utility of grass-fed attribute of meat product.

P_i = present price = Costs + consumer's and supplier's surplus.

$P_i' = P_0 + WTP_{e\,i}$ (or WTP extra i).

$WTP_{e\,i} = \Delta P_i = P_i' - Pi$ = consumer's surplus.

In which, P_i' is the new price indicating local people's willingness to pay specifically for grass-fed or grassland attributes, which allows a direct linkage to be built between urban consumer's preference and the rural grassland sustainable management including construction, maintenance, and management practice.

Fig. 2a) and Fig. 2b). further explains the relation between specific pay for grass-fed products and other types of feeding products. The differences between them are the WTP extra (WTP_e). In another word, total willingness to pay for grass-fed beef product minus current price of non-grass-fed beef is the WTPe for grass-fed production. WTP_e may have positive value which means respondent has willingness to pay for grass-fed production, otherwise, negative. Thus, total WTP can either be higher or lower than the current price of non-grass-fed meat.

WTP for ES. As to the WTP for overall services of grassland, because it is a pure ecosystem service not a visible product or a quantified service, it is impossible to price it in form of per unit or others. Thus, an income ratio was asked to detect the preference or intention of respondents towards such environmental services. The logical verification method was also applied to verify their reliability.

Materials and Methods

Study Sites

Guizhou province is located in the subtropical area of southern China (26.8430°N, 107.2903°E) covering an area of 170,000 km^2 (detail see Fig. 3.) It has temperate a climate with an annual average temperature of 14~15ºC and annual precipitation ranging from 900 mm to 1,400 mm. Where karst grassland covers 24 686.74 km^2, which is 67.57% of the total land cover in Guizhou province. Karst is known as a geographically fragile environment due to its unique soluble rock, significantly mountainous landform, shallow soil depth, and insufficient water-holding capacity in soil that made the ecosystem prone to degradation. Consequently,

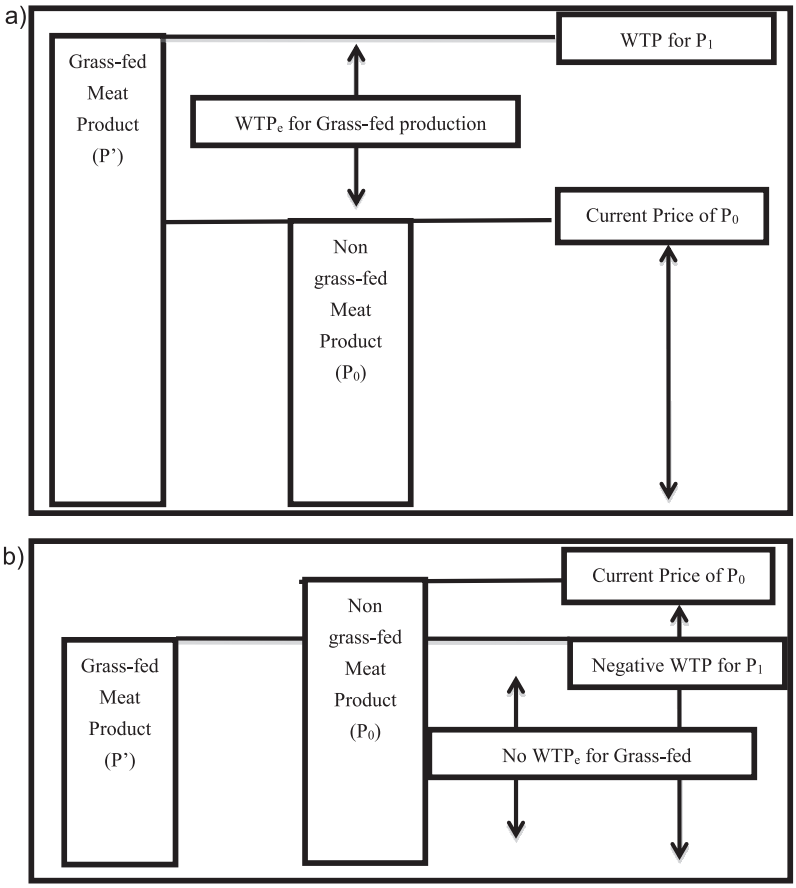

Fig. 2 a) Concept of willingness to pay for grass-fed meat (scenario 1 WTPe >0); b) Concept of willingness to pay for grass-fed meat (scenario 2, $WTP_e \leq 0$).

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39.77% of karst grassland is recognized as degrading grassland.

This province accommodates a population of 35.8 million; the rural population is about 18.7 million living in the mountainous region. Before 2012, there were more than 9 million populations under poverty in Guizhou province.

Traditionally, pork has been served as the dominant course of meat in Guizhou province, which leads to shortages of grass-fed meat production. For example, in 2015, the total production of pork was 1.61 million tons which was nearly 10 times the beef production of 168 thousand tons, and approximately 40 times the lamb consumption of 42 thousand tons. Yet swine feeding does not prefer grass-fed strategy of animal raising because swine is thought incapable of digesting raw fiber content of grasses [13].

As the most typical example of karst in southern China, Guizhou province was chosen for the study of consumers' willingness to pay for the grass-fed attribute of meat in ecologically degraded area due to both ecological degradation and social threat, 35% of the provincial land has been endangered by rocky desertification (RD) at varying levels [50-51]. Four cities were selected out of the total eight cities in Guizhou province for conducting interviews with meat consumers. Land degradation was most severe in Anshun city (Dense-RD), followed by Bijie city (Middle-RD), Guiyang city (Mild-RD), and Qiandongnan city (Non-RD) - (Fig. 3.).

Survey Design

Yamane Formula was applied to calculate the minimum suggested sample size as shown below:

$$n = N / (1+N*e^2) \quad (5)$$

where n = the minimum suggested sample size; N refers to the population in the urban area of the four selected cities in 2015; e represents the margin of error.

According to Table 1., it is necessary to survey at least 400 respondents with 5% error, and 100 respondents with 10% error.

With regard to existing levels of RD (or degradation of the local ecosystem) in all 8 major cities in Guizhou province, a two-stage stratified random sampling method was applied in our survey. For the first stage, serious RD and non-serious RD were separated and each part weighted 50%. In the second stage, each column was further divided into 2 cities, each weighted 25% of the total. Accordingly, medium to dense RD was classified as a serious RD region, while the non-karst, non-RD and mild RD are classified as non-serious RD. Hence,

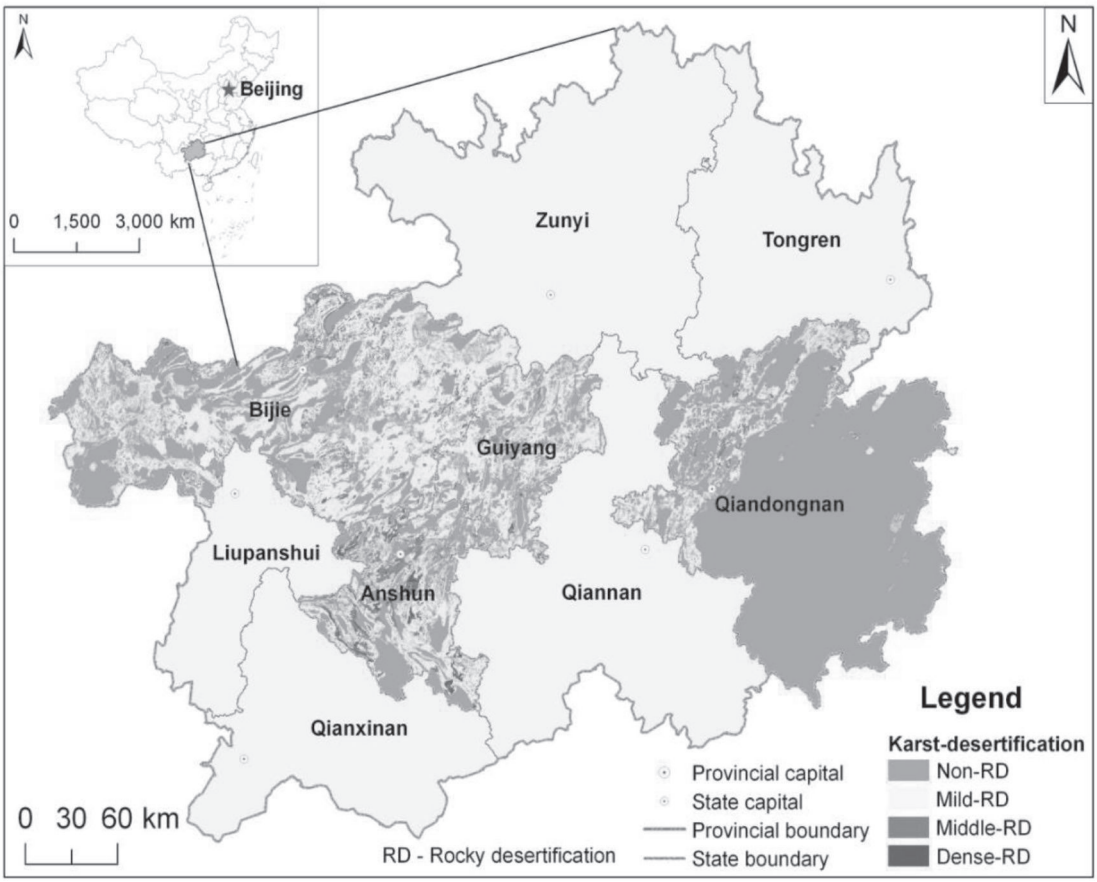

Fig. 3. Study Areas and Degrees of RD in Guizhou Province, China.

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Table 1. Minimum suggested sample size.

N (urban consumers in 2014)	e (margin of error)	N*e2	n (suggested minimum sample size)
14.8 million	5%	37063.3	399.98
	10%	148253.3	99.99

4 sampled cities were chosen along the geographic belt of karst rock as shown in Fig. 2. which are in the line through 107°E, 106°E to 105°E, separately.

The survey was implemented from March to December 2015 with 314 respondents older than 18 years old. Considering China's unemployment rate of 4.04% in 2015, which means the majority is employed people. Thus, in order to save time, a major survey was implemented during break time on working days of full-time occupation sites including government offices, enterprises in central business districts, and on the street during the weekend. Incidentally, the accepted respondents turned out to be more male than female.

The main members of the survey groups were 10 female faculties and master students of Guizhou Normal University.

In-depth interviews were conducted with 20% of the survey respondents for further information about their perception, reasoning, and decision making behind WTP.

Questions about consumers' perception, preference, action, and individual demographic information were asked and answered with yes/no. With these, three layers of information were collected using a brief and simple tool, making the interview process easier and more effective than when using a longer questionnaire. First, a perception layer is comprised of three questions related to food safety, taste, and benefits to the environment. Secondly, a preference layer consisted of three questions in terms of WTP_e for grass-fed beef and lamb, and the WTP for 10 listed items on ecosystem services that were accepted in our pre-survey. Third, the possibilities of individual actions towards supporting grassland and its ecosystem services to the society. Fourth, respondents' demographics were collected such as gender, age, income, education, and residents.

At last, WTP_e for grass-fed attribute and WTP for general ES of grassland were questioned in a free-talk way which allow respondents declare positive, negative or 0 RMB for the grass-fed attribute and any ratio per person per month for grassland to reduce embedded pressure through the words or scenarios implication from interviewers. WTP_e was surveyed for RMB per kg of meat, thus the natural linkage between WTP_e and meat products can be maintained. While WTP was stated based on monthly personal income because compared to meat there was no similar visible product, it is hard for respondents to evaluate their payment unless in regards to their monthly income.

The verification process was carried out with a different set of logical questions which commonly asked the respondents' grass-fed preference from different angles to assess the seriousness level of the respondents.

Statistical Analysis

Mean of WTP_e, standard deviation, frequency of dichotomous choices on perception, preference and action, WTP_e for grass-fed meat, and WTP for ES were calculated to see the quantified preference and their distribution.

Correlation analysis and regression analysis were applied via R 20.0 to infer the relationship between independent variables and WTP_e or WTP, as well as to identify the influencing factors for individual WTP_e or WTP. The influencing factors include varying ecological degradation, local knowledge, personal perceptions, demographic information, and income levels.

In addition, the demand curve, demand aggregate, total value of WTP_e for meat, and WTP for ES were calculated and visualized with modeling formula and R^2 indication.

Arithmetic mean, standard deviation, frequency of DCs on perception, WTPe for grass-fed meat (compared to non-grass-fed meat) and WTP for ES were calculated to determine quantified individual preference and its distribution.

In line with O'Neil and Yadav [52], a dummy variable ($WTP_i^* = X'w_i\beta + \varepsilon w_i$) that determines surveyed WTPe being accounted or not was used. Where $X' w_i\beta$ is influenced by individuals' demographics and εw_i is a distributed error term. In condition the WTP^* lies between two thresholds Tw_{i-1}1and Tw_{i-1}. For a payment at i level, the WTP is determined by the following formula:

$$WTP_e = \begin{cases} 0 & \text{if } -\infty < WTP^* \leqq T_{w0} \\ V1 & \text{if } Tw_0 < WTP^* \leqq T_{w1} \\ \text{.....} & \\ Vj & \text{if } Tw_0 < WTP^* \leqq T_{wj} \end{cases}$$

Since both the positive and negative impacts of demographic factors has been reported, demographics are carefully designed and measured in line with questions related to perception, preference and ecological degradation to further understand the real relationships between consumers' purchase activity and

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the WTPe for beef and lamb as well as the WTP for the overall ES in our selected region.

Among the formula, X' wiβ is decided by the sub-variables of the individuals including residential cities sorted by degrading levels, personal income, age, educational degree, and gender.

The standard WTP_e is then estimated using the OLS probit and Tobit model via R 15.0 language. Regression analysis was applied to infer the co-relationship between independent sub-variables and WTP_e or WTP.

In addition, the demand curves were visualized with a modelling formula, demand aggregate, total value of WTP_e for meat and WTP for ES were calculated and evaluated in the format of tables.

Factor Analysis. The number of consumers who have the WTP_e for grass-fed attribute of beef/lamb, or WTP to pay for ecosystem services of grassland is defined as dependent variables $Y_{WTPe\text{-}B,\ YWTPe\text{-}L\ and\ YWTP\text{-}ES}$. The independent variables define the factors affecting the number of people who have the WTP_e as X. Details are described as follows:

X_1 Cities with varying RD level Qiandongnan (N, non RD); X_{11} = Bijie (M, middle RD); X_{12} = Guiyang (L); X_{13} = Anshun (D).

X_2 Personal income level Low income; X_{21} = middle; X_{22} = high.

X_3 Age Young age; X_{31} = middle; X_{32} = elders.

X_4 Education: Primary education; X_{41} = middle; X_{42} = high.

X_5 Gender Female; X_{51} = male.

The demographic factors were reported as both influencing variables and irrelevant variables to WTP. Some experts insisted that income was the decisive factor that determines the WTP, while some regard education and age etc. were the major influencing variables. Some experts reported the importance of consumer preference or social perception on WTP elicitation.

Here, demographics factors related to, perception, preference, and ecological degradation are all involved.

Results

Profile of Respondents

96.8% of respondents have completed primary education, this is slightly higher than the provincial average of 90.3%. Results show that 72.3% of respondents are male whose gross income per person per year is approximately RMB 18,300 which is higher than the general average of RMB 11,083 (Table 2).

Table 3. shows that 59.6% of the respondents were between 30 and 49 years old; 72.4% were male; 57.0% have relatively high educational background (college-

Table 2. The Basic Social Profile of the Respondents.

Variables	Sampled (n = 314)	Overall Guizhou
Education (% of people with primary and above levels)	96.8%	90.3%
Age (mean years)	48.0	49.0
Gender (% of female)	27.7%	48.4%
Mean gross income (RMB) / person / year	18,300	11,083

Exchange rate: 1USD = 7.0653 RMB (2015)
Source: Authors' survey (2015) and Statistics Bureau of Guizhou Province (2017).

Table 3. Distribution of the Demographic Variables for the Respondents (n = 314)

Variables	Categories		Frequency (%)	Variables	Categories		Frequency (%)
Education	Primary school		16.2	Employment	Full-time		79.9
	Middle school		26.8		Others		19.7
	High school or higher		57.0	Income (yearly)	18,000-35,999		5.4
Gender	Male		72.4		36,000-350,999		55.4
	Female		27.7		≧350,000		39.2
Age	18-29		12.4	City	Anshun	Dense RD	33.8
	30-49		59.6		Bijie	Medium RD	22.3
	50+		27.8		Guiyang	Mild RD	22.3
Total respondents (314)			100		Qiandongnan	Non-degradation	21.7

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level and above); 79.9% were full-time staff; and 91.7% gained monthly income of more than 3,000 yuan, whose food supply is presumably sufficient. The sampling proportion among the four cities was nearly even, except for Anshun city which accounted for 34% of the sampled respondents.

WTPe and WTP

The mean WTPe for beef and lamb per kg were 16.51±4.81 and 34.24±7.37 respectively at the range between -15~+50 for grass-fed beef and -30~+90 for grass-fed lamb via statistical analysis. Previous researchers agreed that the negative or the zero WTP should be removed or regarded as 0 to the overall calculation because it makes no sense to mix two different groups of respondents to display preference of those who are positively willing to pay. Thus, the adjusted mean values per kg are 22.26±11.12 and 42.31±24.50 for grass-fed meat and 5.3% of personal income for general ES value. Therefore, a clear tendency of increase in grassland valuation was observed on the degree of environmental degradation for the adjusted mean WTP_e in relation to both grass-fed beef and lamb. This suggested that there might be a linkage among such factors as environmental crisis, personal preference, and food safety perception. Further research is needed to explore related possibilities.

Table 4. implies that the arithmetic mean of the sample is much lower than the adjusted mean (if $WTP_e \leq 0$, take it as 0) which means some respondents remain non-WTP intention. The adjusted mean WTP_e certainly reflected the positive attitude of respondents' willingness to pay for grassland related goods or services. However, it is crucial to be aware of positive WTP_e and WTP proportion to the total number of interviewees.

In Fig. 4., the x-axis is listed for the potential demand size (%), while the y-axis refers to the WTPe for grass-fed beef, lamb or WTP for ES (RMB per kg or income ratio %). This suggests what percentage of people has the desire for grass-fed meat production attribute or WTP for general ES at different WTP_e.

ΔAB (WTP_e,Q1) denotes the area of consumer's surplus with which consumers are willing to pay or donate to grass-fed meat production, which links grassland sustainability to urban meat consumption. Among which, AB, AL refers to A point for beef or lamb, BB, BL refers to B point for beef or lamb. According to the principle of empirical WTP higher than family income by 5-10% should be excluded as marginal bid [53]. Therefore, reasonable WTP for ES were recalculated and presented in Fig. 4. without the values bigger than 10%. Consequently, reasonable WTP-ES followed linear regression with a significant R^2 at 0.8931.

For both types of grass-fed meat in Fig. 4., the bottom curve (B, WTP_e Q1) represented the WTP_e for grass-fed production process or grassland related management which was collected through direct survey; The above one (A, P0Q0) was the assumed market price of grass-fed meat on the basis of current price of non-grass-fed meat plus WTP_e. If $WTP_e > 0$, WTP for the overall meat product with grass-fed character should be higher than current price. Which suggests that consumers prefer to grass-fed production; vice versa, if $WTP_e \leq 0$, WTP would be lower than or equal to the current price of products which means that consumers tend to regard current price unacceptable and should be reduced.

Along each downwards demand curve, the size of consumer decreased in negative linear correlations with the WTP_e. In Fig. 4., ΔAB (WTP_eQ1) denotes the area of consumer's surplus for both types of meat product.

Verification of WTP_e and WTP. As shown in Table 5., up to 81.5% of respondents agreed that they may receive health benefits from grassland, mainly in terms of healthier meat consumption. As many as 86.3% of individuals declared to have grass-fed preference rather than the high-energy-diet-fed meat (or the industry system produced meat). Moreover, 74.8% are willing to pay specifically for grass-fed attributes of meat. And even 55.7% of respondents said they were ready to

Table 4. WTPe per Kg for the Respondents.

Statistics	WTP_e for Beef (RMB/kg)	WTPe for Lamb (RMB/kg)	WTP for ES (% of income/person/a)
Mean ± SD	16.51 ± 4.81	34.24 ± 7.37	0.053 ± 0.056
Max	50.000	90.000	0.300
Min	-15.000	-30.000	0.000
Mean* ± SD	22.255±11.116	42.309±24.503	0.053±0.056
Mean*_Guiyang ± SD	15.245±7.636	16.610±11.660	0.060±0.052
WTP*_Bijie ± SD	22.755±11.053	25.127±14.155	0.034±0.042
WTP* Anshun ± SD	25.208±8.807	62.526±14.094	0.072±0.069

Note: WTP* is a mean value of WTP excluding the negative or zero value given by respondents. if WTP>0, $WTP_e = WTP^*$; if $WTP^* \leq 0$, $WTP_e = 0$.

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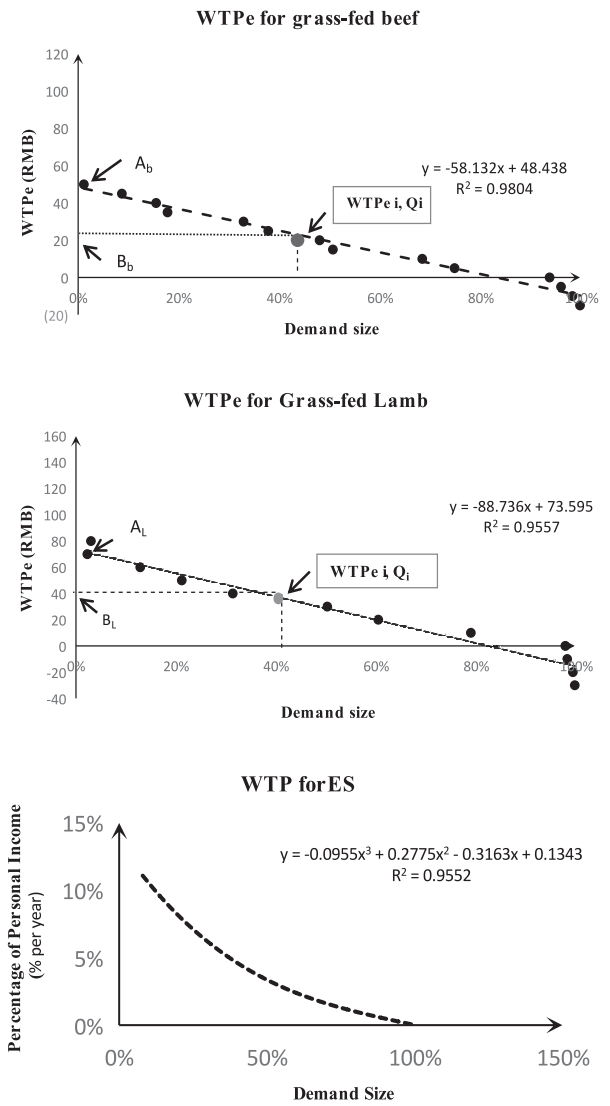

Fig. 4. Plotting the WTPe and demand for Grass-fed meat and WTP for Grassland

ΔA,B,(WTP_{ci},Q_i) denotes the area of consumer surplus with which consumer is willing to pay or donate to grassland construction and maintenance for meat production. Among which, A_B, A_L refers A point for beef, B_B, B_L refers to B point for beef or lamb. According to principle of empirical, WTP higher than family income by 5-10% should be excluded as marginal bid. Therefore, reasonable WTP for ES were recalculated and presented in (d) without the values bigger than 10%. Consequently, reasonable WTP-ES followed linear regression with a significant R^2 at 0.9552.

change meat eating habits from pork to grass-fed meat for health reasons.

However, there was a higher ratio of respondents who gave a price of their WTP_e or WTP and declared that they would prefer not to pay for the grass-fed attribute or grassland ES. As high as 94.6% of the respondents would leave a portion of their yearly income to express their WTP and 81.5% gave a price of WTP for lamb related grass-fed attributes. On the other hand, only 76.1% of the respondents wrote down the price of WTP. This percentage is closest to 74.8% of respondents who indicated their perception.

Comparing the ratios of WTP_e and WTP towards grassland in terms of perception, preference and action, the level of agreement to the importance of the hidden value of grassland varied. It was clear that when directly asked for prices, the respondents tend to give the highest "agree" answer to the interviewers. When "agree-disagree" questions were asked, the respondents also had difficulty to say no to the person in a straightforward manner. Only the questions irrelevant to "agree-disagree" choices possibly got the most real answers.

Based on the above analysis, there could have been an element of boasting or pride when the respondents gave the price of WTP_e and WTP which should be considered.

Factors Influencing Individual WTP_e and WTP

It was found in Table 6. that, using OLS regression analysis, there was significance at the city level between cities affected by RD and willingness to pay extra for grass-fed beef (p< 0.0001). Yet, at the individual level, the income displayed the most significant coefficient (p<0,0001) with the WTPe the price of beef (p<0.0001). Then the important determining variables were identified for the maximum WTP_e for grass-fed beef and lamb, as well as WTP for non-extractive utility of overall ecosystem services of grassland.

In this paper, y_{WTPe} represents the outcome of the WTPe of individuals concerning two most affected variables namely Xcity and Xincome, yWTP_e-ES refers to willingness-to-pay for general ecosystem services of grassland. For Xcity with Qiandongnan as a reference category, b11/L11/E11 indicates Bijie City, b12/L12/E12 refers to Guiyang City, and b13/L13/E13 refers to Anshun City. For the income variable Xincome with low-income class as the reference category, b21/L21/E21 represents middle-income class and b22/L22/E22 denotes the high-income class. The variables for age (Xage), education (Xeducation), and gender (Xgender) were also included. In detail, P_{WTPe-B} refers to willingness-to-pay extra for beef and P_{WTPe-L} refers to willingness-to-pay extra for lamb.

To validate the outcomes of the CVM method, the WTP_e for two types of meat and WTP for ES were modeled to constitute a function of assumed determining variables related to environmental factors of the degree of degradation, economic factor of income, and demographic factors of age, gender, and education. According to the survey results, a small number of respondents gave negative or zero WTP_e. The first strategy to solve this problem is to use a set of Tobit linear regression specifications applied to the whole sample. And the second way is to remove the data with WTP_e lower than 0, and then apply Ordinary Least Square (OLS) model for regression analysis.

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Table 5. Dichotomous Choices for Perception, Preference and Action of WTPe and WTP.

A Set of Verification Questions	Classification	Di =1
Health benefit from grassland	Perception layer	81.5%
Grass-fed preference	Perception layer	86.3%
WTP_e to grass-fed meat or grassland ES	Perception layer	74.8%
Meat habit change trends	Action/practice	55.7%
WTP_e to grass-fed attribute of beef	Preference layer	76.1%
WTP_e to grass-fed attribute of lamb	Preference layer	81.5%
WTP to grassland ES	Preference layer	94.6%

Note, Di =1 means "yes" to the dichotomous question between yes or no.

Table 6. Total Consumer Surplus in Meat Production in Guizhou Province.

WTP_e	WTP	WTP_e per unit	Volume of grassland demand			Value of goods* +50% Volume	Value of goods** +25% Volume
		WTP_e for grassland	Current Volume	Assumed +50% the grass-fed	Assumed +25% the grass-fed		
	(%)	(RMB/ kg)	(10,000 t/ year)	(10,000 t/ year)	(10,000 t/ year)	(RMB/year)	(yuan/year)
Pork Production	-	-	158.9	79.4	119.2	-	-
to grass-fed beef	75.9%	16.51±4.812	14.1	62.9	31.5	7.9×10^9	3.9×10^9
to grass-fed lamb	81.5%	34.24±7.365	3.7	16.5	8.3	4.6	2.3
WTP	(%)	WTP per person	Volume of urban consumers (2018)		Annual disposable income/person (2018)	Personal WTP/a (RMB/year)	General Value of G-ESV/a (RMB/year)
to ES	94.6%	0.053±0.056	1.65×10^7		RMB 31,592	1,674.4	2.61×10^{10}

Notes: G-ESV, grassland ecosystem services valuation; * implied grass-fed meat consumption increased to 50% of the total grass-fed demand; **implied grass-fed meat consumption increased to 25% of the total current demand. Accordingly, the ratio between beef and lamb consults current ratio of (14.1**:** 3.1).

Demand Aggregate and Its Implications in Guizhou Province

As shown in Table 7, 75.9% of the respondents gave a concrete number for grass-fed beef and 81.5% for grass-fed lamb, and even 55.7% declared to change eating habits from non-grass-fed to grass-fed.

Based on above results and 1.65×10^7 (2018) urban population of Guizhou, assuming up to 50% or up to 25% of urban consumers changed their eating habit from pork to beef or lamb, the maximum demand of grass-fed meat would reach 6.29×10^5 t/year or 3.15×10^5 t/year for beef. Which suggests a direct value of 10.38×10^9 or 5.20×10^9 RMB to grass-fed beef production. If policy mechanism permits, these amounts of donations would have capacity to sustain as much as 1.15×10^7 (1000m^2) or 0.57×10^7 (1000m^2) per year for Guizhou province if 900RMB was invested for each ha which is twice of current compensation.

Similarly, in Table 8, on condition of 50% more or 25% more lamb consumers, the maximum demand for grass-fed lamb would be 1.65×10^5 t/year or 0.83×10^5 t/year for lamb in Guizhou market. This potentially provides a direct economic value of 5.65×10^9 or 2.98×10^9 RMB each year that potentially sustains 0.63×10^7 (1000 m^2) or 0.32×10^7 (1000 m^2) if 900RMB was given to farmers per 1000m^2 which doubled current compensation from the government.

Discussion

Kahneman challenged the "purchase model" of the environment-related products and replaced it with "contribution model" and posited that it was the donation, not benefit acquisition, that motivated primarily the underlying positive WTP response [54-55].

In our case, the overall WTP for ES was regarded as an example that follows the donation principle because there was no visible beneficial relationship between respondents and the existing value of grassland. This was mentioned in relation to other ES of grassland

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Table 7. Factors Affecting the Individual Level WTPe for Grass-fed Attribute of Meat of karst ecosystem services.

Variables	Definition	OLS Regression			Tobit Regression		
WTP_e-Beef	**-**	**Estimate**	**Std. Error**	**Pr(>|t|)**	**Estimate**	**Std. Error**	**Pr(>|z|)**
Constant	-	44.027	2.4163	<0.000***	44.78026	2.74365	< 2e-16***
Guiyang dummy	1for Guiyang, 0 if others	8.649	1.155	0.000 ***	8.95492	1.2724	0.000***
Bijie_dummy	1for Bijie, 0 if others	6.2753	1.5513	0.000***	10.5025	1.82075	0.000***
Anshun_dummy	1for Anshun, 0 if others	3.0891	1.3458	0.02239 *	1.70216	1.50872	0.25923
Middle income dummy	1 for middle income, 0 if others	-12.8078	2.0769	0.000***	-11.64645	2.29197	0.000***
High income_dummy	1 for high income, 0 if others	-33.6303	2.4391	<0.000***	-37.22754	2.72947	< 2e-16***
Middle age dummy	1 for middle age, 0 if others	-2.3564	1.3897	0.09098 .	-2.65228	1.64015	0.10586
Older age_dummy	1 for older age, 0 if others	-2.2732	1.5511	0.14381	-2.85866	1.80814	0.11388
Middle education dummy	1 for middle education, 0 if others	-6.751	1.5744	0.000 ***	-7.45719	1.74505	0.000***
High education dummy	1 for high education, 0 if others	-11.4784	1.6957	0.000***	-13.24208	1.89875	0.000***
Gender dummy	1 for male, 0 if female	-2.6129	0.9463	0.00611 **	-3.28593	1.12823	0.00359**
WTP_e-Lamb	**Definition**	**Estimate**	**Std. Error**	**Pr(>|z|)**	**Estimate**	**Std. Error**	**Pr(>|z|)**
Constant	-	31.055	7.365	0.000***	28.08426	8.38175	0.000806***
Guiyang_dummy	1for Guiyang, 0 if others	-22.434	3.521	0.000***	-26.48535	4.04199	0.000***
Bijie_dummy	1for Bijie, 0 if others	-26.255	4.729	0.000***	-30.28424	5.42523	0.000***
Anshun_dummy	1for Anshun, 0 if others	14.382	4.102	0.000524 ***	13.77128	4.63393	0.00296**
Middle income dummy	1 for middle income, 0 if others	12.262	6.331	0.053696	14.52711	7.29769	0.04652*
High income dummy	1 for high income, 0 if others	10.5	7.435	0.158916	13.30182	8.54947	0.11974
Middle age_dummy	1 for middle age, 0 if others	7.448	4.236	0.079728	6.55089	4.79627	0.171992
Older age_ dummy	1 for Older age, 0 if others	15.005	4.728	0.001660 **	16.42626	5.35938	0.002177**
Middle education dummy	1 for middle education, 0 if others	-8.772	4.799	0.068558	-8.68266	5.4283	0.000***
High education dummy	1 for high education, 0 if others	-15.325	5.169	0.003268 **	-14.8224	5.8439	0.0112*
Gender dummy	1 for male, 0 if female	4.798	2.885	0.097317	5.79954	3.3213	0.080782.

Note: Codes for significance: 0.000 '***', 0.001 '**', 0.01 '*', 0.05 '..', 0.1 ' '; R^2 of beef, and lamb for OLS regression analysis are 0.7961 and 0.5092; The censored variables in Tobit Analysis is 267 for beef, 309 for lamb, total df = N-1 equals to 313. Because our CVM was set to an open-ended WTP, the original price for both beef and lamb involve negative value and zero value. In the Tobit regression analysis, WTPe ≦0, excluded, WTPe> 0 was calculated.

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Table 8. Bi-variates Correlation Analysis

Correlations	Q5beef	Q5lamb	Q8ES	Bijie	Guiyang	Anshun	mid-income	high-income	mid-age	older-Age	mid-education	high-education	Gender
Q5beef	1	0.1248	-0.135	0.4041	-0.4855	-0.1366	0.6422	-0.8279	-0.2729	0.3008	0.0418	-0.3033	-0.2816
Q5lamb	0.1248	1	0.2457	-0.3404	-0.4309	0.515	0.1013	-0.1259	-0.3359	0.2806	0.2098	-0.3717	-0.0444
Q8ES	-0.135	0.2457	1	-0.3077	0.0676	0.1784	-0.104	0.1646	-0.1326	0.1316	0.098	-0.1159	0.176
Bijie	0.4041	-0.3404	-0.3077	1	-0.2869	-0.3824	0.3419	-0.3514	0.0984	0.0065	0.0045	0.0828	-0.252
Guiyang	-0.4855	-0.4309	0.0676	-0.2869	1	-0.3824	-0.5355	0.5891	0.3323	-0.215	-0.1966	0.2855	0.3593
Anshun	-0.1366	0.515	0.1784	-0.3824	-0.3824	1	-0.0778	0.1584	-0.3448	0.0794	0.2892	-0.3174	-0.0455
Mid-income	0.6422	0.1013	-0.104	0.3419	-0.5355	-0.0778	1	-0.8946	-0.1126	0.0462	-0.0215	0.018	-0.36
High-income	-0.8279	-0.1259	0.1646	-0.3514	0.5891	0.1584	-0.8946	1	0.2226	-0.1957	0.0367	0.1163	0.306
Mid-age	-0.2729	-0.3359	-0.1326	0.0984	0.3323	-0.3448	-0.1126	0.2226	1	-0.7572	-0.0908	0.286	0.1151
Older-age	0.3008	0.2806	0.1316	0.0065	-0.215	0.0794	0.0462	-0.1957	-0.7572	1	0.1388	-0.4104	-0.2036
Mid-education	0.0418	0.2098	0.098	0.0045	-0.1966	0.2892	-0.0215	0.0367	-0.0908	0.1388	1	-0.7872	-0.021
High-education	-0.3033	-0.3717	-0.1159	0.0828	0.2855	-0.3174	0.018	0.1163	0.286	-0.4104	-0.7872	1	0.0288
Gender	-0.2816	-0.0444	0.176	-0.252	0.3593	-0.0455	-0.36	0.306	0.1151	-0.2036	-0.021	0.0288	1

Note: $|x|$ = 1.0~0.8, very strong correlation; 0.8~0.6, strong correlation; 0.6~0.4, medium correlation; 0.4~0.2, weak correlation; 0.2~0, no correlation.

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instead of provisioning services for meat products. Differently, WTP_e for grass-fed meat was targeted by asking the direct linkage between meat consumption and existing price of grassland. This possibly implied that compared with pure donation for environment well-being, the extra WTP added to the private price of grass-fed meat matched better with benefit acquisition. If the "state of the art" were applied to the survey design, public preference could be revealed in a less biased manner [56].

According to the theory of supply and demand, the economic surplus of a product consists of both consumer's surplus and supply surplus in terms of revenue gained by consumers or suppliers when the real purchase price was lower than the consumer's WTP or higher than the costs of producing the products. When a product costs only a small proportion of an individual's expenditure or income, the consumer's surplus, also called Marshallian's consumer's surplus [57-58], is postulated to be justified by a downward sloping demand [57].

In this study, the price of meat, the WTP_e for grass-fed production process, and the WTP for general services value of grassland all suit the principle. Therefore, the demand curves of grassland services, based on the survey, are all downward sloping curves with very high R^2.

It does not matter whether the WTP_e constitutes a real payment or just a signal for demand of grassland ES. The most important thing is that a mechanism between market and environmental attributes with a natural linkage of demand-and-supply balance should be created. Which have the potential to ensure grassland provisioning and sustainable management as Fig. 5. describes. Referring to the demand for grassland services, consumers have the power to become a stakeholder to decide and manage rural grassland construction or conservation. Their WTP_e combined with investment or compensation funds from government and other sources could be reasonable inputs to sustain grassland construction and management.

However, when the mode of payment is considered, we have to be doubly cautious on the survey results based on CVM, especially on the part of WTP to ES. With regards to the "prospective theory" and all the discussion over CVM, even if the majority of respondents declared that they have willingness to pay for environmental health or exchange for food safety, the psychological factors of the respondents cannot be ignored. Moreover, the indication from low R^2 and weak correlation in the bi-variates analysis related to WTP-ES and WTP_e-lamb should not be ignored. For our study, the value of WTP_e for grass-fed beef is acceptable because of its high confidence value.

Nonetheless, excessive supply of grass-fed meat would come with negative consequences in terms of biodiversity reduction for the ecosystem [3]. It even results in a loss of habitats for animals [59-60]. The target of grassland management is to enlarge yields of beneficial grasses for grazing practice and to minimize the biomass of non-beneficial varieties of vegetation which equals to biodiversity reduction [61-63]. Yet, biodiversity plays an important role in the ecological process and provides supporting services to the productivity of the ecosystem. And it is regarded as a responsive variable to environmental changes and also a factor affecting both ecosystems and human livelihoods.

A previous report revealed that broadcasting, an internet source of information on ecological degradation, arose the WTP for environment products [40]. However, further research on a larger scale is required to reveal the impacts of consumer demographics and social perception on this strong positive WTP_e and WTP in southern China karst area because the reasons are more complicated than expected.

Conclusion

Referring to the previous consumer size of 4.30 kg of beef and 1.10 kg of lamb per person per year on average, it certainly is not enough money to impose impacts to local land use, even the WTP_e is possible to be collected via management strategies to invest in grassland maintenance directly.

However, it has never been seen in China as much as 83.6% of consumers acknowledge their preference for grass-fed meat instead of meat from industry system in the context of food safety concerns. Approximately 76.0% agree they would pay extra for grass-fed production process and declare a price higher than 0 yuan. Furthermore, 55.7% confirm that they would like to give up high-energy-diet meat for environment friendly meat such as beef or lamb to encourage grassland maintenance and their personal food safety. Given half of population the shifting to grass-fed meat, consumers in Guizhou province have WTP for construction or sustainable management of grassland that can raise 62.9 x 10^4 tons of beef or 16.5 x 10^4 tons of lamb. In return, the grassland value embedded in the private product would be as much as 1.04 x10^{10} yuan for cattle-fed grassland or 5.65 x10^9 yuan for sheep-fed grassland per year.

This means that the individual consumer is no longer trivial but has the potential to become an important stakeholder to participate in the construction decision-making or sustainable management of grassland or semi-natural grassland.

The survey results suggest that consumers are strongly willing to pay extra for grass-fed production process, which makes consumers a potentially important stakeholder to participate in grassland management and decision-making. Both the WTP_e with intention to sustaining grassland for meat production process or WTP for general grassland ecosystem services conservation have the capacity to transfer food safety demand of urban consumers and urban to a guidance for rural land use action via their economic action.

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Through this mechanism, a control switch for ecological restoration can be built through the market to avoid over-producing or insufficient production of grass-fed meat or rural tourism.

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Conflict of Interest

The authors declare no conflict of interest.

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Appendix A: Survey Questions

Part I. Demographics

Name, gender, age, education, income, resident, work-type.

Part II. Dichotomous Questions:

Perception

Q1:Do you think grass-fed meat is healthier than fenced-fodder-fed meat because it has less chemical input, less antibody injection during the production process due to grassland and grazing? (Yes or No)

Q2: Do you know that cattle and sheep/goats can be produced from grass which is more healthier than pig/swine/hog that is mainly fed by concentrated components and high-energy diet? (Yes or No)

Preference

Q3: Do you prefer grass fed or chemical fed animal meat? (Yes or No)

Q4: Are you willing to pay extra for grass fed meat? (Yes or No)

Activity

Q6: Did you consider giving up pork for grass-fed beef or lamb? (Yes or No)

Part III. Non Dichotomous Questions:

Q5: If the current price for beef=30 yuan/kg; lambs=50 yuan/kg, how much more do you want to pay for grass fed meat? (Yes or No)

Q7: Grassland provides a set of ecosystem services including items below (other than producing animal meat), please make multiple selection from below options if you agree: 1) purifies air; 2) CO_2 reduction; 3) reduces soil-water loss; 4) reduces pollution; 5) provides entertainment; 6) pollination; 7) water supply; 8) water regulation; 9) provides traditional Chinese herb medicine; 10) supply wild vegetable. (when you agree, please mark items with ☑)

Q8: Do you have the willingness to pay for the above ecosystem that you marked? How much are you willing to pay? (a ratio of your annual income, e.g. 0，0.1%, 0.2%, 0.5%, 1%，2%，5%，10%，30%，>35%.....)