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How do You Want to restore?--Assessing the Public Preferences and Social Benefits of Ecological Restoration for Natural Rubber Plantation in China

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Revealing the public's preference for ecological restoration projects will help increase public support and improve social benefits evaluation accuracy, which is a prerequisite for implementing ecological restoration projects. This study aimed to reveal the public's preference for natural rubber plantation restoration projects and then quantify the social benefits of these projects to provide valuable references for related policy design. Based on choice experiments, we built a hypothetical market of ecological products and conducted a field survey to obtain the public's preferences and willingness to pay (WTP) for natural rubber plantation restoration projects. Then, a random parameters logit model was applied to obtain public preference information, and then the social benefits brought by different restoration scenarios were calculated and compared. The results showed that: 1) residents of Hainan Province had a positive attitude toward ecological restoration for natural rubber plantations and were willing to bear a personal cost. 2) respondents had significant differences in preference for attributes of restoration projects. 3) a restoration project covering 2.1 million mu of rubber plantations, prioritizing the water source protection area, focusing the implementation on state farms, and developing the under-forest breeding economy would gain more social benefits, precisely, 337.543 million yuan/year. Ecological restoration policies should pay more attention to public needs and incorporate them into future guidelines. Policymakers should focus on restoration quality instead of the restoration area. Priority should be given to rubber plantations close to the water source protection area and small householders, and an appropriate under-forest economy should be considered. This study can provide a valuable reference for policy-making related to rubber plantation restoration.

Keywords: natural rubber plantations, ecological restoration, social benefits, public preferences, choice experiments

INTRODUCTION

The introduction of natural rubber cultivation in China's tropical areas has triggered unprecedented economic development, particularly in rural areas. Rubber farming has contributed to the local economy, increased smallholders' income, and reduced poverty (Ahlheim et al., 2015; Ma et al., 2019). As rubber plantations are generally quite lucrative and have provided considerable cash income to farmers who have few alternative sources of income (Min et al., 2019), rubber plantations are encroaching the indigenous rain forests at a large scale and a high speed in the past 2 decades (Warren-Thomas et al., 2015) Additionally, because rubber can be successfully grown in only a small portion of southern tropical China, the strong domestic demand for rubber combined with government policies has caused substantial natural forest loss in China's most biodiverse areas (Yi et al., 2014). As a consequence of the rapid expansion of natural rubber farming, dramatic changes in land use and ecosystems in southern China have occurred, leading to severe environmental problems, such as ecological degradation, biodiversity loss, and soil erosion (Ahrends et al., 2015; Wigboldus et al., 2017; Xiao et al., 2019).

The negative ecological effects of monoculture rubber plantations have recently attracted scientific and governmental concern and led scientists to call for the restoration of natural forests in some geographic regions. Local governments have made the restoration and protection of ecosystems a major policy issue. However, most of China's policy design in the past has been top-down, which is easy to ignore the actual needs of the policy audience, and the effect was often not ideal, sometimes even disastrous (Zhang et al., 2011). As a result, restoration plans of rubber plantations often neglect local stakeholders and the multi-scalar politics in which they are entwined, thereby jeopardizing social and ecological conditions. Admittedly, a decentralized and participatory governance model, which is often characterized as "bottom-up," has been increasingly advocated to achieve environmental policy objectives in a more sustainable and effective manner, as it attends heavily to local interests and searches for context-adaptive solutions to local environmental problems (Ouyang et al., 2020). Facts have also proved that the "bottom-up" policy design is conducive to improving public support and implementation effects (Huang and Kim, 2020; Ouyang et al., 2020). Benefits of the "bottom-up" approach have been demonstrated in many studies, such as the practice of participatory forest management (PFM) and participatory agroforestry development for restoring degraded sloping, which empowered local communities or villagers to own, manage and use the forest resources. (Xu et al., 2012; Gashu and Aminu, 2019). With regard to rubber plantation restoration, it is also essential to fully understand and incorporate public preferences in the policy design.

Many scholars previously focused on the importance of ecological restoration projects and problems faced in rubber plantation restoration, while others have turned their attention to the issues of farmers' compensation and participation in ecological restoration (Grist and Menz, 1995; Smajgl et al., 2015; Gan et al., 2021). The primary forest's rapid transformation into a single rubber plantation helped improve the economic situation of local families. However, it also posed a threat to ecological diversity and the original forest landscape, the massive expansion of rubber hurt the ecological and economic system (Liu et al., 2013; Chen et al., 2016). Restoration projects of rubber plantations currently implemented in China aimed to establish a composite ecosystem, increase biodiversity, and improve ecosystem service capacity (Sturgeon et al., 2014; Bingli et al., 2020). By contrast, a relatively small number of families preferred to reduce their rubber planting areas to eliminate the negative impact on the ecology (Hammond et al., 2017; Widianingsih et al., 2019). Min investigated 612 rubber farmers' willingness to participate in ecological protection in Xishuangbanna, and found that relatively affluent families tended to provide expenses or labor for ecological restoration (Min et al., 2018). As a result, rubber plantations restoration projects should be implemented based on a thorough understanding of public preferences and values.

Theoretically, ecological rubber plantations have strong public goods attributes. Because of its non-market characteristics, the social benefits (social welfare improvement) are often underestimated or ignored, leading to an insufficient supply (Delaney and Jacobson, 2014; Blanco et al., 2018; Blanco et al., 2021). Like most public goods, ecological restoration of rubber plantations faces the same supply dilemma. In the context of the national pilot zone for ecological conservation, the Chinese government has emphasized that agricultural development must be environmentally friendly and conducive to the conservation of ecological conditions. Hence the "Environment-Friendly Rubber Plantation" program, which was proposed in 2009, has been gradually implemented by local governments. Due to the efficient and sustainable future investments in restoration infrastructure and improved services, it is suggested that the government and management agencies should make reasonable payment plans to pay for the supply of ecosystem services (Smajgl et al., 2015). Decision-makers need to weigh the associated costs and benefits of different rubber plantation restoration plans. Therefore, the essential premise is to evaluate the social benefits of rubber plantation ecological restoration to serve as a foundation for relevant ecological governance policies.

In terms of the social benefits of rubber plantation ecological restoration, most existing research has analyzed it qualitatively (Wu et al., 2001; Yi et al., 2014; Wigboldus et al., 2017), calculation from a quantitative perspective has still rarely been conducted (Ahlheim et al., 2015). This gap is partly due to the following reasons, making the market price system and general evaluation methods challenging. On the one hand, rubber restoration projects act as public goods. The externality characteristic makes environmentally-friendly rubber plantations benefit a broader group who depend on the overall quality of the ecosystem. On the other hand, as rubber plantations provide various ecosystem services to the public, a monetary value under non-market valuation is not easily measured. Scholars recently have achieved fruitful results from evaluations of non-market values, which serve as a good reference for this study (Himes-Cornell et al., 2018; Hynes et al., 2021). The most frequently used non-market value evaluation methods include the CVM (contingent valuation method) and CE (choice experiments) (Jin et al., 2018; Yao et al., 2018). The central concept behind these two methods is to build a hypothetical market to simulate ecological product consumption behavior. By observing consumers' behavior in hypothetical markets, researchers can reveal the impact of improved ecological conditions on respondents' welfare and then calculate the non-market value of ecological products.

The difference between these two methods is that the CVM usually assesses the social welfare changes caused by ecological improvements from an overall perspective of ecological products (Johnston, 2007; Ruto and Garrod, 2008). There is only one ecological product in the hypothetical market, and it reflects the improvement in ecological conditions from the current state to a specific state. For this reason, CVM is considered to be more concise and easier to operate. By contrast, CE pays more attention to the multiple attributes of ecological products. It uses representative attributes to form products and derives various products through changes in attribute values. In other words, there are multiple ecological products in the hypothetical market constructed by the CE, and researchers can calculate the increased benefits brought by any possible state of the ecological condition (Yao et al., 2018; Xu et al., 2020). Thus, CE has greater flexibility and is closer to the real market trading scene. It also gives the respondents more opportunities to choose and weigh the pros and cons, thus revealing their preferences for different ecological restoration attributes (Johnston, 2007; Ruto and Garrod, 2008). Therefore, CE is considered the most promising research method and has been widely used to evaluate the social benefits of protection and restoration in many fields, such as watersheds, wetlands, forests, and grasslands (Schaafsma et al., 2012; Olsen et al., 2019; Cai et al., 2020; Petcharat et al., 2020).

Given the importance of rubber plantation restoration for the sustainable development of China, the current work aims to examine the preferences and WTP of residents in Hainan Province for rubber plantation restoration and estimate social benefits from the restoration projects by using a choice experiment approach. The evaluation results derived from different restoration projects may assist policymakers in deciding on which projects should be prioritized. So, we first used a CE to build a hypothetical market by simulating market trading behavior and then evaluated the public's welfare improvement for different potentially possible restoration projects. In the specific analysis, we use the econometric model to reveal the difference in public preferences and then calculate the corresponding social benefits. We expect the findings can provide a scientific reference for the policy design of rubber plantation restoration and aid the design and implementation of rubber restoration projects.

METHODS AND MATERIALS

Choice Experiments

The primary thoughts of CE are to create a hypothetical market with different ecological products and ask the preferences of respondents, which can inform us of their willingness to pay (WTP) for that specific ecological product. Ultimately, social benefits can be calculated by analyzing respondents' ecological product consumption preferences with econometric models (Adamowicz et al., 1998). Like regular products, restoration projects can be regarded as ecological products consisting of specific restoration attributes with various prices. In the field survey, respondents are given a set of restoration projects (or "choice sets") composed of several restoration attributes. The respondents can choose what they feel are the best ecological products by selecting the trade-offs between the different restoration attributes and prices. CE provides respondents alternative ecological products composed of multiple attributes at different levels compared with other evaluation methods, and we can obtain respondents' utility changes from the attributes they select (Syuhada et al., 2020; Ureta et al., 2021). This method could examine how respondents make trade-offs between possible levels of rubber ecosystem services provided by restoring projects. Using responses to the choice experiments, we estimate respondents' WTP. On this basis, the social benefits of different restoration projects can be calculated, thus providing more references for further policy design (Knickel and Maréchal, 2018; Ureta et al., 2021).

In accordance with procedures for choice experiments proposed by Hensher et al., we evaluated the social benefits of rubber plantation ecological restoration following the steps shown in **Figure 1**: 1) based on expert consultations, focus group interviews, and a pilot survey, we selected attributes at different levels which were described in a manner so that every respondent can understand. 2) multiple alternative restoration projects were generated by orthogonal experiments according to attributes we had developed, then various alternative projects were further combined into a choice set in which respondents were asked to choose their most preferred projects. 3) experimental sampling scale was determined according to the data collection requirements, and finally, the implied value of each restoration attribute and the social benefits brought by different restoration projects were calculated using an RPL (Random Parameter Logit)model based on the survey data.

Econometric Model

The theoretical basis of choice experiments is Lancaster's multiattribute utility theory (Lancaster, 1966) and random utility theory (McFadden, 1973). According to them, the utility provided by a specific product can be decomposed into the sum of the utility provided by the attributes which compose it (Lancaster, 1966). Random utility theory assumes that individuals make utility maximization choices according to the trade-offs between different product features. Therefore, a CE transforms the selection problem into a utility comparison problem and uses the maximization of utility to represent the consumer's choice of the optimal product. It is assumed that the utility U_{ni} obtained by respondent n when choosing i from Q alternative ecological products is as follows (Hensher and Greene, 2002; Heiss, 2016):

$$U_{ni} = V_{ni} + \varepsilon_{ni} \tag{1}$$

Where V_{ni} is the measurable portion of utility, representing the effect of observable factors on respondents' utility, and ε_{ni} is the unobservable portion of utility, which means the effect of

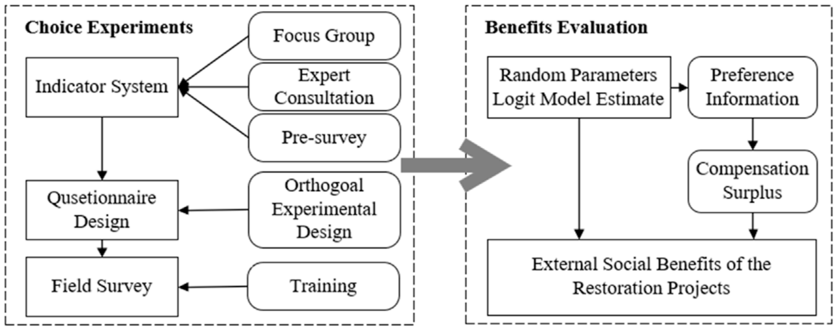

FIGURE 1 | Benefits evaluation based on CE.

unobservable factors on personal utility. For all Q alternative restoration projects, the probability P_{ni} of respondent n choosing project i rather than project s can be expressed as follows:

$$P_{ni} = P(U_{ni} > U_{ns}, \forall i \neq s) = P(V_{ni} + \varepsilon_{ni} > V_{ns} + \varepsilon_{ns}, \forall i \neq s) \quad (2)$$

Then, the utility U_{ni} of a specific restoration project i selected by respondent n can be described as follows:

$$U_{ni} = \alpha_n ASC_{ni} + \beta_n X_{ni} + \gamma_n WTP_{ni} + \varepsilon_{ni} \quad (3)$$

Where ASC is the alternative specific constant, which reflects the baseline utility that maintaining the current ecological environment (taking no restoration measurements) can bring to the respondent; X_{ni} and WTP_{ni} represent the restoration atrributes of project i and the costs of project i, respectively; ε_{ni} is a random disturbance term, which is generally assumed to obey the extreme value distribution of type I (i.e., a Gumbel distribution); and α_n, β_n, γ_n reflect the preference degree of respondent n for each restoration attribute, $\varphi n = (\alpha_n, \beta_n, \gamma_n)$. Then, the probability distribution function of respondent n choosing project i from all Q situations is (Heiss, 2016):

$$P_{ni} = \frac{e^{\alpha_n ASC_{ni} + \beta_n X_{ni} + \gamma_n WTP_{ni}}}{\sum_Q e^{\alpha_n ASC_{ns} + \beta_n X_{ns} + \gamma_n WTP_{ns}}} = \int \frac{e^{V_{ni}(\varphi_n)}}{\sum_Q e^{V_{nj}(\varphi_n)}} f(\varphi_n) d\varphi_n \quad (4)$$

In this paper, the RPL model (random parameters logit model) was used for coefficient estimation. This model can estimate each coefficient's distribution parameters if needed and is not limited to estimating only the coefficients' fixed mean value (Xu et al., 2020). Therefore, if a specific coefficient is set to conform to a particular distribution (i.e., random parameter), its mean value and standard deviation can be estimated by the RPL model. Otherwise, if it is set as a fixed parameter, only its mean value can be estimated. Therefore, the RPL model has the potential to reveal the variability of respondents' preferences for different ecological restoration attributes, which is closer to the real-world situation.

Finally, we used the maximum likelihood estimation to obtain each coefficient's parameters in the above model. Then, the compensation surpluses (CS) of the respondents when they choose different restoration projects (from 1 to 1) can be calculated according to the following formula:

$$\begin{aligned} CS_1 &= (V_0 - V_1)/\gamma &&= [(\alpha + \beta X_0) - \beta X_1]/\gamma \\ CS_2 &= (V_0 - V_2)/\gamma &&= [(\alpha + \beta X_0) - \beta X_2]/\gamma \\ &\vdots \quad \vdots && \quad \vdots \\ CS_i &= (V_0 - V_i)/\gamma &&= [(\alpha + \beta X_0) - \beta X_i]/\gamma \end{aligned} \quad (5)$$

Where α, β, and γ are the average values of each coefficient; V_0 is the status quo without any restoration measurements; and V_i is the value after implementing project i with specific restoration measurements. Therefore, CS_i reflects the respondents' average WTP for restoration project i and the average social benefits that respondents can obtain from restoration project i.

Study Area

Hainan Province is in the southernmost part of China, and its main landmass is Hainan Island, which is located between 18°10'~20°10′ north latitude and 108°37'~111°03′ east longitude and covering an area of approximately 33,900 km^2. It is the second-largest island in China after the island of Taiwan. Hainan Island's climate is characterized by a typical oceanic tropical monsoon climate, with high temperatures throughout the year. The average annual temperature is between 22 and 26°C, and the yearly rainfall is abundant with yearly average precipitation above 1,600 mm. With sufficient light and heat resources, many tropical crops are suitable for growing in Hainan, such as rubber, coffee, cocoa, coconut, and palm.

Natural rubber was introduced to Hainan Island in the early 20th century. Subsequently, the planting area gradually expanded and has grown to 520,000 hm^2, accounting for more than 15% of the total area of Hainan Island. As a result, the original tropical rainforest ecosystem of Hainan Island has been severely damaged, and a series of problems, such as vegetation degradation, soil erosion, a sharp decline in biodiversity, and local droughts have emerged (Xu et al., 2020), which has aroused widespread concern. In April 2018, the central government supports Hainan island in building a pilot free trade zone and supports Hainan in gradually exploring and steadily advancing the construction of a free trade port (FTP), meanwhile "The Guiding Opinions on Supporting Hainan's Comprehensively Deepening Reform

TABLE 1 | Attributes of rubber plantation ecological restoration.

Attributes	Meaning of the attributes	Levels
Restoration Area	Total implementation area of the rubber plantation ecological restoration project	2.1 million mu (25%); 4.2 million mu (50%); 6.3 million mu (75%); 8.4 million mu (100%)
Priority Areas	Priority areas to implement the rubber plantation ecological restoration projects	Over-slope planting area; Water source protection area; Biodiversity preservation area; Rural living area
Priority Implementers	Priority implementers of the rubber plantation ecological restoration projects	Small householders; State farms
Under-forest Space Utilization	How the under-space of the rubber plantations is used	Only planting; Only breeding; Planting and breeding
WTP	How much a family is willing to pay for rubber plantation ecological restoration	0 yuan; 25 yuan; 50 yuan; 75 yuan; 100 yuan

and Opening Up"[1] issued by the CPC Central Committee and the State Council of China stated that the "National Ecological Civilization Pilot Zone (Hainan)" would become one of the main fields for comprehensively deepening the reform and opening up, supporting Hainan by establishing "The Demonstration Province of Circular Ecological Agriculture" and "The Pilot Zone for Green Agricultural Development". In July 2019, "The Pilot Plan for Hainan Rainforest National Park System"[2] issued by the National Park Administration stated that more efforts should be made to promote the establishment of Hainan Rainforest National Park, step up ecological protection and restoration, enhance biodiversity conservation, improve water conservation capacity, and promote the formation of a new pattern of harmonious coexistence between humans and nature. Against the strategic background of national ecological civilization construction, the natural rubber planting in Hainan Province urgently needs to change from a traditional operation pattern to an environmentally friendly operation.

Evaluation Attributes

This paper uses ecological attributes and WTP to describe the ecological products (rubber plantation ecological restoration projects) and their cost. Thus, selecting attributes is a prerequisite to implementing a CE. As we aimed to provide useful information for policy design by understanding respondents' preferences for ecological restoration measures, we focus on the following issues in selecting attributes: how many areas of rubber plantation should be involved? Which regions should be prioritized? Who should be the priority implementers, and what should be done in ecological restoration? In view of this, we chose the attributes through a literature review, a pilot survey, and in-depth discussions with experts in related fields and local government departments to make it representative. Ultimately, four ecological restoration attributes were involved in the final design: restoration area, priority area, priority implementers, and under-forest space utilization. WTP was also included to reveal the respondents' preferences for the attributes of different ecological restoration projects. In addition, the above attribute levels were set based on historical data, expert consultation, and pilot survey results. **Table 1** shows the meaning and level values of the attributes. The selection basis of each attribute and its relation with respondents' welfare are elaborated as follows:

1) Restoration area. According to the "Work Plan for Delimitation of Rice Production Functional Zones and Natural Rubber Production Protection Zones in Hainan Province" issued by the Hainan Provincial Government in 2017, the delimitation of 8.4 million mu of natural rubber production protection zones is set to complete within 3–5 years[3], which will be the total effective area of natural rubber plantation in Hainan province in the future. We assume that ecological restoration projects can cover all rubber plantations if conditions permit. Therefore, we set the maximum restoration area of rubber plantations at 8.4 million mu with 100% coverage. To reveal respondents' preference for the coverage area of the ecological restoration project, we set another level values of 2.1 million mu, 4.2 million mu and 6.3 million mu according to the isometric principle, which is easy for respondents to understand, with coverage rates of 25, 50, and 75% respectively. It is clear that the ecological restoration of millions of natural rubber plantations is a long process, and it is difficult to achieve the goal in a short time. Therefore, we set another two attributes, namely priority areas and priority implementers, to reveal respondents' preferences.
2) Priority areas. Existing studies show that excessive rubber plantations can cause severe environmental problems, such as, soil erosions at over-slope locations (Liu et al., 2017, 2015), water pollution and poor water conservation capacity in wellhead protection areas (Guardiola-Claramonte et al., 2008; Tan et al., 2011), biodiversity decrease in biodiversity preservation areas (including nature reserves, national forest parks, etc.) (Li et al., 2006; Ahrends et al., 2015; Warren-Thomas et al., 2015). In addition, rubber forests in or around rural living settlements may also cause some livable rural environment problems, such as reducing the diversity and aesthetics of villages and the ventilation and lighting

[1]Source: http://www.gov.cn/zhengce/2018-04/14/content_5282456.htm
[2]Source: https://www.hainan.gov.cn/hainan/zchbbwwj/202008/f0a42020ac1547098d502acd161119cf.shtml
[3]Source: http://www.gov.cn/xinwen/2017-11/23/content_5241750.htm

(Zhang et al., 2019). Respondents may have various preferences for the priority restoration areas mentioned above, so we set four alternatives: over-slope planting area, water source protection area, biodiversity preservation area, and rural living area.

3) Priority implementers. Small householders and state farms are the two main types of rubber growers, which respectively operate 54.85 and 45.15% of rubber plantations in Hainan province by the end of 2017 (Liu et al., 2019). There are many differences in production manners, organizational forms, acquisition of production materials, technical level, and production efficiency between these two types of growers (Zhong et al., 2018). Hence, the promotion effects of ecological restoration projects are likely to differ among different implementers. As beneficiaries, respondents expect the ecological restoration project to be better implemented, we set small householders and state farms as two alternatives for priority implementers.
4) Under-forest space utilization. The development of the under-forest economy is of great significance to reducing biodiversity decrease, soil erosion, ecosystem services degradation, and other impacts caused by rubber planting (Huang et al., 2016; Wen et al., 2018). At present, there are only three relatively mature understory space utilization modes, namely, developing under-forest planting industry, developing under-forest breeding industry, and combining planting and breeding. Respondents may have distinct preferences for under-forest space utilization in the restoration process since each mode can affect species diversity differently. Therefore, we set only Planting, only Breeding, and Planting & Breeding as alternatives.
5) WTP. The fifth attribute, willingness to pay, is a household payment to improve the rubber plantation ecosystem. In addition to the cash form of WTP, it can also be presented as an increase in the cost of living due to a rise in environmental protection taxes and fees or indirect costs caused by ecological protection and reduced economic development (Alcon et al., 2020; Hynes et al., 2021). The payment levels were determined through an open-ended CVM in a pre-survey. The payment levels are 25, 50, 75, and 100 yuan, and if the respondents choose "no restoration measures", they do not need to pay.

Questionnaire Design

The selected attributes and levels were combined into several choice sets, and this produces so many alternatives that it would be overly cumbersome and intellectually demanding for respondents to choose among them. Researchers generally design about three choice sets in each questionnaire and three alternatives in each choice set. For the sake of experimental effect, each of our CE questionnaires provided the respondents with two choice sets, and each choice set contained three alternatives: "Project A", "Project B", and "Project C" (shown in **Figure 2**). "Project A" and "Project B″ comprise different restoration measures that are represented by the attribute levels, and "Project C" is an alternative without any restoration measures, and the respondents do not need to pay for it[4]. Hence based on the attributes and their level values shown in **Table 1**, there would be 384 possible alternatives (4*4*2*3*4)[5], 73,536 possible choice sets (C^2_{384}), and 6.627*10^{13}possible CE questionnaires (C^3_{73536}). If all the possible CE questionnaires were tested in the field survey, it would take much work and material resources. After determining the number of alternatives, choice sets, and questionnaires, we used Ngene1.1.1 to conduct an orthogonal experimental design, and representative CE questionnaires were selected based on orthogonality. Finally, eight versions of CE questionnaires containing sixteen choice sets were generated. The efficiency measure results of the orthogonal experiment had a D-error of 0.002194 and an A-error of 0.050781[6]. Then, we checked the rationality of each choice set and adjusted the choice sets with the dominant strategy.

A prerequisite for successfully implementing CE is respondents can understand the questionnaire accurately. Thus following measures were taken to ensure the validity of the experiments. First, we further optimized the expression of each attribute to make sure every respondent could understand the meaning of each attribute. Respondents were required to be presented with a detailed description of the four attributes and informed with survey questions. Second, our CE questionnaires used text and graphics (**Figure 2**), which made the restoration projects more vivid and added to the fun of the experiments to make them easier for respondents to understand. Third, each questionnaire contained only two choice sets to avoid fatigue due to repeated experiments. Fourth, a dual error control mechanism was introduced to judge the experiments' validity, and the respondents were required to evaluate their understanding and attitude toward the experiments, and the investigators needed to assess the respondent's cooperation and seriousness. Fifth, all investigators were professionally trained and informed of the experimental operation process and seriousness in detail to ensure the validity of the experiments before the final survey.

Data Collection

Research data were obtained from a field survey of urban residents conducted in Hainan Province in July 2019. Questionnaires were distributed through random sampling, stratified by population size, socioeconomic development level, and rubber plantation location. Four cities where rubber plantations are surrounded were selected, namely Haikou,

[4]According to the research (Adamowicz et al., 1998), if the "do not participate" option is omitted, it is difficult for respondents to make effective choices when all restoration projects are unattractive. Therefore, "Project C" with "No restoration, no payment" was added to the questionnaire in this article to indicate that the respondents do not support any of the above alternative restoration projects

[5]The level of each attribute corresponding to "0" *WTP* is a fixed value, that is, no restoration measures are taken. Therefore, only four levels of the *WTP* were entered into the calculation

[6]Both the D-error and the A-error were derived from the progressive variance covariance matrix. The D-error takes the determinant of the matrix, and the A-error takes the trace of the matrix. The ideal experimental design can achieve the minimization of the two

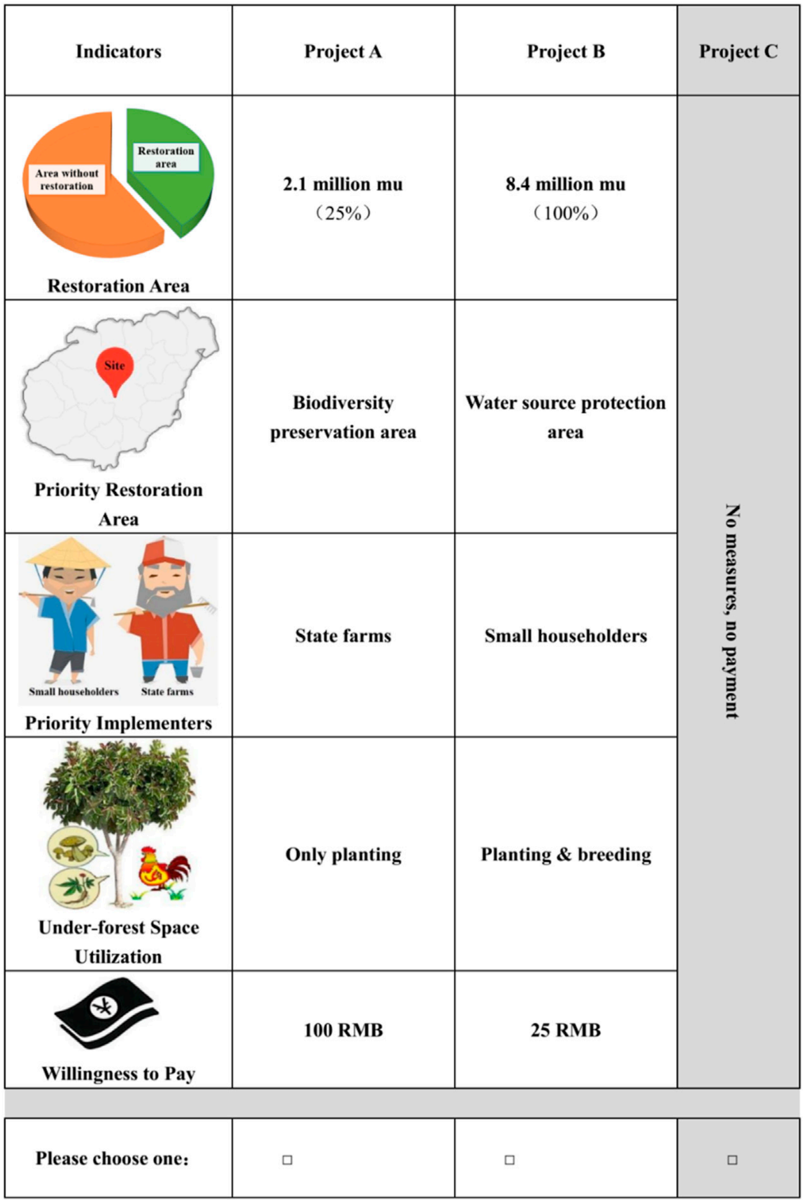

FIGURE 2 | Example of choice sets in the CE questionnaires.

Sanya, Danzhou, and Wanning, located around Hainan Island. Then 2-3 districts were randomly selected from each city, and respondents were randomly selected from the main streets of each district. A questionnaire survey was conducted through face-to-face interviews. Before filling out the questionnaire formally, the interviewer explained the purpose of the survey and the operation process of the CE in detail to the interviewees to ensure the authenticity and validity of responses. Finally, a total of 550 questionnaires were given out, and 518 were valid after inspection of invalid ones, accounting for an effective response rate of 94.18%. **Table 2** shows the socio-demographic characteristics of the respondents.

RESULTS

Variable Descriptive Statistics

Table 3 provides an overview of the mean summary statistics for attribute values of the rubber plantation restoration projects which the respondents selected. The average restoration area was 1.9672, indicating that the selected projects' average restoration area was close to 4.2 million mu. Regarding the priority areas, the over-slope planting area's value was 0.2259, which was the highest, indicating that the respondents were more supportive of promoting ecological restoration projects in this area. For priority implementers, small householders and state

TABLE 2 | Descriptive statistics of the sample.

Items	Meaning and assignment	Min	Max	Mean	S.D.
Gender	Gender of the respondent (male = 1, female = 0)	0.0000	1.0000	0.5598	0.4969
Nation	Ethnicity of the respondent (Han = 1, non-Han = 0)	0.0000	1.0000	0.0927	0.2902
Age	Respondent's age (years)	18.0000	70.0000	32.7432	10.5215
Education	Respondent's education level (1 = primary school or below, 2 = junior high school, 3 = high school, and technical secondary school, 4 = college and undergraduate, 5 = postgraduate or above)	1.0000	5.0000	3.1969	0.9735
Income	Annual average family income (low-income group = 1, lower-middle-income group = 2, middle-income group = 3, upper-middle-income group = 4, high-income group = 5, Each income group sample accounts for 20% of the total)	1.0000	5.0000	2.9691	1.4288
Environmental business	If there are any family members engaged in ecological and environmental businesses (Yes = 1, No = 0)	0.0000	1.0000	0.0637	0.2445
Cognition of ecological restoration projects	Respondents' understanding of rubber plantation ecological restoration projects (not at all = 1, slightly less = 2, general = 3, slightly more = 4, very well = 5)	1.0000	5.0000	1.6853	0.8637
Environmental satisfaction	Respondents' satisfaction with the current ecological environment (not at all = 1, slightly less = 2, general = 3, slightly more = 4, very well = 5)	1.0000	5.0000	3.5116	1.0062
Environmental concern	How often the respondents discuss ecological and environmental issues with other people (no = 1, slightly less = 2, general = 3, slightly more = 4, very frequently = 5)	1.0000	5.0000	3.1255	1.2099
Cognition of the rubber industry	Respondents' understanding of the natural rubber production process (not at all = 1, slightly less = 2, general = 3, slightly more = 4, very well = 5)	1.0000	5.0000	2.2413	1.2889
Attention to the rubber Industry	Respondents' attention to the natural rubber industry (not at all = 1, slightly less = 2, general = 3, slightly more = 4, very concerned = 5)	1.0000	5.0000	2.5541	1.2408

TABLE 3 | Descriptive statistics of variables.

Variable	Mean	Standard deviation	Coefficient of variation
Restoration Area	1.9672	1.4227	0.7232
Over-slope Rubber Planting Area	0.2259	0.4184	1.8522
Water Source Protection Area	0.2095	0.4071	1.9437
Biodiversity Preservation Area	0.1882	0.3911	2.0777
Rural Living Quarters	0.1699	0.3757	2.2116
Small Householders	0.3822	0.4862	1.2719
State Farms	0.4112	0.4923	1.1972
Only Planting	0.2500	0.4332	1.7329
Only Breeding	0.2606	0.4392	1.6852
Planting & Breeding	0.2828	0.4506	1.5932
ASC	0.2066	0.4050	1.9608
WTP	45.2220	33.7846	0.7471

Note: (1) Restoration area was set as a continuous variable if the respondents selected a specific project, 2.1 million mu = 1, 4.2 million mu = 2, 6.3 million mu = 3, and 8.4 million mu = 4. If the respondents did not select a project, this variable was set to 0; (2) Priority areas, priority implementers, and under-forest space utilization were set as unordered multi categorical variables, and if the respondents selected a specific project, the corresponding category in the selected project would be set to 1, and the other categories would be set to 0; when the respondents chose "Plan C", all of the categories would be given a value of 0; (3) WTP, was set as a continuous variable, its value was given according to the actual amount of the selected projects, and a value of 0 would be given if the respondents chose "Plan C".

farms accounted for 38.22 and 41.12%, respectively. More respondents choose to develop planting and breeding (28.28%) under-forest, slightly higher than only breeding (26.06%) and only planting (25.00%). Additionally, the average ASC value was 0.2066, indicating that the probability of respondents choosing "Project C" was approximately 20%. The statistical results of WTP show that respondents were willing to pay for ecological restoration projects, and the average value was 45.22 yuan.

RPL Model Estimation and Public Preferences Analysis

Table 4 presents the results from the RPL model estimated by Stata 15.0. The dependent variable was the respondent's choice, and the independent variables included random parameter variables and fixed parameter variables. The variables of restoration area, priority areas, priority implementers, and under-forest space utilization were set as random parameters to estimate their location parameters and scale parameter, that is, the mean and standard deviation of their coefficients. ASC and WTP were set as fixed parameters, and we could only estimate their location parameter. The results showed that the chi-square statistic reached a significance level of 1% for the model's overall fit, indicating that the econometric model was statistically significant overall.

In terms of the fixed parameter variables, it showed that the mean value of the ASC coefficient was significantly negative at the level of 1%, indicating that respondents preferred to reject "Project C". The mean value of the WTP coefficient was significantly negative, indicating that WTP was negatively

TABLE 4 | RPL model estimation results.

Items	Variables	Coe.	S.E.	95% C.I. Lower	95% C.I. Upper
Mean of Fixed Parameters	ASC	−5.6865***	1.2592	−8.1544	−3.2186
	WTP	−0.0232***	0.0067	−0.0363	−0.0101
Mean of Random Parameters	Restoration Area	−0.8151***	0.2358	−1.2772	−0.3530
	Over-slope Planting Area	0.7823**	0.3960	0.0060	1.5585
	Water Source Protection Area	1.3085*	0.7209	−0.1045	2.7215
	Biodiversity Preservation Area	−0.4924	0.7536	−1.9694	0.9845
	Small Householders	−0.2930	0.2721	−0.8263	0.2404
	Only Breeding	1.2573*	0.6575	−0.0313	2.5460
	Planting & Breeding	0.8508*	0.4415	−0.0145	1.7161
Standard Deviation of Random Parameters	Restoration Area	2.7126***	0.5169	1.6995	3.7258
	Over-slope Planting Area	−2.9328***	0.9182	−4.7325	−1.1332
	Water Source Protection Area	0.4796	1.1081	−1.6922	2.6513
	Biodiversity Preservation Area	6.1075***	1.4520	3.2616	8.9534
	Small Householders	−1.4216	0.8993	−3.1842	0.3410
	Only Breeding	3.2294***	1.0684	1.1354	5.3234
	Planting & Breeding	−3.0782***	0.8516	−4.7472	−1.4091
Log likelihood = -922.1095 LR chi2 (7) = 293.3500***					

*Note: (1) in the model estimation, "rural living area", "state farms" and "only planting" was set as reference variables; (2) *, **, *** represented significance at the levels of 10, 5, and 1%, respectively; (3) the sign before the random parameters' standard deviation estimation result was not used as the basis for interpretation, and the interpretation could be performed with the absolute value.*

related to utility. It means that respondents were willing to acquire more ecological improvements with fewer fees, which is consistent with related studies (Cai, et al.; Yao, et al., 2018). In the random parameter variables, the mean value of the restoration area was statistically significantly at the 1% level, indicating that increasing the ecological restoration area reduced the respondents' utility. According to the field surveys, we also learned that, although most of the respondents supported rubber plantation ecological restoration projects, they did not prefer projects with a larger restoration area because of concern about the negative impact on rubber production and the income of rubber growers. Nevertheless, respondents hoped to prioritize ecological restoration projects in areas they consider critical. The estimation results based on rural living areas showed that mean values of the over-slope planting area were significant at 5%, and the water source protection area was significant at 1%, respectively. It indicated that prioritizing ecological restoration projects in these two areas is more desirable to the respondents than prioritizing projects in rural living areas. The estimated result of the biodiversity preservation area was not significant, indicating that there was no difference in prioritizing ecological restoration projects in this area and rural living areas in terms of the respondents' utility. This result may be related to the residents' low ecological awareness. In the field survey, we found that many respondents still do not realize the ecological problems caused by substituting rubber plantations for natural forests. Some even thought that rubber trees were good for the local ecology because they are green. For priority implementers, the estimated results based on state farms showed that the mean values of the small householders were not statistically significant. It indicates that respondents did not have obvious preferences for prioritizing ecological restoration projects with small householders than state farms. This is possible because those respondents hope both state farms and smallholders can be equally involved in ecological restoration projects. They pay more attention to the implementation scale and location of the project but do not care about who will implement the project. As mentioned above, there are obvious differences between the two types of rubber farmers in many aspects, and the future ecological restoration policy design needs to be differentiated and targeted. In terms of under-forest space utilization, the estimated results based on only planting showed that the mean values of only breeding and planting and breeding were both statistically significant at 10%. It indicates that respondents have a significant preference for only planting and breeding or planting and breeding. The reason may be that some respondents believe that the economic benefits of simply developing an under-forest planting industry may not be high enough to ensure the sustainability of the restoration project.

For the standard deviation of random parameters, the coefficient of restoration area was statistically significant at the 1% level, which means respondents have considerable heterogeneity in preference for the scale of the restored area. The coefficient of the over-slope planting area and the biodiversity preservation area were significant at the 1% level. In contrast, the water source protection area's coefficient was not significant. It indicated considerable heterogeneity existed in the respondents' preferences for the regions of over-slope and biodiversity preservation (relative to rural living areas). There was no significant heterogeneity in the preferences for water source protection areas. The coefficient of small householders was not significant, indicating no significant heterogeneity in the respondents' preferences for small householders (relative to state farms). The coefficients of only planting and planting and breeding were significant at the 1% level, indicating that the respondents' preferences for these two utilization forms (relative to only planting) were significantly heterogeneous. This result also suggested that the assumption of preference heterogeneity with the RPL model was closer to the actual situation (Hensher and Greene, 2002; Birol et al., 2006; Hynes et al., 2021).

TABLE 5 | Compensation surplus and total social benefits of different potential restoration projects.

Potential projects	Restoration area (million mu)	Priority areas	Priority implementers	Under-forest space utilization	CS (yuan/ household.year)	TSB (million yuan/year)
Project 1	2.1	Over-slope Planting Area	Small Householders	Only Breeding	285.4881	300.3620
Project 2	4.2	Over-slope Planting Area	Small Householders	Only Breeding	250.3274	263.3695
Project 3	2.1	Over-slope Planting Area	Small Householders	Planting & Breeding	267.9518	281.9121
Project 4	4.2	Over-slope Planting Area	Small Householders	Planting & Breeding	232.7912	244.9196
Project 5	2.1	Over-slope Planting Area	State Farms	Only Breeding	298.1258	313.6581
Project 6	4.2	Over-slope Planting Area	State Farms	Only Breeding	262.9651	276.6656
Project 7	2.1	Over-slope Planting Area	State Farms	Planting & Breeding	280.5895	295.2082
Project 8	4.2	Over-slope Planting Area	State Farms	Planting & Breeding	245.4289	258.2157
Project 9	2.1	Water Source Protection Area	Small Householders	Only Breeding	308.1903	324.2470
Project 10	4.2	Water Source Protection Area	Small Householders	Only Breeding	273.0296	287.2545
Project 11	2.1	Water Source Protection Area	Small Householders	Planting & Breeding	290.6540	305.7971
Project 12	4.2	Water Source Protection Area	Small Householders	Planting & Breeding	255.4934	268.8046
Project 13	2.1	Water Source Protection Area	State Farms	Only Breeding	320.8280	337.5431
Project 14	4.2	Water Source Protection Area	State Farms	Only Breeding	285.6673	300.5506
Project 15	2.1	Water Source Protection Area	State Farms	Planting & Breeding	303.2917	319.0932
Project 16	4.2	Water Source Protection Area	State Farms	Planting & Breeding	268.1311	282.1007

Social Benefits Calculation

The compensation surplus (CS) can reflect the average WTP of respondents to improve the rubber plantations' ecological condition, that is, the WTP for the social benefits that can be achieved when the rubber plantations' ecological condition is enhanced from the current to a higher level. Generally, the higher the respondents' WTP, the greater the CS, indicating that improving the ecological condition will bring more social benefits. According to the previous analysis and the principle of maximizing social benefits, we made attribute level selection for potential rubber plantation ecological restoration projects design: First, since the mean value of the restoration area's coefficient was negative, indicating that the respondents did not want to restore too much area currently; thus we take relatively low restoration area, 2.1 million mu (25% coverage) and 4.2 million mu (50% coverage) involved. Second, respondents were more inclined to the over-slope planting area and water source protection area; therefore, these two types of areas should be included. Third, the respondents had no significant preference differences between small householders and state farms; thus, both these two implementers should be considered in the potential projects. Fourth, the respondents were more inclined to only breeding and planting and breeding in terms of the under-forest space utilization, so these two utilization forms should be taken into account.

A total of sixteen potential restoration projects were created based on the attributes and levels selected above (shown in **Table 5**), and the CS of each project can be calculated separately. Project 4 has the lowest annual CS of 232.7912 yuan/household, and project 13 has the highest annual CS of 320.8280 yuan/household. We further calculated the total social benefits (TSB) that each ecological restoration project could bring through the sum of individual CS for the whole target population. By querying the "Hainan Statistical Yearbook (2019)[7]", we confirm that the total number of urban households in Hainan Province was 1.0521 million at the end of 2018. Then, we calculated that project had the lowest TSB, at 244.9196 million yuan/year, and project five had the highest TSB, at 337.5431 million yuan/year. The results can be used as the budget basis for implementing the ecological restoration project of rubber plantations in Hainan Province. It also indicates that the public demands these ecological products provided by the government, and also they can accept the corresponding financial expenditure. These budget funds could be used for many aspects of rubber management in the future, such as natural forest reconstruction in critical regions (such as over-slope planting area, water source protection area), the corresponding farmers' compensation fees, diversity of planting and breeding technology promotion, promotion or subsidy of green pollution-free technology related to rubber production, ecological propaganda and education for farmers, etc.

[7]Source: http://stats.hainan.gov.cn/tjj/tjsu/

DISCUSSION

Implementing the rubber plantation ecological restoration project is of great significance to improve the ecological service function of tropical rain forests and the ecosystem of Hainan Island. However, benefits of ecological restoration projects for rubber plantations, such as soil and water conservation, increased biodiversity, and possible recreational opportunities, are not generally traded on the market and therefore do not generally have a clear market price. Failure to incorporate these non-market values into the decision-making process may lead us to make decisions not actually in society's interest (Boyer and Polasky, 2009; Frynas et al., 2017). In addition, effectively connecting the policy design of ecological restoration with the public preference is also a topic worthy of attention, related to whether the corresponding policy design can obtain enough public support. The contribution of this study is to help policymakers get the social benefits of non-market rubber plantation restoration projects and understand the public preference for ecological restoration policies. The results indicate a positive and significant societal willingness to pay for the ecological restoration of natural rubber plantation in Hainan Province, which is consistent with prior studies that have valued other types of ecosystem restoration activities (Lan et al., 2017; Jin, et al., 2018; Xu, et al., 2020; Shi et al., 2021). In addition, there are several aspects worthy of further discussion for the current work.

1) The benefit we measured only reflects the support degree of urban residents in Hainan province for the rubber plantation ecological restoration project and does not include rubber farmers. In fact, rubber farmers will also enjoy ecological benefits from implementing the ecological restoration project. There are two reasons why rubber farmers are not included. On the one hand, as the economic basis of farmers is relatively weak, they rarely can pay for ecological products. Additionally, most farmers are poorly educated, and their ecological cognition are comparatively insufficient, so it is pretty difficult for them to understand the experiments. On the other hand, rubber farmers are both beneficiaries and victims of ecological restoration projects, making it complicated for them to weigh their interests and provide us with accurate information about their willingness to pay. It is also necessary for us to adopt a more appropriate cost-benefit quantitative analysis method in further research to explore the impact of the ecological restoration project on rubber farmers to improve the accuracy of benefit calculation.
2) The estimated coefficient of ecological restoration area is negative, indicating that residents do not want to implement the ecological restoration project on a large scale. As mentioned above, the respondents may be concerned that the implementation of ecological projects will affect the economic income of rubber farmers. As we know, rubber planting is one of the important economic sources for local farmers. In the past 10 years, natural rubber prices have continued to maintain low, significantly impacting rubber growers' income. It also implies that the future ecological restoration policy design needs to pay attention to the sustainable livelihood of rubber farmers. Supporting policies and measures such as subsidies (ecological compensation), skills training, entrepreneurship guidance and credit support can be provided to make up for farmers' economic losses caused by the ecological restoration projects. Moreover, future research may consider restoration projects' influence on rubber farmers' production and life, and corresponding attributes can be involved. We can include the aforementioned supporting policies and measures as one of the attributes in the CE questionnaire to minimize respondents' concern on this issue.
3) We also found that the respondents did not have a sufficient and unified understanding of the ecological and environmental problems caused by rubber planting. Some respondents believe that rubber trees are green and don't cause any ecological problems. This is the actual logic of many respondents, which may affect the experiment results or even hinder the experiment by significantly increasing the proportion of respondents who protest payment. To solve this problem, we set up a warm-up session before the choice experiments to judge the respondents' awareness through simple questions about ecological problems caused by rubber planting. Then, before the formal experiments, strictly trained investigators were required to explain to the respondents the ecological and environmental problems brought by the development of rubber plantations. In this way, we try to make each respondent make choices with consistent background information. It also inspired us to the importance of doing preliminary research, finding potential problems, and taking effective solutions.
4) The research still has two deficiencies in experimental design and model analysis. Firstly, efficient design is a commonly used method in orthogonal experimental design, requiring some prior information. Still, other studies have shown that the random design (which is the easiest to generate) performs as well as the efficient design, and even better if data cleaning is done to remove choice tasks where one alternative dominates the other (Walker et al., 2017). Due to the lack of related studies on the ecological governance of rubber plantations and the tight schedule, we did not obtain enough prior information to conduct an efficient design. In subsequent studies, if prior information cannot be obtained from existing studies, we should try to get prior information through a small range of pre-research and optimize the experimental design based on pre-research data. Secondly, we adopted the RPL model, which assumed that respondents' preferences were heterogeneous and closer to reality, making estimation results for the evaluation attribute coefficients more accurate and reducing model setting errors. However, we focus on analyzing preference differences at the group level and do not further discuss the heterogeneity of preferences among individuals. Subsequent studies can use the Latent Class model (LCM) to analyze further the impact of individual preference differences on benefit evaluation (Strazzera et al., 2012; Barrio and Loureiro, 2018).

CONCLUSIONS

Against the background of constructing an FTP on the whole island of Hainan, the National Ecological Civilization Pilot Zone (Hainan) holds a new strategic position. The state and the local government have successively issued policies and measures to break resource constraints, reduce environmental pollution, and ameliorate ecosystem degradation in Hainan Province. In response to the ecological problems caused by natural rubber planting, accelerating rubber plantation ecological restoration has become the key to improving the ecological quality and sustainability of the natural rubber planting industry.

Based on a CE field survey, this research presented rubber plantation ecological restoration projects to respondents as ecological products and simulated urban residents' ecological consumption behavior in Hainan Province. Then, we analyzed respondents' preferences with different restoration attributes using the RPL model and calculated the social benefits brought by the potential restoration scenarios. The main findings of this study were as follows: first, urban residents in Hainan Province showed a positive attitude toward rubber plantation ecological restoration. They were willing to bear a certain amount of cost to improve the ecological condition of rubber plantations. Second, the respondents had a significant preference for different restoration attributes. For example, in terms of the restoration area, they were not inclined to feel overly involved. Respondents preferred priority restoration in over-slope planting areas and water source protection areas. For under-forest space utilization, they were more inclined to only breeding and planting and breeding. Third, by offering a variety of potential restoration projects, we found that a project covering 2.1 million mu of rubber plantations, prioritizing the water source protection area, focusing the implementation on state farms and developing the under-forest breeding economy would gain more social benefits, precisely, 337.543 million yuan/year.

In response to the findings, we propose the following policy recommendations. First, costs and benefits, especially non-market social benefits, should be considered when designing or implementing rubber plantation ecological restoration projects, which can be calculated by residents' welfare improved by implementing rubber ecological plantation projects. Still, it is challenging to quantify these welfare improvements. At present, some non-market valuation methods, such as CVM and CE, can provide feasible approaches, but undeniably, these methods are still being improved. Second, ecological restoration policies should consider public needs more and incorporate them into future guidelines, which will undoubtedly enhance the accuracy of public environmental policies and the effectiveness of their implementation, as long as we can reveal public preferences well. Third, rubber plantation ecological restoration should focus on restoration quality rather than blindly aiming at the restoration area to maximize social benefits. In the process, priority should be given to selecting rubber plantations close to the water source protection area, small householders as the priority implementers, and an appropriate under-forest economy.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The data are not publicly available due to personal privacy and non-open access of the research program. Requests to access these datasets should be directed to Xu Tao, xutao_2013@outlook.com.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DQ and TX initiated the study concept. DQ, WL, TX led the data collection. TX conducted data analysis and interpretation of the data. DQ wrote the first draft of the manuscript. DZ and YY contributed to language control and revised the manuscript.

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