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Study on Carbon Sink Value of Marine Resources

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***Abstract*—Ecosystem service has two characteristics: one is typical public goods, the other is external, so the development and utilization of ecological environment cannot be realized directly through the market. It is necessary to take adequate measures to make up for the shortage of market mechanisms, so the evaluation of ecosystem service value has gradually become the focus of scholars. This paper uses conditions with Guangdong area as an example, evaluating the ocean carbon sink, the economic value of the services, the influencing factors of Guangdong residents' willingness to pay, it is concluded that Guangdong ocean carbon sinks the higher total monetary value of ecosystem services, the respondent's age, level of education, occupation, family income, degree of understanding of the ocean carbon sink, all the five factors have a significant influence on willingness to pay. Gender did not correlate with a willingness to pay.**

Keywords-Marine resources; Carbon sink value; Guangdong

I. INTRODUCTION

The ocean is the planet's most significant carbon sink, capturing carbon dioxide from burning fossil fuels and thus slowing the pace of climate change. Compared with forest carbon sinks, ocean carbon sinks have the advantages of more extensive carbon storage and longer storage time. The Marine carbon sink converts reactive organic carbon into inert organic carbon by the tiny but abundant micro-organisms in the ocean so that carbon can be stored in the sea for a long time.

Guangdong is rich in water resources, the total annual precipitation of 319.4 billion cubic meters, runoff volume of 181.9 billion cubic meters, plus the neighboring from the Xijiang and Hanjiang River, such as water volume of 233 billion cubic meters, in addition to the deep groundwater of 6 billion cubic meters, per capita water resources available for exploitation of 4735 cubic meters, significantly higher than the average level in China. Guangdong province has numerous rivers, mainly the Pearl River Basin (Dongjiang river, Xijiang River, Beijiang River, and Pearl River Delta Region), the Hanjiang River basin, and the coastal rivers in eastern and western Guangdong, with the catchment area accounting for 99.8% of the province's total area, and the other rivers in the Yangtze River basin are Poyang Lake and Dongting Lake. There are 542 tributaries at all levels with a basin area of more than 100 square kilometers.

II. SAMPLE DATA CHARACTERISTICS AND DATA DESCRIPTION

A. Socio-economic characteristics

Among the respondents, males accounted for a more significant proportion, accounting for 53.5% of the total, while females accounted for 46.5%.

The age of the respondents was mainly between 18 and 30 years old, accounting for 42.4 percent of the total number of respondents. The proportion of 31-40 years old is 30.3%. Those under 18 and those between 41 and 50 accounted for 9.8% and 9.4% of the total. Those aged 51-60 and those over 60 accounts for 5.8% and 2.3% of the total, respectively. The overall age structure of the respondents shows an inverted U-shaped distribution.

The educational level of the respondents covered all levels from primary school to graduate school, with high school education and college education accounting for 30.5% and 27.7% of the total number of respondents respectively, 23.5 percent of those with junior secondary education; Those with primary education or below accounted for 11.7%; Those with graduate degrees or above accounted for 6.6%, which was the most minor proportion.

The respondents' occupations covered a wide range, mainly students, farmers, and enterprise employees, accounting for 26.6%, 25.4% , and 19.2% of the total number of respondents, respectively.

The monthly family income of the investigated is mainly concentrated in the income level of 3000-5000 yuan, accounting for the highest proportion of 50.5%; The second is the income level of 1000-3000 yuan accounted for 26.2% of the overall income level of the survey; The proportion of 5,000-10,000 yuan was 10.9%; The ratio of the public below $1,000 was 9.8%; Those with more than 10,000 yuan accounted for 2.6 percent of the total. It can be seen that in the overall monthly household income structure of the respondents, there are fewer low-income and high-income people, and more middle-income people.

III. EMPIRICAL ANALYSIS OF MARINE CARBON SINK VALUE ASSESSMENT IN THE STUDY AREA

B. Calculation of average willingness to pay

1）Nonparametric estimation of average willingness to pay:

Payment card guidance techniques can be used to reflect the range of willingness to pay variation,

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depending on the maximum value that respondents are willing to pay and the value that they are explicitly unwilling to pay. In the analysis of samples, it is concluded that the maximum WTP scatter points of most respondents are distributed on the numbers 100, 125, 150, 200, 250, 300, and 350.

Based on the calculation formula of willingness to pay for the restoration of Ejin Banner ecosystem services by Xu Zhongmin, Zhang Zhiqiang, and Cheng Guodong, the public's expectation of positive willingness to pay for Marine carbon sink ecosystem services can be calculated as follows according to the frequency distribution of willingness to pay:

$$E(WTP) = \sum PiBi = 162.8(yuan) \quad (1)$$

In the formula, WTP represents the willingness to pay that the respondent accepts;

Pi indicates the frequency of the bid amount that respondents are willing to pay;

Bi said respondents would undoubtedly be willing to pay the bid amount.

Because the payment card guide technology, respondents are willing to pay the biggest value represents the lower limit of the overall average WTP, the respondents are opposed to paying than their chosen number higher level of value, the mathematical expectation formula, can get the limit, the overall average WTP is not willing to pay the minimum amount of:

$$E(NWTP) = \sum PiBi = 224.3(yuan) \quad (2)$$

Where, NWTP represents the value of willingness to pay rejected by respondents.

The maximum acceptable amount of public willingness to pay was 162.8 yuan, and the number of unwillingness to pay was 224.3 yuan. Therefore, it can be estimated that the average desire of Guangdong residents to pay for Marine carbon sequestration services is 162.8 ~ 224.3 yuan.

2）EstimatioParameter estimation method of average willingness to pay

Using payment card guidance technology can directly reflect the WTP range of respondents. Once the variation range of the average WTP is clear, the parameter estimation method can determine the specific value of the average willingness to pay. The parameter estimation method is adopted, which must establish a functional relationship with the interviewees' willingness to pay and the attribute value of public goods. The median bid range is taken as the explanatory variable. The maximum likelihood estimation method is used to estimate the basic information and attribute variables of the median bidding quantity and other ecological services. In the specific application, the lognormal distribution of WTP is generally selected as the explanatory variable.The equation is as follows:

$$\ln(WTP) = X'\beta + u \quad (3)$$

X represents some characteristic attributes of the respondent or ecological, environmental service, and X' represents its transpose matrix; β represents the estimated parameter;

U is the random variable that follows a normal distribution$[0, \sigma^2]$.

Many scholars found in later studies that the assumption in Equation (3) that the expected WTP value is equal to the midpoint of the variation range of the number of bids made by respondents may lead to biased WTP value. Cameron and Huppert treated WTP as a random variable based on Equation (3) and introduced a double-boundary probability model for analysis.

After investigating the range of WTP using payment card guidance technology, respondents expressed the probability of answering 'yes' as follows:

$$Pr('Yes') = Pr(WTP \geq T_L) = 1 - GWTP(T_L) \quad (4)$$

The probability that WTP falls between$[T_L, T_U]$ the bidding thresholds is $GWTP(T_U) - GWTP(TSL)$, where T_L is the maximum value interviewees are willing to pay, and T_U is the minimum value interviewees are not willing to pay. Obviously, the respondents' willingness to pay falls within this range$[T_L, T_U]$. For all participants, the following logarithmic likelihood function can be obtained:

$$\ln(L) = \sum \ln[GWTP(T_{Ui}) - GWTP(T_{Li})] \quad (5)$$

C. Elimination of the total economic value of carbon sinks in Guangdong, Hong Kong, and Macao

According to the above calculation, the average annual amount that sample residents in Guangdong are willing to pay for Marine carbon sequestration services is 183.2 yuan per household. In the 600 questionnaires, the positive rate of willingness to pay is 83.67%, and it can be concluded that the average annual willingness to pay of Guangdong residents is 153.28 yuan/household. Guangdong Province has 42.4692 million households and 4.2225 million collective families, with a population of 111671837 and 14340673, respectively. The average population per household was 2.63 people, 0.57 less than the 3.20 people in the sixth national census in 2010. The total number of households is 46.6916 million, so the number of permanent families willing to pay is 39.9669 million.

Combined with existing studies, this paper intends to measure the value of Guangdong's Marine carbon aggregation by using the annual average willingness to pay (WTP) of Guangdong residents. The calculation formula is as follows:

Total WTP of Residents in Guangdong = average annual WTP of residents × number of permanent households WTP in Guangdong（6）

Substitute in Equation (6), WTP of Guangdong residents to ocean carbon sink is 5.99×109 yuan/year. According to the statistical results of sample payment, the average monthly income of the respondent's family is about 13,512 yuan, and the average annual income is 162,144 yuan. According to this value, the respondents' average willingness to pay is about 0.26 percent of yearly household income. This shows that the Marine carbon

sequestration fund project is within the reasonable range that residents can bear and will not bring a heavy economic burden to families.

D. LOGISTIC regression analysis of willingness to pay

1) Selection and interpretation of variables

All samples in this study are derived from the field research data to evaluate of the Marine carbon sink value in Guangdong in 2021. In this paper, based on the previous studies on conditional value assessment and case analysis, combined with the actual situation of Guangdong, variables affecting the public's willingness to pay for Marine carbon sequestration services are mainly classified into three categories. One is the individual factors of respondents, such as gender, age, and education level; Second, family status, primarily refers to family income; The third is the cognition of Marine carbon sink ecological services. This study selected six possible evaluation factors that may have an impact on the willingness to pay for Marine carbon sink services, and the description of each variable is shown in Table 1:

TABLE I. SELECTION AND EXPLANATION OF VARIABLES

types of variables	variable name	Variable to explain
decision variable	Whether respondents are willing to pay a certain amount for Marine carbon sink ecological services (Y)	Yes =1, no =2
personal factors	Gender (x1*)	Male =1, female =2
	Age (x2*)	——
	Education level (x3*)	Primary school and below =1 Junior high school = 2 High school = 3 University = 4 Graduate students and above =5
	Occupation (X4 *)	Students = 1 Workers = 2 Farmers = 3 Administrative personnel =4 Employee =5 Unemployment = 6 Housewife =7 Self-employed =8 Other = 9
family status	Monthly household income (X5 *)	——
Knowledge of Marine carbon sequestration services	Understanding of carbon sinks (x6*)	I don't know anything about =1 Heard of = 2 We know that theta is equal to 3 Fully understand =4

Note: the (*) in the variable name represents a dummy variable

2) Construction of Logistic regression model

Logistic regression is a regression analysis of qualitative variables, and the Logistic model is one of the commonly used models to study residents' willingness to pay. Logistic regression is an extension of multiple regression analysis, and its dependent variable is a discontinuous variable. This study takes Guangdong residents' willingness to pay for Marine carbon sequestration services as the explained variable. It conducts a Logistic regression analysis on the factors that may affect residents' consent or disapproval to pay. Assign the answer "willing to pay" to 1 and "unwilling to pay" to 0. These factors that may affect the willingness to pay come from the socio-economic characteristics and personal information of the survey sample, such as age, sex, education level, monthly family income, occupation, and the respondents' familiarity with the ocean carbon sink. The Logistic regression model is as follows:

$$\mathrm{Log}[\mathrm{Prob(Yes)}/\mathrm{Prob}(1-\mathrm{Yes})] = [\mathrm{B}_0 + \mathrm{B}_1(\mathrm{age}) + \mathrm{B}_2(\mathrm{sex}) + \mathrm{B}_3(\mathrm{education}) + \mathrm{B}_4(\mathrm{income}) + \mathrm{B}_5(\mathrm{profession}) + \mathrm{B}_6(\mathrm{familiar})] \quad (7)$$

Prob(Yes) represents the probability that residents are willing to pay, and its value ranges from 0 to 1.
Prob(1-yes) represents the probability that residents are not willing to pay;
B is the constant term;
B_1、B_2、B_3、B_4、B_5、B_6represents the regression coefficient of each variable;
Age indicates the age of the respondent;
Education represents the education level of the respondents;
Income refers to the monthly household income of the respondent;
Familiar indicated respondents' knowledge of Marine carbon sequestration services.

3) Model regression results and analysis

TABLE II. MODEL REGRESSION RESULTS

The independent variables	regression coefficient	significance level	χ^2
gender	0.021	0.023	8.463
age	0.016	0.023	10.371
Education Level	0.023	0.043	16.256
professional	0.026	0.037	17.328
Monthly household income	0.041	0.024	12.152
How well we know about ocean carbon sinks	0.163	0.008	10.214

From the above regression results, it can be seen that:
The value of B_1、B_2、B_3、B_4、B_5、B_6 directly reflects the sensitivity of the willingness to pay of the investigated samples.
Gender does not correlation with a willingness to pay.
The age factor in the model shows a significant effect on willingness to pay.

There is a significant favorable influence between the education level and the willingness to pay; the higher the education level, the greater the corresponding willingness to pay. This may be because more educated residents, who are more environmentally conscious and have higher incomes, can afford a higher willingness to pay.

The occupation of residents has a significant impact on their willingness to pay. The more stable their work is, the more concerned they are about environmental protection, and the more likely they are to have a higher willingness to pay.

There is a significant favorable influence between residents' income and willingness to pay. The higher the monthly income of a family, the greater its willingness to pay and the more able it is to pay.

There is a significant influence between residents' knowledge of ocean carbon sinks and their willingness to pay. With more understanding of ocean carbon sinks, residents will realize that ocean carbon sinks play an essential role in mitigating carbon content in the atmosphere and improving residents' living environment. Therefore, the residents are willing to pay a certain amount of money for this, and of course, the willingness to pay will be more vital.

Ⅳ. Conclusion

The main factors influencing WTP are age, household income, education level, and awareness of ocean carbon sink. Gender did not correlate with a willingness to pay. Income is positively correlated with WTP, and the desire to pay of high-income people is generally higher than that of low-income people. The higher the level of education, the greater the willingness to pay. The higher the understanding of ocean carbon sink, the higher the WTP of residents; On the other hand, residents who know little about WTP have fewer WTP and even zero payment. Under the urgent situation of global warming, accelerating emission reduction and increasing carbon sink is a significant issue of international concern, and ocean carbon sink is a critical way to solve the problem of increasing carbon sink effectively. In 2015, the CPC Central The overall plan for reforming the ecological civilization system promulgated by the State Council put forward the "establishment of an effective mechanism to increase marine carbon sequestration" to bring marine carbon sequestration into the national strategic level. In 2016, the country's "more tough choice-- more severe consequences-- in planning officials, marine carbon sequestration will be listed as one of the critical research and development, and oceanic carbon sequestration will be incorporated into the policy system China's economic and social development. It is imperative to accelerate the study of ocean carbon sink in China. The calculation of economic value of ocean carbon sink is the basis for promoting the development of ocean carbon sink projects and carrying out ocean carbon sink trading. It is necessary to continue to strengthen the research and exploration of relevant theories and practices, to provide technical support for China to lead the development of the international ocean carbon sink and respond to global climate change.

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