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Diversity Assessment and Contingent Valuation in Basak Lake of Saguiaran, Lanao Del Sur, Philippines

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Abstract The lake ecosystem in the municipality of Saguiaran serves as a habitat for various flora and fauna species and a main source of water supply for agriculture and livestock production in the surrounding communities. The lake experiences periodic drying and its surrounding ecosystem has been significantly influenced by various anthropogenic activities and the introduction of alien species. Thus, this study assessed the lake diversity and the residents' willingness to pay for the protection. This study used the belt transect method to assess the diversity and contingent valuation to determine the willingness to pay for the protection. Results show that diversity (H' = 1.324) and evenness (J = 0.533) are low. Carabao grass (*Paspalum conjugatum* P.J. Bergius) is with the most abundant species that accounts for about 62% (n = 457) of the total plant individuals assessed. There are four statistically significant variables in correlation analysis and there is a very low degree of multicollinearity among independent variables, with a mean Variance Inflation Factor (VIF) of 1.49. In a regression model, five variables are correlated to the dependent variable, which are all from the demographic profile of the respondent. It includes age, gender, monthly income, household monthly income and number of years living in the area. The average willingness to pay is Php 23.85, which is what respondents paid monthly for Basak Lake protection. The payment for the protection of Basak Lake can generate Php 109,324,931 annually.

Keywords Lake Ecosystem Diversity, Contingent Valuation, Willingness to Pay

1. Introduction

Freshwater wetland serves as a habitat for different types of flora and fauna, such as birds, insects, aquatic plant species, and threatened and endangered species. It provides a wide array of goods and services for animals and plants and the local communities. Freshwater wetlands are important to animals and humans because much of their survival depends on freshwater as a source of water supply. However, climate change has already triggered shifts in species distribution in many parts of the world. The impacts are expected in the future, yet few studies have aimed at a general understanding of the regional basis for species vulnerability [1]. Aside from climate change, other factors are to consider, such as exploitation, conversion of areas or land use, invasion of exotic or alien species, and water pollution. Freshwater ecosystems may well be the most endangered ecosystems in the world. Declines in biodiversity are far greater in freshwater than in the most affected terrestrial ecosystems [2,3]. The assessment of biodiversity in the wetlands area, specifically the freshwater ecosystem, must be implemented to determine the current situation of the ecosystem, population, and threats within the wetlands area. As for the economic value,

Basak Lake is the main source of water supply for each barangay's agricultural activity and livestock. The changes in the lake due to various causes, such as exploitation and climate change, impact the goods and services provided by the lake. Fromm [4] defines in the literature on economic valuation that the value of natural assets for analytical purposes is defined by the components of the so-called "total economic value". The identification of the total value shows which values, in the economic sense, are generated by natural assets.

Nowadays, there are so many changes in the environment due to climate change that they threaten nature, such as the shallowing of some lakes and droughts that affect people's livelihoods and biodiversity in an area. Climate change has a massive effect on freshwater lakes. According to Bertelsmeier et al. [5], freshwater ecosystems and biodiversity are seriously threatened by climate change. As a result, many animals are forced to migrate to other areas due to climate change, which causes the biodiversity of an area to change.

The type of freshwater wetland in the municipality of Saguiaran is a lake, which serves as a habitat for a variety of species and is the main source of water supply for agriculture and livestock in the communities that surround it. Due to climate change and land conversions, the lake is shrinking, and experiences periodic drying especially during summer.

The periodic drying and anthropogenic pressures that have affected the water levels of Basak Lake have also caused changes to the biodiversity such that plant species within the lake undergo upturn and decline due to the rapid growth of other plants and the introduction of invasive alien species. As a result of the shallowness of the lake, surrounding communities visit the lake for hunting and poaching plants, birds, fish, and even threatened species. Animals are forced to move elsewhere due to threats from human activity and climate change. Because of the changes in plants and animals in the lake, new species are added, or existing species may disappear in the area. Therefore, a diversity assessment within Basak Lake must be conducted to better understand the current species diversity and whether the plants and animals there are increasing or decreasing in number. Ecosystem goods and services are essential to support life in different ways. However, some of the goods and services provided by the ecosystem have no market value, but somehow, they are beneficial in other ways. These environmental concerns, which are the changes in the lake that affect goods and services, have become a serious problem.

Thus, this study aimed to assess the lake's species diversity and willingness to pay for the protection of the lake.

2. Method

This study was conducted in Basak Lake, Saguiaran, Lanao del Sur as shown in Figure 1, with a coordinate of approximately 8.0357, 124.2595. The lake is surrounded by three barangays: Maito-Basak, Pantao-Raya, and Pantaon. The lake covers an area of 15 hectares, and the terrain elevation of the lake was estimated at 589 meters above sea level. In 1965, the lake was declared a national park by virtue of Republic Act No. 4190, and it is called "Pantuwaraya Lake National Park."

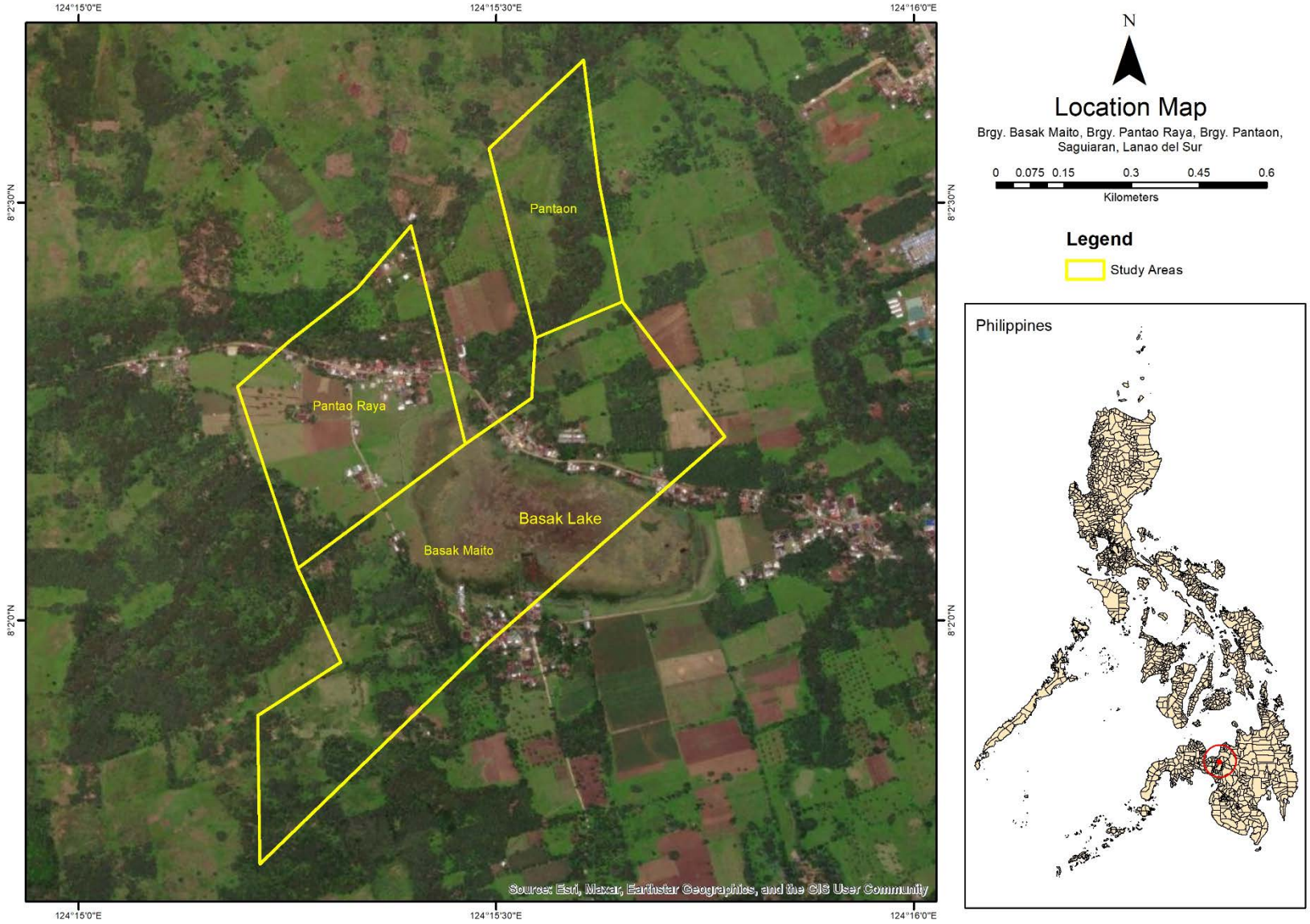

Figure 1. Location of the study

2.1. Diversity Assessment

The researchers used the belt-transect method to assess plant species diversity in those areas of Basak Lake. The 1.75 km baseline transect was established parallel to the shoreline. The baseline transects have seven quadrants and based on the 1.75 km baseline within the lake, the seven quadrants have a 250-meter distance interval to every quadrant to establish the belt transect method by establishing 20-by-20-meter quadrants for tree species, 5-by-5-meter quadrants for shrubs, and 1-by-1-meter quadrants for herbs and grass type species.

2.2. Contingent Valuation

The goal of contingent valuation is to measure the compensating or equivalent variation for the good question [6-7]. In the survey, the researcher used stratified random sampling to select the respondents from three barangays, with a sample size of 195 respondents as stated in Table 1. To determine the sample size, Robert Slovin's formula was used to get the sample data that was needed. The equation is:

$$n = N/(1+Ne2) \quad (1)$$

Where:
n = sample
N = population
e = marginal error e = 0.05

Table 1. Sample size of the study

Respondents	Household population size	Sample size
Brgy. Maito-basak	183	93
Brgy. Pantao-raya	92	47
Brgy. Pantaon	107	55
Total	**382**	**195**

The questionnaire is organized into three sections: knowledge, attitudes, and perception; a hypothetical scenario eliciting willingness to pay; and a demographic profile. The survey focused on contingent valuation using the willingness-to-pay approach, which determines if respondents are prepared to pay for lake protection. The researchers used the single-bounded dichotomous choice format "Yes or No" in the questionnaire, and random bid prices in the questionnaire, such as Php 10.00, Php 30.00, Php 70.00, and Php 100.00, are presented to the respondents to determine their willingness to pay, which was answered with either "yes" or "no," and the survey is conducted via house-to-house interview.

3. Data Gathering Procedure

Before conducting the study, a request letter was sent to the respective Barangay Local Government Units (BLGUs) asking permission to conduct research assessments and surveys in their area of jurisdiction. Also, a gratuitous permit was secured from DENR for the diversity assessment. Seven 1m x 1m were established along a 1,750 meter transects with a 250-meter spacing. All species inside the quadrants were counted and studied and vouchers were collected for identification and verification.

In the conduct of house-to-house interviews, the researchers managed to conduct the survey among available respondent households, and the researcher instructed personal information and explained the purposes of this study and the interview to every respondent. The instruments used in the survey were the questionnaire, pencil, notebook, and camera. This was done for the convenience of the respondent and for the researcher to easily guide them in answering the survey questionnaire. The collected personal information of the respondents was treated with the utmost confidentiality and used solely for the research.

4. Data Analysis

For enumeration, verification, and analyzation of plant species in diversity assessment, the plant diversity in quadrant sample was determined using the following:

Where H' is the Shannon-Weiner Index of Diversity

$$H' = -\Sigma pi \times \ln(pi) \quad (2)$$

Where:
Σ: A Greek symbol that means "sum"
ln: Natural log
pi: The proportion of the entire community made up of species

Divide Shannon's diversity index H by natural logarithm of species richness ln(S) to calculate the species evenness for relative abundance of species.

Where J' is the Pielou's J evenness index

$$J' = H/\ln(S) \quad (3)$$

Where:
H: is Shannon wiener index
Ln(S): Natural log of species richness

In the survey, the methods used in determining the Knowledge, Attitude and perception were the Likert scale and weighted mean with 1 to 5 points range and interpretation [9,10]. It is shown in Tables 2 and 2.1 the scale, range, and interpretation used, which were: 1 is strongly disagree or strongly unaware, 2 is disagree or unaware, 3 is neutral, 4 is agree or aware, and 5 is strongly agree or strongly aware. The weighted mean equation is:

$$W = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i} \quad (4)$$

Where:
W = weighted average

n = number of terms to be averaged
W_i = weights applied to x values
X_i = data value to the averaged

Table 2. Likert scale, range, and knowledge interpretation.

SCALE	RANGE	KNOWLEDGE INTERPRETATION
1	1.00 - 1.80	Strongly unaware
2	1.81 - 2.60	Unaware
3	2.61 - 3.40	Neutral
4	3.41 - 4.20	Aware
5	4.21 - 5.00	Strongly aware

Table 2.1. Likert scale, range, attitude, and perception interpretation.

SCALE	RANGE	ATTITUDE & PERCEPTION INTERPRETATION
1	1.00 - 1.80	Strongly Disagree
2	1.81 - 2.60	Disagree
3	2.61 - 3.40	Neutral
4	3.41 - 4.20	Agree
5	4.21 - 5.00	Strongly Agree

The willingness to pay equation was used, and to determine the other variables that influence the respondents' WTP, correlation analysis such as the Spearman test was also used, as well as multicollinearity and variance inflation factors [9,10]. To determine the respondent's willingness to pay, the researcher used logistic regression, which was a binary logistic regression model.

$$\ln[p/(1-p)] = a + BX \quad (5)$$

Where:
"ln" - is the natural logarithm, log exp.
"p" - is the probability that Y for cases equals 1, p (Y=1)
"1-p" - is the probability that Y for cases equals 0,
1 – p(Y=1) "p/(1-p)" is the odds
ln[p/1-p] - is the log odds.

To determine the logit model result, it was organized and calculated through Microsoft Excel and STATA 11 software. It can analyze the relationship of dependent variables (variable Y) and independent variables (variable X), which was the relationship between the respondent's answer and the other variables as shown in Table 3.

Table 3. The variable of the logistic regression model

Variables	Variable name	Description
Y	Respondent's answer	Whether the respondent is willing to pay (if yes = 1, if no = 0)
X1	Age	Age of the respondent
X2	Gender	Sex of the respondent (if male = 1, if female = 0)
X3	Monthly income	Income of the individual (respondent)
X4	Household monthly income	Total income of household (including the income of member of family)
X5	Education attainment	Educational level of respondent/ Number of years spent in school
X6	Years in school	
X7	Knowledge means	Knowledge, Attitude and Perception of respondent in basak lake
X8	Attitude means	
X9	Perception means	
X10	Bid amount	Bid amount represented to the respondent
X11	Years living in barangay	Number of years living in the barangay
X12	Household member	Number of household member
X13	Civil status	Status of respondent whether single, married, and widow
X14	Occupation	Work of the respondent

5. Results and Discussions

5.1. Species Diversity and Composition

The identified plant species data in every quadrant were analyzed for species diversity, evenness, and composition and are presented in Table 4. The diversity is computed using Shannon-Wiener diversity analysis, it was shown that the H value of plant species was 1.324. [11]. Generally, this H value was still low in terms of species diversity based on the Shannon-Weiner index classification, where the value usually lies between 1.5 and 3.5 and rarely exceeds 4.0 [12].

The result of the study also showed that most plant species found within Basak Lake are from the family of grasses (Poaceae) and sedges (Cyperaceae). As shown in Table 4, there were 12 plant species from seven families, Cyperaceae, Poaceae, Araceae, Asteraceae, Onagraceae, Fabaceae, and Pontederiaceae. Carabao grass (*Paspalum conjugatum* P.H.Raven) is the most abundant species with a total of 457 individuals recorded, representing 62% of the total flora population. Southern cutgrass (*Leersia hexandra* Sw.) and Blunt spike sedge *(Eleocharis obtusa*) population numbers were estimated through cover percentage due to the difficulties in estimating their count. Based on DAO 2017–11, or the Updated National List of Threatened Philippine Plants and their Categories of DENR, none of the recorded species are threatened species. In fact, at least three species are non-native to the Philippines - *P. conjugatum* P.J. Bergius, *A. conyzoides* L. and *P. crassipes* Mart [16]. The latter is considered an alien invasive species [17] in waterways of the country.

The total J value of plant species in Table 4 is 0.533. The low evenness value signifies a high dominance of a few species [11,13].

Table 4. Plant species diversity, relative abundance, and composition

CN	SN	FN	AB	H'	J'	SC
Busikad	*Cyperus brevifolius* (Rottb.) Endl. ex Hassk.	Cyperaceae	123	0.300	0.121	0.168
Blunt spikesedge	*Eleocharis sp.*	Cyperaceae	0.66	0.006	0.003	0.001
Carabao Grass	*Paspalum conjugate* P.J. Bergius	Pinaceae	457	0.294	0.118	0.624
Elephant ear	*Colocasia* esculenta (L.) Schott in Schott & Endl.	Araceae	19	0.095	0.038	0.026
Goat weed	*Ageratum conyzoides* L.	Asteraceae	6	0.039	0.016	0.008
Malapako	*Ludwigia octovalvis* (Jacq.) P.H.Raven	Onagraceae	2	0.016	0.006	0.003
Nut grass	*Cyperus rotundus* L.	Cyperaceae	21	0.102	0.041	0.029
Sigang dagat	*Ludwigia adscendens* (L.) H.Hara	Onagraceae	13	0.072	0.029	0.018
Smallflower umbrella sedge	*Cyperus difformis* L.	Cyperaceae	23	0.109	0.044	0.031
Southern cut grass	*Leersia hexandra* Sw.	Poaceae	1.43	0.012	0.005	0.002
Three-flower beggarweed	*Grona triflora* (L.) H.Ohashi & K.Ohashi	Fabaceae	34	0.143	0.057	0.046
Water lily	*Pontederia crassipes* Mart.	Pontederiaceae	32	0.137	0.055	0.044
Total			732.09	1.324	0.533	1.000

Note:

CN – Common Name; SN– Scientific name

FN – Family name

Ab- Abundance

H'- Diversity

J- Evenness

SC- Species composition

5.2. Percentage Composition

The result of the percentage composition in Figure 2 showed that Carabao grass (*Paspalum conjugatum*) was the most abundant species among the other plants which was 62% of total abundance species. Busikad (*Kyllinga brevifolia*) represents 17% of the species in the area as the second most abundant. Three-flower beggarweed (*Grona trifloral*) 5%, and Water lily (*Eichhornia crassipes*) has 4%.

The least abundant in 12 plant species was Blunt spikesedge (*Eleocharis obtusa*) with the composition number of 0.001, Southern cut grass (*Leersia hexandra*) 0.002, and Malapako (*Ludwigia octovalis*) 0.003.

5.3. Contingent Valuation

5.3.1. Logistic Regression of Variables

Before the regression analysis, the multicollinearity among independent variables was checked using VIF to avoid an overfit regression model. The analysis has shown that the mean VIF is 1.49, indicating a very low multicollinearity level among independent variables. Table 5 shows the result of the regression analysis; 5 out of 14 variables were significant or have influence on the households' WTP. The five (5) variables were from the demographic profile, which was the age of the respondent, gender, monthly income of the respondent, household monthly income (including the income of every household member), and number of years living in the barangay.

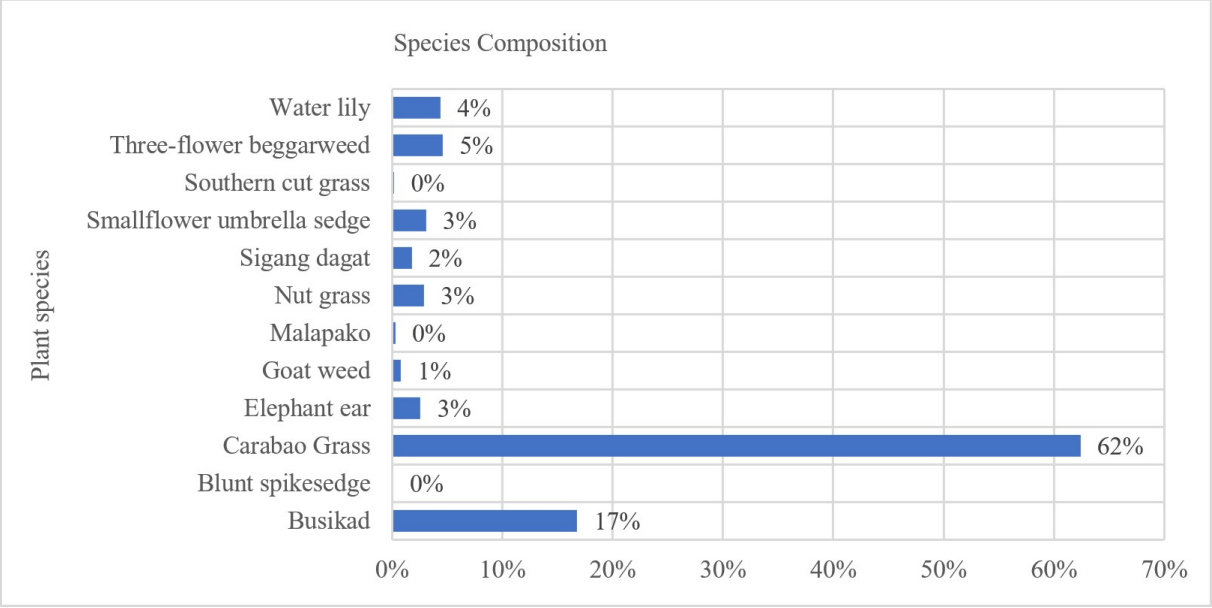

Figure 2. Percentage composition of species

Table 5. Summary of variable for computing WTP

Variables	Coefficient	Mean	Product
Age	0.0340615*	44.39	1.511989985
Gender	0.674405*	0.5282	0.356220721
Monthly income	0.0000633*	8459	0.5354547
Household monthly income	0.000045*	14462	0.65079
Educational attainment	0.0827847	2.6564	0.219909277
Years in school	-0.0279114	10.908	-0.304457551
Knowledge means	0.4495093	3.49	1.568787457
Attitudes means	0.2930123	4.11	1.204280553
Perception means	-0.342166	4.02	-1.37550732
Bid amount	-0.2547159	2.5077	-0.638751062
Number of years living in barangay	0.2621965*	4.0564	1.063573883
Number of household member	0.1220906	2.359	0.288011725
Civil status	0.009362	2.1026	0.019684541
Occupation	-0.0473508	5.9179	-0.280217299
Constant	1.252709		
	a	6.072478609	
	Mean WTP	23.84924305	
	Total household population 2020	382	
	Total annual payment (PhP) for the basak lake protection program.	109,324.9301	
	Total payment (PhP) for the program (10 years)	1,093,249.301	

The age variable was statistically significant, it had an influence on the dependent variable, which means that younger and older respondents were more or less likely to pay [14]. The gender variable was also significant, data showed that 103 (53%) of respondents were male while 93 (47%) were female. The gender variable has a likelihood with respondents' WTP. It shows that more male respondents are willing to pay for the protection of Basak lake. Monthly income was also a significant variable; according to Eridadi et al. [15], the higher an individual's monthly income, the higher their expenditure; Minota [14] stated that the higher a household's monthly income, the more willing that household was to pay. The household monthly income is significant and there is a likelihood to the logistic regression analysis dependent variable. The number of years living in the barangay was also significant to the respondents' WTP; accordingly, the average number of years living in the barangay is 36 years, and the majority of respondents live around the lake and have a range of 23–32 years. The remaining nine (9) variables, such as knowledge, attitude, perception, educational attainment, and number of household members, generate a negative coefficient, which means the nine variables were not influencing the WTP of the respondent or the dependent variable of the logistic regression analysis.

5.3.2. Mean Willingness to Pay of Respondents

The computed mean willingness to pay of every household is Php. 23.85 monthly which the result shows that 65% (126 out of 195) of the respondent are willing to pay for the protection of Basak lake with the payment mode of 90% (113 out of 126 willing to pay) in barangay office while 10% (13 out of 126 willing to pay) in LGU or municipal office. With the total of 382-household population of three barangays in 2020, the payment generated is 9,110.7 monthly, the total annual payment for the Basak lake protection program would be PhP109,324.9301 and PhP1,093,249.301 for the total 10 year of payment for the Basak lake protection program as shown in Table 5.

6. Conclusions

Plant species diversity within Basak Lake is relatively low and unevenly distributed. The abundance of carabao grass (*Paspalum conjugatum* P.J.Bergius) implies its dominance in the study area. Moreover, most of the species

recorded are grasses and sedges associated with disturbed grassland ecosystems and anthropogenic disturbance. This is further supported by the presence of several non-native and invasive species in the study area.

Based on the knowledge, attitude, and perception data, the residents are strongly unaware that Basak Lake was declared a national park in 1965. Until now, they have relied on Basak Lake services directly and indirectly, such as water supply, agriculture, and livestock. The respondents are also agreeing that having a conservation and protection program and promoting CEPA in Basak Lake will prevent lake degradation and increase resident awareness of Basak Lake.

The significant variables that influence the willingness to pay are the age, gender, monthly income of a specific respondent, household monthly income of the respondent, which include the monthly income of household members, and number of years living in the barangay. These variables impact the respondents' willingness to pay for the protection of Basak Lake. The average willingness to pay of respondents is Php 23.85 monthly; the result shows that 65% of the total respondents are willing to pay for the protection of Basak Lake. Based on the annual data, the payment for the protection of Basak Lake would be Php. 109,324.9301 and Php. 1,093,249.301 for the total 10 years of payment for the Basak Lake Protection Program.

7. Recommendations

1. The national government offices, such as the DENR and other related offices, as well as non-governmental organizations, should collaborate with the local government unit of Saguiaran to establish research and study in Basak Lake and promote a seminar on Communication, Education, and Public Awareness on Basak Lake to understand and encourage residents to protect the lake. The resident must be aware of the condition of Basak Lake; aside from environmental awareness, they must also be aware of the economic value of Basak Lake.
2. The national government must have information on Basak Lake, such as a list of plants and animals, their physical and environmental conditions, and their conservation status, to better understand the lake and conduct future studies.
3. The local government unit, especially the BLGUs, must make or regulate their policy regarding the cleanliness of their surrounding area to prevent the growth or expansion of solid waste within Basak Lake.
4. The creation of policies such as prohibition of people (residents or visitors) from poaching plants and animals within Basak Lake must be imposed, as well as the prohibition of the conversion of Basak Lake into other land uses.

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