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Socioeconomic and Environmental valuation of the Ecosystem Services: A Case Study of from Zoobotonical Park in Belém, Pará, Brazil

Antônio Cordeiro de Santana[1]*, Ádina Lima de Santana[2], Gilmara Maureline Teles da Silva de Oliveira[3], Rafael de Paiva Salomão[4], Ádamo Lima de Santana[5], Eder Silva de Oliveira[6] and Washington Aleksander Savaris dos Santos[7]

[1] Federal Rural University of the Amazon. Belém, Pará, Brazil; acsufra@gmail.com
[2] Kansas State University. Manhattan, KS, USA; adina.santana@gmail.com
[3] Federal Rural University of the Amazon. Belém, Pará, Brazil; gilmarateles.eng@gmail.com
[4] Museu Paraense Emílio Goeldi. Belém, Pará, Brazil; rpsalomao17@gmail.com
[5] Corporate R&D Headquarters, Fuji Electric, Tokyo, Japan; alwkynew@gmail.com
[6] State University of Pará. Belém, Pará, Brazil; ederso@uepa.br
[7] State University of Pará. Belém, Pará, Brazil; alex.uepa@gmail.com

*****Correspondence: acsufra@gmail.com; Tel.: +55-91-98858-3266.

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Abstract *—The value of ecosystem services produced by the natural ecosystem preserved by the Zoobotanical Park of Belém (ZPB) was estimated based on the population's perception of the existing link between nature and the well-being that is provided to society. The preserved ecosystem provides the population with physical and mental benefits through individual and collective recreation, contemplation of the environment and direct and indirect interaction with animals and plants, as well as knowledge about endangered species and awareness of the need to preserve natural resources in the Amazon. The wood products were estimated by the Net Present Value (NPV), considering a flow of 100 years, as proposed by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). Three methods of estimating the NPV were adopted: the value of the carbon stock evolving based on the geometric rate of growth of the diameter of the trees, which resulted in the value of (US$ 145,216.75); the value of the carbon stock without growth rate, with a value of (US$ 66,332.21); and the value of the wood volume of (US$ 34,660.36). The value of ecosystem services was estimated by the Integrated Method of Contingent Valuation and generated the socioeconomic and environmental value for preserving the ZPB of US$ 1,464,527.41 and the value of replacing it with another activity at US$ 1,628,657.59. This amount was more than twice the opportunity cost of the park area for the civil construction market.*

I. INTRODUCTION

The Zoobotanical Park of Belém (ZPB), in the State of Pará, Brazil, is located in the center of the city of Belém, and has been managed for more than 100 years by the MuseuParaenseEmílioGoeldi (MPEG), a research institution linked to the Brazilian Ministry of Science, Technology, Innovation and Communications. The green park houses a physical infrastructure for research and preservation an area of 5.2 ha of Amazon forest, including plants and rare/endangered animal species.

The forest and its interaction with biodiversity and human beings constitutes the natural assets with wood and non-wood products of economic value and a set of ecosystem services, which directly and indirectly influences the social well-being of the population associated with the value of use value for leisure, recreation, cultural and scientific knowledge, regulation of climate and air quality; and the value of non-use for the preservation of rare and endangered species of the Amazon ecosystem. The socioeconomic and environmental value of this natural asset was estimated to guide the MPEG management decisions on how to fund the ZPB management activities in order to avoid the threats to its extinction, arising from the local real estate sector and the federal financial budget restriction. Here, the value of products with market prices was estimated by the cost-benefit method; and the ecosystem services without market price was estimated by the Integrated Method of Contingent Valuation (IMCV), proposed by Santana [1].

The ZPB‘s natural asset is formed by arboreal vegetation of the Amazon biome, whose species have a market price; and by rare species of flora and fauna with risk of extinction, which have no market price. This asset generates a flow of ecosystem services that includes the regulation of the city’s microclimate, mitigates greenhouse gases emitted by vehicles, provides cultural and scientific knowledge to the local population and tourists, provides physical and mental comfort to people through leisure, contemplation and interaction with the forest and animals. The result translates into direct gains in well-being for visitors, and indirect gains for the surrounding population in the city of Belém. These products and services make the economy more viable, through tourism and the value of the surrounding homes; additionally providing the population with amenities and opportunities for leisure and well-being. However, even in the face of the population's perception of its benefits, the socio-economic and environmental value of the ZPB is not yet known. The reversal of this reality of threat to the replacement of the park area by residential condominiums must be changed based on the payment for the preservation of the assets and the flow of ecosystem services that it produces over time, by contributing to stabilize the financial budget at a sufficient level for its preservation. Therefore, the basic question is: what is the value of this natural asset in the population's perception and its opportunity cost associated with the urban area market for civil construction?

The lack of knowledge of the total economic value of the park's natural assets and its importance for the population's social well-being is an important issue, as the ZPB is in danger of being replaced by residential condominiums, due to its strategic urban location and the lack of guarantee of resources for its maintenance by the public sector. Thus, the estimation of the value of the natural asset constitutes a technical, socioeconomic and environmental parameter to support the preservation of this natural ecosystem, which references the history of Belém and the Amazon.

In this context, the objective of this research was to estimate the socioeconomic and environmental value of the ecosystem products and services produced by the natural asset of the ZPB, as a way of internalizing this value in the price of the urban property and ensuring the right to have and enjoy this green area of vast content of historical knowledge and socioeconomic and environmental benefits for the population of Belém.

Theoretical Reference

Each day there is an increase in the number of people that realizes the importance of products and services produced by ecosystems for the well-being of the population. Due to this growing knowledge, the needs to manage the use of natural resources as a source of raw material for industrial processes, well-being and quality of life for the population are advancing. Thus, according to Costanza et al. [2,3,4,5], the attribution of value to natural assets is a necessary condition to estimate the opportunity cost of their preservation and/or rational use, within the scope of a sustainable management policy for natural resources. The ecosystem services can be classified into four categories [2,3,6,7,41]:

(1) Provisionservices: includes products such as food and fibers, wood, seeds, resins, roots, genetic resources, biochemical, medicinal, pharmaceuticals, ornamental andwaterproducts;
(2) Environmental regulationservices: includes climate control, pollination, diseases and pests, water and air purification and protection against disasters;
(3) Cultural services: includes cultural, religious and spiritual values, knowledge, recreation, and educational and landscape values;
(4) Supportservices: defines the production of other services such as soil formation and retention,

photosynthesis, nutrient cycling, biological soil activity, water cycling and maintenance of habitat dynamics.

Therefore, without these products and services, there is no economic growth or improvement in the population's quality of life [8]. Furthermore, studies on the valuation of ecosystems contribute to the improvement of valuation methodologies for natural assets that have a market price, and those that are not traded, given the rarity, endemism and non-consumption [5,7,9,10,11]. The basis of the valuation is to include the value of natural assets in the property's equity, and with it enabling the development and implementation of environmental policies, regulating the extraction of resources and estimating the effects of ecological footprints and natural phenomena [9,12,13,14,15]. In the specific case of ZPB, it looks to estimate the value of the asset for the population and to ensure a permanent budget to guarantee the management of the park and the preservation of the natural ecosystem by the continuous provision of these services for the benefit of society.

In general, the valuation of natural assets for the purpose of preservation, indemnification or compensation, has as methodological basis applied by several studies, among them: Santana and Khan [16], Turner et al. [17], Carson [18], De Groot et al. [3], Santana [1], Bentes et al. [19], Santana et al. [20], Rosa et al. [21], Santana et al. [7,22], Acharya et al. [23] and Oliveira et al. [11].

From the considered methodologies, only the Contingent Valuation methods allow to capture the value of existence, or that of non-use of natural assets in the estimation of the Total Economic Value (TEV), which is given by (Pearce [24], Bishop and Romano [25], Carson and Mitchell [12], Adams et al. [13], Carson [18], Santana et al. [7], Oh et al. [26], Eq. 1:

$$TEV = Value\ of\ Use\ (VU) + Option\ Value\ (OV) + Existence\ Value\ (EV) \rightarrow (1)$$

The VU for the products that present a market price is estimated by the economic surplus, which represents the socioeconomic benefits of consumers and producers [2,5,16,17,26,27,28]. For products that have no market price, the value is defined by the willingness to pay for the preservation of natural resources, or the willingness to receive compensation for the use of these resources; which is also based on the consumer surplus or benefit [2,9,18,22,27,29].

The VU can be subdivided into two components: the Direct Value of Use (DVU) and the Indirect Value of Use (IVU). The DVU refers to the consumption or direct enjoyment of natural resources as a source of raw material, food, medicinal and scientific products, leisure, recreation and satisfaction, which can be obtained by hunting, collecting and/or extracting resources, or by visitation of the natural environment. In the case of ZPB, DVU is represented by wood and services oriented to the leisure of visitors. The IVU, in turn, represents the externalities that the natural asset generates through its functions within ecosystems to maintain biodiversity and ensure the preservation of rare and/or endemic species of flora and fauna, climate regulation, water courses, nutrient cycling, among others. The ZPB shelters species that are important for maintaining the dynamics and balance of ecosystems and that influence the regulation of the local climate.

The OV refers to the value of environmental services produced by natural resources that must be preserved for future use, as a way to ensure new discoveries for the benefit of society. From an economic point of view, it reflects the aversion to the risk that resources, in the future, may have their products and services valued so that decisions of use are delegated to the people, since by conserving species of the Amazon biodiversity, the ZPB fulfills this role. Therefore, it is the attribution of value to the natural asset just for its existence is related to rare plant and animal species, in which irrational use and ignorance increase the risk of threatening their existence and new scientific discoveries that benefit humanity.

The value of direct use of the ZPB is given by utility or benefits that ecosystem products and services generate for visitors, local residents and bystanders, through leisure activities, recreation, thermal comfort and other amenities, environmental education and cultural knowledge, and by allowing people to interact with biodiversity in the urban environment. This fact is based on the studies realized by Bishop and Romano [25], Turner et al. [17] and Elmqvist et al. [30], which allow validating the method of benefit of visitation, by the values of use and non-use of the park's natural assets.

The value of indirect use is the benefit or utility that results from the consumption of biodiversity through the contemplation of plants and animals and the aesthetic quality of the fauna and flora of the Amazon. This value is derived from the ecological functions of the ZPB that materialize with the breeding in captivity of endangered species, and the conservation of the regional fauna and flora. The option value is configured by the conservation activity of the environmental asset to reduce the risk of extinction of species and to raise awareness of visitors to guarantee access to the resource in the future. The existence value is given by the benefit that the ZPB offers

to society for preserving the natural resources. The preservation of rare, endemic species with a high risk of extinction generates existence value. In addition, according to Fuller et al. [31], Elmqvist et al. [30] and Santana et al. [32], the biota of natural ecosystems produces human satisfaction or social well-being from the desire, feeling, pleasure, contemplation and altruism of people for the preservation of nature.

The manifestation of people about the intensity of the benefits that ecosystem services generate for their well-being, through the relationship with the value of use (direct and indirect), option value and value of non-use, can lead to results inconsistent with the reality; given the high difficulty of the population to link ecosystem services to the type of value. To overcome this difficulty, we adopted the direct relation between the service and the benefit perceived by the population, and its consequent attribution of value to continue enjoying the benefit or to replace it with another economic activity. This fact encouraged people to evaluate ZPB even without visiting it, due to them being altruistic towards friends, family, users, future generations, fauna, flora, and because they understand that nature has a right to exist and, therefore, it must be preserved. In effect, the technical relation between the visitor and the natural asset, through knowledge, interaction and contemplation, represents the demand for recreation, which makes the consumer surplus close to the incremental benefit of recreation and/or study visits, which associates environmental services to social well-being.

The method of Net Present Value (NPV) was applied to estimate the economic value of wood products, updated at a discount rate of 4% per year, using as economic variables the volume and stock of carbon stored in the aerial part of the trees, as well as the average growth rate of 157 species and 678 individuals from 20 cm in diameter at breast height.

In the valuation of ecosystem services, socioeconomic and environmental relations were integrated with the Integrated Method of Contingent Valuation to estimate the ecosystem services of the natural assets from the ZPB [1,5,41]. The IMCV was specified by the social (SOCD), economic dimension (ECOND) and environmental dimension (ENVD). These dimensions contain the explanatory variables of the equations of the Willingness to Pay (WTP), for maintaining the benefit of the ZPB, and the Willingness to Accept (WTA) compensation, to obtain benefit elsewhere.

IMCV	WTP = f (SOCD, ECOND, ENVD; α
	WTA = f (SOCD, ECOND, ENVD;β)

Which α and β are the parameters vectors to be estimated.

II. MATERIAL AND METHODS

Valuation of wood products

In the cost-benefit analysis, the net present socioeconomic and environmental value of the asset is estimated through an infinite cash flow for vegetation, updated by a social return rate of 4% per year. This was done by estimating the total volume of arboreal vegetation in the ZPB area, based on a forest inventory of trees with diameter, measured at 1.3 m from the ground (i.e. breast height), equal or greater than 20 cm, the value of each tree species from its known market unit price (US$/m^3), and the value of the carbon stock (carbon stock as t times the price of carbon credit in R$/t). Thus, the net present value of the natural asset that has a market price was estimated from the wood forest production, according to Santana [33, 41]:

$$NPVNA_i = \sum_{i=0}^{I=100} VCNSA_i \left[\frac{(1+\theta)^i}{(1+r)^i} \right] \rightarrow (2)$$

Where NPVNA is the net present value of the natural asset, assessed based on the value of the carbon stock accumulated in the trees at the price of international carbon rates (R$/t); VCSNA is the value of the carbon stock of the natural asset in t; θ is the average growth rate of the carbon stock of forest species [34,41]; and r is the discount rate of 4% per year.

This methodology advances in relation to the criteria used, because it includes all arboreal species identified and transformed into a homogeneous product commercialized in general market, which is carbon credit, operated in a competitive market. It also advances because it considers the horizon of continuous time and not just the portion of the forest explored in the cut years proposed by IBAMA. Another methodological contribution refers to the inclusion of the growth rate of the primary forest in the mathematical model to estimate the net present value of the asset, particularly considering the need for empirical studies to obtain the measurements of the diameter at breast height of the species over time.

The data used in the cost-benefit analysis were generated from the forest inventory of 678 individuals of 157 species [35] with WTP (trunk diameter 1.30 cm from the ground) greater than or equal to 20 cm, computing the diameter of the tree, height of the stem and crown, and the wood volume of trees with and without commercial value. Based on these data, the biomass, carbon stock and growth rate for the tree species were estimated [35,36,41].

The net present value of the carbon stock of arboreal vegetation considering only the discount rate of 4% per year in the capital update, and assuming that there is no variation in the carbon stock, is given by:

$$NPVNAsc_i = \sum_{i=0}^{I=100} VCNSA_i \left[\frac{1}{(1+r)^i} \right] \rightarrow (3)$$

Where NPVNAsc is the net present value of the natural asset, without considering the increase rate of the carbon stock over time.

The estimation method using the price of standing wood from a forest for the purpose of indemnification to IBAMA, according to Nogueira and Rodrigues [37], considers a flow of exploitation of the forest area for a period of 100 years, with the cutting of trees with diameter ≥ 45 cm in the years zero, 50 and 100; and those with diameter < 45 cm in the years 25 and 75. In this work, to reproduce the result of this methodology, we considered the value of wood with a diameter equal to or greater than 30 cm (years zero, 50 and 100) and wood with a diameter less than 30 cm (years 25 and 75), as adopted by VALE [38], estimated as follows:

$$NPVWood_i = \sum_{i=0,25,50,75,100} VWood_i \left[\frac{1}{(1+r)^i} \right] \rightarrow (4)$$

The value of wood is given by the market price of standing wood [15,39,40], monetarily adjusted to reflect the opportunity cost of wood (US$/m^3), multiplied by the volume of wood (m^3) of each species. The sum of the values (trees with diameter < 30 cm and $\geq$ 30 cm) was considered and the update was made for the four time points, according to the methodology used by IBAMA for payment for forest suppression.

Valuation of Ecosystem Services

The integration between the functions of ecosystems and the benefits of the population requires decisions to facilitate the combination of natural assets, human capital and manufactured capital in order to maximize economic growth and human well-being [1,2,17,29,41, 42]. Thus, the population's declaration of preference to preserve a natural asset, or to receive compensation for the suppression or loss of that asset, was specified by the equations of willingness to pay and willingness to accept [1].

The value of ecosystem services was estimated using a defined demand curve based on the visitors' declaration of willingness to pay a maximum amount to obtain the benefit of their visits and to ensure that the ZPB remains available for future generations [7,11,21,22]. This technique captures the value of direct and indirect use, revealed by the satisfaction obtained with the visitation and the benefits provided by the environment; as well as the value of non-use for those who do not visit the ZPB, but who, through altruism, they want to keep it for the benefit of others and are therefore willing to pay for its permanence. The interaction between flora and fauna in the park spaces generates services with value of use and non-use for visitors [2,7,10,18,27,41].

The empirical application of IMCV, as proposed by Santana [5], and applied by Santana et al. [7], Santana et al. [22] and Oliveira et al. [11], considering the equations of the WTP for the benefit of the visit and the WTA compensation for not visiting, allows the integration of knowledge about consumer surplus and social well-being with the premises Ecological Economy on the benefits that natural assets generate for the economy and the population. Thus, the WTP and WTA equations, which represent consumer demands for ecosystem services, were specified as follows:

$$WTP_i = \alpha_0 + \alpha_1 + Age + \alpha_2 Gender_i + \alpha_3 Education_i + \alpha_4 Income_i + \alpha_5 TFamily_i + \alpha_6 FVisits_i + \alpha_7 DEnvironmetal_i + \alpha_8 VDR_i + \upsilon_{1i} \rightarrow (5)$$

$$WTA_i = \beta_0 + \beta_1 + Age + \beta_2 Gender_i + \beta_3 Education_i + \beta_4 Income_i + \beta_5 TFamily_i + \beta_6 FVisits_i + \beta_7 DEnvironmetal_i + \beta_8 VDR_i + \upsilon_{2i} \rightarrow (6)$$

Where WTP and WTA are the willingness to pay for the benefit of the visit and the willingness to accept compensation for the non-visit, incorporating all costs of the interviewee (R$/visit); interviewee's Age in years; interviewee's Gender; Education level in years of study; average monthly Income of the interviewee who visits the ZPB, in R$/month; TFamily is the size of the family, given by the number of people; FVisits is the frequency of visits made to the ZPB throughout the year (number of visits/year); DEnvironmental is an indicator constructed based on a set of qualitative variables (regularity of rain and temperature, deforestation, fires, air and water pollution, regulation of the environment by forests, rare and threatened animal and plant species, forest landscape, water springs, etc.); VDR is a dummy variable used to capture the effect of interviewees who are willing to pay a maximum amount for the benefit of each visit equal to or greater than five times the entrance fee currently paid; $\upsilon 1$ and $\upsilon 2$ are the random error terms; α_i and β_i are the vectors of parameters to be estimated by the maximum likelihood method with complete information [43].

The data used to estimate the parameters of the equation were obtained through field research, by applying a specific questionnaire to a representative sample of 548 interviewees from a population of 220,000 visitors per year to the ZPB [1,32].

To configure the environmental dimension, which incorporates the value of all ecosystem services, including the value of existence, an indicator was constructed from nine variables related to the value of direct use, value of indirect use, value of option and value of existence. For this, a factor analysis was applied to build an indicator to represent the average value of the behavior of the variables that define the environmental dimension [32].

III. RESULTS AND DISCUSSIONS

The net present value of wood production will be initially presented, considering the flow of the carbon stock and the volume of wood. Following, the result of the value of ecosystem services of natural assets is shown, based on people's perception of the social benefits obtained through visits to the park.

Value of wood forest product

The biomass of the 678 trees generated the carbon equivalent stock of 847,71273 tons. The average price (R$/ton) of carbon credit was obtained by multiplying the carbon price, of the order of 4.57 euros/ton, by the average value of the August 2017 exchange rate, equal to (R$/euro) = 3.5513, generating the value of R$ 16.23/ton (US$ 5.16/ton - the average value of the August 2017 exchange rate is US$/R$ = 3.1465). Thus, the total value of the wood carbon stock is US$ 4,513.52.

Considering the discount rate of 4% per year, the growth rate of trees and the time horizon of 100 years, this value would then reach US$ 145,216.75 (Equation 7).

$$NPVCS_{tci} = \sum_{i=0}^{I=100} 13{,}757.904_i \left[\frac{(1+0.001037705)^i}{(1+0.04)^i} \right]$$

$$= R\$456{,}924.50 = US\$145{,}216.75 \rightarrow (7)$$

The net present value of the carbon stock, not including the growth rate of the trees, was estimated at US$ 66,332.21 (Equation 8).

$$NPVCS_{stci} = \sum_{i=0}^{I=100} 13{,}757.904_i \left[\frac{1}{(1+0.04)^i} \right] = R\$208{,}714.29$$

$$= US\$66{,}332.21 \rightarrow (8)$$

The methodology adopted by IBAMA for the purpose of indemnifying the suppressed forest generates the amount of US$ 34,660.36 (Equation 9).

$$NPVWood_i = \sum_{i=0,25,50,75,100} = 65{,}658{,}97_i \left[\frac{1}{(1+0.04)^i} \right]$$

$$= R\$109{,}058.81 = US\$34{,}660.36 \rightarrow (9)$$

Therefore, the method that uses the value of roundwood tends to underestimate the value of the forest in relation to the carbon stock, with or without taking into account the growth rate of the forest.

Valuation of Ecosystem Services

Description of the Variables

The total number of valid questionnaires was 548, a number 42.7% higher than the minimum sample, which reduced the sampling error from 5% to 4.18%. Of the interviewees, 44.2% are male and 55.8% female.

The interviewee's age varied between 13 and 90 years. Of these, 37.6% were in the range of 13 to less than 25 years of age, 23.4% from 25 to under 35 years, 19.3% from 35 to under 45, 19.7% with at least 45 years, and with a small portion of 2.9% being at least 65 years old. Therefore, 91.8% of the public that attends the ZPB is under the age of 55, and a good part of them are families that take children and young people to the visits and exercise the principles of environmental education.

Regarding the level of education of the interviewees, the most important factor in the perception of the benefits of ecosystem services for well-being [41], 76.9% are among high school and college, and 13.2% have attended graduate school. The remaining 9.9% attended up to high school.

The modal frequency of visits to the ZPB is once a year, effected by 50.2% of the interviewees. A group of 18.6% make visits every six months, 15.9% monthly, 6.2% quarterly, 4.6% quarterly and 4.6% make occasional visits more than one year. The visit time is around three hours, concentrated on the morning period. The origin of visitors is 68.4% from the Metropolitan Region of Belém, 18.4% from other municipalities in Pará, 12.2% from other states in Brazil and 0.9% from other countries.

All interviewees, in addition to agreeing to participate in the survey, revealed that they have sufficient knowledge to answer questions about the environmental and ecological conditions provided by the park and its influence on the well-being of the population. They declared their willingness to pay for the preservation of the natural assets of the ZPB and to receive compensation for

opting to visit another park instead of the ZPB. In this case, the Botanical Garden Grove Rodrigues Alves was the closest replacement, indicated by 54.15%, followed by the Mangal das Garças by 31.06%, Park of Utinga by 4.49% and other different sites by 10.30%. The main choice of the former as the main substitute place was due to the similarity of the ecosystem services offered by the forest area.

The variable per capita income concentrates 63.1% in the stratum that earns up to three minimum wages (MW) per month, 14.4% between three and five MW, 14.2% between 5 and 10 MW and 8.2% between 10 and 40 MW per month. Regarding the concentration structure, 24.6% earn less than one MW and 1.1% earns more than 25 MW per month.

Perception of ZPB Benefits

The ecosystem services produced by the systemic interaction of the natural assets of the ZPB with the fauna and population that were perceived directly and indirectly by the interviewees who visit the environment, contemplate: regulation of the environment (temperature, winds, rain and pollution); visual landscape (trees, wild animals, forest mosaic in urban environment); biodiversity (rare and endangered animals, Amazonian fauna and flora interacting); environmental education (functions of animals and plants in the ecosystem, values to be preserved, knowledge about the Amazonian flora and fauna); social well-being (comfort and mental relaxation, awareness of preservation); and real estate valuation of the site (land, buildings and other buildings).

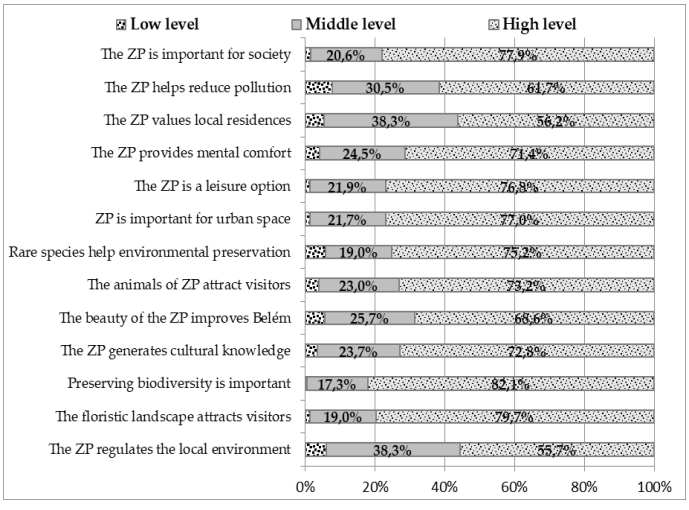

Fig.1. Perception of interviewees on ecosystem services produced by ZPB, Belém, 2017

The importance of ZPB to society was recognized by the interviewees, with 98.5% of them evaluating as medium to high importance. The results presented on the Figure 1 reveal the level of importance that the interviewed perceived and attributed to the ecosystem services produced by the natural assets. These results were superior to those found by Santana et al. [32] and Oliveira et al. [11], due to the higher degree of formal education and knowledge of the interviewees about the effects of the environment on the well-being of humanity.

The results in Figure 1 allow the four groups of ecosystem services offered by the ZPB to fit into the four components of the TEV. The ecosystem services that define the DVU are consumed by direct interaction with the organs of the senses, and were evaluated by the interviewees as being of high importance for the well-being and improvement of the quality of life of people; to note: leisure option (76.8%), fauna as a visitor attraction (73.2%), mental comfort (71.4%). The IVU refers to the utility obtained by the contemplation of plants and animals such as the attraction of the floristic landscape (79.7%), reduction of pollution (61.7%), the scenic beauty improves the image of the City (68.6%), valuation of local residences (56.2%), and regulation of the local environment (55.7%). The OV, which reflects the interest in conserving the natural asset as a legacy to knowledge and/or future use by society, was captured by the responses attributed to the fact that the ZPB contributes to knowledge (72.8%) and is important for environmental education (77.0%). Finally, the EV reflects the utility or benefit generated by the simple fact of being informed about the functions produced by natural assets, and was captured in the answers about the fact that rare and endangered species contribute to the awareness of the population to preserve (75.2%) and that the preservation of biodiversity is fundamental for the well-being of the global population (82.1%).

Representative indicator of the environmental dimension

The results of the factor analysis to be used in the construction of the environmental indicator are shown in Table 1. The correlation matrix presented determinants different from zero, thus admitting inverse and providing a single solution that best represents the phenomenon [32]. According to the KMO test of 0.82 (higher than the acceptable limit of 0.50) and Bartlett's sphericity test significant at 1%, the sample is suitable for factor analysis [45]. The estimated factor loads showed significance at 1%, confirming the adequacy of the factor model. All communalities are greater than 0.50, validating the participation of variables in the definition of factors [45].

The factor model specified to reflect the behavior of ZPB's environmental dimension was configured by three factors and explained 69.4% of the total data variance

(Table 1). Factor 1 explained 30.1% of the variance and represents the combined strength of four variables that, in the interviewees' perception, reflect the recognition of biodiversity and the contribution of the species to the preservation of natural assets, attraction for tourists and the importance in environmental education. This factor represents the preservation of biodiversity. This dimension is the most important, given that it is the reason for maintaining the flow of ecosystem services and their contribution to the economic activity and well-being of the population.

Factor 2 explained 22% of the data variance and represents the effect of the variables: environmental regulation, knowledge about the Amazon, and offering comfort and mental relaxation to visitors. This factor represents socio-environmental regulation and is aligned with the effectiveness of generating usefulness for people through leisure, contemplation of natural beauty, and a differentiated climate for visitors, which contributes to the improvement of well-being.

Factor 3 explained 17.3% of the total variance of the data and is related to the variables that produce positive externalities by contributing to the valorization the homes located around the ZPB, and to the reduction of air pollution. This factor can be called positive social-environmental externality. The increase in the value of homes has a direct effect on increasing people's well-being, as it contributes to increasing the value of built capital and, at the same time, improves people's health and quality of life (e.g. by reducing temperature, air pollution).

Table .1: Factorial load matrix of representative model of the environmental dimension of the ZPB

Variables	**Common Factors**			**Commonality**
	F1	**F2**	**F3**	
Biodiversity Preservation (flora and fauna)	**0.809**	0.227	0.075	0.711
Rare Species Raise Awareness about the Preservation	**0.882**	0.071	0.110	0.796
Wild Animals help to Attract visitors	**0.756**	0.154	0.088	0.603
O ZPB is important to environmental education	**0.750**	0.255	0.169	0.656
The ZPB contributes to regulating the local environment	0.147	**0.818**	0.070	0.696
The ZPB contributes to know about the Amazon	0.247	**0.789**	0.131	0.701
The ZPB provides mental comfort and relaxation	0.155	**0.692**	0.255	0.569
The ZPB values the homes around it	0.117	0.139	**0.860**	0.772
The ZPB contributes to reducing air pollution	0.145	0.199	**0.822**	0.736
Sum of square of the loads	2.708	1.976	1.556	6.240
Percentage of trace (%)	30.10	22.00	17.30	69.40
Factor Weights - θ	**0.434**	**0.317**	**0.249**	**1.000**
Sample Adequacy: KMO = 0.820; BARTLETT'S TEST = 1,727.796 (p < 0,01)				

The environmental dimension indicator was constructed from these results, explained by the set of nine variables that describe the effects produced by ecosystem services on well-being, and that were perceived by the interviewees.

$$EDI = 0.434EF_1 + 0.317EF_2 + 0.249EF_3 \rightarrow (10)$$

Where EDI is the environmental dimension indicator, EF1, EF2 and EF3 are the factor scores, normalized to vary between zero and one, following Santana et al. [32]. This is the variable that will explain the behavior of the environmental dimension in the WTP and WTR models.

This indicator was classified by 58.0% of the interviewees as having medium to high impact on the well-being and quality of life of the people, with 25.0% considered it with high importance. Another 40.0% classified the indicator as intermediate, and only 2.0% observed that the environmental effects are of low importance.

Value of the ecosystem services provided by the ZPB

The gender and age variables were excluded in the WTP and WTR equations of the model because they do not present statistical significance. The value of R2-Adjusted for degrees of freedom indicated that the

explanatory variables used in the model explained 76.71% and 76.37%, respectively, of the variations in the value of the willingness to pay for a visit - WTP and in the value of the willingness to receive for replacing a visit - WTA (Table 2). This result, together with the statistical significance of the parameters, indicates that the set of explanatory variables validated the specification of the system of equations.

Table .2: Results of the parameters estimative of WTP and WTR for visits to the ZPB

Variable	**Coefficient**	**Statistic t**	**Probability**	**WTP (R$/v)**
Intercept - a_{10}	-5.839297	-4.996956	0.0000	-5,8393
Income - a_{11}	0.000289	10.81291	0.0000	1,1043
Education - a_{12}	0.695015	5.899461	0.0000	3,7891
Environmental Dimension – a_{13}	19.80190	11.02310	0.0000	13,3346
Dummy Variable - a_{14}	6.479356	13.73160	0.0000	6,4794
	Total Economic Value of ZPB's WTP =		**R$ 18,8680/v; US$ 6.00/v**	
	TEV of ZPB Ecosystem Services =		**R$ 4.151.211,01; US$ 1,319,310.67**	
Variable	**Coefficient**	**Statistic t**	**Probability**	**WTA (R$/v)**
Intercept - b_{20}	-7.820977	-6.024715	0.0000	-7.8210
Income - b_{21}	0.000272	6.066495	0.0000	1.0393
Education - b_{22}	0.966744	7.186549	0.0000	5.2705
Environmental Dimension - b_{23}	24.66451	12.24482	0.0000	16.6091
D*ummy* Variable – b_{24}	6.117396	12.23450	0.0000	6.1174
	Total Economic Value of ZPB's WTA =		**R$ 21,2153/v; US$ 6.74/v**	
	TEV of ZPB Ecosystem Services =		**R$ 4.667.646,61; US$ 1,483,440.84**	
R-Square Adjusted: WTP	0.767086	Average of the dependent variable		14.32745
R-Square Adjusted: WTA	0.763735	Average of the dependent variable		16.92931
Statistic F: WTP	451.38 (p < 0.01)	Statistic F: WTA		443.05 (p < 0.01)

The results indicate that the increase of US$ 1,000.00 on the interviewees' income tends to generate an increase of US$ 0.29 in WTP for each visit and preserve the park's ecosystem. Likewise, it tends to generate an increase in the average value of the WTA of US$ 0.27 for each replaced visit. Similar results for WTP were found by: Adams et al. [13], in the work on the preservation of the Brazilian Atlantic Forest; Groot et al. [3], in estimating the global value of ecosystems; Santana et al. [5], in the work on the total economic value of the potential damage to fishermen and family farmers from the hydroelectric dams planned for the Tapajós River basin, state of Pará; Rosa et al. [21], in the valuation study to preserve the mangrove in the Bragantine Region of Pará; Santana et al. [7,22], in the study of valuation of the metallophytic savanna vegetation of the Flora of Carajás for compensation by mining companies; Oliveira et al. [11] estimated the value of ecosystem services produced by the agroforestry systems of the county of Tomé-Açu, state of Pará.

It was seen that a higher level of education leads to a higher WTP price for the benefit of a visit, as well as a WTA greater compensation for visiting another location instead of the ZPB and maintaining the same level of satisfaction. This is due to the fact that education adds greater knowledge about the natural asset and in recognizing the gains in well-being and quality of life provided by them. For each additional year of study that the person attended, WTP tends to be increased by R$ 0.70 per visit, while the value of WTR can be increased by R$ 0.97 for each replaced visit (Table 2). This result corroborates those obtained by Lima and Bastos [43] who obtained a positive correlation between education and the perception of benefits generated by ecosystem services.

Some studies on WTP have obtained significant results for education, among them are: Bentes et al. [19], in the work on the economic and environmental value of the damage caused by the Tucuruí Hydroelectric Power Plant to fishermen downstream from the Tocantins River in the state of Pará; Lera-López et al. [47], in the WTP study for reducing the environmental impacts produced by road transport; Adams et al. [13], in the research on the value of WTP for the preservation of the Atlantic Forest; Rosa et al. [21] and Santana et al. [7], respectively for the preservation of the mangrove and metallophytic savannah of the Flora de Carajás; Oliveira et al. [11], for the conservation of agroforestry systems in the municipality of Tomé-Açu, state of Pará. Regarding studies on WTR, Santana et al. [7,22] and Oliveira et al. [11] obtained positive and significant results for education. On the other hand, in the studies by Baral and Bhattarai [14], Subade and Francisco [48] and Veronesi et al. [49], the variable showed a positive sign but was not statistically significant.

The result of the dummy variable, which captures the effect of the interviewees' distribution of purchasing power, indicates that people who are willing to pay at least five times more than the rate currently charged have a higher purchasing power and level of education. This group of people willing to pay US$ 2.06 above the average and receive US$ 1.95 above the average has greater potential to make changes in the environment and influence the preservation or replacement of the ecosystem [22].

The environmental dimension was defined based on the effects of nine variables, associated with the three factors that represent the monetary value of the multifunctionality of ZPB ecosystem services in the perception of the interviewees. Table 2 shows that the increase of one unit in the average value of the environmental dimension tends to generate an increase of US$ 6.29 per visit in the value of WTP to continue enjoying the benefits of visits, and US$ 7.84 per visit in the amount of WTA for the replacement of visits to the ZPB. This result supports the fact that more information, clarification and awareness about the benefits to the population that the ecosystem services of urban environmental parks generate, favors the tourism and the hospitality network, making cities more livable, healthy and resilient to adversity; which stimulates public investment in green infrastructure in the urban environment [30].

According to the results in Table 2, the estimated average WTP value for continuing to visit the ZPB was U$$ 6.00/v (with a maximum value of US$ 7.88/v) and a WTA value for visiting other ZPB substitute locations of US$ 6.74/v (with a maximum value of US$ 8.00/v). These values, considering the visitor population of 220 thousand people per year, have a maximum WTP value of US$ 1,319,310.67 and a value of the WTA of US$ 1,483,440,84. Adding the standard deviation to this value, the maximum value of US$ 1,759,697.60 is obtained.

Participation of the social, economic and environmental dimensions

The participation of the social, economic and environmental dimensions in the total economic value of the ecosystem services produced by the natural assets of the ZPB is shown in Figure 2. The social dimension is defined by the variable level of education, given that it was the only one that presented statistical significance. The economic dimension includes the income variable and the dummy variable that captures the distribution of purchasing power among interviewees. These are the variables that allow to exercise the purchasing power of goods and services, enabling the choice to qualify and diversify the shopping basket that results in maximum utility or benefit.

The environmental dimension represents the influence of ecosystem services on the well-being provided to visitors. The environmental dimension presented the greatest participation, due to the high perception of the population about the socioeconomic and environmental benefits provided by the natural biodiversity of the ZPB of Belém.

The sum of the social and economic components is lower than the value of the environmental component, demonstrating that the natural asset represents the greatest economic value of the park, in the perception of society. This fact justifies the inclusion of environmental capital in the value of the urban property and justifies the investment in the infrastructure of green areas in the city.

These dimensions have an income elasticity of 0.0771, education elasticity of 0.2645 and environmental elasticity of 0.9307 to the WTP. These results indicate that for changes of 10% in income, in years of education and in the environmental dimension, the value of WTP tends to change in the same direction by 0.77%, 2.64% and 9.3%, respectively. Oliveira et al. [11] obtained similar results for the participation of the environmental dimension in relation to the WTP to preserve agroforestry systems in the Amazon. These results justify public and/or private investment in urban environmental spaces for public visitation, considering the importance of natural ecosystems for the improvement of the population's social well-being.

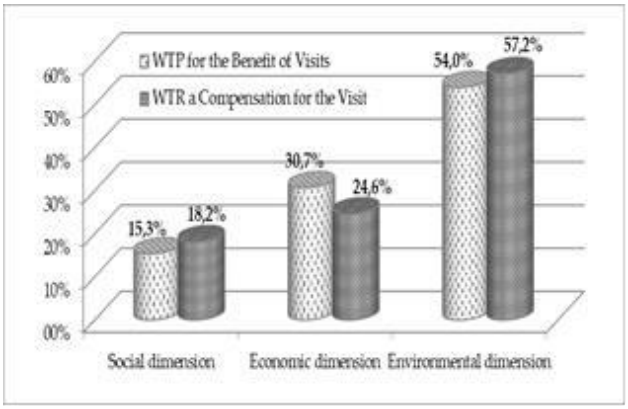

Fig.2 – Participation of the social, economic and environmental dimensions in the value of the natural assets of the ZPB, Belém, 2017.

IV. CONCLUSIONS

The population in the state of Pará elected the ZPB as the foremost public space for leisure, knowledge and well-being of the population; being recognized as such for more than a century.

The WTP revealed a strong recognition of society for the benefits provided by the ecosystem services produced by the natural assets of the ZPB, which justifies the public and/or private investment in the provision of urban natural spaces for leisure, knowledge, interaction with biodiversity and contemplation of the Amazon biome.

The value of the timber forest product was US$ 145,216.75, about 11.01% of WTP for the preservation of the ecosystem services of the natural asset of the ZPB. The WTA to give up visits to the park and obtain the same level of satisfaction was US$ 1,483,440.84, which added to the value of the carbon stock resulted in US$ 1,628,657.59. This value represents the opportunity cost of the area for the civil construction market.

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this work

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