Economics Evaluation of Ecological Services of Some Aquatic Ecosystems in Badagry Division, Lagos, Nigeria

ABSTRACT

Aquatic ecosystem has vast resources and ecological functions, however the economic worth of its services are often ignored. This study appraised the value of ecological services offered by some aquatic ecosystem (Gbaji, Agboju, Topo and Ajegunle) in Badagry Division, Lagos, Nigeria in relation to the current physical and chemical status of these habitats. Data were collected via random administration of structured questionnaires to 168 households across the stations. Methods employed for collection of information include stated preference, divulged preference and market value approaches. Data collected were tested by one-way Analysis of Variance while differences in mean were separated using Least Significant Difference (p=0.05). Results showed that the highest mean annual income from irrigation for farming (N55,730 ±9,156.6), wage/salary for Boat builder/Net maker (N182, 265.4 ±11,655), water for domestic purpose (N64,256 ±16,426.5), water for washing body or clothes (N54,119.2 ±9,642.4), and industrial/domestic waste (500,658 ±25,600) were obtained from Ajegunle station. On the other hand, highest mean annual income gotten from ecological services at Gbaji station includes fishing (N351,440 ±15,680), fish for sale (N312, 618 ±26,465.5), Wood and wood product (N59,387±10,792), medicinal plants (N18,116 ±7,680), firewood for sale (N56, 456.9 ±14,316.5), firewood for cooking (N24,145 ±6,425), livestock watering (N235,385 ±35,617) and religion rites (N70,528 ±16,178). Agboju station had highest income in sand for sales (N135,126 ±34,124), transportation (728,358 ±48,526), sand for construction (67,426.8 ±5,392.9), and research purpose (30,200 ±3,390). Topo station had peak (N45, 828.2± 12,654.6) estimated

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values on fish for household feeding. In comparison of estimated income with hectares of the water bodies, the productivity was in the order of Agboju > Topo > Gbaji> Ajegunle. Overall results confirmed that the water bodies contributed significantly to the household economy of the local people and hence, it is important to protect and improve its management for livelihood enhancement, while also securing their long-term ecological functions.

Keywords: Ecological services, aqua-economics, monetary value, management.

1.0 Introduction

It is often imagined by many people that environmental goods and services have no economic value since they cannot be either sold or bought in the market. However, several literatures have dwelt on this issue, confirming that it is possible to establish the economic value of environment. Valuation is not considered as an end in itself, but rather a methodological and conceptual framework for organizing information to guide decision-making (Garrick *et al.*, 2017).

Ecosystem services entail various benefits that humans obtain from the natural environment and from properly-functioning ecosystems- for free (TEEB, 2011). Findings of UNDP (2017) showed that economic valuation of ecosystem services can effectively inform in-country decision-making in ways that support the transformation of how development is planned and acted upon towards sustainable solutions, depending on certain features of the valuation exercise. These features include an economic analysis that is based on solid science and focused on a clear policy question, careful identification and engagement with decision- makers, broad participation by local stakeholders, and effective communication and collaboration (UNDP, 2017).

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IPBES (2019) divulged that all ecosystem services are water-dependent, irrespective of their role in hydrology, hence without water, ecosystems cease to function. Studies have shown that expressing the values of ecosystem services in monetary terms enables values to be more easily compared with other economic assessments that often use monetary-based units (Costanza *et al.*, 1997). Though some rejected monetary valuation because it undervalues nature, commodifies it or suggests it can be traded (Conniff, 2012; Bresnihan, 2017).

Various methods used to calculate ecosystem service values are similar across ecosystem types. For instance, Russi *et al*. (2013) and Barredo *et al*. (2019) used contingent valuation, choice modelling, restoration costs, value transfer, related goods approaches, production functions, indirect opportunity costs, replacement costs and hedonic pricing, At some quarters, the most commonly used approach is based on the concept of Total Economic Value (TEV). In this approach, impact on environmental resources was broken down into different categories of values with a notion that the resource or service comprises of various attributes, some of which are tangible and readily measured, while others are considered less tangible and difficult to quantify. These values include direct use value (DUV), the non-use value (NUV) and the indirect use value (IUV). The TEV of the good or service is given by the summation of the three categories of values. The DUV are derived from goods, which can be extracted, consumed or directly enjoyed; the IUV are non-extractive use values and they are derived from services that environmental resource provides, while the NUV are benefits or welfare gains/losses that arise from environmental changes independently of any direct or indirect use of the environment (Grazhdani, 2013). In the foregoing, McCracken and Abaza (2000) had explained that direct use values are estimated by methods that elicit preferences by either conducting experiments or by using questionnaire-based surveys, usually using local market prices. Indirect use values and non-use values are valuations that estimate non-marketable good value. Also, indirect use values are estimated by eliciting preferences and observed market-based information.

In their studies, Costanza *et al*. (1997) estimated the economic value of the world's ecosystem services and natural capital by estimating values of ecosystem services per unit area by biome and then multiplying by the total area of each biome; these were then summed over all services and biomes. Costanza *et al*. (1997) revealed that ecosystem services provide an important portion of the total contribution to human welfare on this planet (between $16 trillion and $33 trillion per year), but the technique used has been criticized as being overambitious and as a drastic overstatement (Richard *et al*., 2001). The uses of water are immensely enormous e.g water is also used for power generation, irrigated crops, mining, power generation, livestock watering, washing, flushing, food preparation, gardens and lawns, and firefighting. In other cases, water either directly or indirectly support specific activities, for example, by irrigating golf courses, providing scenic backdrop, filling reservoirs and lakes in the park, swimming pools, fish hatcheries, and supporting boating, angling or other water related recreational activities (TEEB, 2011). According to REMA (2009) the functions of a typical River include biodiversity maintenance and mitigation of climate change, water reservoir, water source, flood control, swamp dam. Its use values include agricultural production, fisheries, water supply to town and cities, timber and non-timber products, tourism and scientific and hydrological interests; while its non-use values include the conservation of biodiversity, flood control and conservation of protected species.

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Mekuleyi *et al.* (2019) had reported on the environmental health status of Gbaji, Agboju, Topo and Ajegunle water bodies in Nigeria, however, the assessment of worth of ecological services offered by these ecosystems has not been documented.

2.1 Materials and Methods

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2.1.1 Sampling stations

Four aquatic sampling stations (Agboju, Ajegunle, Gbaji and Topo) in Badagry Division of Lagos State, Nigeria were examined for this study as shown in Figure 1. Agboju station (Lat. 6^0 40' N, Long.3^0 20'E) is a tributary of Lagos Lagoon, Ajegunle station (Lat. 6^0 40' N, Long.3^0 22' E) is a tributary of Ajegunle creek, Gbaji (Lat. 6^0 20'N, Long.3^0 0'E) and Topo (Lat. 6^0 20' N, Long. 3^0 02'E) are tributary of Badagry creek. While Gbaji and Topo are located in Badagry Local Government Area (LGA), Agboju is located in Amuwo Odofin LGA while Ajegunle is located in Ajeromi Ifelodun LGA (Mekuleyi *et al.*, 2019). These selected aquatic stations are part of renown fishing communities in Lagos State.

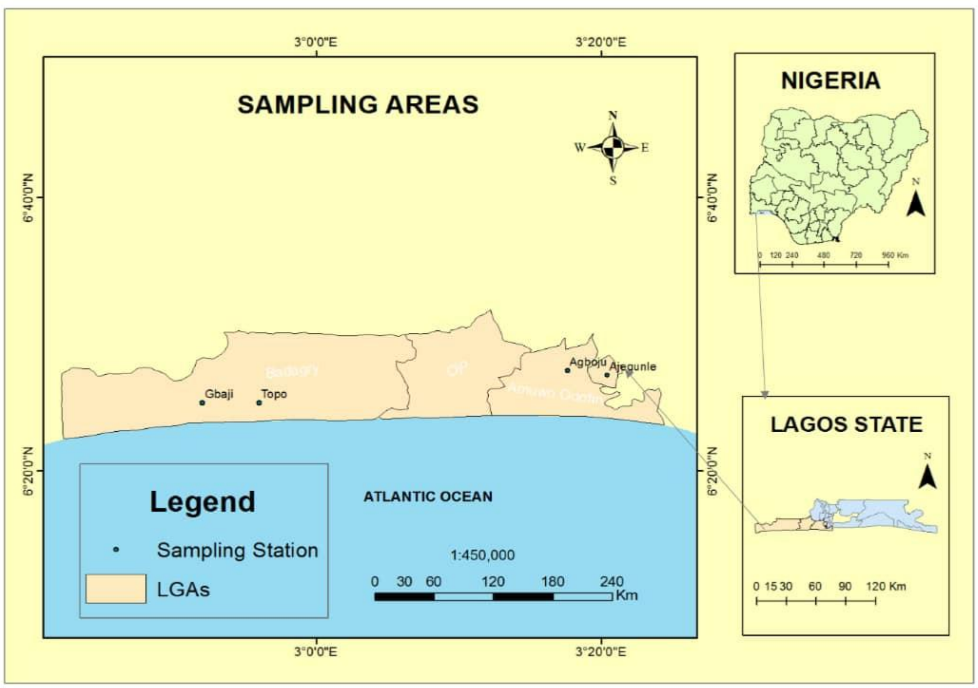

Figure 1: Showing the Sampling Stations within Badagry Division, Lagos, Nigeria

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2.1.2 Sample Population

The population used for this study comprises of boat builders, fishermen, net makers/repairer, transporters, fish mongers, fish processors, herbalist, community leader, and focus group (youth and women) that were users of the selected aquatic ecosystems. A sum of 168 respondents were randomly selected across the stations and interviewed during this study. Specifically, the population composed of 6 fishermen, 4 boat builders, 4 net makers/repairer, 4 transporters, 4 fish mongers, 4 fish processors, 4 herbalists, 4 community leader, 4 youth and 4 women from each station.

Comment [a6]: Specifically, the population composed of 42 respondents from each station including 6 fishermen, 4 boat builders, 4 net makers/repairer, 4 transporters, 4 fish mongers, 4 fish processors, 4 herbalists, 4 community leader, 4 youth and 4 women from each station.

2.1.3 Data Collection

Structured questionnaires with both closed and open-ended questions were designed and employed to generate quantitative and qualitative data. Pre-testing of the questionnaire was conducted to investigate its relevance and validity and to familiarize the people with the concept. Sequel to the pre-testing feedback, the final questionnaire was adjusted and administered accordingly.

2.1.4 Economic Methods Used for Valuation

Method used to value the environmental asset includes revealed preference approaches (which rely on observation of related behavior), stated preference approaches (which rely on direct questioning) and market value approaches (which rely on quantification of production).

Comment [a7]: Methods

Revealed preferences is a method that somehow link the change in an environmental or natural resource, to a market price that can be observed in reality, while the stated preference techniques also known as willingness to pay determine preferences directly from consumers, by using various types of questionnaires.

2.1.5 Total Areas Covered by the Examined Aquatic Ecosystems

The total areas of the sampled aquatic ecosystems were determined by local ecological knowledge (LEK) of the people living within the sampled stations. Also, scientific conversions of the coordinates of each station were used to validate the LEK assertion. Values from both the LEK and scientific conversions were approximately equal.

The total area of Topo (Topo to border of Akarakumo), Agboju (Agboju to Isunba/Amuwo border) Gbaji (Gbaji to start of Agaw Awusa/Ganyingbo) and Ajegunle (Behind Ndokwa Nosamu via Boundary roundabout to start point of Tincan) aquatic stations are 626.94 hectares, 435.23 hectares, 616.58 hectares and 906.74 hectares respectively.

2.2 Data Analysis

Data drawn from the survey were computed with the Statistical Package for Social Scientists (SPSS) version 20.0 software. The data were analyzed using descriptive statistics (mean, frequency and percentage) while Analysis of variance was used to test the significant differences among the value of ecological services documented across the aquatic ecosystems at significant level set at P= 0.05.

3.0 Results

The distribution of ecological services indicated by respondents at each station was presented in figure 2. Number of respondents that reported ecological services were more in Gbaji than other stations.

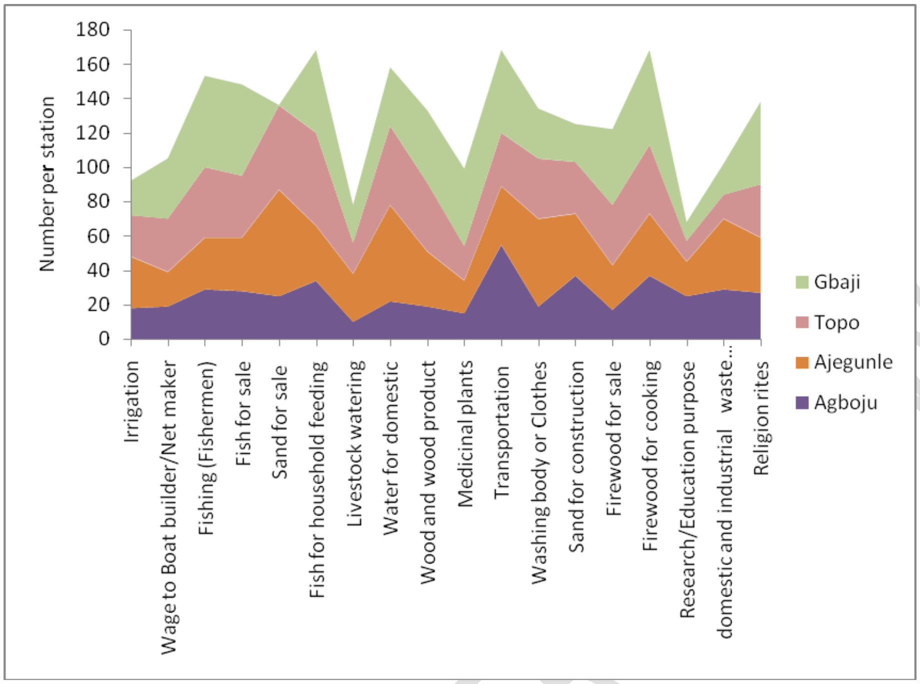

Figure 2: Showing the distribution of the ecological services per sampling stations

Table 1 presented the synopsis of kinds of ecological services offered by the selected aquatic ecosystems (Agboju, Ajegunle, Gbaji and Topo) and its contribution to the income and livelihood of users across the aquatic ecosystems. As extracted from the response of respondents, the services provided by each aquatic station include irrigation, wages, fishing, sand mining, livestock watering, domestic purposes (drinking and cooking), wood/wood product, transportation, research purpose, and religion rites. With regards to the frequency of responses on source of income which the examined aquatic ecosystems provided, transportation (7.32%), fish for feeding house hold (7.32%) and fire wood for cooking(7.32%) were most frequent, followed by Water for cooking/utensil cleaning (6.88%) and fishing (6.67%) while the least was research/educational purpose (2.96%) across the stations.

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Table 1: Estimation of Provisional Services offered by the Selected Aquatic Ecosystems

Category of Economic Valuation	**Source of Income**	**Frequency of Responses per Source of Income**	**Percentage (%)**
Market value	Irrigation for Farming	92	4.00
Stated preference	Wage to Boat builder/Net maker	105	4.60
Stated preference	Fishing (Fishermen)	153	6.67
Stated preference	Fish for sale (Fishermen/fish monger)	148	6.45
Stated preference	Sand for sale	136	5.93
Stated preference	Fish for household feeding	168	7.32
Market value	Livestock watering	78	3.40
Market value	Water for domestic purpose(cooking/utensil)	158	6.88
Market value	Wood and wood product	133	5.80
Stated preference	Medicinal plants	99	4.31
Market value	Transportation	168	7.32
revealed preference	Washing body or Clothes	134	5.83
Market value	Sand for construction	125	5.44
Market value	Firewood for sale	122	5.31
Market value	Firewood for cooking	168	7.32
Stated preference	Research/Education purpose	68	2.96
Stated preference	domestic and industrial waste discharge	102	4.45
Market value	Religion rites	138	6.01

The average annual income which the studied aquatic ecosystems offered to all the examined users were significantly (p=0.05) different across the sampling stations (Table 2).The highest mean annual income from irrigation for farming (N55730 ±9156.6), wage/salary for Boat builder/Net maker (N182 265.4 ±11655), water for domestic purpose (N64 256 ±16426.5), water for washing body or clothes (N54119.2 ±9642.4), and industrial/domestic waste (500658 ±25600) were obtained from Ajegunle station. On the other hand, highest mean annual income gotten from ecological services at Gbaji station includes fishing (N351 440 ±15680), fish for sale (N312 618 ± 26465.5), Wood and wood product (N59387 ±10 792), medicinal plants (N18116 ±7680), firewood for sale (N56 456.9 ±14316.5), firewood for cooking (N24145 ±6425), livestock watering (N235385 ±35617) and religion rites (N70 528 ±16178). However, Agboju station had highest income in sand for sales (N135126 ± 34124), transportation (728 358 ±48526), sand for construction (67426.8 ±5392.9), and research purpose (30200 ±3390). The peak estimated values on amount allotted to fish for household feeding was recorded from Topo station with a value of N45 828.2± 12654.6.

Table 2: Contribution of aquatic ecosystems (Gbaji, Agboju, Ajegunle and Topo) to Income of Inhabitants

Source of Income	**GBAJI(N)**	**AGBOJU(N)**	**AJEGUNLE(N)**	**TOPO(N)**
Farming/irrigation	51614 ± 8275[a]	39985 ±12134[aa]	55730 ±9156.6[ab]	45807.8 ± 5675.8[b]
Wage/salary(Boat builder/Net maker)	144 165.6 ± 9350[a]	152 115.8 ±12410[aa]	182 265.4 ±11655[ab]	155 365.6 ±10350[b]
Fishing (Fishermen)	351 440 ±15680[a]	309 726 ±14548[b]	298 865 ±12 755[bb]	338 860 ±25680[aa]
Fish for sale (Fishermen/fish monger)	312 618 ±26465.5[a]	296 418.9 ±14459.5[ab]	291 532.6 ±14459.5[b]	283 844.8 ±19675.5[bb]

Source of Income	**GBAJI(N)**	**AGBOJU(N)**	**AJEGUNLE(N)**	**TOPO(N)**
Sand for sale	-	135126 ± 34124^{a}	95863 ±23226.9^{ab}	120730.8 ±28956.6^{aa}
Fish for household feeding	32 424.4 ±12350.7^{a}	23 522.7 ±10584.8^{ab}	26 932 ± 6356^{aa}	45 828.2 ± 12654.6^{b}
Livestock watering	235385 ±35617^{a}	39 640 ±5290^{ab}	48825 ±2865^{b}	219650 ±42315^{bb}
Water for domestic purpose(cooking/bathing)	50792.7 ±15462.5^{a}	49126 ±9312.4^{aa}	64 256 ±16426.5^{ab}	53 572.8 ±12312.7^{b}
Wood and wood product	59387 ±10 792^{a}	49826 ±8 548^{aa}	51333.7 ±12 345^{ab}	55868.6 ±10 320^{b}
Medicinal plants	18116 ±7680^{a}	12119 ±6780^{aa}	10225 ±4164^{ab}	16360 ±5680^{b}
Transportation	150 200 ±39800^{a}	728 358 ±48526^{aa}	519 126 ±75824^{b}	328 790.9 ±56323^{ab}
Washing body or Clothes	48299.4 ±4989.8^{a}	46498.7 ±4569.9^{ab}	54119.2 ±9642.4^{b}	48298.7 ±4589.9^{a}
Sand for construction	18560 ± 7457^{a}	67426.8 ±5392.9^{ab}	62500 ±8460.9^{b}	56726.8 ±4589.9^{bb}
Firewood for sale	56 456.9 ±14316.5^{a}	43 846.8 ±9894.7^{ab}	36 458.6 ±8231.4^{b}	48 913.2 ±10231.7^{bb}
Firewood for cooking	24145 ±6425^{a}	12189 ±2165^{b}	14226 ±7668^{ab}	18965 ±5165^{aa}
Research/Education purpose	29148 ±5376^{a}	30200 ±3390^{aa}	27400 ±5800^{ab}	25130 ±6350^{b}
Industrial and domestic waste discharge	335 620 ±12465^{ab}	456 897 ±7400^{a}	500658 ±25600^{b}	456 895 ±62346^{a}

Source of Income	GBAJI(N)	AGBOJU(N)	AJEGUNLE(N)	TOPO(N)
Religion rites	70 528 ±16178^{a}	42 128 ±23152^{ab}	40 218 ±3152^{b}	60 128 ±23152^{bb}
Total Average Annual Income	**1,988,900 ±13 825**	**2,535,149.7 ±12 452.3**	**2,380,533.50 ±14 321.57**	**2,074,734.34 ±18 987.66**

3.1 Discussion

In this study, the greatest income was derived from transportation, followed by fishing and then livestock watering. This implied that any imbalance or catastrophe on the selected aquatic ecosystems would have direct effects on mobility of the people as well as sustainability of the biota. In buttressing the immense contribution of aquatic ecosystems to life, Shewit *et al*. (2017) reported that the backbone of development in Ethiopia is agriculture which is powered by irrigation whose source was from aquatic habitat. Similarly, Tenalem and Degnachew (2007), divulged that irrigation and fishery are the most common source of income for people living near the borders of lake. All the identified ecological services divulged by the respondents used for this study were similar to what was reported for lake Tana's ecosystem services (Abebe, and Geheb, 2003; Wondie, 2010).

Comment [a9]: habitats

The estimated average annual total household income generated from ecological services across the sampling stations in this study was N8, 979, 317.54 while the estimated economic worth of the water in relation to its total areas was in the order of Agboju > Topo > Gbaji > Ajegunle. The observation in which Ajegunle station provided the least annual income in term of the proceeds from ecological services could be attributed to the degree of pollution in this area as reported earlier by Mekuleyi *et al.* (2019). Though an appreciable average annual income of N8, 979, 317.54 was documented for this study, however this amount is still very low when compared

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with reported global for ecosystem services and biodiversity. A global value for ecosystem goods, services, biodiversity, and cultural considerations of US$ 6,579x109 year^{-1} has been estimated for all inland waters and wetlands in comparison to US$ 5,740x109 year^{-1} for all other non- marine ecosystems combined (Junk *et al*., 2013).

In recent time, aquatic habitats are becoming increasingly recognized as among the most productive natural resources, because of their ability to fulfill a range of functions and produce a number of products that are socially and economically beneficial to the local community. IPBES (2019) revealed that the valuation of water is essential as it connects with the 2030 Agenda for Sustainable Development and its five pillars (people, prosperity, planet, peace and justice, and partnership), and with Integrated Water Resources Management, among others. In consideration of just 18 ecological services being identified in this present study, it could be presumed that the people living within the jurisdiction of the examined aquatic ecosystem have not fully utilized all available ecological services which a typical aquatic ecosystems. Therefore, the possibility of misusing the water due to ignorant may not be far fetch. Edward *et al*. (1997) have suggested that the main reason why people destroy wetlands that are an essential element of their ecosystems is due to failure to account adequately for their non-market environmental values in development decisions.

3.2 Conclusion

The four aquatic ecosystems have been identified to provide remarkable ecological services and contributed significantly to the household economy of the people. Hence, long-term ecological functions of these aquatic habitats must be sustained by all users. Also, this study provides baseline information to all users of these aquatic habitat such as local community, industry, researchers, and environmentalist including policymaker on the need to jealously converse the

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biodiversity of the aquatic, and as well provide clue for how to compensates the fishing communities in case of any damage to their livelihood.

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