CONSUMPTION PATTERNS AND UTILISATION OF PROVISIONING AND CULTURAL ECOSYSTEM SERVICES IN LAMBARÉNÉ, GABON

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ABSTRACT

Ecosystem Services are crucial for human well-being and food security, with consequences for socioeconomic wellbeing. To ensure long-term usage and preservation of Ecosystem Services, they must be valued. The current study examines the dependence on provisioning and cultural Ecosystem Services in Lambaréné, Gabon, using a quantitative method approach, data were collected from 405 households, employing both descriptive and inferential statistic through questionnaires. Results show high reliance on provisioning services, with significant dependencies on fish and firewood for sustenance and energy, and strong cultural values attached to religious sites. This highlights the critical role of Ecosystem Services in local livelihoods and underscores the need for integrated management approaches. The study suggested that the next studies may relate to the economic value of provisioning and Cultural Ecosystem Service, examining land use and land cover change, and so far, assessing the link between local traditional ecological understanding and Ecosystem Services.

Keywords: Ecosystem Services, Descriptive Statistical Analysis, Inferential Statistical Analysis, Lambaréné

INTRODUCTION

Humans are dependent on Ecosystem Services, which are defined broadly as the goods and services gained from Ecosystems (Boafo *et al*., 2014). It is also acknowledged that ecosystems play an important role in climate change adaptation. This is because some of the services they offer may alleviate the consequences of catastrophic events and disturbances such as forest fires, floods, and droughts. Moreover, this role is especially important in climate-vulnerable nations, particularly in Africa, where the ability to adapt is hampered by a variety of physical and socioeconomic limits (Leal Filho *et al*., 2021).

According to the Millennium Ecosystem Assessment report, Ecosystem Services can be divided into four categories: provisioning (food, fuel, fiber, and freshwater); cultural (sense

of place, religious values, recreation, and ecotourism); regulating (pollination, water regulation, and climate regulation); and supporting (soil formation and nutrient cycling) (Baskent, 2020; Kumar, 2012). These characteristics indicate the tangibility, intangibility, interdependence, interconnectivity, and significance of this spectrum of services to human well-being. In reality, the term "Ecosystem Services" refers to the economic, ecological, and socio-cultural functions of nature. Ecosystem Services are particularly important for social, ecological, and economic growth, as well as human advancement and survival.

The number of scientific publications on Ecosystem Services (ES) has increased exponentially in recent years (Blicharska *et al*., 2017; Martínez-Harms & Balvanera, 2012). This has resulted in advances in the understanding of ES, particularly in terms of valuation (Blicharska *et al*., 2017; Cerli *et al*., 2012; Haines-Young & Potschin, 2018; Häyhä & Franzese, 2014; Schmidt *et al*., 2017) and biophysical studies (Crossman *et al.*, 2013; Schägner *et al*., 2013; Vihervaara *et al*., 2018). The growth of production, consumption, and demand for ecological services, frequently influenced by external causes such as climate change, has resulted in a loss of resilience and a reduction in the services offered by diverse ecosystems. While human consumption of ecological services grows, their availability declines, with around one quarter of these services degraded or exploited in non-durable ways (Brockhaus & Botoni, 2009). In addition, as population expansion and per capita consumption have increased, the consumption pattern has become more apparent: natural resources, which are meant to be eternally and freely accessible, are becoming limited or deteriorating. Health issues, natural catastrophes, and the expense of technologically replacing natural regulating activities have highlighted the need for a larger vision and resource use plan (Jacobs *et a*l., 2013).

In Gabon, research into conservation and biodiversity is well documented. it is partially based on a global approach to ecosystem management and focuses on the issues of preserving areas from logging and, increasingly, on the question of payment for environmental services. However, the issue of Ecosystem Services is potentially all the more important as it has other implications for Gabon (de Sartre *et al*., 2014). The final report by Biotop (2021) on the identification of the sectors having the greatest influence on biodiversity in Gabon provides a positive image of Gabon's natural ecosystems. They provide several benefits to communities, ranging from wetlands and coastlines that aid in flood management, to forests that trap dust and organically filter the air. These natural ecosystems provide several concrete and intangible advantages, including direct access to food and firewood. In addition, they assist in controlling natural systems, contribute to culture and legacy, and have a significant impact on economic systems. Furthermore, natural ES are beneficial and necessary for human well-being and, in many circumstances, cannot be replaced by man-made things.

Given their importance, evaluating the value and contribution of Ecosystem Services to rural people is important for decreasing poverty and ensuring secure livelihoods, especially in developing nations (Lhoest *et al.*, 2020). To gain a better understanding of interactions and their shifting dynamics, a focus should be placed on local evaluations of the entire spectrum of Ecosystem Services. The findings of such an evaluation may help identify the social, economic, and ecological worth of Ecosystem Services to families and communities, which should also promote effective community action required for sustainable ecosystem management (Boafo *et al*., 2014; Costanza *et al*., 1997; Wangai *et al*., 2016).

This study aims to assess the local people's dependency on both provisioning and cultural Ecosystem Services provided in Lambaréné. It seeks to answer the following question: to what extent do local people in Lambaréné depend on provisioning and cultural ES? hypothesising that there is no significant correlation between the consumption patterns of households and Provisioning and Cultural ES utilisation in Lambaréné. This study is an

interim one, using data from households surveyed in the Lambaréné area as a forerunner. Taking the diversity of this catalyst as an example, considering the lack of studies so far in line with our study and the scarcity of work conducted worldwide, we systematically source all existing research into it. The research is a bottom-up appraisal, covering both provisioning and cultural Ecosystem Services.

Consequently, this study has important implications for sustainable management and policy. Insights into the local dependence on and perceptions of Ecosystem Services provide an opportunity for policymakers to design more effective approaches aimed at securing these functions in the long term. To successfully develop conservation strategies that maximise the social, economic, and ecological merits of Ecosystem Services, it is crucial to include local perspectives in decision-making. This investigation points out the critical importance of Ecosystem Services in sustaining human well-being and livelihoods, particularly in climate-vulnerable areas such as Gabon in general and Lambaréné in particular. The findings indicate the need for additional research and activities on these essential utilities to ensure a safe and prosperous future for the local inhabitants.

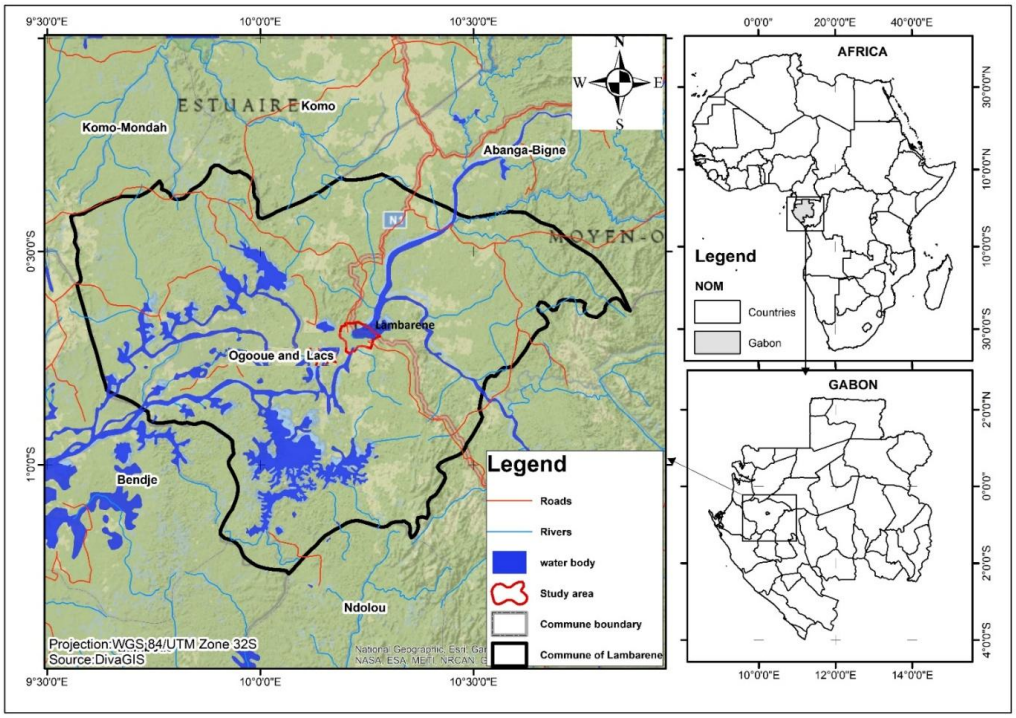
METHODOLOGY

Study area

Lambaréné, the administrative headquarters of Moyen-Ogooué province is located in central-western Gabon, with 38775 residents according to the General results of the Population and Housing Census in 2013 (Rgpl, 2013). Lambaréné is located at latitude -0.7001 and longitude 10.24055 and has a land area of 5,230 hectares, divided into two districts. Established in 1963, Lambaréné was expanded in 1995. The town is divided into 24 neighborhoods. The Ogooué Basin, in which Lambaréné is located, receives significant rainfall, about 1,600-2,200 mm/year (Dongue *et al*., 2022). The country has two wet seasons and two dry seasons (Gil *et al*., 1990) with an average annual temperature is 27°, influenced by the equator.

Lambaréné is a city with lowlands and natural forest vegetation. The Ogooué River, which flows through the province, influences local hydrography. Rainfall and flooding create semi-aquatic regions downstream and marshy parts in the Mbiné and Abanga upstream (Fig, 1). These regions make up a quarter of the Province of Moyen-Ogooué and half of the Department of Ogooué and Lac (United Nations Development Programme, 2016). Lambaréné, a low-lying city in Ogooué et des Lacs, is known for its cultural diversity and economic potential. Its rich fishing resources, diverse fauna, and human resources make it a "Gabon in miniature." Lambaréné and nearby towns are strategically located for logging. along with Ndjolé and Port-Gentil, is the intersection of main watersheds, opening into the Atlantic Ocean, covering an 800 km^2 area (Maloba-Makanga, 2011).

Fig. 1: Map of the study area



In 2010, forestry activity was stopped in Lambaréné, aiming to revitalise the sector and promote the national economy (Moumbongoyo & Kombila-Mouloungui, 2020). The city is experiencing high population growth, with a density of 1206 inhabitants per km^2, suggesting sensitivity to increased demand for ecological services in the area.

METHOD AND MATERIALS

Procedure for determining sample size

The study explored the use of ecological services in the study area. The population is made up of household units. The households on the rivers' right and left banks were chosen using a basic random sampling method. A total of 405 households were selected from a total household population of 38 775 using standard formula modified from and previously applied by Bryman (2012) and Kamga *et al*. (2018), to estimate the size of the smallest category sample since the population target of the study area is more than 10000 people with:

$$n=Z\alpha^2 * P.Q / d^2$$

Where:

n: Design sample size when (N > 10000).

Za: The standard normal deviation is often set at 1.96, which corresponds to a 95 % confidence level.

P: Proportion of the target population projected to have certain traits that are equivalent to 50 %.

Q = 1-P = (1-0.5)
d: Permitted error (5 percent if the confidence level is 95 percent), 0.05

$$n = \frac{(1.96)^2 \text{ x } 0.5 \text{ x } 0.5}{(0.05)^2}$$

n=384.16 ≅ 385

Cited by Kamga *et al*. (2018), Miller & Brewer (2003) provide the formula to maintain the same level of confidence (95 percent), which has also been used to maintain the highest accuracy.

(i) Sample size: $n = \frac{\text{N}}{1+N(\propto)2}$

Where n: Design sample size
N: given population size (Lambaréné).
∝: Level of significance or margin error (5 %)

$$n = \frac{38775}{1+38775(0.05)^2} \qquad n = \frac{38775}{1+38775\ x\ 0.0025} \qquad \text{n=395,92}\cong 396$$

The research interviewed 410 households, yielding 405 completed questionnaires after thorough data pre-processing, despite a moderate change from the anticipated 396 due to practical concerns.

Data collection

This study adopted a survey method for data collection with aim of understanding Ecosystem Services concepts to households, with ethical approvals from provincial and local authorities. The questionnaire was tested in seven households to eliminate potential errors. Data was collected through semi-structured interviews. Kobo collect was used to facilitate data collection, with data collectors trained in questionnaire completion techniques. Interviewers were distributed to minimize bias and facilitate exchanges with the local population.

Data analysis

This article uses a quantitative method approach and the number of representative respondent households was calculated using parametric tests and presented in terms of mean, standard deviation (SD) of the mean, and percentages. The information obtained from respondents for this study was analysed and presented through both descriptive and inferential approaches. The P-value was set at <0.05 for statistically significant results and <0.0001 for highly significant results. The correlation coefficient and P-value tests were used to evaluate the results. Count, percentage, and frequency were considered for the descriptive statistical analysis, while correlation and P-value were used for the inferential statistical analysis method. The data were coded and entered into Microsoft Excel 2016, then imported into R software. Power analysis was performed with R software using the "pwr" package. Simple random sampling was used. Simple percentages were used to analyse the results. Dummy coding was used to convert the categorical variables into numerical variables in the correlation analysis. Specifically, binary variables for gender (0 = male, 1 = female) and origin (0 = local, 1 = non-local) was used. Then a Pearson correlation analysis to examine the

relationships between these dummy-coded variables and the non-categorical variables was performed, the correlation was reported as coefficients (r) and p-values were used to signify the strength and significance of these relationships. Dummy coding allowed for incorporating categorical variables into the correlation analysis while adhering to the assumptions of the statistical test (Duke Global Health Institute, 2020). This approach facilitated the exploration in term of categorical and non-categorical variables in a way that it is simple and easy to interpret.

Results

Provisioning and Cultural Ecosystem Services Identification and Classification

The preliminary field survey identified five Provisioning Services and two Cultural Services based on supply, use, and spatial availability. The provisioning services include water, food, construction materials, wood, and medicinal plants, while the cultural services include leisure/tourism and spiritual/religious.

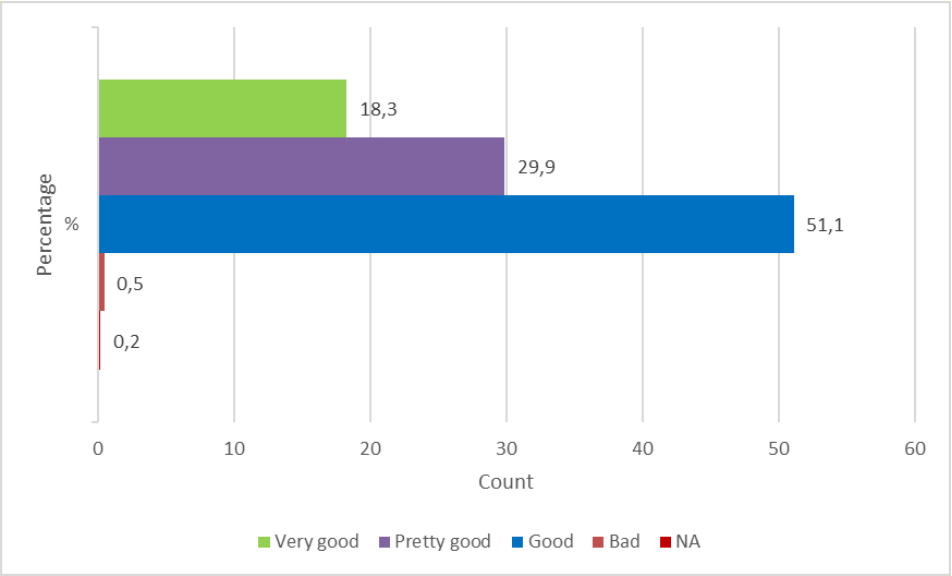
Table 1: Classes of Ecosystem Services and examples at the study site

Provisioning Services		
ES		Examples
1	Water	Domestic supply water from SEEG, River (Ogooué), Rainwater, Well water, Mineral water
2	Food	Fruits, Fish, Bushmeat, Vegetables
3	Building materials	Wood, Sand, gravel, clay, straw
4	Wood	Wood coal, firewood, fuelwood, light wood
5	Medicinal plants	Barks, leaves, roots, grains
Cultural Services		
1	Leisure/tourism	Pleasure in fishing, Historical sites, Conservation site
2	Spiritual/religious	Sacred sites, religious sites, initiation sites

People Perception of the Benefits of Ecosystem Services and Key Activities Supporting Development in Lambaréné

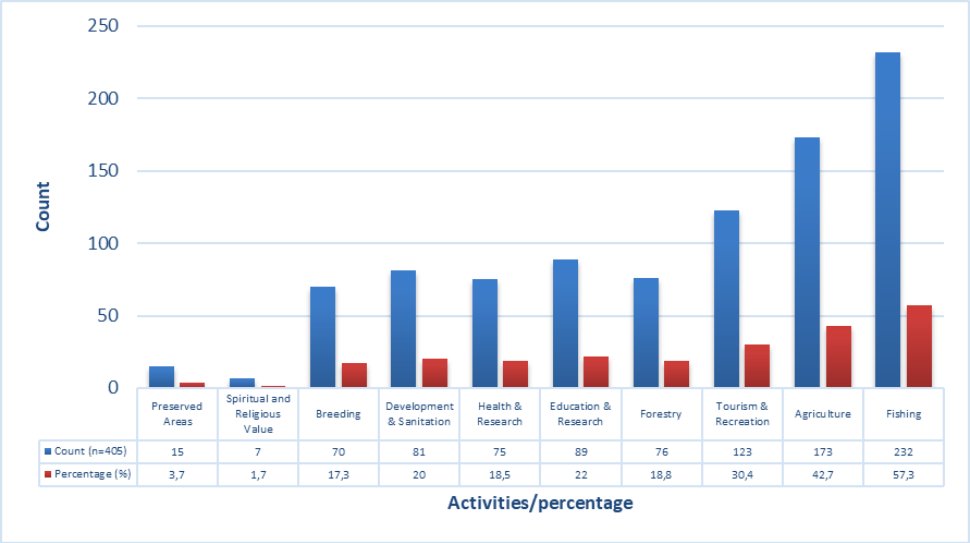
The people's perception of the advantages of Ecosystem Services reveals an interesting and positive perception among the inhabitants of the Lambaréné area (Fig. 2). The data collected shows that 0.2 % reported no advantage, while 0.5% considered it bad, meaning it was not favourable. Nevertheless, the research revealed a significantly larger number of households (51.1 %) that expressed a positive perception of Ecosystem Services in their daily lives and activities. Furthermore, 29.9 % had a pretty positive understanding, while 18.3 % had an extremely positive outlook, showing the locals' belief in the advantages of nature and Ecosystem Services in the region of Lambaréné.

Fig. 2: People's Perception of the Benefit of Ecosystem Services in Lambaréné Area



The data also show that just 1.7 % of households (Fig. 3), or seven people, recognise its spiritual and religious value. This suggests that these characteristics are not significant motivators for community growth in our study. However, 17.3 % of those interviewed felt that livestock breeding and rearing methods were critical to development. In addition, 20.0 % of households interviewed stressed the importance of development and sanitation efforts, highlighting the need for infrastructure and hygiene for overall development in the Lambaréné area.

Fig. 3: Activities to rely on to develop Lambaréné



Health and research activities were considered vital by 18.5 % of households surveyed. This indicates that health and research activities are central to the development of the people of Lambaréné. The majority of surveyed households, 22.0 %, viewed education and research as important activities, indicating that local people prioritise knowledge acquisition and research activities.

Forestry operations were considered important, accounting for 18.8 % of the total responses obtained, indicating the importance of sustainable forestry practices in the context of town development. Tourism and recreation were considered important activities accounting for 30.4 % of the total responses, highlighting the potential for economic growth that tourism represents in the area.

Almost 43 % of the respondents (42.7 % of the total) considered agriculture vital, ranking it second among activities to promote the area's development, with a focus on agricultural techniques and ensuring food security for development. Fishing is the predominant activity, as indicated by 57.3 % respondents of the total. This indicates a high level of dependence on fishing, both for subsistence and for economic progress (Fig. 3) which, firstly aligns with the second objective that emphasise the local community's positive perception of Ecosystem Services in Lambaréné. Secondly, the majority of respondents validated the socio-economic benefits of these services by emerging key activities such as fishing and agriculture as critical activities supporting the idea of considering provisioning services as central to livelihoods in Lambaréné for this study.

Ecosystem Services related to the provisioning and benefits

The study clearly indicates that there is a weak and statistically insignificant link between the distribution of water by SEEG (Société d'Energie et d'Eau du Gabon) and the factors of gender, household size, income, and origin. Nevertheless, there is a notable inverse relationship between river water and income (-.220), suggesting that higher income levels have a detrimental effect on the use of river water. Conversely, there is a positive connection between river water and origin (.224), showing that the origin of individuals favourably effects their utilisation of river water. The data shows a notable positive correlation (0.134) between rainwater and household size, indicating that bigger families tend to use more rainwater. There is a strong positive correlation between income (0.252) and origin (0.110) with mineral water intake, indicating that certain socioeconomic groups and origins have a predilection for consuming mineral water.

Regarding the Food sources, there is a positive correlation between the intake of fruit and both gender (.176) and income (.192), indicating that individuals belonging to these categories are more inclined to eat fruits. The intake of fish is favourably connected with gender (coefficient = 0.121), household size (coefficient = 0.150), and negatively correlated with origin (coefficient = -0.142). The consumption of bush meat has substantial positive correlations with all factors, with the exception of origin. This indicates that gender, family size, and wealth have a favourable impact on the intake of bush meat. On the other hand, there is a notable inverse relationship between veggies and origin (-.138), suggesting that some origins have lower levels of vegetable intake.

The data on the utilisation of sand/gravel and light wood is positively connected with income with respectively (.240) and gender (.109) suggesting that income and gender have an impact on their consumption. The data indicates a positive correlation (0.129) between firewood use and household size, suggesting that firewood is often used in bigger homes. Conversely, there is a negative correlation (-0.171) between firewood consumption and origin which can suggest that firewood usage varies depending on unique origins (Table 2).

Table 2: Correlation between Household Variables and Provisioning Ecosystem Services

Provisioning Ecosystem Services												
	gender			Hshdsize			income			origin		
	cor	*p*		*cor*	*P*		*cor*	*p*		*cor*	*p*	
Water												
Distributed water SEEG	-.024	.631		-.095	.057		.021	.686		-.056	.258	
River	-.042	.405		.045	.369		-.220*	<.001		.224*	<.001	
Rain Water	.035	.487		.134*	.007		.067	.198		-.001	.982	
Mineral Water	.056	.263		-.021	.670		.252*	<.001		.110	.027	
Food												
Fruit	.176*	<.001		.037	.460		.192*	<.001		-.064	.200	
Fish	.121*	.015		.150*	.003		.093	.073		-.142*	.004	
Bush Meat	.199*	<.001		.171*	<.001		.170*	.001		-.052	.296	
Vegetables	.030	.547		.004	.929		.076	.144		-.138*	.006	
Wood	.044	.381		.020	.686		-.019	.719		-.060	.226	
Sand/Gravel	.109*	.029		.029	.561		.240*	<.001		.064	.196	
Clay	.025	.620		.043	.391		-.002	.974		-.003	.957	
Straw building	.057	.256		.075	.134		-.026	.625		-.027	.582	
Wood coal	-.027	.586		.057	.257		-.156*	.003		-.163*	.001	
Firewood	-.015	.763		.129*	.010		-.085	.101		-.171*	<.001	
Fuel wood	.012	.812		.144*	.004		.022	.667		-.061	.217	
Light Wood	.101	.042		.037	.455		-.026	.618		-.080	.109	

Medicine												
Natural medicine (Barks)	.076	.129		.123*	.014		.072	.169		-.114*	.022	
Natural Medicine (leaves)	.071	.155		.121*	.016		.079	.129		-.077	.123	
Natural Medicine (Roots)	.098*	.049		.127*	.011		.147*	.005		-.093	.063	
Grains	.081	.106		.163*	.001		.181*	<.001		-.031	.540	

The utilisation of natural medicines, such as barks, leaves, and roots, is strongly associated with the size of families and income levels, indicating that bigger households and better incomes lead to increased consumption of these medicinal resources. There exists an inverse relationship between the utilisation of these medications and their source, particularly for barks and roots. This suggests that traditional medical practices vary across various sources.

Ecosystem Services related to the cultural and benefits

This section examines the correlation between cultural Ecosystem Services, such as tourism and spiritual and religious activities, and the factors of gender, family size, income, and origin.

According to the statistics, there is a strong positive relationship between gender and enjoyment of fishing (correlation coefficient of .188), historic sites (correlation coefficient of .216), and conservation sites (correlation coefficient of .140) in the context of tourism. Income has a significant link with various cultural activities, notably demonstrating a substantial association with enjoyment in fishing (.219) and historic places (.204). On the other hand, there is a negative relationship between origin and historic places (-.109), suggesting that some origins are less involved in these activities.

The Spiritual and Religious Acts services revealed a notable association between sacred places and gender, with a positive correlation coefficient of 0.193. On the other hand, religious sites exhibit a substantial negative connection with gender, with a correlation coefficient of -0.115. This indicates that there are gender disparities in religious behaviours. The household size has no significant effect on these activities, although wealth presents no positive link with holy places (0.235) and initiation sites (0.220) (Table 3). The origin has no substantial impact on these actions.

The correlations demonstrate the intricate connections between population characteristics and the use of Ecosystem Services in Lambaréné, illustrating the varied cultural and economic environment of the area.

Table 3: Correlation between Household Variables and Cultural Ecosystem Services

Cultural Ecosystem Services												
	Gender			Hshd Size			Income			Origin		
	Cor	P		*Cor*	P		*Cor*	P		*Cor*	P	
Tourism												
Pleasure in Fishing	.188*	<.001		.020	.696		.219*	<0.01		-.090	.072	
Historic site	.216*	<.001		.074	.140		.204	<.001		-.109*	.028	
Conservation site	.140*	.005		.145*	.004		.116*	.025		-.050	.318	
Spiritual and religious act												
Sacred Site	.193*	<.001		.029	.568		.235	<.001		-.033	.513	
Religious site	-.115*	.021		.093	.062		.149*	.004		.020	.682	
Site of Initiation	.195	<.001		.046	.361		.220*	<.001		-.022	.659	

DISCUSSION

Examining people's understanding of the advantages of Ecosystem Services and identifying the crucial activities that foster development in Lambaréné

The results about people's views of the advantages of nature in terms of their comprehension of Ecosystem Services, their use of them, and, as a result, their benefits in the Lambaréné region have been examined. In this way, the function of Ecosystem Services and their benefits to humans are no longer required to be shown.

Indeed, numerous studies have confirmed the link between people's dependence on Ecosystem Services and their socio-economic and cultural contributions on a global scale (Boafo *et al*., 2014; Cao *et al*., 2021; Dupras, 2014; Muñoz *et al*., 2022). Karimi *et al*. (2020) contend that taking into consideration the local population's views is critical for long-term planning. The study highlights the significant dependence on Ecosystem Services in Gabon, with over 95 % of families having a solid understanding of nature's advantages (Fig. 2).

In the case of Lambaréné, among the activities that stand out of our study, it is evident that agroforestry and sustainable fishing can significantly reduce negative impacts in this region. This is especially evident when considering the services that can contribute to development in the town of Lambaréné, where fishing is the primary activity (57.3 %), followed by agriculture (42.7 %), tourism and leisure (30.4%), and forestry (18.8 %), all of which have been identified as key activities for the region's development (Fig. 3).

However, the studies on land use in Gabon of forest lands and mangroves have been shocking due to their disappearing and degradation. For sparse forests, dense forests, and mangroves, simulations show a regressive dynamics where artificial surfaces relying on these may undermine provision of crucial services (Okanga-Guay *et al*., 2018; Randy Essono Mbegha *et al*., 2019). This also shows that it is important to understand better how ecosystems work and the role they play in society. A recent study by Lulu *et al*. (2021) carried out in China has found that the current urbanization has led to destruction of Ecosystem Services (ESs) in the Yangtze and Yellow River Basins area. The study highlights the need to reconsider our approach to economic development in order to enable sustainable growth for the future. Similarly, the findings of Similarly, the results of Mandle *et al*. (2021) show that many more meaningful predictions about how particular decisions will affect both total ES value and collective benefits to different beneficiary groups are necessary if we want ES research to be used in practice at scale. However, to do so at this level requires a far more integrative approach between ecological models and the socioeconomic/cultural dimensions of ES than is currently on offer in existing ES literature.

Correlation assessment of the Provisioning and Cultural Ecosystem Services in Lambaréné

Correlation analysis with Provisioning Ecosystem Services in Lambaréné

With regard to the assessment of the provision of ecosystem services, and in the case of water, there was a positive correlation between origin and household size with rainwater and river water (0.224), indicating a tendency for local populations, regardless of origin, to favour sources of water other than that provided by the public distribution company SEEG. This trend could be explained by problems of access to water on an ongoing basis. On the other hand, in the case of Lambaréné, easy access to river water, including the River Ogooué, is a preferred choice in the town, not forgetting the climatic advantages of Gabon in general, where rainfall is abundant (Mbadinga *et al*., 2019).

Similarly, what would justify the negative correlation (-0.220) between river water or rainwater and income (Table 2) could obviously be related to social conditions according to

their rank by favouring alternative sources of a private nature such as mineral water, representing at least 44.9 % of the households surveyed who say they are not dependent. This finding is consistent with the results of other studies, for example Gondo *et al*. (2020), where socio-economic status was associated with water consumption patterns based on correlation analysis, with a positive and statistically significant relationship between households and water consumption and use, which enabled the impact of residential densities and water sources in Botswana to be assessed. A similar study by Diouf *et al*. (2024) on environmental inequalities highlights that access to drinking water is closely linked to environmental conditions and the social dynamics that shape urban and rural life. In developing countries, especially in sub-Saharan Africa, the most socially and spatially marginalised populations face difficulties in accessing safe drinking water.

In the case of food sources, there is a positive trend, reflected in a significant correlation between fruit consumption and both gender (0.176) and income (0.192) (Table 2), suggesting that there are demographic groups that have easy access to fruit because of its possible affordability in an area where subsistence farming combined with the demographic factor close to rural areas constitute an advantage and influence this choice. This trend is confirmed by a study by Mensah *et al*. (2021), which found that fruit and vegetable consumption was much higher in rural areas, particularly in southern countries, than in urban areas. The study looked at meat, fruit, and vegetable consumption by the population and also tested any association between age, gender, rural and urban residence, or the economic development of a country and meat, fruit, and/or vegetable consumption by the population in sub-Saharan countries in Africa. However, consumption is considered insufficient in countries such as Gabon and Cameroon, according to the CEMAC Food Consumption Survey Pamba *et al*. (2016), which highlights a preference for fatty or oleaginous foods and fish, particularly in households with larger families, which could reflect the eating habits of Gabonese communities. Indeed, the results on bushmeat consumption show a positive correlation with gender, family size, and income (Table 2), all of which are factors contributing to increased consumption. Conversely, we found a negative correlation (-.138) between vegetable consumption and origin, demonstrating how cultural differences can determine food preferences in Gabon in general, which can vary considerably between ethnic groups and their geographical location in the case of the city of Lambaréné.

The results on the use of wood and other resources allow us to appreciate the local population's attachment to the resources available for both construction and energy, resulting in a positive correlation between income and the use of sand/gravel (.240) and light wood (.101), on which the population depends to a large extent. This implies that the inhabitants of Lambarene opt for a greater reliance on natural materials for building and fuels. Next, there was also a positive correlation in use of firewood with the number of persons in a household (.129), which meant that the more people there were in a household, the more the tendency to use firewood because of the need for heat and food cooking.

The data obtained from respondents regarding the use of traditional medicine in Lambarene reveals a positive correlation between household size and income level at (.123), (.121), and (.127), respectively. It is clear that most of the people who live in Lambarene have great trust in the traditional form of medicine (medicinal plants). As such, the positive notion regarding income as a function of the use of roots (.147) indicates a strong inclination towards older traditions. The negative correlation, for example, between origin and bark usage (-.114) shows that culture and local knowledge are a primary factor influencing the use of natural medicine among the communities of Lambarene. Research by Logiel *et al*. (2021) indicated that in Uganda the use of traditional medicine is normal behaviour because it is accessible and does not cost.

Another study of Dembele *et al*. (2023) on the pharmacognosy of leaves, root bark, trunk bark, and the whole root reinforces African beliefs in the use of forest plants in African pharmacopoeia, although there is insufficient data on the overall use of traditional medicine and many aspects still remain obscure.

Correlation analysis with Cultural Ecosystem Services in Lambaréné

The data collected and analysed to assess the dependence of the populations of Lambaréné on cultural ecosystem services revealed a positive correlation with tourism services and the spiritual and religious acts included in this study, justifying once again the dependence of local populations on ecosystem services. With regard to tourist activities in Lambaréné, a positive correlation between gender and preference for fishing seems to be confirmed (0.188). This trend consolidates and supports the results on the importance of fishing in the socio-economic fabric of the town of Lambaréné. In this respect, 57.3 % of households show a major interest in fishing, both for subsistence and for the development of Lambaréné (Fig. 3).

The trend is the same for spiritual and religious activities. There is a positive correlation between sacred sites and gender (0.193) and a negative correlation with religious sites for both sexes (-115) (Table 3), suggesting gender-specific scenarios in the use and consideration of spiritual services in Lambaréné. In fact, these results highlight the involvement of religious or initiation sites in the lives of the people of Lambaréné, with the involvement of both sexes in one or other reflecting the cultural and spiritual roles attributed within local communities.

As such, it provides an understanding of how spiritual beliefs or choices influence environmental behaviours and how spirituality can be creatively harnessed to nurture attitudes that enhance environmental sustainability while navigating carefully between the two dominant divergent viewpoints: The source of spirituality is either religion or nature (Omoyajowo *et al*., 2024).

However, in relation to household size, the results obtained do not reveal a significant correlation (Table 3) when it involves participating in spiritual and religious activities, and income seems to have a mixed influence. However, the negative correlation with origin (-.033) suggests that there are diverse levels of participation in cultural practices from different backgrounds, reinforcing the role of ethnicity and heritage in shaping a community's spiritual and religious behaviour (Ali & Lawal, 2024; Warraich, 2023).

In this way, Considering the Hypothesis dealing with the fact that here is no significant dependency in the consumption patterns of local population and Provisioning and Cultural ES in Lambaréné, which aims to respond to the analysis of the local people's dependency on both provisioning and cultural ecosystem services provided in Lambaréné, accounted for the correlation factor, their opinion of the benefits derived from nature, and the priority activities that could boost development in Lambaréné, and was used as an appreciative and evaluative basis for determining people's dependence on ecosystem services. The results analysed show that 51.1 % of households consider ecosystem services to be beneficial for their daily needs, which underlines their positive perception of ecosystem services.

Thus, comprehensive research that to address the hypothesis of this study, there is no significant correlation between the consumption patterns of households and the utilisation of provisioning and cultural ecosystem services in Lambaréné has been explored.They have taken into consideration Gabon's and Sub-Saharan Africa's outstanding cultural and natural riches in terms of biodiversity and ecosystem services, as well as local and indigenous knowledge, all of which play critical roles in the services, development, and livelihood of the

whole population. The river Ogooué is a crucial water supply source for over 50 % of the interviewed families. Construction materials, food such as fish, vegetables, and bush meat were also included. The portion of these two services is also high, which indicates how much the local community relies on self-supplied natural goods for their welfare. There was a positive association regarding the link between socio-economic profiles and the use of ES. 60.5 % of households partially confirm this hypothesis, suggesting them as users.

Many other researches, like Sanon *et al*. (2024) and Thoya *et al*. (2022) support these findings, claiming that water, food, and fuelwood provision is both a subsistence and prominent income-generating activity for many residents in the localities of the Sub-Saharan region including Gabon.

Not only that, but cultural and religious services, such as cultural sites and respect for ancestral customs, are deemed crucial to the well-being of local communities and also beneficial for conservation operations (De Burca, 2024; Goussoutou, 2024). Socioeconomic variables are also essential, and recent research has demonstrated that gender, income, and family size all influence natural resource use. These studies suggest that more wealthy households are more reliant on alternate sources, in this instance mineral water, rather than natural resources such as river water (Gondo *et al*., 2020; Nyathi *et al*., 2025). These findings support those of this research, which found that the level of household characteristics has a direct impact on the degree of reliance on ecological services in Lambaréné. Furthermore, studies undertaken in Gabon have underlined the need to stress the predominance of Gabon's native natural and cultural legacy in terms of biodiversity and ecosystem services, as well as indigenous knowledge that promotes the economic and social development of local inhabitants (Karsenty, 2021; Kouely, 2023; Tchoumba *et al*., 2020). As a consequence, the hypothesis is based on both the actual findings of this research and the broader literature on ecosystem services in Sub-Saharan Africa.

CONCLUSION

This study looked at the dependence of Ecosystem Services in Lambaréné, Gabon, showing the importance of provisioning and cultural Ecosystem Services to local people in sustaining livelihoods. The study highlights the indispensable role of Ecosystem Services for the well-being of the pooulations and to ensure the cultural heritage of the inhabitants of Lambarene in Gabon. The reliance on provisioning services such as fish, vegetables, and firewood indicate their paramount importance for the local peoples' subsistence and economic activities. The community also religious and spiritual activities and leisure activities for the cultural services of the community which are very important for the people's wellbeing.

These results have implications for sustainable management and policy. By including local perspective in conservation strategies, policymakers can increase social, economic and ecological benefits of Ecosystem Services. This study shows the importance of Ecosystem Services in supporting human well-being and livelihoods in climate vulnerable areas. More research and action is needed to protect these services to ensure a safe and prosperous future for the local people. The results of this study add to the existing knowledge on Ecosystem Services and provide a basis for developing targeted strategies to use and conserve them.

Future studies in this area might involve assessing the economic value of Provisioning and Cultural Ecosystem Services, analysing land use and land cover change, and assessing the link between local traditional ecological knowledge and Ecosystem Services in Gabon in general and in Lambaréné particularly.

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CONFLICT OF INTEREST

The authors state that they have no conflicts of interest.

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