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Community Perception of Riparian Corridors Ecosystem Services and Implications for Environmental Education in Upper Oueme Catchment in Benin, West Africa

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Abstract

The assessment of the local community perception of the value of riparian corridors is relevant to understand their attitude towards the conservation of such ecosystem. We conducted a semi-structured survey on the perception and importance attributed to the ecosystem services (ESs) provided by riparian corridors in 368 households across 70 villages located in a buffer zone of 5 km of servitude around the permanent rivers of the Upper Oueme watershed in Benin. We found that local communities easily reported provisioning and cultural ESs than regulating and supporting ones, indicating their misunderstanding of the main role of riparian corridor. Moreover, the supply of cropping areas was perceived as the most important ES. Educated respondents and high-income households had more knowledge of regulating ESs and supporting ESs, respectively. Overall, the highly perceived importance of the provision of cropping areas indicates a potential risk of agricultural encroachment of riparian corridors. We suggest the consideration of the current local perception of riparian corridor's role in designing a sound environmental education aiming at the change of local population's perception. This perception shift will promote a sustainable management of the riparian corridors.

Keywords

Local Knowledge, Direct Use Value, Soil Formation, Migration, Importance Value, Benin

1. Introduction

Maintaining ecosystem services in the face of global environmental changes and human pressures on the world's natural resources remains a major challenge. Despite the worldwide recognition of the services and functions that forest ecosystems provide, forest degradation continues at an alarming rate, as a result of human-induced changes in the stability of ecosystem functions at the local and global levels [1] [2] [3] [4]. This forest degradation leads to a rapid decline in the quality of ecosystem services (ESs) [5] and exacerbates biodiversity loss [6] [7]. In this regard, recent studies have demonstrated the importance of restoring ecological systems to support the continuous provisioning of ESs to human being [8] [9] [10]. Several land restoration strategies have been used to restore the ESs provided by forests [5] [11] including natural regeneration [12], agroforestry systems [13] and watershed rehabilitation [14]. These restoration approaches depend strongly on the levels of forest degradation and the factors driving ecosystem change [12]. Although it is well acknowledged that the drivers of ecosystem changes are spatially heterogeneous and depend on the socio-economic characteristics of human communities, our knowledge of the importance that local communities attribute to the ESs is still limited [2] [15]. Given the dynamics and complexity of the interaction between people and ecosystems across spatial scales, additional insights on the range of ESs as well as the community perception of their importance in important ecosystems and areas that have received little attention are urgently needed. Knowledge of local perceptions is increasingly said to be effective and reasonable in guiding decision-makers towards ecological sustainability, economic efficiency and social justice [16].

Several integrated approaches have been implemented to assess ESs. Such integrated methods combined ecological approaches that focus on the biophysical properties of ecosystems with social approaches that emphasize the value society places on different ESs, and economic approaches that consider the monetary value of ESs [17]-[22]. Often, the assessment of ESs is more oriented towards the ecological and/or economic approaches than the social approach [23], while the latter is crucial to understand the complex socio-ecological systems [16] [24]. The social approach requires the consideration of stakeholders in order to ensure the optimal provisioning of ESs and the restoration of degraded ecosystems. Taking into account the perceptions of the local community in the early stages of ecosystem restoration process allows to maximize conventional restoration objectives and increase the supply of ESs to forest-dependent people [25]. The concept of ESs, which has recently extended to include the concept of nature's contribution to humans, was invented to highlight the links between ecosystem health and human well-being [26]. The different categories of ESs [10] interact to generate benefits for humans in terms of providing livelihoods, regulating ecological systems, and supporting human life and well-being [27] [28]. Maintaining these benefits to ensure a good quality of life for human societies has been one of the main motivations of the Intergovernmental Science-Policy Plat-

form on Biodiversity and Ecosystem Services (IPBES) [29].

Several authors have emphasized the consideration of local knowledge and perceptions as a basic tool in decision-making policy for ecosystem protection, sustainable resource management and livelihoods [30] [31] [32]. For example, an examination of the differences in perceptions of the provision and diversity of ESs showed that cultural, provisioning and regulating services are best known in various types of major ecosystems in Spain [26] and around forest reserves in northern Benin [33]. Therefore, it is obvious that perception of ESs plays a role in shaping local people's attitude toward ecosystems use and management.

Non-direct ESs such as supporting and regulating services are generally less known to local communities, but are important for improving production systems and ensuring the sustainability of other services [33]. Riparian forests undoubtedly offer contextual conditions that are very appropriate to evaluate indirect services because they primarily serve not only as a refuge for biodiversity and habitat for many ESs (e.g., control of hydro-geomorphological dynamics, cooling of air and water, filtration of pollutants, carbon storage, provision of food or materials, etc.), but also as corridors ("riparian corridors") of dispersion of individuals and genes through the landscapes owing to their serpentine structure along the hydrographic networks of watersheds [34]. These ecological functions of the riparian corridors are even more relevant in arid and semi-arid areas, since they can help buffer the effects of water scarcity and provide environmental conditions similar to those prevailing in wetland ecosystems [35]. Despite their importance, particularly for arid and semi-arid zones, riparian forests have been neglected in development efforts as they are often considered as alternative land use option for the development of human activities [34]. Moreover, the perception of the riparian forests' ESs by local populations, who are the main actors in forest management and the first direct beneficiaries of these ESs, remains unexplored. Understanding how local stakeholders perceive the ESs provided by riparian forests is essential for establishing management strategies that optimize and ensure the proper functioning of these corridors as well as for predicting potential conflicts resulting from heterogeneous demand of ESs and the values attributed to them [36] [37].

This study aims to understand 1) the local communities' knowledge and perceived importance of ESs provided by the riparian corridors of the Upper Oueme watershed in northern Benin and 2) the factors that affect the ability of the local people to perceive ESs and their importance. This study will provide new insights on the importance of knowledge and perception of ESs for the sustainable management of the riparian corridors. In this perspective, we asked three main research questions: 1) How do the communities around the riparian forests identify and perceive the importance of the ESs provided by the riparian corridors? 2) Which factors explain variations in the perception of ESs? Finally, we discuss the implications of our findings for environmental education and the sustainable management of riparian corridors in Sudanian zones.

2. Methodology

2.1. Study Area

The study was carried out in the Upper Oueme watershed, which is located at the outlet of Bétérou in the North Benin, between 9˚9' and 10˚11' north latitude and 1˚30' and 2˚48' east longitude (**Figure 1**). The watershed covers an area of 10,140 km^2. The climate type in the area is Sudanian, characterized by one rainy season (from mid-March to October) with a peak in August and one dry season for the rest of year [38] [39] [40]. The average rainfall in the study area is about 1160 mm over the period 1961-2010 [39]. Ferruginous soil is the dominant soil type of the watershed [39].

The landscape of the Upper Oueme watershed is characterized by savannas, cropping lands, and gallery forests along the rivers pastures [39]. It includes three agro-ecological zones (AEZ) [41]: Zone III (South Borgou Food Zone), Zone IV (West-Atacora Zone) and Zone V (Cotton zone of central Benin). These AEZs are subjected to various agro-pedological constraints and different cropping systems. Yam (*Dioscorea rotundata* P), cotton (*Gossypium hirsutum* L), maize (*Zea mays* L) and groundnut (*Arachis hypogaea* L) are the most cultivated crops in the AEZs. Increasingly, all these areas are engaging in the intensification of cotton cultivation. The local populations in the study area consist of a diversity of ethnic groups (Lokpa, Bariba, Peulh, Nago, Fon and Natimba) with different cultural practices.

2.2. Data Collection

A survey was conducted to collect the data. Three buffer zones of 1, 3 and 5 kms of width were delineated on both sides of the permanent rivers of the Upper Oueme watershed and the residents of the villages that are located within the buffer areas were considered for the survey (**Figure 1**; **Table 1**). A sampling rate of 25% of the villages in each buffer was applied [2] [42] and the sampling villages were randomly chosen. A total of 70 villages were selected out of 280 (**Table 1**). The normal approximation of the binomial distribution of [43] was used to determine the number of sampling households according to the following Equation (1):

$$N = \mu^2_{1-\frac{\alpha}{2}} \frac{Pi(1-Pi)}{\delta^2} \quad (1)$$

where Pi is the proportion of households active in the riparian corridors and which are involved in the primary sector (e.g., agriculture, fishing, hunting); $\mu_{1-\alpha/2}$ = 1.96 is the value of the normal random variable for a risk α equal to 0.05; δ = 5% is the expected margin of error. This equation was adopted because it has been widely used in studies assessing the knowledge and perception of local communities on forest ecosystems [2] [42] [44] [45]. Pi was determined through a prospective survey in the selected villages based on a random sample of 40 households and was equal to 60%. A total of 368 households were surveyed in the 70 villages, belonging to 8 districts: Copargo, Djougou, N'dali, Ouassa-Pehunco, Sinendé, Tchaourou, Bembèrèkè, Parakou (**Table 1**).

The respondents were heads or representatives of households, aged 20 or older. The surveys focused on socio-economic characteristics (age, gender, occupation, ethnicity, income level and education level) and the local communities' perception of the values of the riparian corridors. The latter was assessed using a free listing technique [26] [45]. This resulted in a list of environmental benefits mentioned by respondents known as ESs. The listed services have been classified in the four ES categories (provisioning, regulating, cultural and supporting) of the Millennium Ecosystem Assessment [10]. The respondents were also asked to assess the importance of the perceived ESs based on a four-level score scale (1 for not important and 4 for extremely important). To take into account the culture of the riverside villages, respondents were asked to indicate whether they practice any religious activities (e.g., worshipping) in the corridor (**Table 2**).

Table 1. Sampling characteristics.

Buffers zones	Number of villages	Number of villages selected	Number of households surveyed
0 à 1 km	116	29	153
1 à 3 km	88	22	114
3 à 5 km	76	19	101
Total	280	70	368

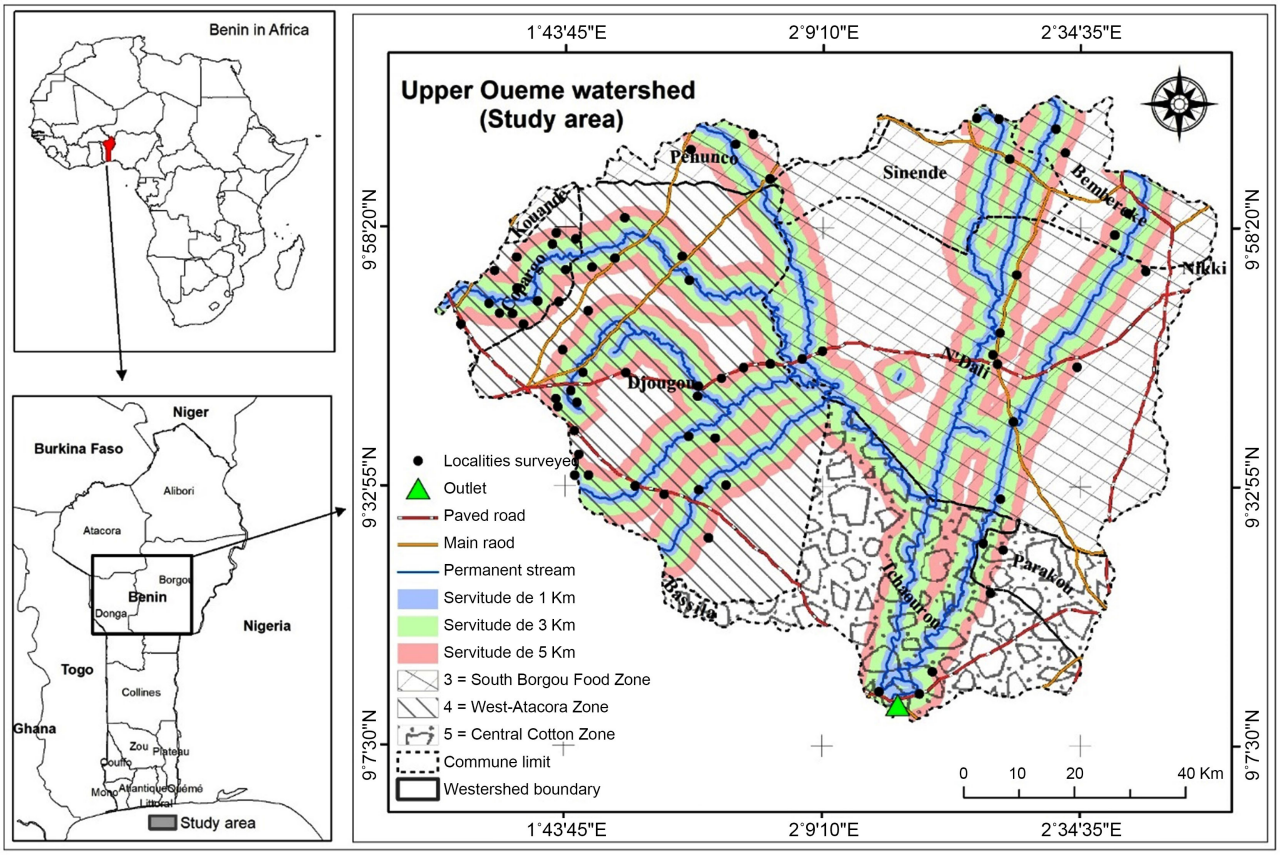

Figure 1. Location of the study area and selected villages.

Table 2. Characteristics of the 368 households surveyed in the riparian corridors of the Upper Oueme watershed of Benin.

Parameters		Number of respondents	Percentage (%)
Town	Bembèrèkè	15	4.08
	Copargo	66	17.93
	Djougou	155	42.12
	N'dali	52	14.13
	Parakou	17	4.62
	Péhunco	20	5.43
	Sinendé	20	5.43
	Tchaourou	23	6.25
Gender	Female	38	10.33
	Male	330	89.67
Age	Young	40	10.87
	Adult	265	72.01
	Old	63	17.12
Ethnic group	Yom	142	38.59
	Bariba	108	29.35
	Lokpa	52	14.13
	Peulh	39	10.60
	Others	27	7.34
Religious practice	Yes	81	22.01
	No	287	77.99
Literacy	Illiterate	156	42.39
	Literate (Basic education)	52	14.13
	School education (elementary, middle or high school)	160	43.48
Main occupation	Farmer	320	86.96
	Herder	13	3.53
	Others	35	9.51
Seniority	<20 years	30	8.15
	>20 years	338	91.85
Income	Lower	89	24.18
	Medium	219	59.51
	High	60	16.30

2.3. Data Analysis

The perception of ESs was assessed by calculating the citation frequency of each service per ES category (provisioning, regulating, supporting and cultural). The citation frequency was the ratio of the number of times a given service was cited

to the total number of investigated households.

To assess the relationship between ethnic groups and the recorded ESs, we develop a matrix of ESs citation frequency, with each row representing a unique ethnic group and each column representing a service recorded in our survey. The matrix was submitted to a Principal Component Analysis (PCA) using the package FactoMineR. Specific benefits of riparian corridors, defined as ESs that differ from those obtained from other ecosystems, were assessed per AEZ and gender categories by calculating the frequencies of citation of the benefits accordingly.

We identified the determinants of respondents' perception of ESs by running a Generalized Linear Model (GLM) using the package MASS [46]. We used a negative binomial error distribution to account for overdispersion in our model. The response variable was the number of ESs citation and the explanatory variables included age, gender, ethnicity, religious practice, level of literacy, occupation, seniority in the village, income level (**Table 2**). We defined three age categories following [47]: young (<30 years), adult (30 - 60 years) and old (>60 years). Similarly, we defined three income levels: low, middle and high on a scale of 1 to 5, of which the average (2 to 3) corresponds to the mean annual income per capita in Benin [48]. On this basis, the respondent attributed the score corresponding to his annual income over the last two years by comparing this income to the annual mean income per capita in Benin. A score of less than 2 corresponded to a low income, a score greater than 3 corresponded to a high income, and a score between 2 and 3 corresponded to a middle income.

To evaluate the perception of ESs importance, a four-Likert scale was defined based on the score values recorded in the field. The four level of importance included: not important (1), somewhat important (2), important (3), and extremely important (4). We ran an ordinal logistic regression model [49] to test the unique effect of each factor and identify the most influential determinants of the importance of the ESs.

3. Results

3.1. Local Communities' Perception of Ecosystem Services

In general, the local community had a good knowledge of provisioning ESs (55%), followed by cultural ESs (23.5%), regulating ESs (19.1%) and support ESs (2.4%) (**Figure 2**). The provisioning of cropping areas (95.9%), medicinal plants (92.1%) and fodder (91.8%) were the most perceived provisioning services compared to the other services. Cultural and regulating services such as cultural practices (59.8%) and storm control (55.4%) were equally well recognized. Soil formation was the only recognized supporting service and was perceived by only 8.4% of respondents.

The PCA results showed that 74% of the relationship between ESs and ethnicities was explained by the first two axes (**Figure 3**). This percentage reflects a strong association between the ESs and ethnic groups. The first axis opposed the Yom, who better recognized cultural ESs (e.g., preservation of spiritual values

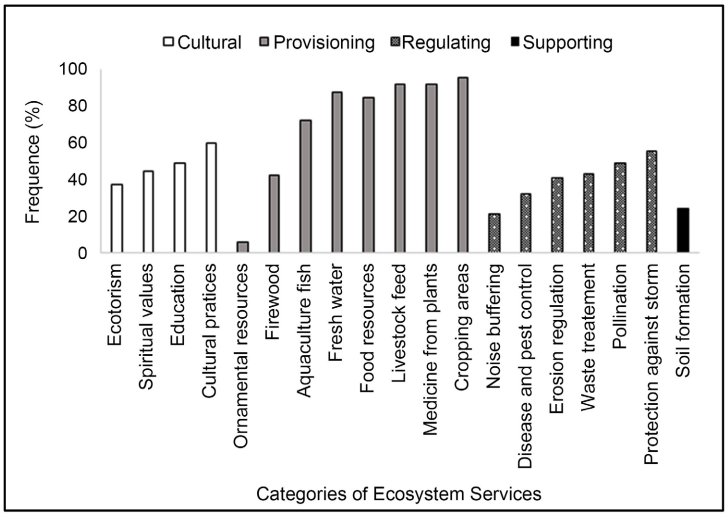

Figure 2. Citation frequency (%) of different ES categories by the local communities along the riparian corridors of the Upper Oueme watershed of Benin.

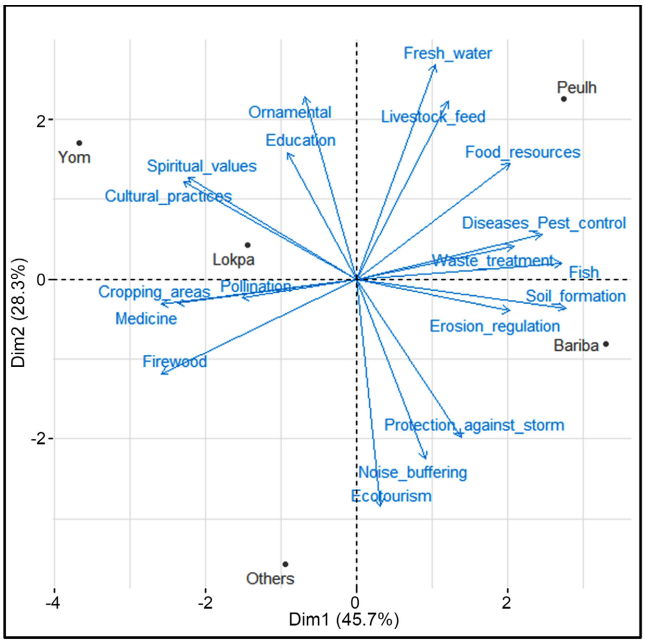

Figure 3. Biplot of the principal component analysis (PCA) showing the correlation between the socio-cultural groups and ecosystem services (ESs).

and cultural practices) to the Bariba, whom perception was more oriented towards the provisioning ESs (e.g., fish collection), supporting ESs (e.g., soil formation) and regulating ESs (e.g., control of diseases and parasites). The second axis opposed the Peulh to the other ethnic groups, which included the Nago, Fon, Dendi, Wama, Adja, Zerma and Natimba. The other groups represented the minority (7.33%) of the population. The Peulh had a better perception of the provisioning ESs (e.g., livestock feed and fresh water) compared to the other ethnic groups, who recognized better the regulating ESs (e.g., storm control, noise miti-

gation) and cultural ESs (e.g., ecotourism).

3.2. Perceived Benefits Specific to Riparian Corridors

Beyond the ESs that other forest ecosystems provide, the local communities in the study corridors identified some specific benefits that led them to exploit the resources in the corridors. These benefits included: high crop yield with low chemical fertilizer inputs, soil moisture availability, high soil fertility, possibility for off-season cropping, supply of freshwater for irrigation and provision of cropping areas. These specific benefits were unanimously mentioned by both men and women (Figure 4).

3.3. Importance Value of Ecosystem Services Perceived by the Local Community

Soil formation was the only supporting ES cited in this study by the local community and was the second most important recognized ES category after the provisioning ES category. The cultural ES category was the least important (Table 3). Among the provisioning ESs, food resource, medicinal plants, cropping areas, wood energy and fresh water were considered most important (importance value above average), while ornamental resources and fodder were perceived as least important (importance value below average; Table 3). Among the regulating ESs, disease and pest control, erosion regulation, protection against storms and pollination were perceived as more important than waste treatment and noise reduction. In the cultural ES category, the cultural practice, education and spiritual value were perceived as more important than ecotourism.

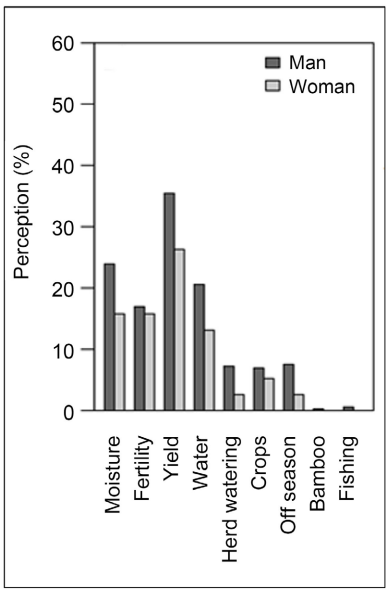

Figure 4. Perception of corridor-specific benefits by the local communities according to gender. Moisture: soil moisture availability; Fertility: high soil fertility; Yield: high crop yield; Water: supply of fresh water; Herds watering: availability of water for herds watering; Crops: provision of cropping areas; Off season: possibility for off-season cropping; Bamboo: bamboo availability; Fishing: possibility for fishing.

Table 3. Importance value of provisioning, regulating, supporting and cultural ecosystem services (ESs) specific to riparian corridors of the Upper Oueme watershed of Benin, as perceived by local communities. Shown are mean and standard deviation (SD) of the scores assigned to each ES based on the four-Likert scale (1 - 4).

Category of ES	ES	Importance value of ES	
		Mean ± SD	Mean ± SD
Provisioning	Foods resources	3.93 ± 0.11	3.20 ± 0.21
	Plant derived medicines	3.83 ± 0.28	
	cropping areas	3.82 ± 0.31	
	Firewood	3.50 ± 0.60	
	Fresh water	3.47 ± 0.62	
	Aqua cultural fish	3.37 ± 0.51	
	Ornamental resources	2.61 ± 0.47	
	Livestock Feed	2.51 ± 0.63	
Regulating	Disease and pest control	2.93 ± 0.20	2.72 ± 0.20
	Erosion regulation	2.91 ± 0.32	
	Storm protection	2.84 ± 0.27	
	Pollination	2.78 ± 0.57	
	Waste treatment	2.56 ± 0.59	
	Noise buffering	2.28 ± 0.46	
Supporting	Soil formation	2.97 ± 0.41	2.97 ± 0.41
Cultural	Cultural practices	2.73 ±0.92	2.52 ± 0.14
	Education	2.61 ± 0.49	
	Spiritual values	2.54± 0.71	
	Ecotourism	2.39 ± 0.47	

ES = Ecosystem Services, SD = Standard Deviation.

3.4. Factors Influencing the Perception of Ecosystem Services Category

With regards to the socio-economic factors, the results revealed that the older respondents reported the regulating ESs more than the adult and young respondents ($\beta = 0.24$, $p < 0.01$, Figure 5(a), Table 4). Moreover, the young respondents identified less the cultural ESs than the adult respondents ($\beta = -0.36$, $p < 0.05$, Figure 5(b), Table 4). The livestock herders recognized the cultural ESs more than the crop farmers and other occupational groups ($\beta = 0.86$, $p < 0.01$, Figure 5(c), Table 4). In contrast, the crop farmers were those who identified the regulating ESs the most (Figure 5(d)). The importance of the seniority was also highlighted in the identification of ESs, since the households with more than 20 years of seniority in the village recognized the regulating ESs the most ($\beta = 0.39$, $p < 0.05$, Figure 5(e), Table 4). Finally, the level of the income significantly influenced the identification of the cultural and supporting ESs. The low-income households recognized the cultural ESs the most ($\beta = 0.39$, $p < 0.01$, Figure 5(f), Table 4). Similarly, the low-income households recognized the supporting ESs the most ($\beta = 0.14$, $p < 0.01$, Figure 5(g), Table 4).

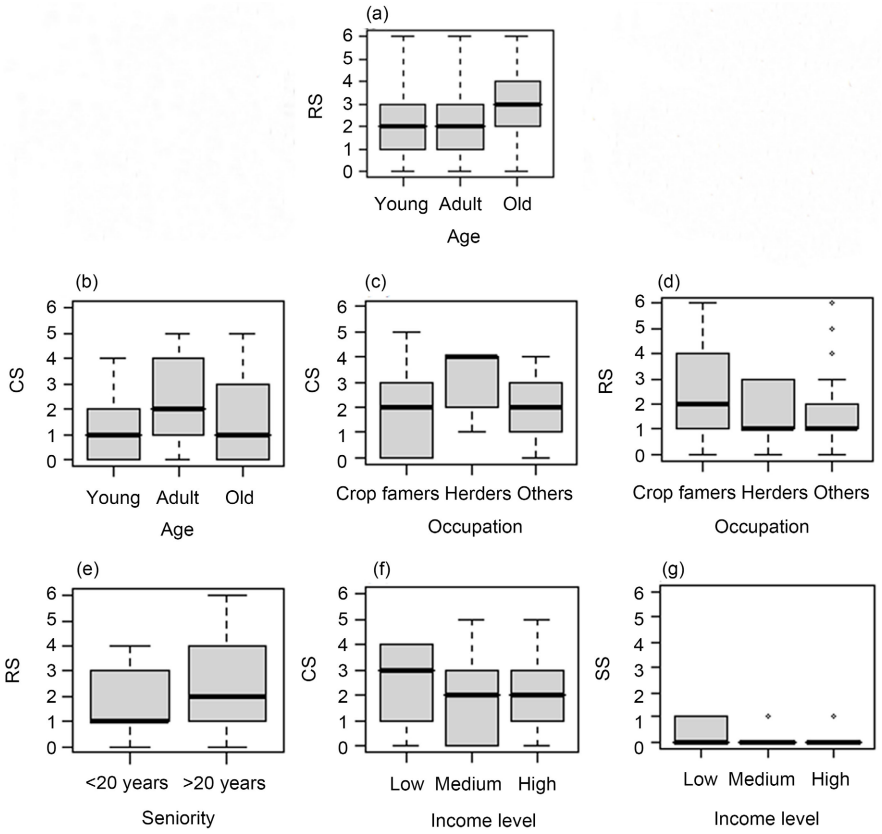

Figure 5. Boxplots showing the distribution of the identification of ecosystem services (ESs) and socio-economic (age, occupation, seniority and income) factors in the riparian corridors of the Upper Oueme watershed of Benin. RS = Regulating Services, CS = Cultural Services, SS = Supporting Services.

Table 4. Results of the Generalized Linear Model (GLM) with negative binomial error distribution, showing the effect of socio-economic variables on the identification of ESs by the local communities inhabiting the riparian corridors of the Upper Oueme watershed of Benin. PS: Provisioning Service; RS: Regulating Service; CS: Cultural Service SS: Supporting Service.

			PS	**RS**	**CS**	**SS**
			β (SE)	β (SE)	β (SE)	β (SE)
Groups	Factors	Intercept	1.73 (0.15) ***	0.58 (0.25) *	0.58 (0.27) *	−1.56 (0.85)
Socio-economic factors	Sex	Male	0.03 (0.08)	−0.01 (0.13)	0.02 (0.14)	0.27 (0.53)
	Age	Young	0.00 (0.08)	−0.11 (0.12)	−0.36 (0.16) *	−0.68 (0.43)
		Old	0.00 (0.06)	0.24 (0.09) **	−0.19 (0.12)	0.19 (0.34)
	Ethnicity	Yom	0.01 (0.08)	−0.14 (0.12)	−0.01 (0.14)	−0.41 (0.38)
		Lokpa	0.04 (0.09)	−0.14 (0.13)	−0.03 (0.15)	−0.10 (0.43)
		Peulh	0.02 (0.09)	0.04 (0.14)	−0.27 (0.20)	−0.08 (0.51)
		Others	−0.03 (0.10)	−0.09 (0.15)	−0.09 (0.19)	0.35 (0.48)
	Occupation	Herder	−0.01 (0.15)	−0.31 (0.27)	0.86 (0.26) **	0.89 (0.66)
		Others	−0.11 (0.09)	−0.30 (0.15) *	0.01 (0.16)	−1.97 (1.04)
	Cultural practices	Yes	−0.04 (0.06)	−0.09 (0.09)	0.11 (0.10)	0.08 (0.31)

Continued

Literacy	Illiterate	−0.02 (0.07)	−0.19 (0.10)	−0.15 (0.12)	−0.33 (0.33)
	School education	0.02 (0.07)	0.11 (0.10)	−0.16 (0.12)	0.15 (0.30)
Seniority	>20 years	0.00 (0.09)	0.39 (0.16) *	0.10 (0.16)	0.07 (0.48)
Income level	Low	−0.02 (0.08)	0.19 (0.12)	0.39 (0.13) **	1.14 (0.39) **
	Medium	0.00 (0.06)	0.09 (0.10)	−0.09 (0.11)	−0.07 (0.36)

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$, PS = Provisioning Service, RS = Regulating Service, CS = Cultural Service, SS = Supporting Service, SE = Standard Error, β = Regression coefficients.

3.5. Factors Shaping the Relative Importance Given to Ecosystem Services Category

Several factors have determined how local communities perceived the importance of ESs. The influence of these factors on the perceived importance of ESs varied between the ES categories (Table 5). The local communities worshiping in the riparian corridors recognized less the importance of regulating ESs than non-believers ($\beta = -0.63$, $p < 0.05$). Also, the level of literacy has significantly influenced the perceived importance of regulating and supporting ESs. On the one hand, illiterate respondents perceived the importance of regulating ESs less than those who had basic education (literate; $\beta = -0.85$, $p < 0.05$), while those who had formal education recognized more the importance of regulating ESs than literate people ($\beta = 1.81$, $p < 0.001$). On the other hand, the illiterate respondents perceived the importance of supporting ESs the most ($\beta = 1.05$, $p < 0.05$). Finally, the level of income influenced the perceived importance of the supporting ESs, with the low-income households being the least aware of the importance of these ESs ($\beta = -1.05$, $p < 0.05$).

4. Discussion

4.1. Perception of Ecosystem Services and Their Importance to Local Communities

Our findings support the opinion that exploring perception within the local community is an effective way to understand traditional ecological knowledge, with implication to ecosystem management [31] [32] [50]. Our results demonstrated that local communities living in the riparian corridors of the Upper Oueme watershed were very attached to the resources provided by the riparian forests, as also reported in previous studies [51] [52] [53]. The local communities identified more easily the most direct ESs (provisioning and cultural) than the indirect (regulating and supporting), likely because of their heavy dependence on these services to maintain their livelihood and cultural values [15] [33] [47]. Indeed, the riparian corridors harbor a great diversity of multi-use plant resources, which are highly valued by local communities. An example is *Pentadesma butyracea* (Sabine), which is highly valued for its social, cultural and economic importance [54]. The riparian corridors also provide freshwater for irrigation [55]. As reported by the local communities, the corridors provide favorable

Table 5. Results of the ordered logistic regression, showing the effect of socio-economic and environmental factors on the perceived importance of ESs provided by the riparian corridors of the Upper Oueme watershed of Benin.

			PS	RS	CS	SS
			β (SE)	β (SE)	β (SE)	β (SE)
Socioeconomic factors	Sex	Male	0.55 (0.42)	−0.16 (0.38)	−0.45 (0.36)	−0.13 (0.50)
	Age	Young	−0.91 (0.46)	−0.83 (0.48)	−0.12 (0.39)	−0.27 (0.49)
		Old	0.24 (0.31)	0.22 (0.31)	−0.14 (0.29)	−0.43 (0.41)
	Ethnicity	Yom	0.51 (0.43)	0.23 (0.43)	−0.47 (0.37)	0.24 (0.47)
		Lokpa	0.37 (0.47)	0.29 (0.47)	−0.75 (0.42)	0.55 (0.51)
		Peulh	0.39 (0.57)	0.12 (0.51)	0.52 (0.42)	−0.19 (0.52)
		Others	0.68 (0.61)	0.46 (0.56)	−0.55 (0.47)	0.11 (0.57)
	Occupation	Herder	0.13 (0.93)	−0.62 (0.77)	−0.85 (0.71)	−0.19 (0.76)
		Others	0.18 (0.50)	−0.03 (0.45)	0.26 (0.42)	0.14 (0.58)
	Cultural practices	Yes	−0.10 (0.32)	−0.63 (0.28) *	0.39 (0.26)	0.32 (0.33)
	Literacy	Illiterate	−0.05 (0.43)	−0.85 (0.35) *	−0.09 (0.33)	1.05 (0.45) *
		School education	−0.73 (0.43)	1.81 (0.42) ***	−0.64 (0.34)	0.77 (0.44)
	Seniority	>20 years	0.45 (0.49)	0.08 (0.46)	0.06 (0.44)	0.37 (0.56)
	Income level	Low	0.04 (0.43)	0.19 (0.39)	−0.06 (0.37)	−1.05 (0.47) *
		Medium	0.41 (0.35)	0.19 (0.31)	−0.27 (0.29)	−0.24 (0.35)
		Somewhat |Important	−3.75 (1.09) **	−0.56 (0.75)	−0.83 (0.71)	2.24 (0.96) *
		Important |Extremely Important	0.82 (0.85)	4.74 (0.84) ***	0.71 (0.71)	4.04 (1.00) ***

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$, AEZs = Agro-Ecological Zones, PS = Provisioning Service, RS = Regulating Service, CS = Cultural Service, SS = Supporting Service, SE = Standard Error, β = Regression coefficients.

conditions for off-season cropping due to the year-round availability of water and prevailing soil moisture. The recognition of the prevalence of high soil fertility in the corridors suggests that the local communities had a good knowledge of the supporting ESs in addition to that of the provisioning and cultural ESs. This knowledge allows them to adopt management strategies that are still not sustainable, as they are confronted with the cumulative effects of climate change [56] and anthropogenic activities [57].

This study shows a strong association between the perception of ESs and ethnicity. The Yom people, who perform more worshipping activities in the riparian corridors than the other ethnic groups, had a very good knowledge of cultural ESs as opposed to the Bariba (farmers in majority), for whom the perception was more diversified but oriented towards the provisioning, supporting and regulating ESs. The Peulh (herders) identified the provisioning ESs (livestock feed and fresh water) mostly. Because of their socio-cultural affiliation, the Peulh are not only nomadic cattle herders looking for new rangelands to graze their animals, but they also live in camps within forest areas and corridors. This divergence in the perception of ESs between socio-cultural groups suggests the

need to account for socio-cultural differences in the design of programs aimed at sustaining the supply of ESs by the riparian corridors.

As reported by several studies [33] [58] [59], the local communities in the study area recognized the importance of provisioning ESs, confirming the idea that the local communities tend to give the highest priority to the most tangible, easy-to-collect services to meet their basic needs [59]. However, although soil formation is the only supporting ES cited in this study by the local communities, this category of ES was recognized as the second most important ES, followed by the regulating ESs (**Table 2**). Similar results were reported in Ethiopia [34], where local communities living around Lake Ziway also ranked the provisioning and supporting ESs at the top of the priority. Among all the enumerated ESs, the provisioning ESs and particularly the supply of cropping areas were the most recognized and important ESs by the local communities in the study area. With regard to the primary roles of the riparian corridors which consist in supplying supporting and regulating ESs and ensuring the dispersal of individuals of animal species and genes across the landscape [34], the greater value assigned to the provisioning ESs points to a potential risk of fragmentation of the riparian corridors if agricultural encroachment is not prevented. Considering that the installation of cropping areas into the riparian corridors is forbidden by the forest legislations of Benin (Law No. 93-009 of 2 July 1993 on forest regime in the Republic of Benin; Law No. 2013-01 of 14 August 2013 on the Land and State Code in the Republic of Benin), our result also highlights a weak enforcement of the existing laws and regulations related to the protection of riparian corridors. Overall, our findings on the perception and importance of ESs suggest a potential risk of an unsustainable use of riparian corridors.

4.2. Effects of Socio-Economic and Environmental Factors on the Perception of Ecosystem Services and Their Importance to Local Communities

Socio-economic and environmental factors influenced the perception of ESs and their importance in the riparian corridors of the Upper Oueme watershed in Benin. We found that the socio-economic and environmental factors did not influence the identification of provisioning ESs (**Table 4**). The provisioning ESs are tangible services and were more recognized by the local communities than the other categories of ESs (**Figure 2**), as previously reported [33] [60] [61]. Moreover, the provisioning ESs are directly involved in the physical, economic and social well-being of the community [15]. Therefore, the lack of significant effect of socio-economic factors on the identification of the provisioning ESs could be attributed to the homogeneity of knowledge on these services across various socio-economic groups. This result suggests that the perceived importance of ESs of an ecosystem by local communities is also determined by the utilitarian value that these services bring them.

The age of the respondents significantly influenced the identification of the regulating ESs but not the perception of their relative importance. The higher

citation of the regulating ESs by older people than the adults and youth, underlines the central role that experiential local knowledge plays in the identification of ESs. Studies assessing changes in ecosystems reported that older people have a history and experience with their environment [2]. The accumulation of traditional ecological knowledge is a lifelong process, indicating that older people had more time to acquire it [62]. Cultural ESs such as cultural practices, education and spiritual value gained more interest from the local communities around the riparian corridors although this category of ES was perceived to be less important. The cultural importance of forests reflects the positive attitudes of the local communities towards its conservation [41]. Thus, the interest in cultural practices and spiritual values observed in this study, which was also recognized for forests and trees in Africa [63], may be an asset in the protection of riparian corridors. Furthermore, the better identification by older people and adults compared to youth reflects a low transmission of the cultural and spiritual values related to riparian forests between generations.

The identification of ESs was also influenced by the type of profession, since the farmers had a better knowledge of the regulating ESs than the herders and other socio-professional workers (traders, artisans, carpenters, etc.). Similar findings were reported by previous studies [61] [64]. This indicates that farmers are aware of the impact of poor agricultural practices (slash-and-burn farming, pesticide use) on the provision of regulating ES. It also emerged from our results that seniority was a significant predictor of local knowledge on the regulating ESs, which is in line with the findings of previous studies [65]. For instance, [41] found that plant knowledge and evaluation were the lowest among migrants. Studies on the drivers of sustainable harvesting of *Syagrus coronata* (Mart) Becc. (Ouricuri palm) leaves in northeastern Brazil came to the same conclusion that local harvesters tend to harvest leaves more sustainably than non-indigenous people [66]. Increasingly, more people are settling down in the riparian corridors in the quest of wet and fertile lands and livestock feed [52]. However, the migrants (defined in our study as people with <20 years of seniority) are less aware of the usefulness of adopting sustainable ecosystem management strategies [66] [67] that guarantee the maintenance of the ecological functions of riparian ecosystems.

We also observed that low-income households were less likely to recognize the importance of the supporting ESs than the high-income households, but they had a better knowledge of the supporting and cultural ESs than the high-income households. This result is in agreement with previous studies reporting that the wealthiest groups perceived the importance of soil protection and fertility [41]. The United Nations Development Program (UNDP, 2022) found that the poorest local populations were not aware of the close links between agriculture and the ESs provided by forests. Although low-income households had a better knowledge of supporting ESs than high-income households, these ESs were not as much important for them probably because they have limited resources to engage in intensive farming activities. It could also be that low-income house-

holds valued more other income-generating activities (e.g., fishing, crafting). The finding that the supporting ESs were more important for the high-come households likely reflects the ability of wealthy households to crop large areas to maximize yields and increase their incomes due to the favorable edaphic conditions (high soil fertility and humidity) prevailing within the riparian corridors, as mentioned by the respondents. This suggests that the wealth conditions of rural households characterize the demand for resource exploitation and the perceived importance of ESs.

The level of education also influenced the perception of the importance of the regulating ESs. The fact that the uneducated respondents mentioned the regulating ESs less than those who were literate or received a school education reflects the link between education level and environmental sensitivity [68]. The same results were reported by [41] and [41]. In Benin, in addition to the environmental concepts inserted in the curricula of school training, the annual celebrations of the various statutory days related to the environment (e.g., International Day of Forests, International Day of Biodiversity, National Tree Day, World Environment Day, World Day to Combat Desertification and Drought) through the development of several topics on the importance of forests or biodiversity for communities, are usually held in schools or educational centers. This likely resulted in the high level of awareness of educated respondents. Finally, we also found that the regulating ESs were less important to the respondents who practiced cultural and religious activities within the corridors. This finding may be explained by the lower level of education of the cultural and religious practioners (56% of the practioners were illiterate whereas the proportion of ilitrate non-practioners amounted to 38%), since our results similarly revealed that ilitrate respondents had a lower perception of the importance of regulating ESs than the litrate ones (**Table 5**).

4.3. Implications of the Findings for the Management of the Ecosystem Services Provided by the Riparian Corridors

The social-economic factors influencing the local perception of the ESs provided by the riparian corridors deserve to be taken into account for the sustainable preservation of the ecological functions of this ecosystem. The finding that traditional ecological knowledge accumulated with age and increased with seniority highlights the need to account for the migration factor in the design of ecosystem management strategies to support the transmission of local knowledge [69]. The close link observed between educational attainment and environmental sensitivity suggests that successful policies for the management of the ESs supplied by the riparian corridors should support the education system through multiple awareness creation and environmental education sessions for the benefit of all social strata. The perception of the supply of cropping areas as the most important ES in this study highlights that the main uses of the riparian corridors by local communities can differ from the primary roles of riparian corridors (regulation and support of ecological processes and landscape connectivity), thereby

underscoring the need to account for the local uses of the riparian corridors for their successful management. Moreover, the promotion of sustainable land management strategies such as integrated soil fertility management, wetland reclamation and irrigation on the plateau could help reduce the potential risk of agricultural encroachment on the riparian corridors. In addition, it is also important for decision-makers to identify and prioritize riparian corridors where management efforts are needed to maintain landscape connectivity [70] [71]. This can be achieved using spatial modelling [70] [71].

5. Conclusion

This study assessed the perceptions of ESs, the socio-economic factors that determine them and the values attributed to the riparian corridors of the Upper Oueme watershed in Benin. The local communities perceived the direct ESs (provisioning and cultural) more easily than the non-tangible ones (regulating and supporting). Moreover, the respondents had limited knowledge of the main functions (regulation and support of ecological processes and landscape connectivity) of the riparian corridors, which they perceived more as providers of ESs. In line with this, the supply of cropping areas was perceived as the most important ES, pointing to a potential risk of agricultural encroachment of the corridors. Age, occupation, seniority, and level of education were key to the perception of the other categories of ESs. In addition, level of education and income were the factors that influenced the perception of the importance of the ESs. Taking these different factors into account would be necessary to design management strategies aimed at sustaining the functions and ESs provided by the riparian corridors.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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