American Journal of Agriculture and Forestry
2024, Vol. 12, No. 2, pp. 113-128
https://doi.org/10.11648/j.ajaf.20241202.16

Research Article

Local Perceptions of Forest-Based Ecosystem Services in Benin, West Africa

Robert Sourokou*, Fifanou Gbèdidji Vodouhe

Laboratory of Economic and Social Dynamics Analysis (LARDES), Faculty of Agronomy, University of Parakou, Parakou, Republic of Benin

Abstract

Ecosystem services are closely linked to the daily lives of local communities, particularly those living near forests. The study of the local perceptions of these services is relevant because they vary depending on the community, the study period, and the environment. So beyond the inventorying of ecosystem services, understanding the perceptions of local communities regarding these services remains a necessity. Our study aims to analyze how local communities perceive the ecosystem services provided by forests and the factors that determine these perceptions. We collected data from 232 heads of households across 23 villages bordering the forest and analyzed them using descriptive statistics and ordered Probit analysis. The results showed that provisioning services (such as plant-derived medicines, rafters and planks, livestock feed, crops, and firewood) were the most important, followed by regulating and supporting services (including soil formation, erosion control, and climate regulation) are the most important. Finally, cultural services (encompassing cultural practices, heritage, and spirituality) were perceived as important. However, communities did not perceive the value of ecotourism. Factors influencing these perceptions included gender (male), age (young individuals), occupation in farming, household size, level of education, Bariba ethnicity and income. To ensure the sustainable utilization of forest resources in the region, it is necessary to encourage young people to adopt environmentally friendly agricultural practices, to use improved stoves that require less wood and promote cultural services to diversify their sources of income.

Keywords

Benin, Ecosystem Services, Forest, Local Communities, Local Perceptions, Natural Resource Use

1. Introduction

The term "ecosystem services" emerged through the works of [1, 2] and finally, [3] highlighting the importance and diversity of services that ecosystems provide to humanity. Although ecosystem services have been defined in several ways [4], we will define them simply as the benefits humans derive from ecosystems [5, 6]. They are categorized into 23 functions [5] or three main categories: provisioning, regulating, and cultural services [7]. In addition, Millennium identifies supporting services as a fourth category [6].

Forests, especially tropical forests, play a vital and well-known role due to the ecosystem services they provide [8]. Indeed, the world's poorest populations depend on forests to varying degrees [9, 10], which provide either direct or indirect benefits. Direct services from forests and trees in-

*Corresponding author: bioyo2001@yahoo.fr (Robert Sourokou)

Received: 27 March 2024; **Accepted:** 11 April 2024; **Published:** 29 April 2024

clude a wide range of products (both timber and non-timber forest products; NTFPs) used for food, feed, energy, construction, and other uses [11-14]. Indirect services include biophysical environmental processes that support long-term food production, access to clean water and nutrients, and improved quality of life [6]. Particularly in developing countries, timber and NTFPs provide approximately 20% of rural household incomes when communities have moderate or extensive access to forest resources [15]; forests and trees outside forests contribute to all four dimensions of food security by providing nutritious food [16, 17], soil fertility and protection, water conservation [13, 17], cultural enrichment, and recreational opportunities [8, 18]. Tropical forests also contribute to carbon sequestration, climate change adaptation and mitigation, and other regulating services [17, 19, 20].

Humans, as part of biodiversity, are largely dependent on the various services that ecosystems provide. Paradoxically, the primary factor in forest loss remains anthropogenic pressure [17, 21]. Forest biodiversity is undergoing progressive human-induced loss [22], leading to debates in the scientific community about the relationship between humans and their environment [8]. The perceptions of the local community, the main stakeholders, and the primary beneficiaries of ecosystem services provided by the forest are also important. These perceptions measure the value of these services because communities with a more positive perception of biodiversity are those who derive more benefits from it [23]. The local community's perception of the services provided by the forest is, therefore, an indispensable tool for decision-making in sustainable ecosystem governance [23-35]. Different methods are required for analyzing the community's perception of the ecosystem services. A social approach is usually adopted for the analysis of the community's perception. On the other hand, an ecological approach is adopted for the analysis of the ecosystem services provided by the forest. The social approach focuses on the values that society attributes to each ecosystem service [36], whereas the ecological approach measures the ecological functions or biophysical properties of the ecosystem [5, 37]. However, this method of evaluating ecological services, which combines social and ecological aspects, is underutilized [37, 38], in favor of a method that combines economic and ecological approaches [39]. Indeed, any valuation of ecosystem services must include the social approach to take into account the perceptions of stakeholders [40]. In this dynamic, it is essential to appreciate the socio-demographic factors that influence the community's perception [41] in order to align forest land planning strategies correctly with stakeholders' needs and uses in a sustainable manner [18].

The present study was conducted in the communes of Kerou, Kouande, and Pehunco (2KP) within a region that houses five forest formations. It aims to analyze the perceptions and the determining factors of local communities regarding the ecosystem services provided by the forest. Specifically, it aims to (i) analyze the local communities' perception of the intensity of ecosystem services provided by the forest and (ii) identify the socio-demographic factors influencing this perception.

2. Methodology

2.1. Study Area

The 2KP region is subject to a trend toward desertification, evidenced by a gradual decrease in rainfall and biodiversity loss. The 2KP forest is the last bastion against desertification in this region.

Covering 10,145 km², the 2KP territory is located in the north-west of the Republic of Benin, between latitudes 9°50' and 11°30' north and longitudes 1°20' and 2°17' east. It includes 150 administrative villages, 23 of which border forest formations.

The 2KP territory has a Sudano-Guinean climate with distinct wet and dry seasons, receiving an average annual rainfall of 800 to 1100 mm. Temperatures range from 25 to 40°C. Given the rural nature of the territory's three communes, the majority of the population is engaged in agriculture (78.8% as per [42]).

The vegetation comprises various ecological landscapes, including fields, fallow lands, savannahs, and forest galleries, which have undergone varying degrees of transformation due to human activities. The region is also home to a large number of classified forests and a hunting zone.

2.2. Sample

A total of 23 villages were selected, representing those bordering forest formations in the study area. The surveyed individuals came from these villages, totaling 232 people, among whom were 70 women (30.17%). This number of women was surveyed because, in the region, 27.1% of the working population is female [42]. Ten people, heads of peasant households, were randomly selected per village to represent various professional activities linked to the forest, including producers, herders, loggers, socio-cultural groups, and others. It should be noted that heads of households are predominantly men in traditional African society, which can affect women's willingness to express their opinions [43].

2.3. Collection Method

A questionnaire was administered. The first part of the questionnaire collected socio-economic data (surname, first name, age, occupation, mother tongue, village, gender, income, household size). The second part focused on the availability and intensity of ecosystem services rated on a scale of 1 to 3 (1 = Low; 2 = Medium; 3 = High). Any service that was unavailable was marked as 0. At the end of the survey, a group of 10 participants reviewed the responses to validate the answers about the different services. These 10 individuals

were randomly selected from farmers, stockbreeders, foresters, socio-cultural groups, and similar categories.

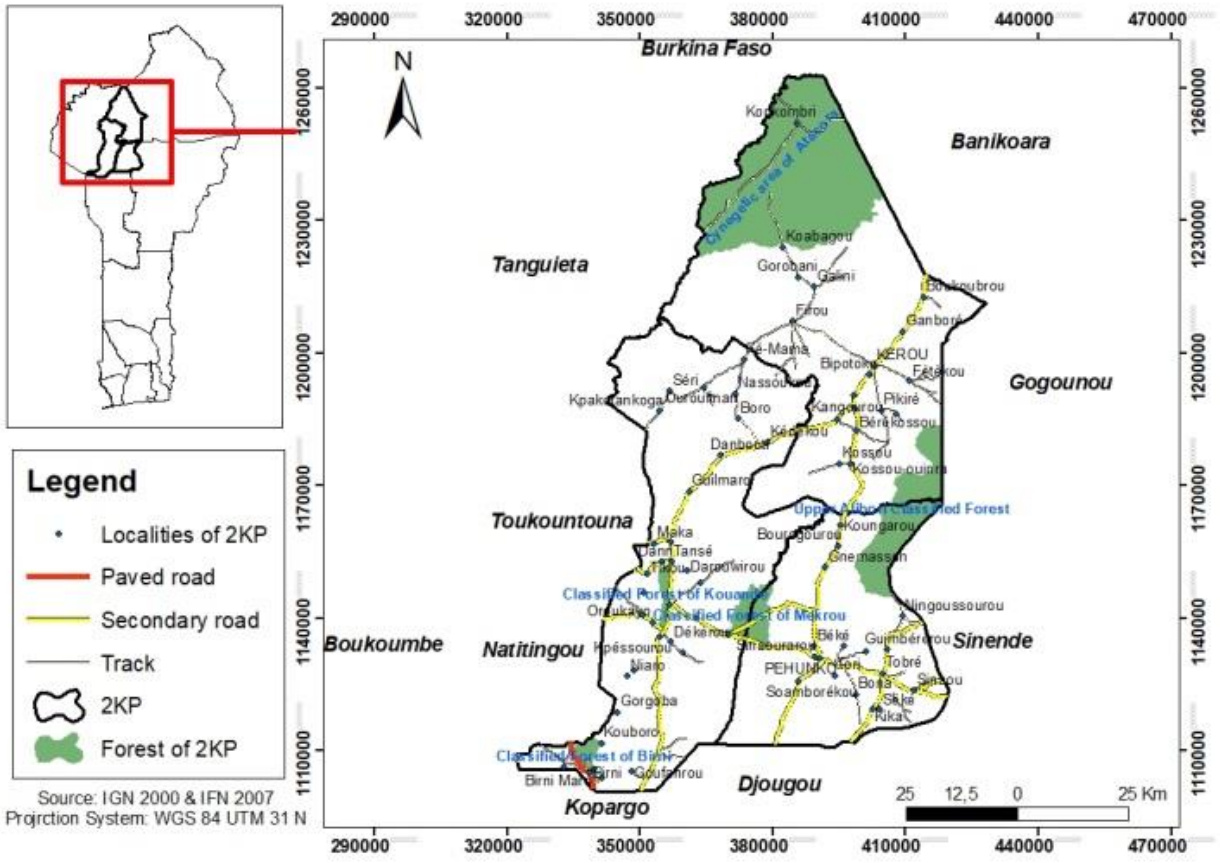

Figure 1. *2KP's forests map.*

2.4. Parameters, Data Collection, and Analysis

The data to be collected consisted of socio-demographic variables: gender (GEN), age (AGE), ethnicity (ETH), level of education (LEVED), professional activity (PROF), commune (COM), income (INC), and household size (HOUS). Previous studies suggest that ethnicity (or origin) and professional activity (or main activity) influence communities' perception of ecosystem services [14, 44, 45], Gender [14, 44-47], age [46, 47], household size [8, 46, 47], income [48] and professional activity [18] are also considered to impact perception. Another influential factor is the level of education [25]. The different variables are summarized in Table 1.

Table 1. *Socio-economic variables of individuals.*

Variables	Symbols	Comments	Variable type
Gender	GEN	Gender (Female = 0; Male = 1)	Nominal
Age	AGE	Respondent's age	Quantitative
Ethnicity	ETHN	Ethnicity or mother tongue of individuals (Bariba = 1; Peulh = 2; Gourmantche / Lokpa / Ditamari / Kabie / Sola / Natimba / Naténi / Yom / Berba = 3; Haoussa / Djerma / Dendi = 4; Fon / Yorouba = 5)	Ordinal
Level of education	LEVED	Respondents' level of education (0 = Uneducated; 1 = Literate; 2 = Primary; 3 = Secondary; 4 = Higher)	Ordinal
Household size	HOUS	Size of household headed by the respondent	Quantitative
Profession	PROF	Profession of head of the household surveyed (1 = Farmer; 2 = Breeder; 3 =	Ordinal

Variables	Symbols	Comments	Variable type
		Logger; 4 = Other)	
Income	INC	Household income according to respondent	Quantitative
Commune	COM	Commune of respondent (1 = Kerou; 2 = Kouande; 3 = Pehunco)	Ordinal

The different ecosystem services were categorized as follows: 0 = Not available; 1 = Low; 2 = Medium; or 3 = High. Therefore, in a random scenario, the probability of a service being rated as high is 25% (given there are four possibilities). This corresponds to 25% × 232 (232 being the sample size) = 58~~7.5~~ individuals. For the purposes of this study, services perceived as intense by 60 individuals (3 = High) were retained in the regression model. The influence of socio-economic variables on these selected ecosystem services was evaluated using the ordered Probit model. This model is capable of modeling both low and high intensities. The R package tool was used for this analysis.

Choices regarding the various ecosystem services were also collected and analyzed using descriptive statistics.

3. Results

3.1. Perceived Availability and Intensity of the Three Service Groups

Figure 2 shows the local perceptions of the availability and intensity of the three groups of ecosystem services in the region. The figure shows that cultural ecosystem services were practically unavailable in some populations. Conversely, provisioning services and regulating and supporting services showed a higher intensity on a scale of 1 to 3, with a slight advantage for regulating and supporting services.

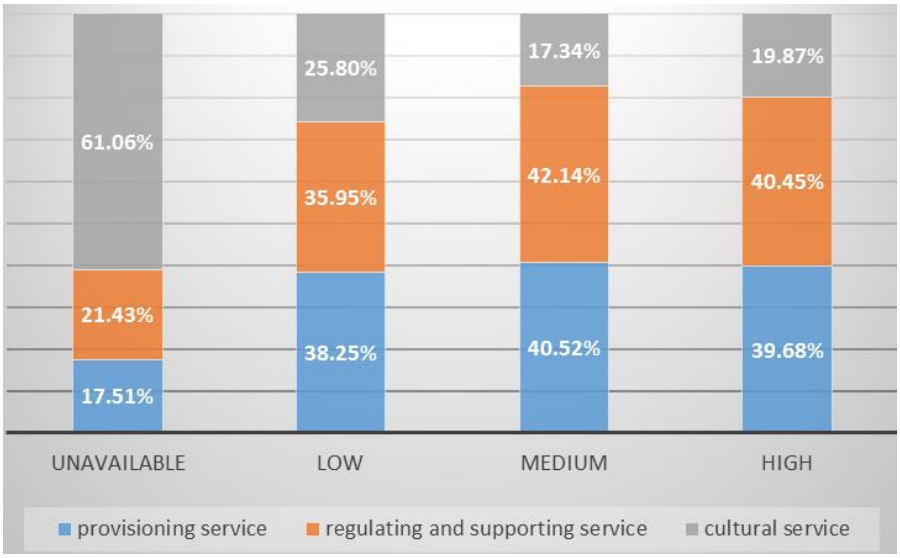

Figure 2. *Local perceptions of the availability and intensity of the three service groups.*

3.2. Service Availability and Intensity

In Figure 3, considering all 29 ecosystem services collectively, ecotourism was perceived as the least available service, with a frequency of 76. Conversely, two cultural services were perceived as intense: cultural practices and heritage (frequency = 89) and spirituality (frequency = 107). Among regulating and supporting services, the most abundant were soil formation (frequency = 128), erosion regulation (frequency =124), and climate regulation (frequency = 132). The most intense provisioning services were those provided through plant-derived medicines (frequency = 116), rafters and planks (frequency = 97), livestock feed (frequency = 67), crops (frequency = 111), and energy (firewood) (frequency = 88). Overall, provisioning service was the most available with five items, followed by regulating and supporting services with three items and cultural service with two items. Note that regulating and supporting services had the highest frequency.

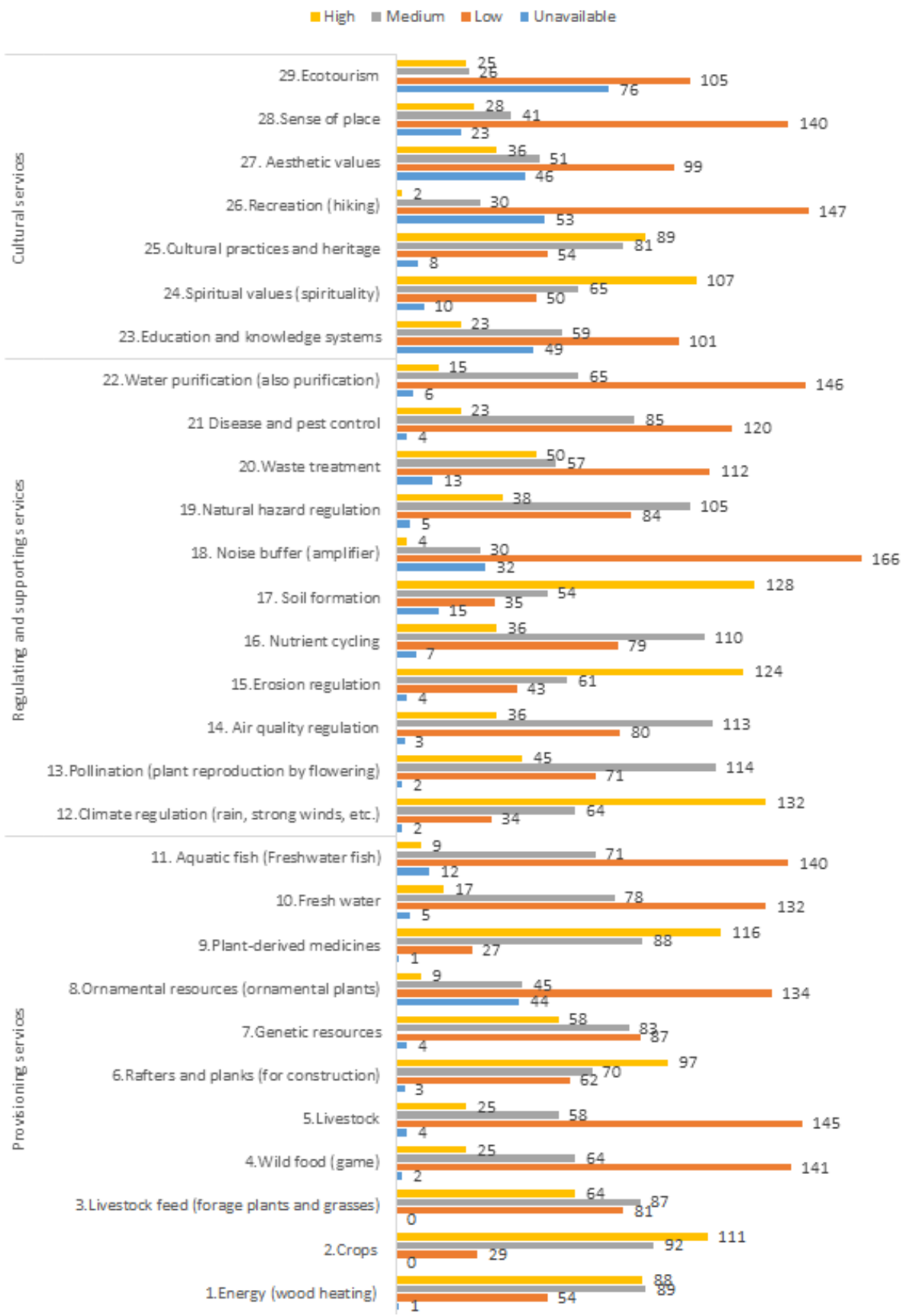

Figure 3. *Local perceptions of the availability and intensity of ecosystem services.*

Table 2. Socio-economic characteristics of individuals (qualitative variables).

Symbols	Variables	Description	Number	Percentage
GEN	Gender	Male	162	69.83
		Female	70	30.17
ETHN	Ethnic group or mother tongue	Bariba	170	73.28
		Peulh	10	4.31
		Gourmantche / Lokpa / Ditamari / Kabie / Sola / Natimba / Naténi / Yom / Berba	44	18.97
		Haoussa / Djerma / Dendi	5	2.16
		Fon / Yorouba	3	1.29
LEVED	Level of education	Uneducated	142	61.21
		Literate	6	2.59
		Primary	36	15.52
		Secondary	42	18.10
		Higher	6	2.59
PROF	Profession	Farmer	204	87.93
		Breeder	9	3.88
		Logger	4	1.72
		Others	15	6.47
COM	Individual's commune	Kerou	31	13.36
		Kouande	141	60.78
		Pehunco	60	25.86

Table 3. Characteristics of quantitative variables.

Variables	Mean	Min	Max
AGE	47.21	20	80
HOUS	9.02	0	30
INC	870,388	45,000	10,000,000

3.3. Socio-economic Characteristics of Individuals

Tables 2 and 3 show the socio-economic characteristics of the surveyed individuals. Among them, 69.83% were men, and the average age was 47.21 years, with an average income of 870,388 F CFA. The average household size was 9.02 individuals. The majority belonged to the Bariba ethnic group (73.28%) and were engaged in farming activities (87.93%), whereas 18.97% were Gourmantché or assimilated. Regarding education levels, 61.21% were uneducated, 15.52% had primary education, and 18.10% had secondary education. Geographically, most individuals originated from Kouande (60.78%), followed by Pehunco (25.86%).

3.4. Impact of socio-economic Factors on the Perceived Availability of Services

According to Figure 3, 10 ecosystem services had an intensity greater than or equal to 60. These services are presented in Section 3.2, comprising 5 ecosystem services from the provisioning services group, three from the regulating and supporting services group, and two from the cultural services

group. Table 4 presents the ordered Probit regression for these services, together with the determining factors.

Regarding the ecosystem service energy (firewood), significant independent variables included gender and higher education level at the 1% significance level, age and occupation (i.e., foresters and other occupations) at 5%, and ethnicity (i.e., Gourmantché and assimilated group) at 10%. This means that these variables had a significant effect on the probability of using wood as a source of heating energy.

The coefficients of significant variables indicate both the direction and intensity of their effect on the dependent variable, assuming all other things are equal. The positive coefficient for gender suggests that men had a higher probability of using wood as a source of heating energy than women. Conversely, a negative coefficient for age means that as age increased, the probability of using wood as a source of heating energy decreased. Regarding education level, the negative coefficient for higher education means that as the level of education increased, the probability of using wood for fuel decreased compared to individuals with no formal education.

The coefficient for foresters was negative, meaning that these individuals had a lower probability of using wood for energy than farmers. Individuals in other professions had a lower probability of using wood for energy than farmers, as shown by their negative coefficients. Similarly, the Gourmantché and assimilated ethnic group had a negative coefficient, suggesting a lower probability of using wood for energy than the Bariba ethnic group.

For the ecosystem service of Crops, only the variables ethnicity, Gourmantché group, and other occupations were significant (at 5% and 1%, respectively), with all coefficients being zero. Thus, Gourmantché individuals had a lower probability of working in the fields than Bariba individuals. Similarly, individuals in other occupations had a lower probability of working in the fields than Bariba individuals, all other things being equal. The coefficients for gender and occupation were positive, indicating that men had a higher probability of using rafters and planks than women, and individuals in occupations such as foresters and others also had a higher probability of using rafters and planks than farmers.

None of the variables explained the ecosystem service of plant-derived medicinal products.

As for the ecosystem service of climate regulation (including Puie, violent winds, etc.), it was negatively influenced at 1% by age and the commune of Pehunco and at 10% by the commune of Kouande. With increasing age, the probability of using climate regulation decreased, and the Kerou commune had a more favorable perception toward climate regulation than the other two communes: Kouande and Pehunco.

The ecosystem service of erosion control was positively influenced by household size (10%) but negatively influenced by the level of education (10% by literate and above) and the commune of Pehunco (1%). This suggests that the higher level of education the less interested people were in this service, and individuals in Pehunco had a less favorable perception toward this service than those in Kerou. Conversely, the greater the household size, the more favorable the perception toward the erosion control service.

The soil formation service was positively influenced by gender (5%) and negatively influenced by individuals from Pehunco (10%). Thus, men had a higher probability of utilizing this service than women, but individuals from Pehunco had a lower probability than those from Kerou.

The spirituality service was positively influenced by gender and negatively influenced by income. As a result, men had a higher probability of using this service than women, but its importance decreased with increasing income.

The final ecosystem service influenced was cultural practices and heritage, which was positively influenced by gender (5%) and negatively influenced by the Haoussa and assimilated ethnicity. Therefore, men had a higher probability of using this service than women, whereas the Haoussa had a less favorable perception toward this service than the Bariba.

In summary, gender had a significant influence on the 1% probability of using ecosystem services. Specifically, men had a 1% higher probability of using ecosystem services such as energy, livestock feed, rafters, and spiritual values than women. They are also more inclined than women to use services such as soil formation and cultural practices and heritage. As for age, being young influenced the use of certain services. Young people were 1% more likely to use climate control and 5% more likely to use energy. With regard to ethnicity, the Bariba ethnic group influenced the use of services: 10% more likely to use energy than the Gourmantché; 5% more likely to use cultural practices/heritage and rafters and planks than the Gourmantché; 10% more likely to use cultural practices/heritage than the Haoussa; and 10% more likely to use rafters and planks than the Fon. Uneducated individuals had a significant influence on the use of the energy service and erosion control than those with a higher level of education. Household size only had a positive influence on erosion control. Likewise, income only had a negative influence on spirituality. Farmers had a significant influence on energy use compared to foresters and other occupations, whereas foresters and other occupations influenced the chevron service. The commune of Kerou had a greater influence on the climate regulation service than the communes of Kouande and Pehunco. Similarly, it has a greater impact on erosion regulation and soil formation services than the commune of Pehunco. However, the commune of Pehunco had a greater influence on the livestock feed service than the commune of Kerou.

Table 4. *Regression analysis of high-intensity ecosystem services and their determining factors.*

Symbole	Variables	Description	1. Energy (firewood)			2. Cultural			3. Livestock feed (forage plants and grasses)		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
GEN	Gender	Female = 0									
		Male = 1	0.5365333***	0.1873449	0.004	0.0435222	0.1867298	0.816	0.4811034***	0.1844536	0.009
AGE	Age	Age	-0.0183686**	0.008152	0.024	0.0071571	0.0082486	0.386	4-0.0066172	0.0079212	0.404
ETHN	Ethnic group	Bariba = 1									
		Peulh = 2	0.2165183	0.5184498	0.676	-0.5081555	0.4972174	0.307	0.0671632	0.4972832	0.893
		Gourmantche / Lokpa / Ditamari / Kabie / Sola / Natimba / Naténi / Yom / Berba = 3	-0.3943931*	0.2174041	0.070	-0.5066514**	0.2215401	0.022	-0.282755	0.2239481	0.207
		Haoussa / Djerma / Dendi = 4	5.453077	134.8353	0.968	0.2871763	0.5775186	0.619	0.457737	0.5072673	0.367
		Fon /Yorouba = 5	-0.1105998	0.6912035	0.873	0.7868114	0.8378213	0.348	0.0299135	0.6419325	0.963
LEVED	Level of education	Uneducated = 0									
		Literate = 1	-0.0756864	0.4747123	0.873	-0.6102095	0.4735596	0.198	-0.0963473	0.4970976	0.846
		Primary = 2	-0.0423326	0.2244661	0.850	0.0648444	0.231841	0.780	-0.2048914	0.2241801	0.361
		Secondary = 3	-0.0281825	0.2162341	0.896	-0.1147655	0.2163523	0.596	0.1801509	0.2107039	0.393
		Higher = 4	-1.395089***	0.4987227	0.005	-0.5757663	0.4850953	0.235	-0.0398752	0.4986553	0.936
HOUS	Household size	Household size	0.0128927	0.0223173	0.563	-0.0110805	0.0235297	0.638	0.0275904	0.0221788	0.214
PROF	Profession	Farmer = 1									
		Breeder = 2	0.3043059	0.5353634	0.570	0.7059093	0.5273774	0.181	-0.2420545	0.5163983	0.639
		Logger = 3	-1.578541**	0.7161471	0.028	0.6205422	0.6969306	0.373	1.009923	0.663216	0.128
		Others = 4	-0.6937696**	0.3030044	0.022	-0.7945195***	0.3093846	0.010	0.4001621	0.3136781	0.202
INC	Household income	Household income	2.22e-08	7.29e-08	0.761	1.25e-07	8.09e-08	0.123	-5.71e-08	6.91e-08	0.408
COM	Commune	Kerou = 1									
		Kouande = 2	0.3858438	0.2410439	0.109	0.0499816	0.2469743	0.840	0.2603887	0.2404278	0.279
		Pehunco = 3	0.2337916	0.2696074	0.386	0.1314934	0.2724136	0.629	0.7218806***	0.2659428	0.007
		/cut1	-3.267329	0.6357754		-0.9803614	0.4209575		0.1316486	0.4043736	
		/cut2	-0.9645391	0.4197498		0.3389249	0.4162922		1.206265	0.4093805	
		/cut3	0.1908453	0.417664							
		Number of obs.	232			232			232		

Symbole	Variables	Description	1. Energy (firewood)			2. Cultural			3. Livestock feed (forage plants and grasses)		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
		LR chi^2 (17)	50.26			33.47			32.22		
		Prob > chi^2	0.0000			0.0098			0.0141		
		Pseudo R^2	0.0987			0.0736			0.0637		
		*p < 0.1; **p < 0.05; ***p < 0.01									

Symbole	Variables	Description	6. Rafters and planks (for construction)			9. Herbal medicines			12. Climate regulation (rain, strong winds, etc.)		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
GEN	Gender	Female = 0									
		Male = 1	0.5659342***	0.1829486	0.002	-0.2333861	0.1886918	0.216	0.2676651	0.1905371	0.160
AGE	Age	Age	-0.0123627	0.0078918	0.117	-0.004195	0.0081868	0.608	-0.0242045***	0.0081725	0.003
ETHN	Ethnic group	Bariba = 1									
		Peulh = 2	0.1493007	0.4772002	0.754	-0.23596	0.498509	0.636	0.6218746	0.5404493	0.250
		Gourmantche / Lokpa / Ditamari / Kabie / Sola / Natimba / Naténi / Yom / Berba = 3	-0.4889425**	0.2283395	0.032	-0.03957	0.2297742	0.863	-0.0423149	0.2383528	0.859
		Haoussa / Djerma / Dendi = 4	0.6792158	0.5652309	0.229	0.0905301	0.5402345	0.867	0.4501663	0.5728505	0.432
		Fon /Yorouba = 5	-1.125749*	0.6480641	0.082	5.064603	182.2247	0.978	-0.0080724	0.701547	0.991
LEVED	Level of education	Uneducated = 0									
		Literate = 1	-0.7533214	0.4826794	0.119	0.6317095	0.5363804	0.239	0.3721401	0.5281798	0.481
		Primary = 2	-0.0210626	0.2188216	0.923	-0.2236989	0.2222506	0.314	-0.3467421	0.2247305	0.123
		Secondary = 3	0.3508293	0.2247814	0.119	0.2219467	0.2235574	0.321	0.1631842	0.2354988	0.488
		Higher = 4	-0.3871822	0.4997415	0.438	-0.3892738	0.4754491	0.413	-0.0020815	0.5532876	0.997
HOUS	Household size	Household size	0.0106042	0.0220661	0.631	0.0004725	0.0229393	0.984	0.0096168	.0228298	0.674
PROF	Profession	Farmer = 1									
		Breeder = 2	-0.6476679	0.4889164	0.185	-0.1332683	0.5159991	0.796	-0.7370866	0.548723	0.179
		Logger = 3	1.341696**	0.6803901	0.049	0.2840881	0.6072535	0.640	1.147129	0.6917975	0.112
		Others = 4	0.8370464**	0.3588407	0.020	0.1365824	0.3320583	0.681	0.4022459	0.3606756	0.265

Symbole	Variables	Description	6. Rafters and planks (for construction)			9. Herbal medicines			12. Climate regulation (rain, strong winds, etc.)		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
INC	Household income	Household income	4.48e-08	6.96e-08	0.520	8.94e-08	7.43e-08	0.229	1.10e-07	8.10e-08	0.175
		Kerou = 1									
COM	Commune	Kouande = 2	0.0591395	0.2478707	0.811	0.2308425	0.2433096	0.343	-0.483731*	0.278143	0.082
		Pehunco = 3	-0.3537007	0.2685224	0.188	-0.2207994	0.2607041	0.397	-1.199471***	0.2998575	0.000
		/cut1	-2.590838	0.4759091		-2.970778	0.5593404		-4.097433	0.5594658	
		/cut2	-0.762255	0.4133415		-1.405578	0.4222163		-2.482382	0.46186	
		/cut3	0.1135296	0.4118423		-0.1738517	0.4138586		-1.530825	0.447408	
		Number of obs.	232			232			232		
		LR chi^2 (17)	39.56			20.26			39.77		
		Prob > chi^2	0.0015			0.2612			0.0014		
		Pseudo R^2	0.0751			0.0442			0.0858		
		*p < 0.1; **p < 0.05; ***p < 0.01									

Symbol	Variables	Description	15. Erosion regulation			17. Soil formation			24. Spiritual values (spirituality)			25. Cultural practices and heritage		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
GEN	Gender	Female = 0												
		Male = 1	0.2367566	0.1939962	0.222	0.4005283**	0.1848106	0.030	0.5786724***	0.1809268	0.001	0.4215157**	0.1783115	0.018
AGE	Age	Age	-0.0026009	0.0082235	0.751	-0.0043681	0.0079423	0.582	-0.0050137	0.0079464	0.528	-0.0025772	0.0077409	0.739
ETHN	Ethnic group	Bariba = 1												
		Peulh = 2	-0.1965223	0.5058934	0.698	0.6472901	0.5112561	0.205	-0.1546186	0.4978157	0.756	-0.6190543	0.4755787	0.193
		Gourmantche / Lokpa / Ditamari / Kabie / Sola / Natimba / Naténi / Yom / Berba = 3	0.1025848	0.2488056	0.680	0.2583307	0.2385832	0.279	-0.2895658	0.2172691	0.183	-0.4149937*	0.2176966	0.057
		Haoussa / Djerma / Dendi = 4	-0.1940564	0.5403399	0.719	0.1656218	0.5343449	0.757	0.3660981	0.5602762	0.513	0.0209709	0.5154004	0.968
		Fon / Yorouba = 5	-0.2708989	0.7599577	0.721	-0.5121188	0.6540117	0.434	-0.2088372	0.6588663	0.751	-0.9168905	0.6437138	0.154

Symbol	Variables	Description	15. Erosion regulation			17. Soil formation			24. Spiritual values (spirituality)			25. Cultural practices and heritage		
			Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value	Coeff.	Std. Err.	P value
		Uneducated = 0												
		Literate = 1	-0.8313948*	0.4898656	0.090	-0.4005879	0.4549153	0.379	0.2732729	0.5151228	0.596	0.3490436	0.5071344	0.491
LEVED	Level of education	Primary = 2	0.1051355	0.2384542	0.659	-0.3447903	0.2193173	0.116	-0.0709479	0.2158652	0.742	-0.1889562	0.2121649	0.373
		Secondary = 3	0.3796764	0.2424094	0.117	0.1972528	0.2287504	0.389	0.2151465	0.2188414	0.326	0.2912489	0.2131009	0.172
		Higher = 4	-0.8775654*	0.4767542	0.066	-0.2128149	0.5208604	0.683	-0.1852872	0.4766085	0.697	-0.4816773	0.4669983	0.302
HOUS	Household size	Household size	0.0409162*	.0235452	0.082	-0.0143946	0.0224486	0.521	0.0112653	0.0217462	0.604	-0.0089511	0.0213146	0.675
		Farmer = 1												
		Breeder = 2	0.2869754	0.5401173	0.595	-0.7826824	0.5045437	0.121	-0.5458172	0.5103836	0.285	-0.2051294	0.5014564	0.682
PROF	Profession	Logger = 3	1.468139	0.7152866	0.400	1.071586	0.6754506	0.113	0.0284682	0.5691207	0.960	0.434769	0.5961783	0.466
		Others = 4	0.5255365	0.3665239	0.152	0.5496993	0.3693427	0.137	0.5304983	0.3291825	0.107	0.8143433	0.3330612	0.114
INC	Household income	Household income	2.39e-08	8.33e-08	0.775	9.19e-08	7.25e-08	0.205	-1.37e-07**	6.84e-08	0.045	-2.17e-08	6.66e-08	0.745
		Kerou = 1												
COM	Commune	Kouande = 2	0.086164	0.2574789	0.738	-0.2033976	0.2516319	0.419	-0.0194304	0.2412518	0.936	0.1296441	0.2350783	0.581
		Pehunco = 3	-1.543888***	0.2833878	0.000	-0.5868342**	0.2755124	0.033	0.1186812	0.2705267	0.661	0.22491	0.26144	0.390
		/cut1	-2.651586	0.5016311		-1.858745	0.4406775		-1.664701	0.4297303		-1.763616	0.4250647	
		/cut2	-0.8590727	0.4312562		-1.034233	0.4228858		-0.5409439	0.4148298		-0.5072389	0.4034872	
		/cut3	0.1529073	0.4263006		-0.3165259	0.4194752		0.2557387	0.414921		0.4823418	0.4042936	
		Number of obs.	232			232			232			232		
		LR chi^2 (17)	92.48			30.18			25.19			26.85		
		Prob > chi^2	0.0000			0.0251			0.0905			0.0603		
		Pseudo R^2	0.1865			0.0576			0.0460			0.0486		
		*p < 0.1; **p < 0.05; ***p < 0.01												

4. Discussion

4.1. Ecosystem Services

According to our findings, 10 ecosystem services had a high intensity in the study area. Among these, 5 ecosystem services belonged to the provisioning services group, three to the regulating and supporting services group, and two to the cultural services group. These findings put the provisioning service in first place. Previous studies have also confirmed this top ranking for the provisioning service [8, 13, 18]. Our results are also similar to those of previous work [41, 43, 50]. The preference for the provisioning service can be explained by the fact that it offers direct, tangible services [8].

Among the 10 ecosystem services with a high intensity, the provisioning service was the most highly preferred, followed by the regulating and supporting service and, finally, the cultural service. This result differs slightly from those of previous studies, for which the provisioning service was followed by the cultural service, with the regulating service being least valued by individuals [8, 18, 50, 51]. This difference in results can be explained by the quality of the individuals in the sample population: over 80% of the individuals in the current study were farmers. Consequently, regulating and supporting services had a direct impact on their agricultural yields through soil fertility and rainfall.

Within each service group, the results showed that the most abundant ecosystem services were plant-derived medicines, rafters and planks, livestock feed, crops, and energy (firewood) for the provisioning service group. Various studies have shown a diversity of services perceived as important by local populations. However, some services enjoy consensus, such as crop [8, 41, 49, 50], firewood [8, 13, 41, 49-51], rafters supply [8, 43, 50], and pharmacopoeia [8, 41, 50, 51]. A few studies also agree on the importance of livestock feed [13]. However, the importance of food provision was not confirmed by our study, as indicated by the results of previous studies ~~of~~ [8, 13, 18, 41, 43, 49]. Therefore, this diversity within provisioning services, despite a consensus on certain services, clearly indicates that perceptions of ecosystem services vary from one region to another, from one community to another, and from one period to another.

Perceptions of the regulating and supporting service group showed the same diversity. Thus, according to our results, the perception of climate regulation service aligned with previous studies [8, 49]. Perception of the soil formation service correlated with other studies [49, 50]. On the other hand, Gouwakinnou et al. argue that the soil formation service is unknown to communities [8]. Regarding the result related to the erosion regulation service, its perception aligns well with previous research [52, 53]. Indeed, when woody formations become degraded, soil degradation also occurs, leading to an acceleration of the water cycle and significant changes in microclimates [52]. This phenomenon takes on critical proportions in the Sudano-Sahelian regions [54], where the study area is located.

The final group was culture, comprising services such as spirituality [8] and cultural practices and heritage. Admittedly, few previous studies have considered the regulating service, particularly the cultural service. Lhoest et al. recommend that further studies on ecosystem services should focus on services such as recreation, tourism, spirituality, air quality, and cultural inspiration [18].

4.2. Influencing Factors

Several socio-economic factors influenced the communities' perception of ecosystem services.

In particular, men determined the perception of ecosystem services. In line with previous studies, the role of men was decisive, especially for the regulating service, specifically water regulation [55, 56]. Men, who are more numerous in the agricultural sector, play a role at several levels, including field activities, animal husbandry, and regulation assessment. Although Allendorf and Yang suggested that the elderly have a significant role in water regulation, our study showed that young people had the greatest influence on the perception of ecosystem services, especially regarding climate regulation [57]. This shows the importance of young people, who remain the lifeblood of production in the study area. To maintain and improve ecosystem services, it is necessary to sensitize and train this segment of the population. The other influencing factor was ethnicity, as shown by Allendorf and Yang [57]. In the context of this study, energy services, crops, cultural practices and heritage, the exploitation of logs for construction, and the Bariba, an indigenous community, had more influence in the use of ecosystem services. It is, therefore, important to raise their awareness of the need for sustainable use of wood for energy and timber (rafters). In terms of their role in the fields, young people need increasing encouragement to practice agroecology, an environmentally friendly form of agriculture. Enhancing their cultural practices can also be achieved through ecotourism, providing an alternative source of income. Regarding educational level, being uneducated had a significant influence, consistent with the work of Dave et al. [43]. However, other studies emphasized the influence of high educational attainment [8, 36, 57, 58]. In this study, the uneducated had a greater influence on the wood energy service and erosion regulation, whereas those with a high level of education used less and less wood energy. Wood is an energy source for villages and counties, Therefore, it is important that these individuals are encouraged to use improved stoves that require less wood. Like Gouwakinnou et al., our results showed that household size had a significant influence [8]. As for profession, farmers perceived the fuelwood and crop services (fields) as important. This is in line with the work of Allendorf and Yang, even though they focused on a particular type of crop: sugarcane [57]. For these individuals, agroecology and less wood-intensive stoves are essential considerations for the sustainable use of wood. Our

results showed that loggers played a leading role in the exploitation of logs as a source of income. This activity deserves to be better supervised. Income in turn influenced ES. Previous work also shows the same result [8, 36, 43, 58]. Note that Dave et al. make it clear that these are people who derive their income from forest use [43]. In our study, individuals with lower incomes had more influence on the use of the spirituality service. Therefore, it is also important to promote this practice in ecotourism in order to improve their income. Finally, our results showed the influence of commune (location) on ecosystem services such as climate regulation, erosion regulation, and soil formation, whereas previous studies have focused primarily on communities living in close proximity to forests [8, 25, 49].

Overall, communities' perception of ecosystem services was linked to the benefits they derive from forests. Thus, the exploitation of these natural resources needs to be sustainable. In addition, for cultural and related services, it is important to involve communities in ecotourism. This will enable them to diversify their income while also protecting these natural resources.

5. Conclusion

Ecosystem services are closely linked to the daily lives of local communities, particularly those living near forests. The study of the local perceptions of these services is relevant because they vary depending on the community, the study period, and the environment. The present study aimed to analyze local communities' perception of the ecosystem services provided by the forest, and the factors that determine this perception. The results showed that out of the 29 ecosystem services, communities perceived only around 10 to be important. Factors influencing this perception included gender (male), age (young individuals), farming occupation, household size, level of education, and income.

This study focused on local communities' perception of ecosystem services. For the sustainable exploitation of the region's forest resources, it is necessary to encourage young people to promote environmentally friendly agriculture and cultural services to diversify their incomes. However, these communities have limited knowledge of ecotourism services, although they are developing actions related to spirituality and cultural practices that can be recuperated through ecotourism. Therefore, we invite future studies to focus on income diversification for forest-dwelling populations and ecotourism.

Abbreviations

ES: Ecosystem Services

NTFPs: Non-Timber Forest Products

2KP: Kerou, Kouande, and Pehunco

F CFA: Franc of the African Financial Community (This is the currency used in Benin. At the time of the study, US$1 was equivalent to approximately 600 F CFA)

Author Contributions

Robert Sourokou: Conceptualization, Software, Data curation, Formal Analysis, Investigation, Visualization, Methodology, Writing - original draft

Fifanou Gbèdidji Vodouhe: Data curation, Supervision, Validation, Methodology, Writing - review & editing

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Conflicts of Interest

The authors declare no conflicts of interests.

References

[1] Westman, W. E. How much are nature's services worth?, *Science*, 1977, 197(4307), 960-964.

[2] Ehrlich, P. R., Mooney, H. A. Extinction, Substitution, and Ecosystem Services. *BioScience*. 1983, 33(4), 248-254. https://doi.org/10.2307/1309037

[3] Costanza, R. *et al*. The Value of the World's Ecosystem Services and Natural Capital. 1997, 387(6630), 253-260. https://doi.org/10.1038/387253a0

[4] Danley, B., Widmark, C. Evaluating conceptual definitions of ecosystem services and their implications. *Ecological Economic. 2016*, 126, 132-138. https://doi.org/10.1016/j.ecolecon.2016.04.003

[5] de Groot, R. S., Wilson, M. A., Boumans, R. M. J. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics. 2002*, 41(3), 393-408. https://doi.org/10.1016/S0921-8009(02)00089-7

[6] Millennium, E. A. *Ecosystems and human well-being: wetlands and water synthesis: a report of the Millennium Ecosystem Assessment*. Washington, DC: World Resources Institute, 2005.

[7] de Groot, R. S., Alkemade, R., Braat, L., Hein, L., Willemen, L. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity. 2010*, 7(3), 260-272. https://doi.org/10.1016/j.ecocom.2009.10.006

[8] Gouwakinnou, G. N., Biaou, S., Vodouhe, F. G., Tovihessi, M. S., Awessou, B. K., Biaou, H. S. S. Local perceptions and factors determining ecosystem services identification around two forest reserves in Northern Benin. *J Ethnobiology Ethnomedicine*. 2019, 15(1), 61. https://doi.org/10.1186/s13002-019-0343-y

[9] Sunderlin, W. D. et al., Livelihoods, forests, and conservation in developing countries: An Overview. *World Development.* 2005, 33(9), 1383-1402. https://doi.org/10.1016/j.worlddev.2004.10.004

[10] Cámara-Leret, R., Fortuna, M. A., Bascompte, J. Indigenous knowledge networks in the face of global change. *Proc. Natl. Acad. Sci. U. S. A.* 2019, 116(20), 9913-9918. https://doi.org/10.1073/pnas.1821843116

[11] Gaoue, O. G., Ticktin, T. Patterns of harvesting foliage and bark from the multipurpose tree Khaya senegalensis in Benin: Variation across ecological regions and its impacts on population structure. *BIOLOGICAL CONSERVATION. 2007*, 137(3), 424-436. https://doi.org/10.1016/j.biocon.2007.02.020

[12] Fandohan, B., Glele, K. R., Sinsin, B., Pelz, D. CARACTERISATION DENDROMETRIQUE ET SPATIALE DE TROIS ESSENCES LIGNEUSES MEDICINALES DANS LA FORET CLASSEE DE WARI-MARO AU BENIN. 2008, 12, 173-186.

[13] Sambou, A., Camara, B., Kémo, A. O., Coly, A. Badji, A. Perception des populations locales sur les services écosystémiques de la forêt classée et aménagée de Kalounayes (Sénégal). 2018, 19. http://rivieresdusud.uasz.sn/xmlui/handle/123456789/671

[14] Vodouhê, G. F., Coulibaly, O., Sinsin, B. Estimating local values of vegetable non-timber forest products to Pendjari Biosphere Reserve dwellers in Benin. *IUFRO World Series.* 2009, 23(63-72).

[15] Angelsen, A. *et al.* Environmental Income and Rural Livelihoods: A Global-Comparative Analysis », *World Development*. 2014, 64, S12-S28. https://doi.org/10.1016/j.worlddev.2014.03.006

[16] Ickowitz, A., Powell, B., Salim, M. A., Sunderland, T. C. H. Dietary quality and tree cover in Africa. *Global Environmental Change*. 2014, 24, 287-294. https://doi.org/10.1016/j.gloenvcha.2013.12.001

[17] FAO, PNUE. *La situation des forêts du monde 2020. Forêts, biodiversité et activité humaine.* Rome. 2020. https://doi.org/10.4060/ca8642fr

[18] Lhoest, S., Dufrêne, M., Vermeulen, C., Oszwald, J., Doucet, J.-L., Fayolle, A. Perceptions of ecosystem services provided by tropical forests to local populations in Cameroon. *Ecosystem Service. 2019*, 38, 100956. https://doi.org/10.1016/j.ecoser.2019.100956

[19] Clark, D. A. Sources or sinks? The responses of tropical forests to current and future climate and atmospheric composition », *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*. 2004, 359(1443), 477-491. https://doi.org/10.1098/rstb.2003.1426

[20] Lewis, S. L. *et al.* Increasing carbon storage in intact African tropical forests. *Nature*. 2009,457(7232), 1003-1006. https://doi.org/10.1038/nature07771

[21] Sloan, S., Sayer, J. A. Forest Resources Assessment of 2015 shows positive global trends but forest loss and degradation persist in poor tropical countries., *Forest Ecology and Management*. 2015, 352, 134-145. https://doi.org/10.1016/j.foreco.2015.06.013

[22] Adjonou, K., Ali, N., Kokutse, A. D., Novigno, S. K. Etude de la dynamique des peuplements naturels de Pterocarpus erinaceus Poir.(Fabaceae) surexploités au Togo. *Bois & Forêts des Tropiques*. 2010, 306, 45-55. https://doi.org/10.19182/bft2010.306.a20431

[23] Vodouhê, F. G., Coulibaly, O., Adégbidi, A., Sinsin, B. Community perception of biodiversity conservation within protected areas in Benin. *Forest Policy and Economics*. 2010, 12(7), 505-512. https://doi.org/10.1016/j.forpol.2010.06.008

[24] Collins S. L., *et al.* An integrated conceptual framework for long‐term social–ecological research. *Frontiers in Ecology and the Environment*. 2011, 9(6), 351-357. https://doi.org/10.1890/100068

[25] Sodhi, N. S. *et al.* Local people value environmental services provided by forested parks. *Biodiversity and Conservation.* 2010, 19(4), 1175-1188. https://doi.org/10.1007/s10531-009-9745-9

[26] Djossa, B. A., Toni, H., Dossa, K., Azonanhoun, P., Sinsin, B. Local perception of ecosystem services provided by bats and bees and their conservation in Bénin, West Africa. *International Journal of Biological and Chemical Sciences*. 2012, 6(5), 2034-2042. https://doi.org/10.4314/ijbcs.v6i5.13

[27] Asah, S. T., Guerry, A. D., Blahna, D. J., Lawler, J. J. Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. *Ecosystem Services*. 2014, 10, 180-186. https://doi.org/10.1016/j.ecoser.2014.08.003

[28] Castro, A. J., Martín-López, B., García-Llorente, M., Aguilera, P. A., López, E., Cabello, J. Social preferences regarding the delivery of ecosystem services in a semiarid Mediterranean region. *Journal of Arid Environments*. 2011, 75(11), 1201-1208. https://doi.org/10.1016/j.jaridenv.2011.05.013

[29] de Freitas, C. T., Shepard Jr, G. H., Piedade, M. T. The floating forest: traditional knowledge and use of matupá vegetation islands by riverine peoples of the Central Amazon. *PloS one*. 2015, 10(4), e0122542. https://doi.org/10.1371/journal.pone.0122542

[30] Boafo, Y. A., Saito, O., Kato, S., Kamiyama, C., Takeuchi, K., Nakahara, M. The role of traditional ecological knowledge in ecosystem services management: the case of four rural communities in Northern Ghana. *International Journal of Biodiversity Science, Ecosystem Services & Management.* 2016, 12(1-2), 24-38. https://doi.org/10.1080/21513732.2015.1124454

[31] Houde, N. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 2007, 12(2). https://www.jstor.org/stable/26267900

[32] LaRochelle, S., Berkes, F. Traditional ecological knowledge and practice for edible wild plants: Biodiversity use by the Rarámuri, in the Sirerra Tarahumara, Mexico. *The International Journal of Sustainable Development & World Ecology*. 2003, 10(4), 361-375. https://doi.org/10.1080/13504500309470112

[33] Parrotta, J. A., Agnoletti, M. Traditional forest-related knowledge and climate change. in *Traditional Forest-Related Knowledge*, Springer. 2012, 491-533. https://doi.org/10.1007/978-94-007-2144-9_13

[34] Braat, L. C., De Groot, R. The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy, *Ecosystem services*,. 2012, 1(1), 4-15. https://doi.org/10.1016/j.ecoser.2012.07.011

[35] Parrotta, J., Yeo-Chang, Y., Camacho, L. D. Traditional knowledge for sustainable forest management and provision of ecosystem services. 2016. https://doi.org/10.1080/21513732.2016.1169580

[36] Martín-López, B., *et al.* « Uncovering ecosystem service bundles through social preferences. *PLoS one*. 2012, 7(6), e38970. https://doi.org/10.1371/journal.pone.0038970

[37] Keune, H., *et al.* Emerging ecosystem services governance issues in the Belgium ecosystem services community of practice. *Ecosystem services*. 2015,16, 212-219. https://doi.org/10.1016/j.ecoser.2015.06.001

[38] Kremen, C., Ostfeld, R. S. A. call to ecologists: measuring, analyzing, and managing ecosystem services. *Frontiers in Ecology and the Environment*. 2005, 3(10), 540-548. https://doi.org/10.1890/1540-9295

[39] Satz, D., *et al.* The challenges of incorporating cultural ecosystem services into environmental assessment. *Ambio*. 2013, 42(6), 675-684. https://doi.org/10.1007/s13280-013-0386-6

[40] Cuni-Sanchez, A., Pfeifer, M., Marchant, R., Burgess, N. D. Ethnic and locational differences in ecosystem service values: Insights from the communities in forest islands in the desert. *Ecosystem Services*. 2016, 19, 42-50. https://doi.org/10.1016/j.ecoser.2016.04.004

[41] Zhang, W., *et al.* Awareness and perceptions of ecosystem services in relation to land use types: Evidence from rural communities in Nigeria. *Ecosystem Services*. 2016, 22, 150-160. https://orcid.org/10.1016/j.ecoser.2016.10.011

[42] INSAE, RGPH-4. PRINCIPAUX INDICATEURS SOCIO DEMOGRAPHIQUES ET ECONOMIQUES (RGPH4-2013). Available from: https://www.google.com/search?source=hp&ei=bzFgXLXaJKivgwfF1ZTAAw&q=RGPH4+ (Assessed 10 february 2019)

[43] Dave, R., Tompkins, E. L., Schreckenberg, K. Forest ecosystem services derived by smallholder farmers in northwestern Madagascar: Storm hazard mitigation and participation in forest management. *Forest Policy and Economics*. 2017,84, 72-82. https://doi.org/10.1016/j.forpol.2016.09.002

[44] Gillingham, S., Lee, P. C. The impact of wildlife-related benefits on the conservation attitudes of local people around the Selous Game Reserve, Tanzania. *Environmental Conservation*. 1999, 218-228. https://doi.org/10.1017/S0376892999000302

[45] Mehta, J. N., Heinen, J. T. Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. Environmental management. 2001, 28(2), 165-177. https://doi.org/10.1007/s002670010215

[46] Ouko, C. A., Mulwa, R., Kibugi, R., Owuor, M. A., Zaehringer, J. G., Oguge, N. O. Community perceptions of ecosystem services and the management of Mt. Marsabit Forest in Northern Kenya., *Environments*. 2018, 5(11), 121. https://doi.org/10.3390/environments5110121

[47] Moutouama, F. T., Biaou, S. S. H., Kyereh, B., Asante, W. A., Natta, A. K. Factors shaping local people's perception of ecosystem services in the Atacora Chain of Mountains, a biodiversity hotspot in northern Benin. *Journal of ethnobiology and ethnomedicine*. 2019, 15(1) 1-10. https://doi.org/10.1186/s13002-019-0317-0

[48] Kinzer, A. Zones of Influence: Forest Resource Use, Proximity, and Livelihoods in the Kijabe Forest. 2018. https://hdl.handle.net/2027.42/145172

[49] Muhamad, D., Okubo, S., Harashina, K., Parikesit, Gunawan, B., Takeuchi, K. Living close to forests enhances people's perception of ecosystem services in a forest–agricultural landscape of West Java, Indonesia. *Ecosystem Services*. 2014, 8, 197-206. https://doi.org/10.1016/j.ecoser.2014.04.003

[50] Hartel, T., Fischer, J., Câmpeanu, C., Milcu, A. I., Hanspach, J., Fazey, I. The importance of ecosystem services for rural inhabitants in a changing cultural landscape in Romania. *E&S*. 2014, 19, 2, art42, 2014, https://doi.org/10.5751/ES-06333-190242

[51] Mensah, S. SELECTED KEY ECOSYSTEM SERVICES, FUNCTIONS, AND THE RELATIONSHIP WITH BIODIVERSITY IN NATURAL FOREST ECOSYSTEMS. Doctoral dissertation, Stellenbosch University, Stellenbosch, 2016.

[52] FAO. La situation mondiale de l'alimentation et de l'agriculture 2005. Available from: http://www.fao.org/docrep/008/a0050f/a0050f19.htm (Assessed 10 février 2022)

[53] Ryan, C. M., Pritchard, R., McNicol, I., Owen, M., Fisher, J. A., Lehmann, C. Ecosystem services from southern African woodlands and their future under global change. *Phil. Trans. R. Soc. B.*2016, 371(1703), 20150312. https://doi.org/10.1098/rstb.2015.0312

[54] Hountondji, Gaoué O. G., Sokpon, N., Ozer, P. Analyse écogéographique de la fragmentation du couvert végétal au nord Bénin : paramètres dendrométriques et phytoécologiques comme indicateurs in situ de la dégradation des peuplements ligneux. *Geo-Eco-Trop: Revue Internationale de Géologie, de Géographie et d'Écologie Tropicales*. 2013, 37(1). https://hdl.handle.net/2268/163267

[55] Hartter, J. Resource Use and Ecosystem Services in a Forest Park Landscape. *Society & Natural Resources.* 2010, 23(3), 207-223. https://doi.org/10.1080/08941920903360372

[56] Warren-Rhodes, K. *et al*. Mangrove ecosystem services and the potential for carbon revenue programmes in Solomon Islands. *Envir. Conserv.* 2011, 38(4,), 485-496. https://doi.org/10.1017/S0376892911000373

[57] Allendorf, T. D., Yang, J. The role of ecosystem services in park–people relationships: The case of Gaoligongshan Nature Reserve in southwest China. *Biological Conservation*. 2013, 167, 187-193. https://doi.org/10.1016/j.biocon.2013.08.013

[58] Poppenborg, P. Koellner, T. Do attitudes toward ecosystem services determine agricultural land use practices? An analysis of farmers' decision-making in a South Korean watershed. *Land Use Policy*. 2013, 31, 422-429. https://doi.org/10.1016/j.landusepol.2012.08.007