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# Farmers perceptions of ecosystem services provided by lowlands in Cote d'Ivoire and Nigeria

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**Acknowledgement:** We would like to thank all the funders who support this research through their contributions to the [CGIAR Trust Fund](#). To learn more about TAFS-WCA and other initiatives in the CGIAR research portfolio, please visit <https://www.cgiar.org/research/cgiar-portfolio/>.

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## 1. Introduction

Ecosystem services refer to both direct and indirect contributions (Julia *et al.*, 2019) that people derive from ecosystems (Rochette *et al.*, 2021). They are identified as procurement, regulation and support services, and cultural services according to Millennium Ecosystem Assessment (MEA, 2005). Ecosystem services are very important for the well-being and survival of people who depend on their continuous supplies, especially in poor countries where ecosystem services are essential to the livelihoods of many people (Jasper and Anil, 2014). Africa, in particular, is home to extraordinarily rich biodiversity with a high level of direct dependence on ecosystem services, which generate flows of goods and many services that are essential to human society and the local economy (Henri, 2020). Ecosystem services thus contribute to poverty reduction (Fisher *et al.*, 2014). For example, more than 80% of the population in sub-Saharan Africa depends on traditional medicines, while firewood, charcoal, crop residues, and cow dung provide 90% of the cooking energy (Zhang *et al.*, 2016).

However, in the face of strong anthropogenic pressures, such as rapid population growth, high dependence on natural resources for livelihoods, better knowledge and integration of ecosystem services into management plans is a key priority for African biosphere reserves (UNESCO, 2023). Indeed, the work of Zhang *et al.* (2016) showed that local residents' awareness, perceptions and value of ecosystem services are increasingly important.

Human interactions with ecosystems, as well as values, beliefs, and socio-economics, shape people's appreciation of what nature has to offer. The ecological characteristics of local landscapes also affect cognitive awareness and appreciation of the benefits of nature. For example, Muhamad *et al.* (2014) found that people living closer to forests were more likely to perceive ecosystem services in West Java, Indonesia. Abram *et al.* (2014) found marked spatial variations in the values and perceptions of local rural people regarding ecosystem services in the forest regions of Borneo. People's awareness and perceptions of ecosystem services, if maintained with conviction and strength, can also shape specific attitudes and behaviours (Willock *et al.*, 1999). For example, farmers who have relevant knowledge about pest regulation and pollination services provided by beneficial insects can refrain from spraying broad-spectrum chemical insecticides that can damage beneficial insect populations, thereby minimizing the negative effects associated

with the indiscriminate use of agrochemicals. Environmental knowledge is also predictive of the level of adoption of conservation practices. Poppenborg and Koellner (2013) examined how knowledge of four services (primary production, flood control, water purification and biodiversity) influences farmers' crop choices in a South Korean watershed. They found that farmers' decisions to plant perennial crops are most often accompanied by positive attitudes towards ecosystem services.

Given the high potential for agricultural production, based on relatively safe water availability and good soil fertility levels compared to the surrounding highlands, the interior valleys offer opportunities to improve the food and nutrition security of smallholder farming families in sub-Saharan Africa, even more so in the face of climate change. With an estimated area of 190 million hectares, inland valleys are common landscapes in sub-Saharan Africa. In addition to agricultural production, i.e. mainly rice-based systems including vegetable, fruit, and livestock production, lowlands provide local communities with forestry, fodder, hunting and fishing resources, and recreational sites and are important as water reservoirs, buffer zones against climatic hazards, and biodiversity hotspots. When designing strategies to improve the use and management of lowlands, it is crucial to take into account the multiple uses and ecosystem services provided by these areas while actively involving stakeholders.

Fewer studies have assessed the levels of awareness and perception of ES in developing countries, particularly in sub-Saharan Africa where the need for sustainable ecosystem management and poverty reduction is more profound (Zhang *et al.*2016). With this in mind, a socio-economic survey was conducted in Côte d'Ivoire and Nigeria to understand local people's awareness and perceptions of the ecosystem services provided by lowlands.

## **2. Objectives**

The objectives of this study are to understand the awareness and perceptions of local populations of the ecosystem services provided by lowlands in Côte d'Ivoire and Nigeria.

### **Specific objectives**

- Establish the typology and characterization of the lowlands.

- To study the awareness and perception of local communities on the ecosystem services of supply, regulation and support, and cultural services provided by the lowlands.
- Identify the determinants of farmers' perception of each type of ecosystem service provided by lowlands

### **3. Material and methods**

#### **3.1 Presentation of the study area of Côte d'Ivoire and Nigeria**

Located in West Africa, Côte d'Ivoire is a coastal country bounded to the south by the Atlantic Ocean for 600 km and covers 322,463 km<sup>2</sup> (MINESUDD, 2020). Its highly cosmopolitan population is estimated at 29,389,150 (RGPH, 2021). Côte d'Ivoire has four types of ecosystems: terrestrial, inland waters, marine and coastal, and wetlands. The terrestrial and aquatic biodiversity of Côte d'Ivoire, according to the current state of knowledge, comprises 17,343 species globally (MINESUDD, 2020). The study area in Côte d'Ivoire mainly consisted of four regions: Tonpki, Gôh, Poro and Gbêkê.

Table 1: Agroecological characteristics of study areas in Côte d'Ivoire and Nigeria

	<b>Côte d'Ivoire</b>	<b>Nigeria</b>
Number of inhabitants	Bouaké (1,010,849), Gagnoa (985,282), Korhogo (1,040,461) and Man (1,387,909).	Nasarawa (2.5 million) and Niger State (6,779,080)
Climate	Tropical climate in Bouaké, Gagnoa and Korhogo with a rainy season (March to October) and a dry and hot season (November to February). Sub-equatorial climate in the south and Sudanian in the north at Man with a rainy season (April to October) and a dry season (November to March).	Nasarawa has a hot and dry desert climate (BWh) according to the Köppen-Geiger classification. Niger also has a very hot climate. The rainy season runs from April to October and the dry season from November to March.
Mean annual temperature	25.7°C in Bouaké, 27°C in Gagnoa, 28°C in Korhogo and 24°C in Man	Nasarawa (29.3°C) and Niger (34°C)
Annual rainfall	Bouaké (1200 to 1600 mm), Gagnoa (900 to 1500 mm), Korhogo (824.7 to 1424.3 mm) and Man (1300 to 2400 mm)	Niger (1317.3 to 1450 mm), Nasarawa (300 to 1302 mm)
Type of soil	Tropical Ferruginous and Ferrallitic soils in Bouaké Ferrallitic soils in Korhogo, Gagnoa, and Man	Nasarawa (shales, banded iron, quartzites, and marble) and Niger granite, gneiss, migmatites, and schists
Types of Crops	- Food crops - Industrial crops: Coffee, cocoa, rubber, oil palm in Gagnoa - Industrial crops and animal production: • Coffee, cocoa, cotton, cashew nut, oil palm, cattle, goats, sheep, etc. in Bouaké. • Cotton, cashew nuts, forestry and livestock farming in Korhogo • Coffee, cocoa, rubber, oil palm, fish farming and cattle, goat, sheep, etc. in Man.	Niger: Cultivation of cereals (maize, Guinea maize, millet, beans, sesame seeds, rice), tubers (yam, cassava, and sweet potatoes), fruits (mango, cashew nuts, guava, shea butter and watermelon), and vegetables (garden eggs, tomatoes, peppers and bitter leaves); Fishing (catfish and tilapia)  Nasarawa: horticulture, fruits, eggs, milk and poultry, maize, taro and sweet potato, fishing and cash crops.

It is all the equipment used to carry out this work. These are:

- a GPS (Global Positioning System) for taking the coordinates of the different localities;
- a digital camera for shooting different environments;
- survey sheets for carrying out surveys;

## **3.2 Methods**

### **3.2.1 Data collection**

Information was collected in these different localities using a questionnaire administered to 254 producers. The latter were chosen by the probabilistic method, which consists of randomly selecting the individuals to be interviewed. As the identification of ecosystem services is driven by human well-being, stakeholder involvement is particularly important to understand people's values and needs. Indeed, the characterization of the ecosystem services provided by the lowlands of Côte d'Ivoire and Nigeria was based on village surveys of producers. In Côte d'Ivoire, 133 producers were selected from four sites, namely Gbêkê, Gôh, Poro and Tonpki. In Nigeria, 121 producers were surveyed at four sites: Bida, Doma, Lambaga and Wushishi. The villages were chosen to take into account the growing environment of the producers based exclusively on the lowlands. The investigations took place from 24 December 2022 to 27 April 2023 in Côte d'Ivoire and from 13 March 2023 to 22 March 2023 in Nigeria. A series of questions were asked of each producer on their knowledge and perception of a wide range of ecosystem services provided by lowlands and their uses.

At the end of the survey, 23 ecosystem services were selected in Côte d'Ivoire and Nigeria and grouped into three categories according to the Millennium Ecosystem Assessment (MEA 2005): 10 supply services, 5 regulatory and support services, and 8 cultural services (Figure 2).

### **3.2.2. Data processing and analysis**

The data recorded on the survey forms were processed and entered into Excel, SAS, and SPSS statistical software. The data analysis used the simple methods of descriptive statistics. Thus, quantitative variables are described using the mean. Qualitative variables are described using percentages.

## **4. Results**

The results of the population surveys will be described in this chapter. It will discuss the socio-demographic characteristics of producers, the typology and characterization of lowlands, producers' awareness and perception, and the determinants of farmers' perception of each type of ecosystem services provided by lowlands.

#### 4.1. Socio-demographic characteristics of producers in Côte d'Ivoire and Nigeria

There were 133 producers surveyed in Côte d'Ivoire. Thus there were 37 in Gbêkê, 27 in Gôh, 37 in Poro, and 32 in Tonpki. In Nigeria, 121 producers were surveyed in the states of Nasarawa and Niger. In Nasarawa State, there were 45 producers at the Bida site and 21 at Doma. The state of Niger included 40 producers at the Lambaga site and 15 at Wushishi. The survey was conducted on both male and female genders. The percentages by gender are presented in Table 2 below.

The age extremes of producers ranged from 20 to 77 years with an average age of 47 years in Côte d'Ivoire, and from 20 to 60 years in Nigeria with an average age of 34 years. The age of producers was divided into three age groups: 20 to 35, 36 to 50, and over 51. The age percentages are shown in Table 2 below.

The socio-economic survey highlighted the academic level of producers in Côte d'Ivoire and Nigeria. Thus, there were the illiterate, those with primary, secondary, and university schooling (Table 2).

Marital ties among the producers surveyed in Nigeria and Côte d'Ivoire included celibacy, divorce, monogamy, polygamy, and widowhood. The survey showed that in Côte d'Ivoire, divorce and widowhood status were only perceived on the Gbêkê site, with relatively low and similar proportions, i.e. 3% divorce and 5% widowhood (see Table 2).

**Table 2:** Percentages of Socio-Demographic Characteristics of Surveyed Producers

Sociodemographic description (%)		Côte d'Ivoire (n=133)				Nigeria (n=121)			
		Gbêkê	Gôh	Poro	Tonpki	Bida	Doma	Lambaga	Wushishi
<b>Sex</b>	Man	95	85	41	84	71	67	60	73
	Wife	5	15	59	16	29	33	40	27
<b>Age range</b>	20-35	11	30	8	22	71	52	65	47
	36-50	54	37	78	22	29	29	35	53
	51>	35	33	14	56	0	19	0	0
<b>Marital status</b>	Bachelor	13	7	3	19	13	19	22	7
	Divorce	3	0	0	0	0	0	0	0
	Monogamous	68	85	65	69	71	67	67	73



	Polygamist	11	4	32	12	16	14	10	20
	Widow/widower	5	4	0	0	0	0	0	0
	None	40	56	78	28	27	5	15	40
<b>Academic level</b>	Primary	35	19	19	41	29	14	7	13
	Secondary	22	26	3	25	31	24	58	27
	Academic	3	0	0	6	13	57	20	20

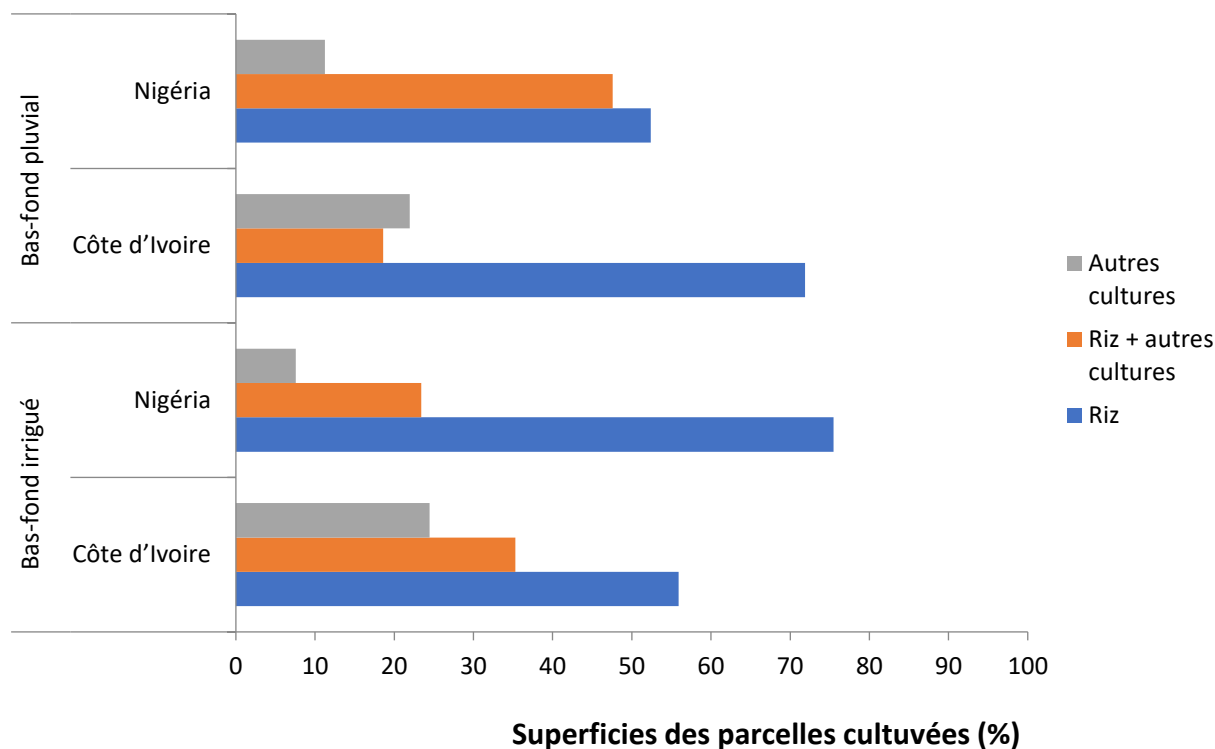
## 4.2. Typology and characterization of lowlands in Côte d'Ivoire and Nigeria

### 4.2.1. Cropping systems in Côte d'Ivoire and Nigeria

The socio-economic survey in Côte d'Ivoire and Nigeria highlighted the cropping systems and types practiced by producers in the irrigated lowlands and in the rainfed lowlands. The latter practices three cropping systems: monoculture, other crops associated with monoculture, and other crops (rotational crops). The cultivated area in Côte d'Ivoire is 215.36 hectares and that of Nigeria is 230.2 hectares, for a total of 445.56 hectares. The types of crops encountered in Côte d'Ivoire are monoculture (rice), other crops associated with monoculture (trees, cereals, vegetable crops, legumes, roots/tubers) and other crops (cereals, cereals and vegetable crops, vegetable crops, vegetable crops and roots/tubers, legumes, roots/tubers). The types of crops found in Nigeria are monoculture (rice), other crops associated with monoculture ( trees; cereals; cereals and vegetable crops; cereals, vegetable crops and roots/tubers; Vegetables; vegetable crops and roots/tubers) and other crops (cereals, vegetable crops, vegetable crops and roots/tubers, roots/tubers).

Figure 1 below shows the percentage of crops as a function of the area under cultivation in the irrigated and rainfed lowlands of Côte d'Ivoire and Nigeria. Monoculture (rice) is more widely cultivated than other crops in Côte d'Ivoire and Nigeria. Indeed, in Côte d'Ivoire rice is grown more in the rainfed lowlands with a proportion of 72% than in the irrigated lowlands (56%), while in Nigeria rice is more grown in the irrigated lowlands with (75%) than in the rainfed lowlands with a proportion of 52%. After monoculture, other crops associated with monoculture have the largest proportion. In the figure, it is higher in the rainfed lowlands in Nigeria with 48% than in the irrigated lowlands which is 23%, while in Côte d'Ivoire this proportion is rather high in the irrigated lowlands with 35% and low in the

rainfed lowlands at 18%. Finally, other crops have a small area with relatively identical proportions in both countries. However, in Côte d'Ivoire, the areas of other crops observed are higher than in Nigeria. In Nigeria, the proportions are 11% in the rainfed lowlands and 8% in the irrigated lowlands. In Côte d'Ivoire, they are 22% in the rainfed lowlands and 24% in the irrigated lowlands.



**Figure 1:** Percentage of crop types by area under irrigated and rainfed lowlands in Côte d'Ivoire and Nigeria

#### 4.2.2. Lowland cultivation practices in Côte d'Ivoire and Nigeria

Table 3 below shows the percentages of the area of cultivation practices in the irrigated and rainfed lowlands of Côte d'Ivoire and Nigeria. Crop residue management, fertilizer management, grass cover management, and pest management are cultural practices of lowland producers. In Côte d'Ivoire and Nigeria, most plots are burned for agricultural practices. The percentages of plots where crop residues are returned are very low, except for Nigeria where slash-and-burn and crop residue restitution in the irrigated lowlands are relatively similar.

In terms of fertilizer management, the various crops were treated with mineral fertilizers, organic fertilizers, and mineral and organic fertilizers. Some plots under cultivation have not received any fertilization. The use of mineral fertilizers was intensified in agricultural practices in Côte d'Ivoire and Nigeria. As for grass management, weeds were chemically removed with herbicides or mechanically by hand or chemically and mechanically.

Mechanical grass cover is little used in weed management in both countries. However, mechanical and chemical methods are much more practiced in crops.

Finally, in pest management, a greater proportion of crops were treated with chemical pesticides. The proportions of crops treated are 61% in Côte d'Ivoire and 58.49% in Nigeria in the irrigated lowlands, then 50.48% in Côte d'Ivoire and 58.55% in Nigeria in the rainfed lowlands. Some of the crops remained intact without the application of pesticides (Table 3).

**Table 3:** Proportional areas (%) of cultivation practices in lowlands

	Irrigated lowland		Rainwater shoal	
	Côte d'Ivoire	Nigeria	Côte d'Ivoire	Nigeria
<b>Crop Residue Management</b>				
Burning	64.52	49.43	74.9	80.04
Restitution	35.48	50.57	25.1	19.96
<b>Fertilizer Management</b>				
No	32.06	21.9	23.38	3.58
Mineral	41.82	50.94	55.28	86.7
Mineral & Organic	12.12	26.41	14.52	9.72
Organic	14	0.75	6.82	0
<b>Grass cover management</b>				
Chemical (herbicide)	36.66	43.77	53.76	38.59
Mechanical (manual)	4.81	3.77	12.92	17.4
Chemical & Mechanical	58.51	52.45	33.31	44.01
<b>Pest Management</b>				
No	24.46	30.94	42.63	41.45
Biopesticides	12.38	0	4.43	0
Chemical Pesticides	61.33	58.49	50.48	58.55
Chemical Pesticides and Biopesticides	1.83	10.57	2.46	0

## 5. Producers' awareness and perception of ecosystem services

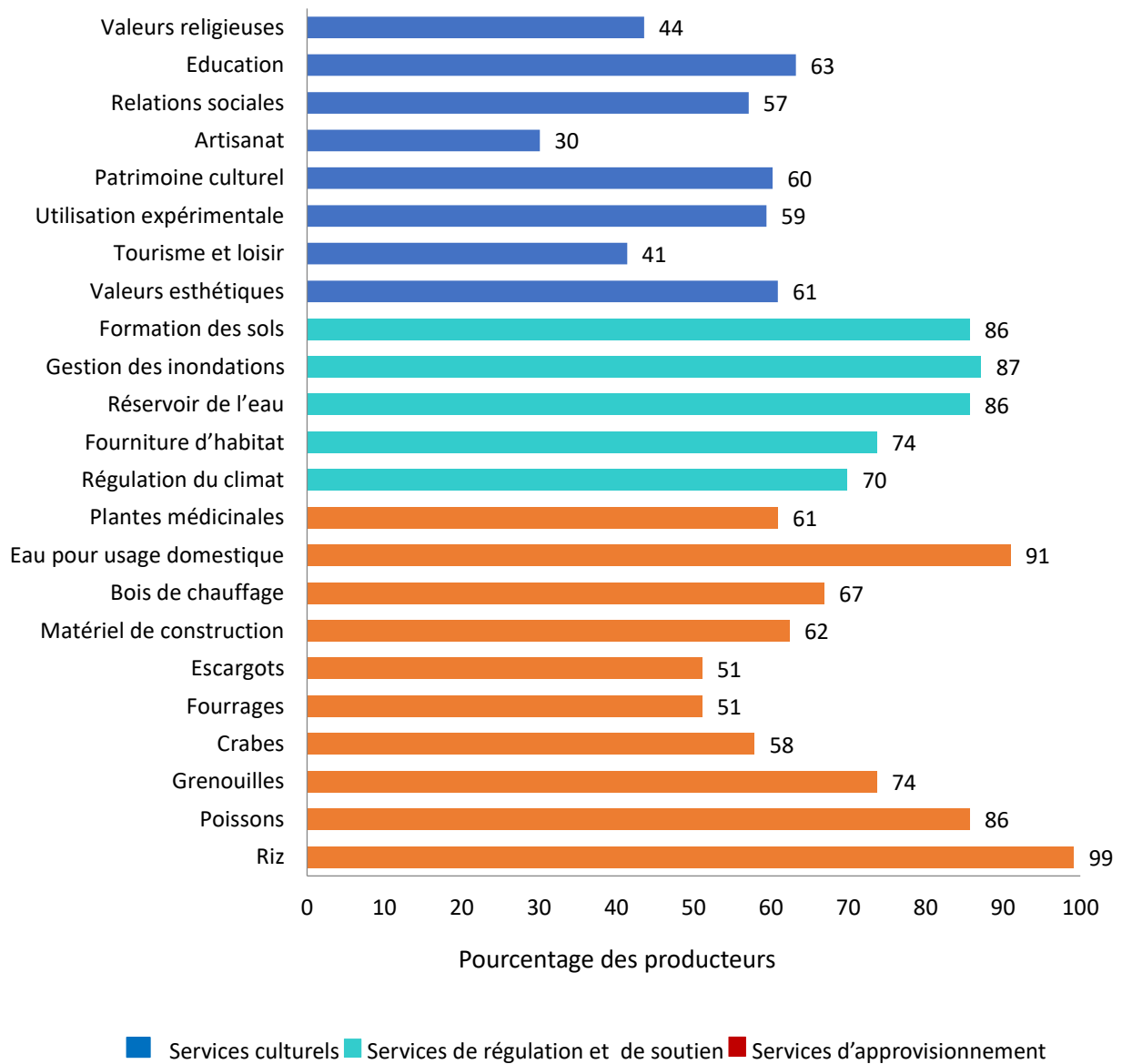
Figures 2 and 3 below show the knowledge or awareness of producers of ecosystem services provided from the lowlands for n=133 in Côte d'Ivoire and n=121 in Nigeria. As shown in Figures 2 and 3, the lowlands of Côte d'Ivoire and Nigeria provide more ecosystem services for rice, fish, frogs, crabs, fodder, snails, construction equipment, firewood, water for domestic use, and natural medicinal plants. Then there are cultural services: aesthetic values, tourism, and leisure, use for experimental purposes, cultural heritage, handicrafts, social relations, education, and religious values. Finally, regulation and support services in

small quantities are climate regulation, habitat provision, water reservoir, flood management, and soil formation.

In contrast to tourism and leisure, handicrafts, and religious values, whose proportions of supply are relatively low (41%, 30%, and 44% respectively), producers stressed the importance of ecosystem services with proportions exceeding 50%. The proportions are higher in regulation and support services with a maximum peak of 86% and a minimum peak of 70%, highlighting their high sensitivity to these services (Fig.2).

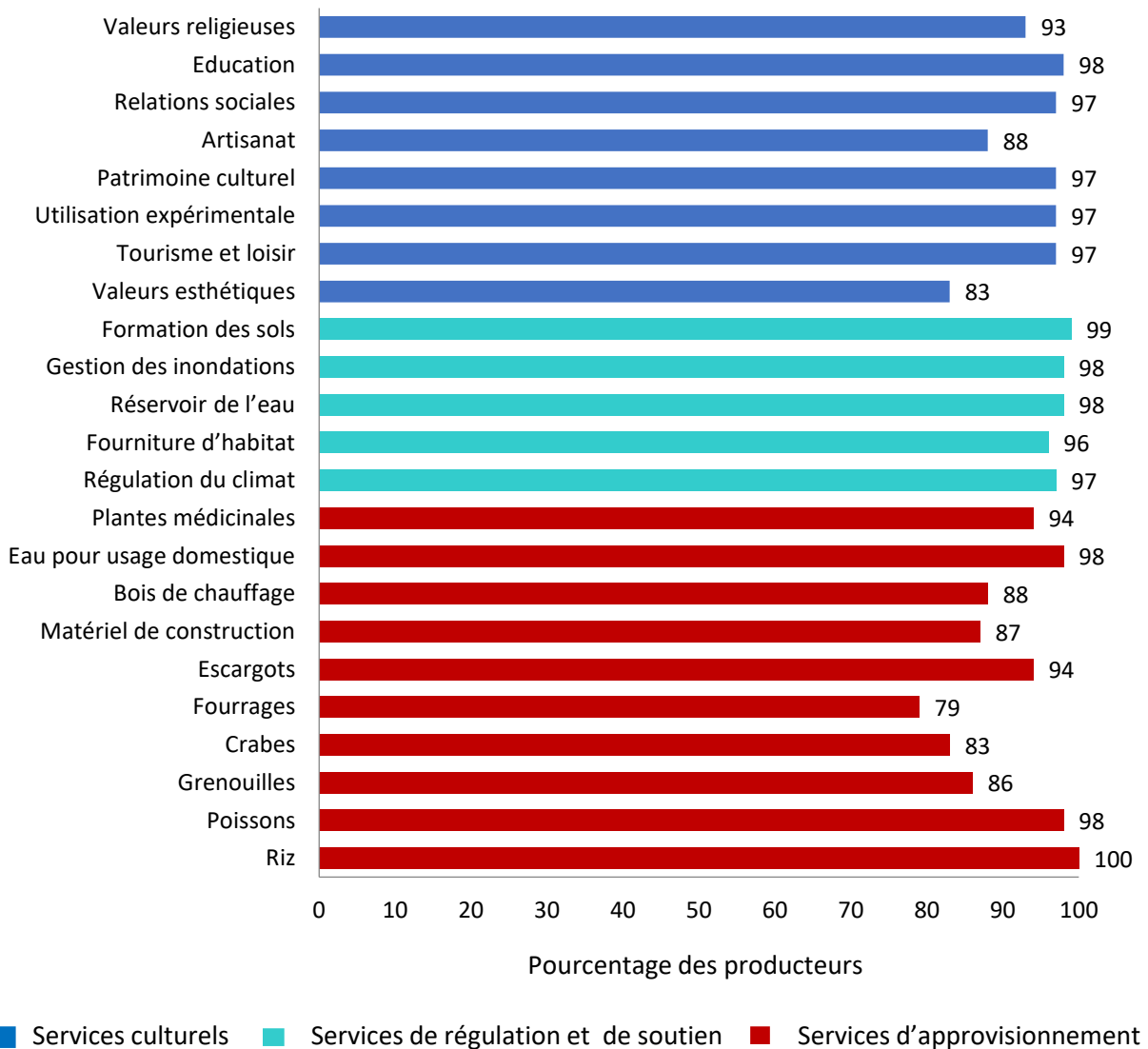
In Nigeria, the majority of producers highlighted the importance of ecosystem services with proportions exceeding 79%. However, these proportions are very high in regulation and support services with a maximum peak of 99% and a minimum peak of 96%, thus showing their very high level of sensitivity to these services (Fig.3).

## Services écosystémiques



**Figure 2:** Knowledge of producers of ecosystem services provided by low-lying areas funds in Côte d'Ivoire (n = 133)

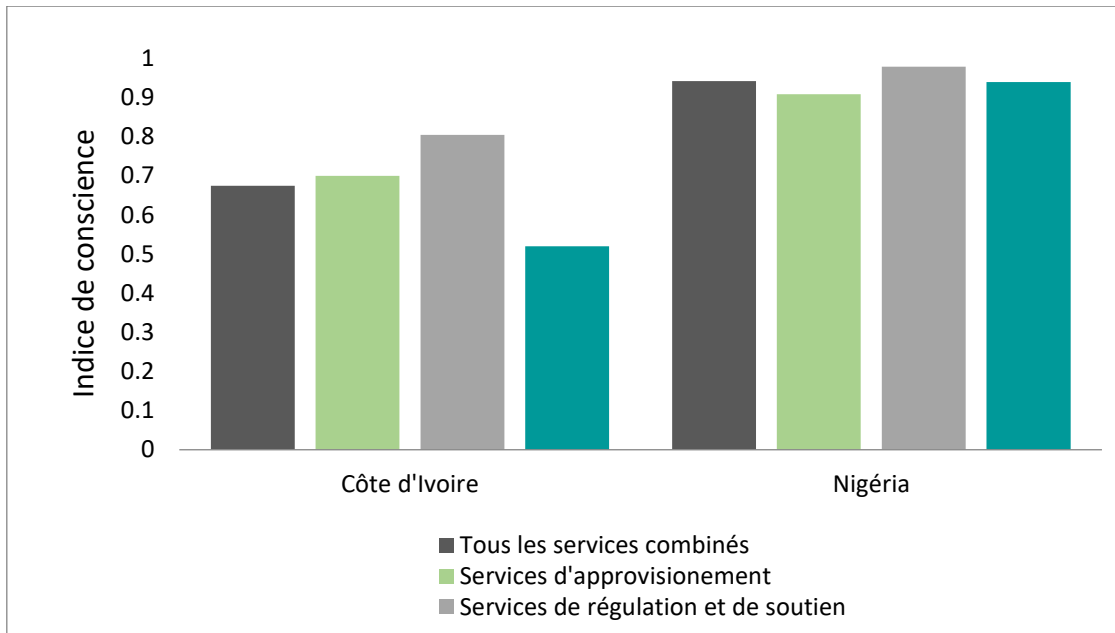
## Services écosystémiques



**Figure 3:** Knowledge of producers of ecosystem services provided by low-lying areas funds in Nigeria (n = 121)

Figure 4 shows the average of the relative levels of consciousness. ecosystem services by producers, using consciousness cues. The awareness index for all services combined in Côte d'Ivoire is 0.64 and that of Nigeria is 0.94. These results show that producers in Nigeria perceive ecosystem services better than those in Côte d'Ivoire.

$$\text{Index} = \frac{\text{somme des SE par catégorie}}{\text{Nombre total des SE par catégorie}}$$



**Figure 4:** The average of the awareness indices for each type of service Ecosystem Lowlands in Côte d'Ivoire and Nigeria

Figure 5 below shows the average response modalities of producers' perceptions to the provision of ecosystem services for supply, regulation and support, and cultural services by the lowlands in the past, present and future in Côte d'Ivoire and Nigeria. In Côte d'Ivoire, irrigated lowlands provide more ecosystem services than rainfed lowlands, while in Nigeria, rainfed lowlands outweigh irrigated lowlands.

## 6. Past provision of ecosystem services in Côte d'Ivoire and Nigeria

In Côte d'Ivoire, ecosystem services provided in the irrigated lowlands are abundant in rice, fish, frogs and water for domestic use, while in the rainfed lowlands they are only abundant in rice and water for domestic use. In the rainfed and irrigated lowlands, ecosystem services provided are moderate in the form of crabs, fodder, snails, building materials, firewood, medicinal plants, aesthetic values, experimental use, social relations, education, climate regulation, habitat provision, water reservoir, flood management, cultural heritage and soil formation. When ecosystem services in tourism and leisure, handicrafts, and religious values, the provision is rare (Fig. Côte d'Ivoire A).

In Nigeria, the provision of ecosystem services in the irrigated and rainfed lowlands is abundant in rice, fish, water for domestic use, water reservoir, flood management, soil formation, firewood and experimental use, while the provision of the rest of ecosystem services (frogs, crabs, fodder, snails, construction materials, etc.) is abundant. medicinal

plants, aesthetic values, social relations, education, climate regulation, habitat provision, cultural heritage, tourism and recreation, handicrafts, and religious values) in the irrigated and rainfed lowland is moderate (Fig. Nigeria A).

## **7. Provision of ecosystem services in the present in Côte d'Ivoire and Nigeria**

In Côte d'Ivoire, no producer has perceived the increasing supply of ecosystem services in the lowlands. However, in the irrigated lowlands, producers perceived stability in terms of the provision of ecosystem services in rice, frogs, water for domestic use, climate regulation, flood management, and education; while in the rainwater lowlands the provision of ecosystem services is stable in terms only of rice and water for domestic use. Also, except for tourism and leisure, handicrafts and religious values which are not provided at all, the rest of the SEs (crabs, fodder, snails, building materials, medicinal plants, aesthetic values, social relations, education, provision of housing and cultural heritage, water reservoir, soil formation, firewood and use for experimental purposes) are exhausting in the bottoms (Fig. Côte d'Ivoire B).

In Nigeria, only rice and water for domestic use are being supplied in increasing quantities in the lowlands. Thus, with the exception of crabs, snails, handicrafts, aesthetic values and religious values, the supply of which is exhausting, the rest of the following ES (fish, frogs, fodder, firewood, building materials, water for domestic use, medicinal plants, social relations, education, provision of housing, cultural heritage, water reservoir, soil formation, tourism and recreation, and use for experimental purposes) are stable (Fig. Nigeria B).

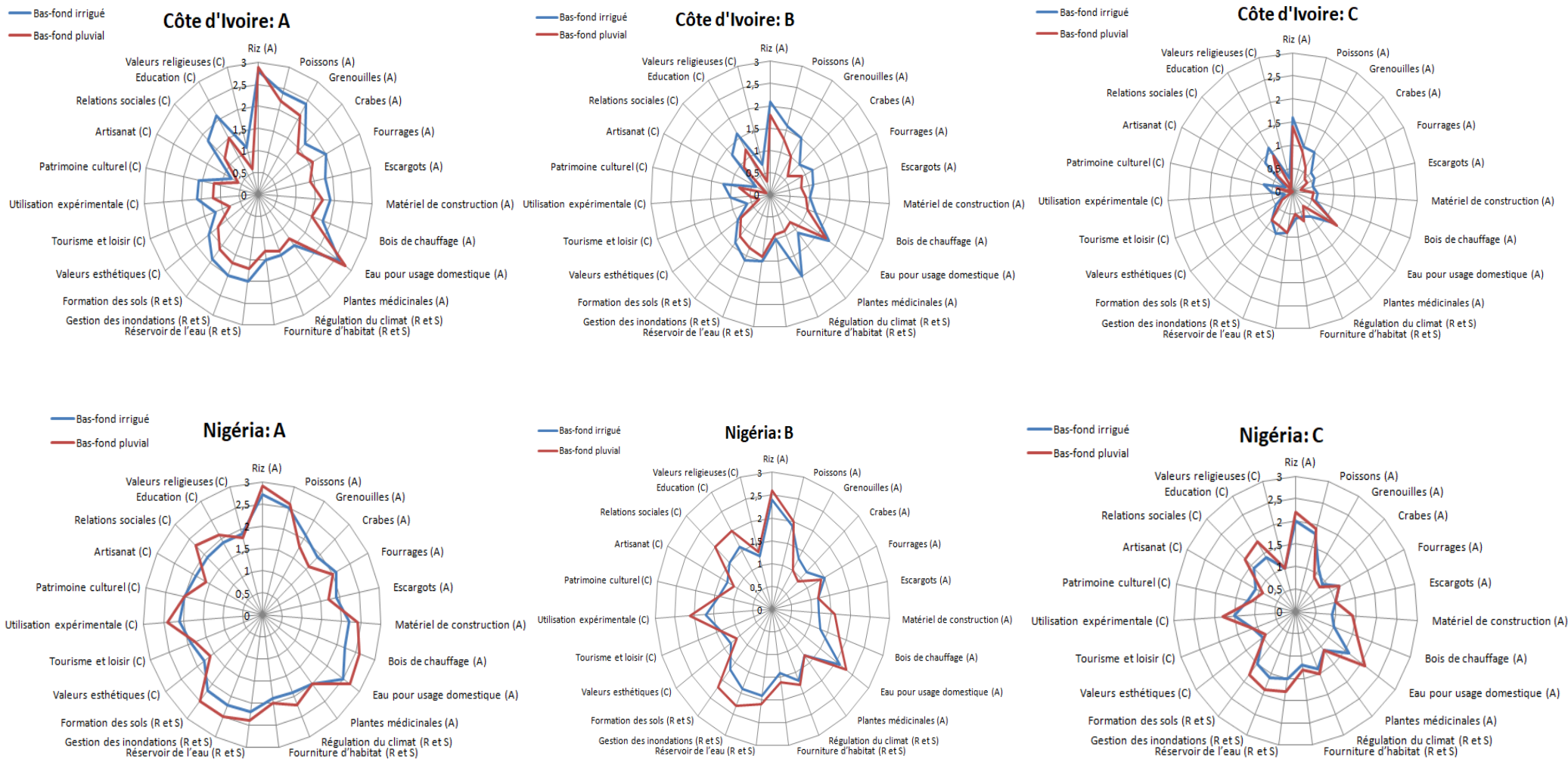
## **8. Future provision of ecosystem services in Côte d'Ivoire and Nigeria**

In Côte d'Ivoire, no ecosystem services will be provided in increasing or moderate quantities in the lowlands. On the contrary, the supply of ES will collapse in rice, fish, frogs, water for domestic use, water reservoir, education, soil formation, flood management and social relations. As for the ES in crabs, fodder, snails, construction materials, firewood, medicinal plants, handicrafts, aesthetic values, use for experimental purposes, climate regulation, tourism and recreation, provision of housing, cultural heritage and religious values, will not be provided at all in the lowlands (Fig. Côte d'Ivoire (C)).

In Nigeria, rice is levied on the SE which will be supplied in increasing quantities to the lowlands in the future. However, the following ES (frogs, crabs, fodder, snails, building



materials, firewood, medicinal plants, tourism and recreation, aesthetic values, cultural heritage, handicrafts and religious values) will collapse while the following ES (rice, fish, frogs, water for domestic use, social relations, education, provision of housing, cultural heritage, water reservoir, soil formation, experimental use, etc.) will collapse. climate regulation and flood management) will be maintained in the lowlands in the future (Fig. Nigeria (C).



**Figure 5 :** Perception des producteurs en moyenne des modalités de réponses aux de services d’approvisionnement, de régulation et de soutien, et des services culturels fournis par les bas-fonds au passé, au présent et au futur en Côte d’Ivoire et au Nigéria.

- Modalités de perception dans le passé : 0 (pas du tout fourni) ; 1 (rare) ; 2 (modéré), 3 (abondant)
- Modalités de perception dans le présent : 0 (pas du tout fourni) ; 1 (épuisant) ; 2 (stable), 3 (croissant)
- Modalités de perception dans le futur: 0 (pas du tout fourni) ; 1 (s’effondrer) ; 2 (maintenir), 3 (croître)

**A :**services fournis dans le passé      **B :** services fournis dans le présent **C :** services fournis dans le futur

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