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Local Perspectives on the Role of Dams in Altering River Ecosystem Services in West Africa

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Abstract

Water-related ecosystem services provide a broad range of benefits, including the mitigation of extreme hydrometeorological events, the provision of water for various uses, the support of tourism, and the provision of cultural services. This study assesses the perceptions and accessibility of these services among communities located near the Alafiarou and Okpara dams in Benin and the Bagré dam in Burkina Faso. The methodology involved designing and implementing a questionnaire in KoboCollect, with trained agents deployed to conduct data collection at each of the three sites. Data analysis indicates that respondents identified biodiversity conservation and the provision of drinking water as the most crucial ecosystem services. Over two-thirds of participants reported observing both positive and negative changes in the services provided by rivers and in socio-economic activities since the construction of the dams. While the majority noted improvements in agriculture, irrigation, water quality, fisheries, and flow rates, other changes included biodiversity loss, a decrease in vegetation cover (notably trees and shrubs), an increase in the population of mosquitoes and other insects, and a decline in fishery resources downstream. Despite these challenges, local communities were strongly willing to participate in initiatives aimed at protecting and restoring river ecosystems and their related services.

Keywords: river and dam ecosystem services; water; local communities' perceptions; Benin; Burkina Faso

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1. Introduction

Freshwater is a vital natural resource for human survival and development [1,2]. However, its sustainable management remains a global challenge, particularly in regions like

West Africa, where climate variability and population growth exacerbate water scarcity [3]. The mobilisation of water resources is often facilitated through dams, which significantly impact river systems. Dams have significant, intricate, and wide-ranging impacts on ecosystems, most of which are detrimental [4,5], affecting both upstream and downstream environments. Despite these impacts, dams provide essential services such as flood control, hydropower generation, irrigation, and water supply. However, increasing climate variability [6], population growth [7], and rising electricity demands are expected to further drive dam construction and water withdrawals, despite the high variability of this resource. The damming of rivers, while beneficial in many ways, has come at a considerable cost to their ecological health and the ecosystem services they provide to society [8,9]. In many cases, water captured by supply and irrigation dams is diverted directly from reservoirs, significantly reducing downstream flow. This is particularly evident in West Africa, where several dams operate without releasing water downstream during the dry season when demand peaks. Examples of such management in Benin include the Okpara Dam, which provides drinking water supply for the City of Parakou, and the Alafiarou Dam, which primarily serves irrigation needs. A similar situation is observed at the Bagré Dam in Burkina Faso, where the dam is utilised for multiple purposes, including hydropower generation and irrigation.

To address these challenges, the Opti-WaM project (Optimising Water Management for Sustainable Ecosystems) engaged a range of partners, including local associations and communities, water professionals and managers, and researchers, to collaborate in a participatory manner [10]. This initiative sought to co-develop solutions to the issues identified in the case studies and to disseminate the findings in a manner that ensures their wide application to similar challenges elsewhere. As part of the case studies, a socio-ecological survey was conducted simultaneously across the three project sites to assess water ecosystem services. This survey provided valuable insights into how water resources from the Okpara, Alafiarou, and Bagré dams are perceived and used to meet community needs. Additionally, it offered a clearer understanding of local challenges, including ecosystem degradation and pressures from human activities.

Efforts have been made globally to evaluate ecosystem services. Gouwakinnou et al. [11] explored the role of both scientific and local ecological knowledge in shaping perceptions of protected areas and ecosystem services in the Madrid and Segovia provinces of Spain. Their findings revealed that perceived bundles of ecosystem services and their impacts, as well as ecological knowledge, emerged as social representations of how residents interact with and understand landscapes. Similarly, Thiemann et al. [12] analysed perceptions of ecosystem services in Bavaria, Germany, by comparing sociocultural and environmental influences. They found that farmers generally placed slightly lower importance on all ecosystem services except for provisioning services. Their study also indicated that sociocultural factors explained variations in the perceived importance of ecosystem services more effectively than land cover or climate gradients.

In Kenya, Ouko et al. [13] investigated community perceptions of ecosystem services concerning forest management. Respondents identified trees, water, fallback land for cultivation, aesthetic enjoyment, and shade as key benefits derived from forests. In Côte d'Ivoire, a qualitative and quantitative analysis of local perceptions [14] highlighted that rural villagers recognise a range of ecosystem services as benefits from protected areas. In northern Benin, Gouwakinnou et al. [8] examined local perceptions and the factors influencing the identification of ecosystem services around two forest reserves. Their results showed that education level, poverty index, household size, and proximity to forests significantly influenced knowledge of ecosystem services.

Despite their significance, the ecosystem services provided by dams and rivers, ranging from provisioning (e.g., water and fisheries) to regulating (e.g., flood mitigation and carbon sequestration) and cultural services (e.g., recreation and spiritual values), are often undervalued in policy and management [15]. Local communities, particularly in rural West Africa, prioritise immediate provisioning services (e.g., drinking water and agriculture) over long-term regulating or cultural benefits [11,13,16]. This disparity highlights a critical gap in participatory decision-making, where local knowledge and needs are frequently overlooked [17,18].

To address these gaps, this study assesses local perceptions of ecosystem services around three West African dams, employing participatory surveys to identify community priorities, challenges, and willingness to engage in conservation initiatives. By integrating socio-ecological data with recent advancements in adaptive dam management such as environmental flows [19], benefit-sharing mechanisms [20], the study aims to (i) Evaluate the perceived trade-offs between dam benefits and ecological impacts, (ii) Identify disparities in ecosystem services valuation across communities, (iii) Propose inclusive management strategies to balance human and ecological needs. Building on initiatives like the *Opti-WaM* project and global frameworks such as the UN Sustainable Development Goals (SDG 6 and 15), this research contributes to regional policy dialogues and offers scalable insights for sustainable water governance in dam-dependent regions.

2. Materials and Methods

2.1. Presentation of the Study Areas

The Alafiarou Dam in Benin is located in the commune of Tchaourou, at geographic coordinates 9.0° North and 2.34° East (Figure 1d). Built in 2002 and rehabilitated in 2022, the dam receives water from the temporary Tèmayé River, a tributary of the upper Ouémé. This region experiences a South Sudanese climate with an unimodal pattern, characterised by distinct dry and wet seasons. Annual rainfall ranges from 809 to 1458 mm (1971–2016), while the daily average temperature varies between 25.01 °C and 30.36 °C. March is the hottest month, while August is the coolest [4].

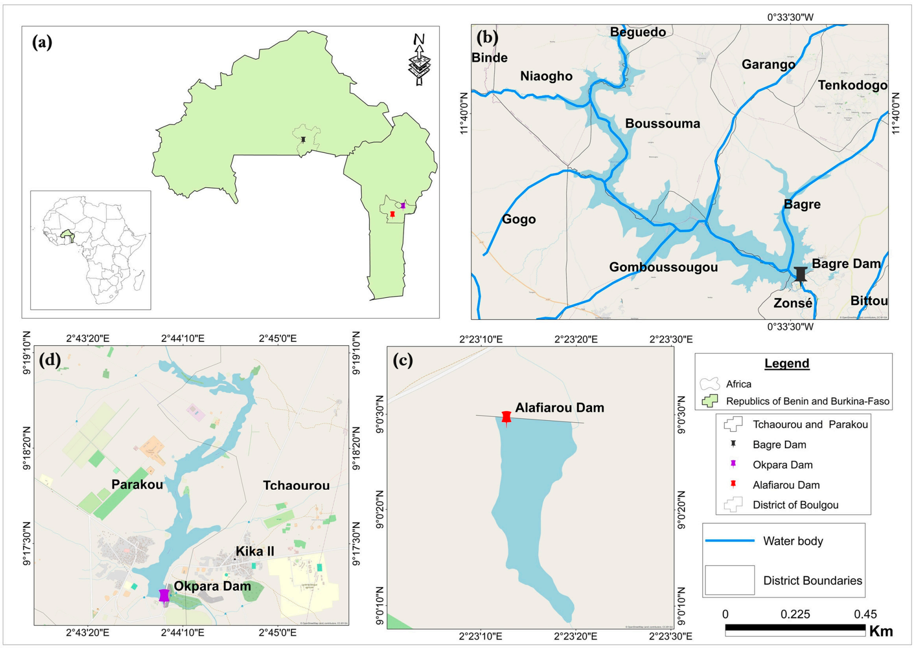

Figure 1. Presentation of the study areas: (**a**) Benin and Burkina Faso within West Africa, (**b**) Bagré dam, (**c**) Alafiarou dam, and (**d**) Okpara dam.

The landscape consists of plains and plateaus, occasionally topped by mounds and hills exceeding 300 m in altitude. These hills contribute to the presence of gravel and granite quarries, which serve as potential economic resources for the commune. The soil in this region is tropical ferruginous with weak concretion, characterised by leaching and deep waterlogging. The eastern part of the municipality contains artificial, natural, and semi-natural forests. Additionally, swamps and backwaters play a crucial role in livestock watering. The commune has eight reservoirs that support market gardening and fish farming [4].

The Okpara Dam in Benin: It is situated in a sub-catchment of the Okpara River, spanning the communes of Tchaourou and Parakou in northeastern Benin, approximately 19 km east of Parakou city (Figure 1c). The site's geographical coordinates are 9.28° North and 2.73° East. The characteristics of this area are largely similar to those of the Alafiarou Dam described in the previous subsection.

The Bagré Dam in Burkina Faso: This dam, located in the southeast of Burkina Faso, on the Nakambé River, is located near the village of Bagré (Figure 1b). Its geographical coordinates are 11°28′37′′ North latitude and 0°32′48′′ West longitude. The Bagre Dam area has a North Sudanese climate and is characterised by an average annual rainfall of 950 mm. The wettest months are between July and September, with October often being the last rainy month of the year. Temperatures are generally high, with an annual average of over 28 °C, with a variation between 17 and 34 °C [21]. The area of the Bagré dam site is a vast, slightly undulating peneplain. It is characterised by a soft model with small rocky massifs like that of Lenga, which constitutes the highest point in the region, with its 386 m altitude. The soils of the area are of the leached tropical ferruginous type and vertisols on clayey material in the upstream part of the lake. There are also the vertic soils that characterise the flooded areas. Finally, the alluvial zones have hydromorphic soils on heterogeneous materials. The vegetation of the dam area belongs to the Sudanian phytogeographic domain and the northern Sudanian phytogeographic sector. This is the domain of degraded savannas, which frequently present a rustic facies. The shrub savannah, consisting of species such as Piliostigma reticulatum, Balanites aegyptiaca, and Ximenia americana, predominates and consists of old fallow lands from the agricultural lands of Tamboussé and Djaminé south of Béguédo [21]. The hydrographic regime is modelled on precipitation, the variations in which influence the volume of rivers and reservoirs. Thus, during the rainy season, the Nakambé often overflows its bed and stagnates in closed depressions. The Bagré Dam Lake is built on the Nakambé basin, one of the country's major rivers. It is a temporary watercourse that flows for only two to three months a year during the rainy season. It flows from north to south for about 516 km before emptying into Lake Akosombo in Ghana.

2.2. Methods

2.2.1. Assessment of Water-Related Ecosystem Services

The participatory approach is used for water-related ecosystem services assessment at the three study sites. It consisted of a survey questionnaire development based on four main parts, the details of which are provided below. The questionnaire is provided in the appendix.

Uses and benefits of the river: Rivers, along with the water and nutrients they carry, sustain forests, wetlands, and other terrestrial habitats while serving as a habitat for numerous freshwater species. They play a vital role in providing drinking water and supporting livelihoods through agriculture, fishing, recreation, and environmental conservation. Additionally, rivers facilitate navigation, transportation of people and goods, and contribute to natural resource development, such as wood and sand extraction. However, access to these benefits is not always guaranteed, particularly for vulnerable and marginalised communities, highlighting the need to assess their benefits of these resources. The first part of the questionnaire focused on evaluating the reasons for river use, its frequency (daily, weekly, rarely), and the benefits residents derive from it.

Perception of ecosystem services: Ecosystem services provide numerous benefits, including crop pollination, air purification, mitigation of extreme hydrometeorological events, wood for various uses, drinking and freshwater supply, tourism and recreation, water purification, climate and flood regulation, and habitat for biodiversity (both flora and fauna). Additionally, freshwater ecosystems support the water cycle, photosynthesis, biomass production, nutrient cycling (carbon, nitrogen, phosphorus), and soil formation and maintenance. The local perception of ecosystem services among communities living near dams was assessed. The importance of these services was ranked on a scale from 1 to 3, with 1 indicating the highest importance and 3 the lowest.

2.2.2. Assessment of the Impacts of Dams

Dams can disrupt river ecosystems in various ways, including altering hydrological regimes, disturbing ecological conditions upstream and downstream, reducing self-purification capacity, modifying erosion and sediment transport processes, storing sediments, fragmenting aquatic habitats, and obstructing the movement of large migratory species. Additionally, they pose a hazard in the event of structural failure and can exacerbate upstream flooding risks. The perception of these potential changes among communities surrounding the three dams was assessed both generally and for each specific impact, using a three-level scale ranging from very negative to very positive. These impacts could further worsen the situation of vulnerable and marginalised communities, whose livelihoods are already precarious. Beyond the aforementioned effects, dams may also contribute to water pollution, health issues related to water quality, and disruptions to fish migration and reproduction. These aspects were also considered in the survey questionnaire.

2.2.3. Suggestions and Recommendations

Regarding the aspects covered in the questionnaire, survey respondents were allowed to provide suggestions and recommendations for improving access to ecosystem services related to dams and rivers. Some multiple-choice options included raising awareness and educating local populations, strengthening environmental laws and regulations, implementing riverbank reforestation initiatives, launching clean-up and pollution reduction programmes, promoting sustainable fisheries management, encouraging sustainable tourism, improving infrastructure to prevent industrial discharges, and managing dam water flows to minimise negative impacts. Additionally, respondents' willingness to participate in local initiatives for river conservation was assessed.

2.2.4. The Questionnaire Implementation Phase

The survey questionnaire was implemented in the KoboCollect tool. KoboCollect is a free, open-source mobile application used for collecting data, particularly in challenging field environments. It is part of the larger KoboToolbox platform and is designed for primary data collection in sectors like humanitarian aid, agriculture, environment, and education. Essentially, it is a mobile app that allows users to fill out digital forms on their phones or tablets and then submit that data to a KoboToolbox server. The surveyors were selected by a call for applications, and their capacities were strengthened for adequate completion of the questionnaires on the KoboCollect application on their smartphones. This field phase took place 19–23 November 2024, simultaneously on the three project sites, taking into account the dams upstream, downstream, and surroundings. The individuals chosen for the survey were selected randomly. To facilitate data collection, quadrennials were formed, and intervention zones were assigned to each quadrennial under the supervision of an identified guide at each site. His role is to facilitate the task of the survey agents in the field. He is a resource person, knowing the field, and is accustomed to local authorities. He is responsible for introducing the surveyors to these authorities and helping them resolve any situations to his possibility's extent.

Each interviewer was expected to interview 8 people per day for a total of at least 32 people over the course of the mission, knowing it would take approximately 45 min to administer the questionnaire. A minimum of two villages were included in the sample upstream, two downstream, and two around the sites of interest. The interviewers had to ensure a diversity of the people interviewed in terms of women, young people, elderly people, different ethnic groups, etc.

2.2.5. Questionnaire Scanning and Results Analysis

After the implementation of the questionnaires, the outputs were extracted from Kobokollect in Excel format, the statistics were calculated, and the graphs were plotted. In particular, the percentages of responses compared to the total were evaluated. The graphs developed include stacked bars, pie and bar charts, etc. By hypothesis, percentages greater than or equal to 40% are considered sufficient to mark the good representativeness of the indicators. The analyses of the outputs were carried out in two stages. First, the presentation of the results was performed by combining the samples from the three sites without distinction. This helps in having an overall idea of the trends at the level of the study areas and to project, perhaps in the sub-region. Then, an analysis highlighting the particularities of each site was performed to take into account the diversity and plurality of the actions and experiences of the communities concerned. Additionally, factorial correspondence analysis [22] was performed on some datasets after performing the independent test [23].

3. Results and Discussion

3.1. Demographic Characteristics of the Respondents

Diversity plays a crucial role in sampling during field surveys, encompassing factors such as ethnicity, gender, age, physical abilities, and cultural background. This section presents the demographic data collected, focusing on key aspects such as gender distribution, age groups, education levels, and occupations.

The survey results indicate that 70.37% of participants are men, while 29.63% are women—a disparity that may be attributed to the random sampling approach. Regarding physical ability, 98.15% of respondents reported being healthy, while 1.85% identified as having disabilities, aligning with the generally low percentage of people with disabilities in the surveyed countries.

In terms of education, 36.11% of participants have no formal education, 29.63% have a primary-level education, and 31.48% have attained secondary education or higher. Respondents represent a range of ethnic groups, with the majority being Nago, Bissa, Bariba, and Peulh, while smaller groups include Mossi, Fon, Adja, Zerma, and Dithamari, among others. Social roles within the community also vary: 80.56% of respondents are ordinary community members, 11.11% are community leaders, and 8.33% are elderly individuals.

Age distribution data show that the majority of participants (61.11%) fall within the 31–50 age group, followed by 19.44% in the 18–30 age group, and 17.59% aged 50 and above. In terms of occupation, agriculture is the primary livelihood, practised by 65.74% of respondents. Other common occupations include trade (15.74%), crafts (8.33%), fishing (3.70%), and livestock breeding (1.85%).

Agriculture is widely practised across all age groups (Figure 2). Trade follows as the second most common occupation, particularly among individuals aged 31–50 (8.33%

compared to 3.70% in other age groups). Similarly, 7.41% of individuals aged 31–50 engage in crafts, whereas only 0.93% of those aged 18–30 do so.

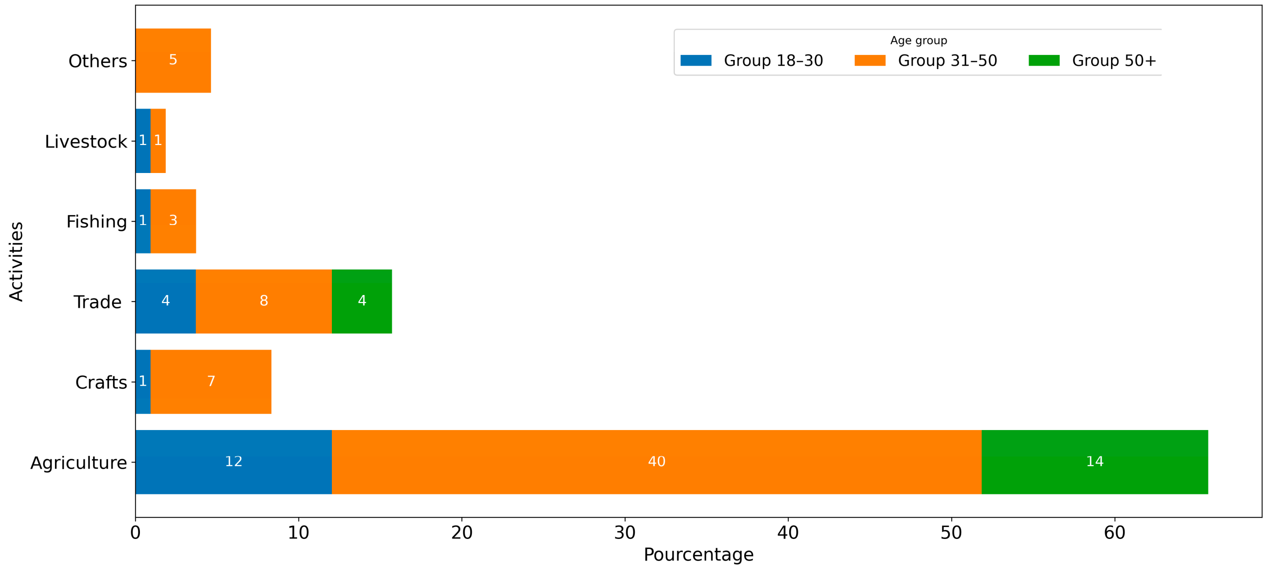

Figure 2. Demographic criteria of the surveyed respondents.

3.2. Major Uses of Rivers and Riparian Ecosystems

Figure 3a presents the primary uses of rivers by surrounding populations, along with the frequency of each use. These uses generally include transportation, recreation, fishing, agriculture, and drinking water supply, with significant variability in usage frequency across the surveyed sites. For drinking water supply, 46.30% of respondents use rivers daily. In agriculture, the primary livelihood of residents in the surveyed areas, more than half (50.93%) use river water for daily irrigation, while 32.41% do so rarely, often due to limited accessibility. Activities such as fishing, leisure, and transportation, which are linked to rivers, are practised less frequently. Between 65% and 94% of respondents indicated that they rarely use rivers for these purposes.

Overall, the findings highlight that rivers serve as essential resources for drinking water, domestic use, and agriculture, the top two priorities. While rivers also support secondary activities such as fishing, they are used far less frequently for leisure and are almost entirely unutilized for transportation.

The main characteristics observed at each site can be summarised as follows. The overall trends remain consistent across all three locations. River use for transport, leisure, and fishing is rare, while agriculture is a daily activity at all sites, with the highest prevalence at Bagré. At Okpara, agriculture is practised less frequently due to the dam's primary function—supplying drinking water to the city of Parakou, located about 20 km away. Additionally, the populations surrounding the Okpara and Bagré dams rarely use them for drinking water, highlighting accessibility challenges, particularly for marginalised communities near the Okpara dam. In contrast, the residents around the Alafiarou Dam rely on its water for drinking purposes.

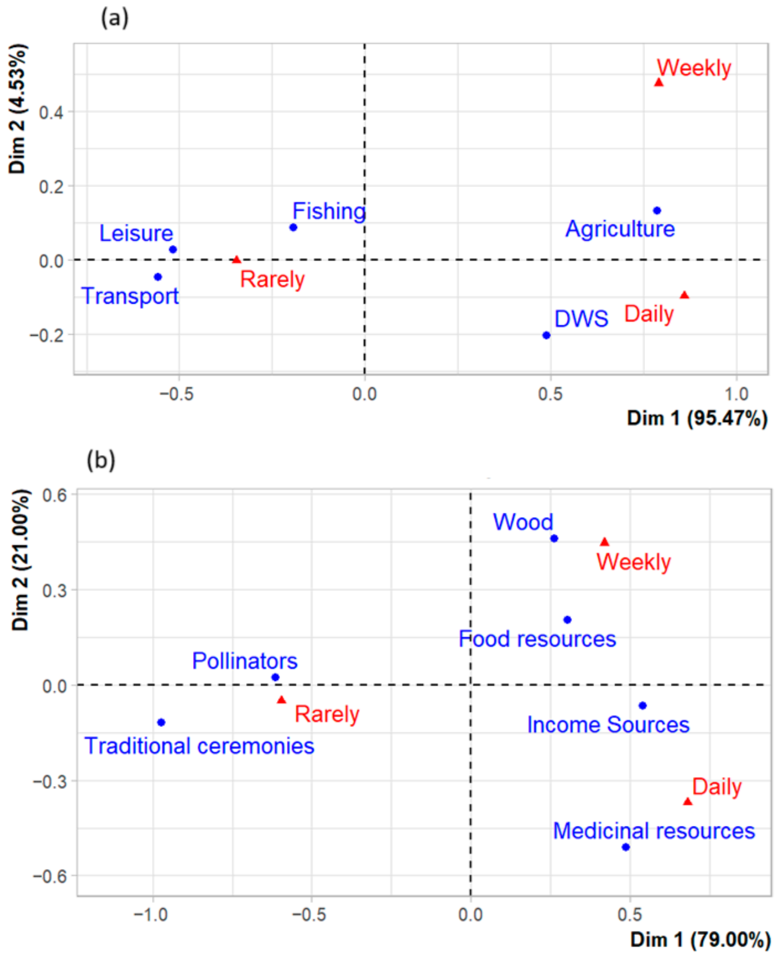

Figure 3. Frequency associated with water usage (**a**) and benefits (**b**) from factorial correspondence analysis. DWS is the drinking water supply.

3.3. Riparian Ecosystems Benefits

The main benefits derived from riparian ecosystems, along with their frequencies of use, are presented in Figure 3b. A third of respondents (35.19%) use medicinal resources from riparian ecosystems daily, while 41.67% use them rarely. Other frequencies are less common, with 14.81% using them monthly and 8.33% weekly. For food resources from riparian ecosystems, the majority of respondents (60.19%) benefit from them daily, while 12.96% use them weekly. Regarding wood, 39.81% of respondents use it daily, 32.41% use it rarely, 20.37% use it weekly, and 7.41% use it monthly, highlighting its importance for domestic and craft activities (Table 1).

Table 1. Percentages associated with the benefits of riparian ecosystems on each site. The values above 40% are indicated in red.

	Rarely			Weekly			Daily		
	HAS	**B**	**O**	**HAS**	**B**	**O**	**HAS**	**B**	**O**
Traditional ceremonies	96.88	96.77	95.35	3.13	3.23	00	00	00	4.65
Pollinator sources	77.13	3.23	93.02	15.63	9.68	00	6.25	87.1	6.98
Sources of income	21.88	90.32	76.74	34.38	00	00	43.75	9.68	18.6
Drink	31.26	32.26	51.16	50.0	19.35	00	18.75	48.39	48.84
Food resources	31.25	00	41.86	40.63	3.23	00	28.13	96.77	58.14
Medicinal resources	28.11	90.32	53.49	15.63	9.68	00	56.25	00	46.51

Most respondents (62.04%) report rarely having financial benefits from riparian ecosystems, while 23.15% receive daily financial benefits. Additionally, 30.56% benefit from pollinators in their fields daily, though more than half (52.78%) report using them rarely. Products for traditional ceremonies are the least utilised benefit of riparian ecosystems, with 94.44% indicating they rarely use them. Riparian ecosystems mainly provide populations with daily food resources, wood, medicinal resources, and pollinators for their fields. In contrast, products for traditional ceremonies are much less exploited, and income from ecosystems is limited to a minority of people.

At each site (Table 2), respondents rarely use ecosystems for traditional ceremonies and primarily view them as sources of pollination and income, except for the populations at Bagré and Alafiarou. Nearly half of the populations at each site use wood from the ecosystem either daily or weekly. In contrast, the populations of Bagré largely do not derive medicinal benefits from water-related ecosystems, while those at Alafiarou and Okpara report using medicinal resources from the ecosystems daily.

Table 2. Percentages associated with the importance of rivers according to several aspects. The values above 40% are indicated in red. AEP means drinking water supply.

Importance	Low			Medium			High		
Site	**A**	**B**	**O**	**A**	**B**	**O**	**A**	**B**	**O**
Cultural/spiritual value	65.63	67.74	48.84	06.25	09.68	06.98	28.13	22.58	44.19
Recreation and tourism	62.50	77.42	95.35	09.38	16.13	04.65	28.13	06.45	00.00
Climate regulation	34.38	41.94	79.07	40.63	48.39	11.63	25.00	09.68	09.30
Habitat for biodiversity	03.13	03.23	00.00	06.25	35.48	02.33	90.63	61.29	97.67
Water purification	53.13	19.35	93.02	12.50	61.29	02.33	34.38	19.35	04.65
Flood regulation	25.00	41.94	95.35	62.50	48.39	02.33	12.50	09.68	02.33
AEP	12.50	03.23	39.53	06.25	38.71	18.60	81.25	58.06	41.86

3.4. Importance of River-Related Ecosystem Services

The importance of the river in line with the ecosystem services was assessed by the people surveyed (Figure 4). The analysis reveals that the ecosystem services deemed most crucial by respondents are biodiversity habitat (85.18%) and the supply of drinking water (57.42%). Aquatic environments are rich in nutrients, which coexist in and outside many populations of organisms, particularly animals [24]. Each river has a unique biodiversity, inhabited by different species of fish. This is the case of the Bagré, Okpara, and Alafiarou dams, including the associated rivers, which constitute rich biodiversity as revealed by the field surveys. These dams also supply drinking water to surrounding populations, such as Parakou in Benin.

Ecosystem services that appear to be of lesser importance include recreation and tourism (80.55%), cultural and spiritual values (60.18%), water purification and flood control (59.26%), and climate control (54.63%). These results denote the lack of awareness of these services by grassroots populations. Apart from the recreational and tourism aspects, cultural and spiritual values that are entirely socio-anthropological and therefore dependent on the activities carried out in these regions, the power of water purification by the ecosystems that coexist there is internationally recognised, even though the surveys do not highlight these aspects. Similarly, freshwater environments help slow down flood risks, help regulate the climate at the local level by cooling the atmosphere, and promote water quality by acting as a filter for groundwater [25]. On a broader scale, freshwater ecosystems, particularly wetlands, participate in carbon storage and reduce the greenhouse effect.

Freshwater ecosystems play a significant role in regulating water quality. They are natural water purifiers, in particular, due to their vegetation and the micro-organisms present in the soil or in the water, which act as a filter, limiting the contamination of groundwater in particular. The ecosystem service of moderate importance and with the highest percentage is flood regulation at 33.33%. However, they are perceived as less significant for aspects such as recreation and tourism, water purification, cultural/spiritual values, as well as flood regulation and climate regulation.

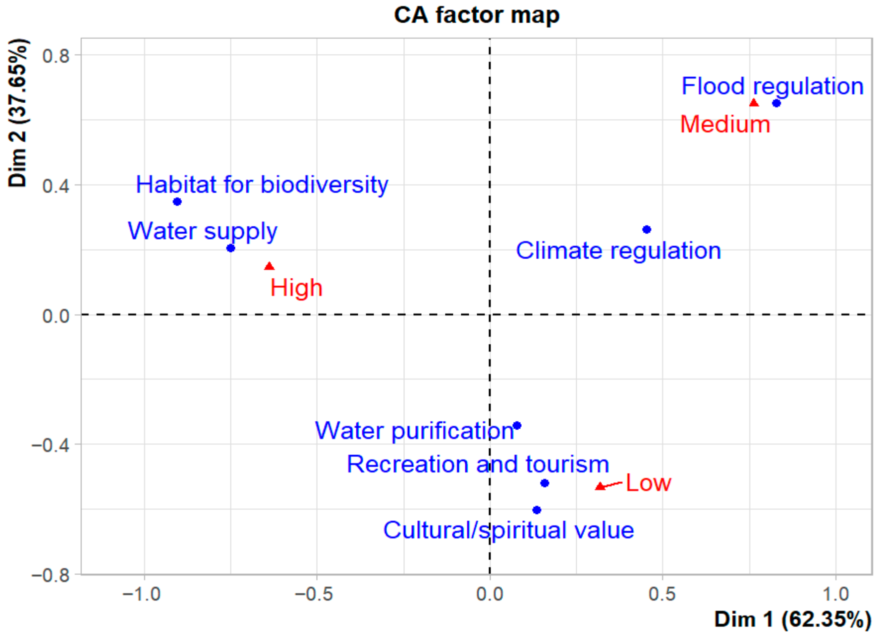

Figure 4. Importance of ecosystem services.

The low importance of cultural and spiritual values, recreation, and tourism of ecosystem services linked to the river and dams is confirmed at each study site. The role of climate and flood regulation played by these dams and related ecosystems is low according to the respondents of Bagré and Okpara, unlike those of Alafiarou, who find them at least medium. Regarding water purification by dams and associated ecosystems, it is of lesser importance according to the inhabitants of Alafiarou and Okpara, but acceptable according to those of Bagré. However, there is unanimity at the three sites as to the great importance of these dams for the supply of drinking water as well as for habitat for biodiversity.

3.5. Dam Impacts

3.5.1. Potential Impacts of Dams in the Study Areas

The potential impacts of the dam on socio-economic activities were assessed through the implemented questionnaires. According to Figure 5, more than half of the participants (68.5%) reported observing changes in the services provided by rivers and socio-economic activities since the installation of the dam. In contrast, 16.7% of respondents believe there has been no change, while 14.8% expressed uncertainty, responding with 'Maybe'. These responses were consistent across all sites, confirming a substantial alteration in the services provided at the three investigated locations.

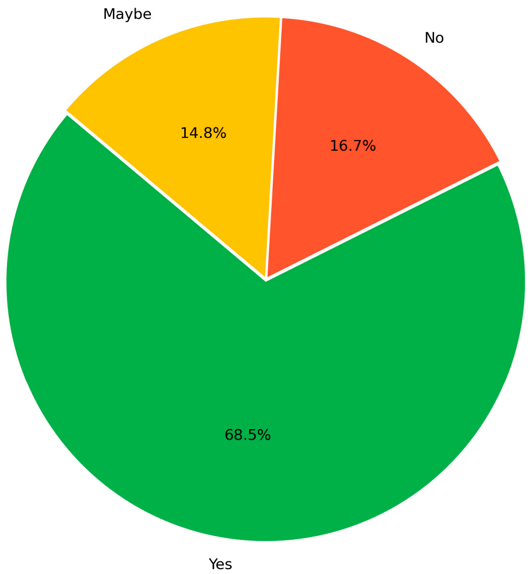

Figure 5. Percentages having observed or no changes.

The potential changes due to the construction of dams in the affected areas are shown in Figure 6. The installation of dams has significant impacts, particularly on biodiversity and vegetation. These impacts include the disappearance of certain species (74.32%), a reduction in plant cover (74.32%), an increase in mosquitoes and other insects (67.57%), and a decline in fish resources (63.51%). Additionally, there is a trend toward a reduction in trees and shrubs (52.7%).

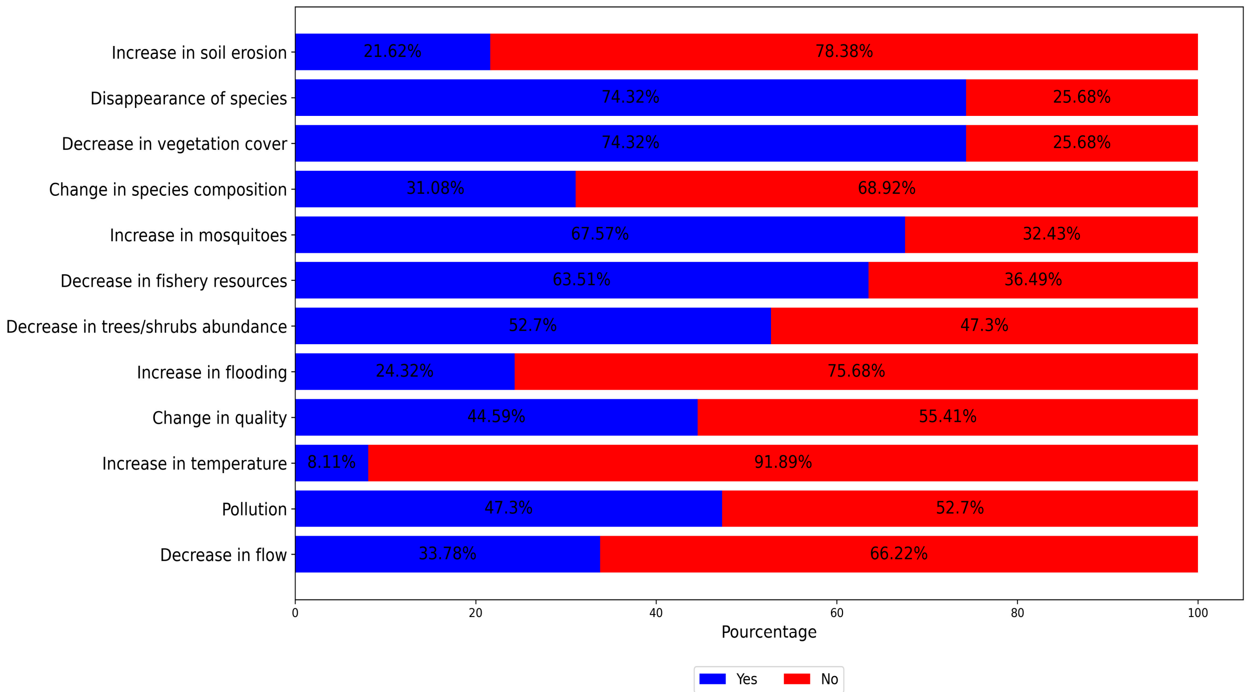

Figure 6. Potential changes due to the construction of dams.

These biodiversity impacts can be explained by the flooding of forests, habitat destruction, and the increased release of greenhouse gases as vegetation decomposes. The ecosystems where dams are constructed host species adapted to those environments. However, the alteration of these ecosystems by dams can harm species that may struggle to adapt. Not only do dams threaten certain species with extinction, but they also disrupt migration routes for some animals, further diminishing biodiversity. Furthermore, dams often force local populations to relocate, as Indigenous homes and territories are sometimes submerged [11,19].

In Alafiarou, the decrease in the abundance of trees and shrubs, reduction in plant cover, and the disappearance of certain species were the most frequently reported impacts. In Bagré, an increase in mosquitoes and other insects was noted, while in Okpara, respondents observed a decline in fish resources and the disappearance of specific species.

3.5.2. Specific Impacts of Dams on Other Activities and Water Uses

Figure 7 illustrates the impacts of the dams on various factors such as water quality, water flow, fisheries, agriculture/irrigation, flooding, and recreational activities. The majority of respondents reported positive impacts of the dams on agriculture and irrigation (68.52%), water quality (55.52%), fisheries (53.7%), and water flow (50.93%). The positive impact on agriculture is primarily reflected in the availability of irrigation water for crops during periods of limited rainfall. The improvements in water quality can be attributed to an increase in the volume of water available, which dilutes the same quantity of pollutants. A comparative study of water quality between ponds and the dam in a pond fish farm in the South-East of Côte d'Ivoire found that the ponds were acidic, low in oxygen, and rich in suspended matter, while the dam's water was nearly neutral, well-oxygenated, and clear [26].

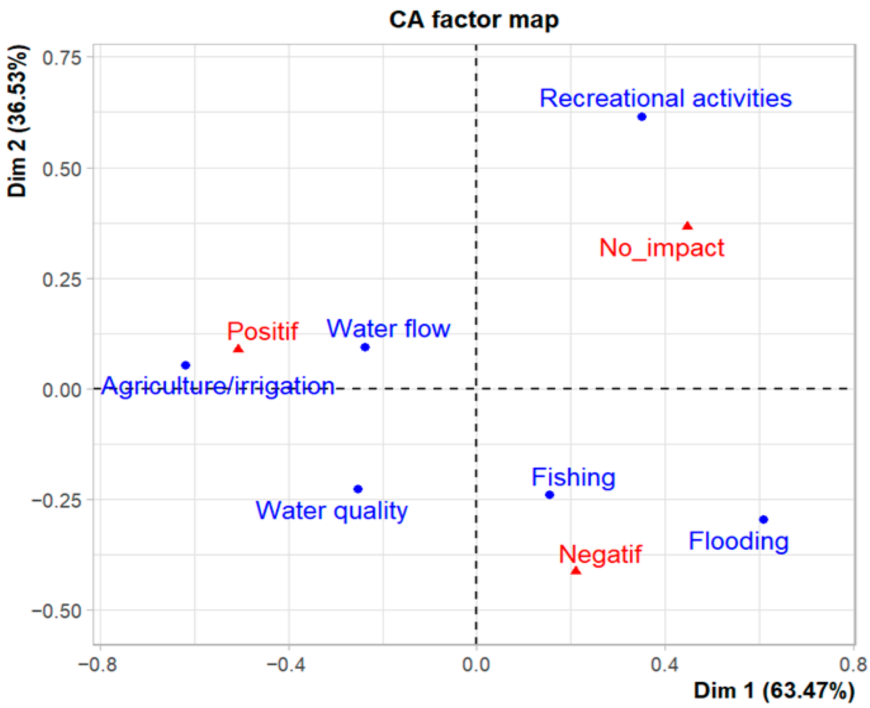

Figure 7. Impact of a dam on some ecosystem services.

The positive impact on fisheries is due to the dams providing reservoirs for fish species, although the dams can sometimes affect aquatic species. In these cases, while fish stocks may be sustained, fisheries might experience reduced success. The positive dam effects on flow rates, as reported by the surveys, can be explained by the dams' ability to regulate flood flows and ensure environmental flows downstream, particularly during low water periods. For example, the Bagré Dam in Burkina Faso and the Markala Dam in Mali support off-season crops through minimum flow provision. However, a negative impact on flow rates, such as reduced downstream flows, was reported at the Okpara Dam, which supplies drinking water to Parakou City in Benin.

The respondents mostly indicated that dams do not impact recreational activities, while 56.48% identified flooding as a negative consequence. Dams can cause flooding, sometimes leading to the water overflowing into nearby communities or, in extreme cases, dam breaches. On the other hand, they can also regulate floods and reduce their downstream impact. Other negative impacts reported by participants included loss of life due to flooding, difficulties in pumping water downstream during low water periods, lack of fishing opportunities at dams downstream, restricted access to dams for livestock, and energy savings at the expense of water resources.

Some particularities are observed by the site concerning these impacts. At the Okpara dam, the responses are unanimous as to the negative impact that the dam has on flooding, agriculture, fishing, flows, and water quality. Conversely, at the Bagré dam, positive impacts were reported, particularly about agriculture, fishing, flows, and water quality.

3.6. Community Engagement in River Protection Initiatives

The results reveal a largely positive attitude towards community engagement in response to the question, 'Would you be willing to participate in local initiatives for the protection of the river?' A significant 78.7% of participants expressed their willingness to actively participate in local initiatives aimed at river preservation. Meanwhile, 13.9% were uncertain ('Maybe'), and a smaller proportion, 7.4%, indicated they did not wish to participate in these initiatives (Figure 8).

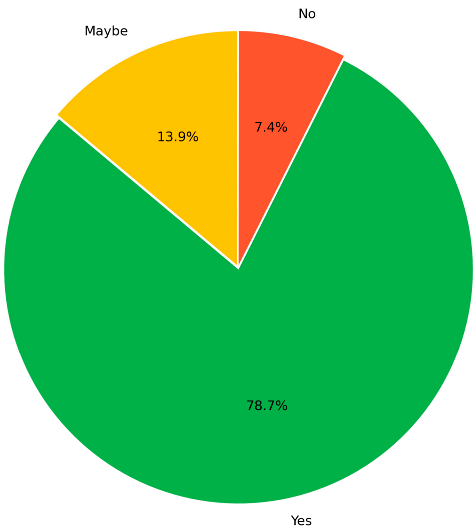

Figure 8. Percentages of people willing to participate in local initiatives for the protection of rivers.

In particular, all respondents in Bagré expressed their willingness to participate in river protection initiatives, compared to 81.2% in Alafiarou and 60.5% in Okpara (Table 3). The significantly lower percentage in Okpara can be attributed to the fact that the local populations do not primarily benefit from the resource exploitation, as the water pumped from the Okpara dam supplies the city of Parakou, located about twenty kilometres away. This highlights the need to include the populations near Okpara in a benefit-sharing plan related to the dam's water use, ensuring they also feel a sense of responsibility for protecting the river that feeds the dam. In contrast, 100% of those interviewed in Bagré indicated their willingness to participate, suggesting that the inclusion of these populations in dam management mechanisms has fostered a strong sense of responsibility for the associated ecosystem services. This data suggests that community engagement is strongest in Bagré, likely due to their direct involvement in dam management, while Okpara's lower rate may stem from a lack of perceived benefits from the dam.

Table 3. The rate of people willing to participate in local initiatives for the protection of rivers at each of the sites.

	Alafiarou	Bagre	Okpara
YES (%)	81.2	100	60.5
NO (%)	15.6	00	16.3
MAYBE (%)	3.1	00	23.3

4. Discussions

The findings of this study highlight the complex interplay between dam construction and river ecosystem services in West Africa, as perceived by local communities. The prioritisation of biodiversity conservation and drinking water supply as the most crucial ecosystem services aligns with previous research emphasising the vital role of freshwater ecosystems in supporting both ecological and human needs [2]. However, the lower importance attributed to cultural, recreational, and climate-regulating services suggests a gap in community awareness, which may stem from limited direct engagement with these services or insufficient education on their broader ecological benefits [11]. This disparity underscores the need for targeted awareness campaigns to highlight the multifaceted value of river ecosystems, as demonstrated in similar contexts [12].

The positive impacts of dams on agriculture, irrigation, and water quality reported by respondents reflect the tangible benefits of regulated water flows, particularly in regions prone to climate variability [6]. However, the observed negative consequences, such as biodiversity loss and reduced fish resources downstream, are in line with the global concerns about the ecological trade-offs of dam construction [8,9]. The case of the Okpara Dam, where downstream communities reported limited benefits, illustrates the importance of equitable water distribution and inclusive management practices. This aligns with studies advocating for adaptive dam operations to balance human and ecological needs [4,5].

The high willingness of communities to engage in river protection initiatives, particularly in Bagré, suggests that participatory management approaches could mitigate some negative impacts. The lower engagement in Okpara, where local benefits are minimal, highlights the critical role of benefit-sharing mechanisms in fostering stewardship [13]. Future efforts should focus on integrating local knowledge and priorities into dam management strategies, as seen in successful cases from Kenya and Côte d'Ivoire [14]. Such approaches could enhance both ecological resilience and socio-economic equity, ensuring sustainable outcomes for river ecosystems and dependent communities.

The prioritisation of biodiversity conservation and drinking water supply as the most valued ecosystem services aligns with studies in other African contexts, such as Kenya's Tana River Basin, where dams similarly disrupted fish migration but enhanced irrigation potential [13]. However, the undervaluation of cultural and recreational services contrasts with findings from Spain, where communities near protected areas recognised these services as integral to their well-being [11]. This disparity suggests that West African communities, heavily reliant on subsistence agriculture, prioritise provisioning services over cultural ones; a trend also observed in Burkina Faso's Dano Basin [27].

On a watershed scale, the reported decline in fish resources downstream of the Bagré Dam support the findings from the Niger River, where dams reduced fish catches substantially [28]. The dams' fragmentation of aquatic habitats disrupts fish migration. Conversely, the positive impacts on irrigation and flood regulation align with benefits observed in Mali's Office du Niger, where dams enabled year-round rice cultivation [28]. These trade-offs necessitate adaptive management strategies, such as environmental flow releases, to balance ecological and agricultural needs [8,9].

Regionally, the role of dams in climate regulation was underrecognized by communities, despite evidence that West African reservoirs sequester carbon and mitigate local temperature extremes [29]. This gap in awareness was observed in Côte d'Ivoire, where rural populations overlooked the wetlands' role in flood attenuation [14]. Transboundary impacts are also critical. The Bagré Dam's reduced flows into Ghana's Lake Akosombo could affect hydropower generation downstream [30], a challenge similarly faced by the Senegal River Basin [31]. Integrating climate-smart dam designs, such as sediment-flushing mechanisms, could mitigate these cross-border risks.

5. Conclusions

This study examines local communities' perceptions of ecosystem services provided by dams and rivers in Benin and Burkina Faso, focusing on the Alafiarou, Okpara, and Bagré dams. The findings indicate that biodiversity conservation and drinking water supply are the most valued ecosystem services in the study area, whereas recreational, cultural, and climate-regulating services are perceived as less important. The perceived impacts of dams are largely positive, with improvements in agriculture, irrigation, water quality, and fisheries. However, negative consequences include biodiversity loss, decreased vegetation, increased mosquito populations, and a decline in fish resources downstream. Additionally, dams disrupt river hydrology, affecting water access and ecosystem balance.

Community engagement in river protection initiatives is notably high, with support reaching 100% in Bagré but only 60.5% in Okpara, likely due to limited local benefits from the dam. While dams provide essential water-related services, they also bring significant ecological and socio-economic changes. Enhancing benefit-sharing mechanisms could strengthen community participation in conservation efforts, ensuring more equitable and sustainable outcomes. In this regard, further research could concentrate on customised and site-specific strategies to offset the negative impacts documented in this paper.

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