ESJ Social Sciences Peer-reviewed

Economic evaluation of the direct use values of goods and services provided by the Bagré wetland in Burkina Faso

Tapsoba Aicha
Institute of Environment and Agricultural Research
Laboratory of the Environment and Forestry, Agroforestry, and Aquatic Ecosystems, Burkina Faso

Doi:10.19044/esj.2024.v20n28p109

Submitted: 26 August 2024
Accepted: 21 October 2024
Published: 31 October 2024

Cite As:
Tapsoba A. (2024). *Economic evaluation of the direct use values of goods and services provided by the Bagré wetland in Burkina Faso*. European Scientific Journal, ESJ, 20 (28), 109. https://doi.org/10.19044/esj.2024.v20n28p109

Abstract

Aim missing this study examines the sustainability of the Bagré wetland in Burkina Faso by assessing the direct use values of its ecosystem goods and services. It is accompanied by practical policy recommendations and aims to contribute to strengthening the country's economic growth. The conceptual framework of Munasinghe's (1992) theory and the economic evaluation guide developed by Somda and Awaïs (2013) made it possible to identify and evaluate the direct use values in the Bagré wetland. A documentary synthesis and individual surveys with a sample of 120 stakeholders spread across nine municipalities were carried out. The summary identifies agricultural, fishing, and forestry resources as the zone's main direct-use goods. Data analysis shows that the monetary value of agricultural and fishery production from 1989 to 2019 is 141,251,106,000 FCFA, distributed into nearly 41% for rice and 29% for fish products. The areas sown during this period cover 89,967 ha. Forestry potential is estimated at around 19 billion FCFA, distributed into 54% for non-timber forest products and 44% for firewood. The direct use value of the Bagré wetland in three decades is estimated at over 160 billion FCFA. The challenges of promoting direct-use goods affect the country's gross domestic product, food self-sufficiency, and job creation. Also, irrational valorization actions negatively impact ecosystems and degrade natural resources. Political implications must be considered for sustainable and inclusive management.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Keywords: Bagré wetland; Assessment; Ecosystem goods and services; values; Burkina Faso

Introduction

Burkina Faso, a landlocked Sahelian country in the heart of West Africa, is among the poorest countries in the world, with nearly 40% of its population living below the poverty line, estimated at 194,629 FCFA/year (UNDP.[1], 2022; INSD[2], 2022). In 2021, it was ranked 184th out of the 191 countries assessed by the United Nations with a human development index (HDI)[3] of 0.449. Its majority rural population, 73.86%, according to INSD (2022), depends on natural resources. These resources contribute 61.5% to household income, of which approximately 67% and 31% come from crop and livestock production, respectively (DGPER[4], 2010). The country's economy is rural and dependent on natural ecosystems. Statistics from the fifth general population and housing census in Burkina Faso show that more than six out of ten people are employed in agriculture, livestock, hunting, and support activities (INSD, 2022). The agricultural sector employs 82% of this proportion. In climate change and population growth contexts, natural ecosystems, particularly wetlands, are undergoing accelerated degradation (Tapsoba et *al*., 2023). However, the significance of these wetlands' socio-economic and cultural problems only becomes apparent when their ecosystems are degraded or lost. This is why studies have attempted in recent years to estimate the economic value associated with the goods and services provided by these humid ecosystems (Somda et al., 2010; Tapsoba, 2015; Daly-Hassen, 2017; Mevanly et al., 2019) on the wetlands (WL) of Bagré.

The Bagré wetland is of capital environmental and socio-economic importance for Burkina Faso. Its agricultural potential was identified in the 1970s, a period of serious drought and famine (Kaboré and Bazin, 2014). It was established as an economic center with hydro-agricultural development plans to respond to the situation at that time. However, its natural resources are not spared from the phenomenon of degradation. Understanding this strategic ecosystem's economic value can help improve its sustainable management through protection and conservation actions. Thus, this study aims to examine the sustainability of the Bagré wetland based on a monetary evaluation of the direct use values of its ecosystem goods and services.

[1]United Nations Development Program
[2]National Institute of Statistics and Demography
[3]Human Development Index: Parameter by which the United Nations (UN) measures people's chances of leading a long and healthy life, of having access to knowledge and a decent standard of living.
[4]General Directorate for the Promotion of the Rural Economy

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

1. Methodology

The methodology used first describes the study area, then defines a sample of direct actors for the surveys, and finally presents the methods used for data collection and analysis.

1.1. Study zone

Data collection occurred in nine municipalities chosen based on their proximity to the Bagré Dam and their relationship with it. They are the four municipalities contiguous to the Dam (Bagré, Beguedo, Boussouma, Gomboussougou) and which shelter the technical units of the fishing area of economic interest (UTP), the three urban municipalities (Bittou, Garango, Tenkodogo) which are crossroads of transactions through their market and the two rural municipalities (Bané, Zonsé), as shown in Figure 1. The municipality of Bittou is the region's heart of economic activities.

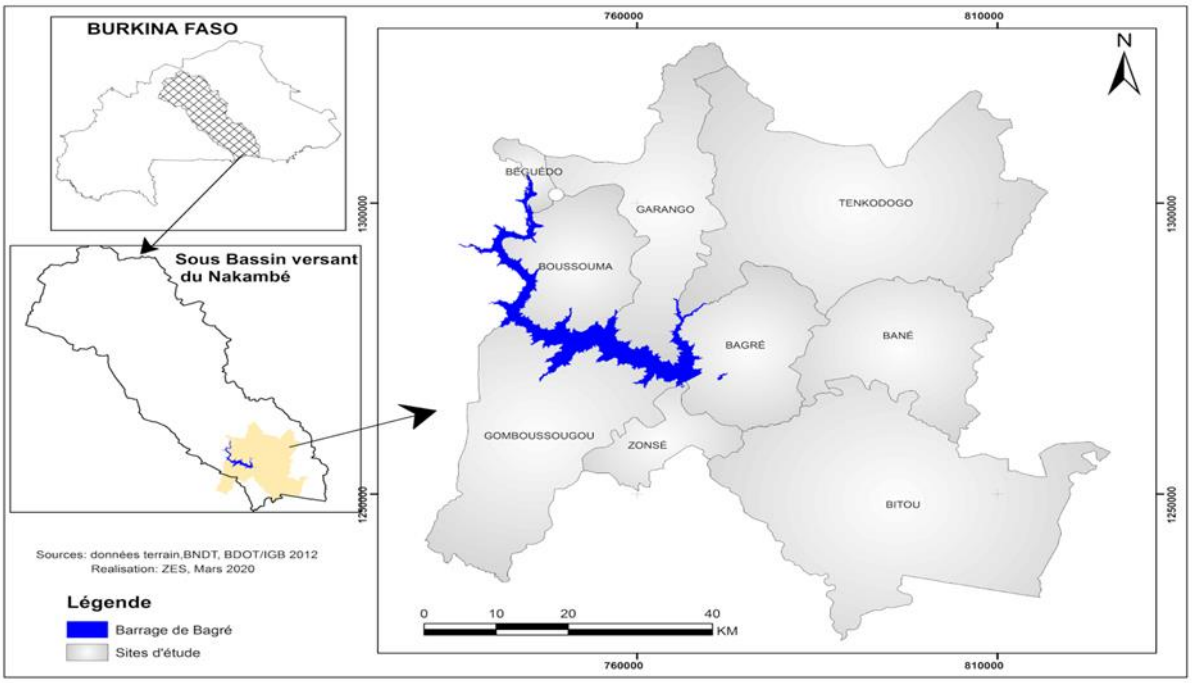


Figure 1: Location of the municipalities surveyed

The Bagré dam was built from 1988 to 1993 and was impounded in 1994 (Venot et *al*., 2017; Daré et al., 2019). The same authors report that the first land developments observed on the left bank covered an area of 680 ha in 1995 and 1,200 ha on the right bank between 1995 and 2002, followed by an extension of a perimeter of 1,500 ha on the left bank between 2002 and 2010.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

1.2. Sampling

The sample size is 120 stakeholders, 72% direct operators of water, land, and plant resources, goods, and services. Initially, 162[5] actors had to be surveyed due to 2 actors per field of activity.[6] Per municipality, at least one respondent per technical service in the three urban municipalities and one municipal representative or a village development advisor (CVD) per municipality.

The choice of direct resource actors was made following an interview with municipal services, which have a directory of peasant associations and organizations in their locality. Thus, two actors were chosen from the repertoire while respecting gender parity. The selection criteria were seniority in the field of activity and the actor's reputation in the locality and the surrounding villages. Thus, approximately 71% of the planned sample was interviewed, distributed as 44% female respondents and 80% direct operators. The stakeholders in rice, market gardening, non-timber forest products, and the production of plants and fruits are the most numerous in the population surveyed, with a proportion of 17%, 15%, 14%, and 10%, respectively. The low rate of fishing stakeholders (7% fishermen and 4% fishmongers) is justified by the fact that data collection occurred outside the favorable period of their activities (July, August, and September). Loggers are solely women, representing 6% and breeders 8% of the population surveyed. The restricted sample is explained on the one hand by the precautionary measures suggested for the municipalities of Gomboussougou and Béguédo due to the reported presence of unidentified armed groups. On the other hand, the workforce is reduced since all activities (market gardening, fish farming, fishing, exploitation of timber and non-timber products, rice growing, breeding, and production of plants) are not carried out in all nine municipalities studied.

1.3. Conceptual frame

The conceptual framework used for this study is Munasinghe's theory (1992). This theory groups values into two categories for assessing total economic value (TEV). The first is made up of direct use values , and the second of those of future uses or non-uses. Pearce and Warford (1993) support this theory by believing several values must be considered when evaluating TEV. However, this study, which tries to evaluate the TEV of the Bagré wetland, will focus on values, particularly direct use values defined by Munasinghe (1992). The guide Somda and Awaïs (2013) developed made it

[5](2 actors x 9 municipalities x 8 areas of activity) + 3 (rural technical service agents) x 3 urban municipalities + CVD/municipalities = 162

[6]Lumberjacks, breeders, market gardening producers, fishing stakeholders (fisherman and fishmonger), operators of non-timber forest products, producers (plants and orchards), and rice producers.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

possible to identify and evaluate the ecosystem goods and services of the Bagré wetland. The conceptual framework of this study is presented in Figure 2.

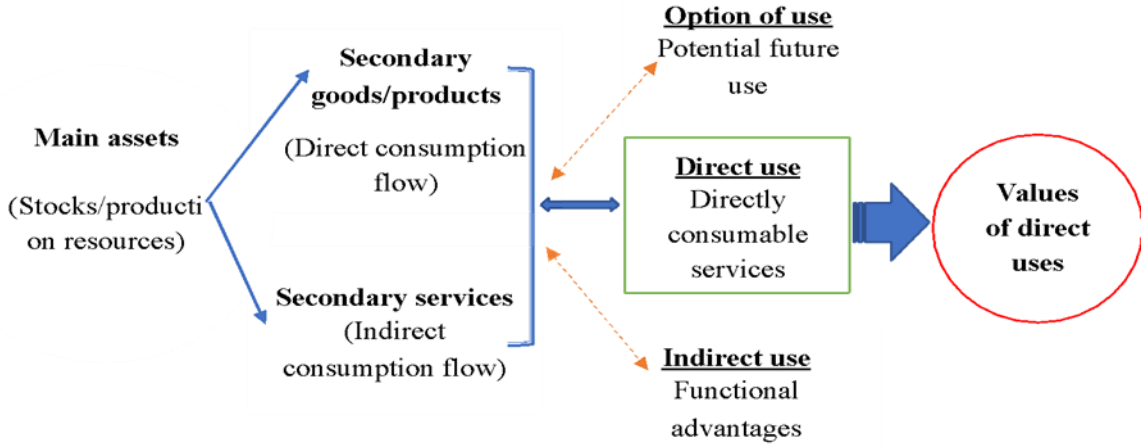


Figure 2: Scheme adopted for the evaluation of use value, adapted from Munasinghe (1992)

This attempt to evaluate the value of the natural potential of the Bagré wetland will only consider values that directly affect the well-being of populations. As a result, it will consider the goods and services from the three production resources: water, land, and plant. These ecosystem goods and services available in the locality of the said zone were identified and then grouped by type of use.

1.4. Collection, nature, and analysis of data

The data collected is more secondary in nature than primary. The approach used first consisted of documentary research, which made it possible to understand the theme and context of the study. This literary review subsequently facilitated the collection of primary information, which made it possible to confirm, refute, or even supplement what was obtained from the documentation. This collection was made from stakeholders related to the management and/or exploitation of water, land, and plant resources on the outskirts of the Bagré Dam. It was carried out through individual surveys administered through a questionnaire organized according to the eight types of actors. The secondary data, of a quantitative nature, are largely extracted from activity reports produced by UTP, Bagrépôle, and the Bagré Growth Pole. Data on the hydroelectric production of the Bagré Dam were collected from the National Electricity Company of Burkina Faso. SPSS v20 and XLSTAT spreadsheets were used to process and analyze the data.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2. Results

The results are from a functional analysis of the Bagré wetland and the evaluation of the direct use values of the ecosystem goods and services it offers.

2.1. Ecosystem goods and services in the Bagré Wetland

In rural areas, wetlands contribute significantly to improving the living conditions of populations. They lead to the development of socio-economic activities[7] and tourism and leisure activities based on the goods and services of these natural ecosystems. In the Bagré wetland, four types of ecosystems are observed: (i) agroecosystems, (ii) aquatic/humid ecosystems, (iii) silvicultural and pastoral ecosystems, and (v) habitation areas. This set provides goods and services to meet the needs of populations (Table 1).

Table 1: Types of ecosystems encountered in the Bagré wetland

Ecosystem	Description
Agricultural/valleys	It is the area of soil nutrients concentration and biodiversity refuge (Adouabou, 2009). It is made up of "the main valleys draining small watersheds (5 to 200 km2), and whose terrain is relatively flat, with a very low slope (less than 1%)" (Lamachère and *al*., 1993).
Wet/Aquatic	Includes the body of water and its hydrographic network. It comprises the receptacle of species of aquatic animals and plants.
Sylvopastoral	The whole consists of grassy, shrubby, wooded, and wooded savannahs of riparian formations. It is also an area of concentration of small ponds.
Housing areas	This is the landscape unit used to construct homes and livestock parks.

Source: Author (2024)

Identifying goods and services in the Bagré wetland facilitates the economic evaluation exercise. In summary, three main ecosystem services are identified, and only one provisioning service is considered in this study. The valued goods and services (G&S) are recorded in Table 2.

Table 2: Environmental goods and services offered by the Bagré Wetland

Ecosystem services	Main assets	Secondary goods
Supply	Water	Freshwater, fishery products, irrigation products, hydroelectric production
	Earth	Arable soils, agricultural products
	Flora	NWFP, wood, pasture/fodder,
	Wildlife	Small wildlife
Regulation & self-maintenances	**Secondary services**	
	Soil nutrients	
	Climate regulation by influencing environmental temperatures	
	Hydraulic regime	

[7]Water supply, fishing, energy, transport, etc.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

	Floor protection
	Stock carbon
	Underground recharge
Cultural and social	Cultural heritage (tourist sites)
	Recreational and educational spaces
	Spiritual and religious spaces

Source: 2020 Survey and Tapsoba (2015)

Table 2 reveals the main goods obtained from procurement services. This preliminary work to identify environmental/ecosystem goods and services allows a monetary estimate of the use values offered by the Bagré wetland.

Halieutics resources

The State's policy of erecting growth poles around large water reservoirs was initiated from the consequences of the droughts of the 1970s. Thus, a program to build large dams was undertaken to contain and control surface water. The Bagré Dam, with a capacity of 1.7 billion m^3 and extending over 25,000 ha during low water periods, was built in 1992. Its fishing potential was discovered in 1994, giving it the Fisheries status. In 2004, the dam was turned into an aquaculture perimeter of economic interest (PAIE) and then as a fishing perimeter of economic interest (PHIE), given the importance of its fishing potential, estimated at 1,600 tons per year. The Bagré Dam is the 2^{nd} fisheries of great importance in terms of surface area and production potential after the Kompienga Dam and that of Sourou.

However, the surveyed actors reveal that certain fish species have disappeared from the Bagré dam over time. Nowadays, the big fish commonly called "Captains" (*Lates niloticus or Nile perch*) large size are no longer encountered during captures. For these stakeholders, the probable explanation is the overexploitation and pollution (silting, pesticides, and chemical fertilizers) of the water body, which would disrupt the reproductive capacity of fish. Primary information unanimously reveals that fishing activities occur in biological resting areas/spawning areas, in areas temporarily closed to fishing, and even during fishing closure times. From a biological point of view, all these practices hinder fish reproduction and the sustainability of fishing activity. Beyond the legislative and regulatory framework that governs the management of hydraulic and fishery resources, efforts must be mobilized to preserve wetland ecosystems. Implementing actions to reduce the overexploitation of fishery resources and slow down the processes of silting and pollution with agricultural chemicals in the Bagré Dam can help improve its sustainable management.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Forest resources

The Bagré Dam wetland is part of the Sudanian phytogeographic domain and precisely the northern Sudanese sector. Field observations made during the study of the spatiotemporal dynamics of resources show that the Bagré area is characterized by former fallows, degraded savannahs, and shrub savannahs predominantly occupied by species such as *Piliostigma reticulatum, Balanites aegyptiaca, and Ximenia. Americana.*

The wooded savannah is dominated by woody species such as *Vitellaria paradoxa, Tamarindus indica, Faidherbia albida, Lannea acida, Acacia gourmaensis, Ficus sycomorus, Khaya senegalensis*, etc. The strata of gallery forests downstream of the dam are formed by species such as *Khaya senegalensis, Anogeissus leiocarpus, Diospyros mespiliformis, Daniella Oliveri, Parkia biglobosa, Tamarindus indica, Pterocarpus erinaceus*, etc.

The shrub, consisting of species such *as Piliostigma reticulatum, Balanites aegyptiaca*, and Ximenia americana, predominates and comprises former fallows to the south of Béguédo.

The relict tree layer is characterized by the absence of crops. It is composed of woody species such as *Lannea acida, Vitellaria paradoxa, Tamarindus indica, Khaya senegalensis, Faidherbia albida, Acacia gourmaensis, Ficus sycomorus*, etc.

The stratum of gallery forests along the river downstream of the Dam, very dense in places, is composed of *Khaya senegalensis, Daniella Oliveri, Anogeissus leiocarpus, Diospyros mespiliformis, Pterocarpus erinaceus, Parkia biglobosa, Tamarindus indica*, etc.

The grassy savannah encountered is quite large and composed of species such as *Andropogon gayanus, Schoenefeldia gracilis, and Cymbopogon schoenanthus.*

The species frequently exploited by the populations of the Bagré wetland are recorded in Table 3 in appendix according to the type of use.
Table 3 shows various uses depending on species. All those recorded in the table are exploited as non-timber forest products (NTFP) in human and animal food and human and animal health care. Furthermore, survey results combined with information provided in the descriptive sheet of the Bagré Ramsar site identify *Vitellaria paradoxa* and *Khaya senegalensis* as threatened plant species. The information collected also attests *that Acacia laeta, Bombax costatum, Combretum aculeatum, Combretum mole, Crossopteryx febrifuga, Daniellia Oliveri, Ficus gnaphalocarpa, Ficus sp., Grewia sp., Lannea acida, Mearua crassifolia, Parkia biglobosa, Securidaca long pedunculate, Terminalia macroptera, Ximenia americana, and Ziziphus micronata* are plant species very rarely encountered in the locality.

Species such as *Vittelaria Paradoxa, Parkia biglosa,* and *Balanites aegyptiaca* have important social, cultural, and economic value. Their NTFPs

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

are the subject of regional, national, and even cross-border trade. However, other species are highly used for their woody material, which is used for energy and lumber. This is the case of *Vittelaria paradoxa*, which is highly used for its firewood and charcoal, although it is a threatened and protected species. In the various municipalities concerned by this study, the standing wood potential is composed, among other things, of trees providing firewood, utility wood, NTFPs, and domestic fruits (Table 4 in appendix).

Table 4 reveals that the study area has a plant potential estimated at more than 9.6 million tree plants with an average density of woody material estimated at around 19 m^3 per hectare. The potential providers of NTFPs (larger) and those providing firewood represent 48% and 39% of the total estimated volume, respectively. Forest resources in the locality constitute a potential supply of NTFPs and energy wood for the populations.

Wildlife Resources

The documentary review reports that the Bagré wetland is home to the following protected areas (PA): the Ouilingoré classified forest (6,850 ha), the classified forest of Yakala (1,600 ha), and the Sitenga classified forest (840 ha). However, each of these PAs has very little rich and varied fauna due to the intensity of the anthropogenic pressure observed there. This fauna is largely made up of small game (hares, small antelopes, rats, squirrels, doves, etc.) found in relics such as old fallows, sacred woods, and hills unsuitable for agriculture. For its survival, almost extinct, Big Game finds refuge in more secure areas except for the population of hippos and emblems of the dam, which led to its classification on the list of Ramsar sites very present in Yakala and Foungou. A few mammals and reptiles are present alongside an avian fauna made up of nearly 150 species of birds. Those with frequent encounters include graylings, cattle guards, doves, small hornbills, herons, francolins, sandgrouses, guinea fowl, and weavers. In addition to hippos, some birds, mammals, and reptiles are observed for aquatic fauna. These are the Nile Monitor, the Nile Crocodile, aquatic turtles, and wild ducks.

Beyond its fish production capacity of around 600 tons on average of fish/year, the ichthyofauna encountered there is quite varied. There are 13 *Chlorophycae*, 2 *Euglenophycae*, 6 *Cyanophycae*, 7 *Chrysophycae*, and 5 *Rhodophycae*; eight genera of Rotifera, a species of *Cladocera*, a species of *Daphnia pulex* and *Copepods; Caelatura aegyptiaca*; 45 species of fish, the most common of which are *Clarias gariepinus* (catfish), *Lates niloticus* (captains), *Oreochromis niloticus, Sarotherodon galilaeus, Tilapia zilii, Schilbe mystus, Protopterus annectens, Brycinus nurse, as well as a species of shrimp (Macrobrachium sp)* and some species of frogs (Rana sp.).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Agricultural resources

The pilot project for rice cultivation, called "Petit Bagré," which extends over 80 ha, was initiated in 1979 to certify the real agricultural potential of the Bagré wetland as well as the capacity of farmers to practice irrigated rice cultivation. This rice field is fed from a hillside lake of 3.5 million m^3, which has become a buffer reservoir in the general irrigation system in the Bagré area. The potential for agricultural land is 30,000 ha, which can be developed upstream (9,000 ha) or downstream (21,000 ha) of the Bagré Dam. Rainfed agriculture and irrigated agriculture are carried out there. Off-season crops employ farmers after the seasonal harvests. The agribusiness (agricultural entrepreneurs) and family farmers live together on the site. The land potential for rainfed agriculture is 170,000 ha from May to October. Irrigated agriculture differs depending on the bank. The left bank is set up for agribusiness-type exploitation (market gardening and fruit growing), and the right bank is occupied by the villages bordering the Bagré Dam and practicing there alongside rice cultivation, that of the off-season (market gardening farming).

Pastoral resources

The synthesis of survey data and information extracted from the literature review indicates three types of breeding. Extensive transhumant, sedentary, and semi-extensive breeding is practiced in the Bagré wetland. The first is practiced by Fulani pastoralists, the second by indigenous farmers, and the third by groups of mixed breeders (Fulani pastoralists and indigenous farmers). Livestock farming concerns cattle, sheep, goats, pigs and poultry. Animals use unmarked trails to access grazing and traditional wells, rainwater reservoirs, and boreholes.

Two pastoral areas covering 7,125 ha[8] are developed in Doubégué and Tcherbo on both banks of the Nakambé. However, woody plants are integral to livestock feeding alongside dry and fresh natural grazing. During the dry season, animals graze along the Nakambé and Bagré Dams. The breeders cut down shrubs, limbs and prune leaves and fruits from trees to feed the herd. During the rainy season, they take their herds away from the fields, mosquitoes, and tsetse flies.

Livestock infrastructure is poorly developed. The information collected shows that the most common animal diseases are anthrax, Newcatle's disease, tuberculosis, avian pox, and pasteurellosis. Animals (goats, sheep, and cattle) from the area are exported to Ghana and Togo.

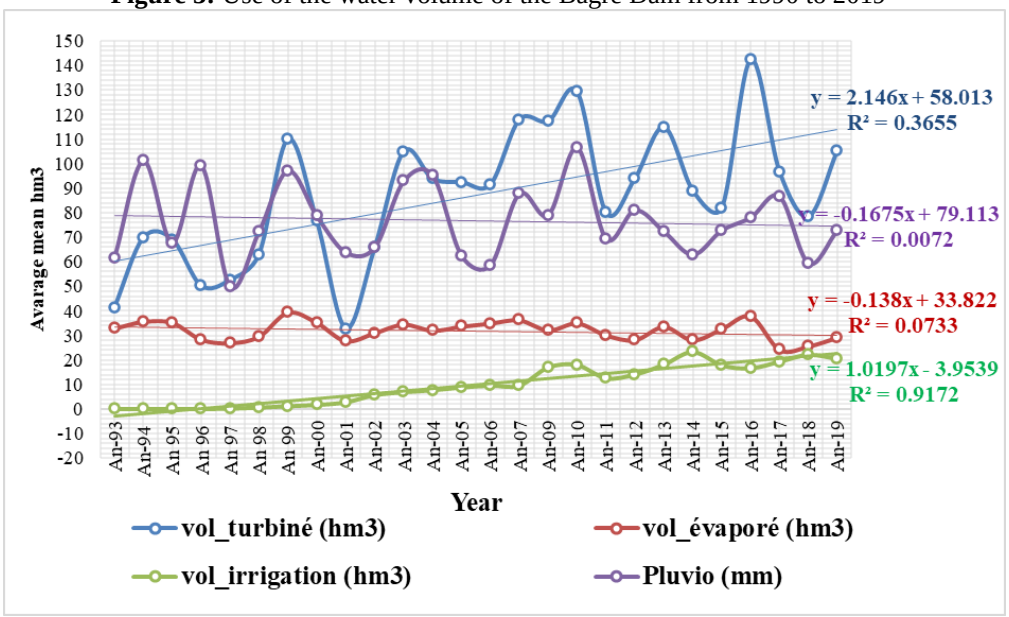
[8](Ouédraogo, 2012)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2.2. Hydroelectric resources

The Bagré Dam, built to address the problem of food insecurity through the development of irrigated agriculture, has also provided electrical energy since 1993 from the hydroelectric power station installed downstream of the dam. The initial planned production of 44 GWh per year almost doubled today. The Burkina Faso National Electrification Company (SONABEL) ensures electricity production and transport. Electricity production has increased over the three decades (figure 3).

Figure 3: Use of the water volume of the Bagré Dam from 1990 to 2019



Source: Author (2024)

Figure 3 shows that volumes of turbines and irrigated water increase over time, while volumes of rainwater decrease over the same period. However, the quantity that evaporates is almost constant over time, implying that the impact of the climatic variable (temperature rise) is significant on the sustainability of the dam's water stock.

Econometric results make it possible to understand better the correlation between the services the Bagré wetland provides for electricity production and irrigation. Thus, the predominance of quantitative variables leads to opting for a multivariate linear regression. Considering the explained variable Y = vol_turbiné (hm^3) and the independent (explanatory) variables Xi with i = year; evaporated_vol (hm^3); vol_irrigation (hm^3); rainfall (mm), the model of the evolution of electricity production from the turbine volume can be written as follows: $Yi = \beta 0 + \beta 1 Xi1 + \beta 2 Xi2 + \beta 3 Xi3 + \beta_4 X_{i4}$ with β0, a constant. The regression results obtained from XLSTAT are reported in Table 5.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 5: Result of multivariate linear regression

Source	Value	Standard error	T	Pr > |t|	Lower bound (95%)	Upper bound (95%)	P-value meaning codes
Constant	-109.643	22,504	-4.872	**<0.0001**	-156.442	-62.844	***
Year	1.709	1.065	1.605	0.123	-0.505	3.924	°
Evaporated_vol (hm3)	3.993	0.665	6.007	**<0.0001**	2.611	5.376	***
Vol_irrigation (hm3)	1.045	0.999	1.046	0.308	-1.033	3.124	°
Rainfall (mm)	0.464	0.166	2.801	**0.011**	0.120	0.809	*

*Meaning codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 <. < 0.1 < ° < 1*

The model of the evolution of the production of the volume of turbid water can then be written according to the following equation:

Y= - 109.6+ 1.709*year + 3.993* evaporated_vol +1.045* irrigation_vol + 0.464* rainfall

The R-squared of the model is 0.845 (R2= 84.5%), indicating that the model is well-specified and adequate. The volume of turbid water is 84.5%, according to the volumes of irrigated and evaporated water and the quantity of rainwater that falls. The results allow us to estimate that the volume of turbined water from the Bagré Dam increases yearly by 1.7%, ceteris paribus. This implies that the need for consumption or supply of electricity is increasing over time.

2.3. Economic evaluation of direct use values

The values of direct-use goods and services in this study are agricultural, fishery values, and plant potential. These three values come from the land, water, and plant resources considered in studying land use dynamics around the Bagré Dam. The Bagré wetland offers economic benefits to populations. Indeed, in addition to fishing opportunities, other income-generating activities are carried out there. For this study, the economic evaluation did not cover all ecosystem goods and services due to the unavailability of statistical data. Consequently, the evaluation of the total economic value of the said zone will be reduced to the evaluation of the direct use values of the goods and ecosystem services it provides.

Monetary values of agricultural and fishery production in the Bagré wetland

The estimated agricultural production is irrigation from areas developed for the occasion. The estimates of values are made in this study based on the ceteris paribus hypothesis. Thus, the potential for developed agricultural land is estimated by multiplying the annual surface area (X= 30,000 ha) by the number of years (n). The potential of agricultural land (Y)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

that can be developed for ten years of agricultural activities is 300,000 ha obtained from the formula "Y= 30,000 × 10".

The total area sown from 2010 to 2019 is 57,903.7 ha. It is obtained from the summary of the annual reports of activities of the "Economic Development Directorate" of Bagrépôle, those of the "Bagré Growth Pole Project" of the Bagré Project manager, and the activity reports of the Technical Unit of the fishing area of economic interest of Bagré. The total agricultural and fishery production in tons recorded in the Bagré wetland between 2010 and 2019 is reported in Table 6 in appendix

The total agricultural and fishery production from 2010 to 2019 is approximately 298,422 tons and 5,616 tons, respectively. Rice production represents 80.42% of the total agricultural production of the decade. Statistical data on production are unavailable from 1990 to 1999 and 2000 to 2009. In fact, from 1990 to 1996, agricultural and fishery production had a zero value (0 tons) because the dam was filled with water in 1994, and the first developed perimeter was recorded in 1995. Also, data on the production of corn, market garden crops, fruit, and fish from 1997 to 2009 are unavailable because they have not been archived.

The summary of the activity reports of Bagrépôle, PHIE-B, and MOB reveals that the total rice production from 1989 to 1999 was 13,134 tons.[9] They were cultivated in an area of 3,444 ha. From 2000 to 2009, 133,711 tons were produced, or 28,619 ha. Furthermore, this economic evaluation study does not include agricultural and fishery production at the “Petit Bagré” pilot project level. Petit Bagré is supplied with water by a hill lake, while the Nakambé River supplies the Bagré Dam, which was the subject of the area's classification on the list of Ramsar sites. Based on the ceteris paribus hypothesis, the missing statistics, apart from the zero values (0 ha and 0 tons) recorded over the period from 1989 to 1996, are obtained from the mathematical formula of the rule of three, which follows:

$$Y = \frac{N \times X}{n}$$

Y= value of agricultural production of corn, market gardening, or fruit sought
X= value of agricultural production of corn, market gardening, or fruit from 2010 to 2019
N = total area sown for the period for which production data are missing
n = total area sown from the period 2010 to 2019

[9]This value represents the sum of the quantities produced during the three years 1997, 1998 and 1999 on areas of 648 ha, 1,248 ha and 1,548 ha respectively.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The total agricultural and fishery production estimated during the three decades 1989 to 1999, 2000 to 2009, and 2010 to 2019 is given in the table (table 7).

Table 7: Agricultural and fishery production (in tons) in the Bagré wetland

Period	**Total sown area (ha)**	**Rice** (Ton)	**Corn** (Ton)	**Market gardening** (Ton)	**Fruits** (Ton)	**Fishery products** (Ton)
1989-1999	3,444	13,134	531.7	1,739, 8	1,204.2	5,713
2000-2009	28,619	133,711	4,419	14,457.5	10,006.3	8,817
2010-2019	57,903.7	239,984.6	8,940.8	29,251.3	20,245.4	5,616.5

Source: adapted from the reports of Bagrépôle (2013, 2014, 2015, 2016, 2018, 2019); MOB (2011); PHIE-B (2016, 2011, 2016, 2018)

As the capacity and expansion of the Bagré Dam (25,000ha) remain unchanged, the total fishery production estimated (ceteris paribus) for the periods from 1989 to 1999[10] and from 2000 to 2009 is obtained from the annual activity reports of the Technical Unit of the Aquaculture Perimeter of Economic Interest of Bagré. A downward trend in fish production has been observed over the last two decades. On the other hand, an intensification of agriculture is observed during the same periods with increasing production.
The monetary value of agricultural and fishery production is estimated by multiplying the quantities produced per decade by their average price per kilogram (kg) (table 8).

Table 8: Monetary value in thousands of CFA francs of agricultural and fishery products

Period	**Rice**	**Corn**	**Market gardening**	**Fruits**	**Fishery products**
1989-1999	1,970,100	97,833	1,304,850	240,840	11,426,000
2000-2009	20,056,650	813,096	10,843,125	2,001,260	17,634,000
2010-2019	35,997,690	1,645,107	21,938,475	4,049,080	11,233,000
1989-2019	58,024,440	2,556,036	34,086,450	6,291,180	40,293,000

- The average price per kg of paddy rice at the edge of the fields is 150 CFA.
- The average price of a kg of corn at the farm gate is 184 CFA francs
- The average price of a kg of freshwater fish is 2,000 CFA francs (Aliou, 2021)
- Average price per kg of organic vegetables: 750 FCFA (Yonli & Ouedraogo, 2023)
- The average price per kg of fruit (banana, citrus fruit, watermelon, yellow melon) at the farm gate is 200 CFA francs.

[10]In the first year of filling of the Bagré Dam in 1994, the quantity of fish captured was 746 tons (PHIE-B, 2006).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The monetary value of agricultural and fishery production in the Bagré wetland during the three decades from 1989 to 2019 is 141,251,106,000 FCFA. Rice production represents 41.08% of the total monetary value, and fishery products represent 28.53% of the total monetary value. These two rates make it possible to confirm the vocation of rice-growing plains and fisheries, which motivated the construction of the Bagré Dam and the hydro-agricultural developments of the dam. Corn cultivation yields the lowest quantity produced in thirty years, with a monetary estimate of 2,556,036,000 FCFA or 2.5% of the total monetary value of agricultural production in the Bagré wetland.

Monetary value of plant potential in the Bagré Wetland

Based on the results of the work carried out by Ouédraogo (2015), "Pricing of wood energy in Burkina Faso: the problem of the internalization of social costs linked to the exploitation of energy," the price of a cubic meter of wood of fire estimated at 2,200 FCFA is used to estimate the monetary value of the potential of standing trees of the benefits cited in table 9.

Table 9: Monetary value of the potential of standing trees supplier of products

Products	Tree volume (feet)	Total value (FCFA)
Fruits	62,351	137,172,200
NWFP	4,665,841	10,264,850,200
Lumber	36,706	80,753,200
Firewood	3,803,528	8,367,761,600
Total	**8,568,426**	**18,850,537,200**

Source: adapted from MEEVCC (2018)

The plant resources, particularly forestry, available on the Bagré site constitute the main supply source for local populations. Its potential is estimated at more than 9 billion FCFA. The value of NTFPs represents 54.45% of the total value, followed by that of firewood (44.49%).

Monetary estimation of direct use values of the Bagré Wetland

The unavailability of statistical data, the extent of the study site, and the diverse multitude of goods and services did not make it possible to have an exhaustive value of the ecosystem goods and services provided by the Bagré wetland. The assessment only concerned direct consumer goods. Table 10 presents the overall economic values of the goods and services supplied in the Bagré wetland.

Table 10: Direct use value of goods and services of the Bagré wetland (FCFA)

Direct use value	Estimated monetary value (FCFA)
Agriculture	100,958,106,000
Fisheries	40,293,000,000
Vegetable	18,850,537,200
Total	160,101,643,200

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

This value of more than 160 billion FCFA is considered minimal. All the direct-use ecosystem goods and services offered by the Bagré wetland could not be estimated in monetary value. This is the case for the potential of pastoral resources. The available statistics on livestock and fodder in the area studied do not cover a third of the 30 years required for a study that considers climate change. In addition, the difficulty of evaluating the price/cost of certain goods and services has led to missing statistics. This is the case for drinking water supply or water withdrawal for purposes other than agricultural irrigation. It appears that agricultural land resources, which represent 63% of the total value, contribute considerably to food security and the socio-economic development of populations. Also, this representative rate approves the primary vocation of the development of the agricultural site. The share of fishery resources in the total monetary value is 25%, followed by forestry resources, 12%. Despite all the limitations, these results can reassure and be useful to all physical and moral actors involved in the sustainable management of the site's natural resources.

3. Discussion

The results highlighted that the Bagré wetland still has great potential for the socio-economic development of the population and even the country. The exploitation and development of these potentialities must be done with wise political will while not marginalizing the needs of future generations. The discussion of evaluating the direct use values of the said zone will be structured around four pillars: social, economic, environmental, and political.

3.1. Socio-economic issues in the development of the Bagré wetland

Establishing the Bagré site as an agricultural growth pole, a hydroelectric production station, and a PHIE demonstrates its multifunctionality and social and economic importance for Burkina Faso. The evaluation of the direct use values of the Bagré wetland from 1989 to 2019 gives a minimum value of 160,101,643,200FCFA. This value is generated from production resulting from the exploitation of its land resources (100,958,106,000 FCFA), water (40,293,000,000 FCFA), and forestry (18,850,537,200 FCFA). This implies that a minimum value of more than 5.3 billion FCFA per year can be obtained from agricultural, fishery, and forestry production in the country's wetlands alone. It is a source of information for building and developing the said wetland. Many scholars estimated the annual value of goods and services of some wetlands in Burkina and concluded that those areas' economic importance is high. These are Somda and *al*. (2010), who estimated the economic value of the Sourou Valley at over 10 billion

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

CFA, and Tapsoba (2015), who assessed the use values of seven sites[11] in Ramsar at more than 85 billion FCFA.

The development of natural resources in the wetlands of Burkina Faso can encourage job creation initiatives and improve the value of its gross domestic product (GDP) and the food self-sufficiency of its population. This corroborates the results of Goyal and Nash (2017), who examined public spending priorities for African agricultural productivity growth. They concluded that the economy of most Sahel countries depends on African agriculture, which contributes to GDP and employs two-thirds of the active population. Furthermore, by exploring the state of poverty, food insecurity, and the vulnerability of agricultural households in the irrigated area of Bagré, Tapsoba (2021) affirms that the development of irrigation is a means used by States to eradicate poverty: poverty and food insecurity. Mevanly and *al*. (2020) assessed the economic value of some ecosystem services[12], including the "Assinie Navigation Canal" wetland on the Ivory Coast. They confirm the socio-economic importance of the said canal and reveal that the minimum monthly income of a palm leaflet weaver is 29,480 FCFA, and that of a fisherman is 59,357 FCFA.

3.2. Environmental impacts of the development of the Bagré wetland

The uncontrolled and sometimes clandestine water, land, and forest resources exploitation in the Bagré site generates much-criticized environmental impacts. These results corroborate the investigations of Limoges (2009) on biodiversity, ecological services, and human well-being, as well as the work of Mévanly and *al*. (2020) on the economic evaluation of the ecosystem services offered by the Assinie Canal (Ivory Coast). They claim that socio-economic activities degrade approximately 60% of the ecosystem services offered by watercourses, particularly wetlands. Indeed, local populations develop socio-economic activities[13] as well as tourism and leisure activities based on the goods and services of these natural ecosystems (Failler and *al*., 2010; Require-Desjardins, 2021). The gradual increase in the volume of irrigated water from the Bagré Dam from 1989 to 2019 reflects the intensification of agricultural practices over time. It is not without damaging consequences for the ecosystems in the area. Consumption and natural resource needs that increase with population could negatively influence the sustainability and even the existence of this wetland of international importance, which reinforces the opinion of Turpie and *al*. (2010), who attest

[11]Lake Bam, Lake Higa, Lake Tingrela, Banh spreading cone, Lake Dem, Kompienga Dam, Tapoa Dam.
[12]Raffia palms, fish, firewood and service.
[13]Water supply, fishing, energy, transport, etc.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

that the factors of wetland degradation are land conversion, overexploitation of natural resources, and pollution.

Furthermore, the downward trend in rainfall observed over the three decades could have a downward influence on the stock (or volume) of water in the Bagré Dam and lead to negative consequences on agricultural and electricity production. Dubreuil (2012) reports that overexploitation, pollution, and reduced rainfall are gradually degrading water resources, and the constant increase in demand could affect 60 million people in 2025.

In the Bagré wetland, the overexploitation of goods and services considered common goods remarkably modifies the structure of habitats and ecosystems. On the other hand, knowledge of the area's economic value can contribute to finding solutions to the phenomenon of degradation of these ecosystems, which supports the statement of Bonin and Antona (2012) and Wallis and *al*. (2011). These authors assert that the degradation of wet ecosystems can be contained by awareness of the economic benefits they bring and the costs of their degradation. Turpie and *al*. (2010) further assert that evaluating wet ecosystem services can contribute to decision-making that leads to sustainable results [14]in the sense that it allows for real costs and benefits from the use and degradation of ecosystems.

3.3. Political implications for sustainable development of the Bagré Wetland

The economic value of the natural resources of the Bagré wetland allows managers, especially the public authorities, to understand development policies better. Some ecosystem goods and services production and income generation capacity now deserve special attention in exploitation and valorization. Knowledge of the economic value of goods and services directly used in the Bagré wetland constitutes an advocacy instrument in favor of sustainable investment, exploitation, and development actions.

The management and planning policy for actions to develop land, water, and forest resources in Burkina Faso should be updated to consider the convergences in their exploitation processes. The exploitation of these three resources is interrelated. The policy for the development of irrigated valleys must also be re-examined. Revising these policies implies adopting a concerted and integrated management approach for the three resources, which makes it possible to limit the actions of their irrational exploitation and slow down the degradation process. It must align with the national socio-economic development policy and decentralized natural resources management policy. Such an approach contributes to building inclusive management that considers the social, economic, and environmental dimensions to ensure a sustainable

[14]ecologically sustainable, socially equitable and economically rational outcomes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

development policy. Indeed, dependence on natural resources has increased over the years, but the results of restoration and preservation efforts are not tangible enough. A new national policy[15] on wetlands that integrates measures to preserve natural resources and conserve ecosystems in its planning framework deserves to be developed.

Conclusion

This study evaluated the direct use values of the ecosystem goods and services of the Bagré wetland based on secondary quantitative data collected from 1989 to 2019. The results obtained from the data analysis made it possible to globally identify the benefits, socio-economic and environmental issues, and political implications linked to the exploitation and valorization of natural resources in the area. Considering land, water, and forest resources, the minimum value in monetary terms estimated in the Bagré wetland is 160,101,643,200FCFA. The assessment showed that this humid ecosystem can provide significant income to the population and foreign exchange to the country through irrigated agriculture, fishery production, and forest products. However, agricultural production increased over the three decades studied while fish production gradually declined. The socio-economic issues linked to the economic development of the Bagré wetland revolve around (i) its contribution to the country's GDP, (ii) food self-sufficiency of the population, and (iii) opportunities for the creation of jobs. The environmental impacts are negative and linked to the modification of ecosystems and the degradation of natural resources. Effective socio-economic development based on wetlands depends on the existential sustainability of their natural resources. The assessment of the economic value of these areas provides both qualitative and quantitative data that contribute to this development and calls for more efforts to preserve resources. Political implications must be considered for better use and development of land, water, and forest resources in the Bagré wetland and other Burkina Faso wetlands. Adopting a concerted and integrated policy approach to management and planning allows for inclusive management of natural resources, considering the three dimensions of sustainable development. A new national policy deserves to be adopted to consider the economic values of wetlands for socio-economic development that preserves natural resources and conserves ecosystems.

Conflict of Interest: The authors reported no conflict of interest.

[15]The vision of Burkina Faso's national wetlands policy is limited in 2015 and there is a need to revise it. We need an updated policy for the exploitation and development of natural resources which makes it possible to fight, among other things, against poverty, food insecurity, unemployment of the population.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Data Availability: All of the data are included in the content of the paper.

Funding Statement: The authors did not obtain any funding for this research.

Declaration for Human Participants: This study has been approved by the doctoral thesis examination committee, made up of a researcher from the Burkina Faso Scientific and Technological Research Centre and lecturers from the Faculty of Economics and Management and the Faculty of Science at the University of Lomé (Togo).

References:

1. Adouabou, B.A. (2009). *Fiche descriptive sur les zones humides Ramsar : Barrage de la Kompienga*. 27p. https://rsis.ramsar.org/RISapp/files/RISrep/BF1875RISformer_160725.pdf
2. Aliou, D.M. (2021). *Revue/Analyse de la contribution de la Pêche et de l'Aquaculture à la Sécurité Alimentaire et Nutritionnelle des populations en zone UEMOA*. Assistance Technique au PAGR-SANAD EuropeAid/139135/DH/SER/BF. 53p.
3. Bonin, M., & Antona M. (2012). Généalogie scientifique et mise en politique des services écosystémiques et services environnementaux. Introduction au dossier. *VertigO*, 12 (3), 10 p. https://doi.org/10.4000/vertigo.13147
4. Daly-Hassen, H. (2017). Valeurs économiques des services écosystémiques du Parc National, de l'Ichkeul, Tunisie. https://www.ramsar.org/sites/default/files/documents/library/valeur_economique_ichkeul_f.pdf
5. Dare, W., Venot, J.P., Kabore, E., Tapsoba A., Traore T., Gerard F., Carboni, S., Idani, D., Kambire, H., & Napon, K. (2019). *Grands aménagements hydroagricoles, inégalités environnementales et participation : le cas de Bagré au Burkina Faso*. VertigO - la revue électronique en sciences de l'environnement. Vol 19 (1).
6. Failler, P., Pètre, E., & Maréchal, J.P. (2010). *Valeur économique totale des récifs coralliens, mangroves et herbiers de la Martinique*. Études caribéennes. http://journals.openedition.org/etudescaribeennes/4410.
7. Kabore, E., & Bazin, F. (2014). *Evaluation économique ex-post du barrage de Bagré au Burkina Faso*. 71p.https://www.iied.org/sites/default/files/pdfs/migrate/G04006.pdf
8. Lamachere, J.M., Maizi, P., Serpantie, G., & Zombre, P. (1993). *Fonctionnement et aménagement d'un petit bas-fond soudano-sahélien*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

(Bidi, Yatenga, Burkina Faso). Actes du séminaire d'Antananarivo, Madagascar, 9-14 décembre 1991. CIRAD, Monpellier, p 469-486.

9. Mevanly, O., Cissé, A. &Tiebre, M.S. (2020). *Valuation of some ecosystem services provided by a wetland subjected to anthropogenic pressures, the navigation canal of Assinie (Côte d´Ivoire)*. IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS), 15(2), 10-24.
10. Munasinghe, M. (1992). *Envionnemental Economics and Sustainable Development*. Paper presented at the UN Earth Summit, Rio de Janeiro Environment Paper N°3, World Bank, Wash. DC, USA. National de l'Ichkeul, Tunisie. Gland, Suisse et Malaga, Espagne : UICN. 104pp.
11. Ouédraogo, L. (2012). *Etude d'impact environnemental et social (EIES) du projet d'aménagement de 1130 hectares de terres irrigables à Bagré*. Ministère de l'Agriculture et de l'hydraulique.
12. Pearce, D.W. & Warford, J.J. (1993). *World without end. Economics, environment, and sustainable development*. Published the World Bank, Oxford University Press, New York.
13. Requier-Desjardins, M., Chazée, L., Khechimi, W., Anougmar S., & Garrabé, M. (2021). *Les services écosystémiques culturels rendus par les zones humides protégées en Méditerranée : élaboration d'un indicateur de suivi*. Natures Sciences Sociétés 29, 4, 423-438. https://doi.org/10.1051/nss/2022007.
14. Somda, J., & Awaïs, A. (2013). *Evaluation économique des fonctions et services écologiques des écosystèmes naturels : guide d'utilisation de méthodes simples*. Ouagadougou, Burkina Faso: UICN. 32p.
15. Somda, J., Zonon, A., Ouadba, J.M., & Huberman, D. (2010). *Valeur économique de la vallée du Sourou : Une évaluation préliminaire*. Ouagadougou, Burkina Faso, Bureau Régional, 72p.
16. Tapsoba, A. (2015). Evaluation des valeurs d'usages de sept sites Ramsar au Burkina Faso. Certificat en gouvernance locale des zones humides. Edition n°2, 57p.
17. Tapsoba, A., Kokou, K., & Sanou, Z. (2023). *Dynamique spatiale d'occupation du sol à la périphérie du barrage de Bagré au Burkina Faso*. Rev. Ivoi.Sci. Technol., (41), 66-82. https://revist.net/REVIST_41/5-ST-890
18. Thiombiano, A., Schmidt, M., Dressler, S., Ouédraogo, A., Hahn, K., & Zizka, G. (2012). *Catalogues des plantes vasculaires du Burkina Faso*. Editions des conservatoires et jardins botaniques. Boissiera, (65) 1-391.
19. Venot, J.P., & Clement, F. (2013). *Justice in Development? An Analysis of Water Interventions in the Rural South*. Natural Resources

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Forum, Blackwell Publishing, 37(1) 19-30, https://doi.org/10.1111/1477-8947.12002.

20. Yonli, T.N., & Ouédraogo, O. (2023). *Les consommateurs des produits maraîchers biologiques à Ouagadougou*. All Open Edition; https://doi.org/10.4000/aof.13957.
21. Goyal, A. & Nash, J. (2017). *Reaping richer returns: public spending priorities for African agriculture productivity growth.* Washington, DC, USA: World Bank, p. 353. https://openknowledge.worldbank.org/handle/10986/25996?locale-attribute=fr
22. Tapsoba, A. (2020). *Pauvreté, insécurité alimentaire et vulnérabilité des ménages agricoles dans un système d'irrigation à grande échelle : le cas du périmètre irrigué de Bagré au Burkina Faso*. Paris : AgroParisTech, 350 p. Thèse de doctorat : Sciences économiques : AgroParisTech
23. Limoges, B. (2009). *Biodiversité, services écologiques et bien-être humain.* Le naturaliste canadien, 133 (2): 15-19.
24. Turpie, J., Lannas, K., Scovronick, N. & Louw A. (2010). *Wetland Valuation Volume 1. Wetland Ecosystem Services and Their Valuation: A Review of Current Understanding and Practice*. Republic of South Africa, Water Research Commission. 132 p.
25. Dubreuil, C. (2012). *Eau et changement climatique : quelle stratégie d'adaptation en Méditerranée ?* Valbonne : Plan Bleu. 4 p. (Les Notes du Plan Bleu n°23).
26. Bonin, M. & Antona, M. (2012). *Généalogie scientifique et mise en politique des services écosystémiques et environnementaux*. Vertigo. Vol 12 n°3.
27. Wallis, C., Blancher, P., Séon-Massin, N., Martini F., & Schouppe M. (2011). *Mise en oeuvre de la directive cadre sur l'eau. Quand les services écosystémiques entrent en jeu*. Les rencontres de l'Onema. Synthèse. Bruxelles. 107 p.
28. ten Brink, P., Russi, D., Farmer, A., Badura T., Coates D., Förster J., Kumar R. & Davidson N. (2013). *The Economics of Ecosystems and Biodiversity for Water and Wetlands. Executive Summary*. Institute for European Environmental Policy (IEEP), Ramsar Secretariat. Executive summary. 16 p.
29. Bagrépôle (2013). *Rapport annuel d'activités de la Direction de la valorisation économique de l'exercice 2013*. 37p.
30. Bagrépôle (2014). *Rapport annuel d'activités de la Direction de la valorisation économique de l'exercice 2014*. 44p.
31. Bagrépôle (2015). *Rapport annuel d'activités de la Direction de la valorisation économique de l'exercice 2015*. 36p.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

32. Bagrépôle (2016). *Rapport annuel d'activités de la Direction de la valorisation économique des exercices 2015, 2016*. 51p.
33. Bagrépôle (2018). *Rapport annuel d'activités de la Direction de la valorisation économique des exercices 2017, 2018*. 51p.
34. Bagrépôle (2019). *Rapport annuel d'activités de la Direction de la valorisation économique de l'exercice 2019.* 59p.
35. INSD (2022). *Cinquième Recensement général de la population et de l'habitation du Burkina Faso (5e RGPH)*. Synthèse des résultats définitifs. 136 p.
36. MEEVCC, (2018). *Second inventaire forestier national (IFN 2) du Burkina Faso, rapport final.* 501p.
37. MOB (2011). *Rapport d'activités de la Maîtrise d'ouvrage de Bagré de l'année 2011*. 28p.
38. PHIE-B (2011). *Rapport bilan 2011 des activités de l'unité technique du périmètre halieutique d'intérêt économique de Bagré*. Ministère de l'Agriculture et de l'Hydraulique ; 32p.
39. PHIE-B (2016). *Projet de rapport bilan d'activités de l'unité technique du périmètre halieutique d'intérêt économique de Bagré*. Ministère des Ressources Animales et Halieutiques ; 20 p.
40. PHIE-B (2018). *Projet de rapport bilan d'activités de l'unité technique du périmètre halieutique d'intérêt économique de Bagré*. Ministère des Ressources Animales et Halieutiques ; 16p.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Appendix

Table 3: Useful plants for populations in the Bagré area

No.	Species	Leaves	Fruits	Seeds/ Kernels	Flowers	Roots	Barks	Rubber	Branches
1.	***Acacia (dudgeonni and laeta)***	X	X			X	X	X	X
2.	***Acacia gourmaensis***	XX	X		X	X			
3.	***Anogeissus leicarpus***	XXX	XX	X		XX	XX	X	X
4.	***Azadirachta indica***	XXX		X	X		X		
5.	***Balanites aegyptiaca***	XX	X	X	XX	X	X		
6.	***Bombax costatum***	X		XXX	XXX		X		
7.	***Capparis corymbose***	XXX	X		X	XX			
8.	***Combretum (glutinosum, fragens, mole)***	XXX				X	X	X	
9.	***Dichrostachys cinerea***	XX	XX	X			XXX		
10.	***Diospyros mespiliformis***	X X	X			X	X		
11.	***Khaya senegalensis***	XX		X		X	XX	X	
12.	***Lannea acida***	XX				X	X		X
13.	***Lannea macrocarpa***	X X	X			X	X		X
14.	***Leptadenia hastata***	X			X	X			
15.	***Mimosa pigra***	X			X	X			
16.	***Parkia biglobosa***		X	X			X		
17.	***Piliostigma (reticulatum, thonningii)***	X				X			X
18.	***Sclerocarya birrea***	X	X	X		X	X	X	
19.	***Terminalia avicennioides***	X X	X		X	X	X		
20.	***Terminalia laxifora***	X				X	X		
21.	***Vernonia colorata***	XX			X	X	X		
22.	***Vitellaria paradoxa*(SEEN)**	X	X	XX			X		
23.	***Waltheria indica***	XX				X			

Legend: X (medicinal use), X (veterinary use), X (edible), X (fodder), **X** (other use)

Source: author, adapted from (Adouabou, 2009; Ouédraogo, 2012; Thiombiano et al., 2012)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 4: Wood potential in the nine municipalities contiguous to the Bagré Dam

Municipality	Firewood		Service wood and potential timber		Exploitable timber		Wood from the main species providing NTFPs		Domestic fruitwood		Other woods		The general average of woods	
	Total existing volume	Density (m3/ha)	Total existing volume	Density (m3/ha)	Total existing volume	Density (m3/ha)	Total existing volume	Density (m3/ha)	Total existing volume	Density (m3/ha)	Total existing volume	Density (m3/ha)	Total volume	Density (m3/ha)
Bagre	272,402	6.76	3,172	0.08	1,878	0.05	369,295	9.16	4,861	0.12	81,214	2.01	732,822	18.18
Bane	437,575	9.54	6,553	0.14	4,131	0.09	421,882	9.2	3,640	0.08	99,438	2.17	973,218	21.21
Beguédo	23,804	5.10	424	0.09	374	0.08	42,784	9.16	802	0.17	8,488	1.82	76,675	16.42
Bittou	1,052,428	8.42	12,792	0.10	6,757	0.05	1,147,809	9.19	11,169	0.09	267,834	2.14	2,498,789	20
Boussouma	176,002	6.73	1,733	0.07	785	0.03	238,018	9.1	2,997	0.11	53,740	2.05	473,275	18.08
Garango	338,175	6.33	4,339	0.08	2,937	0.06	489,195	9.74	7,108	0.19	104,799	1.96	946,553	17.73
Tenkodogo	730,632	6.10	9,042	0.08	5,534	0.05	1,142,637	9.27	18,105	0.12	237,408	2.04	2,143,358	18.21
Zone	111,919	6.69	1,053	0.06	6,045	0.03	155,109	9.54	1,964	0.15	34,200	1.98	304,725	17.89
Gomboussougou	660,591	8.57	11,767	0.15	8,265	0.11	659,112	8.55	11,705	0.15	141,863	1.84	1,493,302	19.38
Total Average	**3,803,528**	**7.14**	**50,875**	**0.09**	**36,706**	**0.06**	**4,665,841**	**9.21**	**62,351**	**0.13**	**1,028,984**	**2.00**	**9,642,717**	**18.57**

Source: Adapted from MEEVCC (2018)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 6: Agricultural and fishery production in the Bagré wetland from 2010 to 2019

Years	Rice		Corn		Market garden products		Fruits		Fish
	Area (ha)	Average production (tons)	Area (ha)	Average production (tons)	Area (ha)	Average production (tons)	Area (ha)	Average production (tons)	Production (tons)
2010	5,678	26,204	114	190	40	550	15	450	493.8
2011	3,262	14,331	41.5	91.25	76.15	785.4	36	549	449.66
2012	3,323	15,666.6	400	150	80	814.6	64	220	471.73
2013	4,836.75	26,265.06	341	1,023	91	2,448	43	1,290	460.70
2014	4,716.73	27,514.9	335	950	71	2,066	161	4,200	386.33
2015	5,855.07	28,176.8	530.5	1,426.13	286.42	4,689.65	36	859.9	320
2016	5,855.07	30,264.55	480	1,176	320.75	4,847.41	136	3,595.5	952
2017	5,974.6	27,626.3	617.5	930.9	422.5	6,263.75	134	2,297	586.58
2018	5,967.78	30,602.22	410	948.5	393.8	6,557.69	134	3,500	797.25
2019	5,322.2	28,999.8	830.408	2,055.01	337	5,076.2	135	3,284	698.43
Sum	**50,791.2**	**239,984.63**	**4,099.908**	**8,940.785**	**2,118.62**	**29,251.29**	**894**	**20,245.4**	5,616.473
Average	**5,079.12**	**26,664.96**	**409.99**	**894.08**	**211.62**	**3,250.14**	**89.4**	**2,024.54**	**561.65**

Source: adapted from reports of Bagrépôle (2013, 2014, 2015, 2016, 2018, 2019); MOB (2011); PHIE-B (2011, 2016, 2018