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Perception of riverine populations in the Nakanbe-Wayen basin on surface water resources in the Sahelian zone of Burkina Faso

Wennepinguere Virginie Marie Yameogo[1-2], Farid Traore[2], Blaise Ouédraogo[2], and Mipro Hien[1]

[1]Environment, Water and Forests Department, Université Nazi BONI (UNB), Bobo–Dioulasso P.O. Box 1091, Burkina Faso

[2]Natural Resources Management Department, Institut de l'Environnement et de Recherches Agricoles (INERA), Ouagadougou P.O. Box 8645, Burkina Faso

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ABSTRACT: Water resources are the economic and social backbone of Burkina Faso. However, these resources are subject to strong climatic and anthropic pressures. The aim of this study was to understand the perceptions of local communities regarding surface water resources in three Ramsar wetlands in Burkina Faso. Data collection was based on field surveys of the riparian population and interviews with resource persons. A pre-designed questionnaire and interview guide were formalized using the Kobotoolbox tool. IBM SPSS Statistics (version 22) was used for data analysis. The results show that the water surface areas of the three Ramsar sites studied - Lake Dem, Lake Bam and the «Nakanbé-Mané Basin» wetland - are on a downward trend. The main causes are siltation of the basins, drought, high evapotranspiration, heavy pressure from uses, inadequate maintenance, etc. Restoration solutions implemented in the watershed include protection and restoration work, awareness-raising and capacity-building, and repair work. Despite the diversification of activities carried out, the results obtained remain insufficient, according to local residents. A package of measures was therefore proposed. These include strengthening water management structures, increasing water storage capacity, restoring structures and ecosystems, and stepping up awareness-raising and training activities.

KEYWORDS: Water resources, Local viewpoint, Ramsar wetland, Climate change, Anthropogenic pressure, West African Sahel.

1 INTRODUCTION

Water resources, essential to all life and to the equilibrium of ecosystems, provide society with a wide range of ecological goods and services [1-4]. These goods and services also act as a link between natural systems and people [5]. However, today's surface water resources are under constant pressure from climate change and anthropogenic pressures [6-13]. The consequences include changes in the surface conditions of water reservoirs [14-17], a sharp drop in their volume [18-21], and so on. This has a major impact on ecosystem functioning and human well-being [22-24]. This situation is increasingly becoming a major concern, especially in the Sahelian countries of West Africa. Burkina Faso, one of these countries, is no exception. Characterized by low rainfall and regular extreme events (heavy rains, long periods of drought), surface water in Burkina Faso, considered the only easily mobilized and available resource [25], is for the most part seasonal, and many water bodies dry up during the dry season. What's more, anthropogenic actions accentuate their early drying-up [26]. In these vulnerable conditions, sustainable management of water resources is an urgent necessity and an imperative for sustainable development. For this reason, the Nakanbé basin has been the subject of several scientific studies aimed at gaining a better Under standing of its hydrological behavior [6, 27-35]. However, most of these studies have not sufficiently taken into account the perceptions of local populations. Yet sustainable management of water resources is inextricably linked to the perception of water by local stakeholders [36, 37]. It is also relevant to a holistic understanding of these resources [38]. The main objective of this study is to apprehend the riparian population's perception of surface water resources in three Ramsar wetlands in Burkina Faso. Specifically, it will examine with them the causes of the regression of water surfaces and identify restoration strategies.

Corresponding Author: Wennepinguere Virginie Marie Yameogo

2 MATERIALS AND METHODS

2.1 STUDY SITES

The Ramsar wetlands[1] studied were Lake Bam and Lake Dem, and the "Nakanbé-Mané basin" wetland. Lake Bam, the country's largest natural and permanent lake [39], covers an area of around 2,350 ha at high water [40]. Its watershed extends over 35 km [3], with an initial water capacity of over 40 million m3. It was designated a Ramsar wetland on October 7, 2009 [41]. Lake Dem is also a natural, permanent water reservoir covering 750 ha and extending over a length of around 20 km at high water, with a volume of 15 million m3 (https://rsis.ramsar.org/fr/ris/1882, consulted on 25/01/2023).

It was designated a Ramsar site on October 7, 2009 [41]. The "N1akanbé-Mané basin" is a seasonal wetland covering 19,477 ha (https://rsis.ramsar.org/fr/ris/2254, consulted on 25/0/2023). The wetland's artificial water reservoir covers an area of 8 ha. It was designated a Ramsar site on February 2, 2016 [42]. These wetlands are the economic lungs of the region [41]. In addition, fishing, livestock breeding, market gardening and the exploitation of non-timber forest products enable riverside communities to meet their daily needs and improve their living conditions [43]. These wetlands are an important refuge for avifauna and aquafauna, especially during the hot season (April, May and June) [40].

The watershed of the sites studied, the Nakanbé-Wayen basin, is characterized by a warm semi-arid climate (BSh), according to Köppen's classification [44]. It is also characterized by the alternation of a short wet season from mid-June to mid-October and a long dry season, with maximum rainfall in August. Water bodies are subject to high potential evapotranspiration, ranging from 2,000 mm to 3,000 mm [45]. A number of studies carried out in the watershed have shown that the water surface area is shrinking, and that the reservoirs studied show a seasonal trend [40, 46-48], reflecting their gradual drying out. The geographical location of these wetlands is illustrated in Figure 1.

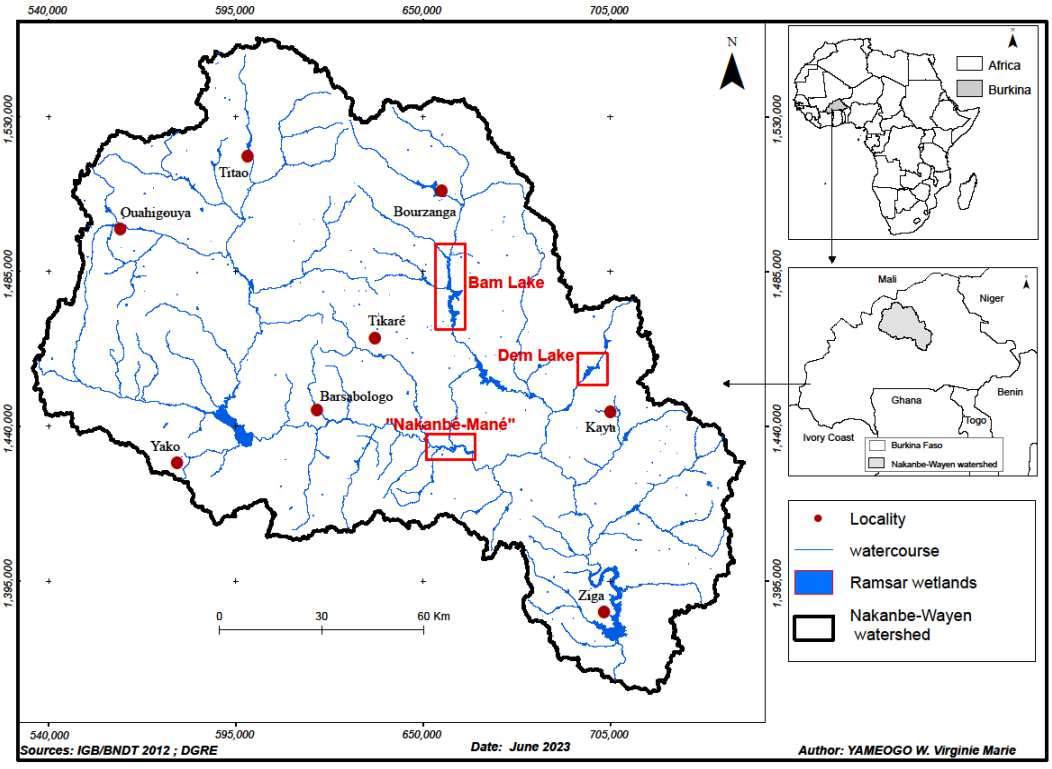

Fig. 1. Location of survey sites

[1] According to the text of the Convention (Article 1.1), wetlands are: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

2.2 SAMPLING

Administrative villages located within a radius of two (2) kilometers of the three Ramsar sites were selected to conduct surveys of heads of households. The household is defined as a group of people, related or not, who live in the same compound, generally eat their meals together and answer to the same head of household [49]. They are chosen according to the age, sex and activities of the head of household. Indeed, it has been indicated that age and gender have an influence in determining people's perceptions of natural resource dynamics [37]. Thus, for the age criterion, respondents should be at least forty-five (45) years old, given the specificity of the study in relation to climate change. This age criterion is recommended because it is assumed that at the age of 15, an individual is capable of memorizing the key events in the evolution of the natural environment thirty (30) years previously [50].

In addition, the head of household must have lived in the same locality for at least 30 years. The head of household's activity should be intrinsically linked to the water resource (agriculture, fishing, livestock breeding, etc.). These people were selected with the support of the Village Development Council (CVD) [2].

In each village surveyed, the gender component was integrated into the sample population. Thus, at least 16% of the sample is made up of women. A total of 319 respondents were selected, comprising 268 men and 51 women. The list of villages surveyed is shown in Table 1.

Tableau 1. List of villages surveyed

Wetland	Village	Number of people surveyed
Lake Dem	Zorkoum,	31
	Dem,	42
	Kamsaogo	32
	Total	**105**
Dam Razinga (Nakanbe-Mane)	Yilou	27
	Malou	28
	Yabo	38
	Total	**93**
Lake Bam	Kora	27
	Zimtanga	28
	Bargo	26
	Kongoussi	40
	Total	**121**

In addition to the survey of the local population, fifteen (15) resource persons, five per site, were interviewed. The identification of these resource persons was based on a reasoned choice according to the criteria of seniority and knowledge of one of the wetlands (Bam, Dem, Nakanbé-Mané). A "resource person" is defined as someone who, thanks to his or her training and experience, is able to help and advise others in the group to which he or she belongs [51].

2.3 DATA COLLECTION AND PROCESSING

Data was collected between February and March 2023 using a questionnaire and an interview guide, designed and sent to the riparian population and resource persons respectively. The riparian population is essentially made up of farmers (rainfed and market garden crops), pastoralists, agropastoralists and fishermen. The group of resource persons is made up of staff from technical services in charge of water, the environment, agriculture and livestock, as well as administrative and customary leaders. The pre-designed questionnaire and interview guide were formalized using the Kobotoolbox tool, downloadable to

[2] A genuine instrument of local community development, the CVD is set up in each village of the rural commune as well as in villages attached to the urban commune.

smart phones via the KoboCollectv1.25.1 application. KoBoToolbox (https://www.kobotoolbox.org/) is a free, open-source digital data collection system based on Google's Open Data Kit (ODK). User-friendly, KoBoToolbox can be adopted to collect quantitative or qualitative survey data, and reduces errors and data entry time by standardizing the method of data collection and entry. The data collected was analyzed using IBM SPSS Statistics (version 22), a benchmark software package for statistical analysis.

When processing the data, the most commonly used variable is the Citation Frequency (CF). It is used to identify trends in a data set, to understand the relative importance of a situation, and to facilitate decision-making based on quantitative observations. The formula for calculating CF is as follows:

$$CF = \frac{NNumber\ of\ citations}{Total\ number\ of\ citations} * 100$$

3 RESULTS

3.1 PROFILE OF RESPONDENTS

The profile of respondents is shown in Table 2. Respondents from the three Ramsar wetlands averaged 84% men and 16% women, with an average age of around 49 years. The low proportion of female respondents is explained by the fact that there are few female heads of household, who are generally widowed.

Nearly all respondents are mainly engaged in farming (over 90%), the main income-generating activity. Livestock rearing, considered the second economic activity, is practiced by 76% of respondents. The exploitation of non-timber forest products, considered to be the third source of income for rural households, is practiced by at least 42% of respondents. Fishing is practised by only 8% of those surveyed. Although mining, especially artisanal mining (gold panning), is booming in the region, we had no respondents who practiced this activity. Over 82% of them are at least literate, with almost 29% claiming to have at least primary school education.

Tableau 2. Profile of respondents

Variable	Modality	lake Bam	Lake Dem	Nakanbe-Name	Total
Gender	Men	101 (82%)	88 (84)	79 (86%)	268 (84%)
	Women	22 (18%)	16 (16%)	13 (14%)	51(16%)
	Total	123	104	92	319
Activity	Agriculture	(113) 92%	95 (91%)	82 (89%)	91%
	Livestock	91 (74%)	80 (77%)	72 (78%)	76%
	Fisheries	11(10%)	9 (8%)	7 (6%)	8%
	Non-timber forest products	53 (43%)	44 (42%)	37 (40%)	42%
Level of education	None	21 (17%)	19 (18%)	15 (16%)	55 (17%)
	Literacy	58 (47%)	62 (60%)	53 (58%)	173 (54%)
	Primary	35 (28%)	16 (15%)	20 (22%)	71 (22%)
	Secondary et higher	9 (7%)	7 (7%)	4 (4%)	20 (6%)

Source: Field survey, March 2023.

3.2 MAJOR ECOSYSTEM BENEFITS/SERVICES PROVIDED

The results of interviews with local residents showed that almost all (94%) of respondents, all categories included, recognized the provisioning service as the best service provided by the water resources of the Ramsar sites studied. This service provides fresh water for human and animal consumption needs, production activities (agriculture, livestock breeding), etc. The other three ecosystem services, namely regulation (maintenance of water regimes, climate regulation), support (biodiversity, soil formation, etc.) and socio-cultural (education, places of worship, leisure/recreation) are less well known. Indeed, the support service is known by 65% of respondents, followed by the socio-cultural service cited by over 57% of respondents, and finally the regulation service, which is cited by 52% of respondents (Figure 2). Also, all types of ecosystem services are cited by over 52% of representatives.

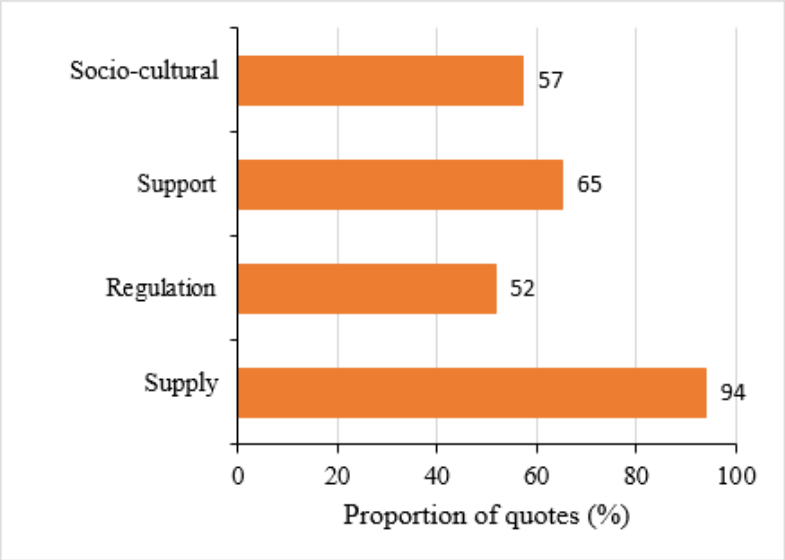

Fig. 2. Proportion of citations for types of ecosystem services

Source: Field survey, March 2023

As far as resource persons are concerned, all types of ecosystem services are cited by over 80% (Table 3).

Tableau 3. Proportion of quotes relating to the types of ecosystem services provided, by respondent category

Respondent categories	Services	Proportion (%)
Riparian populations	Provisioning	94
	Support	65
	Regulation	52
	Socio-cultural	57
Resource people	Provisioning t	100
	Support	95
	Regulation	95
	Socio-cultural	81

Source: Field survey, March 2023.

3.3 DECREASING SURFACE WATER RESOURCES IN WETLANDS

An analysis of the surveyed population's perception of the shrinking water surfaces of the wetlands shows that all respondents recognize a downward trend in the water surfaces of the sites surveyed (Figure 3). This is borne out by the fact that farmers and fishermen are seeing a gradual reduction in the availability of surface water. Perceptions of the extent of the decline vary from site to site. In the Nakanbé-Mané wetland, 100% of respondents felt that the surface water resource in their wetland was much reduced compared with the past, compared with 94% of respondents in the Lac Dem wetland. Although to a lesser degree, the majority of respondents in the Lake Bam wetland feel that their surface water resources have diminished.

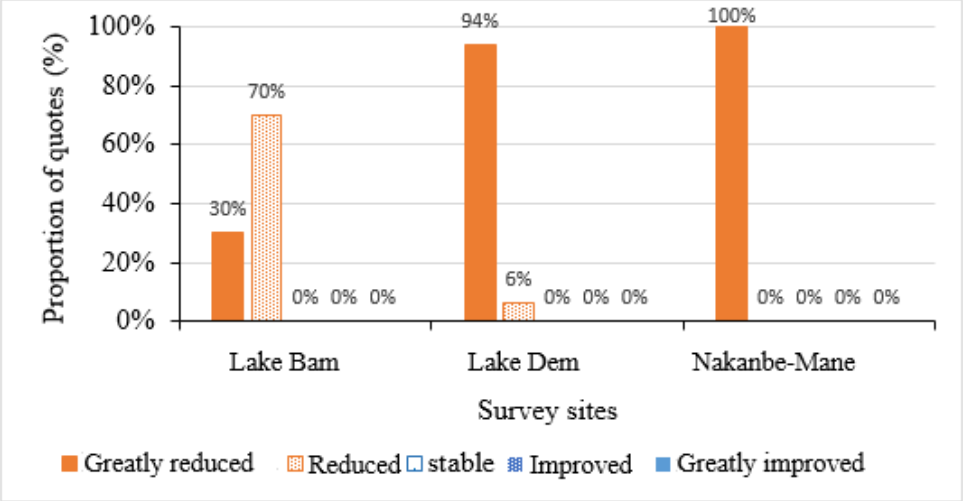

Fig. 3. Proportion of citations relating to surface water dynamics

Source: Field survey, March 2023

The same analysis carried out by the resource persons shows a sharp reduction in all the reservoirs studied. Indeed, the Nakanbé-Mané wetland is completely dry by February for most of the year, while the other two wetlands have seen their reservoirs fall sharply. Lake Bam is broken up into chains of pools in certain places during the periods of high flooding (March, April, May).

3.4 CAUSES OF DECLINING WATER RESOURCES

The main causes of declining surface water resources in the wetlands surveyed, according to local residents, are both anthropogenic and climatic. They are: (i) sedimentation (or silting) of water reservoirs, cited by at least 87% of respondents, (ii) lack of upkeep/maintenance perceived by at least 67% of respondents, (iii) drought cited by at least 65% of respondents, (iv) strong evaporation cited by 58% of respondents, (v) strong pressure of use cited by at least 48% of respondents and (vi) non-rational use cited by 21% of respondents (Figure 4).

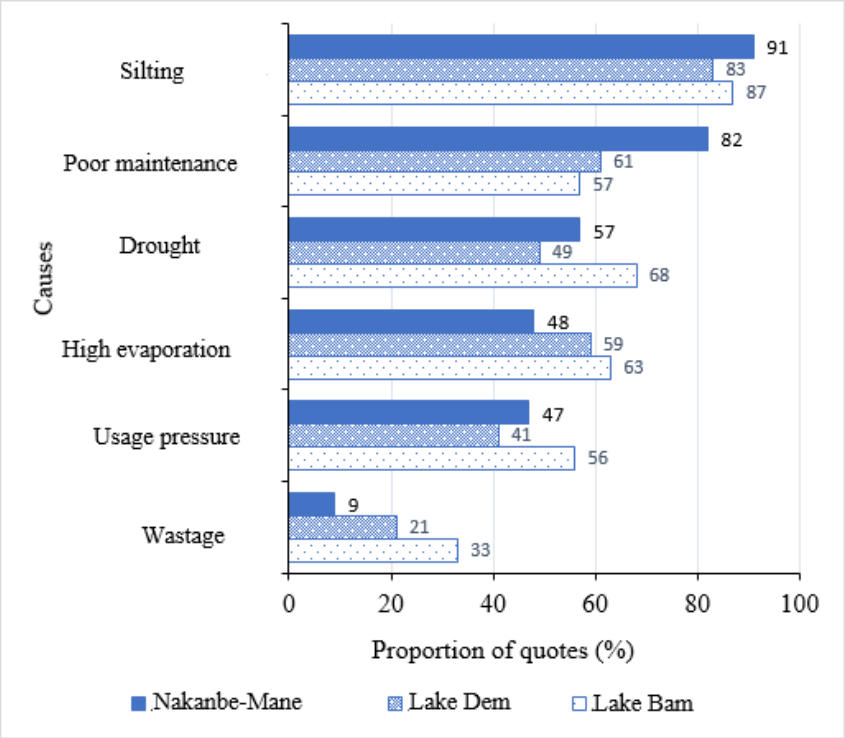

Fig. 4. Proportion of quotes from the riparian population relating to the decline in surface water resources in the wetlands of the Nakanbé-Wayen basin.

Source: Field survey, March 2023

As far as resource people are concerned, the causes of the decline in surface water resources at the sites studied are also anthropogenic and climatic (Figure 5), attributed largely to sedimentation (97%), high pressure of use (96%), high evaporation (85%), droughts (68%), lack or inadequate maintenance (49%) and non-rational use (such as wastage) of water resources (51%).

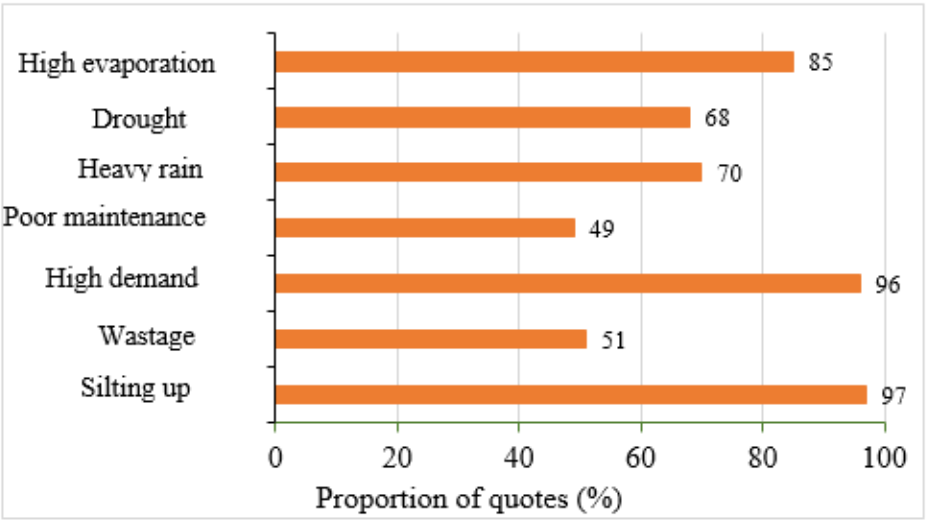

Fig. 5. Proportion of resource persons' quotations relating to the causes of the decline in the level of surface water resources in the wetlands of the Nakanbé-Wayen basin

Source: Field survey, March 2023

3.5 Future Of Wetland Surface Water

The perception of local people about the future of wetland surface water is common. Almost all (at least 90%) predict an uncertain future, with the risk of disappearance, and over 60% predict a complete disappearance of wetland water surfaces if no concerted action is taken to reverse the trend. None believed that wetlands would stabilize or improve under current conditions. Only 9% of respondents gave no opinion (Figure 6).

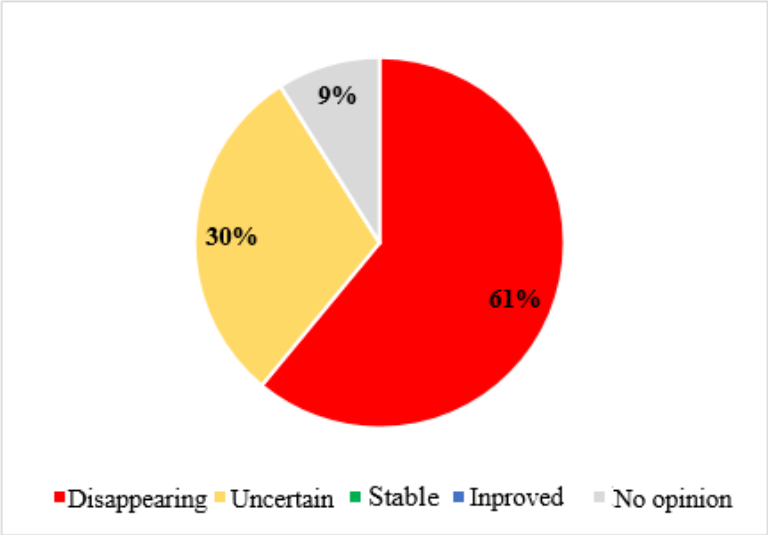

Fig. 6. Proportion of quotes from local residents concerning the future of the sites studied

Source: Field survey, March 2023

Resource people's perception of the future of the water surfaces is in line with that of the local population, but less severe. In view of the evolution of these reservoirs, they predict an uncertain future in the medium term (50 years) for all the sites studied.

3.6 Restoration Solutions

The importance of preserving water resources and wetland ecosystems cannot be overshadowed, not even by the local population, who welcome the efforts made by the authorities to preserve them. The various restoration measures already implemented are categorized into groups of actions. The most frequently cited proposals are as follows: (a) protection and/or restoration work, such as limiting easement strips, stone barriers, hedgerows, etc., by 75% of respondents; (b) awareness-raising and capacity-building for populations/water users, such as training in water and soil conservation techniques (photos 1 and 2) by 58% of respondents; and (c) repair work by 33% of respondents.

3.7 Activities Planned / To Be Implemented

Despite the diversification of activities carried out, the results achieved remain insufficient, according to local residents, due to the continuing regression of wetland surfaces. This assertion is also supported by resource persons. In view of this, strong measures need to be diversified, multiplied and accelerated in order to reverse the regression trend. These include (i) revitalizing water management structures such as local water committees (CLE), water police and water user committees, (ii) increasing water storage capacity, through the creation of new reservoirs and, above all, by desilting (or cleaning out) existing reservoirs in order to reduce the pressure exerted on them, (iii) reinforcing actions to protect/restore structures and ecosystems, such as the protection of easement strips and wetland banks, as well as the complete restoration of their ecosystems (iv) reinforcing awareness-raising and training actions and promoting socio-economic activities such as eco-tourism.

4 DISCUSSION

Analyses of the perceptions of local residents and resource persons show that there is a marked trend towards a reduction in water resources in the catchment area. This assertion is also confirmed by many other authors [21, 40, 48, 52]. The decline in water surface areas is common to many countries [53-55]. This trend towards shrinking water surfaces threatens the sustainability of wetland ecosystems [56, 57] and the well-being of populations [58].

According to the people surveyed, local residents and resource persons, the causes of the downward trend in water surface area are both anthropogenic and climatic. This perception is also borne out by more than one study, which agrees that the loss of wetland surface area is the combined result of natural and anthropogenic factors [59-66]. Observations made in the field during our outings illustrate this state of affairs. In fact, bad farming practices such as cultivation in the easement strip and even in the minor bed, the opening of trenches (photos 3 and 4), the abusive cutting of green wood to extend fields, the exploitation of aggregates in the minor bed, animal pressure (trampling by animals), accentuate the sedimentation (silting) of water surfaces. In recent years, we have also witnessed the proliferation of invasive plants, which contribute to the silting-up and reduction of water surface areas in reservoirs.

In addition, the non-rational use of water resources leads to water wastage. By way of example, the motor-driven pump, equipped with water pipes that are often defective, is the main water extraction tool. This means a lot of water is lost during transport to the plots. What's more, the quantities of water transported are far in excess of the actual needs of the crops in the plots. As a result, water, already scarce, is subject to unprecedented overexploitation, leading to a continuous increase in demand for water for ever-growing populations [67, 68].

Photo 1. Stone cordons

Photo 2. Half moons

Photo 3. Opening trenches in the reservoir basin of a dam

Photo 4. Opening trenches and planting fields in reservoir basin of a dam

Source: Field survey, March 2023

In connection with climate change, high evaporation from surface water reservoirs, droughts and intense rainfall are cited among the climatic causes. Indeed, the upward trend in the intensity and occurrence of heavy rainfall [69], and strong winds [70], accelerate soil erosion or more or less severe gullying, resulting in sedimentation (silting) of water bodies [71]. This is particularly worrying at watershed level [72]. Most of the watercourses in the Nakanbé river basin are covered by extensive sand deposits [52]. As a result, droughts lead to water deficits. In addition, surface waters are increasingly subject to higher and steadily increasing evaporation as a result of rising temperatures [73]. Increased evapotranspiration means that more of the precipitation evaporates rather than runs off the surface [74], exacerbating aridification in the wetland catchment. In addition, average annual evaporation is over 2,000 mm, resulting in the loss of over 60% of water from surface reservoirs [75]. This depletion of water resources creates environmental, social and economic challenges, exacerbating the vulnerability of the populations that depend on it [76].

5 CONCLUSION

This study examined the perception of the local population on water resources at three Ramsar sites in the Nakanbé-Wayen watershed. A downward trend in the water surface area of these sites was observed across all surveys. The causes of this regression are both climatic and anthropogenic, the main ones being the silting up of basins, drought, high evapotranspiration, high usage pressures and insufficient maintenance. Restoration solutions are being implemented in the watershed, but it is clear that despite the diversification of activities carried out, the results obtained remain insufficient and the trend of decline in water surfaces continues. Strengthening the synergy of action between the stakeholders involved, the State and its financial and technical partners in the sustainable management of these sites is essential, in order to restore and preserve the potential that contributes enormously to the socio-economic development of the region in particular and the country in general. In addition, to better empower local stakeholders, the establishment or revitalization of a local management committee, responsible for regulating access to and use of water, is necessary for each Ramsar wetland.

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