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RESEARCH PAPER

Nexus between weeds secondary succession and livelihoods in Hadejia-Nguru wetlands of Nigeria

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Abstract. Hadejia-Nguru wetlands is known as a joule of the Sahel as it is the major biodiversity reservoir of the Sahelian parts of Nigeria. However, series of impediment that follows the Sahelian drought of 1970s has been altering the ecosystem of the wetlands. The secondary succession of invasive weed that follow the habitat changes has altered the wetlands derived livelihood activities. This study examines the livelihoods constrain of the weeds as well as livelihoods derived from the weeds. Information on biodiversity timeline history, types of weeds that grow on the wetland site, the livelihoods activities derived from the weeds, and the livelihoods constraint of weeds were collected through interviews with key informants and focus group discussion. Three focus group discussions were conducted in six wetlands site communities, with participants including farmers, pastoralists, and other categories of wetland users. The qualitative information collected was analysed using grounded theory tool. The study identified 18 weed species that grow on the Hadejia-Nguru wetlands and discovered that the weeds are sources of raw materials for constructions, craft work, and fodder for animals among others. They also constitute the major constraints to livelihood activities such as fishing, transportation, irrigation, rainfed farming, and domestic water supply, among others. The study concluded that weeds are both a constraint and means of livelihood. Hence, the study's hypothesis is that ''the impact of weeds on livelihoods diminish over time'.' It is therefore recommended that all the beneficial weeds in the wetlands should be identified and utilized sustainably, while the growth of the bad ones should be controlled.

Keywords: Nexus; wetlands; weeds; livelihoods; biodiversity; Hadejia-Nguru weetlands

1. Introduction

Hadejia-Nguru wetlands site is one of the Ramsar sites, providing a wide range of ecosystem services and functions to not only the communities living around the wetlands site, but the region at large (Jajere, 2021). The wetlands are the economic mainstay of the wetlands site population, through irrigation, agriculture, fishing, hunting, mining, and raw materials. The wetlands are playing a leading role in moderation of local climate and storage of wide range of flora and fauna. However, since 1970s, a number of impediments have been altering the hydrology of the wetland,

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ranging from drought, desertification upstream water impediment, and population pressure, resulting in large-scale fluctuations in wetlands components (moisture and vegetation), degradation and shrinking (Ikusemora & Ezekiel, 2011; Jajere et al., 2022), conflicts over resources (Ringim et al., 2015).

According to Hollis et al. (1993), the impediments cause shrinking of large areas of farming and grazing land, drying of important fish ponds, and blockage of water channels by invasive weed (typha grass). The inversion of weeds into crop and grazing land is one the major rural livelihoods constraints reported all over the world, especially in developing countries. Bajwa et al. (2019) did a study on the impact of Parthenium hysterophorus inversion on livelihoods of farming households in Punjab, Pakistan. They reported that the weed has significant effects on crop and livestock production, health, and social well-being of the study areas rural communities. Shackleton et al. (2017) estimated the economic value of the impact of Lantana camara weed on an average household in East Africa at US$400–500 per annum.

In recent times, the emergence of invasive grass weeds has been identified as one of the factors affecting the Hadejia – Nguru wetlands. This had been reported in several studies, media and technical reports (Babagana et al., 2018; Abubakar S. Ringim et al., 2015; Sabo et al., 2016; Salako et al., 2016). According to Sabo et al. (2016), most of the weeds are self-sown and they provide competition owing to their faster rate of growth in the initial stages, which reduce the crop yield by 50%. Daily Trust Newspaper of 13th October 2020 reported that ''typha weeds threaten the wetlands'' as reported by Chairman of Nguru Fishers Association (key informant). He, thus, agreed that ''typha grass hinders Nguru wetland economic potentials." Accordingly, the Director General of Nigerian Conservation Foundation (NCF) urged Federal Government of Nigeria to save the wetlands from exploitation.

The available scientific studies on Hadejia-Nguru wetlands weeds largely focus on the impact of typha grass on biodiversity and socio-economic activities. Babagana et al. (2018) investigated typha grass (typha domingensis) and its control strategies along Nguru wetlands. On the other hand, Sabo et al. (2016) focused on how typha grass is militating against agricultural productivity along Hadejia River. Similar studies in the area are those of Zungum et al. (2019) and Salako et al. (2016). However, the latter studied the impact of typha grass on biodiversity loss in the wetlands, while the former carried out a research on how typha contributes to wetland water loss and health risk in the wetlands. Similarly, Ringim et al. (2015) examined the implication of invasive plant typha domingensis on biodiversity of the wetlands. Little attempt has been made on other types of weeds species, livelihood means derived from the weeds, and detail livelihood constraints of the weeds. According to the theory of adaptation, also known as survival theory, ''organisms adapt to changes in their environment and adjust accordingly over time'' (Hutcheon, 2006). As 97% of Hadejia Nguru wetlands site population derive their livelihood means either directly or indirectly from the wetlands (Jajere, 2021), thus their livelihood activities must adapt to the changing wetlands ecosystem.

Field survey observation revealed that the wetlands site population are using the weeds for several livelihood activities. Therefore, this study examines Hadejia-Nguru wetlands weeds' negative and positive impacts on the people's means of livelihood and livelihood activities. The study was carried out by identifying the various weeds that grow on the wetlands, identifying the livelihood benefits of the wetlands, examining the effects of weeds on wetlands livelihood activities, and identifying the weeds control strategies adopted by local populations.

2. Study area and methodology

2.1. Study area

2.1.1. Location and size of Hadejia-Nguru wetlands

The Hadejia-Nguru wetlands lie in the Yobe-Komadugu Sub-Basin of the Chad Basin. They are formed where the Hadejia and Jama'are rivers meet ancient sand dunes lines in a northeastsouthwest alignment and break into numerous channels. They are drained by the Yobe River, which flows east towards Lake Chad. They lie between Sudan Savannah to the south and the drier Sahel to the north. Some of the land is permanently flooded, while other parts are flooded only in the wet season (August and September). Annual rainfall fluctuates between 200–600 mm, during the months of late May to September. The wetlands may have formerly spanned up to 3,000 km^2. Between 1964 and 1971, over 2,000 km^2 were flooded. By 1983, less than 900 km2 were flooded, and less than 300 km^2 were flooded in the drought year of 1984 (Hollis et al., 1993). Ikusemora and Ezekiel (2011) reported that the wetlands shrunk from 3,191.2465 km^2 in 1972 to 2,257.8234 km^2 in 1986 and 1,781.9361 km^2 in 2005. However, Jajere et al. (2022) reported the recovery of the wetlands from less than 1000 km^2 in 1980s to 33,000km in 2001. The map of the study area is presented in Figure 1.

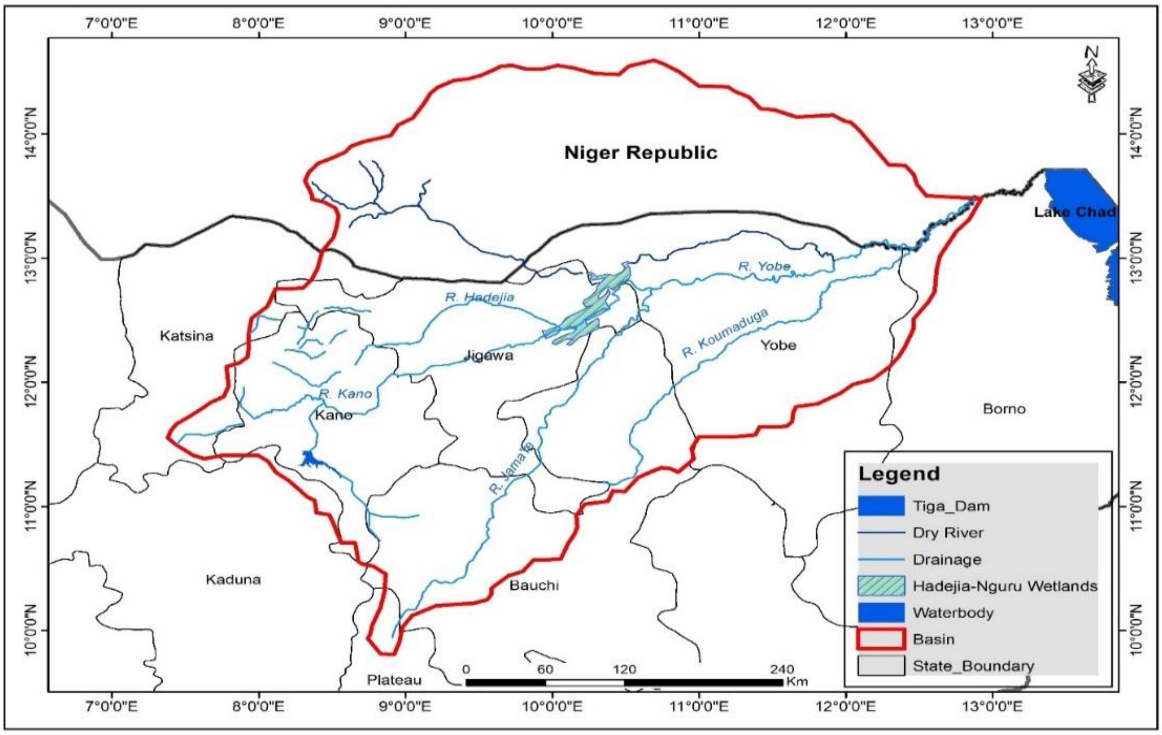

Figure 2. Map of the Kumadugu-Yobe Basin Showing Hadejia-Nguru Wetland sit (Jajere et al., 2022)

2.1.2. Ecology of Hadejia-Nguru wetlands

Ecologically, the Hadejia-Nguru wetlands are on the List of Ramsar wetlands of international importance. Nguru Lake and the Marma Channel complex (58,100 ha) are designated as a Ramsar Site. The wetlands are important for water birds, both for breeding and wintering species of Palearctic water birds. The estimated water bird population is between 200,000 and 325,000 (Hollis et al., 1993). About 377 bird species have been seen in the wetlands, including occasional sightings of the near-threatened pallid harrier and great snipe species, two of which are of global conservation concern (Birdlife International, 2020).

The Bade-Nguru Wetlands sector of the Chad Basin National Park covers 938 km^2 of the wetlands (Hollis et al., 1993). Parts of the wetlands are protected by five forest reserves, a wildlife sanctuary and a ramsar site. As a result of reduced flooding and increasing population, the environment is degrading and there is growing competition between humans and wildlife. Farmers use poison to kill the crop-destroying *Quelea birds*, but they also kill non-target species in the process. Marginal land is now coming under cultivation and tree cover in the forest reserves is being depleted (Akinsola et al., 2000).

2.1.3. Economy of Hadejia-Nguru Wetlands

Economically, the area supports about 1.5 million farmers, herders, and fishermen (Hollis et al., 1993). The wetlands support wet-season rice farming, flood-recession agriculture, and dry-season farming using irrigation. Peppers and wheat are among the crops grown. The wetlands support fishermen, who often also farm and provide fuel wood and leaves used for making mats, fencing mats, gates/doors, local mattress fills, boats called kadai sacks, grain and storage facilities (*rumbu* and *kundai*), ingredient for mud brick making and plaster, basket (*kondo*), boxes, paper making, ceilings for buildings, sealing of loaded bags, load carrying medium/wedge, thatch buildings, building decorations, sack coats for fishermen and ropes. Most of the weeds have some medicinal values and often used as soup ingredients. The lands are also grazed by Fulani cattle (Isma'il et al., 2014). Fishing is an important activity of the people in the basin. A part of the basin is the Hadejia-Nguru Wetlands, which for many years was the pride and joy of the north-eastern Nigeria (Tanko, 2014). This has been critically affected by water release patterns from Tiga and Chalawa Dams at upper stream, as the two dams control over 80% of the flows into the Hadejia-Nguru Wetlands (Odunuga et al., 2011). This results into losses in environmental productivity such as fish stock, livestock production, and general water shortage in the downstream parts of the basin including inflow into the Lake Chad (African Water Facility, 2014).

2.1.4. Impact of upstream water abstraction on Hadejia-Nguru wetlands

The increasing water abstraction from Kumadugu-Yobe Basin, especially upstream dams construction since 1970s, and intensive irrigation activities contribute to the fact that large areas of the floodplains are becoming increasingly drier (Barchiesi et al., 2014). Idris (2008) reported the shrinking of Hadejia-Nguru Wetlands by as much as two-thirds in the last 30-40 years, largely as a result of diversions from dams, irrigation developments, and drought. This, coupled with a rise in domestic water consumption as a result of rapid increase in population and urbanization, land cover changes, and ground water extraction technology, is putting a strain on fresh water resources within the basin. In response to Sahelian drought of 1970s, Kano State Government construct two large dams (Chalawa and Tiga) at the upstream of Kumadugu Yobe, with several small earth dams and irrigation projects along Kumadugu-Yobe and its tributaries (Barbier, 2003).

Tiga Dam is the largest water project in this basin, which was completed in 1974. It was designed to support large scale irrigation project and Kano City domestic water supply. Tiga and Challawa Dams have 2,000,000 m^3 and 904,000,000 m^3 full storage capacity respectively, which affects river flow downstream at Gashua in Yobe State by about 100,000,000 cubic metres (3.5×109 cu ft) per year due to upstream irrigation and by more than 50,000,000 cubic metres (1.8×109 cu ft) due to evaporation from the reservoir (Odunuga et al., 2011).

A number of small dams and associated irrigation schemes have also been constructed or are planned for minor tributaries of the Hadejia River. Jama'are River is relatively uncontrolled in comparison, with only one small dam (Shabaki Dam) across one of its tributaries. However, plans for a major dam on the Jama'are at Kafin Zaki have been in existence for many years, which would provide water for an irrigated area of 84,000 ha. Kafin Zaki Dam work has been facing political challenges from downstream communities, environmentalists, and concerned bodies. Its future is still unclear (Shettima, 1997). The socio-economic benefits of the upstream water developments were at the expense of the downstream ecosystem and livelihood, as a result of floodplain losses.

The floodplains benefits includes flood-recession agriculture, fuel wood and fishing, (Adams, 1993) groundwater recharge that supports dry season irrigated agricultural production, and groundwater recharge of domestic water supply for household use (Acharya & Barbier, 2000). Thompson and Hollis (1995) reported a reduction in Hadejia-Jamaare floodplain from 300,000 ha in 1960s and 1970s to 100.000 ha in 2000s, largely as a result of upstream water development.

2.2. Methodology

2.2.1. Data collection

In order to address the specific objective of this study, data were sourced from a variety of wetlands vegetation variables, including the time line history of wetlands vegetation dynamics, weeds that grow in the wetlands, the impact of the weeds on livelihood assets and activities, and livelihood means derived from the weeds. Nyumba et al. (2018) reported an increased use of FGD techniques within biodiversity and conservation research since 1996. The data were collected using focus group discussion and key informants' interview (see Table 1).

Table 1. Data used and sources

Data used	Source
Information on time line biodiversity history	Key informants' interview
Types of weeds that grow on the wetland sites	FGD
Information on livelihood activities derived from the weeds	FGD
Observation	Field survey

Twelve focus group discussions were conducted in six wetland sites/settlements with wetlands users and community leaders/senior citizens over the age of 70 (Table 2 and Figure 1). The discussants were selected using purposive sampling techniques, community leaders were involved in recruiting participants. Focus group discussions were conducted with a variety of individuals including adult members of wetlands resource user households on the livelihood constraints and benefits of wetlands weeds. Focus group discussions were undertaken at wetlands site and village squares. The focus group discussion followed predetermined checklists of open-ended questions which were unfolded in a reflexive manner that allowed both anticipated and unanticipated themes to be explored.

Table 2. The sites and number of focus group discussions conducted

S/N	Communities/wetland site	No. of FGDs	Number of participant		
			Irrigators	Pastoralists	Fishermen and other wetlands ~~U~~users
1	Nguru (Garbi)	3	9	6	9
2	Birniwa	3	9	6	9
3	Dachia	3	6	9	9
4	Dagona	3	9	9	9
5	Hadejia	3	9	6	9
6	Auyo	3	6	6	9

2.2.2. Method of data analysis

Qualitative data generated through FCD, key informant interviews, and field observation were analyzed using constant comparison or grounded theory as well as narrative analysis. The responses of the key informants and discussants were summarized and presented in tables. The information on time line history of biodiversity dynamics was analysed using discourse analysis. The information on various weeds that grow in wetlands was collected in local language (Hausa), as well as the English and scientific names of the plants (Blench, 2007). The responses of the discussants to the weeds livelihood constraints and means were analysed using content analysis.

Plate 1, FGD with farmers at Dachia Village Square

Plate 2: Key informant interview at Dachia Village

Figure 1. FGD with farmers and informants

3. Result

3.1. Hadejia-Nguru wetlands plants diversity dynamics

The result of the oral interview with key informants revealed that the natural ecosystem of Hadejia-Nguru wetlands were stable before 1970s, made-up of diverse non-xyrophyte plants. Mahogany, manje, and tamarind were the dominant tree species around the wetlands. The major livelihood activities along the wetlands before 1970s were predominantly fishing, rain-fed cultivation, and pastoralism. Irrigation activities as major livelihood activities started after the 1982-1983 droughts. Within the period of over 50 years, according to the key informants, the drastic decline in stream flow and shrinking/drying of flood plains started in 1971. The drought of 1973 was so devastating to an extent that the flood plains dried-up completely, and the river flow dried-up in less than two months (Data oral interview 2018, with District Head of Dago Village who was the chairman of KYR downstream communities since 1970s). During the 1970s drought, most of the mohogany, manje and alambo trees started disappearing. Similarly, in the same period, the marsh wetlands grasses called robber and daura also disappeared, and the vast plains were later colonized by xyrophyte shrubs and grasses. Likewise, the drought of 1982-1983 saw the beginning of an end of non-xyrphytic plants in the wetlands. The marshy vast flood plain dried-up, allowing secondary successions of xerophyte plants to occur (see Plate 2 for key informant oral interview)

During the 1980s drought periods, sand dunes and typha grasses occupied the wetlands, causing the blockage of the water channel that resulted to diversion of the stream water to dryland ecosystem after a recovery in the mid-1990s. Significant flow began in 1994, where dramatic recovery to full capacity was recorded in the year 2000. The traditional wetlands and parts of terrestrial ecosystems was full to capacity during this period. Movement of over 50km between communities was only possible using canoes. Consequently, in the same year, Yobe River discharged into Lake Chad for the first time since the 1970s.

The effects of wetlands drying during the 1970s, 1980s and 1990s caused extinction of non xyrophitic trees and grass species. The respondents reported disappearance of manje, alambo, and mahogany trees, s well as robber and daura grass species. However, the key informants argued that there are few alambo tress around Gogaram ancient Bade settlement.

The conservation project of Lake Chad Basin Development Authority (LCBDA) in protecting the vast wetlands biodiversity shows that the predominant plants found along the wetlands include: *Acacia serhall*, *Acacia radian*, dom palm, baobab tree, *caesalpiniaceae*, prosopis juliflora, dryland mahogany, *ziziphus spina-christi*, caltrop, and neem tree.

3.2. Weeds that grow in Hadejia-Nguru wetlands

The discussants of 12 Focus Group identified 18 various types of weeds at the Hadejia-Nguru wetlands which are presented in Table 3.

Table 3. Weeds that grow in Hadejia-Nguru wetlands

No.	Local name	Scientific name
1	Kirikiri	*Cynbdon dactlon*
2	Bado	*Nymphaea lotus*
3	Kachala	*Typha latifolia*
4	Machara	*Phragmite australis*
5	Daba	*Solomun incanum*
6	Jiji	*Cyperus rotundus*
7	Kaidajini	*Mimosa pigra*
8	Jallobiya	*Echinochloa pigram*
9	Gemun kwado	*Kyllinga spp*
10	Huri	*Pennisetum pedicellatump polystachion*
11	Zaga	*Cocculus pendulus*
12	Roba	*Echinochloa pigram*
13	Kafi reza	
14	Kayayyashi	
15	Gwaigwaya	*Cypertus diues crutundus*
16	Daura	*Vossia,cuspidate*
17	Kachala shala	*Typha angustifolia*
18	Duman rafi	*Ipomoea asarifolia*

Of all the weeds listed in Table 3 above, *Typha* and *Echinochloa pigram* are the dominant weeds that colonized the wetlands, as reported by all the 12 focus groups, which they locally called as Kachalla. The time line history with the key informants revealed that the weed's secondary succession started in 1973, that was during Sahelian drought. The evidence is presented in Plate 1.

Plate 3. Hadejia-Nguru wetlands weeds (Field observation and measurement, 2019)

3.3. Wetland's livelihood options

The 12 focus groups identified 10 livelihood options derived from the wetlands. The wetlands livelihood options categories are presented in Table 4.

Table 4. Wetlands livelihood options

Livelihood options	Livelihood category
Rainfed farming	Primary
Fishing	Both Primary & Secondary
Hunting	Secondary
Transportation	Secondary
Pastoralism	Both Primary & Secondary
Irrigation farming	Both Primary & Secondary
Animal husbandry	Secondary
Raw Materials mining	Secondary
Craft Work	Secondary
Water vending	Secondary

As shown in Table 4, rainfed farming, pastoralism, and irrigation are the only wetlands-derived primary livelihood activities, with others considered secondary. The predominant livelihood activities along the wetlands site include rainfed agriculture, irrigation, fishing, livestock husbandary, and craft work (such as mat making, pottery among others). Others include edible fruits collections, hunting, etc. The wetlands of Hadejia-Nguru provide a wide range of economic functions to the inhabitants of the wetland site which include domestic water supply, agricultural surpluses, grazing resources, and fish. Others include fuel wood, honey, timber, and other resources and services (Boyi and Polet, nd).

3.4. Wetlands weeds as constraints to livelihood activities

Hadejia-Nguru wetlands are the economic backbones of the wetland sites' population, providing a wide range of ecosystem services and functions to the people. The livelihood means of the people of the study area are generally tied to the wetlands. They, however, serve as constraints as well. This study examined the effects of the wetland's weeds on livelihood activities of the people. Table 5 presents the descriptive statistics of the respondents' wetlands livelihood activities.

Table 5. Weeds constrains to livelihoods activities

Livelihood option	Impact of the weed	Livelihood implication
Rainfed farming	Reduce yield output	Low income
Fishing	Reduce fish harvest	Low income
Hunting		
Transportation	Blocked water channels	Increase travel time
Pastoralism	Reduce animal fodder	Increase cost of production and reduce livestock productivity and reproduction
Irrigation farming	Increase cost production and reduce yield	Low income
Animal husbandry	Reduce animal fodder	Low income
Raw material mining	Reduce clay and sand deposit	Increase cost of building
Craft Work	Reduce clay and sand deposit	Increase cost of production and reduce the profit margin
Water vending	Change water quality (test and color)	Affect people's health

This study identified ten major livelihood activities derived from the wetlands as can be seen in Table 5. Rainfed farming, fishing, and irrigation are the predominant livelihood activities of the respondents, which collectively constitute 57%. Hunting, on the other hand, does not constitute as a wetland-derived activity at all. Weeds within the wetlands area affect the entire farming system, such as fishing, rainfed farming, irrigation, and even the livestock activities. Fish distribution and capture by the fishermen are also affected by the weeds which consequently affects their income per capita. Weed also affects the farming system, more especially during dry season by reducing the flow of water to the farming area. Consequently, the expected amount of water reaching the farm lands cannot meet the water requirement of plants such as rice, wheat, vegetable, and maize.

Moreover, as a result of the presence of these weeds, such as typha grass, it was reported that about four families and twenty-two plant species were completely lost or emigrated (Parthipan et al., 2013). In addition, water level fluctuation and high temperature due to the presence of weeds may influence fish distribution and fishing activities. Thus, insufficient flow of water affects fishing activities in the wetlands.

3.5. Impact of weeds on fishing

Fishing is a major livelihood activity of Hadeja-Nguru wetlands population, which is considered as primary livelihoods mean of some households as it can be seen in Table 2. The results in Table 5 shows that the weeds affect the volume of fish caught in the wetlands. The respondents reported that the weeds have reduced the water flow and caused blockage of channels. This view of the FGD discussants has been confirmed by several studies (Abubakar et al., 2016; Ndour et al., 2019; Zungum et al., 2019). The weeds have been affecting fishing activities because they affect water flows and fishing using nets and canoes.

Table 6. Effect of weeds on crop production

Effects	Impact on livelihood
Weeding for several time	Increase cost of production and labour
Increase water demand for irrigation farming	Increase cost pumping water, contaminate water
Reduce crop yield and affect the crop quality	Reduce profit margin and reduce income
Reduce soil fertility	Increase cost of production and reduce yield
Affect water supply of irrigation bed	Increase labour time and cost
Hosting/harbour insect pests and diseases	Reduce crop yield

3.6. Impact of weeds on crop production

The reported effects of weeds on crop production by the FCD discussants is presented in Table 5. Many farmers in the study area reported that before the emergence of some of the weeds, e.g. typha grass, roba, daba, etc, they used to harvest about or over 200 bags of rice from 10 hectares of farmland annually, and now only 50-55 bags could be obtained from the same piece of land. Typha grass has taken over the farmlands which consequently led to reduction in harvest from the farmlands. Typha grass also harbours birds, snakes, and mosquitoes. More than 30% of cereal crops cultivated by the farmers in the wetland communities were consumed by quella birds. In most of the villages, many people used to spend a whole day in the farm scaring away birds. Farmers in the area reported that during 2007 rainy season, they recorded less than a quarter of the expected harvest and they attributed this to quella birds invading their farms. There are few species recognized as prolific and invasive in the animal world, the most commonly mentioned being locusts and grasshoppers. There have also been large population of quella birds these past few years. The proliferation of this species is often associated with the development of weed plants. *Typha austrails* provides them with an ideal medium for protection and reproduction as rightly stated by Sabo et al. (2016).

Grace (1989) also reported that edges of Typha grass areas are occasionally used as nesting habitats for snowy egrets, black-crowned night herons, and yellow-headed black birds. In addition, upland songbirds use fluff from the flowers to line their nests. A few species, such as deer, use the stands for escape cover. Farmers in the area are suffering from a lack of irrigation water due to blockage of main channels distributing water to their farms by weeds. They are also facing serious problems all year due to flooding during rainy season caused by the blockage by Typha grass and siltation aided by the grass. This assertion is similar to what was reported by Thompson et al. (2009) that, "excessive flooding caused by blockage of river channels and siltation has led to adverse consequences of low productivity of crops, particularly rice." Hollis (2011) also added that, in some cases, more than 90% of lands, hitherto used for cultivation and grazing, have been overtaken by flood due to the presence of weeds. Typha grass invasion may deplete soil nitrates with resultant poor crop yields which will require the use of artificial fertilizers and pesticides. Furthermore, if these chemicals are added in excess quantities, they will percolate into the ground water supplies, flow into streams and rivers, and trapped by Typha grass. This may have effects on aquatic and marine life ecosystems, and may lead to public health problems, when the water is used for drinking.

Plate 6. Water transportation on Hadejia-Nguru wetlands (Source: Field observation and measurement, 2019

3.7. Impact of weeds on water supply

The wetland weed affects the water supply around the Hadejia-Nguru wetland area in terms of colour, quality, and volume of water, as reported by the inhabitants of the study area. According to the respondents when answering the question on the colour of water,

> "it can change in colour as a result of colouring by the grass inside the water from its normal colour to another. The taste of the water also changes when the colour changes due to the dissolution of the weed's chemical composition in the water which consequently leads to formation of impure hard water, probably harmful for both human and animal consumption."

Finally, major grasses (weeds) block the water channel, resulting in a reduced flow of water to the farming area. Fishermen in the study area also have issues with inadequate fishing activities, particularly during rainy season. Both the quantity and quality of fish caught, as well as loss of meeting their daily needs, may occur. As weed covers the area, problem of poor access to water can cause challenge to the majority of the livelihood activities of the area at large. Typha grass invasion may also deplete soil nitrates, resulting in low crop yields which will require the use of artificial fertilizers and pesticides. However, if these chemicals are added in excessive quantities, they percolate into the ground water supplies, flow into streams and rivers and trapped by Typha grass. This may have effects on aquatic and marine life ecosystems and may lead to public health problems when the water is used for drinking and irrigation.

3.8. Impact of weeds on transportation

Water transportation is a primary mode of transporting people and goods between wetlands site communities; canoes are also used for fishing. The vast wetland area is over flooded during rainy season, and all motorable roads and footpaths are completely submerged during wet years. Jajere et al. (2022) reported that in 2001, the wetlands and surrounding terrestrial areas were completely submerged, where movement of 50km was only possible using canoes. The responses of respondents during FGD on the impact of the weeds on transportation are presented in Table 7.

Table 7. Impact of weeds on water transportation

Impact of weeds on water channels	Impact transportation
Impedes flow of water in canals & drainage systems	Hinders movement of canoes
Reduce amount of water in canals & drainage systems	Effect dry season water transportation
Reduce visibility	Hinders movement during night time

Typha, Roba, and Daba species affect the means of transportation at the Hadejia-Nguru wetland area. The grass grows widely on waterways, channels, and river banks, as it can be seen in Plate 3. The passage of canoes used for fishing or access to remote farmlands is made difficult by the grasses, as it can be seen in Plate 6. The respondents' responses on the impact of weeds on transportation are presented in Table 7. As it can be seen in Table 5, weeds contribute to a massive failure in the transportation system, especially during rainy season, because in this part of the wetland, only a very small area can be used for movement of people, goods, and services. The movement is limited only to day time as a result of having the small area, making the canoes drivers unable to see one another when driving and therefore accidents may occur. Thus, two canoes can hardly drive on the same way. The Daba species grow on the surface of water within the wetlands as reported by the people of the area. This grass reaches its maturity stage and takes over a large portion of the water surface, which has an implicate on transportation as a result of blockages.

3.9. Impact of weeds on edible fruits

Weeds have an indirect influence on edible fruits, as it was reported during an interview survey that whenever it appears in a location, it has a serious effect on the fruit trees, shrubs, and herbs. For instance, due to the high risk of the grass like typha specie, when it burns, the smoke is transferred to the edible fruits, causing a serious problem with the fruits and even the plants bearing them, and thus puts them into a poor condition. This leads to underutilization of the fruits for human consumption and also affects health of the tree plants around the area.

Table 8. The use of weeds as means of livelihood

Livelihood option	Used of weed	Application
Rainfed farming	Construction of sailors	For grain storing
Fishing	Processing	Fish Sun drying
Hunting	Not been used	
Transportation	Construction of Canoe	
Pastoralism	Fodder	As animal feed
Irrigation farming	Construction of canal, mulching	Reducing water infiltration and evaporation
Animal husbandry	Animal feed	As animal fodder
Raw materials mining	Building material (Roofing, fencing)	Rural and low-income housing construction
Craft work	production of mat, basket etc	As weaving material for various craft work
Water vending	Not been used	

In the wetland, weeds are largely considered as a threat to crop production as they increase competition for nutrients and water with crops. Weeds are, however, used as raw materials for construction, craft work, medicine, among several other uses. This study investigated the various uses of the identified wetlands weeds in the study area. Respondents reported several uses of the wetlands weeds in the area as shown in Table 2. These include craft work such as waving baskets, mats, and canoes, as can be seen in Plates 1 and 2. Other reported uses of weeds include building materials. Thus, locals use weeds as roofing thatch, fence, clay cementation, etc. Weeds are also used as animal fodder, but some are highly toxic; nonetheless, because animals eat a variety of (composite) weeds, the toxical ones are neutralized. The findings of this study reveal that the weeds are means of livelihood to locales living around the wetlands.

Plate 4. Mat produced from Typha weeds (Source: Field observation and measurement, 2019)

Plate 5. Fish processing (Source: Field observation and measurement, 2019)

3.10. Adaptation

The local population of the wetlands site adapts local straggles in coping with the impact of weeds in their livelihoods. The FGD respondents reported that they cope largely through cutting and tillage.

Tillage: Farmers in the Hadejia-Nguru wetland use tillage in order to adapt to the situation of the presence of weeds in their farms which affect livelihood activities. It is used as a local means of adaptation for both wet and dry season within the area of the wetland, and to simplify rearing, grazing, fishing, transportation, as well as to have a good harvest. At the end of the day, tillage gives them ability to have some control over the weeds.

Burning: Burning is the second local way of adapting to the presence of grasses or weeds by people of the wetland, but it is not common to them alone. This method is only used by a few people. The people of the study area reported that it is the oldest method used but they are still practicing it, despite the fact that it reduces soil fertility.

3.11. Mitigation

Mowing/cutting: the people of Hadejia–Nguru wetland use cutting or mowing to control the presence of the weeds that are grown on the wetland by using machines and other equipment such as cutlasses, sickles, knives etc. According to the respondents, this mode of mowing is the simplest and most common method they apply for mitigating the weeds since it is the cheapest means for them to apply. This is because it does not need a huge amount of money and it is not always necessarily requiring them to employ some body for the cutting. Chemicals/Herbicides: The weeds are often controlled through the use of variety of chemicals/herbicides. However, according to the research, it all depends on the timing and nature or family of the weeds, meaning that each grass has a specific chemical that can be applied to it during the control. Moreover, the respondents reported that they used to spray the chemical on the grass or weed at least two to three times in a season.

3.12. Typha grass control measures

In some developing countries, two major methods are used to control Typha species. These include mechanical and chemical control measures. This finding is in accordance with Rao and

Murthy's (2004) assertion that individual farmers along the drain make efforts to reduce the weed mechanically by slashing the weeds to clear their farms and main canals, which was found to be labour intensive**.** However, the method does not provide long term control measure. This is because after clearing the irrigation canals, the Typha stems and seeds were left on the shoulders of the canal through which seeds germinate and the stems sprout and easily get their way into the canal again. Some informants interviewed also affirmed that lands are sometimes recovered from Typha by cutting and at the same time flooding the area. Cutting Typha stems below water surface was another mechanical control method found to prevent oxygen transportation between stems, rhizom,e and roots. Under this condition, the decomposed Typha plant increases the production of ethanol which consequently leads to the death and decaying of plant materials.

Sharma et al. (1990) further reported that cutting Typha shoots decreased the biomass of above ground organs such as leafs and total chlorophyll content. Another mechanical control method for accessibility includes employment of physical forces to remove all the aquatic weeds including Typha from the environment to avoid the full establishment and survival of any type of weeds. This method includes dredging, drying, mowing, manual clearing, chaining, burning, cutting, and slashing when the seed head is still green. Repeated slashing is necessary to maintain controlling of the weeds as single slashing will not kill the Typha species. Covering cat-tail with black polyethylene tarps has been reported as a possible measure of Typha control (Juroszek & Tiedemann, 2012). Actively growing cat-tail tips were killed when completely covered with polythene tarps for at least 60 days. Cattle herders sometimes burn the existing Typha plants purposely to have access to water and this act further stimulates growth of the plant which is later fed on by the animals. Using fire to control cat-tails Typha root offered only remedial control measure because fire set on Typha weed burn only the above ground biomass while the roots remain underground (Juroszek & Tiedemann, 2012). Another method used in the control of Typha weed includes the use of chemicals. However, most of the respondents expressed doubt on the use of herbicide to control Tyhpha, due to the fact that the water in which the Typha plant grows is also used for drinking by the animals and the herdsmen, as well as for other domestic purposes. Thus, fear of the respondents is based on the possible phyto-toxic effect of the herbicide active ingredient on the people and their animals. In the chemical control method, various herbicides are recommended for different situations considering the intended use of the water before deciding which treatment to use.

4. Discussion

The results of this study revealed that the series of drought have altered the ecosystem of Hadejia-Nguru wetlands, as reported by Jajere et al. (2022). This study confirmed that the upstream dam construction in the 1970s, in response to upstream states government response to sahelian drought, mark the major milestone in Hadejia-Nguru wetlands ecological degradation. Similar scenario is reported in Senegal River Delta wetlands by Ndour et al. (2019), in their study of ecological and socio-economic impacts of Ceratophyllum demersum L., an invasive aquatic plant in the Senegal River delta. The study revealed proliferation of the weed species is recent and dates back to the commissioning of Diama and Manantali dams. The filling of water bodies, the fall in fishing yield, and the appearance of the so-called water-related diseases are the most damaging impacts on the ecosystem of the Senegal River delta and the life of the communities. The habibat changes caused by droughts have led to biodiversity dynamics, among which is secondary succession by weeds. Studies on Hadejia Nguru wetlands weeds largely reported Typha grass inversion; this study identified 18 various types of weeds.

The weeds have been interfering with general ecosystem of wetlands as reported by (Babagana et al., 2018; Ringim & Dogara, 2017). Several research have reported on the impacts of wetlands on livelihoods (Mohammed, 2016; Sabo et al., 2016). The results of this study confirmed the impact of weeds on wetlands livelihood activities and assets (Babagana et al., 2018; Mohammed, 2016). The results of this study revealed that the weeds are major constraints to livelihoods of the local wetlands site people. However, they are also a source of income. The most affected livelihoods activities include crop production, fishing, livestock production, water supply and water quality, and transportation. It is similar to what is reported on other wetlands site of African (Masifwa et al., 2020). In their studies on the environmental and socio-economic impacts of Kariba Weed infestation of Lakes Kyoga and Kwania, Uganda. The study reported the impact of the weeds impaired with fishing activities, water quality, water abstraction, and water transport. This study identified 18 various weed species that grow in the wetlands, with Typha as the most widely spread and reported by several studies and media reports. Other species that pose a comparable threat to the wetlands ecosystem function and service were also studied. The results of this study revealed that the weeds affect the wetlands' base livelihoods by reducing crop yield from both rainfed and irrigation, increasing cost of crop production, declining fish harvest, decreasing availability of fodder for livestock, shrinking of flood plain, affecting water quality, decreasing availability of wild life, and decreasing availability of raw materials. Mohammed (2016) reported that proliferation of the invasive Typha grass is a threat to the ecology and economy of the people of Hadejia-Nguru wetlands, increasing the poverty scale among wetlands users' households. The infestation impaired fishing activities, water quality, water abstraction, and water transport in Lakes Kyoga and Kwania, Uganda (Masifwa et al., 2020).

However, this study results indicated that the people of the wetlands site are using the weeds for a variety of livelihood activities such as weaving, animal feed, and building materials, among others. The findings of the investigation demonstrated that the locals have been using the weed to weave mats, baskets, and even canoes. They also used the weed as building materials such as roofing huts and fencing compounds. Although the available studies on Hadejia-Nguru wetlands' weeds largely focus on the negative impact of the Typha grass on biodiversity, hydrology, and socio-economic activities, over the time, people have been exploring the economic benefits of the weeds.

5. Conclusion

The secondary succession of weeds following the Sahelian droughts of 1970s and 1980s poses a serious threat to wetlands' ecosystem and livelihoods. However, the weeds in the Hadejia-Nguru serve two purposes, namely: i. Source of raw materials for so many means of livelihood; ii. Source of major constraints to many livelihood activities. To address local problem regarding weeds, approaches must be tailored to local practice and resource availability. Strategies also need to anticipate likely future changes in soil fertility, water availability, and population pressure, while addressing environmental concerns by avoiding excessive dependency on herbicides. Emerging weed problems include species such as hemi-parasitic, annual grass, and perennial rhizotomous weeds. These weeds are likely to get worse, and effective strategies are required to control them.

Recommendations

It is recommended that all the beneficial weeds in the wetlands should be identified and be utilized sustainably. Effective strategies should be adopted to control the dangerous weeds in the study. The finding of this study will serve as a key document for wetlands conservation agencies and NGOs.

References

Abubakar, M. M., Kutama, A. S., Sulaiman, I. M., & Ringim, A. S. (2016). Impact of climate change on the Hadejia-Nguru: A review. *Dutse Journal of Pure and Applied Sciences*, *2*(1), 150–158.

Acharya, G., & Barbier, E. B. (2000). Valuing groundwater recharge through agricultural production in the Hadejia-Nguru wetlands in northern Nigeria. *Agricultural Economics: The Journal of the International Association of Agricultural Economics*, *22*(3), 247–259. https://doi.org/https://doi.org/10.1111/j.1574-0862.2000.tb00073.x

Adams, W. M. (1993). Indigenous Use of Wetlands and Sustainable Development in West Africa. *The Geographical Journal*, *159*(2), 209. https://doi.org/10.2307/3451412

African Water Facility. (2014). *African Water Facility supports the development of Komadugu-Yobe Basin in Nigeria*. https://www.africanwaterfacility.org/news/african-water-facility-supports-development-komadugu-yobe-basin-nigeria

Akinsola, O. A., Ezealor, A. U., & Polet, G. (2000). Conservation of waterbirds in the Hadejia-Nguru Wetlands, Nigeria: Current efforts and problems. *Ostrich*, *71*(1–2), 118–121. https://doi.org/10.1080/00306525.2000.9639885

Babagana, M., Mbatudde, M., Adamu, A., Magama, Y. A., & Suleiman, G. A. (2018). Typha grass (typha domingensis) and its control strategies along Nguru wetlands. *International Journal of Agriculture, Environment and Bioresearch*, *3*(2), 93–107.

Bajwa, A. A., Farooq, M., Nawaz, A., Yadav, L., Chauhan, B. S., & Adkins, S. (2019). Impact of invasive plant species on the livelihoods of farming households: evidence from Parthenium hysterophorus invasion in rural Punjab, Pakistan. *Biological Invasions*, *21*, 3285–3304. https://doi.org/https://doi.org/10.1007/s10530-019-02047-0

Barbier, E. B. (2003). Upstream dams and downstream water allocation: The case of the Hadejia-Jama'are floodplain, northern Nigeria. *Water Resources Research*, *39*(11). https://doi.org/10.1029/2003WR002249

Barchiesi, S., Cartin, M., Welling, R., & Yawson, D. (2014). Water and nature initiative (wani) case study Komadugu Yobe Basin, upstream of Lake Chad, Nigeria. *IUCN Water Programme*, *1*, 12.

Birdlife International. (2020). *2019 Highlights*.

Blench, R. (2007). Using Linguistics to Reconstruct African Subsistence Systems: Comparing Crop Names to Trees and Livestock. In *Rethinking Agriculture* (1st Editio). Routledge.

Hollis, G. E., Adams, W. M., & Aminu-Kano, M. (1993). *The Hadejia-Nguru Wetlands-Environment, Economy and Sustainable Development of a Sahelian Floodplain Wetland*. Gland : IUCN.

Hutcheon, L. (2006). *A Theory of Adaptation* (1st Editio). Routledge.

Idris, M. (2008). *Damming Nigeria's Wetlands People: Communities Work Together to Restore Lives And Livelihoods*. International Rivers. https://archive.internationalrivers.org/resources/damming-nigeria-s-wetlands-people-communities-work-together-to-restore-lives-and

Ikusemora, M., & Ezekiel, Y. (2011). Remotely sensed data and geographic information system techniques for monitoring the shrinking Hadejia – Nguru wetlands, Nigeria. *Lagos Journal of Geo-Information Sciences (LJGIS): An International Journal of the University of Lagos, Nigeria*, *1*(1), 73–86.

Isma'il, M., Musa, I. J., & Jajere, A. A. (2014). Analysis of Future Urban Growth Scenario of Damaturu Town in Yobe State, Nigeria. *Global Journal of Research and Review*, *1*(3), 117–124.

Jajere, A. ., Ibrahim, J. ., & Adamu, A. . (2022). Geographical Description of Kumadugu-Yobe River Basin of West Africa. *Journal of Geography, Environment and Earth Science International*, *26*(3), 1–13. https://doi.org/https://doi.org/10.9734/jgeesi/2022/v26i330338

Jajere, A. A. (2021). *Wetland's Response to climatic variability: Emperical evidence from Kumadugu-Yobe River Basin. Ph.D Thesis presented to*. Ahmadu Bello University, Zaria, Nigeria.

Juroszek, P., & Tiedemann, A. von. (2012). Plant pathogens, insect pests and weeds in a changing global climate: a review of approaches, challenges, research gaps, key studies and concepts. *The Journal of*

Agricultural Science, *51*(2), 163–188. https://doi.org/https://doi.org/10.1017/S0021859612000500

Masifwa, W. F., Beine, P., Ogwang, J., Matuha, M., Amondito, B., & Nabwire, R. (2020). Environmental and Socio-Economic Impacts of Kariba Weed Infestation of Lakes Kyoga and Kwania, Uganda. *Uganda Journal of Agricultural Sciences*, *20*(1), 57 – 71. https://doi.org/DOI: http://dx.doi.org/10.4314/ujas.v20i1.4

Mohammed, Y. (2016). *Analysis of the effects of thypha grass infestation on the livelihood of the farmers living within Hadejia-Nguru Conservation Project*. Ahmadu Bello University Zaria, Kaduna State Nigeria.

Ndour, S., Mbaye, M. S., Diouff, J., Mballo, R., Sarr, M., Gueye, M., & Noba, K. (2019). Impacts écologiques et socio-économiques de Ceratophyllum demersum L., une plante aquatique envahissante dans le delta du fleuve Sénégal. *International Journal of Biological and Chemical Sciences*, *13*(6), 2739–2749. https://doi.org/10.4314/ijbcs.v13i6.25

Nyumba, T. O., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/https://doi.org/10.1111/2041-210X.12860

Odunuga, S., Okeke, I., Omojola, A., & Oyebande, L. (2011). Hydro-climatic variability of the Hadejia-Jama'are river systems in north-central Nigeria. *IAHS-AISH Publication*, *344*(July), 163–168.

Parthipan, T., Ravi, V., Subramanian, E., & Ramesh, T. (2013). Integrated weed management on growth and yield of transplanted rice and its residual effect on succeeding black gram. *Journal of Agronomy*, *12*(2), 99–103.

Rao, A. S., & Murthy, K. V. R. (2004). Effect of sequential application of herbicides on nutrient uptake by rice fallow blackgram. *The Andhra Agriculture Journal*, *50*(3), 360–362.

Ringim, A.S., & Dogara, M. M. (2017). A survey of avifauna and vegetation communities in Hadejia-Nguru Wetlands, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *10*(2), 1–10.

Ringim, Abubakar S., Abubakar, M. M., Mohammed, S. I., & Shuaibu, T. (2015). Wetlands resource use, Conflict, Management and Conservation: Review of the Hadejia-Nguru Wetlands, Northeast, Nigeria. *International Journal of Innovative Science, Engineering & Technology*, *2*(10), 507–516.

Sabo, B. B., Karaye, A. K., Garba, A., & Ja'afar, U. (2016). Typha Grass Militating Against Agricultural Productivity along Hadejia River, Jigawa State, Nigeria. *Scholarly Journal of Agricultural Science*, *6*(2), 52–56.

Sabo Babura, B., Sabo, B. B., Karaye, A. K., Garba, A., & Afar, J. '. (2016). Typha Grass Militating Against Agricultural Productivity along Hadejia River, Jigawa State, Nigeria. *Scholarly Journal of Agricultural Science*, *6*(2), 52–56. http://www.scholarly-journals.com/SJAS

Salako, G., Sawyerr, H., & Olalubi, O. (2016). Does Typha spp. Contribute to Wetland Waterloss and Health Risk: A Case Study of Hadejia Nguru Wetlands (HNW) System NE Nigeria. *Open Journal of Ecology*, *6*(4), 151–158. https://doi.org/10.4236/oje.2016.64015

Shackleton, R. T., Witt, A. B. R., Aool, W., & Pratt, C. F. (2017). Distribution of the invasive alien weed, Lantana camara, and its ecological and livelihood impacts in eastern Africa. *African Journal of Range and Forage Science*, *34*(1), 1–11. https://doi.org/10.2989/10220119.2017.1301551

Sharma, K. P., Khushwaha, S. P. S., & Gopal, B. (1990). Autotoxic effect on Phragmites karka (Retz.) Trin. Ex Steud. plant on its seed germination. *Geobios*, *17*, 287–288.

Shettima, K. A. (1997). Dam Politics in Northern Nigeria: The Case of the Kafin Zaki Dam. *Refuge*, *16*(3), 18–22. https://doi.org/10.25071/1920-7336.21922

Tanko, A. I. (2014). Water Resource Development and Management. In *KANO Environment, Society, and Development*. Adonis & Abey Publishers Ltd.

Thompson, J. R., & Hollis, G. E. (1995). Hydrological modelling and the sustainable development of the Hadejia-Nguru Wetlands, Nigeria. *Hydrological Sciences Journal*, *40*(1), 97–116. https://doi.org/10.1080/02626669509491393

Zungum, I. U., Imam, T. S., Ahmad, A. G., Abubakar, T., Benjamin, B., & Daya, M. G. (2019). Impact of Typha Grass on Biodiversity Loss of Hadejia-Nguru Wetland Located between Jigawa and Yobe States of Nigeria: A Review. *Journal of Applied Sciences and Environmental Management*, *23*(10), 1847–1853. https://doi.org/10.4314/jasem.v23i10.13