The invasion of Cattail (*Typha species*) in Hadejia-Nguru Wetlands area, an Appraisal towards Exploring Various Management Techniques and Utilizing its Economic Benefits in The Area

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Abstract
The Hadejia-Nguru wetland is an important wetland in the Sahelian region of Northern Nigeria. The wetland is very important to the regional economy by providing fertile alluvial soil for flood recession farming and dry season irrigation farming of vegetables and cereals (rice and wheat). It provides fish resources, fuelwood and other non-timber forest products. In recent years the area is facing a lot of problems and challenges among which are construction of dam at the upstream which distracts the normal flow of water to the downstream, population pressure causing conflicts between herders and farmers. The most serious problem is the proliferation of Typha spp an invasive species which blocks water ways and impedes farming and fishing activities, causing siltation and harbouring pests of grain crops (Red billed quelea), and vectors of malaria (Mosquitoes). The paper highlighted some management options for the Typha including, physical, mechanical, biological and chemical control as plan A. The Paper highlighted the various economic uses of the plant as option B for management including using it for biomass production, bio -coal production, harnessing the medicinal uses of the various plant parts, as a phytoremediation agent, using it as a source of food and incorporating it in the mixture of animal feeds among others.

Key words: Wetland, Hadejia-Nguru wetlands, *Typha species*, Invasion, Management techniques

I. Introduction

Wetland ecosystem have a diverse array of direct and indirect functions. directly they supply water, provide a lot of wetland products such as fish and plant resources. indirectly they help in recharging the underlying aquifers (Acharya, 2000). Wetlands which includes fresh water swamps, marshes and peatlands covers an area of about 6-8 million km^2 worldwide and are ecosystems which are abundant source of natural capital (Barbier, 2011). They are among the most productive ecosystems in the World, only comparable to rain forests and coral reefs. They are regarded as the biological supermarkets, they produce great quantities of food that attract many animal species(Fagorite *et. al.,* 2019). wetlands serve a lot of functions, they provide services such as water purification and regulation of flows, fish and other related resources, provide habitat for plants, animals and microorganisms, they also serve as a site for recreation and tourism. hydrologically they serve as buffer against drought and flooding(Silvius *et al*., 2000). The economic importance of dry Sahelian wetland like Hadejia- Nguru wetland can never be over emphasized as highlighted by Kimmage and Adams (1992). They provide agricultural surplus in most years (rice, wheat and vegetables). They are also an important source of fish and fuel wood. The Hadejia-Nguru wetlands are of international importance for breeding and wintering waterfowl. It was in this recognition that the Royal Society for the protection of birds (RSPB) and the World Conservation Union (IUCN) launched the Hadejia-Nguru wetlands conservation project in 1987 with the aim of conserving the natural resources and functions of the Hadejia-Nguru wetlands (Polet, 2000). The area is declared a Ramsar site for being an important Bird Area (IBA) and a wetland of national and international significance holding resident, inter-African and palearctic migrant birds in sub-Saharan region (Sabo *et al*., 2021). Despite the severe ecological changes experienced by the area recently, it supports about 1.5 million people who relies directly or indirectly from its aquatic resources such as fuel wood, potash, vegetables, fish etc.(Edegbene, 2018; Munishi, and Jackson, 2012). Furthermore, Wetlands play an important role in global climate change regulation by its ability to sequestrate carbon(Benalcazar, *et.al*., 2019). They play an important role by serving as a transition zone of varying water regimes, they acted as natural filters that improves water quality through reduction in nutrients loadings, water aquifer, hence bearing the name " Kidneys of the catchment"(Apeverga, *et. al.*, 2019). Estimates puts it that more than 40% of the entire World's species and 12% of all animals are found in the wetlands (Ibrahim, 2020). Wetlands are considered as highly productive ecosystems they provide many goods and services to the people near and far away from them (Abdullahi., 2018).The Hadejia-Nguru wetlands (Fig. 1) is so important to the regional economy in terms of ecosystem provisional services. For this reason they have one of the earliest existing ecosystem valuation studies of any Nigerian (or African) wetland (Ayeni *et al*., 2019). While Ayeni *et al* (2019) focused on monetary valuation of the provisional services of the wetland. other researchers such as Barbier *et. al*.(1993). assessed the economic importance of the wetlands highlighting the opportunity cost of their loss to the nation. Others such as Eaton and Sarch (1997) focused on the economic importance of wild resources in the Hadejia-Nguru wetlands.

Furthermore, Hollis *et al* (1995) Conducted a more general study of the natural resources climate and the hydrology of the HNWs. For Amans *et. al.(*1992)they looked at the productivity, stability and sustainability of farming systems in the wetlands**.** The primary drivers of degradation and biodiversity loss in the wetland include change in the climatic conditions in the area, Construction of dams and other infrastructures, land use change, water withdrawal, pollution, over-exploitation of resources and above all the introduction of invasive aquatic species -*Typha* (Tafida, and Galtima, 2015).

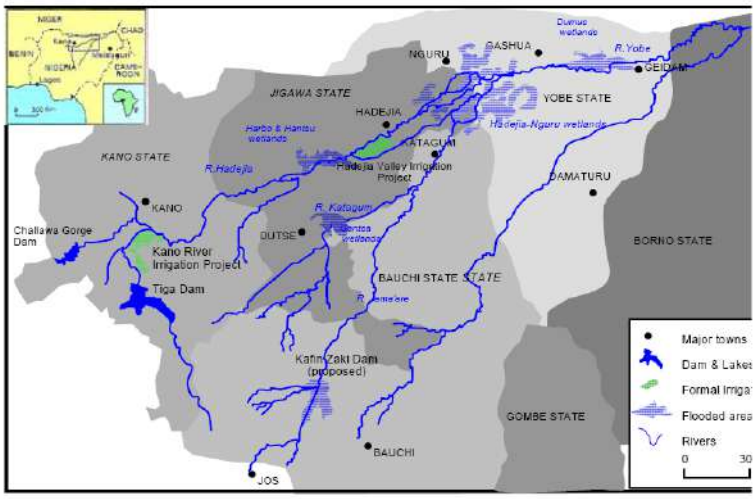

Figure 1: The Hadejia –Jama'are Komadugu-Yobe Basin

Fig 1. Map of Komadugu Yobe basin including Hadejia- Nguru and Jama 'are river.

II. Problems Associated with Hadejia - Nguru wetlands

Wetlands are under intense pressure from anthropogenic activities which include agricultural expansion, urbanization, pollution from agricultural production, industry and households. Other factors that are negatively affecting the sustainable management of the wetlands include poverty, pressure from population growth and immigration (Tafida, and Galtima, 2015). Some of the institutional problems of this basin includes the modification of the natural run off by the construction of dams and the associated large –scale irrigation schemes such as the Tiga and Challawa dams and the Kano irrigation schemes (KRIP) in the upper basin, The Hadejia valley irrigation project (HVIP) in the middle. While on the Jama'are River there is the construction of the Zaki Dam (Chiroma, 2002). The major threats facing the wetlands include population pressure, invasive *Typha* grass, overgrazing, overfishing and shrinking of the floodplains because of diversion from dams, irrigation developments and drought (Idris 2008; 2013; Mohammed 2014; Olalekan 2014; Abubakar, 2016). *Typha* is a common problem of the wetlands throughout the world, they tend to choke off any other vegetation and make a poor habitat for many waterfowl and other birds (Mitsch & Gosselink, 2015). *Typha* is the primary producer of estuarine ecosystems, which has the ability to concentrate elements and compounds from the polluted soils and water bodies and to metabolize molecules in its tissues(Ali et al., 2020). Consequently, it can incorporate large amounts of elements from the environment (Minkina *et al*., 2021). Cattail stands provide nesting sites for birds and spawning areas and protection for fish (Mitich, 2000).

In addition, the invasive aquatic plants reduce the flow of water in the irrigation canals by reducing the available space and acceleration of frictional resistance to the flow, thus expediting a sedimentation process in the infrastructures. Fisheries are threatened and rice paddies, which depend on a good irrigation system is successively invaded reducing the agricultural yield (Sabo *et al*. 2010). Furthermore, the need to investigate the effect of this grass on the livelihood of people living in this area becomes prominent. The need to carry out this research work stems from the fact that the plant (*Typha*) presence in the wetland has interfered markedly with the utilization of water and land resources. This inhibits the development and expansion of agriculture which is the primary occupation of the inhabitants. From the foregoing, it become imperative to investigate the level which this weed affect livelihood of the people of the area, because assessing the effect of this weed will

give a clear understanding of the damages and constraints to wellbeing of people. Consequently, this study answers the following research questions. One of the serious problems affecting the wetlands is bio invasion. *Typha* have been reported to be invading rice and cassava fields, these blocks and redirects the flow of rivers and channels of the associated rivers, this alongside affects the fishing in the area. This makes the area liable to environmental degradation and ecosystem food chain imbalance, biodiversity deformation, this is mostly caused by human activities such as industrialisation, , mineral exploitation urbanisation and civilisation *(Olalekan et al*., 2014).

To add more, *Typha* species have been the primary focus of research on wetland biomass crops in Minnesota because of their productivity, adaptability, large sugar and starch rich rhizome system, exceptional pest resistance, and aggressive growth and regeneration characteristics. Evaluation of the commercial potential of *Typha* plants as an energy resource depends on an understanding of the tradeoffs between productivity and production costs (Johnson, 1988). Upstream developments have affected incoming water either through dams which alter the timing and size of flood flows or through diversion of surface or groundwater for irrigation activities. The main cause of unexpected reduction in extent of the flooded area is also linked to reoccurring drought which is a persistent, stochastic environmental problem facing most arid and semi-arid environments (Bukar *et al*., 2021).The spread of invasive *Typha* spp, taking over flood rice and cassava fields, blocking river channels, and undermining fisheries, is seen as a major problem. See figure 2, 3, 4 and 5 for *Typha* invasion). *Typha spp* or 'cattail' is a species of water loving plant that can, under favourable conditions (that is. in shallow permanently inundated areas), proliferate and become difficult to control, making the plant an invasive species (Chiroma, Mohammed J., 2003). Cattail (*Typha spp*), is a plant known to local people as Kachala around Hadejia-Nguru wetland area of North-eastern Jigawa and north western parts of Yobe States (Akinsola *et al*., 2010)**.** 24% (8 of 33) of the World's most invasive plants are wetland species (kercher, 2004). The invasion of this plant species In the Hadejia – Nguru wetlands and in the Hadejia-Jama'are Komadugu Yobe basin in general has caused a serious problem that can be considered a threat to ecology and economy in the past seven years or so (Ayeni *et al*., 2019; Murray-Hudson and Mmopelwa, 2011).

Fig 2. A fisher man floating on gourd at Hadejia- Nguru River. Fig.3 Fishermen paddling canoe in Hadejia-Nguru wetlands. Notice the invasion of *Typha* grass on the fore ground.
Source: *Hadejia - Nguru wetland.*

In the last fifteen years, river channels, lakes and fadamas in the wetlands have been taken over by *Typha*, along with many hectares of farmland and potential grazing lands. On the Marma channel and Nguru Lake for example, where *Typha* invasion is more severe, over two thirds of potential farming and grazing lands have been taken over by the plant. Conversely it has contributed to the desiccation of Burun gana channel, where about 60% of dry season

irrigation farms are wasting. In addition, the grass provides a harbour for large flocks of quelea birds that seasonally destroy cereal crops. This problem of *Typha* has over the years become a serious concern to the local communities and to traditional authorities, government institutions and line agencies with a responsibility for enhancing the livelihoods of people living in the affected areas. Repeated efforts, ecological studies and manual clearing have yielded very little results in the past. (Chiroma, Mohammed J., 2003).

Typha swamp harbour more mosquito larva than the open water. This make the surrounding community of *Typha* infested rivers prone to mosquito bites and malaria disease.(Salako *et al*., 2016, Layne, 2009) . Ramsar,(2000) reported the colonisation of wetlands by *Typha* (*Typha Australis*) as an example of the growing problem worldwide (Sulaiman, I.M., Cresswell, 2014)**.** Invasion events have increased substantially in the last 200 years due to human migration and commerce (Mitchell, 2011)**.** Biological invasions are considered as a key threat to biodiversity (Borokini *et al*., 2012). *Typha* is a species of hardened aquatic macrophyte that grows wildly on water channels and river banks During the recent time it is a common feature along the HNW and is a serious nuisance to the communities. It makes passage by canoe used for fishing difficult or access to remote farmlands (Kaugama & Ahmed, 2014). Changes in water regime from season to all year round have caused the invasive *Typha* to establish itself in the basin This causes difficulty in manipulating water to be used for Agriculture. *Typha* impede the flow of water for irrigation by growing naturally in ditches, swamp and marshy areas. They are identified as one of the commonly water loving plants (M.M., 2012). They have been considered second major threat to biodiversity following habitat destruction (Babagana *et al*., 2018) . The specie has been identified as a serious threat to the sustainability of the whole farming house hold. It is a serious problem threatening the sustainability of the whole irrigation scheme. About 90% of the main channels were blocked by this perennial species, this eventually blocked free flow of water into irrigation fields(Bukar *et al*., 2021; Sabo, 2016). This has inflicted object poverty to majority of communities to the extent that people are thinking of migrating to neighboring Niger republic or Chad after losing hope of any intervention from government. The specie has been identified as a threat to the livelihood of many families in the basin. *Typha* invasion increases methane production relative to native dominated marshes in the Great Lakes region. studies showed that above ground biomass doubled with *Typha* invasion and was positively correlated with methane emissions (Lawrence *et al*., 2017). A large productive Fadama land amounting to about 60% has been taken over by *Typha* grass in Jigawa state. Around the Madachi area in Kirikasamma local government the figure is as high as 80%. Productivity in fadama (Valley –bottom or flood plain around a river that floods or becomes wet when the river is high) agriculture has, as a result, shrunk to 4% of its former value(Chiroma, *et. al*., 2003). The plant which can grow up to two or more meters in height has a higher growth rate than any other aquatic plant (Zungum, IU; Imam, 2019).

Figure 4 and 5. Rice field inside the wetlands and mounds of cleared aquatic vegetation inside water. Source Julian Thompson (2001)

While food and fish production are reducing, the extent of *Typha* invasion is undergoing exponential increase in the past 5 to 10 years. This gradual increased the silting of channels caused by the slow all-year round flows. In the overall scenario *Typha* invasion have increased from 550 ha to over 200 square kilometers in the last 10 years (Yarima Mohammed, 2016). In North Dakota USA, another problem with cattail-choked wetlands is the assemblage of large numbers of migrating Red-winged black birds (*Agelaius phoeniceus)*, Common Grackles (*Quiscalus quiscula) and* Yellow-headed black birds *(Xanthocephalus xantthocephalus) r*oost there and damage nearby crop fields (Dan Svedarsky *et al.*, 2019; Linz *et al*., 2011). In Hadejia-Nguru wetlands the dense stands of cattail provide a roost for the migratory Red-billed quelea *(Quelea quelea*) which damages nearby rice fields and other grains.

III. Management of Typha Grass (Cattail):

Cattails are aggressive species that quickly inhabit disturbed areas, ultimately reducing diversity and productivity of wetland systems. They disperse seeds over a wide area and pre-empt spaces rapidly following a disturbance. They are mainly self-pollinators, but can also cross-fertilize *(Sharp et al*., 2002). Several efforts were made to control *Typha* in Hadejia-Nguru wetlands. From available information from cited literatures several efforts were made by communal people to clear water channels and construction of local dykes by the people to prevent flooding which pose threat to their settlements. The Jigawa State Government did some mechanical excavation to clear the channels. Local government due assist people in manual clearance of the *Typha* in channels using cutlasses and sickles. During dry seasons when the waters dry up burning is prescribed as means of *Typha* clearance. Non- governmental organizations also help in clearing the *Typha* vegetation and raise awareness among the communities to participate in communal efforts and also fund some proposals by people(Sabo B.B., 2016). Some of the NGO's includes, Joint wetlands livelihood project (JEWEL) Nigeria Conservation Foundation (NCF) Hadejia-Nguru wetland Project (HNWP), Coalitions for change C4C (a DFID project), Wings over Wetlands, IUCN ROCA, LCBF/GEF project, Ramsar Swiss Grant, Komadugu Yobe basin Development initiative and Hadejia – komadugu -Yobe basin trust fund, *TYPHA* Project an action research component of TRIMING (Transforming Irrigation Management in Nigeria), funded by the World Bank, 2017-2020. Also, in participation were governmental bodies such as Federal ministry of water resources, Hadejia-Jama'are River Basin Development Authority (HJRBDA), Federal and State Integrated Water Resources Management, Chad Basin Development

Authorities (CBDA). Right now, The Yobe State Government is doing a clearance at Magujin Idi in Kirikasamma Local Government Area. Some months back the Federal Government and some prominent politicians have done the same effort in the area. There are three alternative control methods for the management of cattail. These are: -

1. **Physical method of controlling *Typha* grass**

Physical management involves the manipulation of the plant which in turn acts on the plant. several physical methods are available including dredging, drawdown, benthic barriers shading or light attenuation and nutrient inactivation(Madsen, 2000). Account of how the plant was controlled using shading was described by Abdullahi *et al*., (2019) using Black Tarpaulin in different measured sampling sites with a given counted species of *Typha* and leaving another site with the *Typha* species exposed with no covering with the Tarpaulin. It was found out that there was high mortality of *Typha* covered with Black Tarpaulin. Other physical methods of cattail control include:- shading and manipulating water levels(Solberg & Sojda, 1993; Svedarsky *et al*., 2019).. This method is mostly done by the communal people. Hand or mechanical cutting of cattails followed by submergence of all cattail stems results in high control (Apfelbaum, 1983). Mechanical methods use machines such as mowing machines, . The efficiency of cutting *Typha* using mowing boat was tried in Senegal river and was found to be effective in removing the aquatic weed. However, the method is slow and regrowth of the vegetation was observed in some portions of the experimental sites(Hellsten *et al*., 1999). This is mostly carried out by government and other agencies. Various mechanical methods of control were applied including clearing using cutlass and sickles. After cutting the area is flooded 15 to 18 inches above the cut stalk. This method was successful in the Murrumbidgee irrigation area of South Wales (Project, 2017). cutting, crushing, disking prescribed burning, grazing, Mowing during winter time over ice followed by flooding for the duration of the growing season reduced a *Typha* standby 89% depending on how the cutted stems are submerged inside water after the flooding the result could be 100% reduction in the *Typha* stand (Miklovic, 2000). (Birnin Yauri, *et al*., 2019). Cutting and reflooding with at least 8cm (3.1 in) of standing water was found to be effective as reported by Afpelbaum (1985). He also reported the use of black polyethylene tarps to control cattail (Apfelbaum, 1985). However, because of the tedious nature of using hand implements in removing weeds, particularly that the weed has to be removed from the water at the end of the day. Long stretches of rivers and lakes larger than one acre and above may therefore require some mechanised approach (Seagraves, 1988). From the above examples it can be seen that, the method can be applicable to Northern Nigeria.

It has the following advantages: -

- It is target specific.
- No danger of chemical toxicity to the environment.
- The cut weed can be used for other purposes.
- There is availability of cheap labour in comparison to places like UK and USA where manual labour is very expensive.
- Generally, people in Northern Nigeria are collectivist, they have the tendency to come and work together for the benefit of the whole community. They can engage in a voluntary communal work locally known as (aikin gayya). Communal voluntary work is something very common in Northern Nigeria. If all the stake holders in the study area, the government, NGO's, traditional rulers, politicians, all other community members will come together to make it participatory where each and every one will have a certain role to play. The government will play the role of execution of policy and planning, budgeting and financing, the NGO's will help with expertise and advice and donations. The local people will help with their local experience and manual labour when it is needed. Government will buy hand tools such as sickles, syches, and chain.

2. Chemical method of controlling *Typha* grass

Chemicals used to control plants are called herbicides. About 200 herbicides are registered in the US and only fewer than a dozen is labeled for use in the aquatic sites. These herbicides under various trade names contains combination of seven active ingredients copper, 2,4-D, dichlobenil, diquat, endothall, fluoridone and glyphosate (Fennessy, 2001). The use of chemical in controlling *Typha* has also been reported by Afpelbaum but with great cautious as using chemical in natural areas have some effects on non-target species (Apfelbaum, 1985). Using aquatic herbicide to reduce cattail appears successful in some wetlands. Glyphosate is the only registered herbicide with the EPA. Using Glyphosate to treat cattail appears successful but the cattail may grow back in later years (Ralston & Bleier, 2004). In Pakistan a trial of different management options for cattail was done using 8 different treatments with glyphosate under different treatments (1.0, 1.5,2.0 kg a.i. ha^{-1}), isoporoturon (0.741 kg a.i. ha^{-1}), Clodinafob-propargyl 90.3 kg a.i. ha-1), and halosulfuron methyl (0.0375 kg a.i. ha^{-1}) , along with a hand-weeding treatment and an untreated control. it was find out that glyphosate did well out of the 8 options and glyphosate dose of 2 kg a.i. ha-1 proved the best in *Typha* control (Gul *et al*., 2018). Kanatas (2019) reported the combined use of mowing and herbicide give an efficient result. in particular, no any herbicide succeeded to adequately control *Typha* spp without previous mowing. The combined use of mowing and latter applying herbicide gives a better result (Kanatas, 2019). In consonance to this Wilcox *et al* (2017) reported the cutting of cattail ramets during the period with reduced rhizome carbohydrates followed by hand wicking resprouted ramets with herbicide in later summer, this allows herbicide to be absorbed by the rhizomes and consequently gives a better result (Wilcox *et al*., 2017).

Elgersma *et al* (2017) reported that under high-nutrient conditions in Typha stand, combinations of treatments (burning, mowing and using herbicide) were generally more effective than treatments applied singly. and conversely combinations were not more effective than singly-applied treatments in the low nutrient wetlands. They concluded that controlling nutrients inflow into wetland is potentially more effective than using burning, herbicide and mowing, the effectiveness of these methods is context-dependent and strongly modified by nutrient availability (Elgersma *et al*., 2017). Effectiveness of glyphosate in controlling *Typha* using different doses have also been reported by (Sesin *et al*., 2021). A mixture of dalapon (15-30 kg/ha) and amitrole (6-12 kg/ha) applied to foliage of the weed at its full spike stage will destroy its shoots as well as the shallow rhizomes. In North Dakota US, depredation by black birds on Sunflower was identified. A benefit/ cost analysis of cattail control using chemical was conducted to identify trade-offs and to estimate the efficacy of chemical treatment. Both Sunflower farmers and the society benefited as damage on sunflower was markedly reduced and population of waterfowl increase with the fragmentation of cattail stand. A 70:30 ratio of open water body and cattails was achieved(Leitch et al., 1997).

3. Biological method of controlling *Typha* grass

This involves the use of organisms such as Grass carp, Cattail borer (*Bellura oblique*). This insect belongs to the order Lepidoptera and family noctuidae. It is one of the three species of *Bellura* found in Florida and presumably the south eastern United States(Pratt, 1986). The host plant to this specie of this insect is the *Typha specie*. Not very much is known about the mode of life and extent of destruction caused by this specie. They normally bore through the stem of *Typha* plant hence the name cattail borer. A high population of this insect could lead to dramatic impact to cattail (Grodowitz et al., 1998). Furthermore, another insect Cattail caterpillar *(Simyra henrici*) belongs to the class insecta, order Lepidoptera and family noctuidae. It is common widespread specie found to be feeding on cattails. Other plant hosts are *Salix* spp, *Cephalanthus spp polygonun specie*. The larval stages are the only

damaging stage (Grodowitz et al., 1998), etc. Insects cause considerable damage or mortality to cattail aerial shoots, spikes, and rhizomes. *T. latifolia* is more heavily damaged by herbivorous insects, especially the leaf-mining and stem - boring noctuid moths *Bellura obliqua* and *Achanara oblonga* (Smith, 2017).Damage by black bird is reduced by fragmenting dense cattail stands near sunflower areas.(Ralston & Bleier, 2004). Some aquatic mammals such as the manatee or sea cow (*Trichechus manatus*) have also been found to be herbivorous in nature and feeds actively on aquatic weeds such as *Typha*, water hyacinth and other aquatic vegetation(Richardson, 2008; T., 2000; Zimdahl, 2007). Manatee is a threatened species in Nigeria and there is need for a gradual build-up of its stocks. The animal has been identified as an excellent aquatic weed controller in areas where the weeds are considered a nuisance. In addition, the animal has also been found to be a popular specie for attracting tourist worldwide and therefore may be an important animal for game viewers and for the location of hotel. Even though there are various existing methods for the control of aquatic plants, there is no single method that is suitable for every situation(Hussner et al., 2017).

IV. Harnessing the Economic importance of Typha grass

Cattail served a variety of economic needs, In the US it was an important element in several aspects of Salish ritual life. In particular, cattail down was strongly associated with traditional funerary rites among the Salish. The ritual significance of the down may be in part associated with the symbolic importance of the color white in the worldview of the Coast and Interior Salish (Ostapkowicz *et al*., 2001). Aquatic macrophytes play a vital role in the removal of pollutants and the maintenance of the overall system. The aquatic macrophytes have multiple roles to play in constructed wetlands, which have made them an essential component in constructed wetland systems. In Portugal industrial waste water treatment from tanneries was tried in a constructed wetland by planting two species *Phragmite australis* and *Typha latifolia* and the two species provided high removal of organics from the tannery waste water (Calheiros *et al*., 2009).

The macrophytes promote a series of chemical and bio-chemical reactions by providing an oxygenated environment for the microbes in the root zone resulting in the decomposition of organic matter, bacterial growth and assimilation of nutrients into their tissues. The choice of macrophytes is very important because, it not only serves the purpose of nutrient removal from the wastewater, but also be of economic interest. Among the emergent macrophytes, Phragmites and *Typha sp.* were widely used in wastewater treatment in CWs.(Arpudhalin, 2017).

Under a controlled environment in a constructed wetland, aquatic macrophytes and bacteria use the natural processes such as sedimentation, filtration, adsorption, photolysis, degradation, microbial uptake, plant uptake, volatilization, nitrification/denitrification, biotic/abiotic etc. to treat the waste water (Arpudhalin, 2017). For a very long time *Typha latifolia* and *T. angustifolia* have been used by man as a source of food (Mitich, 2000). They are potentially used in the production of active carbon. They are used as substrate for the growth of mushroom. They also have a potential use for biomonitoring Cu, Cd, Cr, Fe, Ni ,Pb and Zn contamination through analyzing their concentration in plants (Fahlgren & Fahlgren, 2017). In lake Winnipeg Manitoba , harvesting cattail as biomass have attracted a lot of benefits for both public and private sector (Dohan & Grosshans, 2012). Harvesting novel plants such as cattail as a sustainable and renewable biomass feedstock for use in the biomass industry also delivers valuable ecological services through nutrient capture and reduction of nutrient loading (i.e. phosphorus) to downstream water bodies(Grosshans, 2014). Brinson et al. (1981) report values for above-ground biomass of between 0.996 and 1.68 kg dry mass m-2 for *Typha latifolia* marshes in wetlands characterized by high water level fluctuations in North America and England. Paludiculture is the cultivation on wet peat meadow areas. ("Palus "Latin for "swamp"). The method was developed in Germany around the 1990s and it enables a sustainable use of previously degraded land by

rewetting the peat lands. One of the promising plants for paludiculture is the marsh plant cattail (*Typha spp*) (Kenniswerkplaats *et, al.*, 2017). Agriculture on peat meadow areas is based on water drainage of the lands, which is needed for e.g. ploughing, sowing and harvesting. cattail has been proposed as wet crop for cultivation peatlands in the North East of Friesland.

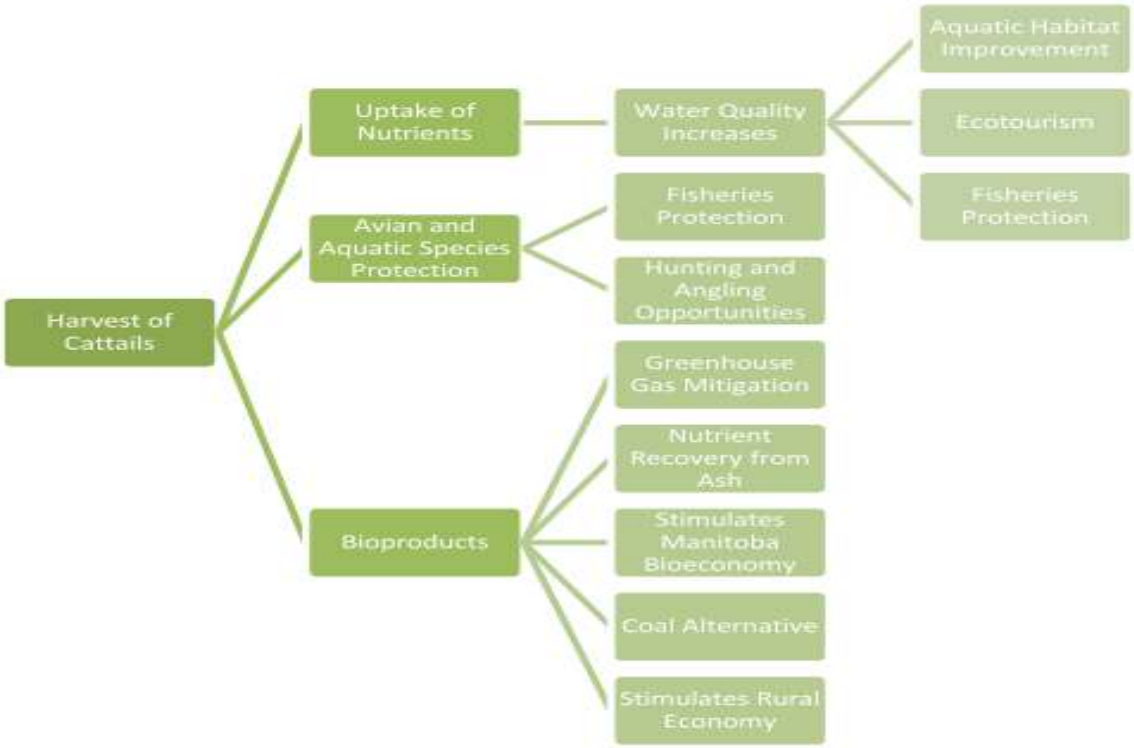

Fig. 6: Benefits of cattail harvesting in Manitoba flow diagram.

Current water management practices in the agricultural sector of the Netherlands have resulted in highly productive soils. Specifically, a region of major importance for water management is North-East Friesland with its rural and (wet) peat meadow areas. Unfortunately, these peat meadow areas are facing severe problems (Kostecke *et al*., 2005). Cattail is a monocotyledonous, hydrophilic crop that can grow on high water levels. Cattail has long and big leaves and its flowering time is from June to July. Using cattail for bio-energy production is mostly used in the U.S., Canada, Switzerland, and Italy (Geurts, personal communication, 2017). However, currently the most potential application seems to be the usage of cattail for insulation material. This application is being used mostly in Germany, Austria, and Switzerland (Geurts, personal communication, 2017). Cattail has a high potential for insulation material because it has a high amount of the "air space" tissue "aerenchyma" in its leaves and stem. This aerenchyma provides material with a low heat conduction and thus excellent insulation value. Cattail has a high nutrient removal ability of phosphorous and nitrogen. Therefore, it can be excellently used in the first stage of a transition of dairy farming in peatlands towards wet agriculture (Figure 4). After wetting the soil by raising the water levels, many stored nutrients from the soil will be released into the water. Both aboveground and belowground harvest of *Typha* stands increased plant diversity and richness for two years following treatment. Some economic importance of Typha includes:

1. *Typha* as a source of biomass

Harvesting *Typha* biomass for bioenergy production may be an appropriate alternative to herbiciding and burning methods in Great Lakes wetlands (Lishawa *et al*., 2015). Using *Typha* for

biomass has also been tried in Imawa Kano state Nigeria (Mukhtar, A.A. and Abdullahi, 2020) . The demand for charcoal in Senegal and many other African countries is a threat to the forest and ecosystem. Much effort is given in finding alternative sources of charcoal. World bank and GTZ projects have evaluated *Typha* as a potential source of Charcoal (Elbersen, 2005). Research have been conducted to characterize the textile properties of extracted cattail fiber it was found that cattail have excellent fiber diameter, moisture regain, burning behavoiur and thermal properties similar to commonly used textile fiber such as cotton, wool and polyester. *Typha latifolia* have been considered as potential crops because of their high productivity, interesting chemical composition and natural growth on a substantial portion (Chakma *et al*., 2017).

2. Typha as a source of food

Common cattail is probably the most famous of all the edible plants of the northern hemisphere (M. Larry, 2000). Cattails are widely regarded as great untapped plant resources of enormous potential benefit Many parts of this plant are edible for human consumption. Rook (2004) states that the "native Americans used leaves and stems as food. Rhizomes were dried and ground into flour or eaten as cooked vegetables, young stems were eaten raw or cooked, and immature fruiting stalks were roasted" In spring, the root stock and rhizomes were important food source for native people when other food was scarce. *Typha latifolia* over time have been used for many other uses. It has been used for thatch in roofing, or woven into mats, chairs and hats. It was a source of fiber for rayon and a crude, greenish brown paper; torches and tinder. Pollen was used in making fireworks; stuffing pillows, insulation, crude floatation devices, wound dressing, and lining for diapers (Boreal Forest, 2005). According to Rook (2004) Emerging young *Typha* plants are edible and the tender developing spike is also edible. He added that they were considered by many people as delicacies. Mitich (2000) Noted that "common cattail is probably the most famous of all the edible plants of the northern hemisphere. They are widely regarded as great untapped plant resources of enormous potential benefit. He further stated that "no one should starve or even go hungry in an area where cattails are abundant. The Native Americans pulled up the young spike or cut the rootstocks (rhizomes) for food. Harrington and Matsumura 1967 in Mitich (2000) find out that one hectare of cattails yield about 2,265 kg of flour, containing about 80% carbohydrates and around 6% to 8% protein. The plant yields flour that is as rich in protein as corn (Zea *mays*) rice (Oryza *sativa*) and wheat (*Tritium aestivum).*

3. Incorporation of *Typha* for animal feed

A study was designed to evaluate the effects of *Typha* silage as substitute for sorghum straw on feed intake, blood profile, economics of production and growth performance of beef cattle. The result showed that up to 300g/kg TS can be incorporated in the diet of beef cattle to replace sorghum straw with no negative influence on feed intake, blood profile, economics of production, and growth performance of beef cattle (Olayinka *et al*., 2022).

4. *Typha* as phytoremediation agent

Phytoremediation is an effective technique in decreasing the unparalleled pollution in the aquatic environments(Ali et al., 2020).The high biomass growth rate, and clonal expansion rates of *Typha* result in stands of *Typha* acting as N and P sinks, this makes it useful for phytoremediation efforts (Bansal *et al*., 2019).*Typha latifolia* and other vegetations are found to possess extensive root systems that show greater pollutant removal efficiency related to rhizosphere (Parzych *et al*., 2016). The higher efficiency in pollutant removal is due to some antibacterial properties of this plant situated in the rhizome (Shingare *et al*., 2017). Because of their low -cost, simple operation/ maintenance and environmental friendliness aquatic plant -based systems such as constructed wetlands have being used for treatment of all kinds of waste water including pharmaceutical and personal care products (PPCPs)(Zhang et al., 2014). Using cattail for the processing of insulating materials has good

strengths. Cattail-based insulation material has the excellent capability of heat insulating comparing to traditional insulation material, for example glass fibre (Berg, 2015). One example of wetland plants that act as either critical components or biological invaders in wetlands around the world are cattails (*Typha spp*.). Cattails comprise 10–15 species of perennial, semi-aquatic plants that are widespread in temperate and tropical wetlands of the northern and southern hemispheres, occurring in all major land masses except Greenland and Antarctica *Typha spp*. can be found in diverse wetland communities, ranging from early to late successional stages and from large, monospecific stands to scattered clumps or individuals distributed throughout mixed-species stands. In Nigeria, recently the Federal government and the World bank have jointly funded a project titled " *TYPHA* PROJECT" focused on developing economic uses of invasive *Typha* biomass. The idea is to produce Biogas by fermenting *Typha* as a source of clean energy for lighting and for cooking (Iglesias *et al*., 2018), (Minggagud and Yang, 2013). 38% of the World's population lack access to clean cooking and typically use inefficient stoves or open fires in poorly ventilated spaces. More than 90% of households rely on wood, charcoal, and garbage for cooking in 25 countries, mostly in sub Saharan Africa. Nearly 90 million Nigerians cook with wood on the traditional "three- stone fire''. Regrettably, Nigeria experiences the highest number of smoke-related deaths in Africa (Iglesias *et al*., 2018).

The Natural Resources Research Institute (NRRI) of the University of Minnesota - Duluth is a research institute dedicated to the fostering economic development of Minnesota's natural resources in an environmentally sound manner to promote private sector employment. They Visited Mauritania in 2013 to Explore NRRI-Developed Option for Conversion of *Typha australis* to Bio coal (Strzok, 2013). The project was titled "Conversion of *Typha australis* and other biomass to a Biocoal for local use in heating and cooking". In Senegal river valley over 30 million people are adversely affected by *Typha* invasion and over 346 000 hectares of land were covered by *Typha*. Production of Biocoal form *Typha* have been a very good option to control the menace of the specie. The diagram below summaries the production of bio coal from *Typha* raw material.

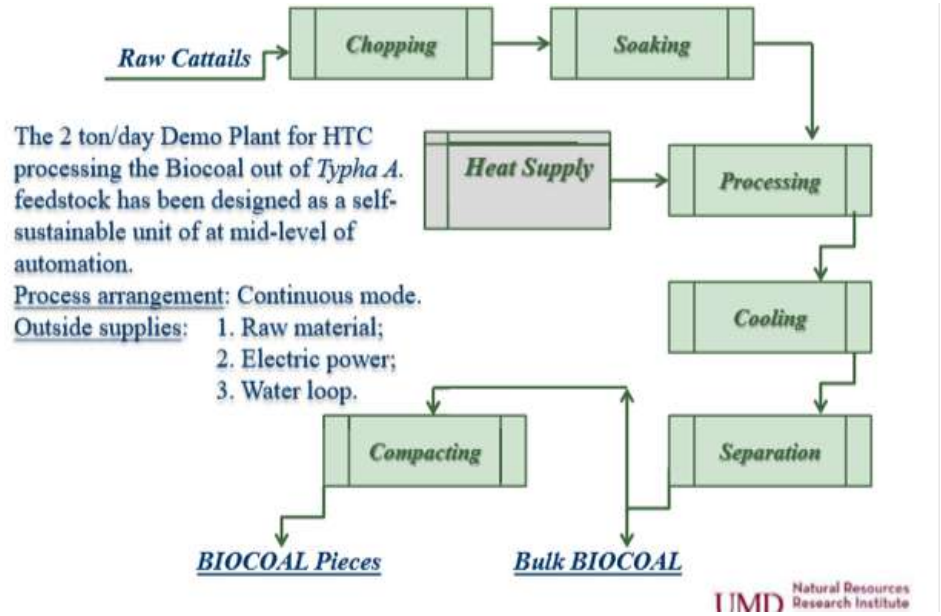

Figure 7: Flow diagram of *Typha* conversion from Raw cattail to Bio coal

In Senegal and Mauritania, the project **Tyccao** was introduced in order to boost their energy need and to mitigate climate change. The aim of the project is to harness *Typha* for a source of bio coal and construction material. The project was jointly funded by five major non-governmental organizations namely DEEC, ADEME, Bio Build concept, OMVS and GRET in Senegal and Mauritanian governments.

5. *Typha* as source of fuel

The utilization of aquatic plants for bioenergy in form of bioethanol and biogas not only produce bioenergy but also produces benefits by removing fugitive nuttirents from aquatic systems. The method has more advantage by recycling nutrients back into agricultural system, in the long run displacing inorganic fertilizer production(Wilkie & Evans, 2014).

The *Typha* Fuel Construction West Africa (TyCCAO) project aims to contribute to the energy transition and the fight against climate change, by developing the use of renewable fuels and energy efficiency in the building sector. the massification and dissemination of products based on *Typha*. Apart from the possibility of harnessing the plant as a food material. The plant also has the potential of being exploited for fuel. People are proposing the utilisation of *Typha* as a source of energy. Elbersen, (2005) stated that cattail has been proposed as a biomass crop for renewable energy. According to him, harvesting Typha for biomass and bio coal production is very economical considering the present energy global crisis. Similarly, In Hadejia – Nguru wet land there is a proposal for experimenting the plant by UNIDO in 2007 as a fuel source.

6. *Typha* cultivation for construction, insulation and other domestic uses

The realization of the use of cattail as an insulation material in buildings increase a larger demand for the product in some EU member countries. This necessitate for the cultivation of the product where suitable cultivation areas were proposed in order not to rely on importing the products from elsewhere (Krus, 2013). In Germany cultivation of *Typha* was initiated under the project titled " Rohrkolbenanbau in Niedermooren" (cultivation of *Typha* in fens). This is owing to the vast number of uses of the plant including phytoremediation, land restoration, absorption of carbon, resistance to pest and disease, high productivity, source of raw materials for building and construction(Krus et al., 2014). *Typha* species are among the most productive plant species (Wetzel 1983; Mitsch and Gosselink 2000); however, their performance is strongly influenced by the environment. Phytoremediation with the wetland plant *Typha latifolia* is a technique that could potentially aid the restoration of polluted surface water(Papadopoulos et al., 2009). Cattails are physiologically better able to tolerate permanently flooded conditions than are many other emergent species. Cattail seeds can germinate without oxygen(Vaccaro, 2005).

7. *Typha* as source of medicine

Cattail is used by native Americans for multiple purposes including medicine, clothing and bedding. The remnants of the crop were then taken back into the soil where they decomposed over time , providing structure and nutrient to the soil (Deziel & Magner, 2022). *Typha domingensis* is an important medicinal plant it is traditionally used in the treatment of neurological disorders and skin malignancies. *T. domingensis* is nontoxic and can be a potential source of phytoconstituents with promising pharmacological potential (Dilshad *et al*., 2022). The leaves of *Typha domingensis* is effective in the treatment of nose bleeds, hematemesis, hematuria, urine bleedings, dysmenorrhea postpartum abdominal pain were treated using the pollen of *T. domingensis*. The leaves of *T. domingensis* have also been used as a diuretic in Chinese medicine. Furthermore, seeds and rootstocks of *T. domingensis* have also been used in treating homeostatic conditions in human (Albert Banunle, Bernard Fei-Baffoe, 2021). Furthermore, Musara and Aladejana (2020) reported the medicinal uses, chemical and pharmacological properties of *T. capensis* pointing its anti-microbial, fertility promoting effect, anti-inflammatory, anti-oxidant and cytotoxicity effects of the plant (Musara & Aladejana, 2020).

V. Conclusion.

In conclusion Wetland is an area of land that is a transition between a terrestrial and aquatic habitat that is inundated for most of the times. It is

an ecosystem that is very rich and provide a lot of direct and indirect services to man. Directly they provide water, fish, fuelwood and other natural resources. Indirectly they serve as a source of filter and provides aquifer for recharging water sources. The Hadejia-Nguru wetland is a very important wetland in Sahelian region of northern Nigeria. The wetland is so important to the economy of the region by providing natural resources to the inhabitants. They are environmentally important as area of conserving wildlife population particularly afro paeleatic and other wintering bird species. It was so important in terms of conservation that it was declared a Ramsar site. In 1987 the RSPB in conjunction with NCF open the Hadejia-Nguru wetland conservation project. In recent years the area is facing a lot of problems including construction of dams at the upstream which distract the smooth flow of drainage particularly to the downstream region. Population pressure resulting into conflicts between farmers and herders. In addition, the proliferation of invasive *Typha* has been the major issue of concern blocking water ways and impeding farming and fishing and providing roost for birds to damage cereal crops. Several management options were adapted to control *Typha* including mechanical, Physical, chemical and Biological method as plan A for the management. The plan B option of the management is harnessing the various economic uses of the specie including using it for food, medicine, construction, insulation material, using it for carbon sink, phytoremediation agent, a source of biomass, a source of bio coal and a mixture in preparing animal feed.

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