Typhaceae in the Kano River Irrigation Project (West) Zone and Management Issues

By

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DEDICATION

I dedicate this book to my late parent,Alhaji Lawal Abdullahi and Haj. Fatima Ahmadu.

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ABSTRACT

This book is a product of a study that focuses on the identification of the *Typha* species present in the Kano Irrigation Project area and the relative importance of some abiotic factors that influence the weed, among others, because after more than three decades of operation in the Western zone of the project area, one of the visible feature of changes in the environment is the prolific growth of a *Typha* sp. and its effects on human activities as well as the environment. Field sampling of the *Typha* species at different sites/locations and subsequent analysis of the weed, using field measurement; description and identification, comparison with notable taxonomic members, and expert confirmation of sample specimen; stem density per quadrat and water depth gradient among other method(s) were adopted to generate information and data for the study. The management activities of the project were analyzed and those involved in the exploitation and control of the weed were also interviewed. The results indicate that *Typha domingensis* Pers. is the species found in the area. There was a substantial reduction in plant biomass after control measures were employed. However, the plant shows a high regenerative capacity shortly after and there were apparent negative impact of these measures on both the biota and the habitat where these measures were applied. It is concluded that knowledge about the plant's flowering period (phenology) and responses to water depth gradient would be very useful in controlling the weed more effectively. For a more lasting solution, an integrated environmental and water management plan is suggested that can address the environmental impact of the project in the area through the weed and other factors.

TABLE OF CONTENTS

CHAPTER THREE
MATERIALS AND METHODS

CHAPTER FOUR
PRESENTATION AND DISCUSSION OF RESULTS

CHAPTER FIVE
PROPOSAL FOR AN INTEGRATED ENVIRONMENTAL MANAGEMENT

CHAPTER SIX
SUMMARY, CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

OTHER TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

In response to the drought of the early 1970's, the government of Kano State at that time searched for ways to improve the management of water resources in the state. In 1969, the state government under Alhaji Audu Bako commissioned the Dutch Engineering Firm NEDECO to carry out feasibility study on irrigation on the Kano River, from which the Tiga Dam and the Kano River Project developed. The Kano River Project phase I began in 1969 is yet to be completed. Similarly, the KRIP phase II (extension to 40,000 ha) is also yet to be completed. Also the phase I of the Hadejia Valley Project (12,500 ha) designed to receive water by gravity from a pond on the River Hadejia above the floodplain, using water released from Tiga has faced several problems (Adams and Hills, 1987). The Tiga Dam was commissioned in March, 1975 by the former Head of State, General Yakubu Gowon. The Dam is 4.72m high and 7.24km long, has a reservoir with a capacity of 1514 million litres of Water. The water is to be used to irrigate 180,000 hectares (phase I and II) of land in the Kano River Basin under the KRIP. The Kano River is a lifeline for a region of about 10 million people based on 2006 national head count. It conveys water over a distance of 50sq kilometer. The Kano River Irrigation Project has provided vast opportunities for multi-crop agriculture, raising new crops, intensive livestock production, flood control, development of fisheries, site for tourist attraction. The main objective of the project is to bring a rapid increase in hectarage under cultivation and raise output per hectar

After almost thirty three years of operation of the Kano River Irrigation Project, it is useful to try and identify some of the effects (positive and negative) on the environment. For the inhabitants, water availability is the most important criterion. They previously suffered from chronic water shortages. Farmers now specialized in irrigation based production of more crops. At present, the rate of utilization of irrigation system (facilities) is very high. However, evaporation and evapo -transpiration could be high due to the fact that the open water in reservoirs and channels is subjected to intense heat characteristics of the weather condition for most of the year. Similarly, evapo-transpiration is further aggravated by the widespread aquatic plants in these ecosystems. Most importantly, the inability to limit or constrain further expansion of *Typha* invasive weed has become an obstacle to water circulation and has some negative effects on farming activities as well as fishing. Others include siltation of reservoir, distribution canals, and channels; clogging of irrigation canals and drainage; flood damage to farmlands and roads.

These impacts are socio-economic and environmental. The economic and environmental losses due to these weeds could be high. Indeed, the breadth of the impact means that it is almost difficult to estimate. Traditionally, the people control *Typha* aquatic weeds by mechanical means. However, these weeds have remarkable growth capacity. Thus, mechanical control is really not effective in the control of infestation which is large and widespread as evident in the Kano river irrigation area. This issue clearly highlights a fundamental water management problem. The risk of adverse side effects for users of the water must always be given priority. Accordingly, aquatic weed management must be developed which is socially and environmentally sustainable.

1.2 STATEMENT OF THE PROBLEM

Irrigation activities in the Kano river irrigation project area is seriously affected by the unwanted growth of *Typha sp*. aquatic weed. The dense growth of this plant in canals, drainage ditches, water reservoirs and farm ponds impedes the flow of water, allows silt to settle down and became deposited on the bed of the dam as well as the numerous distribution channels. Overabundance of these weeds in the area is a direct response to the changes created by irrigation structures and human activities. Over time the weed has become very difficult to control by farmers and the water management authority (HJRBDA). With increasing demand for water propelled by economic growth of the population, the sustainability of irrigation activities in the Kano River Irrigation Project areas could be hampered in the nearest future. The consequences of the collapse of irrigation in the area would be enormous. Khoff and Pietese (2003) reported the effect of dense growth of aquatic weeds in the Diana dam on the Senegal River. Similarly, Varis and Fraboulet-Juttila (2002) also reported that extensive *Typha* sp. in the lower Senegal River Basin provided sanctuary for huge population of grainvorous birds which caused serious damage to crops of which 50% of the rice grown were destroyed by the birds.

1.3 AIM AND OBJECTIVES OF THE STUDY

The main aim of this study is to establish the current status of *Typha* species aquatic weed, its nature, ecology and effects on the surrounding land use, formulate a water management approach that enhances sustainable operation of the irrigation scheme in view of the *Typha* invasion. Specific objectives to achieve this aim are:

i) To identify the particular species or specie of *Typha* found in the area, its nature, spread, and habitats.
ii) To determine the type specific physico-chemical indicators predicators of this weed; and thus to obtain useful information about its phenology and ecology that can be employed in its control and management.

iii) To investigate the effects of these weeds on farming and other water related activities by the people

iv) And use data obtained in the study to produce a conceptual water management approach linking aquatic weeds, water and human activities.

1.4 JUSTIFICATION FOR THE STUDY

The cause of the vulnerability of the Kano River Irrigation Project Area to *Typha* species weeds is not adequately understood and has not been thoroughly investigated. Landscapes of intensive agricultural row crop production are subjected to high levels of nutrient enrichment from surface runoff and sub-surface drainage, particularly enrichment by nitrate.

It is believed that this condition enhances the susceptibility of a habitat to invasion (Burke and Grime 1996; Galatowich ,*et.al*; 1999; and Systad 2000). It is therefore necessary to learn more about the growth, habitat conditions, and the attempts at controlling the weed so as to avoid a situation in which the plant species will constrain the ability of the people (farmers) in the area to derive maximum benefit from the water project particularly in this difficult economic situation in the country.

1.5 THE STUDY AREA

The Kano river project irrigation zone is a large area approximately phase I is 22000ha (figure 1). It was established after the creation of the Tiga dam in 1974. The irrigation system extends about 30 km on the Kano-Zaria road, from “Karfi” to “Chiromawa”. The dam distributes water by gravity through an 18km long main canal, which splits into eastern and western branches. The branches further split into lateral distribution and field canals to deliver water to farmlands or plots. In addition, eight storage reservoirs were also created with an elaborate drainage system which drains the project area of excess irrigation flow and rain water. Several smaller ponds, and burrow pits created as a result of earth excavation for soils, gravels or clay have become permanent and conspicuous features of the irrigation environment. These smaller depressions retain water throughout the year. Two cropping systems are practiced each year in the irrigation area. In the rainy season rice, maize and some millet/sorghum are raised while in the dry season, maize, wheat, tomatoes, onions, sugar cane, as well as cucumber and watermelon are produced in commercial quantity. For over two decades, both the canals, drainages, reservoirs and the different types of ponds in the area have been overgrown by an emergent aquatic weed belonging to the *Typhacaee* family. It is common practice for the locals, farmers and fishermen in the Kano River areas to clear canals, drainage and channels by cutting and removing these plants since it is absolutely necessary to do this in order to meet their water needs. However, in the face of multiple use scenario of the environment, promoting economic development which takes into consideration traditional livelihoods and ecology is of primary importance.

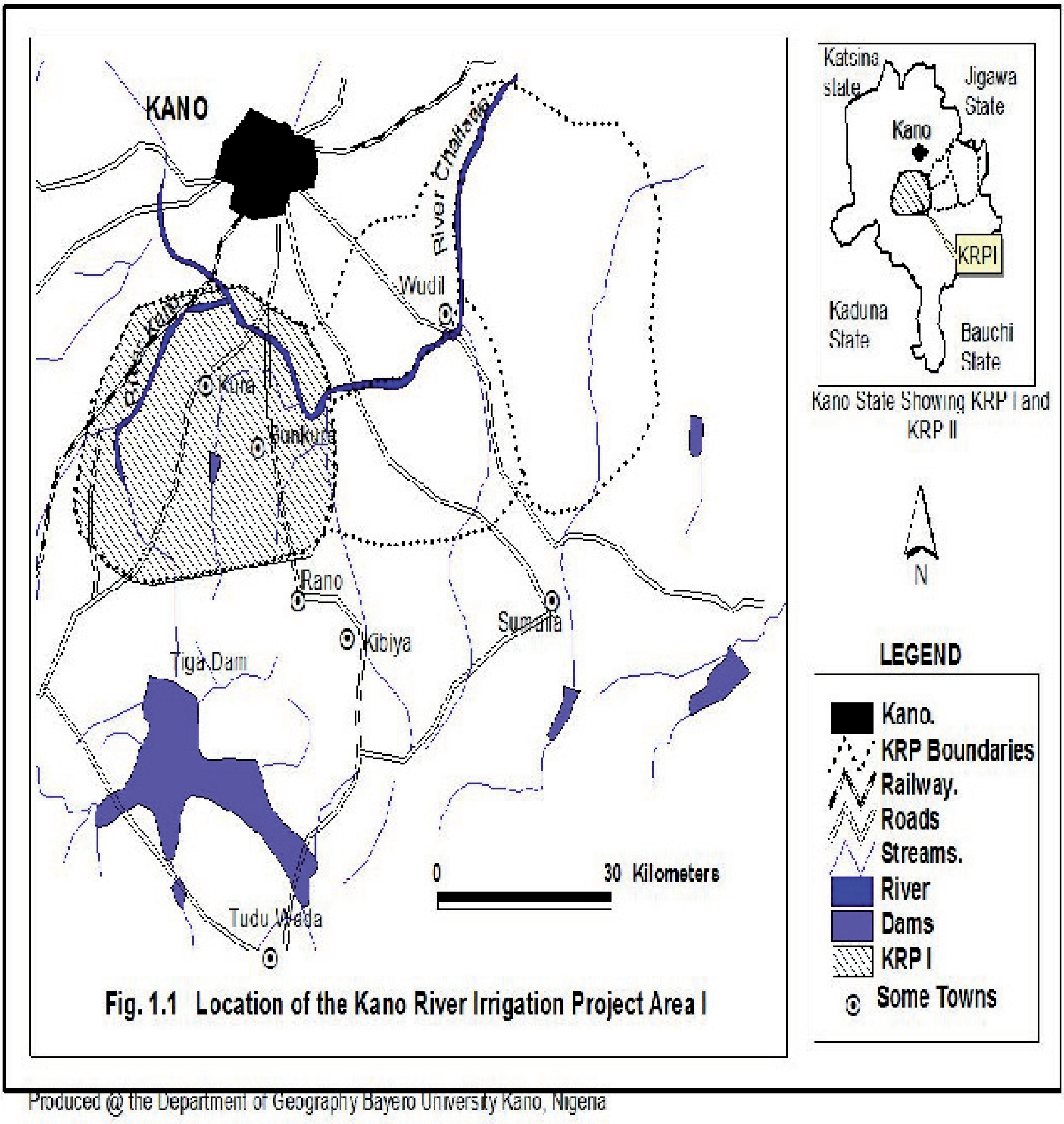


Figure 1.1: Location of the Kano River Irrigation Project Area I

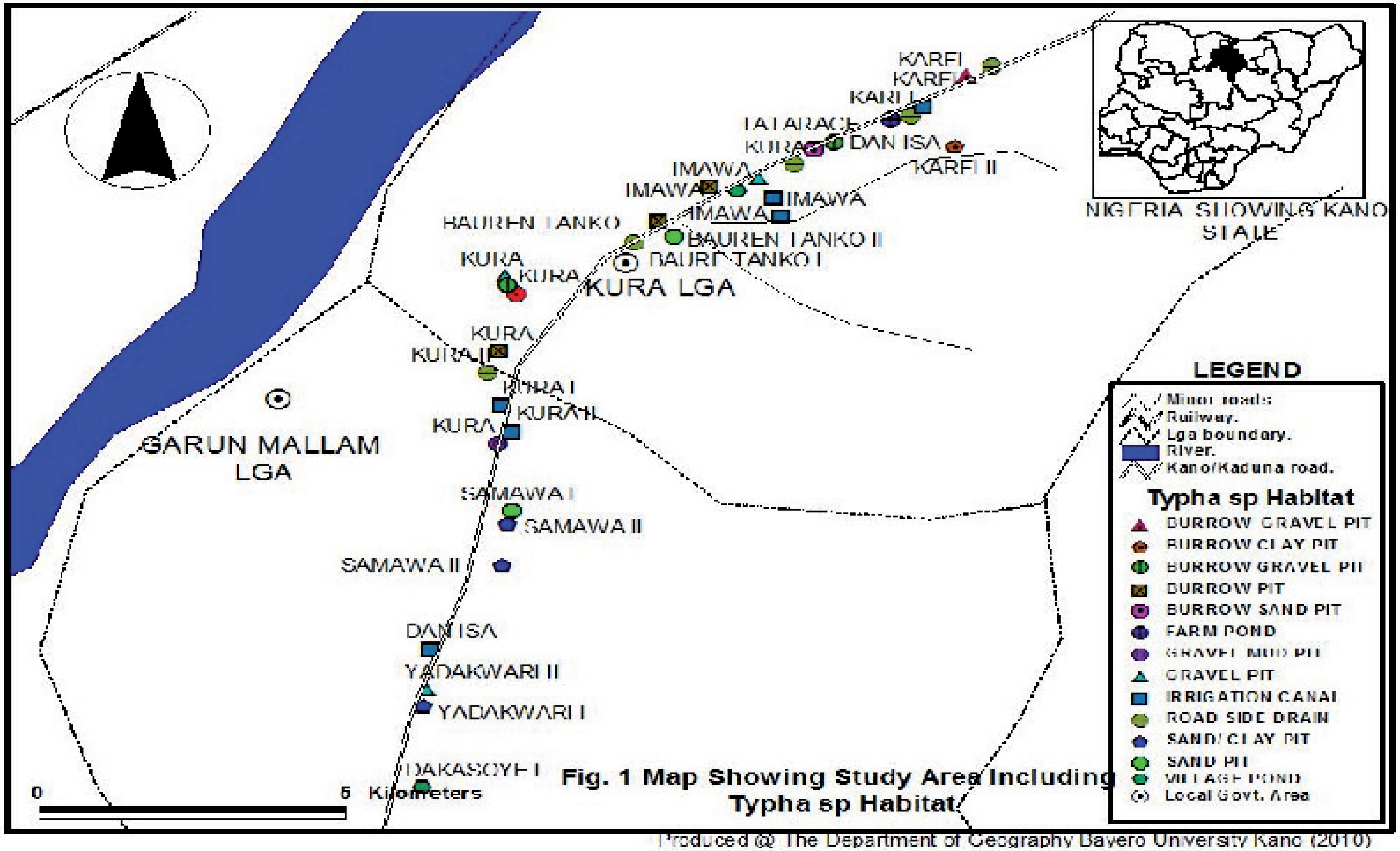


Figure 1.2: Location of the *Typha* Sp habitats studied at Kano River Irrigation Project Areas

Key: Geographical Position of *Typha* sp habitats in the KRIP areas
G.P.S. Coordinates

CHAPTER TWO

LITERATURE REVIEW

2.1 IRRIGATED AGRICULTURE AND ENVIRONMENT

Irrigation involves complex interactions among ecological, social and economic process at a variety of scales, with important implications for agricultural production, income generation, poverty reduction and environmental quality. Irrigation has contributed to dramatic increase in global crop yields and production over the past four decades.

Irrigation is described by Willardson(2003) as a means of taking advantage of the productive capacity of suitable fertile soils which lack only adequate water for crop plants in their normal growing season. It is therefore obvious that irrigation became a necessity in arid or semi-arid areas. In these areas, the season of limited rainfall corresponds to the season of maturity of food crops. With irrigation, it is possible to grow crops in areas of very low rainfall or areas where nearly all the precipitation falls in the non-growing season. As far as the development of irrigation across the world is concerned, Egypt claims to posses the world's oldest dam built around 3000 B.C (Isrealsen and Hansen, 1962). China also has some ancient irrigation works on grand scale. The great imperial canal has a length of more than 1000 Km (650m) and connects two rivers. When the Spaniards conquered Mexico and Peru, they discovered irrigation on a relatively large scale (Kings, 1912). With the advancement in engineering and science, irrigation became modernized and widespread in many countries with many of them not arid or even semi-arid. Water wheels were used to lift water out of rivers and streams by 1800. Water was diverted from rivers and carried for long distances. The world irrigated land was estimated to be 8 million ha before 1900 (Fukuda, 1976). By 1900, the writer estimated the total irrigated land in the world was about 48 million ha.

Given projected trends in demand for agricultural commodities, agriculture and food production, availability and condition of land, and other natural resources, irrigation will continue to play a critical role. Global demand for agricultural commodities has increased as a result of growth in population, income, and other factors. Based on continued growth in these factors, the food and Agricultural Organization (FAO,2000) and the International Food Policy Research Institute (2001) projected that global demand for cereals will increase by 1.2 % - 1.3% per year over the next decades. Most of the increased demand is projected to come from developing countries, especially in Asia and Africa (most of which are already highly dependent on irrigation). The FAO report also stated that the total area devoted to annual and permanent crops worldwide has increased by about 0.3% per year, since 1961, to 1.5 billion ha in 1998. It also estimated that additional 2.7 billion ha currently in other uses are suitable for crop production, but this land is unevenly distributed and includes land with relatively low yield potential and/or significant environmental value.

The International Panel on climate change, (2002), projects that the earth's climate will change significantly during the 21st century because of increasing concentration of carbon dioxide (CO_2) and other "greenhouse" gasses in the atmosphere. The resultant effect is change in precipitation and temperature (and thus, in the spatial and temporal distribution of water). Freshwater is abundant globally, but only a small part of the 10,000 km^3yr^{-1} is renewable and available for human use. Of this portion about a third is currently withdrawn for human use (Seckler *et.al* 1998). Agriculture accounts for about 70% of water withdrawals in low-income developing countries (Meinzen- Dick and Rosegrant, 2001).

Water withdrawal for agriculture average about 1m in depth over all irrigated areas in 1990 in 118 countries studied by Seckler *et al* 1998). Wood, *et al* (2000) noted that global estimates of irrigation efficiency (i.e. the proportion of water withdrawal for irrigation that is actually consumed by crops) average about 43% with most of the remainder being returned to the river or to the groundwater aquifer. Irrigated cropland now produces 30% - 40% of the world's crop output including nearly 2/3 of all rice and wheat, the irrigated share accounts for a total value of roughly $400 – 530 billion dollars per year (Wood, *et al*, 2000).

In recent years, Reisner (1986) commented on the controversies surrounding environmental changes caused by irrigation and other water related activities. According to the statistics by the International Commission on irrigation and drainage based in India, there are 25 countries in Africa, 16 in the America, 29 in Asia and Oceania, and 38 in Europe that have significant areas under irrigation. The Commission also reported that in 1998 there were more than 271 million ha of land under irrigation in the world (FAO, 1996) the extent of irrigation cropland worldwide has grown at an average annual rate of 1.8 % since 1961 (Rosegrant *et al* 2001). However, FAO FAOSTAT, online database (2002) projected that irrigation will slow down to an average increase of 0.6% per year through 2030. As demand for irrigation water increase, farmers face growing competition for available water from urban and industrial users, and from demand to protect river ecological functions. Rosegrant *et al* (2001) expressed fears that water will likely become a major constraint to the increase of food production and food security in many developing countries, especially in central and western, Asia and in Africa.

Seckler *et al* (1998) had reported that already there are signs in many countries, that water has become the single most important constraint to the increased food production.

Population and its growth are crucial factors that derive water development strategies whether for food production, or for domestic or industrial purposes. International Water Management Institute (IWMI) examines the trends in irrigation, food production and food consumption, and assesses the impacts on water availability and water use in the tropics.

2.2 AQUATIC WEEDS FROM GLOBAL TO LOCAL SETTING

Aquatic weed is "any undesired plant that grows so profusely as to crowd out more desirable plants or detracts in some way from the usefulness and/or appearance of an area". Unfortunately, many aquatic ecosystems develop over -abundant aquatic vegetation which interferes with human activities, destroys aesthetic values, and adversely affects aquatic life.

The global scenario of aquatic weeds include wide population of aquatic vegetation in different aquatic ecosystems broadly based on type of eco-environment that is, lakes, dams, ponds, tanks and canals of various categories, which are adversely affected by aquatic vegetation. Some of the common aquatic weeds are illustrated in Table 2.1 in relation to Southeast Asia, Australia, Africa, South American, Europe, USA and Mexico. Table 2.2 illustrates the major aquatic weeds worldwide.

Table 2.1: Distribution of Aquatic Weeds in Different regions of the World.

Region	Important Weeds	Affected/Infested Areas
South-East Asia	*Eichhornia crassipes; Lemma perpusilla; Elodea Canadensis; Phragmites karka; Alternanthera philoxeroides; E. crassipes; Salvinia molesta; Panicum repens; Salvinia auriculata; Pistia stratiotes; Typha spp; Limnocharis flava; Typha pp; Pist; Hydrilla verticillata; Typha latifolia; Chara spp; Nymphaea spp; Potamogeton spp; Ipomea aquatica; pistia spp; Typha angustata; T.latifolia; Phragmites karka; Myriophyllum spicatum; Trapa natans; Lemna gibba.*	Canals, drainage ditches, rivers and man-made lakes, ponds, water reservoirs for city water supply; and tanks causing floods, damage irrigation and drainage systems, deep water rice infestation, aquatic sports and aesthetic value.
Australia	*Typha spp; Phragmites spp; Sagittaria graminea; Juncus spp; Potamogeton ochereatus; Vallisnaria spirallis; E.cassipes; Eleocharis spp;Myriophyllum spp; Azolla spp; Salix spp; Ceratophyllum demersum; Lagarosiphon major; Nitella hookeri; Hydrodicttyon reticulatum; Spatinna townsendii.*	Navigation, damaging rice fields and inland fisheries, water bodies, irrigation canals and drainage ditches. Damages hydro-electric power generation, navigation, and irrigation systems.
Africa	*Potamogeton pectinatus; E. crassipes; Salvinia molesta; Pistia stratiotes; Alternanthera philoxeroides; Ludwigia spp; Polygonum barbatum;*	Lakes, canals irrigation, water reservoir, and drainage systems. Obstructs navigation.
South-America	*Hydrilla verticullata; Potamogeton illionoinsis; P. stratiotes; E.crassipes; Salvinia spp.*	Water flow problems in irrigation canals and navigation.
Europe	*Potamogeton pectinatus, P.fluitans; Myriophyllum spicatum; Lemma sp; Ranunculus fluitans; Hydrocotyle ranunculoides.*	Irrigation canals, rivers, water reservoirs, lake constrance, Rhine river, Shallow water areas, and Eutrophied areas
USA and Mexico	*Typha domingensis, Scirpus spp; Cyperus spp; Pectinatus;*	Lakes, and irrigation and distributaries, water resource, canals problems in

	Hydrilla verticillata; E. crasipes; Elocharis spp; Pistia stratiotes; Salvinia spp; najas flavilis; Utricularia biflora; Potamogeton crispus; Myriophyllum sibiricum; Alternanthera philoxeroides.	navigation, and recreational activities; more in south-eastern slates and California.

Source: International Commission on Aquatic weeds (2005)

TABLE 2.2: MAJOR AQUATIC WEEDS OF THE WORLD

Scientific Name	**Common Name**
Eichhornia crassipes	Water hyacinth
Typha spp	Cattail
Ipomea carnea	Besharam
Hydrilla reticillata	Carpet weed
Alternetnthera philoxeroides	Alligator weed
Monochoria vaginallis	Carpet weed
Sagittaria spp	-
Potamogeton spp	Pond weed
Pistia stratiotes	Water lettuce

Source: Fieldwork, 2008

***TYPHA* SP.**

Dallwitz and Watson (1992) provided a comprehensive description of the plant family *Typha*ceae juss. *Typha*, from the Greek, *tufh* (*typhe*), “bulrush, cattail”, perhaps from *typheli*-smoke or to emit smoke, in allusion either to the use of the spikes for making smoky fires or to the smoky brown colour of the fruiting spikes. Other names of *Typha* include “cattail” in USA, in UK lesser “bulrush”, small Reedmace, *Bodam Palka Waskolistna* (Poland), *Smalkaveldum* (Sweden), *Schmalbl rig, Rohrkolben* (German), “Geron tsuntsu” (Northern Nigeria).

An extensive literature on the morphology and taxonomy of *Typhaceae* was reviewed by Muller-Doblies and Muller (1977); Dahlgren and Clifford (1982); Dahlgren *et al* (1985); and Thieret and Luken (1996). However, Engler (1886) placed the genera *Sparginium* and *Typha* in separate families.

[1]Muller-Doblies (1970) re-examined the relationship between the two genera and concluded that the five different characters used by Engler to create the family *Sparganiaceae* were wrong and without significant Taxonomic basis. Hence, according to the APG (1998) classification and Taxonomic serial number 42325, the taxonomy of *Typha* is as follows:

- Kingdom *Plantae*, the Plant
- Division *Magnoliophyta*, (flowering plants)
- Class *Liliopsida*, the monocotyledons
- Sub Class *Commelinidae*
- Order *Typhales* or *Poales* the cattail
- Family *Typhaceae*
- Genus *Typha*

2.2.1 PLANT DESCRIPTION AND IDENTIFICATION

Plant an aquatic herb, perennial, with either a basal aggregation of leaves or terminal aggregation of leaves. Plant a rooted and rhizomatous, hydrophytic to halophytic, Leaves emergent, alternate, distichous, triangular in section or flat, *leathery, sessile*, and sheathed. Leaf lamina is entire, linear, parallel-veined, but without cross-venules. Leaf also has persistent basal meristem of basipetal development.

Notes: The APG system of plant classification is a new system of plant taxonomy which was published in 1998 by a group of scientists called the Angiosperm phylogeny Group. Since then, the system has been revised in 2003 and 2009. Each edition is superseded by earlier edition. The AGP system is based on the cladistic analysis of the DNA sequences of three genes, two chloroplast genes and one gene coding for ribosome. In otherwords, it is based on molecular evidence and not on total morphological and other evidences. The family *Typhaceae* is one of the 462 families recognized by the APG system. It is placed under the clade: Commelinoids.

DESCRIPTION:

a) The plant is monoecious, that is, it has both male and female reproductive organs on the same plant. Female flowers with staminodes but gynoecium of the male flowers is absent. Floral nectarines also absent. Pollination is by anemophilous (wind pollination).

Flowers are densely aggregated in inflorescences; compound, dense in spikes. Inflorescence scariflorous; terminal; a dense compound spike, with condensed secondary/tertiary branches formed from closely approximated annular meristems, the female flowers in the lower part, the males above. Flower small. Floral receptable has a gynophore or with neither androphore non gynophore. Perigone tube and hypogynous disk also absent. Male flowers light brown; female flowers often green during bloom, dark brown during seed fruit non-fleshy. The fruiting carpel a follicle but with tiny achene-like wing Fruits cigar-shaped, with soft, downy seeds. Dispersal is usually with the perianth-hairs forming a parachute. Dispersal is by wind.

IDENTIFICATION:

b) *Typha* sp is a C_3 plant as regards physiology. Similarly, its anatomy is non C_4 type. The Plant either contains cyanogic compounds or not. Alkaloids present, or absent. Proto anthocyanidins present; cyaniding-flavonols present; Kaempferol and quercetin, ellagic acids, arbutin and saponins/sapogenins are absent.

DISTRIBUTION:

c) The plant has a cosmopolitan distribution from temperate to tropical regions:

- It is found almost anywhere soil remains wet, saturated, or flooded most of the growing season including meadows, marshes, fens, pond, estuaries, roadside ditches, irrigation canals, oxbow lakes, and back areas of rivers and streams. Tolerates continuous inundation, seasonal drawdown and blackish waters.

- It produces enormous quantities of litter; established stands tend on soils with high amount of organic matter. May grow on fine texture soils, but usually with organic matter on the surface layers. Can also grow on pure sand, peat, lay and loamy soils.
- It forms dense, nearly single species communities in shallow, freshwater marshes and ponds.
- Its response to fire effect varies with water depth and soil moisture. On flooded sites, or sites with exposed but saturated soils, fire consumes most of the above-ground growth, but underground rhizomes remain undamaged and plants survive.
- Geese, herons, egret, red-winged blackbirds, and other waterfowl used dense yellow-headed blackbirds, wrens
- *Typha* stands as feeding and nesting habitat. (Delesalle, 1998 and Pojar, 1994). Cytology. X = 15. (2n = 30) number of chromosome.

d) **Economic uses, etc:** Most species of *Typha* have been used in many ways by the local cultures, wherever they grow. Stems have many uses, make a good thatch; can be woven into mats, baskets, chairs and hats. Parsapajouh,S and F;Ghahremaninejad (2004) documented the various uses of *T.domingensis* in the life of sister community in Southeastern Iran. The people utilized long and thick leaves of *T.domingensis* to construct a boat called “tootan” for hunting wild-birds, fishing and also transporting loads; two main sorts of covering are produced from the leaves of this plant. One is a kind of mat called “aseel” and the other a kind of curtain called “pardeh” from the stems. The “pardeh” is used to protect structure from intense sunlight and blowing sand; lastly, several sorts of baskets for storing and for carrying are made from the young leaves of *T.domingensis*.

The local names are "sele" (a box for storing) and "songoorak" (a kind of basket with two handles for carrying). *Typha* is a good source of biomass, making an excellent addition to the compost heap or used as a source of fuel etc. According to the phytomass files (Duke, 1981), annual productivity for *Typha latifolia* ranges from 6-20 MT/ha, other species reporting intermediate yields. A fibre obtained from the leaves can be use for making paper. The fibres are cooked for 2 hours with soda ash and then beaten in a ball mill for 10 hours to make a green or brown paper. Similarly, a fibre obtained from the roots can be used for making string; the hairs of fruits are used for stuffing pillows, the outer-layer of the stem is removed except for a small strip, running the entire length to give stability and them soaked in oil to make rush lights (Turner, 1998; Balick and Cox, 1996). Roots, raw or cooked is usually peeled before use, it can be boiled and eaten like potatoes or macerated and boiled to yield sweet syrup. The root can also be dried, grind into flour and then used as a thickener in soups or added to cereal flours (Arenas and Scarpa, 2003). Hartwell (1971) reported that the roots of *Typha angustifolia* are anodyne, anticoagulant, astringent, aphrodisiac, diuretic, emetic, sedative, tonic, vermifuge and vulnerary, and is also used in folk remedies for tumors in Chile and Argentina. *Typha* pollens are also astringent and diuretic. The dried pollen is said to be anticoagulant, but when roasted with charcoal it becomes homeostatic and use internally in the treatment of kidney stones, haemorrhages, painful mensuration, abnormal uterine bleeding, post-partum pains, abscesses and cancer of the lymphatic system; externally, in the treatment of tapeworms, and injuries (Duke and Wain, 1981 and Ertug, 2000).

2.2.2 TYPE OF *TYPHA* SPECIES

- *Typha angustifolia* - Lesser Bulrush or Narrow leaf cattail
- *Typha angustifolia x T.latifolia* - Hybrid or white cattail
- *Typha latifolia* - Common cattail
- *Typha domingensis* - Southern cattail
- *Typha laxmanii* - laxman's Bulrush
- *Typha minima* - Dwarf Bulrush
- *Typha orientalis* - Raupo
- *Typha Shuttleworthii* - Shuttleworth's Bulrush
- *Typha angustata* - Indian Typha/Cattail
- *Typha australis* - Australian cattail

Source: A compilation by the researcher

The most widespread species is *T.latifolia*, extending across the entire temperate Northern Hemisphere. *T.angustifolia* is nearly as widespread, but does not extend to the far north (Smith, 1961, 1962, and 1967). In the U.S *T.domingensis* is a more southerly American Species, extending from the U.S. to South America.

Thieret and Luken (1996) described *T.domingensis* as extremely variable species while *T.laxmanii*, *T.minima*, and *T. Shuttleworthii* are largely restricted to Asia and parts of Southern Europe.

Worldwide distribution of cattail species is summarized by Morton (1975). Cattails have a cosmopolitan distribution and wide ecological amplitude (Wilcox *et al*; 1984). In general, the most common *Typha* species are *T.latifolia*, *T.angustifolia* and *T.domingensis*. The three species can be distinguished according to their differing habitats and morphological differences (Smith, 1961; Marsh, 1962; Thieret and Luken, 1996). Smith (1961) listed 15 morphological characters distinguishing *T.latifolia*, *T.angustifolia* and *T.glauca*. Mcmanus *et al* (2002) found differences among these *Typha* species in selected anatomical trials of the shoots and remarked that the trials would assist in explaining the habitat differences in the three species in Wetlands of N.America and form a basis for new areas of study in the genus. *Typha*. Sarena and Snow (2004) studied the phenology and relative invasiveness of cattail (*Typha*) species at the Olentang River Wetlands Research Park Ohio. It involves which cattail taxa are present and mapping their distribution, their flowering periods (phonology) throughout the wetlands. The morphological measurements along with flowering times were analyzed against DNA evidence for accuracy in visual identification of the three taxa. The result indicates that the overlap in flowering tine between *T.latifolia* and *T.angustifolia* was minimal. They concluded that it is difficult to assess the true effects of *T.xglauca* on the native populations due to the fact that they cannot clearly distinguish the three taxa. They recommended the application of molecular techniques which will provide more precise species identification.

Wilcox *et al* (1984) states that most early herbarium specimens of *Typha* are *T.latifolia*. Later *T.angustifolia* and *T.domingensis* specimens were collected. *T.latifolia* and *T.angustifolia* were both named and described by Linnaeus in 1753, while *T.domingensis* was first described by C. H. Person in 1807. The status of *T.domingensis* as a district species separate from *T.angustifolia* was questionable through the 1960s, but morphological and protein characteristics, two types of chemical tests, serology, and disc electrophoresis have determined that it should be maintained as a distinct species (Lee and Fairbrothers, 1969). *T.xglauca* is a hybrid of *T.angustifolia* and T.latifolia and was first described by D.A. Gordon in 1844. *Typha xglauca* is distributed where *T.angustifolia* and *T.latifolia* are sympatric; Lending further support to the hypothesis that they are the parents (Sharizt *et al* 1980). *T.latifolia* x *T.domingensis* is also included under *T. xglauca* because it is morphologically similar and hard to differentiate from *T.angustifolia* x *T.latifolia* (USDA 2001, Smith 1967). Most *T.xglauca* plants observed in nature are of the F_1 generation (Kuehn and white 1999). Kuehn *et al* (1999) gave possible reasons for this situation. This include; unsuitable habitat for advanced hybrids, reduced seed germination, problem in seedling development, advanced hybrid may be competitively inferior to F_1 plants for other species of *Typha* (Kuehn *et al*; 1999).

All four species *T.latifolia*, *T.angustifolia*, *T.domingensis* and *T.xglauca* can be found growing together in the same locality (Hotchkiss and Dozier 1949; Smith 1962). *T.latifolia* is considered to be a climatic generalist, subject to reselection, that invests more in sexual reproduction than *T.angustifolia* and *T.domingensis* (McNaughton 1975). Some consider both *T.angustifolia* and *T.domingensis* to be subject to K-selection as they are restricted to nutrient conditions (Rivard & Woodard 1989). *T.domingensis* is the most tolerant of salinity (McMillan 1959).

McJannet *et al* (1995) described *Typha* as a clonal dominant that is in the matrix functional group or guild that can cover entire gaps in the landscape. Grace and Harrison (1986) reported that there are ecotypes of *Typha* natives to areas in nature.

Galatowitch *et al* (1999) concluded that unless agricultural runoff of chemical fertilizers is halted, *T.domingensis* will continue to expand its range in the US. The *Typha* species found in the Kano River Irrigation Project areas has not been reported by anyone or described in any of the records available.

2.3 DAMS AND IMPOUNDMENTS

Dams were constructed for irrigation to divert water from streams and to store water almost from the first beginning of irrigation (Sandra, 2000). Dam also provided flood control along rivers and a power source from early water wheels to modern hydroelectric turbines. Construction of dams, diversions, and canals became a major part of irrigation development.

Water storage is a key component of the strategies to overcome spatial and temporal variability in precipitation and river flows. National governments and local communities have invested heavily in dams over the past 100 years. In recent years however, Meinzen-Dick *et al* (2001) reported that investments in dams are becoming increasing expensive in financial, environmental and political terms. Groundwater has been withdrawn at rates in excess of recharge and degraded through contamination in many areas. Inter-basin transfers becomes costly, water recycling and desalination remain costly for extensive use.

Population and its growth are crucial factors that derive dam water development structures for food production, or for domestic or industrial purposes. Horowitz (2001) and Kloff,(2002) have pointed out that dams cause quite some extra, unpredicted costs, such as management of displaced population; medical health projects to relieve waterborne diseases; collapse of millet fishery sector in Mauritania, and the issue of aquatic weed problem in the lower valley of Senegal river.

2.3.1 IMPACT OF AQUATIC WEEDS ON AGRICULTURE, HEALTH AND ENVIRONMENT

Vasconcellos' book (1970) on the taxonomy of aquatic and emergent plants was the first to address these biological communities in scientific literature. More than 300 taxa are listed in this book. Haslem, (1987) reported on about a hundred common river macrophytes in the rivers of Western Europe. Later Franco and Roccha Afonso (1988) presented the distribution of the most troublesome aquatic plants. Both works were essentially descriptive and did not approach more ecological issues such as type of water bodies where nuisance growth occurred and the environmental conditions of the occurrence. To establish the exact dimension of weed problem in Portuguese freshwater ecosystems, a prospective enquiry was undertaken covering all organizations involved in water resource management, utilization, planning and Regional Authorities of Agriculture, Forestry and Environment and farmers' Association (Aguitar *et al*, 1996). The results showed that aquatic weed problems are locally important whilst not geographically widespread. Among aquatic weeds, algal mats are usually the primary cause of concern as a particular problem in irrigation canals and river systems associated with crop production. Artificial irrigation canals provide an aquatic environment that is extremely favourable for the growth of periphytic macrophytes (Ferreira *et al*, 1999c) Emergent plants such as the common reed (*Phragmites australis* (cav) and reedmaces (*Typha* spp) are in second place. Emergents are considered troublesome in many aquatic systems, preventing flow of water and angling activities in many tropical and sub-tropical areas (Haslem 1987; Arsenovic and Konstantinovic 1990 and Hulina 1990). Stands are frequently mono-specific or species-poor and include such species as *Typha* sp and *Phgramites austratis*. These two taxa are frequently referred to as invasive flora, as occurred in 'Albufera de Valencia' spain(Jambrino and Fornendez – Anero, 1997). Similar observations were made by Olumide (2000) in Hadejia-Nguru wetlands, Nigeria. Many small wetland areas and more or less permanent pools closely connected with superficial aquifers are considered important biodiversity reserves and particularly valued for their bird populations such as the Hadejia-Nguru wetlands. Many of these wetlands have also become heavily infested with the most troublesome aquatic weeds, like *Typha* sp., parrotfeather and water hyacinth. Weed infestations are probably related to the enrichment of the water due to inflow of agricultural chemicals, abnormally low flow conditions related to dry years and river regulation. In fact, disturbed or man-made habitats are frequently associated with plant invasions by *Eichornia crassipes* ,*Myriophyllum aquaticum* and *Typha* sp.(Ferreira *et al* 1998).

However, due to lack of historical vegetation records, invasive movements are difficult to assess. Many of the disturbances that are already degrading our aquatic systems have long temporal lags in revealing their full effects (Pittock, 2003). The response of the biota to a disturbance consists of both resistance (capacity to withstand) and resilience (capacity to recover) (Webster *et al*, 1983). The resilience comes from species having evolved adaptations to withstand and recover and these adaptations include attributes such as high reproductive potential and colonization capacity, short life cycles and the use of refugia (Lake 2002, 2003).

In a study of vegetation-environment relationship in the El-Salam Canal, Egypt, Mamdouth and Khedr (2001) reported that dense aquatic weeds cause loss of water through evapo-transpiration as well as impedes water flow in the canal; this is accompanied by reduction in its capacity to carry water, and problems for the constructed pumping stations by lowering the water level. Furthermore, these weeds obstruct canal flow and speed up erosion of banks. Aquatic weeds often reduce the effectiveness of water bodies for fish production. They also cause reduction in oxygen levels and present gaseous exchange with water resulting in adverse fish production (Mohd and Fauzi- Ramam (1991). Aquatic weeds have been found to severely reduce the flow capacity of irrigation canals thereby reducing the availability of water to farmer field. They also cause damage to structure in canals and dams, clog gates, siphons, etc. Impediment in the flow of water may result in localized floods in nearby areas. In India with the largest canal network in the world, aquatic weeds are responsible for reducing the velocity of water annually by about 30 – 40% (Vijayakumar *et al*, 1998). Ferreirer *et al*, 1995), reported the presence of toxic and highly invasive species *Myriophyllum_aquaticum* and *Paspalum paspelodes* which posed serious threat to Pestiegere river system in Peru.

Hydrilla verticulata has become a serious aquatic weed of irrigation canals in Costa Rica causing slowness in water flow and resulting in flooding of adjacent roads (Rojas and Aguero1998). Dense growth of, aquatic weeds provide ideal habitat for the development of mosquitoes responsible for malaria, encephalisis and filariasis.

2.4 CONTROL OF *TYPHA* AQUATIC WEED

Overabundant aquatic weeds in general interfere with human activity. The biomass of *Typha* sp. varies in different aquatic habitats – canals, channels, roadside drainages, rivers, ponds and wetlands. In many of these habitats it has become necessary to control these weeds. There are several methods of managing or control *Typha* sp. Mechanical harvesting, prescribed burning or fire suppression, changing the aquatic environment, biological control, chemical control and perhaps integrated management. The application of any of these methods is determined by the particular use to which the water will be put, and by the available resources. Several researches on *Typha* sp. aquatic weed management had been conducted in many places where this species is a problem. Mechanical control is the oldest method (Jefferies and Mills 1990). The techniques consist of cutting, mowing, raking, digging or pulling the plant and removing it from the water. In large expanses of water, a boat equipped with a cutting machine or an aquatic harvester is used to mowe the plant. When *Typha* was cut below water 95 -100% of the underground biomass died compared to 15 – 20% for the uncut controls (Sale and Wetzel 1983). Similarly these researchers also found that three cuts made underwater during the growing season resulted in an oxygen shortage with ethanol being produced, accompanied by excessive tissue breakdown, and ultimately in almost complete death of the above ground biomass.

However, Sherma and Kushwaha (1990) carried out three cuts during one growing season of *Typha angustata* in India, 5cm above the water level, but did not kill the plant, although above ground as well as below ground biomass decreased rapidly. In their work on Lake, Lac de Guiers in Senegal, Seppo-Hellsten *et al* (1999) carried out cutting of *Typha* using a hydralic weed cutting boat at 20cm and 50cm below the water surface and found it to be very effective at removing *Typha* stands. However, re-growth was observed during a relatively brief period (approximately three months). The final result showed that difference between depths of cutting was unexpectedly small. Although mowing was quite effective, it was calculated that clearing one hectare would take at least 35 hours. Consequently, from an economic point of view, the researchers concluded that this type of boat is less appropriate for controlling *Typha* under the prevailing conditions in Senegal.

In Iowa (Weller, 1995) reported that cutting *Typha* and re-flooding with at least 8 cm of standing water over plant stems was effective. This author also found clipping *Typha* very early in the growing season (e.g. May) stimulated their growth and resulted in a 25% increase in stem counts the following year, with an eventual decline to pre-clip levels. August clipping achieved up to 80% control only if followed by submergence. Crushing and re-flooding showed that *Typha* injured after June has poor recoveries.

Success of crushing depended on the load used, number of times an area was crushed, and standing water depths after treatment (Apfelbaum1990). Shading is another physical method used. In this approach, black polyethylene tarps were used to cover *Typha* as a control measure (Nelson & Dietz, 1986). *Typha* is generally not shade. Actively growing *Typha* tips were killed when completely covered for at least sixty days. Greatest control was achieved in July when food resources of *Typha* were presumed to be lowest (Linde *et al* 1976). However, the shortcomings of this method include holding tarps intact under wind and rain condition and the degradation of the material in tropical condition.

Water level modification has also been used to control *Typha*. High water condition in a *Typha* stand can affect the growth of seedlings and can break off mature stalks. Low water conditions maintained by drainage of a wetland significantly affects the overall community (Mallik and Wein 1985). However, to inhibit *Typha* growth, a wetland can be drained and then burnt during the summer. McMillan (1959) reported that mature *T.latifolia* and seedlings less than one year old are killed by water depth of 63.5cm and 45 cm or more respectively. *T.angustifolia* was unaffected by this degree of flooding. *Typha* sp. are known to transpire significant quantity of water (2-3ml of water/acre/year)(Fletcher and Elmendor 1985, Zohary 1982). Flooding must account for evapo-transpiration loss of water to maintain a level that is effective to control *Typha*. Dredging is one of the techniques used to control *Typha* along with excess silt is removed from drains and ditches. Pieterse and Murphy (1990) described the method and stated that it is a common method of cleaning ditches, canals and reservoirs from *Typha* and *Scirpus* weeds species. This technique like other physical approaches is slow, time consuming and costly.

In general, the advantages of employing physical or mechanical control of *Typha* include – utilization of available manpower resources, environmentally friendly and target specific, yields immediate results, provides fewer chances of permitting ecological shifts in aquatic flora. In addition, harvested *Typha* stems may have various utilities such as feed, mature, energy source etc and most importantly the measures can be employed in any localized area of water bodies. The limitations include limited effectiveness as reported earlier through re-growth. Physical removal could lead to the spread of the plant to new areas.

Typha sp. is also controlled by burning, fire suppression or heat treatment. Querner and Kirby, (1994) stated that in general higher temperature treatment results in coagulation of cell protoplasm which stops the enzymatic process leading to the death of the plant. Heat treatment for weed control is provided with the help of fire through flame throwers. For effective control, burning is combined with mowing followed by herbicide application on re-growth.

Aquatic weeds are also control by herbicides. There are a number of herbicides which have been found to be effective in controlling *Typha* sp. Egypt has about 38000km of canals and drains which are heavily infested with aquatic weeds. About 6000km of channels are treated with herbicides mainly acroien, dalapon, and glyphosate (Mamobuh and Khedr, 2001). Dalapon (2, 2-dichloroproprionic acid) is a translocated non selective, foliar applied herbicides. It is very effective in controlling grassy weeds like *Typha; Phragmites*, etc in irrigation and drainage channels. In Egypt, a dose of 10kg/ha repeated after 2 weeks gives excellent control of *Typha domingensis, Phragmites australis* and *Echinocloa stamina* (Mamobuh and Khedr, 2001). Glyphosate is another herbicide used in controlling *Typha* and other grassy broad-leaved weeds. It is regarded as a broad spectrum herbicide. It’s mode of action is slow, visual symptoms begins with wilting and yellowing of foliage, complete browning of the above ground and complete destruction of roots and rhizomes below the ground. It may take 7-10 days or more to observe the symptoms and may take 30 days or more to complete destruction (Smith, 1967). Table 2 shows the amount of glyphosate required for control of some common weeds.

Table 2.3: Amount of Glyphosate required for Chemical Control of selected Weeds

Name Of Weed	Kg/ha
Eichornia crassipes	1.5-2
Glyceria maxima	1.5-2
Phragmites communis	2.0-3
P. karka	2.0-3
Typha angustifolia	2.5-3
Typha latifolia	2.5-3
Ipomea carnea	2.0-3

Source: US EPA (1996)

The use of herbicides may at times create problem in the aquatic environment. It is argued that a single herbicide that controls aquatic weeds as well as being safe for all possible uses of the treated water is yet to emerge. The use of herbicides has the disadvantage of being in water as residue; its performance is affected by temperature; speed of water flow in the system; and its effect on aquatic food chain and food web (Chandi and Nagpal, 1987).

Owing to the increasing awareness about ill effects of herbicide, biological management of aquatic weeds is a broad term for the exploitation of living organisms or their products to reduce or prevent the growth and reproduction of weeds. However, it is more complex than chemical control because it requires long term planning, multiple tactics and manipulation of cropping system to interact with the environment. Julien (1989) worked out the total releases made against weeds by biological agents. After 13 releases of agents for classical control of weeds in the first decade of this century, he found the number of releases per decade increased nearly exponentially. But the rate of effectiveness declined from 29% of all releases in 1980 to 25% of all releases by 1985. Biological agents are diverse, they include insects, pathogens, nematodes, mollusk, fishes, mammals and rodents, parasitic and competitive plants. Several works on technical aspects of the use of plant pathogens were reviewed by Julien, [1992). Spencer (1994) has dealt in detail the use of fish in biological control of aquatic vegetation. Among the species of herbivorous fishes that feeds on aquatic weeds include, *Tilapia zilli, T.nilotica* program to stimulate the growth of *Potomogeneton spectabilis* and plant consumption by the herbivorous fish *Etenophary-godon idella* (tripod grass carp) under environmental conditions of Northern California irrigation system. It was concluded that for temperature of 12-24$^{O}{}_{C}$ would require more than 300kg fish/ha. Barrett *et al* (1990) reported that grass carp grow rapidly therefore their food demand increases. Hence, periodic cutting or re-stocking is necessary to maintain satisfactory result. The efficacy of biological control agents is restricted by ecological factors (Oki, 1995).

It should be noted that no single method will guarantee the success of aquatic weed management. The combined use of several appropriate methods or integrated management is also advocated. Aquatic weeds in general are an essential feature of aquatic environment. *Typha* sp is reported to provide a number of benefits to the ecosystem, these include, production of oxygen through photosynthesis; cover for young fish; site for attachment by a number of organisms; protection against wave erosion and soil erosion of banks; food supply for wildlife; and removal of nutrient from the water (Gangstad, 1992). *Typha* sp. also has other functions, for example as livestock feed, mulch, compost or for handcrafts (Balick & Cox, 1996, Arenas and Scarpa 2003,and Parsapajouh andGhahreninejad 2004).

They may also serve as ornamental plants, and add to the beauty and serenity of an aquatic landscape (Soerjani 1989). Many aquatic weed share these functions, thus, the utilization of *Typha* can be considered an important aspect of their management. Oki (1992) reported the use of *Typha* sp, *scirpus* *sp*, Iris sp. and *Phragmite* sp on both natural and artificial land for wastewater treatment in Japan. The result showed 83% reduction in total N and 92% reduction in total P. in their study of metals in sediments and water of three reed stands, Oliveira *et al* (1999) reported that reed-periphyton complex plays an important role in the absorption and retention of cations especially of heavy metals.

2.5 MANAGEMENT OF DAMS/IRRIGATION SYSTEM/AQUATIC ECOSYSTEM

Halse and Massenbaurer (2005) define Management as the policy development and operational actions undertaken to ensure aquatic systems retain their natural ecological functions and biodiversity, within constraints imposed by existing and planned human activities. Information about aquatic habitats, such as wetlands, ponds, lakes, their values, and the ecological processes within them forms the cornerstone of such management (Szaro *et al*, 1998). Commissioned research is one source of information; other cost-effective sources one pre-existing research results, Collaboration with colleagues in other management agencies, improving links with universities (where the information may lie in student projects), reading literature and talking to locals (Cullen, 1990).

While encouraging the use of existing information, we are cautioned against over-enthusiastic extrapolation to new situations because of the inherent variability between aquatic systems and the difficulties of using information designed for one question in answering another (Underwood, 1998). When ecosystems are poorly understood, management is an iterative process of action and monitoring (Walters, 1986). Transfer of research into management is not only about communication (cf. Cullen, 1990). It also depends on key issues such as scale, pattern, and biological uncertainties.

An example of scale is that information about water chemistry at the sediment/water interface of aquatic systems provides insight into the biological status of some aquatic organisms (Burke & Knott, 1997) however management is easier if the occurrence of biota can be related to a single water sample that is easily collected (e.g. Knott *et al*, 2003). The second scale issue is that the importance of environmental factors in controlling biological distributions usually depends on the degree of variation in the factors within the region (Davis, 2000).

As regards pattern, the form of survey and taxonomy, would lead to better informed conservation planning at the regional level (Halse, 1998). Halse, (2004) argue that uncertainties arise when economic benefits of the scheme (such irrigation project) are substantial and quantified whereas environmental impacts are poorly understood. Management authorities perceive researchers as focusing on the uncertainties and the need for more data, rather than applying themselves to choosing the best outcome. In a review by Ryder and Boulton (reviewed in Jerkins *et al*, 2005) these workers argued for the need to have interactive and collaborative research rather than the more common reactive approaches and in full recognition of the fundamental role of the hydrologic variability.

The degree of productivity in irrigation is highly dependent upon the degree of cooperation among farmers and with the body responsible for managing the irrigation system. From the mid-19th century through the 20th century, about ¾ of the irrigation systems across the world are administered by government irrigation agencies. Majority of these irrigation systems in developing countries are not properly maintained. Skogerhoe and Merkley (1996) remarked that there is growing perception that these public irrigation agencies lack the incentives and responsiveness to improve management of the water facilities. Keller, *et al* (2000) stated that the management of natural resources, especially water takes on added significance as population increases and changes in resource utilization places greater pressure on land and water.

2.6 PROCEDURE FOR SELECTING SAMPLING SITE

Hatcher *et al*; (1999) pointed out that there is a superficial resemblance between rivers and man-made linear water bodies such as canals, ditches, and drainage channels. There are also important differences which affect the choice of methods that can be used to survey their plant communities. These authors also hinted on reasons for survey of aquatic plants. For instance, a baseline for an environmental impact assessment may demand a complete inventory of species and mapping of at least rarities; for a national comparative survey, rapid, standardized, semi-quantitative techniques may be appropriate; to decide strategy for a weed control programme, a simple visual assessment may suffice. However, in each of these circumstances, survey methods are tailored to the stated objectives. Catchpole and Wheeler (1992) argued that practicability must to a large extent govern the choice of methods used.

2.7 AN ANALYSIS OF THE KRIP OBJECTIVES AND STALKHOLDERS IN THE CONTEXT OF ECOLOGICAL CHANGES IN THE AREA AND ITS IMPACTS

Kano Urban water supply, local household water supply, agricultural water demand (irrigation and recess culture), fish and fisheries, livestock/cattle breeding, water and soil conservation, control of load/diffuse pollution from irrigated agriculture, cattle breeding and villages, and flood control are analyzed.

Water management in the Kano River Project I areas faces rapidly expanding pressure on this valuable resource. On top of the growing needs, the local population is growing very fast from 342,168 figures of 1991; it has grown to 436,183 by the turn of the millennium. (Census figures, 2008). Changes in the project's water ecosystem, increased use pressure, and aquatic macrophytes *Typha* weeds in particular has trigger the need for improved water management. The project's water system is a significant natural asset and is used by an array of stakeholders. The most important stakeholders are; Urban Kano,

communities in the projects' surrounding areas largely comprises of a single ethnic and cultural group. The people engage in small-scale farming, cattle rearing but little fishing. Fishing is carried out by relatively few people in the area. However, it is becoming widespread with the introduction of fish ponds by private individuals. The local population use water directly for irrigation as well as a source of domestic/household water. Their supply of water is hampered by excessive macrophyte stands (*Typha* sp.) and some algal blooms.

Agriculture is split into intensively irrigated, large-scale cash crop (rice, tomatoes and onions), and local partly irrigated, small-scale farming. Agriculture employs thousands of people, contributes greatly to the State's gross local product and represents a significant percentage of the total economic contribution. This sector, in turn, is responsible for generating about 1/5 of the total income of the region.

Fishing is one of the alimentation of the local population. In the dry season, livestock rearing is totally dependent on access to surface water. The number of nomads is increasing in the area due to immigration driven by worsening conditions and population growth in neighboring sahelian countries such as Niger and Chad. On the other side of this increased rearing, the growing number of herds there is a consequence of overgrazing. The ecological balance is very fragile and very sensitive to climatic factors.

The activities of the stakeholders discussed earlier shows that the Kano River Project I environment has been affected in the last 1-2 decades by frequent changes in annual precipitation and water flow; expanding agriculture, particularly irrigation; macrophytes growth and; other pressures of a rapidly increasing population, such as deforestation and overgrazing.

Irrigated agriculture is a major threat to water quality in terms of salinization, eutrophication and chemical contamination (Varis and Fraboulet-jussila 2002). Local uses and urban water supply sit on the other side of the table, the river water being an important raw water source for urban Kano and communities within the area. Nutrient enrichment is a serious problem; macrophytes particularly *Typha* sp. is seen as a threat to both local human population and the water resources management authorities. At present a special concern is caused by the unsustainable management of the KRIP environment. The management setting is characterized by rapidly increasing pressure on the water resource.

2.7.1 Policy Analysis

It is difficult to analyze the management of water and irrigation system of the Kano River Project I because of the apparent low level of empirical data from the basin authority. The local ministries (agriculture, water resources and environment) had few documents of varying relevance, and a few internationally published documents existed.

Therefore, the current situation of the Kano River Irrigation Project area with regards to the objectives and stakeholders cannot be adequately assessed.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter explains the procedure employed in this study. In the present study, a survey of large number of field sites distributed over a wide geographical area is involved. Based on Alcock and Palmer (1985) 33 representative sites were selected. The term representative is used to mean ‘has a flora that appears to be typical’, one in which the plant specie being studied is represented. The sites are accessible and the plant specie *Typha* sp is of special interest to the investigator. The site was chosen randomly in accordance to Hegarty and Cooper (1994). Different authors have used different site length for plant survey. For example, 50 meters (Haury *et al*, 1996); 100m (Peuulas and Sa’bater, 1987); 200m (Nilsson *et al*, 1998); 500m (Demars and Harper, 1998) or 1000m (Holmes *et al*, 1998). *Typha* sp like other hydrophytes present a very patch distribution with locally important cover. 50m site length was used in this study to survey canals, burrow pits/village ponds and roadside drainages. The investigations involved largely field activities carried out in phases; which includes, survey of *Typha* sp invaded habitats, identification of the specific *Typha* sites, determination of environmental variables that influence the growth of *Typha* sp; plant growth characteristics and life cycle; sampling of plants, description and identification of plant sample, observation and determination of the impact of these weeds on water related activities, uses of plants, monitoring of control strategies employed by the people to reduce the impact or management of the weeds and analysis of the data obtained.

3.2 TYPES OF DATA COLLECTED

3.2.1 Data on *Typha*

At the sampling sites, data collected on this plant include; nature of the habitat; its spread and distribution; its nature of growth (whether in association with other aquatic plant species or mono-specific); responses to water depth in *Typha* invaded site; shoot density per meter squares quadrat; characteristic features such as plant height; length, width and shape of leaf, arrangement and number of leaves; leaf and colour; stem length; reproductive features (male & female); flowers length and shape; nature of the arrangement of reproductive parts; fruit length, shape and colour; the phenology (that is, flowering period) of the plant.

3.2.2 Data on peoples' view on the impact of *Typha*, including the use of Plant

The Effect of *Typha* population or dense growth in the irrigation systems – canals, drainages, channels, reservoirs and farm ponds such as clogging of these water networks and the resultant impact on farming activities, and other uses of the water. In addition, the massive *Typha* cover harbors nesting grainvorous birds causing substantial loss to grain crops in particular. Data was obtained on loss of farm produced from farmers through direct interviews/discussions.

Using guided questions (see appendix), type and extent of uses of *Typha* by the locals were also identified and recorded.

3.2.3 Data on control methods

The control method or management is largely directed at reducing the spread of the weeds. Most control methods are generally aimed at reducing the spread to the level where they do not cause economic damage.

3.3 SAMPLING TECHNIQUES AND SAMPLING SIZE USED

Random sampling was used. For the survey of aquatic plants, 50m between sites was used as described by Haury *et al* (1996). Quadrat sampling was used to sample *Typha* sp in each habitat. A sampling unit of 1m square quadrat was used as recommended by Pessons (2001) in ponds, canals, reservoirs and channels. Each quadrat represents individual stations located at the sampled sites in the study area. The quadrat size was chosen as the minimum representative area based on the criteria of plant density and average plant height. 100 respondents were selected from farmers, fishermen, extension workers, community members and others that interacts with this weeds.

3.4 METHODS OF DATA COLLECTION

3.4.1 SELECTION OF SITES AND COLLECTION OF SPECIMEN

After reconnaissance survey visits of the irrigation areas in 2006, 21 burrow/gravel pits consisting of village ponds; 6 roadside drains and 5 canals sites were identified and their geographical positions recorded using a GPS equipment model Germin GPS 407M. The detailed study was conducted in 2007.In the study area, as in several places around the world, burrow/gravel pits and ponds are important refugia for wetland plants (Biggs, *et al*; 1994). Ecological researches have been carried out on these habitats than on large freshwater bodies (Boothby, 1997). The pits/ponds are numerous but sparsely distributed (approximately 100m apart on average). Sites from each of the three major habitats were selected on the basis of richness in *Typha* species. The pits (gravel, clay/ sand) were generally created by excavation for soil and gravels needed for buildings and road construction. The village ponds were originally used as water sources and washing stock, now amenity ponds usually with population of semi-tame water flow. The pits/ponds receive direct precipitation and surface runoff. The canals received irrigation water from main water channels while the roadside drains collect water from both irrigation network as well as surface run off. A 1 meter grid was laid with ropes over each of the sampling sites and depth measurements were taken against the water level at 5 different points. *Typha* species were sampled using 1m^2 quadrat was constructed using wooden plank with one of the sides not fixed and only fixed during sampling. The quadrat is placed at the site with the help of at least three people. Counting of stem density with the quadrat is conducted by the three people each for his side and the figures are later added to get the total. Specimens collected were examined in detailed from the nature of the plant base (cylindrical or fan-shape); type and shape of leaves; and herbarium preparation is made as follows:

a) All specimens were collected as a complete plant consisting of a portion of the stem 20 – 30 cm long, showing the leaves in position together with flowers and or fruits.
b) Specimens were then dated and the place of collection also given as well as the growth habit, height, flower colour, habitat, and where possible type of soil.
c) The specimens were pressed between newspaper sheets and placed between two cardboard papers. Specimens were not wrapped in damp papers or plastic in line with recommended procedure.
d) Specimens were subsequently forwarded for identification to the appropriate herbarium, department of agriculture or water resources authority.
e) The KRIP *Typha* specimen was kept at the department of Biological Sciences, Bayero University Kano for reference.

3.4.2 IDENTIFICATION AND MEASUREMENTS OF PLANT FEATURES

Visual examination and aided by reference materials (books, computer records and specialists were consulted for easy and reliable identification of KRIP *Typha* species. Reference materials used includes, Domogalla (1976), USDA – NRCS (1992) and the University of Florida Herbarium (database 1999). Measuring of plants features such as, number of leaves, leaf width, and length; plant height as well as other relevant taxonomic characters were made in meters.

3.4.3 DETERMINATION OF RELEVANT ENVIRONMENTAL PARAMETERS

Measurements of the environmental parameters were carried out in the field using a portable digital multi-meter model checkmate 90. The average water depth was determined by a meter rule (average of 3-5 different points in each site); temperature was recorded in degree centigrade; conductivity ($\mu sm^{-1}/cm$) and P^H were also determined using the digital millimeter equipment on the field. The equipment is also designed to measure this parameter but the particular probe that reads oxygen was missing. The use of relatively manual approach by titration after refrigeration was not possible due to persistent lack of power in the daylight hours during period of the fieldwork. Temperature, P^H and conductivity records/readings were taken on weekly basis.

3.4.4 ADMINISTRATION OF QUESTIONNAIRE AND INFORMAL INTERVIEW

a) Peoples view on impact (Questionnaire)

Questionnaires were administered to farmers, farm workers, artisans and community members by the investigator and his two assistants. The interaction with the farmers was usually on the field or farmlands when they were engaged in farming activities. The investigator asked the questions while the two assistants recorded the responses and where necessary special notes were also taken from the explanation. For instance, the amount of crop lost to bird infestation or localized flooding is usually given in “solo” which is equivalent to a 50kg bag of shelled rice or wheat. Some of the farmers gave the size of their farmlands in ‘basin’ which is about 100sq.meters.

About 100 respondents were selected from the different groups of people engaged in activities affected by the weeds. They include farmers, artisan, fishermen, farm workers, extension workers, *Typha* stalk sellers, and buyers as well as members of the community. Farmers constitute the major group of respondents and were selected from each of the designated areas namely; ‘Karfi’, ‘Kura’, ‘Bauren Tanko’, ‘Samawa’, ‘Yadakwari’ and ‘Kadawa’.

b) Investigation of people’s use of *Typha*, informal and in-depth interviews with different people including farm workers that were using parts of this plant for various items as well as a source of earning some income.

Farm workers cutting *Typha* stalks were encountered at both the sites and the tomato market where these stalks were subsequently transported and sold. At the field where cutting of stalks was carried out, the stalks were arranged along their lengths in bundles of 30 – 35 stalks a bundle and cost between =₦=35 to= ₦=80. The weight of a bundle of stalks was also measured using a 10kg weighing equipment. The people also use the plant particularly the stalks stems to construct fence around homes or thatched roof. A popular item made up of the *Typha* stems and called “Asabari” consist of fresh stems devoid of the leaves arrange closely in a mat-like form using string to tie them along the length. These items are also sold to interested persons.

3.4.5 MONITORING OF *TYPHA* CONTROL ACTIVITIES

Attempts at controlling the weed by farmers and other users of the water were carefully monitored during the study period. The extent of plant cover affected by each type of control measure used, the purpose intended, the implications on the ecosystem, as well as the period taken by the weed to recover or regenerate were noted.

Nine sites were identified as areas where control of *Typha* was being carried out deliberately by the people either for the water, or to drive away destructive birds that attack field crops especially rice and wheat. Visits to the site were carried out on weekly basis. Each site was visited eight times from the time control activity began to the time the plant started recovering and also after initial signs of recovery.

3.5 ANALYTICAL TECHNIQUES

Results obtained from the various aspects of the study were analyzed using appropriate statistics. Data obtained from environmental variables determined in the different *Typha* species habitats were summarized to find the mean, range, and standard deviation. Similarly, the sales of *Typha* stalks as well as losses incurred by farmers due to flooding, and infestation by birds were also analyzed.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

This chapter presents the results of the study using the methods indicated in chapter three (3). The results are discussed under the following headings: the habitats of Typha in the study area, their characteristics; water parameters influencing Typha growth; respondents survey; an assessment of the control measures adopted and marketing of Typha stalks.

4.2 MAJOR HABITATS OF *TYPHA* SP IN THE STUDY AREA

Table 4.1 to 4.3 shows the type of habitat of the *Typha* and the locations of the sites by name description and geographical position (GP) of the location.

Table 4.1: Type and Location of Typha Habitats

S/N	HABITAT TYPE	NAME OF LOCATION AND GPS CONCRETS	NATURE OF SITE AND DESCRIPTION
1	Burrow/gravel pit	'Karfi' I N11^{o}.49'07.7" E008^{o}29'28.5"	A large pit, very wide, more than 50 meters, retains water throughout the year. Water depth variable, relatively shallow at the edges but over 1 meter towards the centre.
2	Burrow/clay pit	'Karfi' II N11^{o}.48'58.9" E008^{o}29'22.5"	A relatively small pit, about 5 meters wide, contains water for most part of the year. Water depth ranged from 30-50cm and mud-bricks making is the most common activity at the site.
3	Farm pond	'Dan-Isa' N11^{o}.48'39.5" E008^{o}28'49.1"	A very large pond with about 70 meters in diameter, water available almost all year round. Water depth about 25cm – 30cm at the edges and about 1 meter towards the centre. Unlike other pits, this pit is fairly spherical in shape. *Typha* sp is the only plant growing and are mostly at the edges. Fishing activity is widely carried out at this site.
4	Burrow/gravel pit	'Tatarace' N11^{o}.48'24.6" E008^{o}28'19.4"	A remarkably large pit, diameter about 80 meters. Water available all year round. Water depth about 40 – 50 cm at the edges but much deeper towards the centre. *Typha* sp. covers the entire margin of this pit. No visible activity is taking place in this pit.
5	Burrow/sand pit	'Tatarace' N11^{o}.48'20" E008^{o}28'08.8"	An average sized pit, diameter about 20 meters. Water available throughout the year. Water depth about 25 – 30 cm at the edges, and about 75 cm towards the centre. *Typha* sp. cover very dense, but mostly at the margin. This site has a unique wild bird's population.
6	Gravel pit	'Imawa' N11^{o}.48'00.9" E008^{o}27'39"	Also a large pit but divided into smaller depressions. Water available all year round. *Typha* sp in patches, but dense. Weed in association with other aquatic plants. Water depth about 23 – 42 cm but varies from time to time. People usually collect gravels from this pit.
7	Village pond	'Imawa' N11^{o}.47'53" E008^{o}27'27.8"	Pit spherical in shape and very deep. Water level usually very high, depth at the edges from 65 cm to about 1 meter. *Typha* sp. is the only plant growing but largely at the margins. Plant cover also dense. Pit close to settlement and farmlands.

8	Burrow pit	'Imawa' N11^{o}.47'55.6" E008^{o}27'26.1"	Pit also large, irregular and close to the road and farmlands. Water level high most of the time. Depth about 60 – 75 cm, but also fluctuates. *Typha* sp. cover dense, other aquatic plants like lilies and water lettuce.
9	Burrow pit	'Bauren Tanko' N11^{o}.47'27.1" E008^{o}26'41.9"	A relatively small pit and shallow. Water level low, water depth about 10 – 35 cm. *Typha* sp in dense cover.
10	Gravel/burrow pit	'Kura' N11^{o}.46'45.9" E008^{o}25'31.6"	The largest pit and remarkably deep depression. Site intended as a fish pond by the Local Government Council. Water level fluctuates. *Typha* sp. found only in areas where water is available most of the time. The *Typha* species found in this site were remarkably tall about 5 – 7 meters and with unique fruits (fruits about 1 meter long).
11	Gravel pit	'Kura' N11^{o}.46'57.6" E008^{o}25'25.7"	Referred to as "Kogin'Madara". The pit is an ancient gravel collection site. It is very deep and has water almost to the brim of the pit. Water is available all year round but level fluctuates. *Typha* sp. grows only at the margin where water depth is less than 1 meter. Washing activity is taking place in this site all the time.
12	Burrow pit	'Kura' N11^{o}.46'08.9" E008^{o}25'23.0"	Pit small, water level low, depth about 25 – 40 cm and also fluctuates. *Typha* sp growing together with other aquatic plants. *Typha* sp cover dense. Pit surrounded by farmlands.
13	Gravel/mud pit	'Kura' N11^{o}.45'08.3" E008^{o}25'22.2"	Pit separated into smaller depressions. Water sometimes filled up the depression. *Typha* sp in dense cover but also in association with lilies. Mud-brick making is the usual activity taking place there.
14	Sand pit	'Samawa' I N11^{o}.44'20.4" E008^{o}25'29.4"	An average size pit, with regular shape, and shallow. Water available most part of the year. Water depth about 15 – 28cm. *Typha* sp. covers most of the pit, also growing are water lilies and other aquatic plants. Pit also situated by farmlands.
15	Sand/clay pit	'Samawa' II N11^{o}.44'16.5"	A very big pit about 70m^2 and rectangular in shape. Pit surrounded by farmlands. Water level relatively high and available throughout the year. Water depth about 45 – 65 cm but fluctuates. *Typha* sp. in dense cover and in association with water-lilies

		E008^{o}25’27.1”	and other plants. Fishing activities takes place.
16	Sand/clay pit	‘Yadakwari’ I N11^{o}.42’12.3” E008^{o}25’20.4”	Pit is second largest after Tatarace I. Pit is shallow with water all year round. Soil clay, water depth about 15 – 65cm. *Typha* sp. in dense cover. This site has a remarkable population of wild-birds including stocks, heron were found.
17	Gravel pit	‘Yadakwari’ II N11^{o}.42’22.6” E008^{o}25’21.6”	A fairly spherical pit and deep. Water level low, depth about 20 – 40cm. *Typha* sp. cover sparsely distributed at the margins. Also found growing in the pit were various aquatic plant species.
18	Village pond	‘Daka soye I’ N11^{o}.41’18.7” E008^{o}25’19.5”	A big pond partially surrounded by settlements. Water level very low, depth about 10 – 30cm and changes from time to time. *Typha* sp. cover very dense.
19	Gravel pit	‘Daka soye’ II N11^{o}.40’08.9” E008^{o}25’10.7”	A small pit, irregular in shape and partially surrounded by farmlands. Water level high, depth about 35 – 70cm but also fluctuates. *Typha* sp. cover is dense.
20	Sand/clay pit	‘Samawa’ II N11^{o}.43’49.6” E008^{o}25’23.7”	A big pit fairly spherical in shape and shallow. Water level high, depth about 25 – 53cm. *Typha* sp. cover very dense.
21	Sand pit	‘Bauren Tanko’ II N11^{o}.47’24.3” E008^{o}26’44.3”	Also a big pit, irregular in shape. Water level low, depth about 20 – 48cm but also fluctuates. *Typha* sp cover very dense.

Table 4.2 Location of Habitats at Roadside Drains

S/N	TYPES OF HABITAT	NAME OF LOCATION (CONCRETS)	NATURE OF SITE AND DESCRIPTION, GP
1	Roadside drain	'Karfi' N11^o.49'13.5" E008^{o}29'42.1"	Drain about 100meters long and about 10 meters wide. Water available most of the time in the year. Water depth about 20 – 54cm and also fluctuates. *Typha* sp cover dense but only at one part of the drain. Site with abundant water lilies.
2	Roadside drain	'Karfi' II N11^o.48'41.8" E008^{o}28'59.7"	Drain relatively narrow, water availability not regular. *Typha* sp cover sparse.
3	Roadside drain	'Kura' N11^o.48'10.1" E008^{o}27'58.3"	Drain between the road and farmlands. Also a long drain, water available throughout the year. Water depth about 30 – 65cm but also fluctuates. *Typha* sp cover very dense. Other aquatic plants present include *Pistia* (water lettuce).
4	Roadside drain	'Bauren Tanko' I N11^o.47'19.5" E008^{o}26'34.5"	A very long drain stretching to about ½ kilometer long. Water level high, depth about 15 – 30cm. *Typha* sp cover very dense. Other aquatic plants also present.
5	Roadside drain	'Kura' II N11^o.48'08.4" E008^{o}00.2	Drain about 100 meters long. Water level low, depth about 10-30cm. *Typha* growing together with other aquatic plants.

Table 4.3: Location of Habitats along Irrigated Canals

S/N	TYPES OF HABITAT	NAME OF LOCATION	NATURE OF SITE AND DESCRIPTION, GP
1	Irrigation canal	'Karfi' N11°.48'48" E008°29'05.9"	Canal about 3.5 meter wide, water not frequently available, depth about 10-35cm. *Typha* sp cover dense. Other aquatic plants growing profusely in the canal.
2	Irrigation canal	'Dan-Isa' N11°.42'49.1" E008°25'24.2"	Canal earthen, very long and about 3 meters wide. Canal silted, water level low, depth about 10-25cm. *Typha* sp cover also dense.
3	Irrigation canal	'Kura' I N11°.45'33.3" E008°25'24.8"	Canal network extensive, also silted. Water level fluctuates, depth about 10-30cm. *Typha* sp cover very dense. Also present are different species of aquatic plants.
4	Irrigation canal	'Samawa' N11°.47'48.8" E008°27'47.4"	Canal seriously silted. water level changes from time to time. Depth about 10-30cm. *Typha* sp cover very dense.
5	Irrigation canal	'Kura' II N11°.45'16.6" E008°25'29.7"	Canal close to a major channel. Also silted, water depth about 10-20cm. water not available most of the time. *Typha* sp cover sparse.
6	Irrigation canal	'Imawa' N11°.47'45" E008°27'51.2"	Canal partly with concrete walls but also silted. Water level fluctuates, depth about 15-40cm. *Typha* sp cover relatively dense. *Typha* growing together without aquatic plants.

Source: Fieldwork 2007

Three major groups of *Typha* sp. habitats were identified at the study area, namely excavation pits, roadside drains and canals. The pits are of various origins – sand, clay, gravel and village scattered, farm ponds and varied in shape and sizes. These pits have become relatively permanent ponds or water pools. Water depth in the pits ranged from 15cm to 1meter. The roadside drain is an extensive network of long, but narrower and shallow too. The canals are also a system of network. Some have concrete walls but most have earthen walls. The canals are in some cases much deeper than the roadside drains. Conditions in these habitats support several aquatic organisms with *Typha* sp. as the most dominant plant species.

The three major *Typha* sp. habitats identified in the KRIP environment comprises of excavation pits, roadside drains and irrigation canals. As can be observed in Table 4.1 – 4.3., the pits, usually retain water for most part of the year and thus has become a suitable habitat for aquatic organisms particularly floating and emergent plants. The floating species include water lilies such as white water lily (*Nymphaea* sp.), yellow water lily (*Nuphar* sp.); and water lettuce (*Pistia stratistes*). The dominant aquatic plant in these pits is *Typha* sp. Because of the nature of the habitats, which is relatively enclosed with water for most part of the year, and perhaps a suitable substratum, the *Typha* sp. was able to grow and spread in such a way as to cover nearly the entire surface of the pits. The plant forms dense cover particularly where the water level or depth is within its tolerable limits. *Typha* were found in water depth of 15cm to 1m.

There are some human activities being conducted close to these pits most of the time. These include local fishing, mud/gravel and sand collection, mud-brick making, as well as water abstraction by farmers to supplement irrigation and for other uses. Therefore, water level in these pits constantly fluctuates. The pits also support unique wild bird population such as herons, red winged black birds and yellow head black birds which usually use *Typha* plant for nesting as well as for protection against poachers. These birds were said to have migrated from other places in either West Africa or Northern parts of the continent. The roadside drains are relatively linked not scattered like the pits. However, the drains are shallow but also retain water for most part of the year. *Typha* sp. cover in the drains is less dense compared to that of the pits. The occurrence and distribution of aquatic plant species including *Pistia* and *Lymphae* in the drains is far greater than in the pits. Change in water level in the drains produce a more dramatic situation than in pits. However, human activities in the drains are less pronounced as in the pits. The canals had mostly *Typha* sp. and other aquatic plant species. The *Typha* sp. cover is dense in some places and sparse in others. Water level in the canals also fluctuates regularly because the canals depend on supply from the irrigation system (channels and reservoirs). This system is periodically controlled by the water management authorities. As such, the canals are sometimes without water. Because the canals are silted, moisture retained in the silts supports the *Typha* sp. and other plants. The canals are usually interfered by humans particularly farmers and villagers alike who collect water from the canals.

4.3 CHARACTERISTICS OF THE *TYPHA*

The characteristic features of the *Typha* species vary considerably. Information on *Typha* sp. specimen collected from sampled sites were closely examined and measured as illustrated in Table 4.4.

TABLE 4.4: KRIP *T*ypha sp. Characteristics and Measurements

PLANT CHARACTER	MEASUREMENTS	OBSERVATIONS/REMARKS
Height	1.4 – 6.0 meters tall	Plant height varies even within the same habitat. The height was taken from the base to the longest leaf.
Leaf length	2 – 6.0 meter long	Plant base is generally fan-shape. The leaf is usually longer than the stem, which terminates with

		the fruit or flower inflorescence.
Leaf width	1 – 2.20cm wide	Leaves narrow as compared to those of *T.latifolia* which measures about 5cm wide.
Number of leaves	12 – 22	Because the leaves are relatively lightweight, wind effects was observed to be responsible for breaking of these leaves. Similarly, the closely packed nature of the *Typha* stands contributes to the fall of these leaves before maturity.
Leaf colour	-	The leaves exhibit variable colours from pale green, light green to deep green.
Fruit length	14cm to 97cm long	Fruit length varies considerably. However, the longest fruits were found at one location throughout the field survey. That was, at Kura burrow pit I.
Fruit thickness	1.32cm – 10cm thick	Thickness also varies. Some are stouty while others are slender.
Fruit colour	-	Greenish brown, but light brown to brown at maturity.
Fruit shape	Cigar-shape to long sausage-shape	Shape is also variable. Some are short and stouty; others long and slender.
Fruit texture	-	Some have smooth surface, others have rough surface.
Other unique features of fruits observed	Fruits divided into 2, 3 or and sometime 4 parts	The 2, 3 or 4 parts arise from the single peduncle (stalk).
Root system (Rhizome)	10 – 11cm thick, with about 3.20cm gap between nodes.	Grows below the soil surface. It is a creeping underground stem.
Flower structures	-	Male and female reproductive organs borne on the same plant (Unisexual/monoecious).
Male stalk (spike) staminate	22.50 – 40.50cm long, and 1.2cm wide	A long cylindrical- like structure, greenish yellowish powder at maturity. The male flower is above the female flower but separated by a gap. Later, the male flower disintegrates, leaving behind a slender, smooth stalk.
Female stalk (spike) pistillate	9.70 – 69cm long and 2 – 3.5cm wide	Also a long, cylindrical, sausage-shape which subsequently transforms into the flower
Separate gap between male and female flower stalks	1.0 – 6.6cm long	The gap separating the two stalks varies considerably.

Source: Fieldwork 2007

The KRIP *Typha* sp. is relatively tall, leaves long but narrow in width. Female flower stalk longer than male flower stalk, and separated by gap with an average length of 3.3cm. Fruits of average length about 55cm, however, fruits samples collected at one of the sites were exceptional long with average length of 1meter. Fruits also exhibited division into parts from the main stalk.

Table 4.4 shows the measurement, observation and comments. Plant height ranged from 1.4 meters to 5.6 meters, leaf range from 2.0 meters to 6 meters long, and the leaf width ranged from 1 to 2.20 cm. the fruits ranged from 14 cm to about 97 cm long and about 1.32 cm to 10 cm thick. Plant bears both male and female flowers on same body. The stalk bearing the male staminate is about 22.50 cm to 40.50 cm long. While the female stalk is between 9.70cm to 69cm long. The male and female stalks are separated by a gap. The gap is from 1.0 cm to about 6.60 cm long. Although, the height, width, length, and thickness of a plant or its parts is important in some respect, its value in terms of taxonomic significance or relevance is very minimal. These characters in an organism are highly variable among members of the same taxonomic group or species. However, such characters have high adaptive value. The plant has a basal aggregation of leaves ranging from 12 – 22 in number. Other special features of the leaves observed are leaves also entire; linear; and parallel-vein. The shapes of its fruits also varied from cigar-shape to long sausage-shape; some of the fruits had smooth surface, others had relatively rough/warty surface. Some fruits were divided into two, three and four parts but all arising from the single fruit stalk. Some fruits were also found to have separated into two by a gap of about 1-2cm. this separation of fruits into duplet, triplet or quadruplet was not described or explained in available literature. Although not a common phenomenon in the study area, it is rather difficult to give a specific reason for this rare manifestation. We can only speculate on the possible cause of this phenomenon. It is likely that a genetic change or mutation may have been responsible for the occurrence of such character.

The measurements as well as the detailed observations carried out on the plant specimens are very important because they provide valuable clue in determining the true identity of the species found in the area. This activity or procedure is usually the first step in the process of identification of an unknown plant species. From the analysis of the data obtained about the plant's growth habit, height, flower, colour and habitat, a description of the KRIP *Typha* species is given as follows:

Table 4.5: Description of Typha Specie found at KRIP

The *Typha* species found at the KRIP has the characteristics described below:

SPECIES	DESCRIPTION
HABIT:	Plant is an erect, tall, with average height of 3 meters, rhizomatous, and aquatic herb.
LEAF:	Leaves erect, many, linear, flat, sheathed narrowed and emerges from the base (basal leaves)
STEM:	Long, cyndrical and tapers at the tip with the flower structures
INFLORESCENCE:	Plants are monoecious/unisexual, the flower structures consists of the staminate portion (male flowers) above the pistillate (female flower) portion; separated by stalk with varying length.
ROOT:	Rhizomatous, stouty and bears numerous rhizoids.
SITE CHARACTERISTICS:	Wet soils, saturated or flooded areas
COMMON HABITAT:	Roadside ditches, drains, irrigation canals, burrow, gravel, clay, sand pits, village ponds, channels, and reservoirs. Generally restricted to areas where water depth does not exceeds one meter.
PHENOLOGY (Flowering period) :	December – March = Flowering March – April = Fruit ripening April – May = Spike burst, releasing the fruits. Sporadic seeds dispersal happens in dry condition and low humidity. June – August = Shoots showed remarkabl leaf senescence.

Fieldwork, 2008

4.3.1 IDENTIFICATION OF THE KRIP *TYPHA* SPECIES

After describing the *Typha* sp found in the Kano River Irrigation Project area, the next step is to compare it with a **Type specimen** from a herbarium so as to establish its true identity. That is, to find out what species of *Typha* is it. Unfortunately neither the herbarium in the Department of Biological sciences Bayero University, Kano; Ahmadu Bello University, Zaria nor any other herbarium in the country has records of this particular plant taxa or group. It became necessary to extract comparative information from as many sources as possible including experts on the subject around the world. This was made much easier by the internet services which allows access to plant's character list, illustration, full and partial description, diagnostic description, differences and similarities between taxa, list of taxa exhibiting specified attributes, summaries of attributes within groups of taxa, geographical distribution, genera included in each family, classifications by (Dahlgren; Cronquist; APG) and notes on the APG classification. Other materials consulted include, the plant database, database version 4.04 1999 and version 5.11 2000. With this information a comparison was made between the KRIP *Typha* sp and the most notable and widely distributed *Typha* species. Table 4.4 shows the comparison drawn. The KRIP species was compares with *T.domingensis, T.angustifolia* and *T.latifolia*. From the diagnostic descriptions and exhibiting features of these species, the KRIP Typha sp is certainly not a broad leaved species, that is, *Typha latifolia*. But rather a narrow-leave species, its leaf width is less than 1.5cm compared to *T.latifolia's* width of 5cm. another conspicuous difference between *T.latifolia* and the KRIP species is the flower stalk. In *T.latifolia*, the male and female flowers on the stalk are not separated. The male flowers is directly on top of the female flowers while in the KRIP *Typha* species, the male and female flowers are separated by a relatively long stalk about 1-6.5 cm. The KRIP *Typha* species share many common features with both *T.angustifolia* and *T.domingensis*. it is a narrowed-leave species like the two species, and also its flower stalk has a gap separating the male flower from the female flower. However, its average number of leaves is similar to that of *T.angustifolia* which is about 12 compared to that of *T.domingensis* which is about 10 leaves.

From the available diagnostic descriptions of notable *Typha* species used to determine the identity of the KRIP *Typha* species, it seems the KRIP species is either *T.angustifolia* or *T.domingensis*. In the past, the status of *T.domingensis* as a distinct species from *T.angustifolia* was contested, but protein characteristics, serology and disc electrophoresis techniques indicted that it should be maintained as a distinct species (Lee and Fairbrothers 1979). Olumide (2000) in a report to the IUCN described the extensive growth of *T.domingensis* in the Hadejia – Nguru Wetlands in Jigawa- Yobe and Bauchi States, Nigeria. He stated that high nutrient of the soils has aided the growth of this *Typha* species in the area. Similarly, Davis (1991) reported that *T.domingensis* is expanding its range in the U.S. due to environmental changes from low to high nutrient condition. This findings collaborates the work of Hotchkiss and Dozier (1949) which reported that *T.domingensis* is the most tolerant of salinity, followed by *T.angustifolia, T.latifolia* and *T.xglauca*. Even on the basis of this latter information, we deem it necessary to contact experts as well as international centres for assistance to ascertain the true identity of the KRIP species of *Typha*. In Britain, Dr. K.J. Murphy an expert on aquatic weeds based in IBLS-DEEB, University of Glasgow was contacted. Another expert on the subject in Iran Dr. Farrokh Ghahremaninehad of the department of Biology, Tarbiat Moallem University was also contacted. Plant description (characteristics and measurements) as well as pictures of the plant including different parts were sent to these two scholars in early 2008. In two separate responses, Dr. Murphy confirmed that the KRIP *Typha* species is *T.domingensis*.

4.3.2 COMPARISONS OF CHARACTERISTICS FEATURES OF SAMPLED SPECIES WITH SOME IDENTIFIED *TYPHA* SPECIES

The similarities and differences between the KRIP Typha sp. and most common Typha species were recorded. The result is presented in Table 4.6.

Table 4.6: Comparisons of Characteristic features of Sampled Species with some Identified *Typha* Species

Type of Typha Species	Common Name	Plant Height (M)	No. of Leaves	Average Leaf Width	Leave Shape	Leaf Colour	Length of Mature Female Spike (CM)	Flower Structure	Flower Colour	Interval between male and female spike (CM)	Fruit features	Length of fruit (CM)
Typha domingensis	Slender cattail or native cattail	2 - 3m tall	6 - 9 equally or slightly exceeding female spike	06 – 1.2mm wide. Moderately convex on back	-	Light yellowish green	15 - 25cm	Comprises of both male and female flowers	Light cinnamon brown to buffy or grayish	1.5 – 3.5	Cigar shaped	15 - 25
Typha angustifolia	Narrow leaf cattail	3 – 6m	12 – 16	06 - 1.27 cm		-	-	A cylindrical spike at the end of stem bearing both male and female.	-	1 – 3	A cigar shaped	5 - 15 cm
Typha latifolia	Broad leaved cattail	5 - 10 tall (3m)	12 - 16 leaves do not extend beyond the spike	3.0 – 6.5m	leaves alternate and tightly gasping at the base, simple, linear, flat erect	Pale greenish to green	10 - 15cm (female)	The staminate (male) is positioned above the female (pistilate). They are continous or slightly separated.	Female flowers are sausage shape, Dark brown	Absent	-	10 - 15cm
KRPI *TYPHA* SP	*Typha*	1.4 – 6.0	12 - 18 and it is cylindrical or convex in cross-section exceeding the spike.	2.2 – 3.0mm	Leaves erect, flat, simple and linear and arising from the base.	Variable pale green deep to light yellowish green	27 - 75cm	Male and female flowers on same body. Male flowers on top of the female flower.	Light brown, brown	1.50 - 4.50cm	Fruits separated into 2 unequal parts. Some cigar-shape, yet others sausage-shape	18 - 97cm long

Source: Fieldwork 2007

The KRIP *Typha* is taller than *T.domingensis* but shorter than *T.angustifolia* and *T.latifolia.* It's average number of leaves is similar to *T.angustifolia* and *T.latifolia* but much more than that of *T.domingensis*. It's leaves are more broader than those of *T.domingensis* and *T.angustifolia*. Flower stalks separated by gap as in *T.domingensis* and *T.angustifolia.*

In Table 4.6 an attempt was made to relate KRIP species with other common *Typha* species. The KRIP *Typha* sp. was compared with most common *Typha* species; namely, *T.domingensis, T.latifolia* and *T.angustifolia*. The *Typha* sp. found in the area is taller than *T.domingensis* but about the same height as *T.angustifolia*. It is however shorter than *T.latifolia*. The KRIP species has similar number of leaves as *T.latifolia* and *T.angustifolia* and about double the number of *T.domingensis*. However, the leaves in both the KRIP and *T.domingensis* exceeds beyond the spike. Although, the leaves of KRIP *Typha* sp. may not be described as broad leaves as in *T.latifolia*, but it is much broader than both *T.angustifolia* and *T.domingensis*. However, the KRIP species shares another important taxonomic feature with *T.domingensis* and *T.angustifolia* with the presence of a separation gap between the male and female flower stalks and the gap is relatively similar in length to both species.

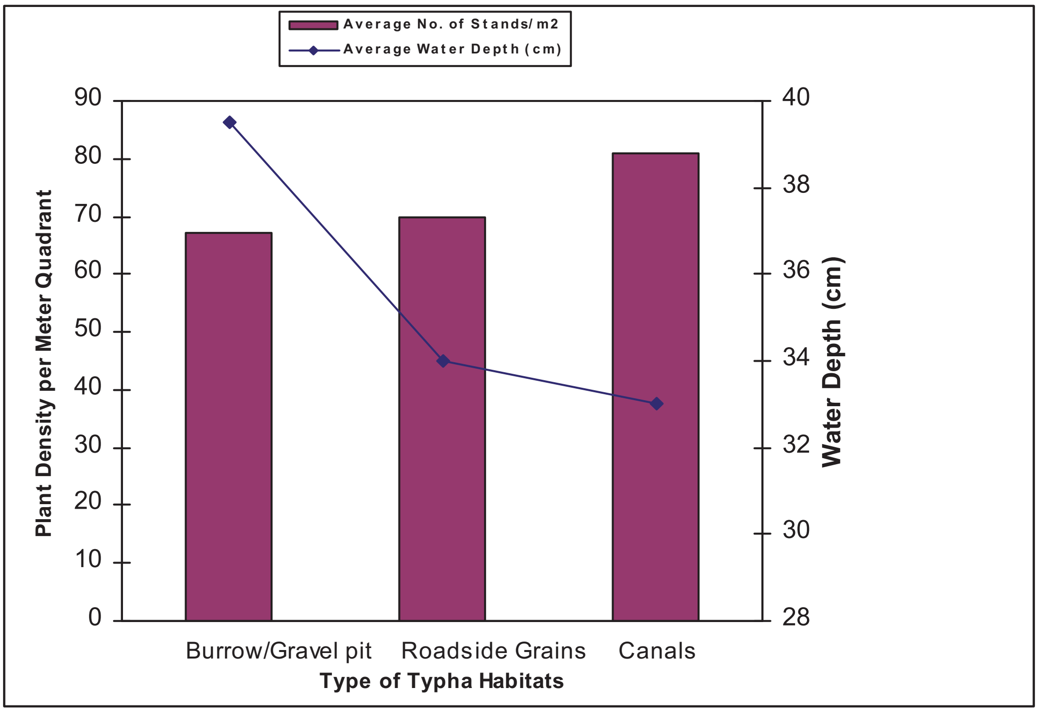
4.4 WATER PARAMETERS INFLUENCING *TYPHA* GROWTH

Typha weeds grow and cover an invaded habitat. The plant (stem) density per square meter (m^2) quadrat is an estimate of the relative extent of plant cover in relation to water depth. The result of this investigation is illustrated in Table 4.7.

Table 4.7: Plant density (per 1m quadrat) and average Water depth in the different *Typha* sp. Habitats in the KRIP area

***Typha* sp. Habitats**	**Average No.of Stands/m^2**	**Average Water Depth (cm)**
Burrow/gravel pits	67	39.25
Roadside drains	70	34
Canals	81	33

Source: Fieldwork 2007



Source: Fieldwork 2007

Figure 4.1 Plant Density and Average Water Depth in different Typha habitats at KRIP

Table 4.7 shows that canals with shallow water depth display the highest plant density. Indeed, the result indicates that the shallower the water depth, the greater of the plant colony.

Typha sp. in all the sampling sites grows as monoculture or rather as mono-specific community. The shoot density (number of stem per m^2 was determined in the three different *Typha* sp. habitats. Table 4.7 shows the average number of shoot (stem) density and the average water depth of the major *Typha* sp habitats. From the results, burrow/gravel pits had the lowest average stem density. While canals had the highest average stem density of about $81/m^2$, and followed by the roadside drains with 70 stem per m^2. However, with regards to the average water depth, the situation was reversed. The canals had the lowest of 33cm, while the average water depth for the burrow/gravel pits was 39.25cm and was followed by roadside drains with 34cm. The situation shows that as water depth increases, shoot or stem density decreases. Thus, in the Kano River Irrigation Project area, the species of *Typha* found exhibit greater or lesser growth aggregation in response to water depth. *Typha* sp growing in a site/habitat where the water is deep, the shoot/stem density is low. However, in places where the water is low or shallow, the shoot/stem density is higher. The waters in burrow/gravel pits are much deeper because of the nature of the site (a depression). Canals and roadside drains are not as deep because these are constructed or designed to facilitate water flow. Dykyyova *et al* (1991) and Curtis (1989) reported that shoot density in *T.latifolia*, *T.angustifolia* and even *T.domingensis* ranged from $28/m^2$ to $108/m^2$.

4.4.1 *TYPHA* SP. GROWTH RESPONSES TO WATER DEPTH GRADIENT IN THE STUDY AREA

The influence of water level condition on the KRIP *Typha* growth characteristics was determined and the result is shown in Table 4.8.

Table 4.8: *Typha* sp. growth responses to water depth gradient in the study area

WATER CONDITION	RANGE OF WATER DEPTH (CM)	OBSERVED PLANT GROWTH CHARACTERISTICS
Low water condition	1 – 29	- Plant cover very dense - Stands density per meter square quadrat about 61 – 80 - Leaves broad, longer, usually fresh and deeply green - Plants are usually tall, height ranges from 3-5 meters. - Flowering and fruiting commences as soon as the reproductive period is due and becomes widespread within a short time
Average water condition	30 – 45	- Plant cover dense - Stem density about 40 – 60 per meter square - Leaves also broad, but green to light green - Plant height about 2 – 4 meters tall - Flowering and fruiting starts relatively late around March to April. Plants growing in locations where the water level is around 30cm deep usually commence flowering and fruiting much earlier than those in waters that are 40 cm or more deep. Flowering and fruiting in *Typha* sp. growing in deeper waters are usually delayed.
High water condition	46 and above	- Plant cover sparse - Plants concentrates mostly in areas within the habitat that is within tolerable depth limit. In burrow pit, *Typha* sp.grows only at the edges or sides where the water depth is usually less than 1 meter. - Stem density is about 40 -45 stands per meter square. - Where the water depth remains unchanged or stabilized for a long time, the leaves are pale green, sometime yellowish green. - Leaves are also narrower about 1.80 cm wide. - Senescense of above-ground biomass is also common. - Flowering and fruiting is delayed for a considerable period. Flowering and

		fruiting did not commence at these sites, 'Karfi' roadside ditch I; 'Tatarace' A & B; 'Kura' 'K/Madara' burrow pit; 'Yadakwari' burrow pit I; 'Samawa' burrow pit III and 'Bauren Tanko' burrow pit II until the water level had reduced considerably.

Source: Fieldwork 2007

Growth responses were observed under 3 different water level conditions. In water depth of less than 30cm, the *Typha* sp. grew faster and dense taller; leaves fresh and green; flowering and fruiting also faster than in average and high water conditions.

Water level fluctuation is perhaps the most common phenomenon in the Kano River Irrigation Project area. *Typha* sp in the area were found to respond to these changes in different ways. Table 4.8 shows plant responses to water depth gradient in the study area. Three levels of water conditions were identified; these include, low, average and high water conditions. In low water condition where the depth ranges from 1-29cm, *Typha* sp exhibits the most remarkable growth characteristics such as dense plant cover in the site; higher stem density per meter square quadrat; better plant height, leaves deep green, longer and fresh; flowering and fruiting commences as soon as the reproductive period is due, that is, in the month of March. Under average water depth condition that ranged from 30-45cm, the plant exhibits a relatively dense cover. However, stem density is much lower compared to those growing in low water depth; leaves are also broad but are either green or light green in colour. Plant height is about 2-4 meters tall; while flowering and fruiting starts relatively late around late March to April. The process of flower formation was found to commence with varying degree within the same habitat whether canals, roadside drains or burrow pits. However, *Typha* sp growth response to high water condition was quite interesting to observe. The plants were found in patches ,or rather, plant cover is sparse; these patches of *Typha* are usually places where the plant is able to adapt or tolerates the water level condition. This growth pattern was specifically observed in burrow/gravel pits where stem density is very low about 40-45 stands per square meter; leaves are either pale green or yellow-green. Leaves were also narrower about 1.80 cm wide; senescence of the above-ground biomass is very common in the plants. Flowering did not commence until the water level had reduced considerably. The situation showed a difference of nearly two months (May/June) after plants in both low and average water condition had flowered and fruited. McMillan (1992) reported that high water condition affects growth of seedling, break off mature stalks, leaves become pale green, narrower leaves; and absence of fruiting heads (indicates stress). Similarly, Steenis *et al*, (1990) reported that Cattail establishment was prevented when water levels are maintained at 1.20 meters or deeper in narrow-leave *Typha* species. In water depth experiment Grace (1989) reported that *T.domingensis* flowered when growing at depth of 5, 22, 42, 58, 70, 83, 105, 110 and 115 cm below the surface of the water. But *T.latifolia* died out when growing in depths greater than 95 cm.

4.4.2 MEAN VALUES OF SOME PHYSICAL PARAMETERS OF WATER FROM *TYPHA* SP. HABITATS FROM APRIL 2007 – 2008 IN KANO RIVER IRRIGATION PROJECT

Important water parameters that influence Typha sp. growth in the 3 major Typha sp. habitats in the KRIP area that were investigated produced the data in Table 4.9.

TABLE 4.9: Mean values of some water parameters from *Typha* sp. Habitats from April 2007 – 2008 in Kano River Irrigation Project

a) Burrow Pit

Parameters	Mean	Standard Deviation	Range
PH	8.20	0.70	7.00-9.70
Temperature ^{0}C	24.80	2.90	17.80-30.90
Conductivity µsm^{-1}	198.50	43.30	143.30-268.30

Source: Fieldwork 2007

b) Irrigation Canals

Parameters	Mean	Standard Deviation	Range
PH	8.20	0.30	6.90-9.70
Temperature ^{0}C	24.50	4.00	18.50-30.30
Conductivity µsm^{-1}	123.10	58.60	32.20-217.30

Source: Fieldwork 2007

c) Roadside Drains

Parameters	Mean	Standard Deviation	Range
PH	8.20	0.30	5.60-9.80
Temperature ^{0}C	24.90	3.90	18.30-30.90
Conductivity µsm^{-1}	153.00	54.80	82.00-264.00

Source: Fieldwork 2007

Table 4.9 shows that the mean P^H of water in all the 3 major sampling sites was slightly basic. Similarly, the mean temperature of water was also very close. However, the mean conductivity in the pits is more than in roadside and canals respectively.

When a plant species has succeeded in reaching and establishing itself at a certain aquatic habitat, it is subsequently influenced by the environmental conditions within the water reach. Table 4.9 shows the mean values for Temperature ^{0}C, P^H and conductivity of water in *Typha* sp. habitats for a year. The mean P^H value for all three major *Typha* sp. habitats is 8.20, however, the range varies. In the burrow pits, the range tends from neutral to slightly alkaline (7.00 – 9.70) while in the canals, it ranged from slightly acidic to slightly alkaline (6.90 – 9.70). But in the roadside drains, the P^H is from moderately acidic to slightly alkaline (5.60 – 9.80). This difference in the range of P^H between these habitats was largely as a result of water level fluctuations in both canals and the roadside drains and subsequent chemical reactions that yield hydroxyl ions in the water. The P^H affects the chemical constituents of water as well as the chemical and biological reactivity. Water level is more stable in the burrows/gravel pits because these habitats are less disturbed compared to the canals and roadside drains. The mean temperature value of water for the different habitats is relatively similar (24.8^0 C, 24.5^0 C, and 24.9^0 C) for burrow pit, canals and roadside drains respectively. The range of temperature for burrow pit (17.8^0C – 30.90^0C) is closely similar to that canals and roadside drains (18^0 C – 30^0 C). Temperature is a very important parameter because it creates the necessary condition for life activity in any system. As regards conductivity, the mean conductivity value varies considerably between the three main habitats. There is a remarkable difference between the habitats in terms of total dissolved solid concentration or conductivity. The burrow pits have the highest conductivity followed by roadside drains and canals. The burrow pits are largely enclosed, no outlet for the water and all the impurities including salts, nutrient, accumulated in pits. Therefore greater specific conductance whereas canals and roadside drains are open, shallow and water together with these solids is lost in water circulation processes in these habitats.

4.4.3 GRAPHICAL PRESENTATION OF WATER PARAMETERS INFLUENCING *TYPHA* GROWTH IN THE STUDY AREA

Changes in the condition of water in *Typha* sp. habitats as regards these parameter, P^H, temperature and conductivity was also analyzed on monthly basis across the two climatic seasons. Figure 4.2 shows the average monthly P^H of water in the *Typha* sites in the wet season which covers May to September. In May, the P^H of water for the all *Typha* sp habitats was the same that is about 8. Similarly, in June, all three sites/habitats had same P^H but it is slightly higher than in the month of May. However, in July which is the middle of the rainy season in that year, the P^H of water in the burrow pits was slightly lower compared to that of the roadside ditches and canals. In the month of August, the P^H of water increased remarkably to about 10 for all the three major sites/habitats. The situation was the same in

September which was the last month of the rains in that year. Figure 4.3, shows that in October the average monthly P^H of water drops to about 9/0 in all the major *Typha* sp. site/habitats. Again in November there was a further drop in P^H to about 8.0 in the burrow pits. A further drop in P^H also recorded in the burrow pit in March. These drops in P^H of water in the burrow pits are mainly as a result of biological activity which brings about changes in chemical composition in the habitats. Therefore, $P^H$of the water changes to slightly basic from highly alkaline conditions. Another explanation is apparent loss of water either through evapo-transpiration or abstraction which leaves behind much of the ions responsible for lowering P^H or moving shift it towards slightly acidic condition. In April there was a dramatic in P^H of water across the *Typha* sp. habitats. In the canals, the P^H suddenly dropped to a level slightly acidic or neutral condition. Water in the canals was grossly inadequate, much of it was absorbed in the soils very little is available on the surface. Chemical reaction taking place in the soil matrix could be responsible for this remarkable change in the P^H. The canals are seriously silted and were densely covered by *Typha* sp. and other aquatic plant species. While the burrow pits maintains a P^H at almost the same level as in March. The roadside ditches had the highest average P^H in the month of April. It is important at this point to mention that the months of March and April are usually the driest and hottest in this part of the country. Evaporation and evapo-transpiration are very active hence, chemical reaction increases in the environment particularly in aquatic habitats.

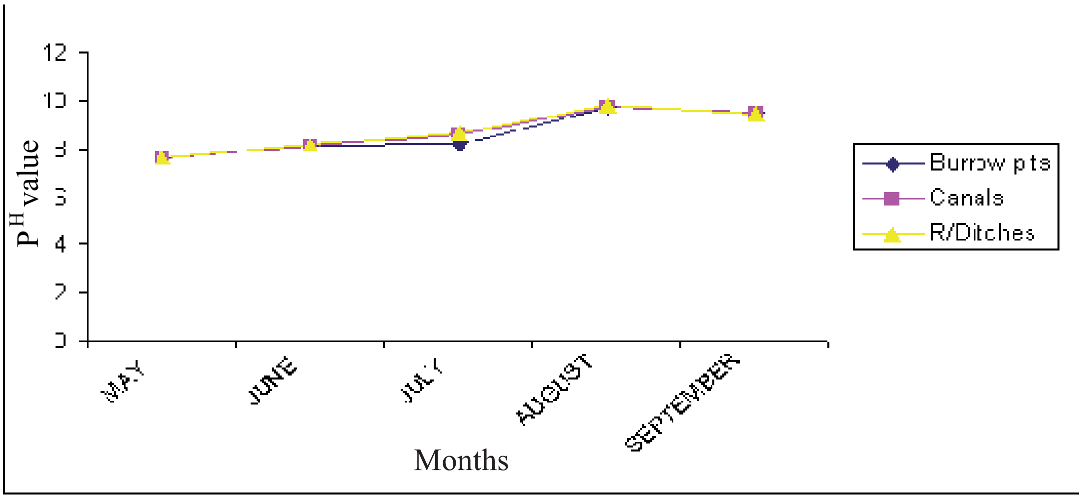


Figure 4.2: Monthly Average P^H of water from *Typha* sites in the KRIP areas (2007/2008 Wet Season)

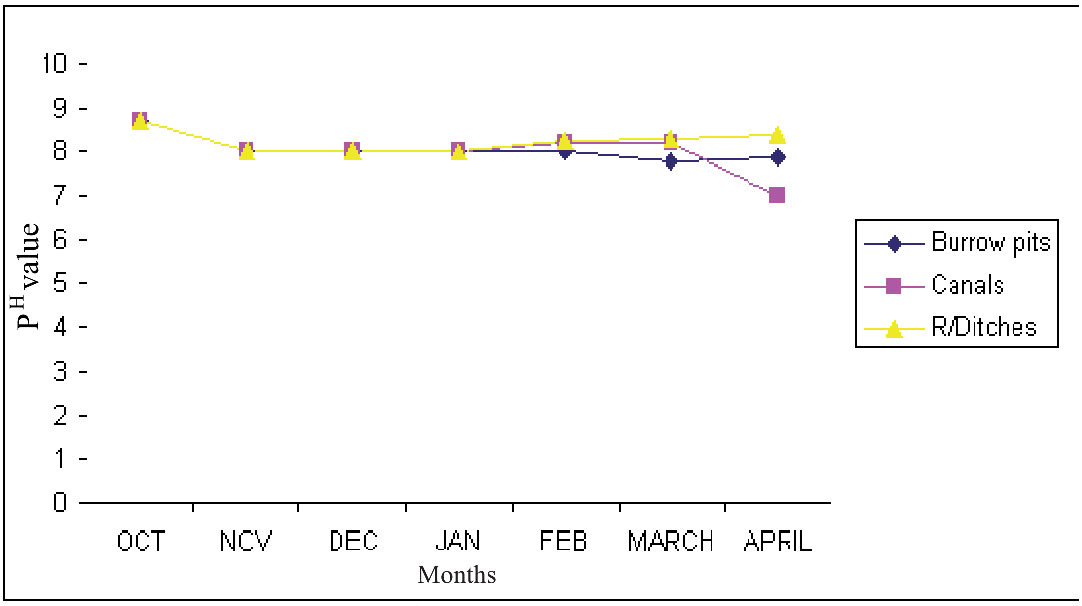


Figure 4.3 Monthly Average P^h of Water from *Typha* Sites In The KRIP areas (2007/2008 Dry Season)

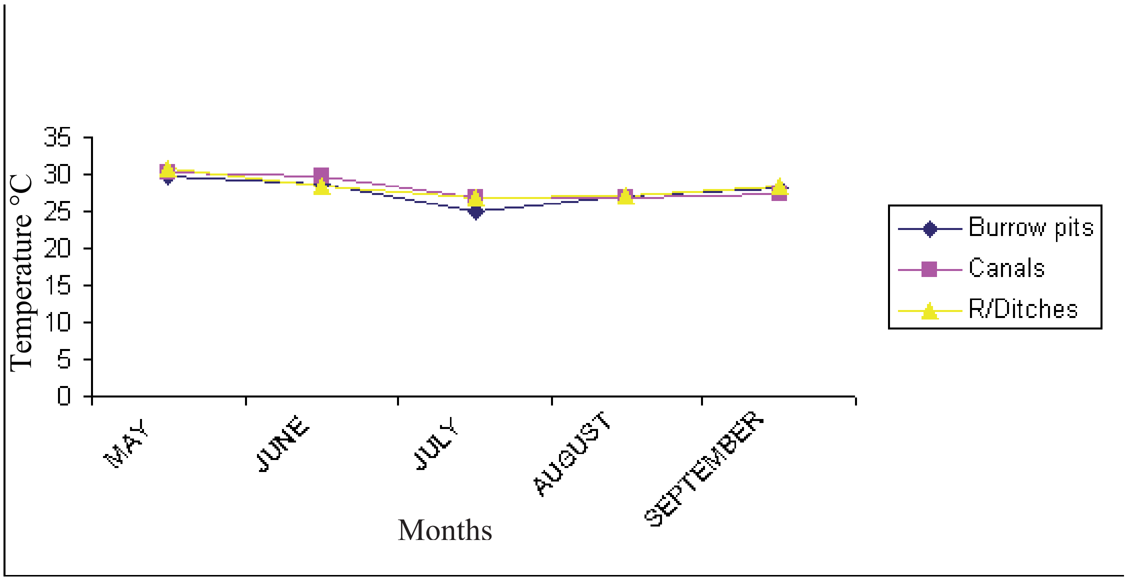


Figure 4.4 **Monthly Average Temperature (^{0}C) of Water from *Typha* sites in the KRIP areas (2007 Wet Season)**

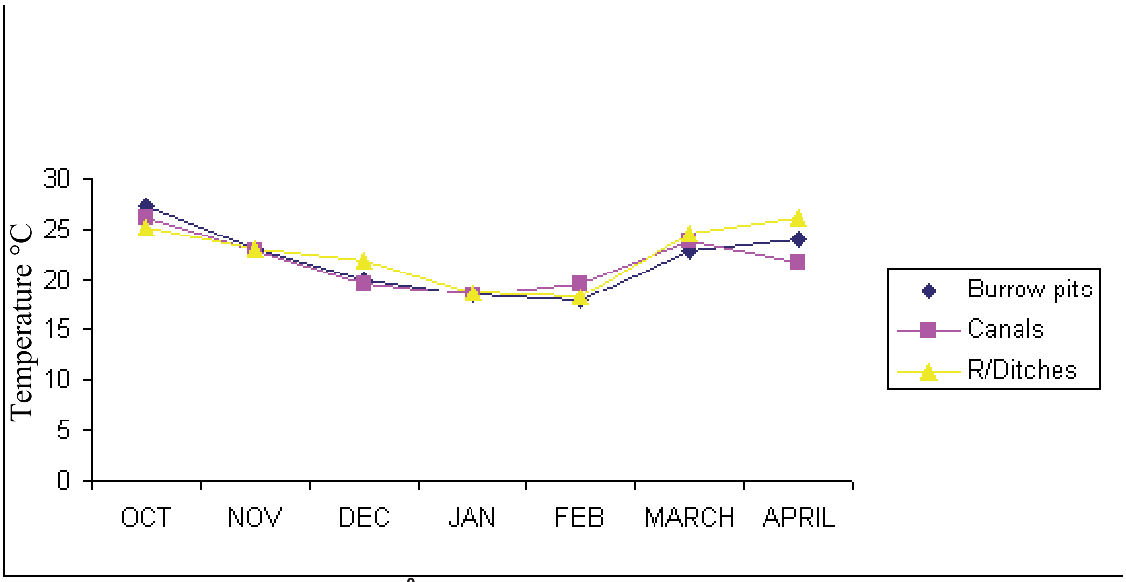


Figure 4.5 **Monthly Average (^{0}C) Temperature of water from *Typha* sites in the KRIP areas (2007/2008 Dry Season)**

The monthly average temperature of water during the wet season is shown in fig.4.4. In May, the burrow pits had relatively lower temperature compared to that canals and roadside ditches. However, in

June the pattern changed with the roadside ditches having less than 30^0 C while the burrow pits and canals had same average temperature. In July, the middle of the rainy season, all the sites had lower temperature. The burrow pits had the lowest average temperature of about 25^0 C. However, in August and September the last month of the rains, there was slight rise in temperature to about 30^0C and was relatively similar for all the major sites or habitats. Although, the average monthly temperature in July fell below 30^0C, it was however, within the range (25^0 – 27^0C) for normal physiological activities for aquatic organisms. The pattern of temperature in the wet season collaborates the findings of Sifton (1989) and Bonnewell *et al*; (1993) which reported that *Typha* species requires warm temperatures from 77 – 86 degrees Fahrenhiet (25^0 – 30^0C) for both germinations and seedling establishment.

In the dry season as can be observed in Fig.4.5, the average monthly temperature of water for the month of October was slightly below 30^0C in all the major *Typha* habitats. Although it was higher in the burrow pits followed by the canals and about 25^0C in the roadside ditches. In November, the temperature was the same about 25^0C for all the habitats. However, in December the temperature for both burrow pits and canals dropped significantly to about 23^0C. While that of the roadside ditches remained at about 30^0C. This fall or drop in water temperature coincide with the hamattan period during which air (atmospheric) temperature drops remarkably to about 20^0 – 18^0C as the case may be. Similarly in January, the average temperature of water was below 25^0C in all the major habitats. But in February, the average temperature in the canals was about 25^0C while it was less in both burrow pits and roadside ditches. Suddenly in March, the average water temperature across the sites or habitats rose above 25^0C. The rise in temperature continued in April but only in the burrow pit and roadside ditches. But it fell or dropped in the canals. The sudden rise in water temperature in the months of March and April is understandable because these are the hottest and driest months in this part of the country.

Changes in environmental temperature invariably affect components of the environment including aquatic systems. It is important to note that in spite of the drop in average temperature of water in the study sites in the dry season, the water temperature largely remain within the required normal temperature of about $25^0 – 27^0C$.

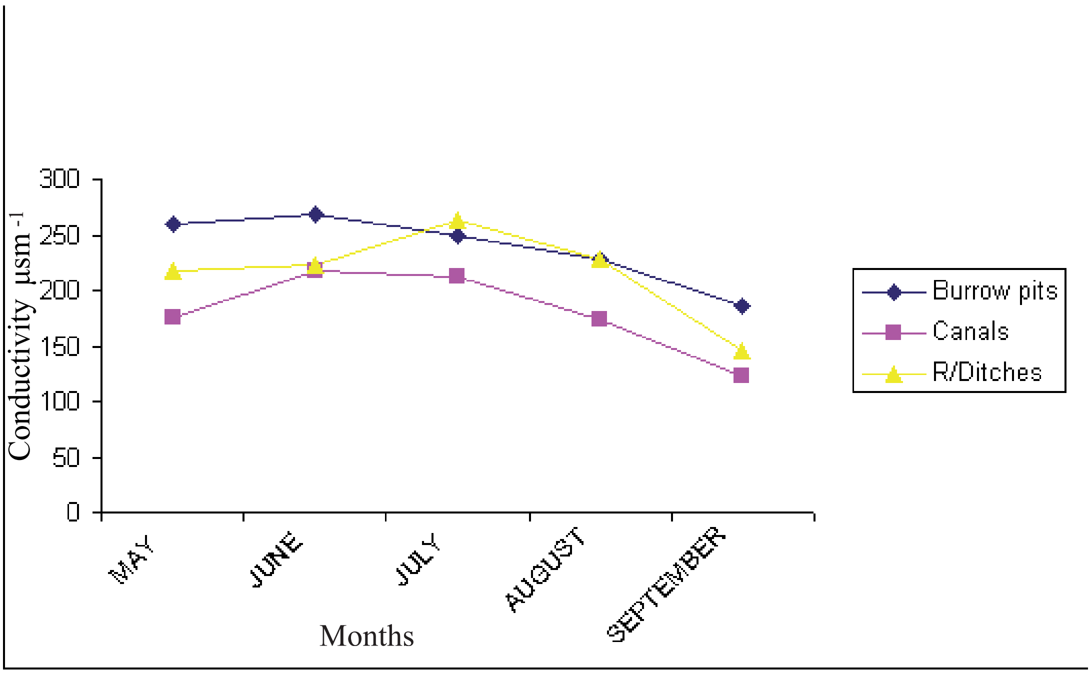


Figure 4.6: **Monthly Average Conductivity (μsm^{-1}) AT 25^0C of water samples from Typha site in the KRIP areas (2007 Wet Season)**

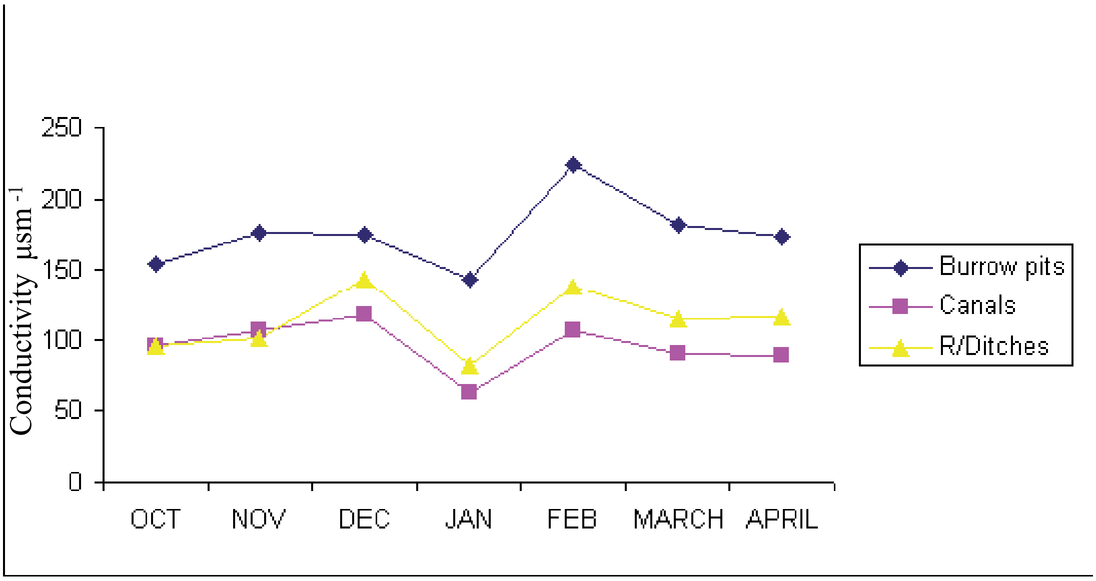


Figure 4.7: Monthly Average Conductivity (µsm^{-1}) at 25^{0}C of water samples from in the KRIP areas (2007/2008 dry season)

Salinity is reported in terms of total dissolved solids (TDS in mg/L^{-1}) or electrical conductivity (EC in µsm^{-1} at 25^{0}C). The average conductivity of water in the various Typha species habitats were also plotted for the two seasons. Figure 4.6 shows the changes in conductivity during the wet season of 2007. The average monthly conductivity of water was higher in the burrows pits across the period May to September compared to that of roadside ditches and canals.

However, the pattern indicates a gradual decrease from June to September. In the case of roadside ditches, there was a remarkable increase in conductivity in the month of July and subsequent decrease in August and September. The lowest average conductivity in the burrow pits was in the month of September about 200 µsm^{-1}. The canals had the least average monthly conductivity of 170 µsm^{-1}. There was an increase in June and July to somewhere above 200 µsm^{-1} but subsequently there was a decrease in August and September below the 200 µsm^{-1} level. It is obvious in all cases that the average conductivity decreased consistently as the rains progresses from July to September. The relatively high conductivity of water in the wet season could be as a result of runoff from land and farmlands. However, as the rains progresses, the salt or solute load decreases thus, the gradual decline in conductivity in all the sites from July to September.

Figure 4.7 shows the changes in average conductivity across the habitats in the dry season which covers October 2007 to April 2008. it can be observed that burrows pits has much higher conductivity readings than the other two major habitats, that is, roadside ditches and canals. Unlike in the rainy season, the highest conductivity of 250 μsm^{-1} in the burrow pit and was recorded in the month of February. In both the roadside ditches and canals, the average conductivity across the season was lower than150 μsm^{-1}. The lowest average conductivity for both roadside ditches and canals of less than100 μsm^{-1} was recorded in January. The average conductivity of water in the dry season is generally lower than that of the wet season. This is because much of the solutes have been losses through the process of evapo-transpiration or leaching. The main solutes contributing to salinity are the cations such as calcium (Ca), sodium (Na), and Magnesium (Mg); and the anions like chloride (Cl), sulfate (SO_4), and bicarbonate (HCO_3). These solutes are reactive in water and soil solution, participating among others in cations exchange and mineral solubility. Excessive accumulation of Na^+ in soil in water or soil solution and exchanged complex has been described as a critical factor in the sustainability of irrigated agriculture (FAO, 1996).

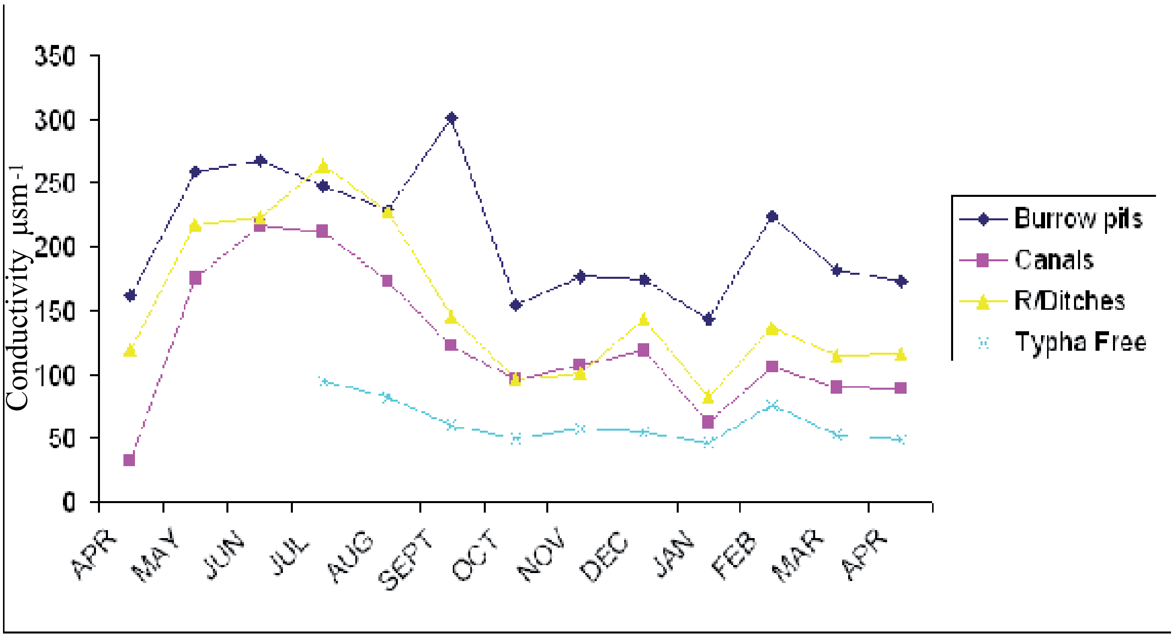


Figure 4.8: Comparison of Average monthly water Conductivity (µsm^{-1}) at 25^{0}C between *Typha* species sites and Typha Free habitats in the KRIP area (2007/2008)

In order to show the pattern of changes in water conductivity across the habitats over a period of one year, the average monthly conductivity of water in both *Typha* invaded habitats and *Typha* free habitats were compared in Figure 4.8. On the whole, the burrow pits had much higher conductivity from April 2007 to April 2008. it is followed by roadside ditches, canals and *Typha* free habitats respectively. The pattern of changes in conductivity in the burrow pits shows that in May there was a remarkable increase in June but dropped to below250 µsm^{-1} in July and August. However, it increased considerably in September to more than300 µsm^{-1} and which is the highest average conductivity of water determined in this study. Surprisingly, the conductivity dropped remarkably to slightly below the 150 level in October. In November and December it rose slightly above 150, but dropped again in January 2008. However, in February, the conductivity increased to about 230µsm^{-1} and there was subsequent decline in March and April of 2008. It is curious to note that the average reading of conductivity in April 2008 was relatively similar to that of same month in the previous year.

Most importantly, the pattern of changes in average conductivity differs greatly between the various habitats sampled. In the roadside ditches, the highest average conductivity was obtained in July while the lowest of less than100µsm^{-1} was in January. The canals had the highest average conductivity of about 220µsm^{-1} in June while the lowest was less than 100µsm^{-1} in January. It can be observed that conductivity was on the decline in the canals from August to November.

In the *Typha* free habitats which comprises of the main water distributing channels and the reservoirs, measurements of conductivity began in July after it was observed that *Typha* sp appeared in the Kadawa reservoir. Inspite of the little presence of *Typha* at the Kadawa reservoir, the average monthly conductivity of the water was remarkably lower than 100µsm^{-1} from July to April 2008. The main channels have concrete walls with narrow base which is also concrete. They are designed to ensure effective water flow by gravity as such do not retain water for any considerable time. Water that flows through these channels comes directly from the dam. It is therefore obvious that the water had little salt concentration as indicated by the level of conductivity. Although, the reservoirs were meant to keep water for a relatively short period, these reservoirs have outlets that release the water into canals. Therefore, it is less prone to high salt concentration. However, the embankment of these reservoirs are not concrete walls and because water stays in the reservoirs for long, other aquatic plants including *Typha* are gradually becoming established. Also the reservoir at 'Kadawa' and 'Imawa' are not surrounded by farmlands which are likely to contribute more chemicals from runoff into these reservoirs. In the long run these reservoirs are likely to have higher salt content and therefore high level of conductivity and invariably dense cover of *Typha* sp.as well as other opportunistic aquatic plants.

Differences in conductivity of water in the major *Typha* species habitats as well as *Typha* free habitats are mainly a result of differences in the concentration of charged solutes and to as lesser extent in the nature of the solutes and of temperature which accelerate the rate of chemical reaction. The fact is that the higher the concentration of charged solutes the higher the conductivity. Growing plants extract water through evapo-transpiration and leave behind most of the dissolved salts, increasing its concentration in the soil water. Irrigation is reported to add to the salt load in the irrigation return flow (IRF) by leaching natural salts in the soil profile, or deposited below (Yaron, 1989). Tamji (1998) remarked that salinity and chemical composition of irrigation return flow depends on the characteristics of the irrigation water, the soil and subsoil, and the hydrogeology, as well as on the management of the irrigation water.

4.5 RESPONDENTS' SURVEY

The 60 respondents interviewed have been engaged in farming in the area from 7 to 30 years, cultivating between 0.5 and 5 hectares and producing wet season crops like rice, sorghum, millet, maize and sugarcane, and dry season crops such as wheat, maize, onions, tomatoes, sugarcane, cabbage and water melon.

a) Awareness and origin of the *Typha*

There seem to be some awareness of the existence of *Typha* in the KRIP area for along time between 15 and 30 years. When asked for what they perceived as the origin or cause of the *Typha* invasion, they give responses as illustrated in Table 4.10.

TABLE 4.10: Respondents' Perception on the Origin of the *Typha*

PERCEIVED ORIGIN/CAUSE	FREQUENCY	%
Came via water	41	68.33
Seeds dispersed by wind	3	5
Imported seeds and dressings	10	16.67
No idea	6	10
Total	60	100

Source: Fieldwork 2007

Table 4.10 shows that the majority of the respondents believed that the irrigation water brought the weed to the idea while about 17% believed it came by way of the imported seeds and or their dressings.

It is however important to know how long *Typha* sp has been in the Kano River Irrigation Project area. Table 9 summarizes the response of farmers and others sampled. Respondents were residents of the area for about 20 – 50 years and are engaged in farming activities ranging from 7 years, to as long as 30 years. *Typha* sp. is said to be in the area for a very long time, about 30 years ago perhaps almost the same period when the project was established. There was however differences as to how the plant came about in the area. A significant numbers of those contacted believed that the plant was transported by water from other places. 10 of the respondents suspected that the plant was introduced through imported seeds and seed dressings. Few believed that the plant came about through seed dispersed by wind. However, some of the people said they are not certain how the plant came about in the area. Holm, *et al* (1979) and Heywood (1978) reported that *Typha* has a cosmopolitan distribution in freshwater environment. The plant according to these reports grows in shallow waters or water bodies where water recedes and rises with the season or regular releases from a large water body or reservoir. Such situations are permanent features of our landscape where minimum and maximum water levels are consistent. Such places include banks of canals, periphery of water bodies found mostly in earthen dams, drainage ditches, and water ponds near villages. The presence of *Typha* in the Kano River irrigation Project area perhaps pre-dates the establishment of the irrigation project in 1973. It is possible that the people in the area were not keen observers to take note of the plant. The belief that the plant was transported by water may be due to the fact that the plant has become a visible feature of water bodies around the area. The views that the plant is an exotic species introduced through seeds and seed dressings may not necessarily be correct. *Typha* has been shown to behave like aggressive introduced weed, but in reality is a native flora found in a variety of natural plant communities (Anderson and Ascher, 1999). Apfelbaum (1990) observed that disruption of hydrology or nutrient enrichment of water bodies favours *Typha* growth in dense monocultures. A strong correlation has been demonstrated between increased nutrient load and shift in species composition and species dominance in ombrotrophic and minerotrophic fens (Verhoeven *et al*, 1988). A similar shift along with overall reduced species richness has been demonstrated in eutrophied aquatic systems (Tilman *et al*, 2001).The construction of Tiga dam has modified surface hydrology of the Kano river, and enriched runoff from farmlands, perhaps operating synergistically, led to the growth of *Typha* sp. as monocultures or nearly monospecific communities in various habitats in the area. *Typha* sp in the Kano River Project irrigation area has become a weed. A weed as described by Domogalla (1987) is "any undesired plant that grows so profusely as to crowd out other plants or detracts in some way from the usefulness and or appearance of an area, and adversely affects human activities."

b) Effects of the *Typha* on Respondents Activities and Productivity

The investigation of the respondents concerning the effects of the *Typha* in the study area produced the information in Table 4.11 and 4.12.

Table 4.11: Respondents description of the effect of *Typha* sp in the KRIP area

Category of respondents	No. Involved	No. Affected	% affected	Nature of effect
Farmers	**60**	**60**	**100**	**- Prevention of water flow** **- Flooding of crops** **- Loss of produce to avian pests**
Fishermen	**20**	**6**	**30**	**- Dense *Typha* cover prevents good catch** **- Reptiles (snake) and leaches attack**
Community	**20**	**Affected indirectly**	**100**	**- Harbors reptiles attacks and bites** **- Habitat for mosquitoes and other disease vectors.** **- Obstruct movement across the farmlands.**
				- Clogging of canals, pumps,
				drainage and reservoirs
				- Aid water losses through
				evapo-transpiration process.
				- Damages to structures such
				as canal walls, gates and veirs
				- Siltation of canals and drainages

Source: Fieldwork 2008

The interaction with different groups of stakeholders regarding the effects of Typha aquatic weeds indicates that all the farmers and extension workers were seriously affected by the weed in several ways. Local fishermen were partially affected while members of the community were indirectly affected.

The plant has invaded irrigation canals, farm ponds, burrow pits, and drainage ditches. In Table 4.11 different groups of the people in the area describe how *Typha* sp is angling their activities. All the farmers sampled were affected by the weed in various ways. It prevents much needed water flow into canals from which they draw onto their farms/plots, and cause localized flooding of farmlands with consequent lost of farm produce such as rice. Dense growths of these weeds in the water irrigation system, silt deposition, and during rainy season, cause higher water levels in these systems which subsequently floods rice farmlands. Another effect of *Typha* according to the farmers is the incredible number of avian pests that nest in the plants. Thousands of red-winged blackbird, yellow-headed blackbird nesting within the *Typha* cover emerges during the rice season, attack and destroy several hectares of rice fields. Some artisan fishermen also describe how *Typha* affects their activities. The dense growth makes it difficult to catch the fishes raised in the burrow/gravel pits. Sometimes even reptiles particularly snake and leeches hidden in *Typha* growth attack the fishermen.

Residents of the area also said that they are affected but indirectly. *Typha* invaded pits around the settlements are habitats for mosquitoes and other vectors of diseases. Also these sites harbours reptiles which often attack and bite people. In some places *Typha* growth impedes movement in the area.

For the extension workers, *Typha* clog canals, gates, and crowd edges of reservoirs making water movement slow. *Typha* growth in canals and reservoir encourage water losses through evapo-transpiration process. Fletcher and Elmendorf (1985), Zohary (1982) reported that cattails or *Typha* sp. can transpire significant quantities of water about 2 – 3m litres of water/hectare/year. Their establishment in such ecosystem exacerbates water level instability in the system. These plants are also said to cause siltation of canals and drainages which affects efficient movement of water in the irrigation system. The creeping rhizomes of these plants cause damages to the irrigation structures, e.g. canal walls (see plates 1-3).

Table 4.12: Estimated Loss of Farm Produce by some Farmers due to the effects of *Typha* sp in the Kano River Irrigation Project (West) between 2003 – 2008

Year	Crop Affected	Cause(s)	Quantity Estimated Lost (in bags)	Amount ₦	Remarks
2004	Millet	Grainvorous birds. Red-winged black birds and Yellow headed blackbirds	10 bags or 50kg x 10 = 500kg	N4,000 x 10 = N40,000	Loss due to birds infestation. Birds used *Typha* stands as habitat, from where they launch attack on the fielded crops.
2007	Rice	Birds infestation	12 bags of shelled rice	N4,200 per bag x 12 = N50,400	
2006	Rice	Localized floods	10 bags	N3,000 per bag x 10 = N30,000	Dense *Typha* growth in canals impeded water flow and rain water over-flow the farmlands and destroy some of the expected rice yield.
2004	Rice	Bird infestation	3 bags	N3,500 x 3 = N10,500	Birds infestation
2003	Rice	Birds infestation	7 bags	N3,500 x 7 N24,500.00	Birds infestation
			TOTAL	**₦155,400.00**	

Source: Fieldwork 2008

Losses incurred by farmers at the study site were caused by mainly grain eating birds and localized flooding. These birds live and nest in the *Typha* fields emerged and attack rice/crops in large numbers (often in 1000s). *Typha* in canals impede water flow and wheat during rainy season, water becomes extremely large, overflow the canals and subsequently the growing rice and wheat's farms.

Attempt was therefore made to estimate in monetary terms losses caused by factors related to the dense growth of *Typha* weeds in the area. Table 4.12 showed that from 2003 to 2007 some farmers lost farm produce on the fields largely as a result of heavy infestation by grainvorous birds. Rice is the dominant crop grown in the rainy season in the area, as such it suffers heavy attack from these birds. Millet, another popular grain of these birds is rarely grown by most farmers, because the level of destruction and losses in millet is said to be much higher than in rice. These birds are described as moving in hundreds or thousands from their resting place in the *Typha* stand's between 6-7am and also between 2-4pm when there is relative quiet in the area and the farmers have gone. Hence, most farmers have stopped growing millet in the area. In 2004 a farmer reported that he lost about 10 bags of millet which at that time cost ₦4,000.00 per 50kg bag, to these birds. From 2003 – 2007, some farmers also reported loss of rice on the fields mostly to birds' attack and destruction. The highest loss was reported by a farmer in 2007, he lost an estimated 12 bags of rice from his expected 4 acre farm. At ₦4,200.00 per bag, the amount loss is about ₦50,200.00. In 2006, a farmer lost about 10 bags of rice as a result of flood on his farm. He describe the situation that the crop was at the maturity when the rains came and water released from the channel overflow the canals which subsequently raised the water level on the rice farm considerably to cover the crop. By the following day when he arrived, most of the rice growing heads have collapsed thus indicating plant death. He had to desperately discharge the excess water so as to avoid total loss of the crops.

Although the sum of ₦155,400:00 was estimated as the total cost of farm produce lost by farmers interviewed. However, extent of the loss varies from one farmer to another. The amount of produce lost affect the investments made, both in financial and human efforts. Farmers in the area have also devise measures such as erecting epigy and producing loud sound from drums to scare away these birds during the day from attacking their crops in the fields. Many farmers in the area believe that the incidence of bird attacks on rice fields has not been as frequent as in the last five or six years.

4.5.1 *TYPHA* CONTROL IN THE STUDY AREA

Field investigation revealed that the respondents were applying some controlling measures to combat the menace of the *Typha*. Table 4.13 illustrates these measures and their effectiveness at particular monitoring sites.

Table 4.13: Some aspects of *Typha* Controlling Measures at some Irrigation Areas between 2007 and 2008

S/NO	MONITORING SITE	TYPE OF CONTROL APPLIED	OBJECTIVES OF CONTROL	% PLANT COVER AFFECTED	PERIOD TAKEN BY *TYPHA* SP TO START RECOVERY	OBSERVATIONS AFTER THE CONTROL
1	'Karfi' R/side ditch I	cutting of *Typha* stalks	To sell *Typha* stalks - economic	60	3 weeks from stumps	Surface water in the ditch has reduced partly from increased evaporation and reduced waterflow into the site.
2	'Dan-Isa' Burrow pit	Removal and use of fire suppression	To obtain access to water for irrigating crops by farmers.	98	42 days from unaffected underground rhizomes	Site became dried and top soil cracked. However 4 weeks after water flows into the pit from nearby roadside drain, plants recovered.
3	'Bauren Tanko' Burrow pit I	cutting of *Typha* Stalks	To sell *Typha* stalks by *Typha* stalks sellers.	45	2 weeks from stumps	Surface water available most of the time, however, water level reduces.
4	'Kura' Canal I	Clearing and desilting	To allow water flow through the canal and also prevent local flooding	100	30 days from deep underground rhizomes	Site is virtually moist all the time.

			during raining season			
5	'Kura' Burrow pit	Use of fire suppression and water abstraction.	To reduce cover and allow for easy access to fishes raised in the pit.	50	2 weeks from underground rhizomes unaffected by the heat.	Water level at the site was reduced significantly. Site became very muddy.
6	'Samawa' Burrow pit II	cutting of *Typha* stalks	Selling of *Typha* Stalks	80	3 weeks from cut stumps and underground rhizomes	Although site has water most of the time, the level fluctuates.
7	'Yadakwari' Burrow pit II	Removal of plant and use of fire suppression.	To obtain acess to water	100	30 days from deep underground rhizomes	Site became completely dried, because farmers nearby have abstracted the water before setting burning the plants.
8	'Daka Soye' Burrow pit I	cutting of *Typha* stalks	Selling of *Typha* Stalks	65	4 weeks from cut stumps	Surface water became very low but soil remained moist.
9	'Kura' Canal II	Clearing and desilting	To allow for water flow and prevent local flooding farmlands.	100	3 weeks from rhizomes buried underground.	Surface water available most of the time.

Source: Fieldwork 2007

Cutting of *Typha* stalks, removal and use of fire suppression, and clearing and desilting were the control measures used in the area. All these approaches are relatively effective. However, clearing and desilting was the most effective. All the control approaches lasts for only a short term before the weed recovers.

Various methods of controlling *Typha* weeds are employed in the Kano River irrigation areas. Table 4.13 described the relative effectiveness (in terms of plant coverage) of these measures. Apart from cutting of *Typha* stalks for sell, other control measures combine two approaches. The control of these weeds in canal by clearing and removal of silt was found to be the most effective. The approach successfully removed all the standing plants including most of the underground rhizome/root systems. Similarly, the removal and use of fire suppression was also very effective as was observed in “Dan-Isa” burrow pit and “Yadakwari” burrow pit. However, the approach was found to be fairly effective in “Bauren Tanko” burrow pit I, where the percentage cover affected was about 50%. Cutting of *Typha* stalks for sell contributes greatly in the reduction of the plant biomass in all the four sites where this control method was monitored. The percentage cover affected by cutting of *Typha* stalks ranged from 45% to about 80%. In the KRIP area, after cutting the weeds, re-growth occurred but after considerable period (approximately three months). Although in the KRIP area, cutting was carried out manually. However, in the Kano River Project area, cutting of *Typha* was found to be made only once and relatively below the water surface. Thus, leaving much of the under water biomass healthy and thereby capable of regeneration. The various control methods at KRIP showed varying degree of effectiveness. The desired objectives of removal and use of fire suppression as well as clearing/desilting were intended to allow for water flow in the case of canals and access to water in the burrow/gravel pits by farmers. The cutting of *Typha* stalks is mainly carried out by farm workers and the unemployed. These people engaged in the activity to obtain direct benefit in other words, earn some income from the sells of these stalks. Indirectly, however, their activity help control the weed and also facilitates the flow of water while in some situation provide access to water for other users such as farmers and fishermen. All the methods employed to control *Typha* sp weeds in the area are basically mechanical or physical approaches. Removing, cutting, use of fire suppression and desilting only reduce the above ground biomass and is usually short term control measure. It was observed in all the nine sites that the cut weeds re-establish itself after a couple of weeks. The difference in the period of recovery was found to be a function of water level at each site. Where the water level submerged the cut-stumps, recovery was observed to take longer period, while at sites where the water level is low, or the soil saturated, re growth was faster. Smith (1989) reported that *Typha* sprout quickly from surviving rhizomes following fires that remove the top growth.

4.6 ASSESSMENT OF THE CONTROL MEASURES ADOPTED AT KRIP

From site observation the result of the assessment of the control measures in terms of the scope, impact and ecological implications of the various control Typha measures is presented in Table 4.14.

Table 4.14: Comparison of the different *Typha* sp Control Measures employed at the Kano River Irrigation Project Irrigation areas 2008

CONTROL METHOD	EXTENT OF PLANT COVER AFFECTED	LIMITATIONS	NEGATIVE IMPACT	ECOLOGICAL IMPLICATIONS
Use of fire suppression	50	Fire burns only the above water level or above ground biomass. Underground rhizomes and roots are unaffected and regrowth from rootstocks and rizhomes occurs.	Destruction of wild bird's nests; kills birds, fishes, phyto and zooplanktons which play significant role in the flow energy in the habitat; contributes carbon dioxide and other gases into the atmosphere; and changes water chemistry.	Long term destabilization of the ecosystem and possible loss of biodiversity.

Manual/mechanical removal and fire suppression	98 – 100	Labourous and often costly; usually only the above water or ground levels biomass are affected. Where a mechanism was used, some of the stumps and rhizomes are also affected.	Also cause the destruction of wildlife habitats particularly birds. The use of tractor causes serious destruction to fishes and other aquatic animals.	Temporary to long term disruption of the equilibrum balance of the habitat.
Cutting of *Typha* stalks for sale	45 – 80	Largely/mostly fresh stems and leaves are removed at the base. The stumps are left intact. It is also a labourous activity and could also be risky.	Also cause the destruction of wild bird's nests, and lead to the displacement of fishes and other aquatic animals like rodents and reptiles.	Temporary disruption of the natural balance of the habitat.
Clearing and desilting	100	Labourous, time consuming, and often costly. Some underground rhizomes are usually unaffected. Similarly seeds buried in the soils are provided with the necessary condition for subsequent germination.	Destroys other organism that carries out life activities in the water environment or depends on the *Typha* for survival.	Relatively long term disruption of the habitat stability and possibly the loss of biodiversity in the habitat.

Source: Fieldwork 2008

Combined approaches like removal and fire suppression and clearing and desilting contributes to substantial reduction in *Typha* sp. cover/biomass. Single approach such as cutting of stalks and use of fire suppression barely remove half of the plant cover. However, each of these measures has some limitations, negative impact and ecological implications.

In Table 4.14 Comparison of the Typha sp. Control measures employed at KRIP is presented. The major limitation of fire suppression is that the heat only burns the above ground or water level plant biomass. The underground root and stem systems remain unaffected and from which the plant regenerate new ones. In addition, fire suppression is destructive because it usually kills other animals and destroys their nitches and this has long term ecological consequences on the environment and biodiversity. It should be noted that seemingly harmless alteration in the plant water environment could sometimes results in irreversible ecological damage. The use of manual removal combine with fire suppression is labourious and often costly. The farmers have to do it or engage other people to do it for them but at a cost. It also has the same disadvantage as the use of fire suppression alone.

Cutting of stalks is indeed labourious, time consuming and risky. Workers are often attacked by snakes and leeches. It takes hours to cut, remove and arrange the stalks into bundles. This approach resulted in the destruction of several wild bird's nest. The activity of these stalk cutters takes 3-4 hours because they select fresh ones and in the process temporarily disrupt the equilibrium state of the habitat. Controlling *Typha* sp weeds in the canals is more rigorous, it involves many people depending on the length of canal to be cleared, and takes several hours or few days. At the KRIP, affected farmers formed groups to carryout the clearing and desilting work but sometimes, they have to engage the services of farm workers for a fee. The only impact of this approach is that it destroys lower organisms living and interacting in the water. Although cutting of *Typha* stalks is regarded as one way of reducing these weeds, however, the sale of these plant materials in the area provided another perspective on this plant.

It is obvious from results so far that *Typha* sp .has caused some problems to farming and other related activities in the irrigation area. However, attempt at controlling the weed was limited to mainly physical//mechanical approaches. These measures has no doubt helped to reduce the impact of these weeds in the area but are inadequate and less effective, because only a small part of the areas invaded by *Typha* sp. the control was applied. A greater part of the canal network invaded by the weeds was not touched for about two years during the course of this study. Clearing *Typha* from such an extensive network of canal from “Karfi” to “Kadawa” requires huge resources, both human and materials which is beyond the capacity of the farmers affected by lack of effective water flow in the canal system. In an interaction with farmers in the area, most of them said they have been carrying out *Typha* reduction measures for nearly two decades either individually or as group. They complain that the water management authority i.e. Hadejia Jama’are River Basin Development Authority (HJRBDA) has neglected the clearing of weeds in the canals, channels and reservoir. There was also another complain about the water authority as regards the refusal to release water into the system regularly. This problem in addition to the clogging of the water flow caused by *Typha* growth, seriously affects their activities. The issue of payment of water rate has been a controversial issue between the farmers and the basin water management authority. The basin authority acknowledged the problem of *Typha* sp in the area. In an interaction with an extension official at the study site stated that lack of funds constrained the control of these weeds .He also expressed concern on the lack of routine maintenance of the irrigation facilities to ensure efficient water flow. We have observed that whenever water supply is not coming through the systems, farmers resort to collect water from the gravel/clay and sand pit to irrigate their crops by using pumping machines.

It was also observed that competing for water in the area has been intensified by increased farming activities, community water demand, and newly established fish farms. Almost on daily basis hundreds of children and adults are seen washing their clothes and taking both in the main water channels at “Kura”, “Samawa”, “Yadakwari” and “Kadawa”. Substances contained in the detergent used will dissolved or react with the water to form ions and complexes that could become serious pollutants. Another source of pollutants is the washing of fuel and oil tankers and equipment particularly at the

"Kadawa" reservoir. Long term contamination and subsequent movement into the food chain (crops) or food web could have a serious health implication.

4.7 MARKETING OF *TYPHA* STALKS AND INCOME EARNED

The investigation revealed that the stalk of the *Typha* is sold and used for several purposes. Table 4.15 illustrates the quantity and value of *Typha* stalks cut and sold at Kwanar Gafan Tomato market. Also, Table 4.16 illustrates the average income realized from the sales of *Typha* stalks by people engaged in buying and selling of these stalks between January and April.

Table 4.15: Average Monthly Supply of *Typha* stalks Traded at the Kwanar Gafan Tomato Market in 2008 Season

PERIOD (MONTH)	AVEARGE NUMBER OF BUNDLES OF *TYPHA* STALKS SUPPLIED PER DAY	TOTAL BUNDLES PER MONTH	AVERAGE WEIGHT OF BUNDLE (KG)	TOTAL WEIGHT (KG)	MONTHLY UNIT COST PER BUNDLE SOLD BY SELLERS (₦)	UNIT COST PAID BY *TYPHA* STALKS DEALERS (₦)	MONTHLY INCOME REALIZED BY *TYPHA* STALKS SELLERS (₦)	MONTHLY SELLING COST PER BUNDLE TO TOMATO TRANSPORTERS (₦)	MONTHLY INCOME REALIZED BY DEALERS AT THE MARKET (₦)
JAN	400	12000	35	420,000	30	50	240,000	70	240,000
FEB	800	24000	35	840,000	40	60	720,000	80	480,000
MARCH	1200	36000	35	1,260,000	45	60	1,260,000	80	720,000
APRIL	700	21000	35	735,000	35	50	735,000	70	420,000
TOTAL		**93000**		**3,675,000 tonnes**			**2,955,000**		**1,860,000**

Source: Fieldwork 2007

NB:- Each bundle of *Typha* stalk is transported from the surrounding area to the market at the cost of ₦10.00

Typha stalk is an important item at the 'Kwanar Gafan' tomato market. In the 4 months of tomato season, several thousands of the plant stalks are supplied and sold to the tomato traders. This activity `contributes to the removal of over 3000 tonnes of the plant biomass annually from the area. From the sales of these stalks, two groups - farm workers and labourers engaged in cutting and collecting these stalks as well as *Typha* stalks dealers earned reasonable incomes.

Table 4.16: Average Income of *Typha* stalk Sellers

MONTH	QUANTITY OF *TYPHA* STALKS PER BUNDLE SUPPLIED	TOTAL AMOUNT REALISED ₦	NO.OF TYPHA STALK SELLERS INVOLVED	AVERAGE INCOME PER SELLER ₦	AMOUNT REALIZED BY SELLERS ₦	NO.OF DEALERS INVOLVED	AVERAGE INCOME PER DEALER ₦
JANUARY	12000	480,000.00	72	6,666.70	240,000.00	9	26,666.70
FEBRUARY	24000	1,200,000.00	72	20,000.00	480,000.00	9	53,333.30
MARCH	36000	1,800,000.00	72	25,000.00	720,000.00	9	80,000.00
APRIL	21000	840,000.00	72	11,666.70	420,000.00	9	46,866.70

Source: Fieldwork 2007/2008

A *Typha* stalk seller earn between ₦6, 000:00 – ₦25,000:00 with the 4 month of the tomato season. While a stalk dealer earns between ₦26, 000:00 – ₦80, 000:00 from January to April. The peak period for the sales of *Typha* stalk is between February and March.

In Table 4.15, the average monthly supply of *Typha* stalks and amount realized is highlighted. A total of 93000 bundles of fresh *Typha* stalks weighing about 3675000kg of Typha stalks were supplied to the "Kwanar Gafan" tomatoes market between January and April 2008. The *Typha* stalk sellers realized over ₦2.9 million naira including the cost of transporting the material to the market at the cost of ₦10 per bundle charged for transporting the plant, It was estimated that ₦930,00:.00 was spent to transport the stalks from January to April 2008. The balance of 2,015,000 is the actual amount earned by the *Typha* stalk sellers. *Typha* stalks dealers on the other hand realized a total of ₦1, 860,000:00 in four month. What is however most important is the huge amount of the plant biomass about 3, 675, 000kg that is removed within a relatively short period. It is equally important to see the socio-economic significance of *Typha* a source of earning income. It can be observed in Table 4.16, that some 72 farm workers/unemployed youths were involved in cutting and selling of *Typha* stalks during the period of study. Individual income increased from ₦6, 666:70 to about ₦25,000.00 per month. The *Typha* stalk dealers are fewer and operate as a registered outfit. The dealers earned an average of ₦26, 666:70 to about ₦80,000.00 per month. It must however be emphasized that supply of *Typha* stalks to the market is not on daily basis, but depends on the volume of tomatoes reaching the market and ready for transportation. The peak period for the tomatoes business is from February to March. The trade in *Typha* stalks no doubt supports a number of unemployed people economically. The cutting and trade in Typha stalks is vividly captured in the appendix (see plates 1-3).

But why is the plant *Typha* important in the transport of commercial tomatoes from the "Kwanar Gafan" market? Part of the answer relate to the nature of the plant. The leaves of this plant stores considerable amount of water which makes it an ideal choice for preserving perishable items like fresh tomatoes intended for distant transportation under the prevailing hot weather condition during the tomatoes season. The other part of the answer is that the plant is readily available, cheap and convenient to use.

The Kano River Irrigation Project area is one of the major tomatoes production centre in the country. "Kwanar Gafan" market is perhaps the most popular commercial tomatoes market in Kano State. Every year between January and May, thousand of vehicles transport tomatoes from the market to different parts of the country. It is however difficult to obtain reliable record of the number of vehicles as well as the quantity of tomatoes transported from the market .However, one make a conjecture. A 30 tons truck is usually loaded with 350 – 400 average size baskets of tomatoes and covered by 30 bundles of *Typha* stalks. It was also learnt that *Typha* stalks are sometimes transported to Jama'are in Bauchi State for use to load tomatoes from there to other parts of the country. However, the cost of a bundle of *Typha* stalk there is much higher than at the Kano market. It is important to note that at present the system of transporting commercial tomatoes from "Kwanar Gafan" market and "Jama'are" is by cane woven baskets loaded onto trucks and other smaller vehicles which take some days to reach their destination. The fresh leaves of the *Typha* stalks provide both cushining and the necessary moisture to protect the items during the journey. It is evident that without this plant material the extent of loss of tomatoes caused by wilting is remarkably high. Although some losses are incurred due to the compact arrangement of the tomatoes in the baskets, however, the extent of loss in most cases is said to be low. It was observed that the cut stalks often include parts of the fruit and seeds and are subsequently transported together with the tomatoes to other parts of the country. This practice will no doubt help greatly in the dispersal of this plant to areas where the plant does not exist. Once the plant becomes successfully established in the new areas, the long term ecological implication may be very costly for both the people that would be directly affected as well as government.

Apart from cutting and selling of *Typha* stalks, the people also uses the plant in different ways. The leaf of the plant is use in raising seedling of tomatoes onions, water melons, and other crops. The leaves are used to cover seedling beds the objective is to provide some moisture and necessary warmth for the germinating seeds, but also to protect the seedlings but also to prevent animals from eating the seedling. These seedlings are usually sold to farmers. Farmers purchase and transplant them on their plots. Similarly, the *Typha* stalks are cut and used for fencing of farmlands or plots against stray animals. Some people use the leaves as Thatched roofs, and pens. Some people collect the stem and weeve them into basic household items for sell. Children collect and consume the immature male inflorescence. Besides these uses of the plant, many people in the area particularly farmers prefer the eradication of these weeds. It was clearly observed that the sell of *Typha* stalks, and its ethno-botanical (socio-cultural uses) and the control measures usually employed has not led to a significant reduction of the weed, however, these activities have to some extent reduced the impact of the effects of the weeds and thus in its management.

As part of the objectives of this study, data obtained would be used to produce a conceptual approach for environmental management of the Kano River Irrigation Project area. The approach would link *Typha* aquatic weed, hydrology and human activities.

The KRIP project is used to cover human needs in many ways. The irrigation system is very important to the economy of Kano state. It supports millions of people, contributes substantially to the gross local product among others. However, widespread growth of *Typha* sp. hampers its uses in different ways. Two key aspects of the proposed approach for efficient water management in the KRIP areas, relate to the KRIP project objectives and stakeholders and the issues investigated in this study.

CHAPTER FIVE

PROPOSAL FOR AN INTEGRATED ENVIRONMENTAL MANAGEMENT

5.1 INTRODUCTION

From the observations and data generated in this study it is realized that an integrated environmental approach is required in the study area for a sustainable water and irrigation management. The water management problem in the area is associated with a high number of objectives and stakeholders that are involved. These are variables that are known with a low or very low level of accuracy but that are strongly interconnected and belong to different scientific disciplines (chemistry, biology, engineering and socio-economics, etc). The types and qualities of information from different components of the system is necessary. This information had to be arranged and structured so as to allow systematic analyses.

5.2 NATURE OF THE APPROACH

After nearly thirty (30) years of irrigation in the Kano River Irrigation Project area, it is useful to try and assess the positive and negative effects. Significance of the investment in the project structure can be evaluated by the dam and the amount used to irrigate crops and produced drinking water. Such issues are very difficult to assess without a management model. The integrated management approach presented here cannot give quantitative estimates of impacts; it only gives a good idea of what can be done.

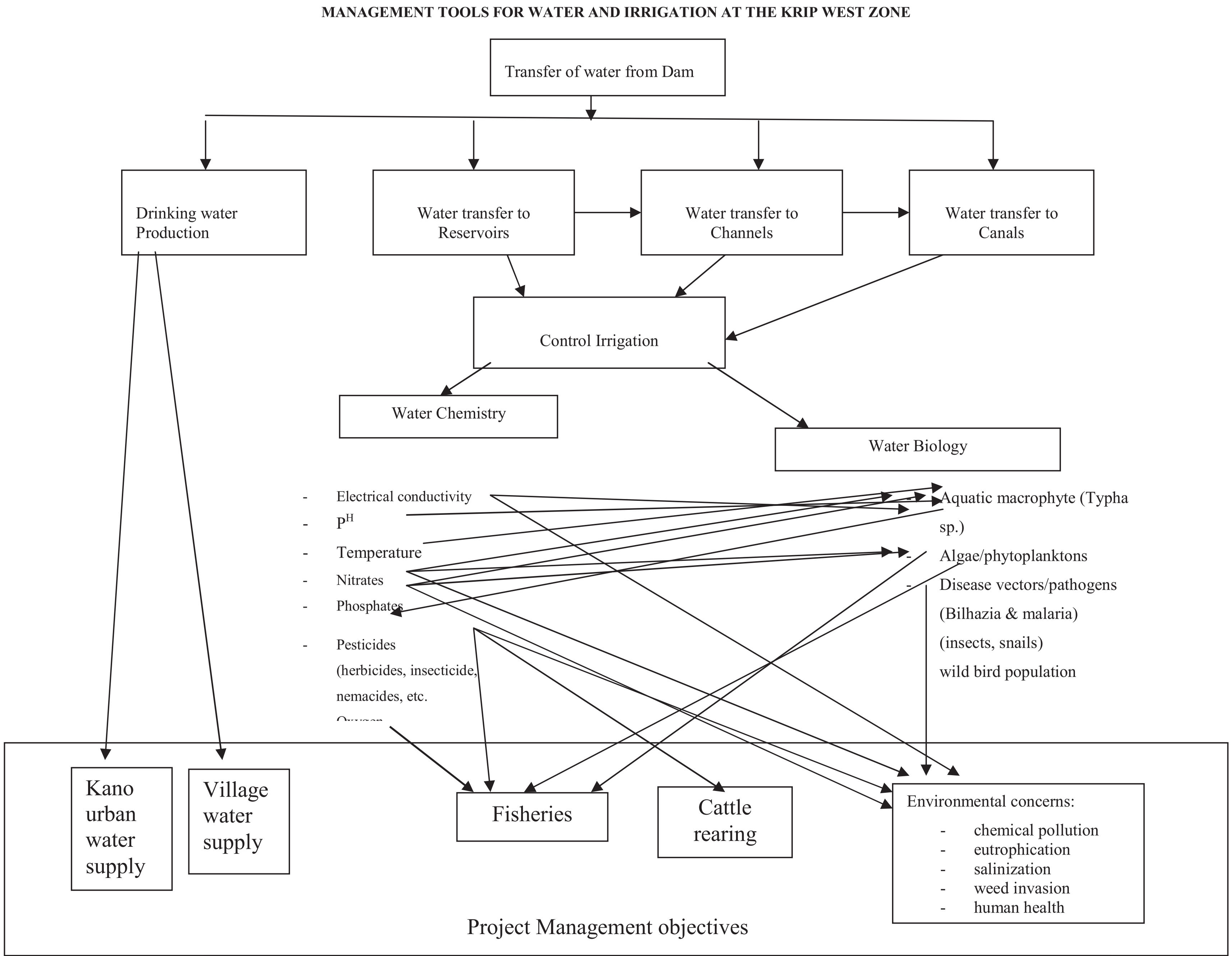


Figure 5.1: A Flow chart that demonstrates the broad set of impact matrices regarding water and irrigation activities in the KRIP area.

A solid line stands for a strong link and a dotted line for a weak link. The flow chart is classified into activities of the water and irrigation management authorities; water chemistry; water biology and management objectives. Management variables are integrated to cover the river project itself as well as its economic importance, whereas water biology and water chemistry variables are specific impacts of irrigation activities.

A flow chart of such an important ecosystem is fairly complex. Yet, it is very interactive and intuitively clear. It is designed on a mixture of very diverse types and qualities of information from different components of the project and its impact. Water from the dam is used for producing drinking water, and stored in reservoirs, distributed through main channels and subsequently into irrigation canals. Controlled irrigation is facilitated by water from the reservoirs, channels and network of canals. Crop production and other human activities in the irrigation area affects water chemistry by either creating and or increasing the level of dissolved solids (electrical conductivity); nitrate; phosphate; low oxygen level; P^H; temperature; and chemical pollutants (from herbicides, insecticides, nematocides, etc). Change in water chemistry in turn affects water biology. Notable effects include aquatic weed invasion such as *Typha* sp.; algal/phytoplankton growth; disease vector/pathogens such as insects (mosquitoes); snails; and large population of wild bird. Similarly, chemical pollutants find their way into fishes as well as cattle and other livestock that consume the water. Local fishing and cattle rearing are alimentation for the local population. In the dry season, cattle rearing dependent greatly on access to surface water (in reservoirs, burrow pits and canals). The Kano River Irrigation Project (KRIP) is situated in a relatively fragile environment that has undergone changes in recent decades due to decreasing precipitation and river flow; expanding agriculture, particularly irrigation; other pressures of a rapidly increasing population, such as deforestation. Irrigated agriculture is a major threat to water quality in terms of salinization, eutrophication and chemical pollution. Nutrient enrichment is also a problem; macrophytes, particularly *Typha* sp. as well as blue-green algae are favoured by the nutrients; and associated with the dissolved solids which enters the water from runoff, are also sources of micro pollutants. Additional threats are from huge population of wild birds which feeds on grains (rice, wheat, millet and sorghum). These issues remain the most serious environmental concerns in the study area.

Table 5.1: Relevant issues for an integrated management of Kano River Irrigation Project Environment

1. **Some of the issues studied:** • Basic water chemistry: P^H, conductivity, temperature *Typha* aquatic weed	2. **Short and long term water quality problem:** • Salinity • Eutrophication • Macrophytes Malaria and schisbsomes
3. **Objectives and Stakeholder:** • Urban Kano water supply • Local water supply • Agricultural water demand (irrigation) • Fishing and cattle rearing Environment	4. **Management challenges:** • Control of dissolved solutes and nutrient load from irrigated agriculture • Control of diffuse pollution • Control of macro vegetation

5.3 THE NEED FOR AN INTEGRATED ENVIRONMENTAL MANAGEMENT APPROACH

From the Figure 5.2, we have illustrated some of the issues regarding irrigation and the environment of Kano River Irrigation Project and thus, the need for a better and scientific understanding of this environment in order to mitigate environmental impacts. An integrated ecosystem based management approach is put forward as a means to maintain sustainability of irrigation in the area and to mitigate negative impacts on the environment. Interdisciplinary and holistic research is needed to further analyse such complex variables and scenario analysis in a coherent fashion. This approach encourages a learning process from scarce, incomplete and subjective information that would lead to a complete, causally structured, and consistent database which allows the analysis of policy related scenarios and therefore a tool for decision making.

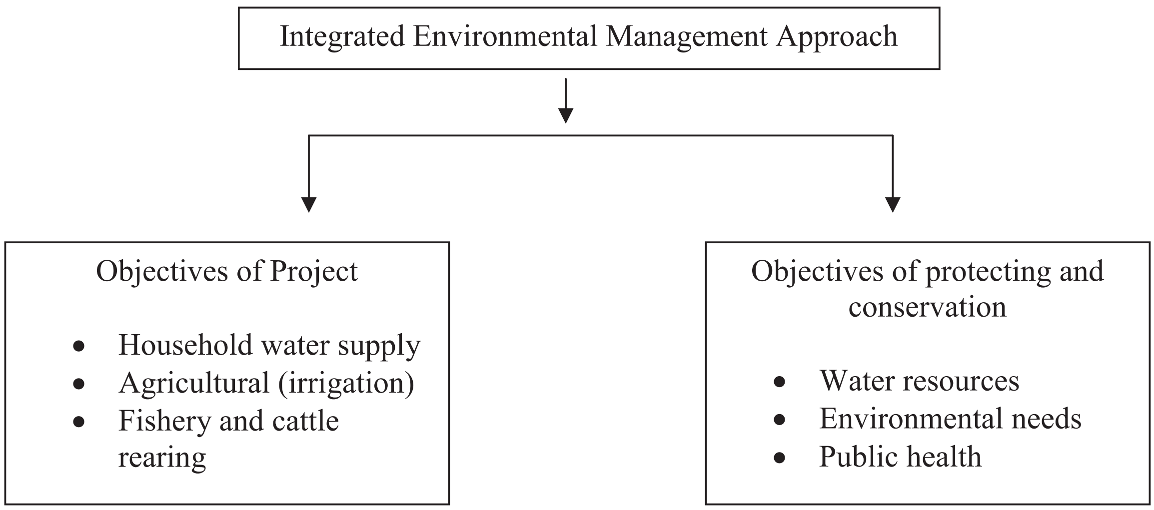


Figure 5.2: Trade-offs and balance between socio-economic activities and sustainable resource use for the KRIP zones

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY OF FINDINGS

It is evident that *Typha* is a species of weed in the study area. It is found in irrigation canals, channels, reservoirs, farm ponds, roadside drains, and pits of different origins. Based on diagnostic features; description, size, comparison with members of the plant's group or taxon as well as confirmatory comments by some taxonomists, the species found in the Kano River Irrigation Project area is *Typha domingensis* pers. This particular species is also found in the downstream areas of the Kano River at the Hadejia barrage, Baturiyya reserve, and the Hadejia-Nguru wetlands where it has caused irreparable damage to the ecosystem and constrained human activities like farming and fishing.

The species has a remarkable tolerance to water level fluctuations, high nutrient level, produce an average of 78 shoot/stems density per meter square. In addition, the mean values of physicochemical condition of the water such as temperature, P^H, and conductivity are within its optimum levels for growth and development. This partly explains the presence of dense growth of this weed in the invaded sites.

It is probable that prior to the establishment of the project, this plant was not a common plant of the area. But as a native flora of tropical freshwater environment, it has greatly taken advantage of changes in water condition and increasing human activities in the area to proliferate and spread rapidly over the years. The spread of this plant in the irrigation system networks, has affected human activities as regards the use of water by the people. The plant is responsible for inefficient water flow in the system, loss of water through evapo-transpiration, siltation of canals, channels and drainages; and provided a cover as well as nesting habitats for huge population of destructive bird species.

The consequences of this situation are inadequate water for growing crops which affects farm activities; loss of farm produce such as rice due to localized floods and birds infestation suffered by farmers.

Farmers and others affected in the course of using the water, employ fire suppression or burning, cutting, physical removal, clearing and desilting to clear *Typha* from water sources so as to ensure effective flow and access. The measures taken has to some extent enable the people minimize the impact of these weeds. However, it is only for a brief period of time before the weeds recovers and the cycle continues.

An interesting finding of this study is the trade in *Typha* stalks at the 'Kwanar Gafan' tomatoe market. The plant stalks are sold as articles to tomatoes traders who use it to preserve and transport large quantities of the crop across the country during the tomatoes season. The stalk has become a source of income for some people and this activity seems to be expanding to nearby states like Jama'are in Bauchi State. Cutting and selling *Typha* stalks contributes substantially to the management of the weed in the area at present and perhaps in the nearest future, because it is readily available, cheap and convenient to use.

Finally, it has been shown that the interplay of environmental factors nutrient enrichment such as water level fluctuation, water depth, moderate temperature, conductivities ranging from about 40 to over 330μsm^{-1} and P^H greater than 6.0 are important part of action plans covering research policy, monitoring, and management that would contribute to the continuous realization of the project objectives.

6.2 CONCLUSION

It is obvious that conditions in the Kano River Irrigation Project environment has changed over the years, and one of the dramatic effects of this change is the proliferation of dense growth of *Typha domingensis* – a serious aquatic weed. The spread of this weed particularly in irrigation system hampers farming activities in varying degree. Control measures used are inadequate, relatively effective but short-lived. The control approaches are not based on any knowledge of the plant's life cycle or growth strategy. If conditions favourable to this weed continue to manifest with no appropriate intervention in the nearest future, the objectives of the KIP project would be seriously undermined.

The use of *Typha* stalks in packaging and transportation of large quantities of tomatoes opens yet another opportunity for the utilization of this plant in broad economic activities. The use of this plant could be considered important aspects of its management. An environmental management for protection of the environment and sustainable water resource management is part of the project objectives, but increasing environmental problem in the areas indicates poor or failure to implement the necessary measures. Thus, there is the need for improved management in the context of current impacts.

6.3 RECOMMENDATIONS

The following recommendations are made towards a sustainable irrigation in the study area:

Firstly, *Typha domingensis* pers., the otherwise species found in the Kano River Irrigation Project area will continue to expand its range in this area and other similar ecosystems in the region, unless changes in ecology and environment of the area are adequately monitored and controlled by the water management authority.

Secondly, improving control strategy for *Typha* weeds. This requires greater understanding of the biology particularly its phenology and reproduction as well as the environmental factors that enable it to colonize and dominate habitats or ecosystem and subsequently landscape. Control or managing of *Typha* in the area deserves quite some attention because farmers and other water users lack the capacity to deal with the weed adequately. It is therefore necessary to include *Typha* control as part of the integrated management of aquatic invasive weeds as an important objective of the water management authority (i.e. Hadejia-Jamma'are River Basin Development Authority), as well as the Federal Ministry of Environment.

Thirdly, introduce an irrigation habitat survey (IHS) that would obtain detailed assessment of aquatic plants, physical habitat, and water chemistry of the area. The survey data will help to determine the link between ecological factors of habitat, water chemistry, trophic status, with the phyto-sociological plant association.

Fourthly, there is the need for further study of Typha sp. on the eastern zone as part of Environmental Impact Assessment.

Finally, there are prospects for the use of *Typha* as biofilters and chemical traps especially of heavy metals, nutrient or troublesome nitrogen and phosphorous; folk medicine and energy or biomass fuel. These should be explored through research either separately or jointly by the National University Commission and Raw Materials Research and Development Council of Nigeria.

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APPENDICES

QUESTIONAIRE ADMINISTERED TO *TYPHA KACHALLA* STALK DEALERS AT THE FAMOUS KWANAR GAFAN TOMATOE MARKET IN GARIN MALLAM LOCAL AREA OF KANO – 2007.

1. How long has he been engaged in this trade?
   - A. 1 to 2 yrs
   - B. 3 to 5 yrs
   - C. 5 to 10 yrs
   - D. 10 to 15 yrs
   - E. Above 15 yrs

2. How much does he buys a bundle of fresh Typha stalks?
   - A. ₦30
   - B. ₦40
   - C. ₦50
   - D. ₦60
   - E. Above ₦60, specify ………

3. How much does he sells a bundle to the Tomatoe dealers in the market?
   - A. ₦50
   - B. ₦60
   - C. ₦70
   - D. ₦80
   - E. Above ₦80, specify ………

4. About how many bundles does he buy a day?
   - A. 10-20
   - B. 20-30
   - C. 30-50
   - D. 60-100
   - E. 150-200

5. When is the peak for this type of business?
   - A. Beginning of the tomatoe season
   - B. At the height of the tomatoe season
   - C. Towards the end of the Tomatoe season

6. Are there other people or group participating in the business of Typha stalks in the market:
   A. Yes B. No

   If yes, specify

   …………………………………………
   …………………………

7. How many bundles are required to load a truck of tomatoes?
   - A. 10 bundles
   - B. 20 bundles
   - C. 30 bundles
   - D. 40 bundles
   - E. Above 40, specify………

8. How many baskets of Tomatoes are required to fill a truck:
   - A. 50
   - B. 80
   - C. 100
   - D. 120
   - E. Above 120, specify……..

9. On the average how many trucks of Tomatoes are loaded daily?
   - A. 10
   - B. 20
   - C. 30
   - D. 40
   - E. Above 40, specify………

10. What is the weight of a basket full of tomatoes?
    - A. 10 kilogram
    - B. 15 kilogram
    - C. 20 kilogram
    - D. 25 kilogram

E. 30 kilogram
F. Others, specify…………

11. How long does tomatoe season last?
    A. 2 months
    B. 3 months
    C. 4 months
    D. 5 months
    E. 6 months

12. Does he have an association of tomatoe dealers?
    A. Yes B. No

13. Is this trade a sustainable means of livelihood?
    A. Yes B. No

14. Does he engage in other means of sustenance besides trading in Typha stalks?
    A. Yes B. No

    If yes specify

    …………………………………..

15. Is he aware of the concerns by farmers regarding this Typha plants?
    A. Yes B. No

16. Does he support the call by others for the total elimination/eradication of these plants in the area?
    A. Yes B. No
    Give reasons…………………………………
    ………………………

17. Could he give an average income from the trade in Typha stalks per day?
    A. ₦500
    B. ₦1000
    C. ₦2000
    D. ₦5000
    E. Above ₦5000, specify…..........................

QUESTIONNAIRE ADMINISTERED TO FARMERS IN THE KRIP ZONE – 2007

1. Years of farming in the area
   A. Less than 5 yrs
   B. 5 – 10
   C. 11 – 15
   D. 16 – 20
   E. Over 20

2. Size of farmland
   A. Less than 1 acre
   B. 1-4 acres
   C. 5-10 acres

3. Crops raise in dry season (Tick as many as are relevant)
   A. Tomatoes
   B. Onions
   C. Sugar cane
   D. Cabbage
   E. Water melon
   F. Garden egg
   G. Maize
   H. Wheat

4. Crops raise in wet season
   A. Rice
   B. Maize
   C. Millet
   D. Guinea corn
   E. Others, specify………………

5. Average crop yield in dry season crop. Amount (No.of bags, baskets, No.of stalks)

Crop	Amount
A. Tomatoes	…………………
B. Onions	….......................
C. Sugar cane	…………………
D. Cabbage	…………………
E. Water melon	…………………
F. Garden egg	…………………
G. Maize	…………………
H. Wheat	…………………

6. Average crop yield in wet season (Bags Tonnage)

Crop	Amount
A. Rice	…………………
B. Maize	….......................
C. Millet	…………………
D. Guinea corn	…………………
E. Others, specify	…………………

7. Is he aware of the Typha Geron Tsunsu plant (Kachalla) in the area?
   A. Yes B. No

8. When did he first notice these 'kachalla' plants in the area?
   A. 1 – 5 yrs ago
   B. 6 – 10 yrs ago
   C. 11 – 15 yrs
   D. 16 – 20 yrs
   E. Over 20 yrs

9. Is the plant (Geron tsunsu) an indigenous species?
   A. Yes B. No

10. If the plant is an exotic species, where does he think it came from?
   A. From nearby States
   B. Along with the irrigation Project
   C. Transported via water from distant places
   D. Introduced by foreigners
   E. Came along with imported seeds

11. Does this plant affect his farming activity?
   A. Yes B. No

12. How do these plants affect the yields of crop in his farmland?
   A. Seedling growth
   B. Crop maturity
   C. Yield loss
   D. Flow of water
   E. All of the above

13. What aspects of the life of these plants (kachalla) (biology) Geron tsunsu does he know?
   A. Water level necessary for their growth

B. Rapid growth
C. Slow growth
D. Nature of dispersal of seeds
E. Growing all year round

14. Is he engaged in some control of these plants?
A. Yes B. No
15. If yes, which of these measures was used
    A. Manual cutting and removal
    B. Use of herbicide
    C. Mowing
    D. All of the above
16. Which of the measures used was the most effective?
    A. Manual cutting and removal
    B. Use of herbicide
    C. Mowing
    D. All of the above
17. What difficulties are encountered in this control?
    A. Labourous/tedious
    B. High cost of chemicals inadequate effectiveness
18. Were there attempts by government or non governmental organizations to control these plants in the area?
A. Yes B. No
19. Does he require assistance to control these plants?
A. Yes B. No
20. Should these plants be cultivated completely from this area?
A. Yes B. No

If yes, give reasons
………………………………………
…………………………

QUESTIONNAIRE ADMINISTERED TO PERSONS CUTTING AND SETTING *TYPHA* STALKS IN THE KRP PHASE ONE ZONE 2007

1. How long has he been engaged in this activity?
   A. 1 - 2 yrs
   B. 3 – 4 yrs
   C. 5 – 9 yrs
   D. 10 – 15 yrs
   E. Over 15 yrs

2. What prompted him to engage in this activity?
   A. Lack of employment
   B. To earn a living
   C. To earn some money

3. How did he care about this type of work?
   A. Through a friend
   B. Through those engaged in it
   C. Information from ………

4. Does it require any skill?
   A. Yes B. No

5. What tools does he require to carryout the activity?
   A. Knife B. Strings C. Sickle
   D. Others, specify ___________
   ____
   ____

6. What stage of the plant is?
   A. Young stage
   B. Before flowing
   C. After flowing
   D. Fruiting stage

6b. What part of the plant is useful to him?
   A. Stem/Stalk
   B. Leaves
   C. Stalk and Stem

7. How many stalks are there in a bundle?
   A. 5
   B. 10
   C. 15
   D. 20
   E. 25 and above

8. Who determines the number per bundles?
   A. Discretion
   B. The buyers
   C. Pricing convenience

9. Who determine the price of one or the bundle?
   A. You
   B. The buyers
   C. Rate of supply
   D. Market demand

10. How many bundles does he sell in a day?
   A. 5 - 9
   B. 10 - 14
   C. 15 – 19
   D. 20 - 24
   E. Above 25

11. Can he estimate the average income made from the sales of these plant stalks in a month?
   A. ₦5,000 – ₦9,000
   B. ₦10,000 – ₦14,000
   C. ₦15,000 – ₦19,000
   D. ₦20,000 and above
   E. N25,000.00 and above

12. Is he aware of the reason(s) why this particular plant is preferred by the buyers?
   A. Yes B. No

12b. If yes, specify…………………

…………………………………

13. How long does this type of trade last?
    A. One month
    B. 2 months
    C. 3 months
    D. 4 months
    E. 5 months and above

14. What is the best season for type of activity?
    A. Dry season B. Wet season

15. Does he have an idea of the number of people actively engaged in this type of activity?
    A. Yes B. No
    If yes, give number
    …………………………………

16. Is he aware of other uses of this plant besides packaging of Tomatoes?
    A. Yes B. No
    If yes, specify
    …………………………………

17. Is this a sustainable means of income generating activity?
    A. Yes B. No

18. Which of these activities does he engaged in besides cutting & selling Typha plant stalks?
    A. Self employed farming
    B. Hire labour on farms
    C. Loading farm products on vehicles
    D. All sorts of menial work
    E. Trading in farm products

19. Is he aware of the concerns by farmers about these plants in the area?
    A. Yes B. No

20. Does he support the call for the complete elimination of these plants from the area?
    A. Yes B. No

21. If not, give reasons
    ………………………………………..
    …………………………………………
    …...
    ....

22. Are there risks involved in this type of activity?
    A. Yes B. No
    If yes, specify…………………

23. Where did he come from?
    A. A resident of the area
    B. From another Local Government Area
    C. From another State
    D. From outside Nigeria

INFORMATION REQUIRED ON THE ACTIVITIES OF THE HADEJIA-JAMA'ARE RIVER BASIN DEVELOPMENT AUTHORITY (HJRBDA) KANO

1. What are the activities of the authority?
   i. ……………………………………………
   ii. ……………………………………………
   iii. ……………………………………………
   iv. ……………………………………………

2. When was the authority established?
   ……………………………………………

3. What are the achievements of the authority from the inception to date?
   i. ……………………………………………
   ii. ……………………………………………
   iii. ……………………………………………
   iv. ……………………………………………
   v. ……………………………………………
   vi. ……………………………………………
   vii. ……………………………………………

4. When did irrigation begin in your zone of operation?
   ……………………………………………

5. What is the estimated size of land under irrigation in your zone?
   ……………………………………………

6. Is the authority aware of Typha species (kachalla) or ('Geron-tsuntsu') in the area?
   A. Yes B. No

7. When was this plant first noticed in the area?
   ……………………………………………

8. Do you have any idea of its origin or how it came to the area? Please explain:

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………

9. List possible factors that have facilitated its spread in the area?

   i. ……………………………………………
   ii. ………………………………………………
   iii. ………………………………………………
   iv. ………………………………………………
   v. ………………………………………………

10. Does the plant, Typha sp cause any problem to irrigation around the area?

   A. Yes B. No

11. What are the problems caused by Typha sp in the area? Please list them.

   i. ………………………………………………
   ii. ………………………………………………
   iii. ………………………………………………
   iv. ………………………………………………
   v. ……………………………………………

12. What specific measures were taken by the authority to control these weedy plants in the area?

   i. ………………………………………………
   ii. ………………………………………………
   iii. ………………………………………………
   iv. ………………………………………………
   v. ………………………………………………

13. Are there available records on these plants with the authority?
A. Yes B. No
If yes, kindly allow us access to these records.

14. Were there studies on Typha sp or investigation conducted by officials of the authority?
A. Yes B. No
If yes, please
specify…………………………………………………………………………………
…………………………………………..

15. Has the authority received complaints from farmers in the area regarding these plants?
A. Yes B. No
If yes, how many of such complaints were
received………………………………………………………………………………
……………..

16. Are there records of crop losses as a result of floods created by blocked channels, and canals in the area?
A. Yes B. No
Please give specific case and estimated losses
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………....

17. Is the authority aware of any economic value of the plant?
Please, specify them.
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………

(a) AVERAGE MONTHLY RECORDS OF P[H] OF WATER SAMPLES FROM *TYPHA* SP HABITATS BURROW PITS IN THE KANO IRRIGATION ZONE 2007/2008.

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	PH	PH	PH	PH	PH	PH	PH	PH	PH	PH	PH	PH
1	Karfi I	7.38	8.23	8.64	9.72	9.54	8.51	7.97	8.01	8.01	8.23	8.12	8.21
2	Karfi II	7.66	8.42	8.71	9.79	9.55	8.56	7.97	8.05	8.02	8.21	8.14	8.17
3	Dan Isa	7.63	8	8.58	9.66	9.55	8.56	7.96	8.02	8	8.25	8.18	8.22
4	Tatarace	7.22	8.16	8.65	9.76	9.57	8.58	7.96	8.02	7.88	8.22	8.21	8.24
5	Imawa I	7.38	7.95	8.54	9.73	9.58	8.6	7.96	8.01	8.01	8.21	8.14	8.22
6	Imawa II	7.63	8.02	8.53	9.69	9.6	8.61	7.96	8	8.01	8.2	8.18	8.25
7	Imawa III	7.51	8.11	8.61	9.7	9.57	8.63	7.97	8.01	7.68	8.21	8.22	8.24
8	Bauren Tanko I	7.48	7.96	8.62	9.71	9.63	8.65	7.97	8.03	8.02	8.23	8.21	8.23
9	Bauren Tanko II	7.63	8.14	0	9.8	9.36	8.72	7.96	8.04	8.04	8.28	8.23	8.45
10	Kura I	7.31	7.92	8.61	9.64	9.58	8.6	7.98	8	8.02	8.25	8.18	8.24
11	Kura II	7.64	8.29	8.71	9.71	9.6	8.64	7.99	8.02	8.01	8.24	8.24	8.23
12	Kura NRC	7.56	8.24	8.71	9.71	9.56	9.66	7.98	8.02	8.03	8.23	8.21	8.26
13	Kura Mud-bricks	7.82	8.29	8.72	9.73	9.58	8.65	7.97	8.01	8.02	8.22	8.21	8.27
14	Yadakwari I	7.75	8.09	8.62	9.8	9.33	8.71	7.98	8.03	8.03	8.21	8.25	8.27
15	Yadakwari II	7.74	8.16	8.83	9.73	9.34	8.65	7.96	8.03	8.04	0	0	0
16	Daurawal Sallaw	7.76	8.29	8.76	9.69	9.36	8.7	7.95	8.02	8.03	8.27	8.37	8.41
17	Dako Soye	7.86	8.17	8.67	9.81	9.37	8.69	7.97	8.02	8.02	8.26	8.36	8.37
18	Samawa I	7.66	8.28	8.67	9.68	9.6	8.69	7.97	8.01	8.03	8.23	8.21	8.26
19	Samawa II	7.73	8.01	8.56	9.71	9.52	8.67	7.98	8.02	8.02	8.25	8.19	8.28
	Mean	7.5974	8.1437	8.197	9.7247	9.5153	8.69	7.97	8.02	7.9958	7.8	7.7815789	7.83263
	Sample Variance	0.31	0.02	3.96	0.002	0.01	0.06	9.90E-05	0				
	Standard Deviation	0.18	0.14	1.99	0.05	0.103	0.24	0.01	0	0.0837	1.88899	1.8854539	1.89803
	Standard Error	0.04	0.03	0.46	0.011	0.023	0.06	0	0				

(b) AVERAGE MONTHLY RECORDS OF TEMPERATURE(°c) OF WATER SAMPLES FROM *TYPHA* SP HABITATS BURROW PITS IN THE KANO IRRIGATION ZONE 2007.

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.
1	Karfi I	28.48	27.2	25.45	26.53	26.98	25.75	22.67	19.3	17.83	16.43	21.93	23.1
2	Karfi II	28.87	27.2	25.2	26.2	26.75	25.4	19.63	14.6	16.2	16.03	19.65	22.3
3	Dan Isa	28.2	26.48	25.23	26.43	26.1	23.83	19	17.4	16.97	16.83	23.28	23.73
4	Tatarace	27.93	27.32	25.5	26.35	26.38	25.63	21.21	18.68	17.3	15.98	22.6	23.83
5	Imawa I	28.27	26.22	26.28	26.05	27.93	26.5	20.33	19.08	17.8	17.45	22.68	22.63
6	Imawa II	29.1	27.9	26.45	26.95	27.28	26.4	22.97	20.67	17.7	18.58	23.75	24.7
7	Imawa III	28.6	27.38	26.03	26.35	27.15	26.25	22.8	19.8	17.43	17.55	23.13	24.75
8	Bauren Tanko I	28.57	27.75	26.1	26.93	27.52	26.23	21.2	18.13	17.73	17.5	23.68	24.48
9	Bauren Tanko II	32.3	31.3	0	27.73	28.83	28.55	25.17	23.68	19.87	22.73	28.05	28.95
10	Kura I	27.6	30.13	26.1	27.1	28.8	27.45	23.63	19.58	17.83	19.1	23.5	24.8
11	Kura II	29.6	28.63	27.02	27.28	28.93	28.38	24.73	22.13	18.53	18.89	24.88	26.1
12	Kura NRC	30.23	28.45	26.38	27.4	29.13	27.93	22.8	19.73	18.97	15.1	23.3	25.33
13	Kura Mud-bricks	30.5	29.1	26.1	27.2	28.98	27.13	23.2	20	17.97	20	24.78	25.83
14	Yadakwari I	32.5	32.25	28.03	28.28	28.7	28.58	23.9	18.83	19.3	24.43	27.33	28.55
15	Yadakwari II	32.23	30.4	25.27	29	30.1	31.18	25.9	21.45	19.9	0	0	0
16	Daurawal Sallaw	29.9	30.08	26.73	28.35	29.2	29.65	26.5	20.4	20.2	20.75	25.3	27.55
17	Dako Soye	28	29.25	27.22	27.8	28.65	28.53	24	23.75	20.9	22.1	26.15	27.18
18	Samawa I	31.87	29.7	26.78	27.45	28.6	30.35	26.17	22.73	18.3	19.7	25.3	27.1
19	Samawa II	31.4	29.4	26.73	26.83	28.28	27.22	22.8	19.4	18.2	18.85	23	24.88
	Mean	29.692	28.744	24.87	27.169	28.121	27.42	23.08	19.965	18.365	17.7895	22.752105	23.9889
	Sample Variance	2.74	2.72	36.83	0.64	1.2	3.36	4.54	4.82				
	Standard Deviation	1.66	1.65	6.07	0.8	1.09	1.83	2.13	2.1959	1.2076	4.95625	5.8375181	6.10752
	Standard Error	0.38	0.38	1.39	0.183	0.25	0.42	0.49	0.5				

(c) AVERAGE MONTHLY RECORDS OF CONDUCTIVITY (μsm^{-2}) OF WATER SAMPLES FROM *TYPHA* SP HABITATS BURROW PITS IN THE KANO IRRIGATION ZONE 2007.

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.
1	Karfi I	600	608	588.3	536	301	278.5	332	244.75	313	518.25	375.5	331.25
2	Karfi II	140	145	151.3	123.66	110.75	87.25	110	191.5	92	113.25	89	123
3	Dan Isa	124	138	150.5	158.25	117.25	150.25	282.66	386.25	59.33	104.25	74	107.5
4	Tatarace	164	196	145.3	174.75	123.75	90.25	102	144.75	69.33	98	70.5	77.75
5	Imawa I	333	318	442.8	270.75	204.25	166.5	142	202.5	177.7	220.75	217	202
6	Imawa II	164	166	224.5	187.5	139.25	109	119	127.5	109	144.75	119.73	112.5
7	Imawa III	185	158	141.3	186.5	147.75	106.25	126	124.75	86.33	140	78.5	80
8	Bauren Tanko I	330	326	263	181.5	155.5	132.5	185	150.25	112	207	164.25	139.75
9	Bauren Tanko II	173	160	0	273.25	208.25	118.25	74	82.25	84.7	126.75	120	199.5
10	Kura I	797	673	554.3	562.5	598.25	501.75	446.66	371.25	424	574	470	430.75
11	Kura II	227	239	253.5	215	166.5	109.75	130	124.75	112.7	190.5	138.5	134
12	Kura NRC	119	159	202.3	149.5	142.25	113	116	114	84.33	141	128.5	108.5
13	Kura Mud-bricks	150	139	109.3	130.75	89	81	85	110.5	83.33	143.25	104.75	98.75
14	Yadakwari I	218	369.5	252.3	166.75	186	86.33	118.66	123.5	163.7	350.5	219.25	230.5
15	Yadakwari II	528	537.25	248	222	151.25	131.25	147.66	137.75	140.5	0	0	0
16	Daurawal Sallaw	143	188.75	175.8	157.5	116.25	97	102.66	96	73.7	181	72.75	75.25
17	Dako Soye	215	263.5	311	153	184.75	103.25	98	96.5	87	151.75	111	100.25
18	Samawa I	174	174	197.3	191.75	186.5	313.75	425	207.25	89.33	123.75	91.25	166.75
19	Samawa II	136	139	308.3	303.5	212.25	149.75	213	281	361	727	808.75	583
	Mean	258.9	268.3	248.3	228.7	186.4	153.98	176.59	174.58	143.31	223.987	181.74895	173.737
	Sample Variance	34658	27823	21521	15107	12295	10922	12728.1	7948.2				
	Standard Deviation	186.2	166.8	146.7	122.9	110.9	104.51	112.82	89.15	105.28	186.413	188.02563	139.385
	Standard Error	42.71	38.27	33.66	28.19	25.44	23.98	25.88	20.45				

(d) **AVERAGE MONTHLY RECORDS OF P^H OF WATER SAMPLES FROM TYPHA SP HABITATS (IRRIGATION CANAL) IN THE KANO IRRIGATION ZONE 2007/2008**

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	**SAMPLING SITE**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**
1	Karfi canal	7.59	8.09	8.64	9.76	9.64	8.6	8.01	8.07	8	8.22	8.17	0
2	Dan Isa Canal	7.37	8.23	8.58	9.75	9.57	8.58	7.97	8.03	8.01	8.28	8.2	8.21
3	Kura Canal I	7.67	8.44	8.72	9.63	9.61	8.68	7.99	8	7.98	8.22	8.21	8.24
4	Samawa Canal	7.53	8	8.65	9.71	9.31	8.67	7.95	8.04	8.02	8.19	8.31	8.36
5	Kura Canal II	7.7	8.1	8.78	9.72	9.41	8.65	7.96	8.03	8.03	8.12	8.27	8.37
6	Imawa Canal	7.75	7.97	8.44	9.87	9.44	8.74	7.97	8.03	8.05	8.24	8.28	8.42
	Mean	7.6017	8.138	8.635	9.74	9.497	8.65	7.98	8.03	8.015	8.2116667	8.24	6.9333333
	Sample Variance	0.02	0.03	0.013	0.01	0.02	0	0	0				
	Standard Deviation	0.14	0.17	0.12	0.08	0.13	0.07	0.02	0.02	0.0242899	0.0538207	0.0544059	3.3975854
	Standard Error	0.06	0.07	0.05	0.03	0.05	0.02	0.01	0.01				

KEY

- **Karfi canal - behind the MTN mask - Samawa canal**
- **Dan Isa canal - - Kura canal II - behind NRC Office**
- **Kura canal - before 'kogin Madara'/Kura B**

(e) AVERAGE MONTHLY RECORDS OF TEMPERATURE(°c) OF WATER SAMPLES FROM *TYPHA* SP HABITATS (IRRIGATION CANAL) IN THE KANO IRRIGATION ZONE 2007/2008

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.
1	Karfi canal	27.43	26.3	24	24.95	25.78	21.68	17.03	14.5	16.3	16.13	20	0
2	Dan Isa Canal	27.23	26.28	25.2	25.68	26.23	23.18	19.2	17.4	16.4	16.6	20.5	23.73
3	Kura Canal I	28.63	29.45	25.95	26.35	27.55	27.4	24.1	20.65	18.2	18.5	23.85	25.55
4	Samawa Canal	33.6	32.5	27.13	27.38	28.38	28.15	27.7	22.5	20.83	21.87	26.63	25.5
5	Kura Canal II	30.97	31.48	28.68	29	28.9	29.75	26.6	23.33	20	23.03	27.18	28.4
6	Imawa Canal	34.1	31.95	29.93	27.9	27.43	26.73	23	19.53	19.2	21.33	25.4	27.58
	Mean	30.327	29.66	26.82	26.88	27.38	26.15	22.94	19.65	18.488333	19.576667	23.926667	21.793333
	Sample Variance	9.25	7.87	4.91	2.25	1.44	9.53	17.26	10.85				
	Standard Deviation	3.04	2.81	2.22	1.49	1.2	3.09	4.15	3.29	1.871261	2.903733	3.073419	10.80449
	Standard Error	1.24	1.15	0.9	0.61	0.49	1.26	1.7	1.34				

KEY

- Karfi canal - behind the MTN mask - Samawa canal

- Dan Isa canal - - Kura canal II - behind NRC Office

- Kura canal - before 'kogin Madara'/Kura B

(f) **AVERAGE MONTHLY RECORDS OF CONDUCTIVITY (µsm-2) OF WATER SAMPLES FROM TYPHA SP HABITATS (IRRIGATION CANAL) IN THE KANO IRRIGATION ZONE 2007/2008**

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.
1	Karfi canal	152.33	134.5	175.75	150.5	116.25	109	153.66	149	67	93	80	0
2	Dan Isa Canal	155.33	170.75	236	145.25	115.25	119	119.66	241	74.7	93.5	82.5	122.75
3	Kura Canal I	111	139	158.33	92.5	65	50	69	63	50.7	101.25	52.75	47.75
4	Samawa Canal	393.33	267.5	435	297.5	208.25	126.75	125	107	62.33	152.25	141.25	120.5
5	Kura Canal II	97	332	118	112.5	65.5	69.75	59.66	63	47.33	83	53.5	50..67
6	Imawa Canal	146.66	260.33	148.66	239	165.33	99.75	115	85	73	114.25	127.5	153.5
	Mean	175.94	217.3	212	172.9	122.6	95.71	106.99	118	62.51	106.20833	89.583333	88.9
	Sample Variance	11909	6536	13470	6255	3167	892.44	1282.1	4670				
	Standard Deviation	109.13	80.85	116.1	79.09	56.27	29.87	35.81	68.34	11.39067	24.83416	37.16943	63.0755
	Standard Error	44.55	33.01	47.38	32.29	22.97	12.19	14.62	27.89				

KEY

- **Karfi canal - behind the MTN mask - Samawa canal**
- **Dan Isa canal - - Kura canal II - behind NRC Office**
- **Kura canal - before 'kogin Madara'/Kura B**

(g) AVERAGE MONTHLY RECORDS OF P^H OF WATER SAMPLES FROM <u>TYPHA SP</u> HABITATS, (ROADSIDE DISHES) IN THE KANO IRRIGATION ZONE 2007/2008

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	**SAMPLING SITE**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**	**PH**
1	Karfi I	7.63	8.42	8.87	9.87	9.54	8.54	7.99	8	8.03	8.22	8.14	8.57
2	Karfi II	7.41	8.16	8.58	9.75	9.6	8.59	8.04	8.06	8.01	8.24	8.15	8.24
3	Kura I	7.81	8.2	8.66	9.72	9.4	8.71	7.95	8.03	8.03	8.23	8.34	8.3
4	Kura II	7.43	8.09	8.67	9.78	9.37	8.71	7.95	8	8.02	8.28	8.35	8.55
5	Bauren Tanko I	7.58	8.28	8.68	9.82	9.37	8.71	7.97	8.01	8.03	8.26	8.31	8.5
	Mean	7.572	8.23	8.692	9.788	9.4	8.65	7.98	8.02	8.024	8.246	8.258	8.432
	Sample Variance	0.026	0.016	0.011	0.003	0.011	0.01	0	0				
	Standard Deviation	0.163	0.126	0.11	0.059	0.11	0.08	0.04	0.03	0.0089443	0.0240832	0.1042593	0.1515586
	Standard Error	0.073	0.057	0.05	0.026	0.05	0.04	8.02	0.01				

- Karfi I – close to Texaco Filling Station - Bauren Tanko I - on one side of the main road

- Karfi II - close to MTN mash - Bauren Tanko II - on the other side of the road

- Kura I - very close to the road and near MTN mash

- Kura II - adjacent to SDP Office

(h) AVERAGE MONTHLY RECORDS OF TEMPERATURE(^{O}C) OF WATER SAMPLES FROM TYPHA SP HABITATS, (ROADSIDE DISHES) IN THE KANO IRRIGATION ZONE 2007/2008

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.	TEMPT.
1	Karfi I	26.73	25.3	24.13	25.38	25.95	24.15	20.57	17.4	16.33	14.63	20.45	22.18
2	Karfi II	27.75	26	25.88	25.8	25.9	22.43	20	15.9	16.43	16.57	20.8	21.55
3	Kura I	32.97	31.18	27.9	27.35	28.5	21.73	25.6	23.2	19.57	21.1	27.9	28.93
4	Kura II	33.8	32.8	28.43	29.4	30.13	28.95	26.33	27.2	20.17	22.3	27.2	28.73
5	Bauren Tanko I	33.15	26.6	27.78	27.7	28.1	28.6	23.13	26.01	21.2	16.7	27	29.58
	Mean	30.88	28.38	26.82	27.13	28.5	25,17	23.13	21.94	18.74	18.26	24.67	26.194
	Sample Variance	11.27	11.42	3.2	2.59	3.25	11.61	8.17	25.73				
	Standard Deviation	3.36	3.38	1.79	1.61	1.8	3.41	2.86	5.07	2.232129	3.2731407	3.709717	3.9705453
	Standard Error	1.5	1.51	0.8	0.72	0.8	1.52	1.28	2.27				

- Karfi I – close to Texaco Filling Station - Bauren Tanko I - on one side of the main road

- Karfi II - close to MTN mash - Bauren Tanko II - on the other side of the road

- Kura I - very close to the road and near MTN mash

- Kura II - adjacent to SDP Office

(i) AVERAGE MONTHLY RECORDS OF CONDUCTIVITY (μsm^{-2}) OF WATER SAMPLES FROM TYPHA SP HABITATS, (ROADSIDE DISHES) IN THE KANO IRRIGATION ZONE 2007/2008

		MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV.	DEC.	JAN	FEB	MARCH	APRIL
S/NO	SAMPLING SITE	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.	COND.
1	Karfi I	215.7	289.5	230.5	138	95.25	84.5	97.66	94	81.33	147.5	106.75	124.33
2	Karfi II	157	151.75	225.8	148	110.25	108.3	81	191	82	99.25	90.75	101
3	Kura I	108.7	142.5	242.3	228	164.5	90.75	85	123	78	121	84.75	67.75
4	Kura II	431.7	337	340.5	264.75	234.5	112.8	161	142	95.7	188.5	186	182
5	Bauren Tanko I	179	194	281	199.66	125.5	84.5	80	166	72.7	131.7	105.7	103
	Mean	218.4	223	264	228	146	96.15	100.93	143.2	81.946	137.59	114.79	115.616
	Sample Variance	15714	7454	2300	2858	3112	180.6	1177	1408.7				
	Standard Deviation	125.4	86.34	47.96	53.46	55.79	13.44	34.31	37.53	8.5237069	33.4287	40.922051	42.26912
	Standard Error	56.06	38.61	21.45	23.9	24.95	6.01	15.34	16.79				

- Karfi I – close to Texaco Filling Station - Bauren Tanko I - on one side of the main road

- Karfi II - close to MTN mash - Bauren Tanko II - on the other side of the road

- Kura I - very close to the road and near MTN mash

- Kura II - adjacent to SDP Office

(j) AVERAGE MONTHLY RECORDS OF P^H, TEMP. AND CONDUCTIVITY OF WATER SAMPLES FROM *TYPHA*-FREE HABITATS IN KANO RIVER IRRIGATION PROJECT AREA

		JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
S/NO	SAMPLING SITE	P^H	TEMP. ^0C	COND. (μsm^{-1})	P^H	TEMP. ^0C	COND. (μsm^{-1})	P^H	TEMP. ^0C	COND. (μsm^{-1})	P^H	TEMP. ^0C	COND. (μsm^{-1})	P^H	TEMP. ^0C	COND. (μsm^{-1})	P^H	TEMP. ^0C	COND. (μsm^{-1})
1	IMAWA MAIN WATER CHANNEL	8.81	24.6	96	9.73	26.28	81	9.43	27.2	62	8.61	25.93	52	7.96	21.87	57	8.01	19.33	54
2	KURA M.W. CHANNEL	8.8	25.6	96	9.65	26.3	80	9.62	27.82	59	8.64	27.48	46	7.98	24.1	62	8.01	20.73	55
3	SAMAWA M.W. CHANNEL	8.88	26.13	89	9.74	27.45	81	9.48	28.3	60	8.66	28	53	7.97	25.4	47	8.01	22.45	56
4	YADAKWARI M.W. CHANNEL	8.85	25.5	88.7	9.81	27.7	79	9.36	28.8	58	8.69	28.13	49	7.97	23.8	62	8	22.58	56
5	KADAWA MAIN WATER CHANNEL	8.56	26.33	89.33	9.74	28.05	82	9.23	28.13	61	8.69	28.23	51	7.98	26.23	62	8.01	22.45	48
6	KADAWA RESERVOIR	8.89	26.66	105.7	9.77	29.2	92	9.34	28.35	62	8.65	30.19	46	7.97	27.37	52	8	24.48	61
	Mean	8.8	25.8	94.12	9.74	27.5	82.5	9.41	28.1	60.33	8.66	27.99	49.5	7.97	24.8	57	8.01	22	55
	Sample variance	0.015	0.54	43.76	0	1.23	22.7	0.02	0.29	2.67	0	1.88	9.1	5.7	3.82	40	2.70E-05	3.13	17.6
	Standard deviation	0.122	0.73	6.61	0.05	1.11	4.76	0.13	0.54	1.63	0.03	1.37	3.02	0.01	1.95	6.32	0.01	1.77	4.19
	Standard error	0.049	0.3	2.7	0.02	0.02	1.94	0.05	0.22	0.67	0.01	0.56	1.23	0	0.8	2.58	0	0.72	1.71

Source: Fieldwork, 2008

Plate 1: A typical root system of *Typha* sp in a shallow aquatic habitat at 'Kogin Madara' near 'Kura' study site. GPS Coordinate: N11^0,46'57.6" E008^0 25'25.7

Plate 2: A concrete irrigation water drain clogged by *Typha* sp. Close to 'Samawa' main water channel

Plate 3: A *Typha* stalk seller busy cutting and arranging the stalks into bundles at ‘Tatarace’ *Typha* invaded burrow pit. GPS Coordinate: N11^{0},48’20” E008^{0} 28’08.8”

Plate 4: A scene at the ‘Kwanar Gafan’ market with a truck loaded with bundles of *Typha* stalks for used in Tomatoes transportation.

Source: Gafan Market, 2008
Plate 5: A 35 tonne Truck being loaded with baskets of tomatoe using *Typha* stalks to cushion and prevent water loss or hitting during the long journey to the South.

Source: GAfan Tomatoes Market, 2008.
Plate 6: Labourers arranging baskets of tomatoes together with *Typha* stalks. This truck takes a minimum of 300 baskets.

Plate 7: A site at Karfi burrow pit after *Typha* control activity of cutting and use of fire suppression. GPS Coordinate: N11^0,49'07.7" E008^0 29'22.5

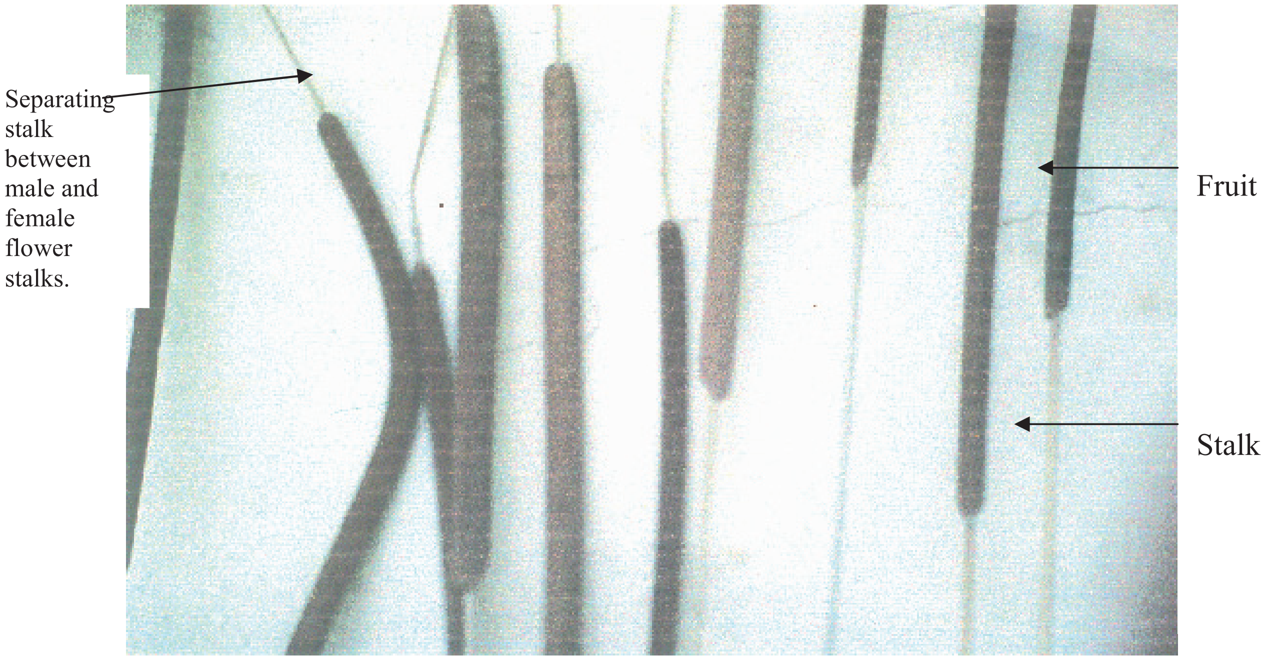
Plate 8: A canal near 'Kogin Madara' at Kura after control of *Typha* sp through clearing and desilting of the canal. GPS Coordinate: N11^0,45'33.3" E008^0 25'24.8

Plate 9: A man cutting *Typha* stand/stalks in a canal at ‘Tatarace’ burrow pit near ‘Kura’ in the study area.

Plate 10: A truck loaded with bundles of *Typha* stalks ready for transportation to ‘Kwanar Gafan’ market near ‘Kadawa’ also in the study area.

Plate 11: *Typha* sp. Showing leaves and fruits of exceptional size at Kura burrow pit GPS Coordinate: N11^0,46' 45.9" E008^0 25'31.6

Plates 12: The researcher examining the root and other parts of *Typha* in a shallow pit at Kura



Source: fieldwork, 2007

Plate 13: Different sizes of KRIP *Typha* sp fruits

Source: Fieldwork, 2008

Plate 14 : A burrow pit invaded by *Typha* sp. The centre of the pit where water depth is high, only floating white and pink lilies can be seen.

Plate 16: A burrow pit at ‘Samawa’ site surrounded by *Typha* sp. and the centre completely covered by *Pistia Stratoites* (water lettuce) or ‘Kainuwa’ locally.