CHAPTER 1

1. Introduction

The Okavango River Delta is a large land locked alluvial fan located in the north western part of the semi-arid Kalahari basin of Northern Botswana. It covers an area of about 22 000 km^2 of which approximately 6 000 km^2 is permanent swamps, 10 000 - 12 000 km^2 is seasonal flooded grasslands and the rest is low lying dry savannah (McCarthy *et al.*, 1993). Water and sediments are distributed across the fan by meandering and isolated channels which are flanked by extensive swamps. The position of the channel and hence the distribution of water and sediments are constantly changing due to channel avulsion, leading to a fairly even distribution of sediments across the upper permanently flooded portions of the fan (McCarthy *et al.*, 1993). The Okavango Delta lies within the grabens at the southern extremity of the East African rift system (S.M.E.C., 1986; McCarthy, 1993a). It represents the terminal depository for the Okavango River system which drains from central Angola, as all the sediments transported by the River are deposited on the fan. The area is of international environmental importance as one of very few remaining relatively undisturbed inland Delta ecosystems in the world.

Seasonal flooding is the driving force behind the functioning of floodplain ecosystems in the Okavango Delta. When the water level rises in May - June, the trampled and grazed grasslands are flooded, nutrients are released and primary production of phytoplankton, attached algae and macrophytes explode, and aquatic herbivores of all kind from zooplankton to fish migrate in to feed and spawn (Merron, 1991; Project Memo., 1995). When the water level recedes from August - September, large terrestrial ungulates move in to feed on the grasses that established or resprouted in this zone, which is a reliable grazing resource during the dry season (Project Memo., 1995). It is thus likely that the seasonal floodplains are to a large extent an influential factor determining the amount of fish found in the perennial swamps and rivers and dependent predators such as crocodiles, fish eagles, herons, otters, and man. Similarly it is likely that the amount of wildlife found on the arid floodplains is regulated by the amount of high quality grazing produced on the

seasonal floodplains after the water has receded.

The seasonal flood regime of the floodplains in the Delta is directly tied to the timing, duration and, magnitude of the Okavango River annual flood level, which in turn is determined by rainfall in its catchment area in Angola (Merron, 1991). In addition natural disturbances such as channel blockage by giant papyrus reeds (*Cyperus papyrus*) and sedimentation due to human activities, such as burning of the aquatic and floodplain vegetation, may result in constant changes in the distribution of water in the floodplains (McCarthy, 1993a; Biggs, 1979). Every year most of the vegetation of the Delta is burned. Hunters and safari operators deliberately cause nearly all the burning. These fires begin as early as the end of May and have a considerable effect on the local movement of animals. In seasonal burned floodplains, progress of rising flood is accelerated due to the removal of much of the vegetation, which act as a barrier (Paterson, 1976). Thus the spatial and temporal variation of the seasonal flooding is high. The annual alteration and interaction of the above parameters almost assure that no two flood seasons produce the same regularity, duration, or pattern of flooding over the Delta (Biggs, 1979). A massive alteration in water distribution down to the Delta will affect the distribution of aquatic vegetation types since these communities are dependent on water throughout the year. Some plant community types can however tolerate short periods of absence of surface water in dry seasons. The floodplain communities are known to be most sensitive to change in flooding regimes (S.M.E.C., 1989; Ellery *et al.*, 1993).

At least two types of flooding can be distinguished; regular floods and irregular floods. The latter occur predominantly along rivers and are caused by unpredictable changes in water levels of the river (Blom *et al.*, 1990). The sources of flooding have often been identified as heavy rainfall in catchment areas as it is the case with the Okavango Delta. The floodplains of the Okavango Delta experience regular seasonal flooding, but the lower parts of the floodplains experience irregular flooding since they only get flooded in years of exceptionally high floods.

Vegetation of the floodplains of the Okavango Delta exhibits a marked pattern of zonation in the seasonal floodplains along the moisture and elevational gradient (Ellery *et al.*, 1993). Clear vegetation zonation in floodplains was also reported in other systems like the Kafue Flats in Zambia (Ellenbroek & Werger, 1988), the Bengweula Basin in Zambia (Grimsdell & Bell, 1976), the Southern Sudd region of the Upper Nile in Sudan (Sutcliffe, 1976), the Nile River valley in Egypt, the Amazon Basin in Brazil, the floodplains along the Mississippi River in U.S.A, the Euphrates, Ganges, Bramahputra and Hwang Ho river in Asia (Brandy, 1990). Elevation directly influence the duration and extent of flooding and is likely to be the major factor governing vegetation zonation, resulting in an unique pattern of rainfed and seasonally flooded grassland types and their intermediates (Ellery *et al.*, 1993). Kozlowski (1984), Ellenboek & Werger, (1988), Ellery *et al.* (1993) and Blom *et al.* (1996) reported that species composition, and phytosociological position of vegetation of floodplains are influenced by factors such as flooding frequency, duration of flooding, depth of water, a variety of soil factors and flood tolerance of seedlings. Blom *et al.* (1996) pointed out that vegetation zones in the floodplains often reflect differences in flooding stress at the individual plant level. Transient floods particularly, induce vegetation zonation and small-scale spatial heterogeneity in terms of oxygen and nutrient availability (Biggs, 1979; Blom *et al.*, 1996).

While interaction between water, nutrients, grazing by large herbivores and fire have often been identified as driving forces behind the processes of vegetation dynamics in savanna ecosystem, the Okavango Delta seasonal floodplains are unique in the sense that vegetation processes are driven by these factors as well as by seasonal flooding.

Early and Middle Stone Age implements found at Chanoga, Toteng, Samedupe, Sehitwa and Kgwebe indicate that man has inhabited at least the southern periphery of the Delta for 100 000 years or more (Campbell, 1976). Apparently there are three factors which influenced human settlement in the Okavango Delta: the topography of the land which in the past influenced resource distribution, the spread of noxious insects, particularly tsetse fly (*Glossina morsitans*) and malaria mosquitoes (*Anopheles sp.*) and the historical mode

of the people's subsistence themselves (Campbell, 1976). Habitation of wetlands by human beings, particularly floodplains is steadily increasing world wide, as the benefits of living in the floodplains outweigh the risks (Blom & Voesenek, 1996), especially in that seasonally flooded areas are among the most productive ecosystems in the world. The probability of flooding is increased by human activities such as removal of natural vegetation, improvement of drainage systems, overgrazing by livestock and wildlife and straightening of meanders to facilitate shipping (Blom & Voesenek, 1996). However such intensive human activities are minimal in the Okavango Delta, thus leaving it as one of the least disturbed wetland ecosystems in the world. Nevertheless, proposals and plans that could interfere and change this natural ecosystem have been tabled, with the most recent being the Boro dredging (S.M.E.C., 1989) and the Namibian pipeline (Bonyongo, *et al.*, 1996). The two proposals drew a lot of attention from environmental organisations, both locally and internationally.

Human utilisation of natural resources in the Okavango Delta is linked directly to the ecological integrity and productivity of the river and its floodplains and the woodlands, which provide opportunities for fishing, grazing for livestock and game, grasses for thatch, reeds and palms for building, fencing and basketry, clay for pottery, wild fruits and herbs for food and medicine, and wood for building boats and implements (Campbell, 1976; Afriyie, 1976). Tourism which is the third largest foreign exchange earner of foreign exchange for Botswana (I.U.C.N, 1993) is most active in the Okavango Delta. Tourism in Botswana is based upon wildlife in its natural habitat, and while there are many good wildlife areas in the country, there is no doubt that the Okavango Delta is the focus for a great diversity of species. It is in the Okavango Delta that semi-arid and wet lands integrate, and the Moremi Wildlife Reserve is the dry season visiting place for many species which spend the wet season in the drier areas surrounding the eastern part of the Delta (Campbell & von Richtner, 1976).

Utilisation of grazing resources by large herbivores on the floodplains has been observed to be spatially as well as temporally variable. As a result some vegetation zones are more

heavily utilised by grazers than others. Differences in utilisation patterns of grass species are common in other ecosystems. McNaughton (1988) reported that mineral content of the foods is an important determinant of utilisation of forage resources within Serengeti National Park, Tanzania. He further reported that magnesium, sodium and phosphorus appear to be of particular importance in as far as forage utilisation is concerned. Seasonal patterns of flooding was found to determine the pattern of grazing in the Kafue Flats (Ellenbroek & Werger, 1988) and that is likely to be the case in the Okavango Delta floodplains. Digestibility, phenology and availability of grazing resources over time have also been associated with selectivity and utilisation of grazing resources (Valentine, 1990).

Water level fluctuations in the Okavango Delta floodplains are likely to influence not only accessibility, but also phenology of growth, availability and quality of the grazing resource. Furthermore species-specific differences in digestibility may occur. Prolonged flood deficits in floodplains have been observed to cause major changes in species composition of floodplain grasslands with areas previously dominated by perennials species giving way to annual species (Diarra, 1988). However little is known about the relative importance of water level fluctuation for plant community distribution and plant growth and utilisation patterns by herbivores of the Okavango Delta floodplains.

At present there is an increasing pressure to utilise water from the Okavango Delta. It is likely that substantial reduction of inflow will affect the seasonal floodplains. A broad understanding of the ecological function of the seasonal floodplains is of paramount importance, if the long term impact of flow changes on vegetation and wildlife populations are to be predicted with any certainty.

1.2. General objectives

This study will therefore focus on the following aspects:

i) vegetation zonation in relation to elevation gradient,

ii) variation in soil water regime and soil mineral nutrients along elevation gradients.

iii) phenology of growth, nutrient contents, digestibility and utilisation of grasses by herbivores in relation to flooding regimes.

These objectives in themselves lead to the formulation of hypotheses:

1.3. Hypothesis

H1 Vegetation zonation in the floodplains is due to variation in elevation, which influence the extent and duration of flooding.

H2 Vegetation zonation may be co-determined by soil water regime or variation in soil chemical and physical properties, or a combination of the above.

H3 Utilisation of grazing resources in the floodplains are temporally and spatially variable due to variation between vegetation zones in availability (quantity and time of biomass availability) and quality (nutrient content, digestibility and secondary compounds) in relation to flooding regimes.