CHAPTER 2

Study area

2.1. Location and General description

The Okavango Delta is located between 19^0 and 20^0 S and 22^0 and 24^0 W and has its main catchment in the Angolan Highlands (Ellery *et al.*, 1991). The main study site is by Nxaraga lagoon (19^0 35' S 23^0 10' W) on the Southwest side of Chief's Island in the Moremi Wildlife Reserve (D.S.L., 1987) (Fig.2.1). The Boro River, currently the main outflowing river from the Delta, seasonally floods the study site.

Two main river systems, the Cubango and the Cuito, drain into the Okavango River which spreads out into a deltaic shallow water body which covers approximately 22 000 km^2. The Okavango Delta swamps are divided into three physiographic regions; (i) the upper pan handle which is characterised by meandering channels flanked by permanent swamps which are confined between the shoulders of the Kalahari sand and laterally confined by what appears to be eroded fault scalps, and the permanent swamps which are largely unconfined around the apex of the fan itself, with perennial surface water up to 4 m. (ii) The low lying seasonally-indudated areas, the extent varies to a large degree depending on the magnitude of annual floods from Angola and the amount of local rainfall. (iii) The higher, dry land masses, of which there are three major examples: Moremi Wildlife reserve, Chief's Islands and Western sand-veld tangue (Paterson, 1976, McCarthy *et al.*, 1991, 1993). Within these three broad divisions is an interocking mosaic of habitat types which contributes most of the diversity of Delta's wildlife spectrum at all phylogenetic levels. Most of the conspicuous wildlife species utilise the last two zones to varying degrees, but the first provides suitable habitat for comparatively few large wild animals (Paterson, 1976).

The floodplains are divided into three areas: the primary floodplains which are the first to receive flood waters overflowing from the outlet channels in the seasonal swamps area, secondary floodplains which are higher-lying floodplains of grasslands elevated above primary floodplains by 1 m or less, and Island grassland which are short grassland dominated by *Sporobolus spicatus* and characterised by the presence of evaporates (Biggs, 1979). The primary floodplain community of the mid-Delta is dominated by sedges of *Scirpus inclinatus, Fimbristylis complanata* and other *Cyperus* species and the forbs *Alternanthera sessilis* and *Ludwigia stolonifera* (Biggs, 1979). This vegetation type is very dense and forms thick mats of mostly dead material when dry. The mean vegetation height is approximately 75 cm and these areas are flooded for a major part of each year, often to a depth of half a meter or more (Paterson, 1976). All secondary floodplain communities support open grasslands but herbaceous plant density and composition vary in accordance with flooding frequency, duration and utilisation by grazing animals. Secondary floodplains are characterised by tall grasses such as *Imperata cylindrica, Setaria sphacelata, Chloris gayana, Eragrostis lappula, Eragrostis inamoena, Paspalidium obtusifolium* and *Panicum repens*. The *Sporobolus spicatus* Island grassland community is not subject to flooding in average and poor flood years. During bigger floods, the flooding of Island grassland communities may vary between 0.01 and 0.03 m and the water table is low (Biggs, 1979). The main species from the upper catena positions are *Cynodon dactylon, Sporobolus acinifolius* and *Sporobolus spicatus*.

Another important component of the Okavango's physical environment is the large number of *termitaria* which occur through out the Delta. Widespread in the dry areas, they are of some importance to various animals as either vantagepoints or convenient browsing sites (Paterson, 1976). In the areas of permanent swamps, they provide sites for colonisation by woody species forming a category of very small islands and increasing the diversity of that zone (Paterson,1976). Here again they provide vantagepoints and lying-down places, for lechwe in particular. It is however the zone of seasonal flooding where they are most important. As well as performing the functions described above, they have been attributed with having a substantial effect on regulating the flow of flood waters and

initiating the formation of new islands (Paterson, 1976). As many termite species are unable to establish mounds under conditions of annual flooding, most of the termitaria in the floodplains, may therefore have been formed under drier conditions than it is now.

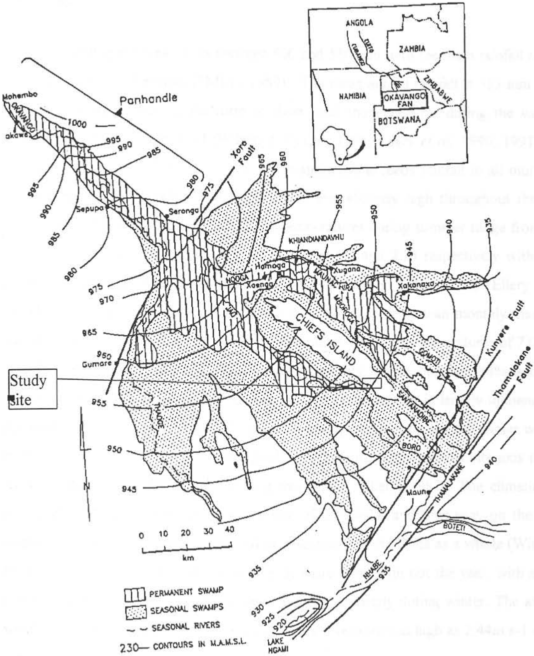

Fig. 2.1 Topography and vegetative zonation of the Okavango Fan (Stainstreet *et al*, 1993)

2.2. Climate

Annual rainfall in the area varies between 500 and 550 mm with the main rainfall months being November to February (SMEC, 1989). The mean annual rainfall is 515 mm $^{-1}$ (see fig. 2.7). Showers occur in the form of short local thunderstorms during the summer, November until March or April (Wilson & Dincer, 1976; Ellery *et al,* 1990; 1991). The annual evaporation is about 1800 mm, and evaporation exceeds rainfall in all months of the year (McCarthy, 1993b). The temperatures are relatively high throughout the year. The mean monthly maximum and minimum temperatures during summer range from 30.5 ^{0}C to 33.7 ^{0}C and 14.8 ^{0}C to 19.2 ^{0}C (see Fig. 2.2 and 2.3) respectively with mean relative humidity at 0800 hours between 50 and 78 % (Fig. 2.4 and 2.5) (Ellery *et al.*, 1991). The cooler, drier winter months (June - August) have a mean monthly maximum temperature of 25.3 ^{0}C to 28.7 ^{0}C and a mean monthly minimum temperatures of 7.0 ^{0}C to 10.0 ^{0}C (see Fig. 2.2 and 2.3), while relative humidity ranges between 43% and 63% (Ellery *et al.*, 1991). Frost seldom occurs. The summer weather is largely influenced by the southward movement of Inter - Tropical - Convergence - Zone and the winter weather by the northward movement of subtropical high pressure belt which has its axis not far south of the Tropic of Capricorn during this period (Ellery, 1987). The climatic data recorded in Maun, on the south eastern side of the Delta, and Shakawe, on the south western side of the Delta, are considered representative of the Delta as a whole (Wilson & Dincer, 1976; Ellery, 1987). Winds are mainly easterly through out the year, with a more north easterly wind blowing in the summer and south easterly during winter. The average wind speed for the year is 1.81 ms^{-1} which can reach velocities as high as 2.44m s-1 during early summer (Ellery, 1987).

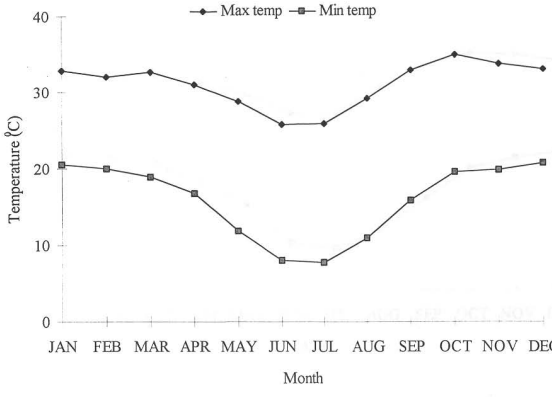

Fig. 2.2. Monthly average values for maximum and minimum temperature measured at Maun Station (Period of measurements 1986 to 1997; Source: Botswana Meteorological Services).

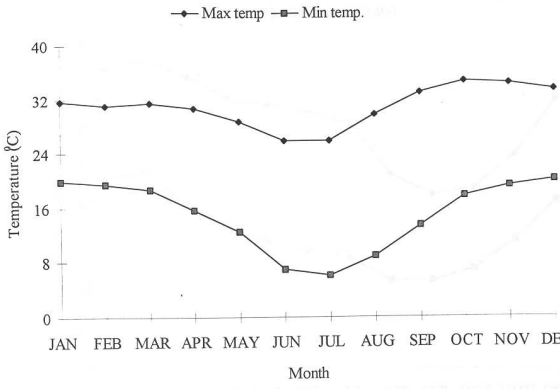

Fig. 2.3. Monthly average values for maximum and minimum temperature measured at Shakawe Station (Period of measurements 1986 to 1997; Source: Botswana Meteorological Services).

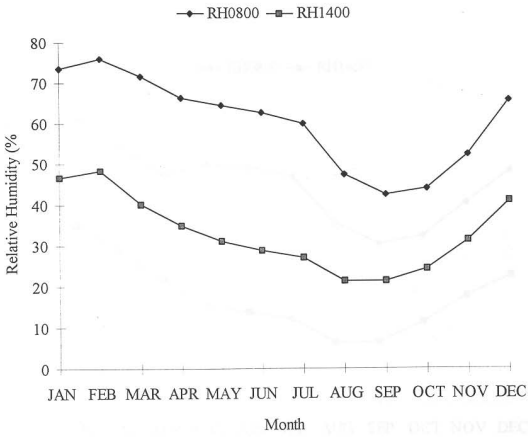

Fig. 2.4 Monthly average Relative Humidity in Maun (period of measurements: 1986 to 1997; source: Botswana Meteorological Services)

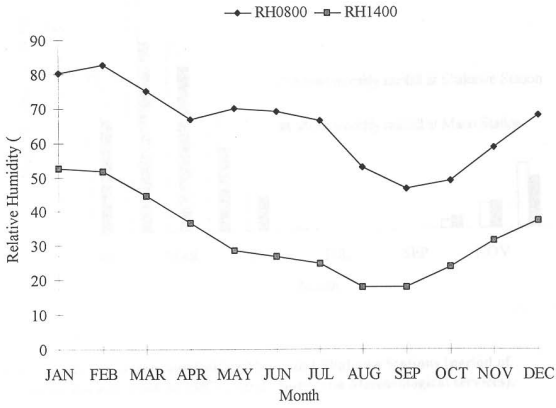

Fig. 2.5 Monthly average Relative Humidity in Shakawe (period of measurements: 1986 to 1997; source: Botswana Meteorological Services)

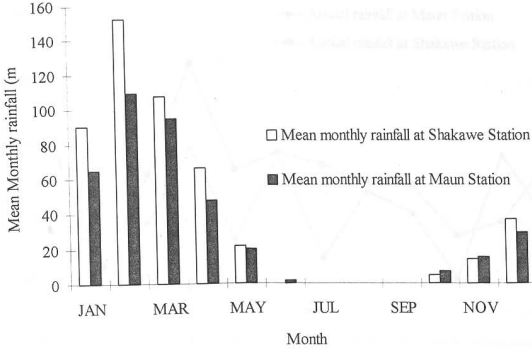

Fig. 2.6. Mean monthly rainfall for Maun and Shakawe Stations (period of measurement: 1986 to 1997; source: Botswana Meteorological services).

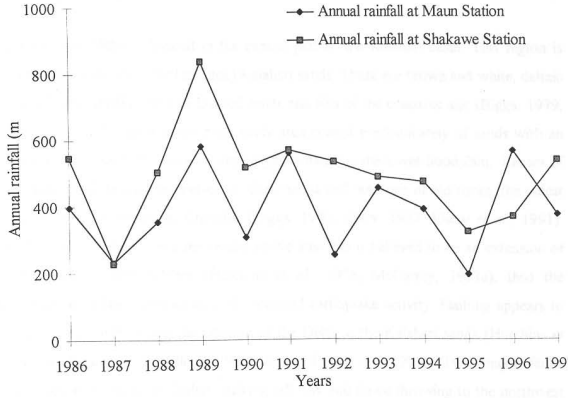

Fig 2.7. Annual rainfall for Maun and Shakawe Stations. (Period of measurement: 1986 to 1997; source: Botswana meteorological Services).

2.3. Geology and Soils

The Okavango Delta is located in the central part of the Kalahari basin. This region is covered with deep (up to 300 m thick) Kalahari sands. These are brown and white, deltaic and windborne, medium to fine grained sands and silts of the cenozoic age (Biggs, 1979; Ellery *et al.*, 1991). Soils in the main study area consist predominately of sands with an increase in the amount of peat and other organic matter in the lower floodplain. Lenses of calcrete and silcrete are interspersed in these sands and outcrops of old rocks, the oldest being the Archaen Basement Complex (Biggs, 1979; Ellery, 1987; Ellery *et al.*, 1991). The Okavango Delta lies in a seismically active area that is believed to be an extension of the East African Rift System (Hutchins *et al.*, 1976; McCarthy, 1993a), thus the Okavango Delta lies within an area of continued earthquake activity. Faulting appears to be important in determining the position of the Delta in the Kalahari sands (Hutchins *et al.*, 1976, Biggs, 1979; Ellery, 1987; McCarthy *et al.*, 1991). Two major faults (Thamalakane and Kunyere faults) striking NE-SW and down throwing to the northwest define the southern eastern limit of the Delta (Fig, 2.1). The parallel Gomare fault appears to trancect the Delta at the southern end of the Panhandle with down throwing to the southeast (Hutchins et al., 1976; McCarthy, 1993a). In the nine year period September 1965 to August 1964, a total of 38 events in the vicinity of the Delta were detected by the Rhodesian Meteorological Services (Hutchins *et al.*, 1976). A number of seismic events during 1952 (27 events ranging from 4.3 to 6,3 Richter Scale) has been postulated to have caused a major change in the drainage pattern in the Delta or more specifically in the north central part of the Delta and also increased the flow of the Boro River (S.M.E.C, 1989).

2.4. Topography

The topographic surveys show that the Delta has a suprisingly regular conical shape with a slope of about 1 in 3600. Relatively small irregularities provide the pattern of channels, islands and madiba (the local name for what are often incorrectly referred to as lagoons) (Wilson, 1976). The conical shape favours the spreading of flood waters, but the nature in this spreading is in some ways analogous to water spilled on a flat table top, the area of spill being nearly proportional to the amount spilled (Wilson, 1976). On the surface of the cone are three obvious ridges; Chief's Island, the Sandveld Tongue and Moremiland mass (Wilson, 1976). There are also some lesser ridges, and the one which runs from northwest from Beacon Island to beyond the upper Xudum is of particular interest. Its north western extremity is a narrow alluvial levee cut across by a few small but significant rivers and providing possibilities of engineering control works (Wilson, 1976).

2.5. Hydrology

The Okavango River, whose major tributaries are the Cubango River (catchment area 115 000 km^2) and Cuito River (catchment area 65 000 km^2) (McCarthy, 1993), enters Botswana at Muhembo. It has an average annual discharge of 11 500 x 106 m^3 with rainfall contributing approximately 5 000 x106 m^3 a^{-1} (Ellery *et al.*, 1991). The usual range of annual inflow is 7 x 109 m^3 to 15 x 109 m^3 (Ellery *et al.*, 1991). There is a regular seasonal rhythm to the inflow, which peaks between mid-March and early May, then recedes until November (S.M.E.C., 1989). The flood wave is slowed considerably during its passage across the Delta, and peaks discharge at the lower extremity occurs in July or August. The minimum discharge at Muhembo is in the range of 120 m^3s^{-1} to 200 m^3s^{-1} (S.M.E.C., 1989). The maximum discharge is more variable, ranging from around 400 m^3s^{-1} to 1000 m^3s^{-1} (S.M.E.C., 1989). Almost 97% of the inflows are lost to evapotranspiration and ground seepage (S.M.E.C., 1989, McCarthy, 1993a). Losses to ground water are considered minimal while a larger portion of the water is lost through evapotranspiration. Seasonal fluctuations in the water levels ranges from 0.9 m to > 3 m in

both the panhandle and the lower reaches of the seasonal swamps while the central, permanent swamps have a considerably smaller annual rises and fall ranging from 0.15 m to 0.25 m (Ellery *et al.*, 1991).

In occasional years relatively small outflow volumes may reach the Mababe Depression or the Linyanti swamps via the Kwai or Magwegqana, but more generally all the outflows from the Delta is to the south from the Boro, Kunyere and Shashe Rivers (S.M.E.C., 1989). Of these, the Boro River predominates and it is the only one that flows every year as far as the Thamalakane fault at the distal end of the Delta (S.M.E.C., 1989). The Thaoge and Jao/Boro tributaries leave the Okavango River at the lower end of the Panhandle and carry water to the western and central region of the Delta respectively (McCarthy, 1993a). The Ngoga channel, which is a continuation of the Okavango, River carries water out towards the east. This channel formally linked to Mboroga River, but this linkage was broken as a result of channel blockage by vegetation and the failure of the lower Ngoga, a process which is still continuing today (McCarthy, 1993b). The Ngoga River supplies water to the Maunachira River, which takes water out towards the Kwai River and now also supplies the Mboroga-Santantadibe system (McCarthy, 1993b).

The hydrology of the Okavango Delta is never entirely stable. A complex interplay of vegetation, water, sediments deposition and other factors ensures that the Delta is forever changing (S.M.E.C., 1989). Small variations in relative volumes of flow in different channels occur every year, and on the decadal time scale of 5 - 15 years, significant inflow regimes occur in some distributaries (S.M.E.C., 1989). Vegetation, particularly, plays a remarkable role in controlling and regulating the physical environment (McCarthy & Ellery, 1993). Channel flanking by plants such as *Cyperus papyrus, Phragmites australis* and *Miscanthus junceus* forms permeable channel margins and facilitate a wide spread and distribution of water, at the same time regulates and localises the deposition of sediments. *Cyperus papyrus* also grows in failing, rapidly agradding channels, preventing avulsion and causing the formation of filter areas (S.M.E.C., 1989). This ensures that new channels which form, do so at some distance from the failing channel and, as a result, the swampy

area ahead of the failing channel desiccates.

2.6 Vegetation

The deeper parts of the permanent swamps are dominated by the tall growing reed-sedge *Cyperus papyrus* and the fern *Thelypteris confluens* with *Vossia cuspidata* along the channel margins. In the swallow swamps, *Typha latifolia* and tall growing reed *Phragmites australis* are common (McCarthy, 1993b). Down stream *Cyperus papyrus* becomes stunted and gives way to a tall growing grass *Miscanthus junceus. Nymphaea* species are common in the swallow, slow flowing, open water together with a variety of emergent and submerged plants, notably *Eichhornia natans, Najas pectinata, Trapa natans* and *Typha capensis* (McCarthy, 1993b). On island margins large trees which include *Diospyros mespiliformis, Ficus sycomorus, Acacia nigrescens, Garcinia livinstonei, Combretum imberbe, Lonchocarpus capassa, Croton megalobotris, Kigelia africana* and palms such as *Phoenix reclinata* and *Hyphaene petersiana* are common. Grass species on the islands include *Cynodon dactylon*, with *Imperata cylindrica* on the moist margins and *Sporobolus spicatus* on the centre of the islands where the soils are drier and saline. Seasonal swamp areas are dominated by *Panicun repens, Cyperus articulatus, Oryza longistaminata, Scipus inclinatus, Paspalidium obtusiflium, Eragrostis inamoena, Setaria sphacelata, Schoenoplectus corymbosus.*

Biggs (1979) assessed the vegetation of the Okavango Delta and classified it into five vegetation groups namely aquatic vegetation, floodplain vegetation, riverine vegetation, marginal vegetation, and dryland vegetation. The aquatic vegetation type includes submerged, free floating, and rooted, water dependent plants. Floodplain vegetation types are intermediary between wetland and dryland types but are more associated with the wetland types. Riverine vegetation is represented by luxuriant, large tree species with overlapping crowns, forming a deep shade layer in which herbaceous sciophytes predominate. The marginal vegetation type occurs in soils slightly more elevated and slightly sandier than those supporting riverine woodland. Dryland vegetation is not

normally subjected to surface inundation from floodwaters. Surface inundation may occur under certain circumstances and this may result in death of species which are not flood tolerant (Biggs, 1979).