GOVERNMENT OF BOTSWANA
MINISTRY OF LOCAL GOVERNMENT AND LANDS
NGAMILAND DISTRICT LAND USE PLANNING UNIT

KALAHARI CONSERVATION SOCIETY

ECOLOGICAL ZONING OKAVANGO DELTA

FINAL REPORT

VOLUME I - MAIN REPORT

April 1989

Snowy Mountains Engineering Corporation
Cooma NSW Australia

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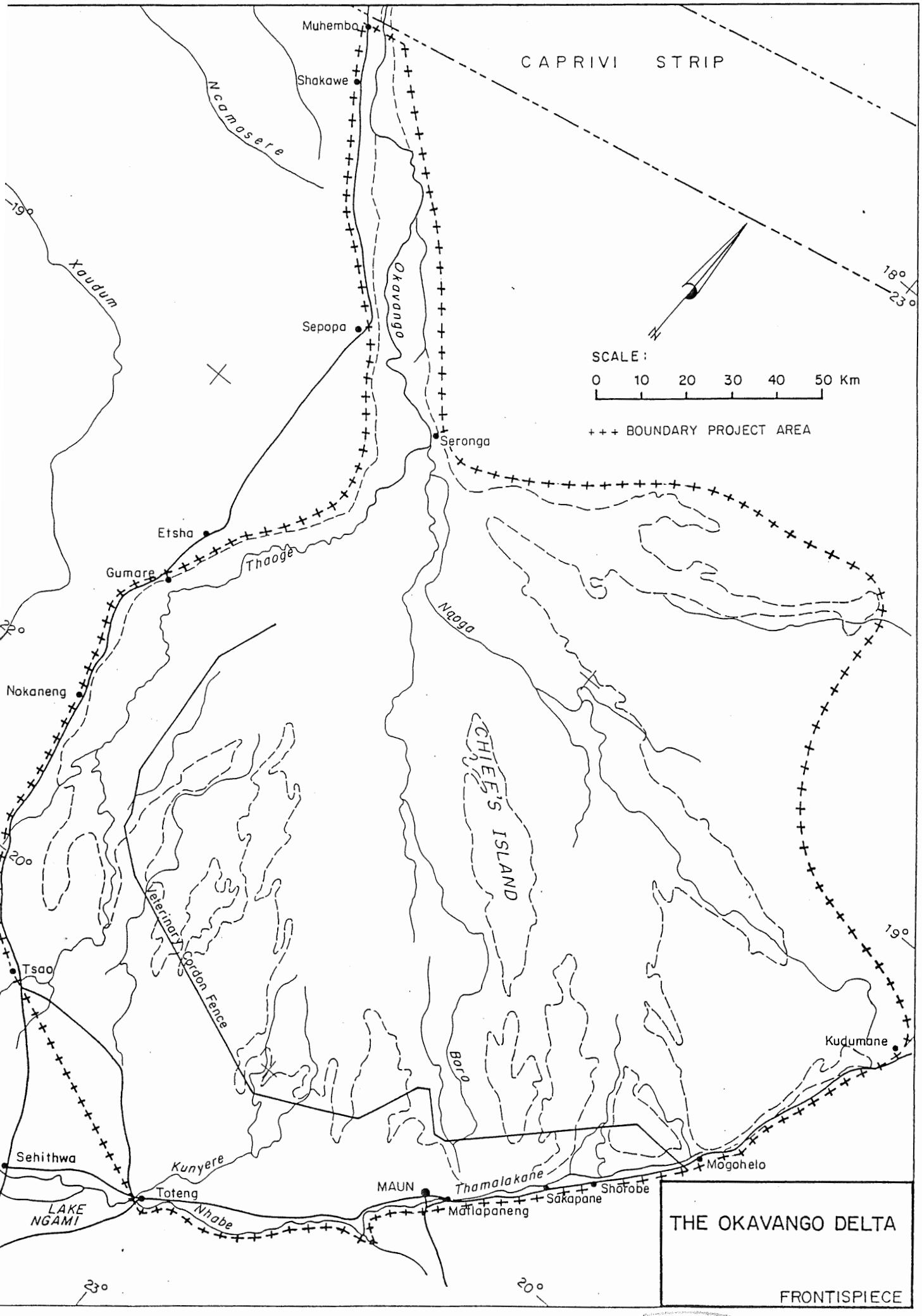

THE OKAVANGO DELTA

FRONTISPIECE

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Gaborone

The Executive Committee,
Kalahari Conservation Society,
P.O.Box 859,
Gaborone

Att: Miss E Warr
(Conservation Officer)

19 May 1989

Dear Madam,

Subject: **FINAL REPORT ECOLOGICAL ZONING - OKAVANGO DELTA**

We have pleasure in submitting herewith sixty copies of the Final Report for the above-mentioned project, comprising Volume I, Maun Report, and Volume II, Appendices.

In addition to the Ecological Zoning Map at a scale 1:250 000, included in this report, the following maps were prepared and submitted separately:

- Ecological Zoning Map (15 sheets, scale 1:100 000)
- Present Land Use and Tourism (15 sheets, scale 1:100 000)
- Vegetation Zones (15 sheets, scale 1:100 000)
- Hydrological Zones (15 sheets, scale 1:100 000)
- Terrain Units (1 sheet, scale 1:250 000)
- Tourism Infrastructure (1 sheet, scale 1:250 000)
- Wildlife Biomass and Controlled Hunting Areas (1 sheet, scale 1:250 000)

and the working maps:

- Vegetation Zoning (on 1970 Photomaps) (50 sheets, scale 1:50 000)
- Hydrological Zones and River Systems (53 overlays, scale 1:50 000).

It should be pointed out that the report is meant to be a supporting document for the various maps prepared. It provides background information on the selection of the zoning components in addition to a large amount of information, collected during the study, which cannot be presented on maps. Therefore, the report should not be considered on its own as being fully descriptive of the zoning of the Okavango Delta.

WINNER OF SECOND AUSTRALIAN AWARD FOR OUTSTANDING EXPORT ACHIEVEMENT
WINNER OF THE GOVERNOR-GENERAL'S AWARD FOR EXPORT EXCELLENCE
MEMBER AUSTRALIAN PROFESSIONAL CONSULTANTS' COUNCIL

We trust that the maps and the report are adequate and in sufficient detail to allow the proper planning of the future use of the Delta. An early completion of such a plan and its enforcement is regarded by the team to be of the utmost importance for the preservation of the Okavango Delta for future generations.

Meanwhile we wish to thank the Kalahari Conservation Society for entrusting SMEC with this important project and the Steering Committee for the fruitful discussions and guidance received during the study.

Yours faithfully,

S. Raadsma
PROJECT MANAGER

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Ecological Zoning Map	1:100 000	15
Present Land Use and Tourism	1:100 000	15
Vegetation Zones	1:100 000	15
Hydrological Zones	1:100 000	15
Terrain Units	1:250 000	1
Tourism Infrastructure	1:250 000	1
Wildlife Biomass and Controlled Hunting Areas	1:250 000	1
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Vegetation Zoning (on 1970 Photomaps)	1:50 000	53
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1. INTRODUCTION

1.1 PERSPECTIVE

It is recognised, both by the Government of Botswana and internationally, that the Okavango Delta is a unique ecosystem meriting the highest conservation effort. The potential for conflict between a number of current and proposed land and other resources uses, to the detriment of the Delta's ecological integrity, has increased significantly in recent years. With a rapidly growing human and livestock population, coupled with substantial growth in tourism in the area, have come plans during the last decades for tsetse-fly control, veterinary cordon fences, water resource development projects, development of peripheral arable lands, irrigation schemes, mineral exploration and tourism development. All these plans have been viewed with concern and have thus led to uncertainty and in some instance ill-informed, though well-meaning, criticism of Government's development plans for the region.

The Ministry of Local Government and Lands, (MLGL) has in recent years embarked upon an intensive programme of Land Use Planning on a country-wide basis at the district and sub-district level through the establishment of District Land Use Planning Units (DLUPU). In Ngamiland, the DLUPU has recognised that the complexity and sensitivity of the Delta's environment demand detailed knowledge of the ecology and current land use for planning, resource allocation and management to proceed with confidence. The determination of ecological zones and their potentials for and constraints to use is an essential first step in this process.

For this reason MLGL requested the Kalahari Conservation Society (KCS) to organise and supervise a study, based on available information and knowledge without detailed field investigations, to result in an ecological zoning of the Okavango Delta. The majority of the funds for the project has been made available by the U.S. Agency for International Development (USAID) to KCS.

Following an advertisement by KCS calling for proposals, the project was entrusted to the Consultant, Snowy Mountains Engineering Corporation (SMEC) of Australia, by Letter of Intent dated 15 July 1988. The Memorandum of Agreement between the two parties was signed on 8 August, 1988.

1.2 THE PROJECT AREA.

The project area as depicted in the Terms of Reference (Appendix A) is presented on the Frontispiece and comprises:

- The Okavango River "Panhandle" and its associated communities on the east and west banks

- The Okavango Delta and its immediate fringes, contained largely in the west and south by the main roads joining

Gumare, Tsao and Toteng with Maun (excluding Sehithwa and Lake Ngami) and in the south east by the Nhabe/Thamalakane River axis, extended by the road from Shorobe to Kudumane (Mababe) village. In the north east, the study area is taken to include the southern portions of Controlled Hunting Areas 5 and 7 (Kwando-Khwai) because they have a bearing on ecological and land use aspects of the Delta proper.

1.3 STANDARDIZATION OF PLACE NAMES

It was agreed with the Steering Committee that the recommendations of the Place Names Commission would be followed for the names of localities and their spelling. Accordingly, the Third Report of the Place Names Commission, issued in September 1984, has been used as the authority. In the many instances where place names used in this report were not listed by the Place Names Commission the spelling on the 1:350 000 scale map of the Okavango Delta, published by the Department of Surveys and Lands, Gaborone January 1987, was followed. A glossary of place names used in this report and alternative spellings in common use is given in Appendix L.

1.4 OBJECTIVES AND APPROACH

The objectives for the ecological zoning of the Delta have been laid down in the Terms of Reference in which eight "parameters" have been listed for zoning purposes: vegetation, hydrology, wildlife, topography, soils, geomorphology, superficial geology and climate. It is proposed to use hereafter the terminology "zoning components", which are not limited to the eight items mentioned above.

By mapping each component at an appropriate scale, cartographic records have been obtained of the available knowledge of the Okavango Delta. This was done on the basis of relevant literature and available data, specific knowledge of the team members and that collected by third parties, and interpretation of remote sensing imagery and aerial photography. The working maps thus produced were used to divide the ecosystem of the Delta into zones with specific ecological characteristics, mapped at a scale of 1:100 000 and 1:250 000 (the latter presented at the back in this report).

Different map scales were used to derive useful working maps. Vegetation, hydrology and current land use were mapped at a scale 1:50 000 and onto the base map with the required scale of 1:100 000. Available information on other components did not allow mapping in such detail, e.g. soils could only be mapped at 1:250 000 scale, and other components could not be mapped at all, e.g. amphibians and reptiles, birds and small mammals.

In summary the following process has been followed to meet the objective:

i. For each zoning component a set of maps with a scale 1:100 000 or another as appropriate to the component was

prepared. Each set of maps is accompanied by a short descriptive text and appropriate tables for the data base

ii. Maps (1:100 000 scale) of existing land and water resources and their use in the Delta have been prepared

iii. The ecological zones which can be recognised in the Delta on the basis of the working maps have been presented on maps with a scale 1:100 000 and 1:250 000

iv. Recommendations have been made for future investigations to improve the data base, if considered necessary, and preliminary proposals for future use of ecological zones have been suggested.

1.5 STAFFING

The following team members participated in the study:

Project Manager:	Mr. S. Raadsma (SMEC)
Team Leader:	Prof. J. Loveridge (Univ. Zimbabwe)
Wildlife Specialist:	Dr. L. Patterson (Gaborone)
Hydrologist:	Dr. J.W. Porter (WR.SIM Pty. Ltd)
Geomorphologist:	Dr. P. Shaw (Univ. Botswana)
Vegetation Specialist:	Mr. P. A. Smith (DWA, Maun)
Land Use Planner:	Ms. H. Bendsen (MOA, Maun)
Infrastructure:	Mr. M. Murray-Hudson (ECOSURV.)
Land Use/Tourism Specialist:	Mr. J. Prosser (Environmental Planning Associates)

1.6 SCOPE OF THE REPORT

The various sections (2 - 8 inclusive) of the report constitute the written documents to accompany the maps of the zoning components. Each section outlines the data base, mapping methodology, a description of mapped units and perceived gaps in the data. The report is not intended as a descriptive document of the ecological zones recognised in the Delta. To the contrary, it provides the data base for zoning components which could be mapped and provides other information, which could not be mapped, in tabular form.

The zoning of the Delta's ecosystem is based on a resource map compiled from the three components:

- hydrology, particularly frequency and extent of flooding
- vegetation, based on typical vegetation aspects recognised in relation to extent and frequency of flooding
- landscape units, based on available information on soils and geomorphology.

This resources map provides a picture of a static situation as encountered in the first half of the 1980's. Aerial photography dated 1983 has been used, updated with LANDSAT imagery dated 1979 to 1987, and SPOT imagery 1988 available for a part of the Delta. On the zoning map (scale 1:100 000) the areas whose present ecological status should be maintained have been identified and labelled with a modifier indicating the basic reasons for protection of these areas.

On the present land and water use map, including the Delta's present use for tourism (a major source of income for Botswana), the resource utilization has been shown, based on modifiers for specific aspects of utilization.

The application of these modifiers has changed the resources map into an ecological zoning map, which together with the supporting maps and data, indicates the present and possible future situation in the Delta. Obviously, one potential important modifier, the frequency and degree of future earthquakes cannot be indicated but should be kept in mind for any future work.

The maps and the supporting document provide an adequate basis for planning of the future use, management, and above all, the protection of the unique Okavango Delta for generations to come.

1.7 ACKNOWLEDGEMENTS

The continuous cooperation and support received from the Steering Committee has contributed to Consultant's attitude and inspirations to make this study a worthwhile effort.

The assistance received from the various Government Departments and Agencies, in particular from the Ngamiland District Land Use Planning Unit, the Ministry of Local Government and Lands and the Kalahari Conservation Society during the study is gratefully acknowledged. The financial support from the United States Agency for International Development, who also provided two otherwise unavailable LANDSAT images, has made this important study a reality. Thanks are due to the Ministry of Agriculture and the Regional Agricultural Office, Maun, for providing the services of Ms Bendsen, and to the Department of Water Affairs for releasing Mr P Smith for the project; without the efforts of these two people with their intimate knowledge of specific aspects of the Delta the study team would not have been able to complete its immense task within such a short timeframe.

2. GEOMORPHOLOGY & SOILS

2.1 INTRODUCTION

The Okavango Delta is a large alluvial fan sloping at low gradient from c 1000m asl in the upper Panhandle to c 925m asl at the Thamalakane-Boteti divergence. Descriptions of the morphology and physical characteristics of the Delta have been published elsewhere (e.g. Hutchins et al., 1976a; UNDP/FAO, 1977).

The Delta environment comprises a series of landform systems (landscapes) which contain a basic suite of landform facets produced by fluvial deposition. These landform facets may be subsequently modified by the processes of fluvial erosion, fire, decay of organic material and zonation of minerals by both surface and groundwaters. Limited aeolian activity may also occur at the Delta margins, whilst tectonism is effective on a longer time scale. The topographic range within these landform systems is limited - relief rarely exceeds 5 - 10m in any location. Accurate topographic data for the Delta are very limited, and it is not practical to produce maps of absolute relief at the present time (Inception Report - p.4). However, relative relief is an important component in the close relationships between landform, hydrology, soils and vegetation.

The basic suite of landforms, with some modifications, is encountered throughout the Delta irrespective of the degree of flooding. The present distribution of the suite in the zones of perennial swamp, areas liable to flooding and non-flooded areas is dependent on the magnitude of seasonal floods, and the climatic, tectonic and hydrologic history of the Delta on a variety of time scales. Hydrological fluctuations on the Quaternary (<45 000yr) and historical (<200yr) time scales have been identified (Shaw, 1985; Wilson 1973).

Soil development is dependent on parent material, position in the landscape and hydrological characteristics, both past and present. Given the arenaceous nature of the parent material it is not surprising that similar soil catenas have developed in different parts of the Delta in relation to different landform systems, particularly where calcareous soils are concerned - for example, the soil catena developed on islands in the Delta (Unit 3b) is similar to that developed on the Thaoge fossil floodplain (subunit $3c^4$). Conversely, variations in the history of inundations will lead to variations in soil development in similar landform facets - for example, the floodplain of the Thamalakane, which receives flood waters in most years, comprises Eutric Fluvisols, whilst the floodplain of the Sankuyu, which has rarely received water since the mid-century, is composed largely of more mature Gleyic Luvisols. Renewed flooding could lead to further deposition and reversion to Eutric Fluvisols.

2.2 GEOMORPHOLOGICAL DATA

Following early topographic work which sought to elucidate the hydrological complexities of the Delta (Stigand, 1923; Du Toit, et al. 1926; Brind, 1955), geomorphological data has fallen into

four categories as follows:

1) General geomorphological descriptions of the Delta or parts thereof, usually as part of a wider description of the Okavango environment. (e.g. Hutchins et al., 1976a, 1976b; UNDP/FAO, 1977; SMEC, 1987a)

2) General geomorphological descriptions within the framework of a land systems approach, usually incorporating terrain units maps or annotated aerial photographs (e.g. Langdale-Brown and Spooner, 1963; Astle, 1977; Staring, 1978; Roeters and Riezebos, 1986) These also appear under soils data (section 2.3.2).

3) Papers describing changes in the hydrology of the Delta over time spans ranging from the Quaternary to the historical (e.g. Wilson, 1973; Shaw, 1984, 1985, 1986).

4) Research into specific processes, such as channel evolution and carbonate pathways at specific locations within the Delta (e.g. McCarthy et al., 1986a, 1986b, 1987, 1988). The findings of these papers are discussed further in Sections 2.7 and 2.4.

2.2.1 Limitations of geomorphological data

Although some of the published research is of interest in terms of the evolution of the Delta, including possible future changes, the available data are inadequate as a source for geomorphological mapping. The land systems maps that are available are of small scale, appear to lack field checking, and contain a number of anomalies which cast doubts on their veracity. There is no geomorphological map as such of the Okavango Delta.

2.3 SOILS DATA

The following sources are available for the project area:

2.3.1 Soils maps:-

FAO soils maps with associated memoirs:
(* indicates sheets not yet published. Drafts have been made available for the project)

1:250 000 Sheet 6 Maun
1:250 000 Sheet 9 Toteng*
1:250 000 Sheet 5 Nokaneng (discussions with surveyor only)
1:100 000 Panhandle* (covers parts of 1:250 000 sheets 1 + 2)
1:50 000 Boro-Shorobe sheet (Molapo Project)

2.3.2 Soils reports:-

Astle, W. (1977) Land Systems. UNDP/FAO BOT/71/506, Tech note 32, Gaborone.

Astle, W. & Braun, H. (1977) Soil Profile Descriptions,- UNDP/FAO BOT/71/506. Tech. note 35, Gaborone.

Bawden, M.G. (1965). Some soils of northern Bechuanaland - Land Resources Division, DOS Tolworth, U.K.

Roeters, B.B. and Riezebos, H. Th. (1986). Geomorphology, soils and land suitability near Gumare, Western Ngamiland, Botswana. Report to the Ministry of Local Government and Lands. State University, Utrecht.

Siderius, W, (1971). Soils of the Shorobe area - UNDP BOT 67/501 Tech. note 23, Gaborone.

SMEC(1987a Vol.II, 1987b). SOIWD soils reports for Nhabe River and Western Delta

Staring, G.J.(1978). Soils of the Okavango Delta. - FAO/UNDP BOT/72/019 Field Doc. 14. (Includes a terrain units map at 1:500 000)

2.3.3 Limitations of soils data

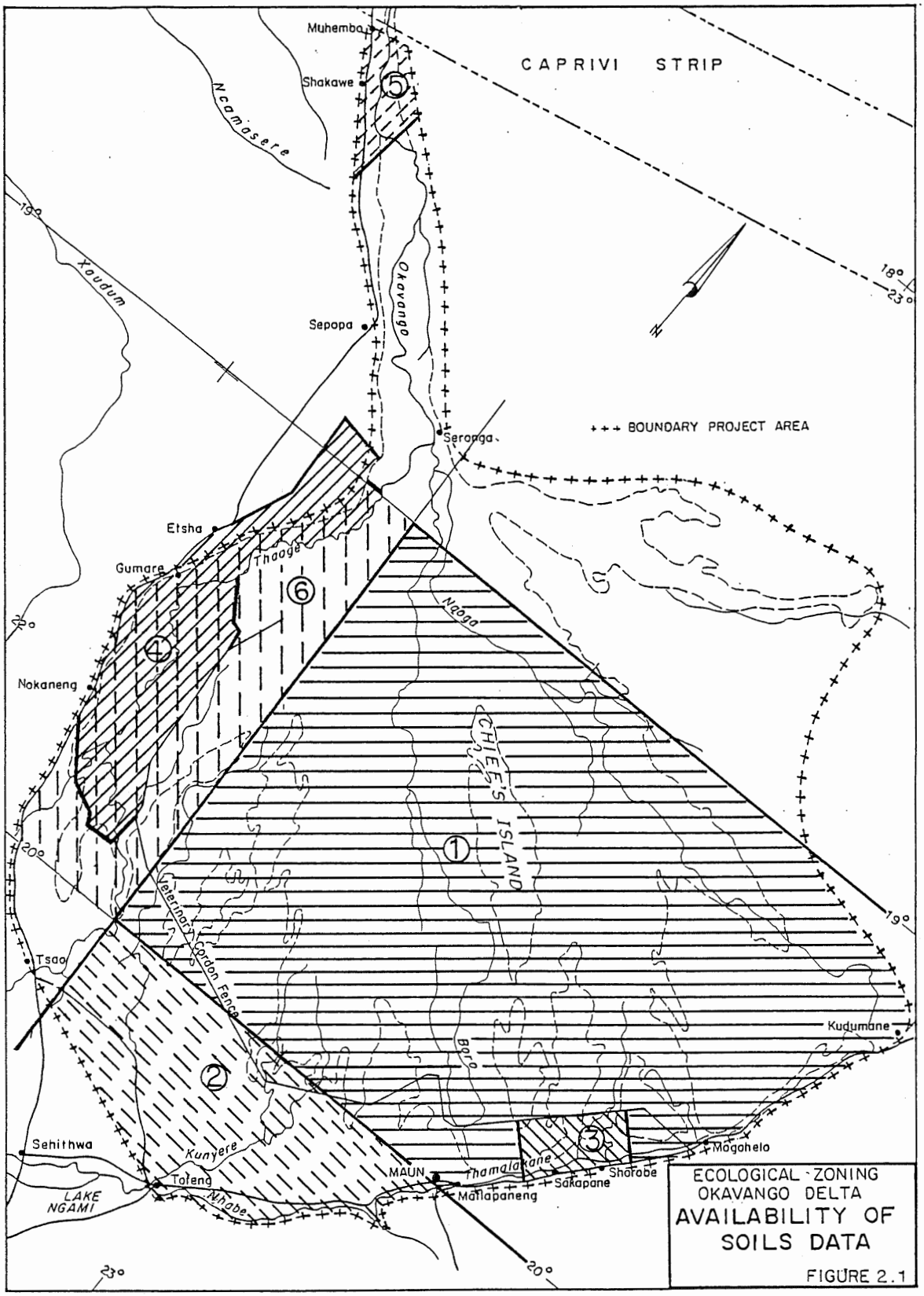
2.3.3.1 Data Quality:-

Soil data on the FAO/UNESCO classification is available for approximately 75% of the project area at a minimum scale of 1:250 000. It has been derived from examination of aerial photography, LANDSAT imagery dated June 1981 and August 1983, and field visits. At this scale it is considered to be reconnaissance data, with some areas lacking field checks. Accurate soils surveys at 1:100 000 and 1:50 000 are limited to peripheral areas in the western Delta, the Panhandle, Lake Ngami and the Molapo Project, related to specific projects (see fig. 2.1).

The areas without reconnaissance cover at present comprise the lower Panhandle, the Magwegqana system and a belt eastwards from the main Thaoge channel to 22°30'E. Work is in progress on the latter at the present time. For the present exercise these areas have been interpolated from LANDSAT imagery of April 1985, and checked against imagery of April 1983 and August 1983 to provide continuity with the FAO survey.

2.3.3.2 Data classification:-

The FAO soil surveys do not classify soils within the area defined as permanent swamp. The FAO soils legend proposes some 47 units and approximately 40 sub-units for alluvial soils in Botswana. Maps available for the Delta use about 25 of these units, frequently as part of distinctive catenas or soil associations. Some common catenas (e.g. islands) are individually identified.



1 — 1:250 000 MAUN SHEET

2 — 1:250 000 TOTENG SHEET (DRAFT)

3 — 1:50 000 BORO-SHOROBE (MOLAPO PROJECT)

4 — 1:100 000 SOIWD WESTERN DELTA

5 — 1:100 000 SOIWD U. PANHANDLE

6 — 1:250 000 NOKANENG (SURVEY DATA ONLY)

SOIWD soils maps for the upper Panhandle and western Delta utilise 21 units which are comparable to the FAO legend. Comparable FAO maps are available for the upper Panhandle, but not, as yet, the Nokaneng sheet (sheet 5). Staring (1978) has produced a terrain unit map at a scale of 1:500 000, incorporating 14 soil series with vegetation and landform associations. The soil series have been verified from approximately 125 sample locations, mostly at the periphery of the Delta.

The soil series are expressed in terms of % area within each terrain unit. Only seven of the units are derived from alluvial or lacustrine deposits, the remainder, including sand tongue associations, are categorised as originating from Kalahari Sand. There are some doubts as to the accuracy of this map.

Other soils surveys above contain limited data incompatible with the FAO soil classification, with exception of the derived exercise of Roeters and Riezebos (1986), which covers a limited area.

Correlation of soil units between surveys is provided in Appendix C.

2.4 GEOLOGY AND SURFICIAL MATERIALS

The entire project area is covered with sediments of the Okavango Series, part of the larger Kalahari Group. At no point within the area does hard rock outcrop at the surface, with the exception of a band of unidentified sandstone, possibly silcrete, across the Okavango River north of Muhembo.

The sediments encountered are mostly unconsolidated alluvial sands and organic peats, together with the products of chemical alteration of the sands, namely calcrete and silcrete. Variations occur at the periphery of the Delta, particularly in the western Delta, where the Thaoge has been responsible for the deposition of a silt-rich load, and below the Kunyere Fault Line, where the alluvial deposits are relatively rich in clays. These silt and clay sediments give rise to specific soil types, and carry higher erosion risks.

Some debate arises over the origin of the sands south of the Kunyere Fault Line. The FAO Soil Survey believes the sand comprising the islands to be the remnants of an old dune field, which has been altered by subsequent inundation. Although the islands in this area appear to follow a NW-SE alignment the sediments cannot be differentiated from alluvial sand, and give rise to the same sequence of soil catenas. The precise origin of the features remains to be studied within an academic context.

Calcrete, in the form of petrocalcic horizons within and beneath the soil, is common throughout the Delta, and has formed by the capillary rise of groundwater, followed by evaporation and precipitation of calcium carbonate, together with trona and thermonatrate on islands within the swamp. Detailed models of

carbonate accumulation have been provided by Rhebergen (1985) and McCarthy et al. (1986b). The greatest accumulations of calcrete occur at the periphery of the Delta, and in areas that have become desiccated over recent centuries.

Silcrete is uncommon within the Delta, but has been encountered as sills and bars along the Thamalakane, Nhabe and Boteti Rivers, as for example, in the vicinity of Matlapaneng Bridge. It has also been encountered at a depth of about 5m in boreholes on the Thamalakane floodplain, where it appears to be forming at about the present time (SMEC 1987a, Vol.II). The main mode of formation appears to be by precipitation from silica-rich groundwater caused by changes in pH.

2.5 TECTONISM

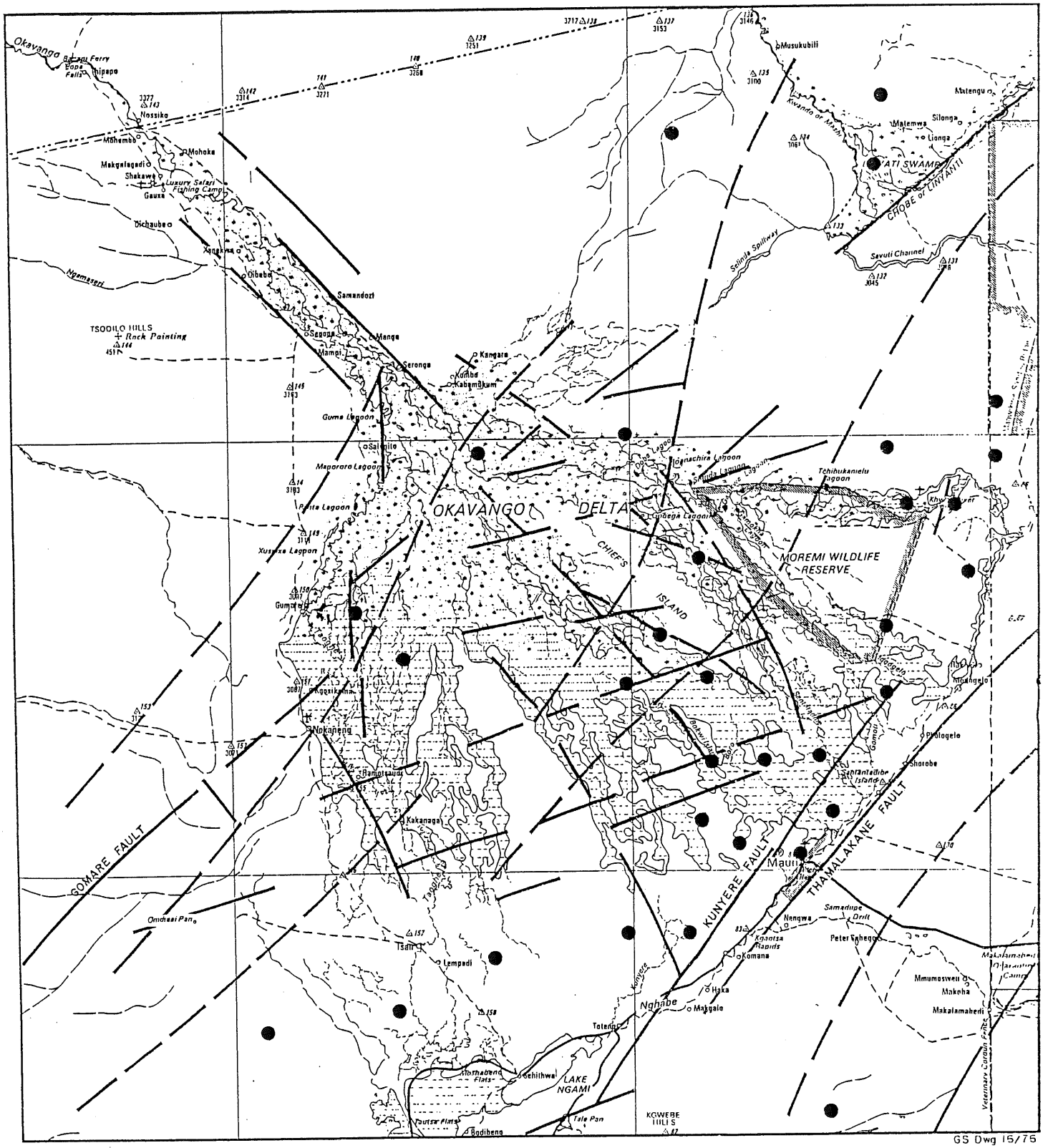
The Okavango Delta forms part of the infill of the Okavango Graben, with frequent tectonic adjustment to changes in distribution of sediment and water. Tectonism is indicated by minor seismic events in the vicinity of faultlines; a total of 38 such events, 31 greater than 3.0 on the Richter scale, were recorded between September 1965 and August 1974 (Hutchins et al. 1976a).

Three major fault lines running NE-SW (figure 2.2), the Gumare, Kunyere and Thamalakane Faults, play a major role in controlling flow and sedimentation in the Delta and are active at the present time. NW-SE faults also control the form of the Panhandle. Hutchins et al. (1976a,b) also map a number of lineations from satellite imagery which may be fault structures. The use of other remote sensing techniques, such as side-scan radar, may help define these features more clearly.

Unfortunately no research has been carried out on tectonism since the UNDP/FAO Project of the 1970's. Tectonic activity has been suggested as a cause of hydrological shifts (e.g., Pike 1970) but this is by no means proved (for discussion see SMEC 1987a, Vol.III, p.37). The mapping of faults and lineations has not been included as part of the ecological zoning exercise.

2.6 AEOLIAN ACTIVITY AND EROSION RISK

No studies of aeolian erosion or transport have been carried out in The Okavango Delta, or, indeed, anywhere in northern Botswana. However, land degradation is invariably accompanied by the loss of topsoil by deflation in areas above the water table. This is particularly acute in areas of fine soils; the SMEC report (1987b, p. 79) on the western Delta notes the loss of 7cm of topsoil over a period of a few months in the vicinity of Gumare. For this reason all soil in Terrain Unit 3 with high clay or silt contents have a high erosion risk and have been mapped with the appropriate modifier. Research into this topic is urgently required.



LEGEND

- Earthquake epicentres registered by the Rhodesian Seismograph Network
- Main faults and linears determined by photogeological and satellite imagery interpretation and geophysical investigation
- Regional tectonic trends suggested by geophysical evidence

10 5 0 10 20 30 40 50 60 70 80 90 100 km

FIGURE 2·2 MAIN STRUCTURAL ELEMENTS AND EARTHQUAKE EPICENTRES IN THE OKAVANGO (From Hutchins et al. 1976a)

2.7 FLUVIAL PROCESSES

Hydrological changes are indicated by variations in the annual distribution of seasonal swamp and pro rata changes in the water volumes carried out by the distributary channels. These variations are discussed in Section 4.

Recent work by McCarthy et al. (1986a, 1987, 1988) on the Nqoga channel suggests that switching of channel systems occur on a time scale of c.100 years as a response to aggradation and blockage, followed by desiccation and burning of the surrounding peat. This in turn, leads to relief inversion of the moribund channel form to produce sinuous ridges, whilst the water flow is diverted to a new channel system. The research suggests that channel grade alone will lead eventually to cycles of channel evolution, although this may be hastened by other factors. This interesting hypothesis may have wide application in the upper Delta, but awaits confirmation from other sites.

2.8 FUTURE DEVELOPMENTS

The Okavango Delta is a dynamic system liable to changes on a variety of time scales in response to a number of factors, including hydrological and climatic shifts, tectonism, natural cycles of channel evolution, vegetation changes, the activities of animals, and above all at the present time, human activity. Without an understanding of these factors individually it is not possible to predict future changes within the Delta, except to point out that the range of conditions experienced within the Delta over the past 150 years (Shaw, 1984) is far greater than that indicated during the span of hydrological measurements. Future changes are inevitable as a result of both natural evolution and human interference. An indication of areas where changes are occurring at the present time is given in Sections 4.1.4 and 5.10

2.9 RECOMMENDATIONS FOR FUTURE WORK

An understanding of the landscape of the Okavango Delta is hindered at present by the lack of base-line data on geological and geomorphological processes, particularly with reference to process rates and continuity. Data collection at present is largely concerned with hydrological parameters, and can be considered as barely adequate. The following topics need to be addressed:

a) The processes and rates of sedimentation within the Delta, including solution and flotation (i.e. organic) loads
b) An investigation into the processes of channel evolution within the upper Delta, extending the work of McCarthy et al. into other types of distributary system. This should involve historical studies from available aerial photography, shallow coring for stratigraphy and potential radiometric dating, and water/sediment data collection
c) The distribution and rates of wind erosion, particularly in the western Delta

d) A resumption of tectonic and seismic studies to follow up the work carried out by Hutchins et al. (1976a)
e) A refinement of hydrological monitoring from remote sensing sources.

2.10 THE GEOMORPHOLOGY AND SOILS MAP

2.10.1 Approach to geomorphological and soil mapping

The aim of the study has been to produce a consistent reconnaissance level map of soils and geomorphology from available data at a scale of 1:250 000, bearing in mind the following limitations:

1) That the available data are (a) incomplete, (b) based on the state of the Delta at the time of survey. As some of the data have been interpolated (see section 2.3.3.1) **soils information should not be regarded as accurate as that indicated on the source maps.**

2) The complexity of the Delta mosaic makes it unrealistic to identify individual land forms or soil units at a scale of 1:250 000.

3) The dynamic nature of the Delta ensures that many of the landforms are ephemeral by nature, and that even the soils units are liable to change on a relatively short time scale.

The initial approach has been to divide the Delta into three zones based on liability to flooding, i.e. perennial swamp, zones liable to flooding, and zones not liable to flooding. The landforms and soils of each of the three zones have been assessed and subdivided on the basis of common association. The Delta has been divided into land form systems (landscapes) and landform facets (landforms) on the basis of geomorphology. These, in turn, have been combined with common soil associations to give terrain units. **Terrain units and sub-units, therefore are based on the recurrence of associations of landform facets and soils.** Where similar soil associations occur within different landform systems, the classification has been biased towards geomorphological characteristics. A detailed description of the terrain units is given in the following sections. A summary of soil terrain unit associations is given in Appendix D, including correlation between terrain units with similar soil associations. Idealised landform/soil profiles are shown in figures 2.3 - 2.8.

2.10.2 Geomorphological classification

The Delta can be divided into a series of landform systems, comprising associations of landform facets, which can be feasibly mapped at 1:250 000. Landform facets are those landforms considered to be sufficiently large to be identified from aerial photography. They may, in turn, contain smaller integral landforms, such as point bars, meander loops, termitaria fields,

etc. The main landform facets identifiable are:

Landform Facets	Perennial Swamp	Zones Liable to flood	Non-flooded zones
discrete channels:			
1) confined	x	x	x
2) unconfined	x	x	
channel complexes	x	x	x
madiba (lagoons)	x	x	
floodplains:			
1) flats(unconfined)	x	x	x
2) terraces (confined)		x	x
raised terraces		x	x
ridges:			
1) inverted and aggraded channels	x	x	x
2) levees		x	x
islands	x	x	x
pans:		x	x
sand plateaux			x
linear dunes			x

2.10.3 Soil classification

The soil classification used is the FAO/MOA classification for Botswana.

2.10.4 Description of Terrain Units

UNIT 1: PERENNIAL SWAMP

General Comment: soils within the zone of perennial swamp have not been mapped during the course of soil survey. For the most part they are comprised of interbedded sands and peat layers formed during channel shifts in the swamp zone, together with some sand ridges. Some islands too small to map at this scale also occur, with the soil associations of unit 3b.

Landform facets: discrete channels (confined and unconfined), madiba floodplains (flats), ridges, islands.

Dominant soils in association: Histosols, Eutric Arenosol, Eutric Fluvisol.

Associations mapped: none

UNIT 2: ZONES LIABLE TO FLOODING

General comment: this large unit, which occupies much of the lower Delta, has been defined on the basis of flood area in a single year, and its definition is not, therefore, as accurate as that employed in the vegetation and hydrological surveys at a

scale of 1:100 000. Within the unit there is obviously a range of flood characteristics from annual inundation to intermittent and occasional flooding which are dependent on hydrological factors.

In general terms, the regularity of flooding controls soil development. The type of soils present, therefore, indicates these flooding characteristics for the recent geological past. A division into subunits 2a and 2b has been made on the approximate frequency of flooding.

Subunit 2a[1]: Seasonal floodplains

General Comment: floodplains liable to inundation most years, including the terrace floodplains of the lower Delta distributaries, and flats within the Delta itself. The dominant soils are poorly drained sandy loams, with clay in the Boro-Thamalakane floodplains, and silt loams in the middle Thaoge. Islands are generally absent from these areas.

Landform Facets: floodplain (flats), floodplain (contemporary terrace).

Dominant soils: Eutric Fluvisol, Arenic Eutric Fluvisol.

Subsidiary soils: Calcic Luvisol, Orthic Luvisol, Haplic Phaeozem, Eutric Arenosol, Eutric Gleysol, Arenic Eutric Fluvisol (clay phase).

Associations mapped: A24, A24a, A24b, A24d, A24e, A24b-31a, A24b-40, A40-24b, DA1, TR3, TR4, TR5, TR6.

Subunit 2a[2]: Island and Floodplain complexes - seasonal flooding (Figures 2.4 and 2.7)

General comment: areas within the Delta comprising a mosaic of island and channels which are liable to inundation in most years. Below the Kunyere Fault line the category is restricted to areas adjacent to the Boro and Santantadibe Rivers where annual flooding has been much reduced over recent years. A complex category including both island (unit 3b) and floodplain categories.

Landform Facets: discrete channels, channel complexes, island, floodplain (flats), floodplain (contemporary terrace), ridges.

Dominant soils in Association: a) islands: Calcic Arenosol, Arenic Calcic Luvisol (party sodic), Calcic Luvisol (partly sodic)

b) floodplains: Eutric Fluvisol, Eutric Gleysol, Eutric Arenosol.

Subsidiary soils: Gleyic Luvisol (partly sodic)

Associations mapped: y-A24b, y-A31a, y-A24b-31a, y-A24b-31b, y-A24b-40, y-A24b-40-31b, y-A40-24b, A24b-y, A24-24b-x, x-24-31b, A31b-24-x, A31a-7-24-x, A31a-7-24-y, A40-24b, SV1-TR5, TR5-SV1, DA1-SV1, DA1-SV2,SV1-DA1,SV6-TR5,SV2-TR1.

Subunit $2b^1$: Occasional floodplains

General comment: restricted to the Thaoge floodplain between the terminal blockage northeast of Gumare and the confluence with the Karongana. The floodplain, apart from the channel and limited adjacent areas, has been undergoing desiccation since the 1940's and is unlikely to be flooded at the present time. It adjoins the older terrace sediments of Unit $3c^3$, and is liable to wind erosion.

Landform facets: floodplain (flats), floodplain (contemporary terrace), minor sand dunes.

Dominant soils: Eutric Fluvisol, Orthic Luvisol.

Subsidiary soils: Calcic Luvisol, Haplic Phaeozem, Albic Luvisol.

Associations mapped: TR4-6, TR2-4, TR4-2, TR4-5, TR4-3.

Subunit $2b^2$: Island and floodplain complexes - occasional flooding

General comment: landform facets similar to Unit $2a^2$, but which are either higher (usually adjacent to sand plateaux) or occur in areas of the Delta which have become desiccated over recent decades, as around the Khwai and Gomoti distributaries. Includes the lower Delta distributaries such as the Sankuyu which rarely contain flow. In general the Eutric Fluvisols and Eutric Gleysols of Unit $2a^2$ give way to Gleyic Luvisols and Calcic Luvisols in the lower topographic positions.
Landform facets: discrete channels, channel complexes, islands, floodplains (flats), floodplains (contemporary terrace), ridges, pans.

Dominant soils in association: a) islands: Calcic Arenosol, Arenic Calcic Luvisol (partly sodic), Calcic Luvisol (partly sodic)

b) floodplains and channels: Eutric Gleysol, Gleyic Luvisol, Calcic Luvisol, Eutric Arenosol.

Subsidiary soils: Calcic Luvisol (party sodic)

Associations mapped: y-A31a-7, y-A7-31a, y-A31b-7a, y-L24, A7, A7a-31b-40, A31a-7-y, A31a-7-7b-y, A31a-7-40-y, A31a-31b-y, A40, A40-y, A40-7, A40-7a, A40-31b-y, A40a-7, SV1-SV2-DA1, SV1-TR5, TR5-SV1.

Subunit $2b^3$: Island and floodplain complexes - occasional flooding, high clay content

General comment: restricted to the zone between the Kunyere and Thamalakane Faults. Landforms and dominant soils as above, with increased proportion of clay-rich Gleyic Luvisols and Calcic Luvisols. Prone to wind erosion.

Associations mapped: A7-9-x, A7-9-y, A7-7b-31a, A7a-7b, A31a-7-x, A40-7, A40-7-9, A40-9a-7b, x-9.

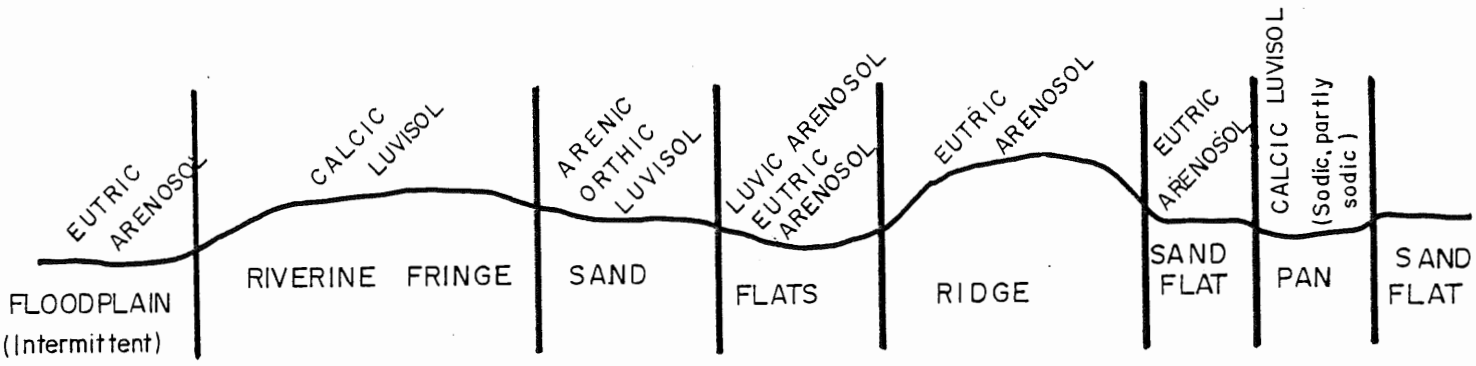
UNIT 3: ZONES NOT LIABLE TO FLOODING

General comment: this major unit incorporates all areas above the level of flooding in the Delta, although the soils themselves are derived from alluvial deposits, with the possible exception of the "flooded dunes" of the Fault Zone (see: geology and surficial materials, Section 2.4). The length of time since the cessation of flooding varies between subunits; areas such as the sand plateaux are likely to have remained above the inundation level for much of the late Quaternary, whilst other areas, such as the lower Thaoge, became desiccated during the last century. Soils are generally arenaceous by nature, with some clays in topographic lows which may become intermittently inundated by rain. the unit as a whole is liable to wind erosion, particularly where finer materials prevail. The unit may be subdivided as follows:

Unit 3a: Sand Plateaux (Fig. 2.3)

FIGURE 2.3

UNITS 3a / $3a^1$ / $3a^2$ SAND PLATEAU – LOWER DELTA



General characteristics: alluvial sands elevated to flat to undulating plateaux, with some ridges and minor depressions. Channel alignments present on LANDSAT, also some linear dune formation, particularly in the Nhabe-Kunyere Tongue.

Main Locations: Mopane Tongue, Chiefs Island, Sandveld Tongue, Nhabe-Kunyere Tongue. Also areas peripheral to the Delta where alluvial sand soils grade into the arenosols derived from the Kalahari Sand.

Landform facets: sand plateaux, channel complexes, pans, ridges, linear dunes.

Dominant Soils in Association: Eutric Arenosol, Luvic Arenosol, Arenic Orthic Luvisol.

Subsidiary Soils: Calcic Luvisol (partly sodic), Calcic Arenosol, Petrocalcic Luvisol, Arenic Calcic Luvisol.

Associations mapped: A40-41-15a, A40-40a-9a, A41-15a-9a, A40, A40b-40, A40-40a-41, A40a-40-9, A41-40, A40-41-15a-40b, A40-21a A40-41-15a-9b, S17-A40, A15a-41-40b, A15a-41-40-21, SV 2,3,4,5,6.

Subunit 3a^1: Sand Ridges (Fig. 2.3)

General comment: sand ridges occur within the Delta either as levees bounding the major channels, or as sinuous forms created by channel inversion and aggradation (McCarthy et al., 1988). Although the sinuous ridges, in particular, are common throughout the swamps, they are only mapped individually where they are sufficiently large to be discerned on LANDSAT imagery. Other ridges are included in Unit 3a.

Landform facets: ridge (channel inversion), ridge (levee)

Dominant Soil: Eutric Arenosol

Associations mapped: A40b, SV2.

Subunit 3a^2: Sand plateaux with depressions (Fig. 2.3)

General comment: lower lying areas of the sandveld at the edges of the Delta liable to limited flooding following heavy rain. The most common occurrence is as a series of pans between vestiges of channels observable only from the air, as in the Mopane Tongue.

Landform facets: sand plateaux, ridges, channel complexes, pans.

Dominant soils in association: Eutric Arenosol, Arenic Orthic Luvisol, Gleyic Luvisol (partly sodic).

Subsidiary soils: Calcic Luvisol (partly sodic), Luvic Arenosol.

Associations mapped: A40a-7, A15a-9-41-7, A7-40a, A7-15a-9.

Unit 3b: Islands and Riverine Fringes (Figs. 2.4 and 2.5)

FIGURE 2.4

UNITS 3b/2a[2] ISLAND AND FLOOD PLAIN ASSOCIATION – LOWER DELTA

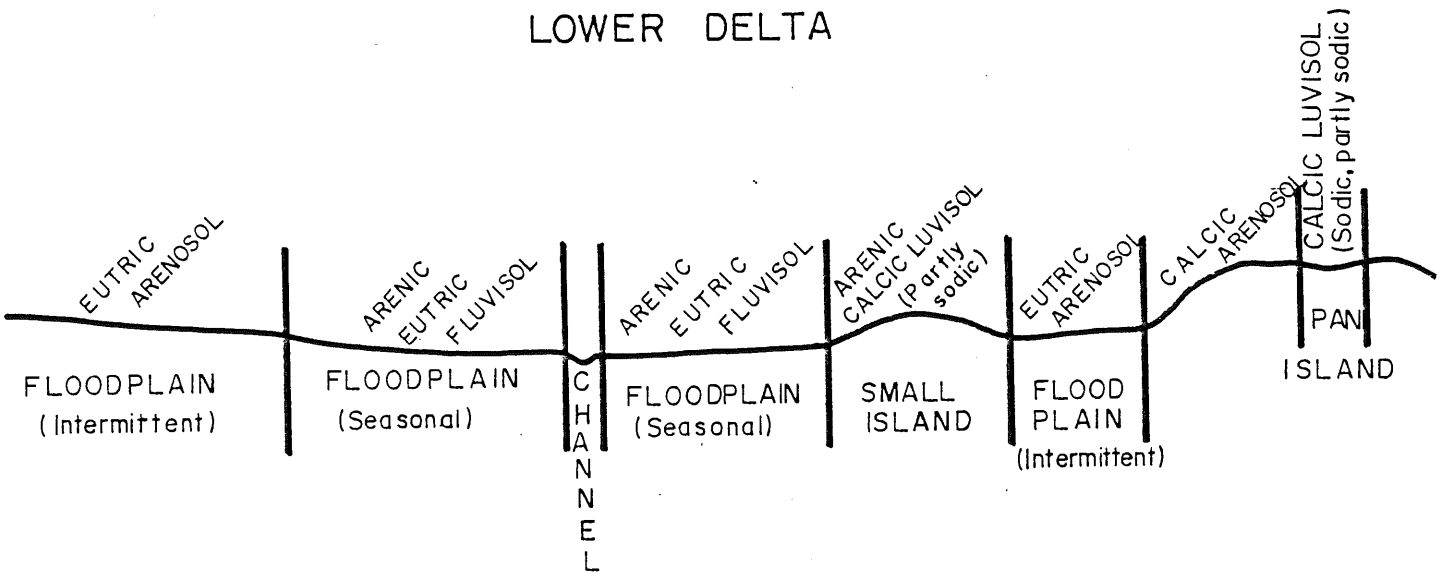
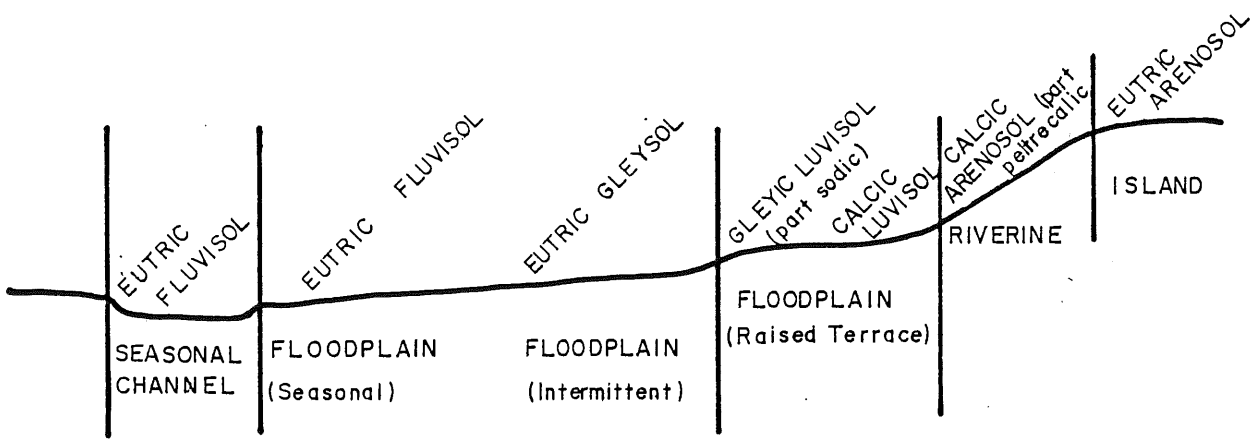


FIGURE 2.5

UNITS 3b/3b[3] ISLAND AND FLOOD PLAIN ASSOCIATION KUNYERE-THAMALAKANE FAULT ZONE.



The FAO legend identifies a characteristic catena associated with islands in the Delta, irrespective of either fluvial or aeolian origin of the parent material. The same catena appears along the riverine fringes of sandveld units, particularly in the lower Delta. It has only been possible to map the larger islands- smaller features are inherent in the classification employed for

areas liable to flooding (unit 2). The main characteristic of the catena is the presence of calcic soils, occasionally with a petrocalcic layer, as a consequence of present or past capillary rise of sub-surface water. The islands are likely to have surface depressions (pans) which may contain partly sodic soils. the mechanisms of salt deposition on islands has been described by McCarthy et al. (1986b).

Landform facets: islands, pans, sand plateaux

Dominant soils in association: Calcic Arenosol, Calcic Arenosol (partly sodic), Eutric Arenosol, Arenic Calcic Luvisol (partly sodic).

Subsidiary soils: Petrocalcic Arenosol, Calcic Luvisol (sodic, partly saline).

Associations mapped: *x(A9a-A21-L24a), *y(L11-L24a-S13-S13a-S17), A40-9a-21, y-A40-40b, A40b-40-y, A21-9-40, A21-40-15, A21-40, A9-15a-21, A9a-21-40, A9-21a, A9a-40, SV1, SV2-6, SV5, SV1-TR4, TR6-SV1.

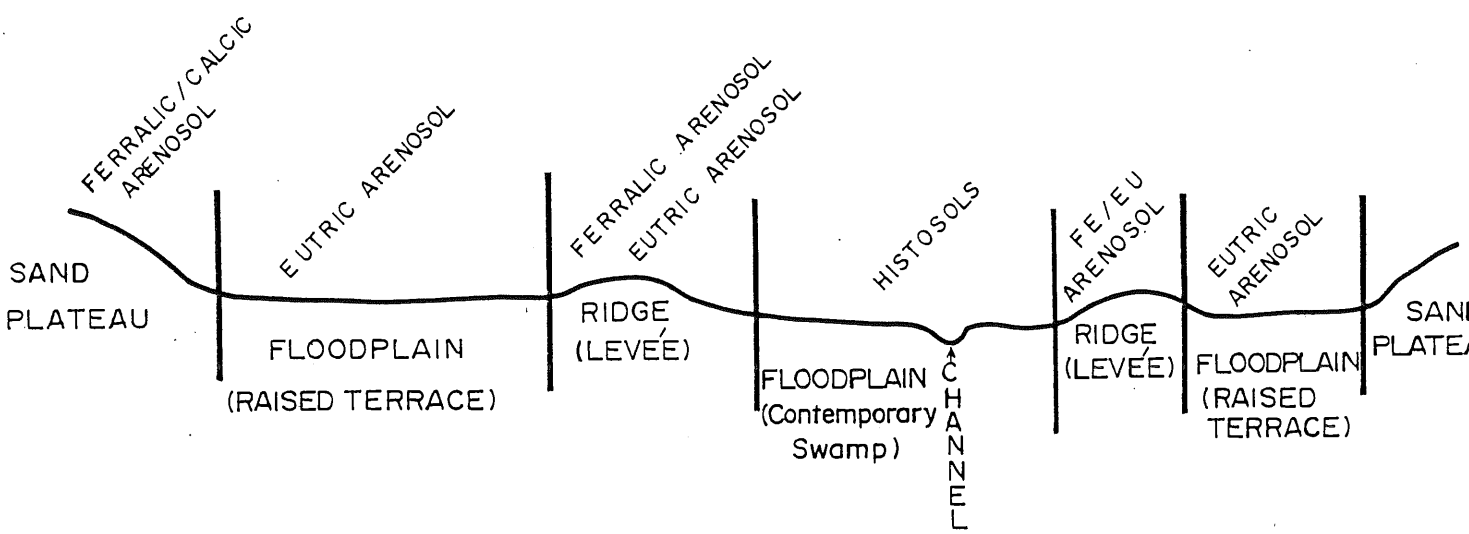
(* = recurring catena, identical soils in x & y)

Unit 3c: Fossil terraces and floodplains:

Peripheral areas of the Delta, and the Panhandle itself, contain terraces and floodplains now above or beyond the range of the contemporary flood regime. These landform systems have been formed at different times during the late Quaternary, and, although they have a common origin, show considerable variety in landform facets and soils. This landform system has not been mapped per se, but as a series of subunits:

Subunit $3c^1$: Panhandle Terrace (Fig. 2.6)

FIGURE 2.6
UNITS $3c^1/3c^2$ PANHANDLE



General characteristics: sandy soils of the terrace between the levee and sandveld in the Panhandle. Soils very similar to the sand plateaux adjacent to the Panhandle. Surface depressions flooded by rainfall are common.

Landform facet: floodplain (terrace)

Dominant soils in Association: Eutric Arenosol, Cambic Arenosol.

Associations mapped: A22-40, A40-22, A22a.

Subunit $3c^2$: Panhandle levees (Fig. 2.7)

General comment: the upper Panhandle in particular, has pronounced levees bounding the present channel system, although similar features appear throughout the western Delta. Soils contain more iron than the typical arenosols.

Landform unit: ridge (levee)

Dominant soils in association: Ferralic Arenosol, Eutric Arenosol.

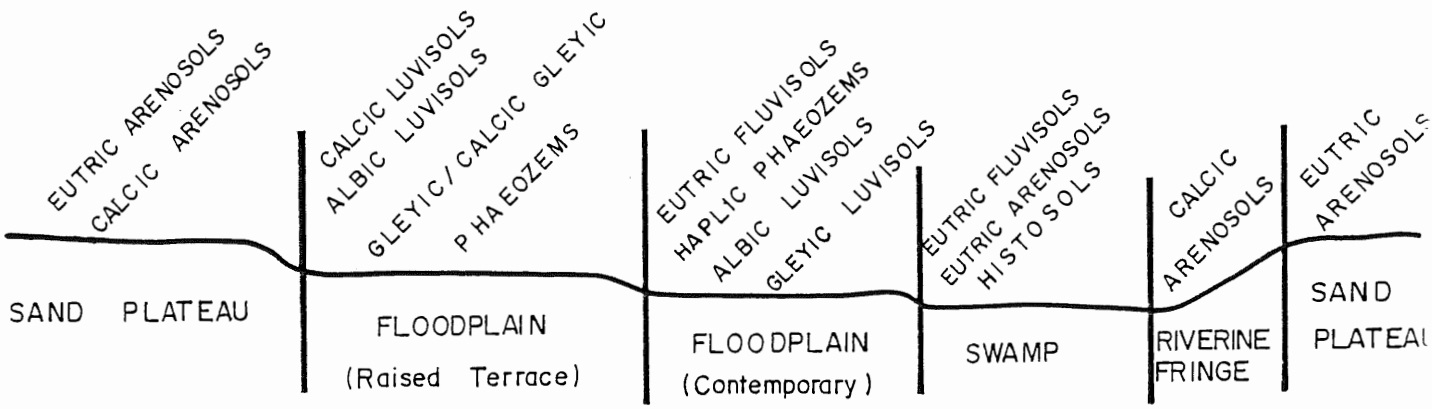
Subsidiary soil: Arenic Ferric Luvisol, Arenic Calcic Luvisol

Associations mapped: A19-40, A19-12.

Subunit $3c^3$: Thaoge Western Floodplain (Fig. 2.7)

FIGURE 2.7

UNITS $3c^3/2a^1/2b^1$ THAOGE WESTERN FLOOD PLAIN



General comment: a complex area of old swamp soils, now classified as silt-rich phaeozems, occurring mainly in a belt between Gumare and Tsao. The areas probably dried out with the diminution of the Thaoge flow in the late 19th century, thus their hydromorphic properties are relict. They are unlikely to be flooded at the present time, but are very prone to wind erosion. Land degradation in this unit is severe, and much of

the surface landforms are now obscured by deflation and dune formation. South of Nokaneng the subunit grades imperceptibly into subunit $3c^4$.

Landform facets: discrete channels, channel complexes, floodplains (relict flats), islands, minor dunes.

Dominant soils in association: Albic Luvisol, Gleyic Phaeozem, Calcic Gleyic Phaeozem.

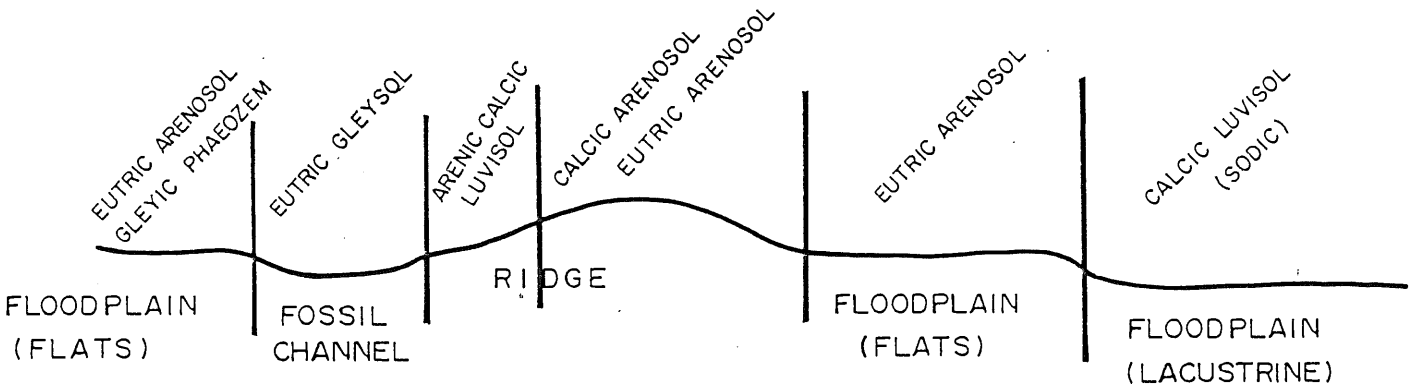
Subsidiary soils: Calcic Arenosol, Eutric Arenosol, Calcic Gleyic Luvisol.

Associations mapped: A7b(TO4), TO1-TO3, TO3-TO1, TO3-SV2, TO4.

Subunit $3c^4$ Thaoge Terminal Floodplain (Fig. 2.8)

FIGURE 2.8

UNIT $3c^4$ THAOGE TERMINAL FLOOD PLAIN



General comment: a soil catena similar to that developed in the island and riverine fringe landscape system has been identified on the fossil terminal flood plain of the Thaoge, between Tsao and the beach ridges on the northern side of Lake Ngami. The landscape here is flat to undulating, with a complex pattern of anastomosing sand ridges and channels. Calcic horizons here are likely to be related to the retreat of the floodzone from this region in the last decades of the 19th century, although some areas around Tsao may have been flooded as late as the 1920s. The soils become increasingly silty towards the fossil lake bed north of the Magotlwanen Ridge and grades into Gleyic Phaeozems and Eutric Arenosols north of Tsao. As already noted, the boundaries between subunits $3c^3$ and $3c^4$ are indistinct in the region. A similar silt-rich association is developed over a limited area in the lower Kunyere above Toteng.

Landform facets: channel complexes, ridges, pans.

Dominant soils in association: Arenic Calcic Luvisol (partly sodic), Calcic Arenosol, Eutric Arenosol.

Subsidiary soils: Luvic Arenosol, Calcic Arenosol (partly sodic), Gleyic Luvisol, Calcic Luvisol (sodic, partly saline), Gleyic Phaeozem.

Associations mapped: A9a-21-40, A9a-40a-21, A7b-40b-L7, L11a-A40-21a-41, A47-21-14a, A9a-21-L24a, A21-9a-L24a.

Subunit $3c^5$: Lower Thamalakane Raised Terrace

General comment: a floodplain terrace related to the high discharges of the late Quaternary is developed at altitudes of 936-940m asl in the lower Thamalakane at its junction with the Boteti and Nhabe Rivers. The terrace is relatively flat, with a number of surface depressions liable to flooding by rainfall. The soil association is very similar to subunit $3a^2$ (sand plateaux with depressions).

Landform facets: floodplain (relict terrace), pans.

Dominant soils in association: Eutric Arenosol, Orthic Luvisol, Arenic Calcic Luvisol (partly sodic), Calcic Luvisol (petrocalcic).

Subsidiary soils: Calcic Gleyic Luvisol (partly sodic).

Associations mapped: A40-14a-9b, A40-9b-14a, A40-9a-14a, A14a-9b-7b.

3. CLIMATE

3.1 REGIONAL CLIMATIC INFLUENCES

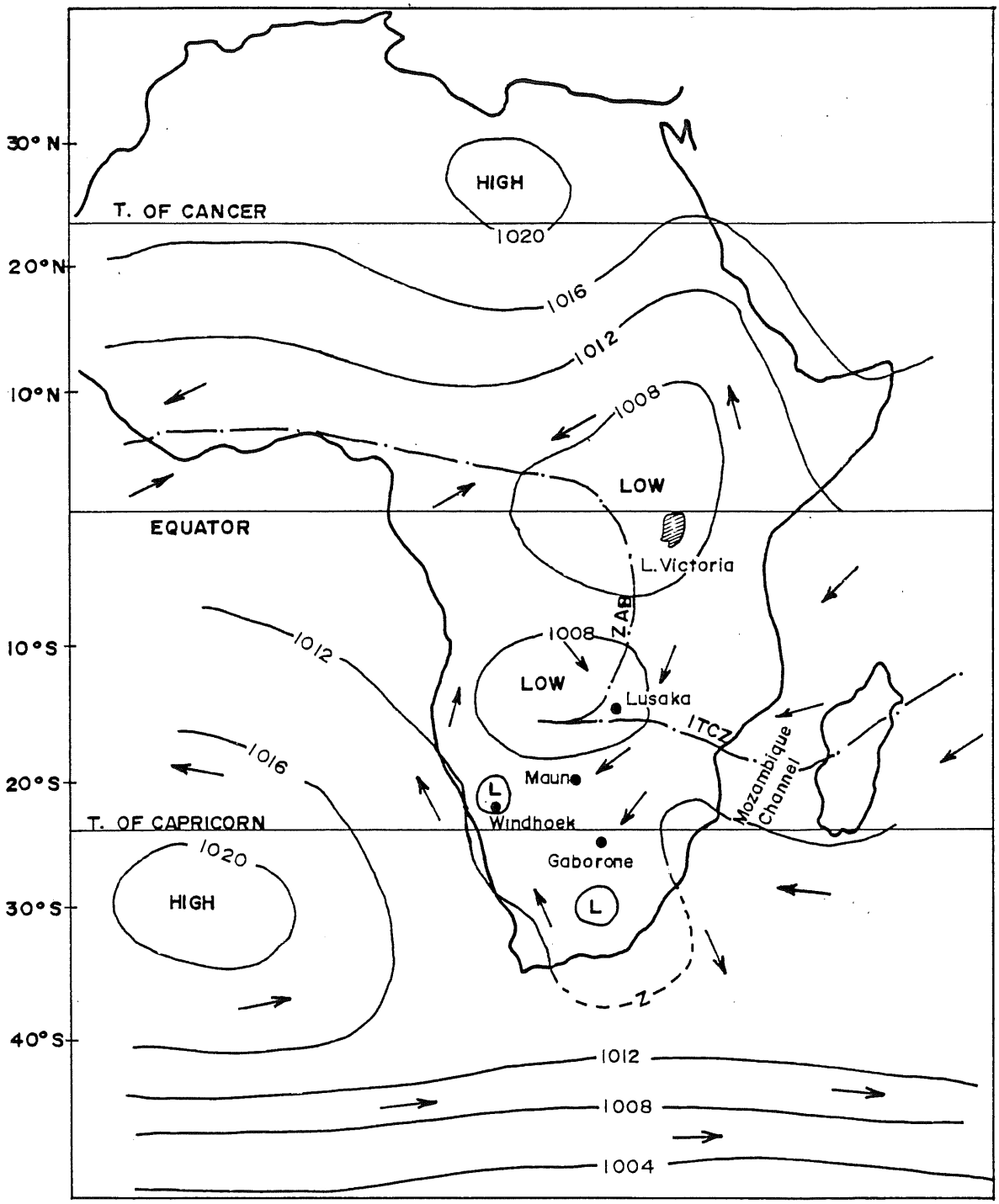
The climate is influenced by the location of the Okavango Delta in the centre of the southern African land-mass, remote from ocean sources of moisture, and by its latitude which places it just within the tropics but outside the usual range of major tropical disturbances.

The Okavango Delta and Makgadikgadi Pans are in the centre of a large central plateau which is a slight depression between mountain escarpments far to the east and to the west. As a result the air passing over the plateau is very dry, and the lack of relief in the terrain means orographic effects are absent. Consequently, during the cool months of June to August when a strong cell of high pressure prevails over the Transvaal, the climate is always very dry and often rainless. Minimum temperatures may occasionally fall to around zero at this time of year, but daytime temperatures remain mild.

In the months of October and November, immediately preceding the wet season, precipitation may be initiated by oscillations from the higher latitude westerly airstream, sometimes in the form of a cut-off low pressure system. At this time of year (and in April, which is a post-rainy season transition month) the westerly airstream at high altitude slopes farthest north toward the equator. Upper level disturbance may then produce light rainfall. This mechanism is less influential in northern Botswana, however, than in the south-east around Gaborone. Consequently, both early season and late season rainfall are rather less than in south-eastern parts of the country.

The other influence in pre-season rainfall in October and November is the southerly shift of the Zaire Air Boundary (ZAB). As the rainy season approaches, a sub-equatorial low pressure systems begins to develop over Angola, causing the south-east trade winds in the Atlantic to recurve over Zaire, producing a very moist airmass known as Zaire air. Although this moist airmass proceeds further south-east into Zambia as the season progresses, in the early pre-season months rapid temporary displacements to the south can occur, producing some rainfall by thunderstorm activity. From December the ZAB is usually established into Zambia, and good rain may result from incursions of this moist airmass into the Okavango region. This is usually associated with north or north-west winds.

By January the southern boundary of the inter-tropical convergence zone (ITCZ) has moved to its southernmost latitude over Zambia and Malawi (Figure 3.1). This boundary is the northern limit of the south-east trades where they are deflected eastward by the summer high pressure cell in the Indian Ocean and prevail along the eastern African coast at this latitude as a moist unstable airstream. Perturbations from this airstream may produce good rain in northern Botswana in the following months until the ITCZ dissipates and reforms further north, usually in March.



Mean surface pressure (mb)
and prevailing wind directions in January

ITCZ Southern edge of Inter Tropical Convergence Zone

ZAB Zaire Air Boundary

— After Bhalotra (1984)

ECOLOGICAL ZONING
OKAVANGO DELTA

SYNOPTIC SITUATION IN JANUARY

Figure 3·1

Precipitation produced from this system is most often in the form of thunderstorms and is associated with east to north-east winds. Because the mean position of the ZAB and the ITCZ do not normally extend this far south, summer rainfall in the Okavango Delta is much lighter and less regular than in the lower latitude tropics. Several weeks without rain can occasionally occur even in the wettest months of the year, December to March. Conversely, in rare seasons when the ZAB/ITCZ complex extends further south than usual heavier and more persistent rains may occur.

The other mechanisms of note are tropical storm cells or 'cyclones' which may develop in the Mozambique Channel in summer months from late December to March. Those forming in the Mozambique Channel average about one per year and only some of these strike land. The strength of the convective cells weakens rapidly if they move inland, and these systems rarely penetrate as far as northern Botswana. When they do they are weakened to low pressure systems without the violent circular motion of tropical storms, but may produce good general rain. Tropical storm cells which persist in the Mozambique Channel may actually produce very hot and dry conditions in northern Botswana during these months by inducing a dry southeasterly airflow over the southern centre of the continent.

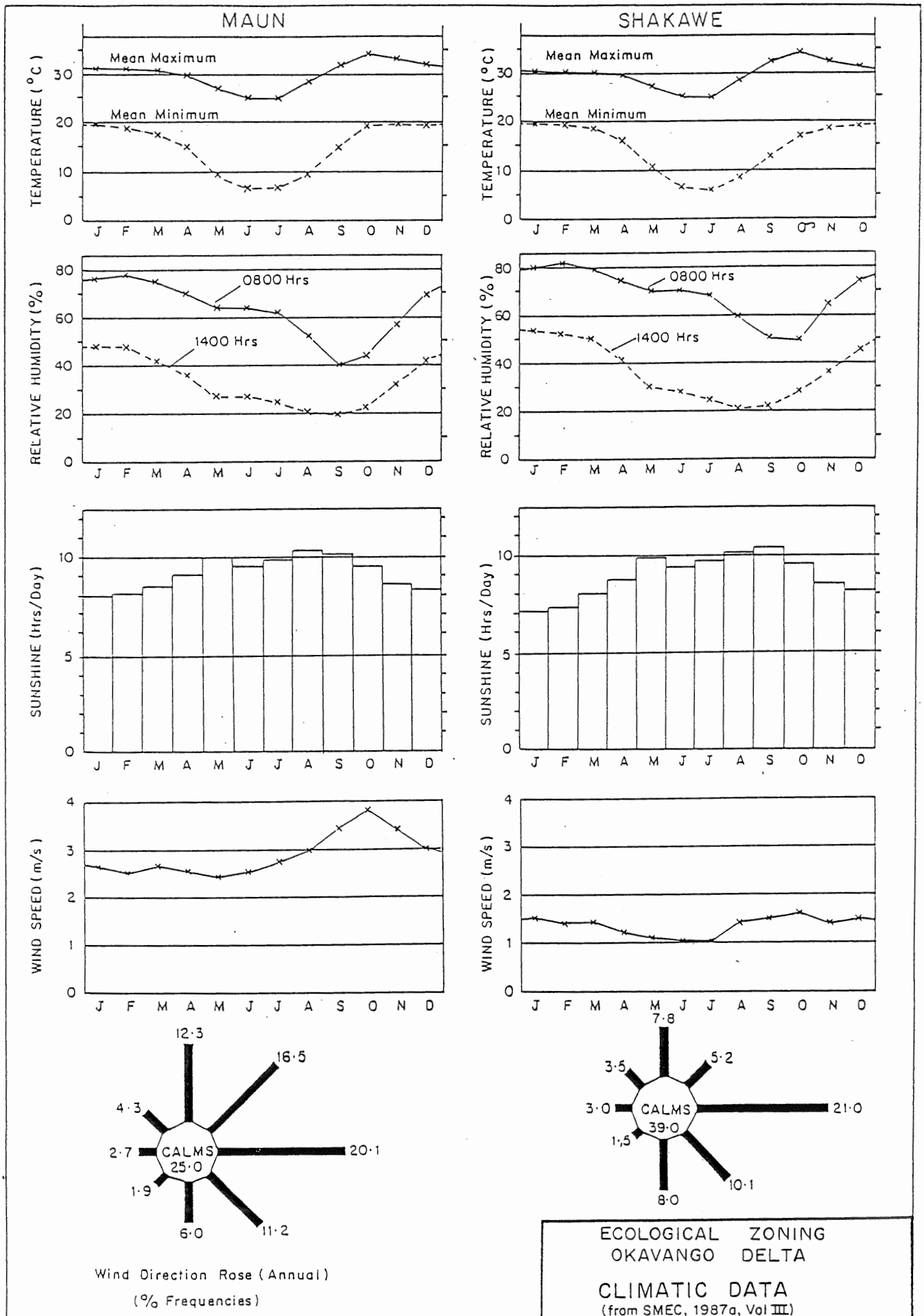
A more detailed description of climatic controls is given by Bhalotra (1984).

3.2 CLIMATIC CHARACTERISTICS

According to the widely used Köppen system of climatic classification, the climate of the Okavango Delta is type BShw. This signifies that it is a dry, semi-arid climate with high temperatures and a pronounced winter dry season.

Annual rainfall averages between 420mm in the south-west to 560mm in the north-east while potential evapotranspiration is of the order of 2 000mm (SMEC, 1987c). Rainfall deficits occur in all months, so that for agricultural purposes no favourable growing season exists without the application of surplus water (e.g. flood recession/melapo farming, or irrigation). Rainfall is highly seasonal, with 90% of annual rainfall typically occurring over five months, November to March inclusive. Most summer rainfall is produced by convective thunderstorm activity and is of relatively short duration. There is marked diurnal variation, with higher probability of precipitation occurring in late afternoon and early evening (Bhalotra, 1987).

Winters are mild and dry. Zero rainfall often occurs for three to four months continuously, the driest months being June, July and August. Summers are hot and relatively more humid. The hottest month occurs before the rainy season in October, but maximum temperatures decline only slightly in ensuing months as atmospheric moisture increases. The coolest months are June and July, with mean monthly temperatures of 16°C. Ground frosts are estimated to occur about 10 days per year at Maun, and 3 days per year at Shakawe, and are virtually restricted to the months of June and July (Bhalotra, 1987). Winds are generally light, and predominantly from the east, especially in the dry season.



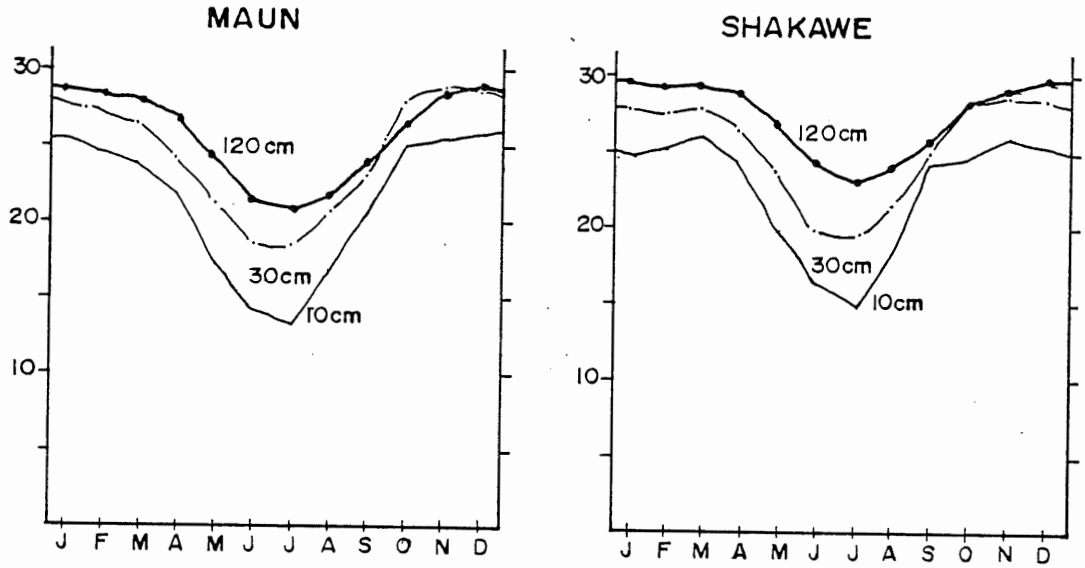
Wind Direction Rose (Annual)
(% Frequencies)

ECOLOGICAL ZONING
OKAVANGO DELTA

CLIMATIC DATA
(from SMEC, 1987a, Vol III)

FIGURE 3.2

Synoptic stations exist at Maun and Shakawe. The seasonal variation of selected climatic variables other than rainfall are shown in Figure 3.2. It should be noted that the exposure of the anemometer at Shakawe is poor leading to under-registration of windspeed, and sheltering is particularly significant to the north and east. The source of the data is DMS (1984), to which the reader is referred for more details. Soil temperature data are shown in Figure 3.3.



Mean monthly soil temperatures under bare soil at 0800 hrs.

Data from "Climate of Botswana Part II: Elements of Climate" YPR Bhalotra DMS (1987)

SOIL TEMPERATURES

Figure 3·3

Rainfall data are available from Maun since 1922, and from Shakawe since 1932. Much shorter records are available from several other locations within and around the Delta, but the quality of these data are poor and probably underestimate total rainfall (SMEC 1987a, Vol.III). The seasonal variations of monthly rainfall at Maun, Shakawe and Sehithwa are shown on Figure 3.4, and additional statistics on rainfall at Maun and Shakawe are presented in Table 3.1.

TABLE 3.1 - MONTHLY RAINFALL STATISTICS

MONTH	MAUN								SHAKAWE							
	PRECIPITATION (mm)				RAINDAYS Number				PRECIPITATION (mm)				RAINDAYS Number			
	Ave	Max	Min	Max 24-hr	≥0.1 mm	≥1.0 mm	≥10. mm	≥20. mm	Ave	Max	Min	Max 24-hr	≥0.1 mm	≥1.0 mm	≥10. mm	≥20. mm
Jan	108.0	396	14	101.8	11.7	9.6	3.6	1.8	129.6	369	18	75.0	11.7	10.9	5.4	2.8
Feb	100.0	366	8	139.5	11.1	9.1	3.4	1.5	136.0	402	12	85.0	10.0	9.4	4.3	2.3
Mar	73.5	274	0	120.4	8.1	6.6	2.4	1.0	79.7	319	0	57.6	7.9	7.1	3.1	1.6
Apr	25.2	120	0	46.8	3.9	3.1	0.8	0.3	23.7	134	0	56.3	2.8	2.6	0.9	0.2
May	5.6	62	0	23.9	1.0	0.8	*	*	2.6	30	0	15.5	0.6	0.5	*	0
Jun	0.8	17	0	15.5	0.2	0.2	*	0	0.3	11	0	8.3	0.1	*	0	0
Jul	0.1	5	0	3.5	*	*	*	*	0.0	1	0	0	*	0	0	0
Aug	0.3	28	0	18.0	0.2	0.2	*	0	0.1	2	0	2.3	*	*	0	0
Sep	2.7	32	0	25.8	0.6	0.3	*	*	2.5	36	0	26.0	0.7	0.4	0.1	*
Oct	16.6	101	0	54.6	3.2	2.4	0.4	0.2	13.3	67	0	41.5	2.5	1.8	0.4	0.1
Nov	49.1	170	0	54.4	7.1	5.3	1.6	0.5	57.7	292	0	100.5	7.0	6.4	2.3	1.1
Dec	81.6	262	13	71.1	9.8	7.8	2.8	1.2	100.9	236	20	89.5	10.7	10.0	4.9	2.7
ANNUAL	465.	1 188 (1973/74)	193 (1932/33)		57	45	15	7	546.	1 094 (1954/55)	239 (1948/49)		54	49	21	11

NOTES: 1. *Negligible, <0.1
2. Years for annual totals are from October through to September.
3. Data from computer listings provided by Botswana Meteorological Services.

(From SMEC, 1987 a, Vol. III)

Tyson (1986) proposed a cyclic variation of rainfall for southern Africa (including the study area) in which 9 years above average rainfall is succeeded by 9 years below average rainfall. The statistical evidence is tenuous, and while variations in sub-continental synoptic conditions are adduced as a model for the variation, the mechanism for producing these changes and the regularity of the cycle are not explained. Recent experience of the 1980s and evidence from the 1930s and 1940s demonstrate that unusually persistent dry spells can and do occur. The available precipitation records from Maun and Shakawe do not lend convincing support to the hypothesized 18-year cycle, however.

A special study of open water evaporation in Botswana was recently completed (SMEC, 1987c). Open water evaporation estimated by Penman's formula for Maun and Shakawe is shown in Table 3.2.

TABLE 3.2 OPEN WATER EVAPORATION * (In mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
Maun	209	175	191	160	140	115	128	165	207	237	220	222	2 169
Shakawe	202	177	190	164	144	115	129	162	200	226	205	214	2 128

* Estimated by Penman's formula (SMEC, 1987c)

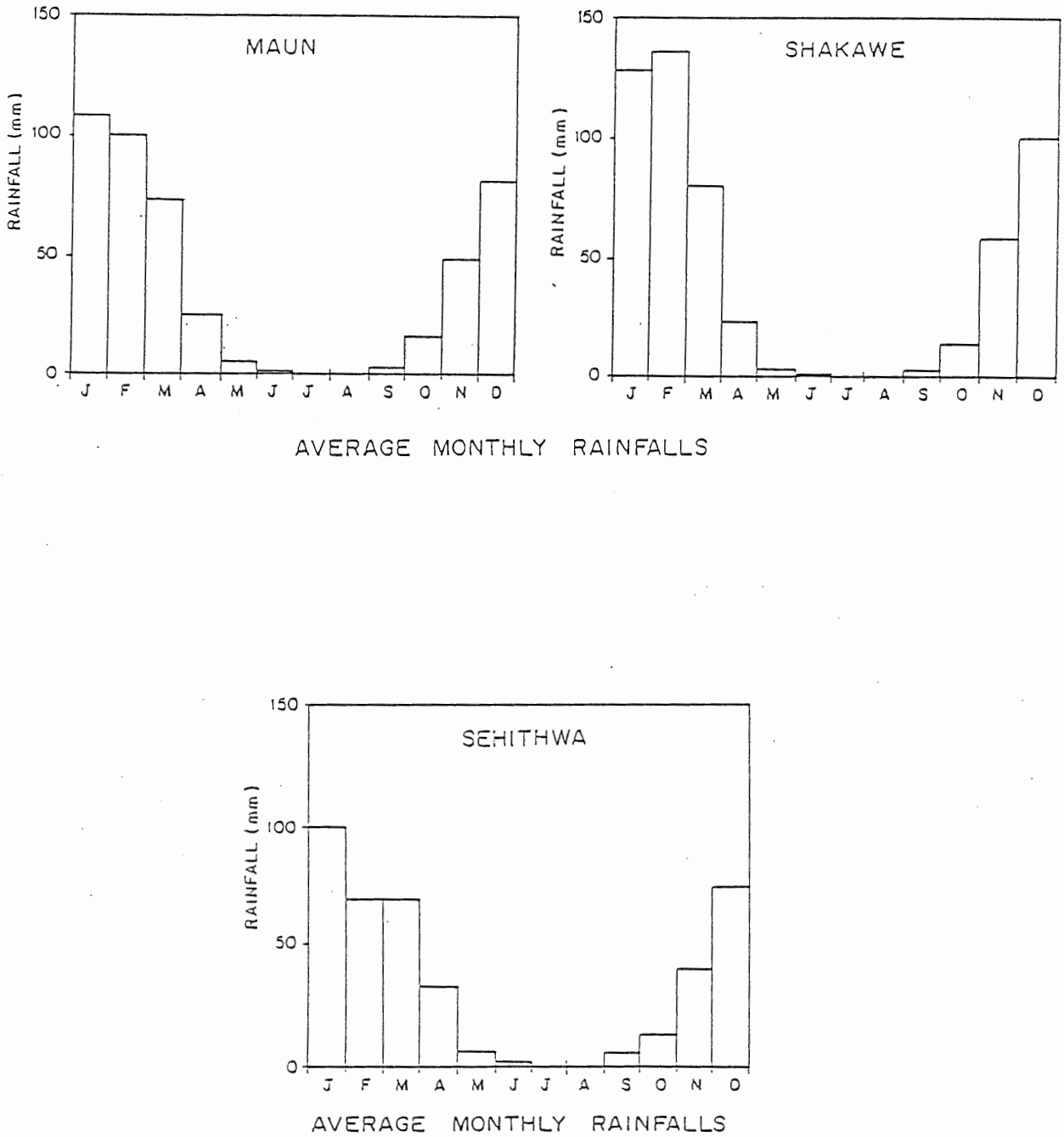
3.3 SPATIAL VARIATIONS

Apart from rainfall, there is only minor variation of climatic characteristics within the region. A comparison between conditions in Shakawe at the proximal end of the Delta and Maun at the distal end is provided by Figures 3.2 to 3.4. The difference between wind characteristics is mainly due to poor site exposure at Shakawe, as noted above.

Within the Delta itself experimental stations at Beacon Island and Chief's Island were operated for a short time in the mid-1970s. No significant differences in humidity were established between these Delta stations and stations around the periphery, but a slightly lower diurnal range of temperature noted at Beacon Island may indicate a minor ameliorating influence due to swamps (UNDP/FAO, 1977).

Three automatic weather stations installed at Kwihum, Xugana and Tubu in the 1980s could provide some additional evidence on the influence of the swamps. There have been some operational difficulties with these stations, however, and the processing of the data is such that results are not readily amenable for analysis and comparison (the primary purpose of the stations is to provide daily estimates of potential evaporation using Penman's formula).

The operation by DWA of pluviometers and storage gauges within the Delta since the early 1970s has not been managed successfully, and it is impossible to estimate rainfall over the Delta with any accuracy (SMEC, 1987a, Vol.III). From rainfall data available along the western and southern sides of the Delta it is possible to deduce a rainfall gradient increasing



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SEASONAL RAINFALL VARIATION

(from SMEC, 1987a, Vol III)

FIGURE 3.4

approximately from south south-west to north north-east. An approximate isohyetal map is presented in Figure 3.5.

3.4 DATA REQUIREMENTS

The synoptic stations at Shakawe and Maun provide basic information about regional climatic characteristics, and demonstrate that only minor climatic variation occurs from north to south. The question which remains unresolved is whether the swamps have any significant local influence on climatic characteristics.

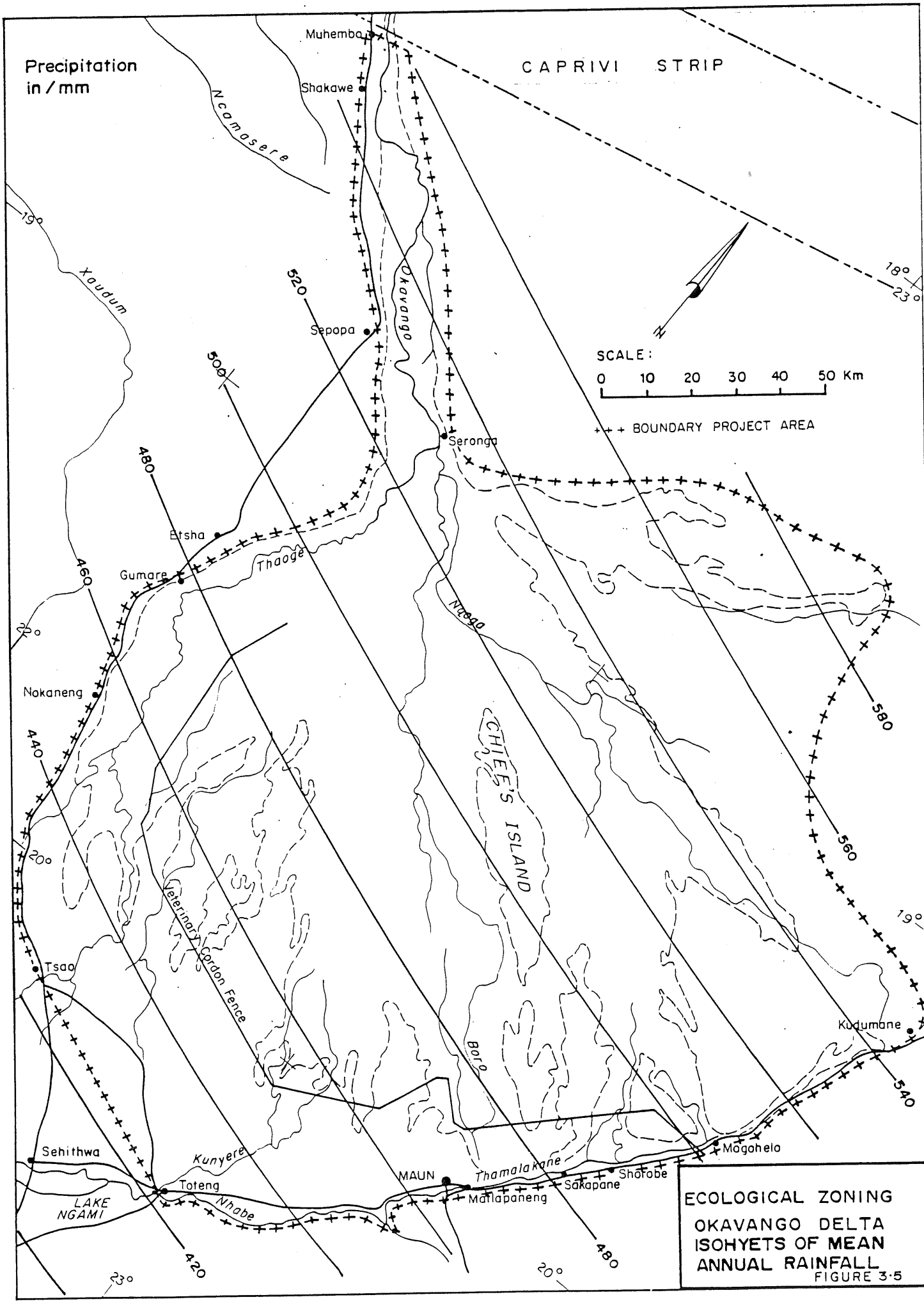
The automatic weather station at Kwihum is ideally located to provide the answers, and this station should continue to be operated so that long-term records become available for comparative study. Extraction of the data available to date would enable a preliminary assessment to be made, and this is recommended as a separate sub-project. Efforts should be directed towards:

a) overcoming the operational difficulties experienced;
b) modifying the processing of data to provide daily and monthly summaries of climatic variables;
c) enabling the processing to be done in Botswana (not in U.K. as at present).

The results to date should be evaluated and consideration should be given to replacing the equipment at Kwihum if these shortcomings cannot be overcome.

The major data deficiency with regard to climate is precipitation, which is more variable than other parameters. The only good quality data sets are from Shakawe and Maun. Other shorter records to the west and south are of poor quality and the DWA records available from within the Delta are erratic and unreliable. No useful records are available in the east or north (with the exception of a short, intermittent poor-quality record from Seronga). If operational problems were overcome, the automatic stations at Kwihum, Xugana and Tubu would go far towards improving our knowledge of rainfall distribution within the Delta.

As recommended in a previous study (SMEC, 1987a, Vol. III), DWA should improve their operational procedures and update equipment at their Delta raingauge sites. If operated and managed correctly, these gauges provide an excellent network. The only outstanding omission then would be a good quality station in the south-west of the Delta. A reliable station at Nokaneng or Tsao would be a valuable addition to a network which already potentially exists.



ECOLOGICAL ZONING
OKAVANGO DELTA
ISOHYETS OF MEAN ANNUAL RAINFALL
FIGURE 3·5

4. HYDROLOGY

4.1 SURFACE WATER

4.1.1 Sources of information.

The Department of Water affairs (DWA) operates over 50 hydrometric stations in the Okavango Delta region, but many are secondary stations which were attended irregularly in the past. Stage-discharge characteristics are generally unstable. Even at the few locations where flow is confined to a channel the variable hydraulic resistance of aquatic vegetation renders discharge ratings unstable. An important exception is at Muhembo, where the Okavango enters Botswana. At 29 primary stations channel discharges are measured about monthly. At stations on channels flowing out of the Delta - such as those on the Thamalakane and Kunyere - discharge is measured approximately weekly while flow persists. At Muhembo discharge is measured daily. The lengths of these records vary, but most are now 15-20 years long.

The most recent and detailed hydrological studies of the Delta were undertaken for DWA by SMEC (SMEC 1987a, Vol.III; SMEC 1987b; Porter and Muzila, in press). Earlier studies were conducted by UNDP/FAO (e.g. UNDP/FAO, 1977; Wilson and Dincer, 1976; Dincer, Child & Khupe, 1987). Dincer was responsible for development of a water balance model of the Delta which is a useful aid for understanding how the Delta functions hydrologically.

4.1.2 Water Balance of the Delta

The long term average inflow to the Delta is around $10 \times 10^9 m^3$ per annum, and this amount is known to an accuracy of ± 2.5% (SMEC, 1987a, Vol.III). The usual range of annual inflow is $7 \times 10^9 m^3$ to $15 \times 10^9 m^3$. The coefficient of variation is 23%. There is a regular seasonal rhythm to the inflow which peaks between mid-March and early May, then recedes until November. Minimum discharges at Muhembo are in the range $120 m^3/s$ to $200 m^3/s$. Maximum discharges are more variable, ranging from around $400 m^3/s$ to over $1000 m^3/s$.

Average annual precipitation on the swamps contributes around $4 \times 10^9 m^3$ additional runoff. This is more variable due to annual variations in rainfall and in the areal extent of swamps.

In occasional years relatively small outflow volumes may reach the Mababe Depression or the Linyanti Swamps via the Khwai or Magwegqana, respectively, but more generally all outflow from the Delta is to the south from the Boro, Kunyere and Shashe channels. Of these, the Boro predominates and is the only one which flows every year as far as the Thamalakane fault at the distal end of the Delta. The Santantadibe also provided very small outflow volumes until 1981. It has not flowed through to the Thamalakane since, not even in response to the good flood of 1984, and its future is uncertain. It is also possible for higher floods to breach the Kunyere faultline in several places between the Boronyane and Santantadibe. In these circumstances some flow reaches the Thamalakane via melapo systems which are not identifiable channels.

The average total volume of outflow from these systems amounts to 0.45 x 10^9 m^3 per annum, only just over 3% of the inflows (river inflow plus local precipitation).

TABLE 4.1 AVERAGE ANNUAL VOLUMES

LOCATION	m^3 x 10^6
Okavango River at Muhembo	10 000
Thamalakane River at Maun	323
Kunyere River at Toteng	92
Shashe River at bridge	33
Boteti River at Samedupe	285
Source: SMEC (1987a, Vol. III)	

Almost 97% of inflows are lost to evapotranspiration from the swamps and to groundwater seepage. The former loss predominates heavily. Evaporation loss cannot be determined precisely, but the annual depth of evapotranspiration is of the order of 2000mm (SMEC 1987c, SMEC 1987a, Vol.III). The area of the swamps varies seasonally in the range 5 000km^2 to 10 000km^2, providing an annual evaporation loss of the same order as the volume of water available. Therefore, as for the outflows, losses to groundwater beyond the Delta cannot amount to more than a few percent of the volume input to the Delta. This conclusion is supported by studies which indicate that groundwater to the south and west of the Delta has quite different isotopic characteristics which are associated with rainfall recharge. (Hutton & Dincer, 1976; Dincer, Hutton & Khupe, 1978). This does not signify that seepage within the Delta is insignificant, but implies that fluxes to groundwater are balanced by the evaporative flux from groundwater. Thus virtually all the moisture accretion to groundwater is transpired by the vegetation which fringes the swamp (SMEC, 1987a, Vol.III), and is accordingly registered in the total water balance as evapotranspiration loss.

4.1.3 Descriptive

In the 95km long Panhandle the river meanders within the confines of a 12km broad swampy floodplain. Beyond Seronga the swamps fan out in a 90° arc to form the central swamp area, which is perennially flooded. Exhibiting the classical 'birds - foot' formation, a number of distributary systems convey water towards the distal end of the Delta. Commencing in the south and proceeding counter-clockwise the major distributary systems are those of the Thaoge, the Matsebi/ Kunyere, the Boro, the Mburoka (subdividing into the Santantadibe and Gomoti), the Mogogelo, the Mwanachira/Khwai, and Magwegqana. Each of the major distributary swamp systems features at least one major channel which is more or less continuous and acts as an important conduit for conveying water to the distal end of the Delta. There is also a major feeder channel through the central swamps. This is the Nqoga, in fact merely the extension of the Okavango within the Delta, which functions to convey water toward each of the major distributary systems.

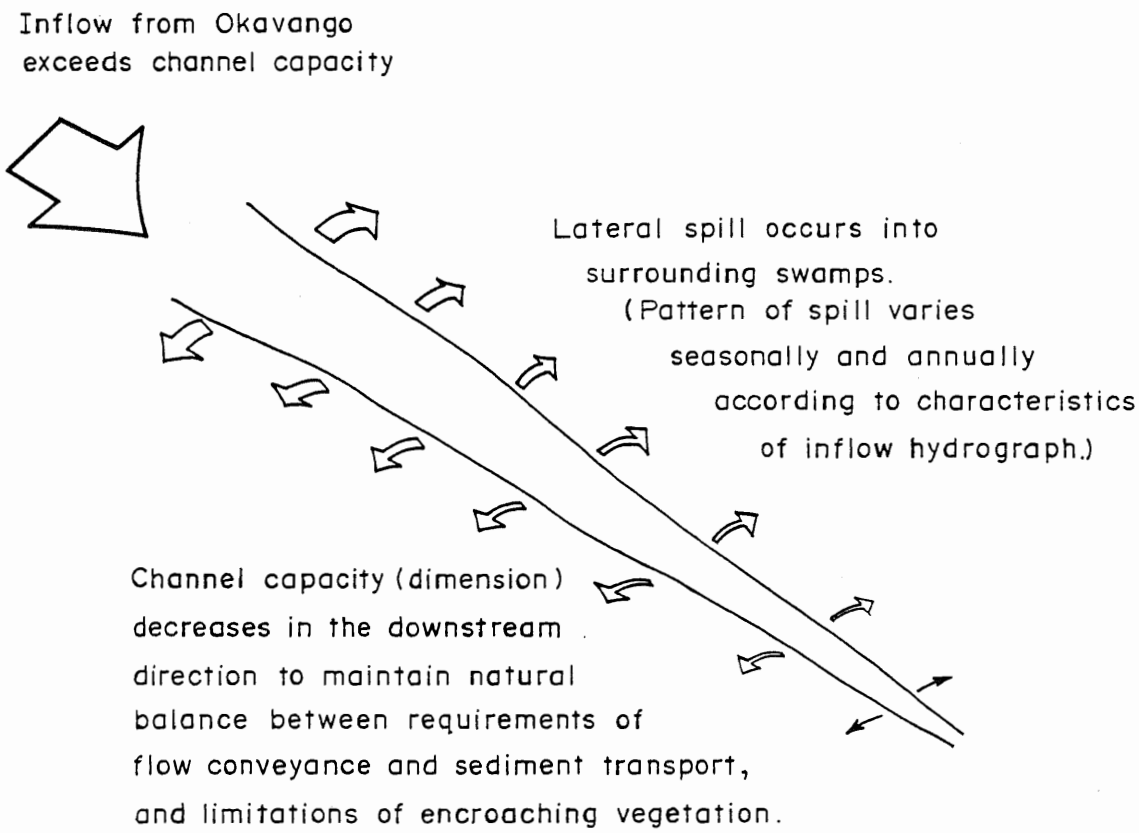
Although navigational links may exist, generally channels do not connect in the hydrological sense. A secondary channel (say, the Boro) collects lateral spill from a primary channel (in this case, the Nqoga). As the spill accumulates in the direction of primary flow a parallel channel develops, gains integrity, and diverges to distribute water away towards the periphery of the Delta (SMEC, 1987a, Vol.III). Exceptions are the Matsebi and Magwegqana, for which there are no obvious connections near the primary source. These distributaries are more seasonal in character and act as spillways when the central swamps expand.

All the channels within the swamps are unconfined and have permeable banks. Due to the abundant growth of vegetation bordering the channels and enjoying optimum conditions of light and nutrient supply and some entrapment of sediment therein, there usually exists considerable hydraulic resistance to lateral flow so that a lateral water surface gradient can be maintained. This can be very apparent where the bank is breached for navigational purposes and a vigorous side current is produced, as has happened at a number of locations within the Delta. Therefore despite the rather permeable banks the surrounding swamps function as floodplains for the channels, although the floodplains may be perennially inundated and in places they may convey substantial quantities of water at certain times of the year.

The seasonal flood peak from the Okavango overcharges the capacity of the primary channel system (through the Panhandle and down the Nqoga) along most of its length, promoting substantial lateral spill. This is facilitated by a gradual reduction in channel capacity in the downstream direction, which must be a feature of a natural balance attained by the channel - swamp floodplain complex. This is achieved by a reduction in channel dimension (principally in width), but the channel velocities remain sensibly constant to maintain the transport of sediment well towards the termination of the channel. Fig. 4.1 shows the situation diagrammatically. As the seasonal inflow flood recedes, the overcharging of channel capacity retracts toward the proximal end of the Delta but significant lateral spill continues throughout the year in the Panhandle (where surface gradients are lower and the swamps are partially confined) and at the top end of the central swamps.

Presumably distributary channels function similarly to some extent but the distributary swamp systems also gain water directly from the central swamps so that the flow model is more complicated.

The relative amounts of water entering the distributary systems are not known accurately, but certainly most of the inflow is distributed to the Mwanachira and Boro systems, perhaps 65% to 70% after allowing for intervening evaporation losses. The Mwanachira currently feeds all the distributary systems to the east of Chief's island. About 15% is distributed to the Thaoge system (SMEC, 1987b), and the Magwegqana and Matsebi systems must attract even less.



DIAGRAMMATIC MODEL FOR PRIMARY FLOW SYSTEM

FIGURE 4.1

The Thaoge channel is now blocked through most of its length. The blockage is terminated with a dry plug of peat a short distance above Gumare which is only occasionally bypassed during higher floods. The Thaoge has been in decline for over a century.

In addition to attracting seasonal overflow from Jao Flats (central swamp), the Matsebi/Kunyere system also receives flow laterally from the central Boro system via the Xudum and Xwaapa systems. Water from the Xudum and Xwaapa congregate in the Nxaragha valley along the Kunyere faultline before discharging via the Kunyere. The Matsebi drains along the edge of the Sandveld Tongue and feeds the Kunyere directly. The Kunyere flows through to Lake Ngami in about 70% of years.

The Xudum and Xwaapa flows originate in the Xo Flats segment of the Boro system where the channel network becomes ill-defined and fragmentary. Another channel originating in Xo Flats, but recurving towards the Boro, is the Kiri - but the lower reaches of the Kiri have been blocked by vegetation in recent dry years. Floodwaters from the lower Boro and Kiri accumulate in a basin behind the Kunyere faultline. The first channel to flow beyond the faultline is the Boro, the second is the Shashe, but in years of higher flood many other places along the faultline may also be breached.

The Mburoka distributary was once supplied directly or almost directly from the Nqoga, but in the past 50 years a major blockage has occurred in the Nqoga because of aggradation of the channel bed (McCarthy et al., 1986a, 1987), and a large area of dry land is emerging. The Mburoka now acquires most water from the Mwanachira, main beneficiary of the Nqoga blockage, and also via two lesser channel systems feeding between the blockage and Chief's Island. The Gomoti which was a direct continuation of the Mburoka, is now a tertiary flow system accumulating lateral spill from the Mburoka channel via the Guekha. This is a recent development which will be discussed under the dynamics of the Delta hydrology. The Gomoti still derives some water through the major vegetation blockage which developed on the former channel, and receives some seasonal overflow from the Mogogelo. The Santantadibe is and was a tertiary flow system, accumulating lateral spill from the Mburoka in the vicinity of Kuui and Dxaaba.

The Mwanachira benefited greatly from the development of the Nqoga blockage, and to some extent by the creation of a navigational channel connecting it directly to the primary source of the Nqoga. It in turn supplies water to the Mburoka and Mogogelo distributaries. At its eastern extremity it becomes known as the Khwai.

The Mogogelo is an elongated distributary system only separated from the Gomoti by a very thin strip of higher ground in its middle reaches. In years of good flood it feeds into the Sankuyu valley, and in exceptional years may penetrate to Mababe Depression.

Lesser distributary systems also exist, as may be seen on the hydrological maps.

The seasonal progression of flood waves through the distributary systems is greatly attenuated because of flat gradients, limited channel capacities and dense aquatic vegetation. Consequently floods emerging from the Delta in the Boro and Kunyere channels peak approximately 4 months after the peak occurs at Muhembo. At the extremities of distributary systems with longer flow paths (e.g. Santantadibe, Mogogelo) peaks occur even later.

When the Boro flows through to the Thamalakane seasonally, flow may not commence until late June or early July, but it can and often does flow throughout the year. A guide to occurrence of flood peaks within the Delta is provided (Figure 4.2).

The most regular determinants of the annual magnitude of distributary flows are the annual volume and peak discharge of inflows to the Delta from the Okavango River. Other factors are summer rainfall and the storage remaining in the Delta from the preceding year(s). The former can be an extremely important determinant, and highest floods at the distal end of the Delta are invariably associated with above average rainfall. A second flood peak can therefore sometimes occur which is entirely out of phase with the regular peak outflow, generally occurring at the end of the rainy season around March or April. This phenomenon occurs in perhaps 20% of years, and can occasionally be substantial. Record flood levels in Maun were associated with a rainfall-induced flood in early 1955.

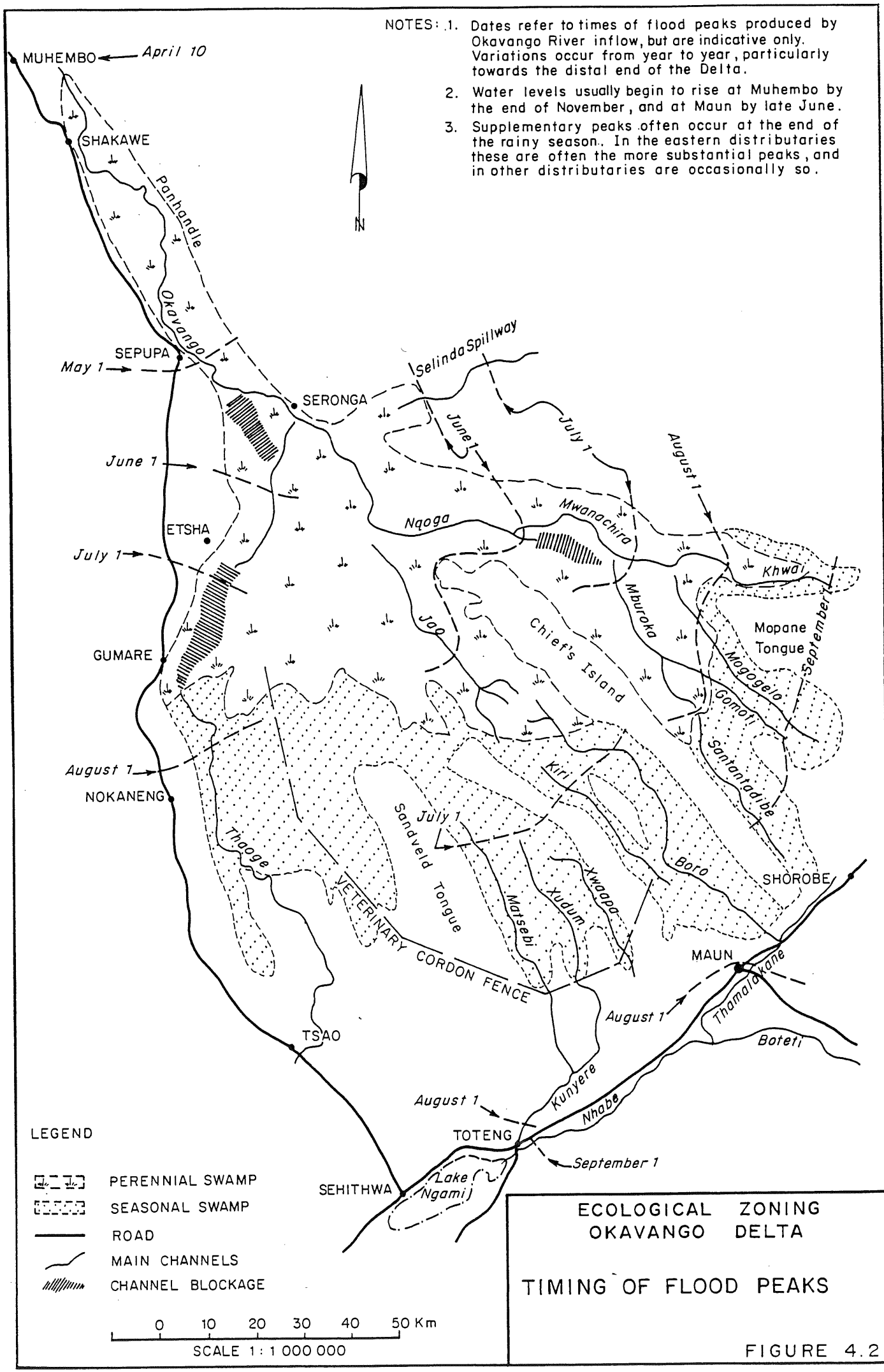
The impact of storage remaining from preceding years is less significant, but contributes to magnifying the amplitude of prolonged wet and dry spells. The water balance model of the Delta demonstrates, however, that even without this carry-over effect, a reduction of 10% of Delta inflow produces a 30% reduction in Delta outflow, so that even with a random sequence of inflows the natural variability of flow is magnified three times by the hydrology of the Delta.

4.1.4 Delta dynamics

The hydrology of the Delta is never entirely stable. A complex interplay of vegetation, water, sediment deposition and other factors ensures that the Delta is ever changing.

Small variations in the relative volumes of flow in different channels occur every year, and on a decadal time scale of 5-15 years significant shifts in flow regime occur in some distributaries. Six significant regime shifts within 54 years were identified by SMEC (1987a, Vol.III) in the Boro distributary, for example. The last shift, which occurred in 1982, coincides with an observed increase in channel discharge in the Xudum at Thapagadi relative to channel discharge in the Boro at Xakue (SMEC, 1987a,Vol.III), implying that Xo Flats play an important role in the distribution of flow. Similar sensitive zones probably occur to some extent in most distributary systems.

On a longer time scale more lasting changes are taking place. The decline of the Thaoge, which until the 1880s flowed as far as Lake Ngami, is well-documented (e.g., Wilson, 1973; Shaw, 1985;


NOTES: 1. Dates refer to times of flood peaks produced by Okavango River inflow, but are indicative only. Variations occur from year to year, particularly towards the distal end of the Delta.
2. Water levels usually begin to rise at Muhembo by the end of November, and at Maun by late June.
3. Supplementary peaks often occur at the end of the rainy season. In the eastern distributaries these are often the more substantial peaks, and in other distributaries are occasionally so.
N
MUHEMBO
April 10
SHAKAWE
Panhandle
Okavango
SEPUPA
May 1
SERONGA
Selinda Spillway
June 1
July 1
August 1
ETSHA
Nqoga
Mwanachira
Khwai
Mburoka
Jao
Chief's Island
Mopane Tongue
Mogogelo
Gomoti
Santantadibe
September
GUMARE
Kiri
Thaoge
Sandveld Tongue
Matsebi
Xuduma
Xwaapa
Boro
SHOROBE
VETERINARY CORDON FENCE
MAUN
Thamalakane
Boteti
TSAO
Kunyere
Nhabe
TOTENG
September 1
SEHITHWA
Lake Ngami
LEGEND
PERENNIAL SWAMP
SEASONAL SWAMP
ROAD
MAIN CHANNELS
CHANNEL BLOCKAGE
0 10 20 30 40 50 Km
SCALE 1 : 1 000 000
ECOLOGICAL ZONING
OKAVANGO DELTA
TIMING OF FLOOD PEAKS
FIGURE 4.2

SMEC, 1987b). The Nqoga, which early this century flowed directly to the Mburoka, has over the past 60 years progressively retracted due to sediment deposition and subsequent vegetation blockage. Repercussions of this change have occurred in the Gomoti, which has been relegated to the role of a minor tertiary distributary, and the Santantadibe, which has ceased to flow in its lower reaches only in the current decade.

Examination of satellite imagery during this study has pinpointed the timing of a change in the major source of the Gomoti. Imagery in April 1983 shows the Gomoti connected by a permanent channel to the Mburoka near Dxaaba. The Guekha was an ill-defined system which did not convey water as far as the Gomoti. The flood of 1983 was very low, and August 1983 imagery shows it had virtually no impact in this part of the Delta. February 1984 imagery shows the perennial swamp had retracted so as to sever the channel link between the Mburoka and Gomoti downstream of Dxaaba. When the higher flood of 1984 arrived this perennial swamp link was irrevocably blocked, but the July 1984 imagery shows a connection to the Gomoti had been forged via the Guekha. One system was extended while the other retracted. Field reconnaissance in 1986 (SMEC, 1987a, Vol.III) revealed that this remains true, and the source of the Gomoti has definitely changed.

This sequence of events serves to illustrate what has been postulated as the most frequent cause of Delta dynamics, which is the response of swamp vegetation to episodes of drought or major flood (SMEC, 1987a, Vol.III). The very low flood in 1983 reduced the water levels and flow velocities in the channel below Dxaaba to such an extent and for sufficient time for the papyrus and other aquatic vegetation to bridge the gap and close the channel. The same conditions in the shallower Guekha system had a different effect, it is hypothesized. There the channel became dry and aquatic vegetation died off. When a good flood arrived in 1984 the hydraulic resistance to flow in the former channel of the Gomoti was drastically increased and that in the Guekha was substantially reduced, leading to a change in the primary source of the Gomoti which may be observed today.

Another major factor influencing distribution of flow is sediment deposition. On a continuous basis this is virtually restricted to the primary Nqoga channel system (e.g. McCarthy et al., 1986a), but local scour and deposition during flood peaks may affect flow distribution within distributary systems to some extent.

Tectonic activity has been postulated as an impetus for change (e.g., Hutchison and Midgeley, 1973); while this is indisputably important on a geological time scale its role in Delta dynamics has been overstated. It cannot explain the frequency or the nature of most changes which are occurring.

Other factors are the intervention of man and beast within the swamps. The creation of navigation channels has been adduced as a contributing factor to changing flow distributions in the Nqoga-Mwanachira system (SMEC, 1987a, Vol.III) and in the Thaoge (SMEC, 1987b), and informal bunding activity for agricultural purposes has regulated spread of floodwaters in terminal reaches of the Thaoge and Santantadibe. Hippopotamus paths and (in

former times) hippopotamus hunting have also been suggested as factors (SMEC, 1987a, Vol.III), but the evidence is tenuous.

Another feature influencing hydrological change in the Delta is the peculiar characteristics of climatic variability in southern Africa which have already been referred to. Prolonged deviations from mean precipitation can lead to sequences of wetter than average years or drier than average years, and a cyclic variation of 18 years (9 years wet, 9 years dry) has been proposed (Tyson, 1986). An insignificant correlation between annual Okavango River inflows to the Delta and annual precipitation in Ngamiland (Andersson, 1976) implies that this pattern does not extend to the upper catchment in central Angola and lessens the impact on Delta hydrology of any cyclic variation in Ngamiland rainfall. Nevertheless, recent experience in the 1970s and 1980s and evidence of a prolonged dry sequence in the 1930s and 1940s (SMEC, 1987a, Vol.III; Shaw, 1985) illustrate that unusually long sequences of low flood years or high flood years do occur.

4.1.5 Sedimentology

No systematic measurement of sediment transport rates into the Okavango Delta are available, but empirical formulae have been used to estimate rates of 660 000 tonnes/annum (UNDP/FAO, 1977) and 500 000 tonnes/annum (Dincer, reported in SMEC, 1987a, Vol.III) for bedload. Suspended sediment transport is low. The bedload comprises sand grains of relatively uniform grading but median of grain sizes decrease a little from the proximal to the distal end of the Delta.

Deposition of the sand bedload is initially restricted to the primary flow channel, currently the Nqoga. The bed of the primary channel is therefore aggrading at a significant rate, which leads to the channel becoming moribund with subsequent relocation of the primary channel. A centennial time scale for channel formation and relocation has been postulated (McCarthy et al., 1988). Ultimately sand is reworked throughout the Delta, where local scour and deposition within distributary and minor channels is occurring continuously on a modest scale. Aeolian processes can also be a factor, particularly around the Delta periphery.

4.1.6 Sensitive Zones

Areas which are sensitive in a hydrological context are areas where intervention by man could produce significant changes to the distribution of flow within the Delta. Changes in distribution of flow alter the ecological balance both in the areas which will receive more water and in those which will be deprived. Put in perspective, natural changes are likely to occur in these sensitive zones which will affect the ecological balance of areas below them. The Delta as a whole is not a stable system. Nevertheless, activity by man in areas which can be identified as hydrologically sensitive should be controlled, and the environmental impact of any intervention should be carefully assessed.

One of these sensitive zones is at the base of the Panhandle and the top of the central swamps. There, where the confined floodplains of the Panhandle give way to the alluvial fan which

forms the Delta proper, there is an increase in grade (McCarthy et al., in press). The direction which the primary channel (the Nqoga) takes as it enters the alluvial fan determines the gross distribution of water throughout the Delta, so this must be regarded as a sensitive zone although it is not clear whether it is particularly susceptible to influence by man.

The entire length of the primary Nqoga channel should also be regarded as a sensitive zone. The active sediment deposition in this channel creates an aggrading bed. A lateral water gradient exists away from the channel which is only sustained by the dense vegetation on either side.

To some lesser extent, parts of secondary channels such as the Thaoge, Boro, Mburoka and Mwanachira are sensitive for the same reasons. Although sediment deposition is not currently very active in these channels, lateral water gradients do develop in places during passage of floods.

The Boro system assumes the greatest economic importance, and within that system a critical area where water is redistributed occurs. In Xo Flats inflowing water from the upper Boro or Jao is distributed to the lower Boro, the Kiri, and the Xudum. An area with a complex of indistinct and/or discontinuous channels, Xo Flats is susceptible to change which affects flow regimes of the lower distributaries.

The flow in any channel in the seasonal swamps is likely to be sensitive to alteration within that portion of perennial swamps at the head of the channel system. Particular areas which might be so identified are the three portions of the Jao Flats or central swamps:

i) just to the north of the Matsebi system
ii) at the head of the Potae, Mathabanelo and Xene systems, and
iii) just north of the Karongana.

Another more localized type of area which is hydrologically sensitive occurs where flow systems pass through gaps in higher ground. There are several such places in the seasonal swamps. As examples, Nxabega and Thapagadi may be cited. Human intervention at the sites could have substantial impact on considerable extents of seasonal swamps downstream.

Areas deemed hydrologically sensitive have been identified on the hydrological mapping by the annotation P_h.

4.1.7 Direction of Changes

Much has been stated about the unstable or dynamic nature of the Delta hydrology, and with such a highly complex system it would be presumptuous to predict future changes. It is possible, however, to examine those changes which have occurred in the recent past, and to speculate on the future. Some changes which have occurred are complete, others are still continuing.

The retraction of the Thaoge system over the past century is well-documented (e.g., Wilson, 1973; Shaw, 1985), and there is some agreement that the most probable cause is a depletion of supply from the source (McCarthy et al., 1986a; SMEC, 1987b).

The rate at which the main channel is desiccating appears to have slowed significantly, and the system may be approaching a quasi-stable state, in balance with the available volume of inflow. If the vegetation blockages in the channel expand, however, more of the inflow could be forced to move laterally from the channel, causing a redistribution of swamp extent.

It has been argued that this has already happened to a certain extent, and that the Karongana, Potae and Mathabanelo systems may be beneficiaries (SMEC, 1987b). The lack of incised channels in the systems may signify recent development of flow paths, but the hypothesis has not been substantiated.

Future change in the Thaoge could be instigated by channelization works, some of which have already been initiated (see Section 4.1.8). Water which is successfully conveyed and utilised below the terminal blockage will be water taken from the swamps above the blockage. Some local contraction of those swamps would therefore be anticipated, and the impermeable plug at the bottom end of the terminal blockage may migrate up channel.

The lower Boro has, over the past 55 years, undergone shifts in flow regime on average once every eight years (SMEC, 1987a, Vol.III). Currently (1989) it has been operating under a regime of low flow for the past 7-8 years. One may anticipate future changes in outflow from the Boro, and on past experience it is more likely to increase than to decrease. This implies a redistribution of water upstream. If redistribution occurs in Xo Flats, the Xudum and Xwaapa systems could conceivably be affected adversely; but if redistribution occurs further upstream the impact may be more widespread and less concentrated, and the Xudum and Xwaapa could even benefit along with the lower Boro.

In recent years the lower reaches of the Kiri have become clogged with vegetation as a response to lower water levels during the long drought. When years of good flood return, flow in the Kiri will be either re-established in the lower reaches, or it may be diverted along a new route, most probably further to the south and west. If this latter occurred, flow could conceivably be invigorated in the Shashe, or even in the relict Nxotega.

During the past fifty years sediment in the lower reaches of the Nqoga has lead to vegetation blockage and progressive abandonment of the former channel from the lower or Mburoka end. This has had profound impacts on the eastern Delta and the process is not yet complete. Some effects of this process are:

- the desiccation of a large area of former perennial swamp to the east of Letetenetso Island

- increased flow to the Mwanachira system, with expansion of flooded areas, particularly on the north side of the Mwanachira and Khianadiandavhu

- an extension of swamps into the TsamTsam melapo

- decreased flow into the Mburoka distributary, leading to contraction of swamps along the Gomoti and Santantadibe arms

- increased water levels upstream of Hanamozeyo in the vicinity of Xaenga

- encroachment of swamplands into the northern end of Chief's Island

- gradual development of flow paths towards the Mburoka between the blockage and Chief's Island (e.g. Nambopi channel, and another unnamed channel complex further north).

As noted in Section 4.1.4 the main source of the Gomoti has shifted to the Guekha. Considerable drying out of former swamps along the Gomoti has been succeeded recently by peat fires and some surface subsidence. One possible scenario if the Guekha source develops further is that flow down the middle portion of the Gomoti may be facilitated by the reduction of organic detritus, leading to a revival of supply to lower reaches.

The general question has been posed: what would happen if the water supply to the Delta was reduced; or conversely, if the supply of water somehow increased. It is not possible to be specific about such an hypothetical question. In general terms, the total area of flooding would clearly contract or expand in response to a reduction or increase in inflow or rainfall. Many parts of the areas zoned PF would continue to be subject to perennial flooding if supply of water was reduced, and many parts of the areas zoned DL would remain dry land even if supply increased. Most affected would be seasonal swamp areas and particularly at the distal end of distributaries. In general terms the zoning of Section 4.4 provides a basis for prediction. Significant changes in the water balance of the Delta would be likely to induce a phase shift within the five-zone classification. Thus a zone designated OSF (occasional seasonal flooding) would be likely to become HFO (high flood only) if water supply to the Delta were reduced, or shift to RSF (regular seasonal flooding) if supply increased.

4.1.8 Use of Surface Water

Surface water from the Delta is used for domestic purposes and limited small-scale agriculture along both sides of the Panhandle and on the western edge (Thaoge arm) as far as the Etsha villages. The quantity of water extracted by these users and by scattered settlements and tourist camps within the Delta is minute in relation to supply.

Seasonal outflow from the Delta has traditionally been used for melapo (flood recession) farming, as the water recedes just prior to the rainy season. Crops may be planted to make use of residual moisture in the soil, and are usually sustained by summer rains. The largest contiguous areas where this form of agriculture has been practised is in the Boro/Shorobe area, utilizing Thamalakane backflow, where up to 5 000ha have reportedly been farmed under favourable conditions.

The diamond mine at Orapa is also partly dependent on surface water which flows down the Boteti River from the Delta to an offtake point at Mopipi. An off-river storage exists at Mopipi. Flow down the Boteti River was enhanced in 1972 by construction of a low bund across the Nhabe River near Kgantsang.

In 1988 construction was completed of a channel from Qhosenga Lediba to a point on the Thaoge near Gumare. The purpose is to divert water for agricultural use by bypassing the organic plug at the bottom of the terminal blockage. Action to improve supply by extending the channel to connect Qhosenga with the Thaoge above the blockage (DWA, 1988) is expected to proceed in 1989. Schemes to bypass the entire terminal blockage from between Weboro and Wabe madiba, or to restore the Thaoge channel by dredging have been considered at reconnaissance study level (Kraatz, 1976; Kraatz, 1983; SMEC, 1987b). The economic justification of such schemes would rely upon commercial irrigation in the Nokaneng Flats and adjacent areas.

Feasibility studies are complete and design is proceeding (in 1989) for construction of three dams on the Thamalakane, Boteti and Nhabe Rivers to create two reservoirs to regulate outflow from the southern Delta (SMEC, 1988). The first dam at Matlapaneng would create a small storage ($24m^3x10^6$) which would become the main source of Maun water supply and regulate supply of water to the Boro/Shorobe melapo. Development of melapo farming through technological and organizational improvements has been the subject of separate study for several years (e.g., Roostee, 1986).

The second larger storage ($138m^3x10^6$) would extend along the valleys of the Thamalakane (below Matlapaneng), Boteti (above Samedupe) and Nhabe (to Toteng). Primary purposes of this storage would be to enable development of commercial irrigation, principally along the Nhabe arm, and to regulate releases for downstream users, most notably the diamond mine at Orapa. Benefits from tourism and fishing are also anticipated; and together with impending construction of a sealed road connection to Maun this project is expected to foster accelerated development of the Ngamiland region. As a result increased people pressure on the southern fringe of the Delta may be anticipated.

Design is also complete for an associated scheme of river improvement on the lower Boro from the Thamalakane junction to 25km upstream of the Veterinary Cordon Fence. Some reduction in flooding within the adjoining faultline basin above the Kunyere faultline will occur when this is implemented, affecting an area of 70-100km².

Tentative consideration has been given to diverting water from the Panhandle near Sepupa (e.g., SMEC, 1987b) for use in the Nokaneng Flats or for transfer further south. The very high cost of such a development would require extremely lucrative benefits to merit serious consideration, but it remains an option for future planners.

More serious and more tangible threats to the hydrological integrity of the Okavango Delta are posed by potential developments upstream, in Angola or Namibia. The only definite plan for which information is available is a scheme to supplement water supply to the Eastern National Water Carrier in Namibia (Ravenscroft, 1985) by drawing water from the Okavango in Caprivi. This scheme would draw a maximum of 3 m^3/s, and only during water shortages in the rest of the country. This in itself would have almost negligible impact on the Okavango. A

tentative proposal for hydro-electric development at Popa Falls would have no impact on the Delta. Informal reports of plans for irrigation developments near Runtu have been received, but nothing is known of development plans in Angola.

There is a need for better consultation between governments which has been thwarted in the past by regional strife, but improved prospects exist given current peace settlement proposals. The Botswana government should take the initiative in promoting consultation, with the long-term aim of establishing an international covenant on the Okavango River. This is a matter of vital concern for Botswana. Construction of a major storage in Angola, for example, could have devastating effects on the Okavango Delta. From previous study of Okavango Delta hydrology (SMEC, 1987b), it is possible to state that a 10% reduction of inflow from the Okavango River would reduce the area of swamps by a similar percentage and have substantial impact on the distal extremities of the Delta.

4.1.9 Data Requirements

The hydrometric network operated by DWA provides adequate information for general hydrological purposes, and the initiation of the network of sampling stations will provide data on water quality too. One aspect of field data collection which is outstanding is sediment sampling. A programme of regular sampling of bedload and suspended sediment at a location in the Panhandle would provide more reliable estimates of sediment influx to the Delta. This could be combined with spot samplings at other locations, concentrating on the main sediment conduit, the Nqoga.

Groundwater resources data is inadequate for regional assessment of reserves and perennial yields. In particular there is very little data at all from the northern and eastern sides of the Delta.

For such a large and complex area with difficult problems of access, use of remote sensing is invaluable. For hydrological studies, continuing acquisition of satellite imagery is recommended. At least two, and preferably four sets of images should be acquired in each year. Prime months would be March and July or August. Additional images in May and November or December would be advantageous because maximum and minimum extents of flooding do not occur simultaneously throughout the Delta. Acquisition over a period of many years would provide a valuable data base and better insight into how the Delta responds under varying conditions of river inflow and local precipitation. Colour imagery is essential for hydrological analysis.

Considering the potential uses of satellite imagery in Botswana -in the Okavango, the Linyanti/Chobe region, and in the Kgalagadi rangelands and reserves - development of an earth receiving centre capable of processing satellite imagery in Botswana should be considered by the government.

4.2 GROUNDWATER

4.2.1 Background

Considering the water balance of the Okavango Delta and results

of isotopic studies (Section 4.1.2) the amount of subsurface water moving out across the study area boundary is a relatively low percentage of the total water balance, of the same order of magnitude as surface outflow or less. This is consistent with several findings of studies of lateral groundwater movement from channels, which demonstrate that within a few hundred metres of channels the recharge from seasonal floods in the channels is negligible (eg. SMEC, 1987b; SMEC, 1987a, Vol.IV). This is attributable to the highly significant lithological variation associated with a complex sequence of fluviatile depositional processes.

Saturated strata within the alluvial fan of the Delta extend to considerable depths, but salinity rapidly increases with depth, indicative of very long residence times. Regular recharge from flooding is restricted to shallow depths and is mainly limited to channel sand and sandy alluvium contiguous with active channels or floodplains (SMEC, 1987a,Vol.IV). Much of the residual groundwater in the Thaoge floodplain below the current blockage near Gumare is now dependent on precipitation for recharge (SMEC, 1987b).

Because of the abundance of surface water in most parts of the study area, groundwater resources and potential have not been intensively studied. Localities where studies have been concentrated are around Maun (BRGM, 1986) and Gumare (Leenaers, 1986; Wieske, 1987; SMEC, 1987b).

The quality of shallow groundwaters in or near active or recent channels and floodplains has low TDS (<1000ppm) characterised by a predominance of bicarbonates and carbonates of calcium, magnesium and sodium. Chloride is low, but increases away from recharge zones. The quality of these waters is suitable for all purposes, but yields are generally poor due to low soil permeability and low transmissivity of near-surface aquifers.

4.2.2 Current Use

A major user of local groundwater resources is the village of Maun, which depends for its supply on groundwater pumped from a wellfield in the Shashe valley about 5 km to the west. This is a clean river sand aquifer with transmissivity values of around $500m^2$/day, which is dependent for recharge upon seasonal floods in the Shashe River. The current demand exceeds the sustainable yield, and this source will soon be supplemented or superseded by development of surface water resources involving a storage on the Thamalakane River upstream of Maun.

Limited use of groundwater for domestic and stock watering purposes occurs along the western and southern fringes of the Delta, and most notably in the relict floodplain of the Thaoge between Gumare and Tsao.

A regional survey of water points (Bendsen, 1985) located over 90 boreholes and wells within the study area. All are around the periphery of the Delta, with most concentrated near Maun or along the western fringe from Tsao to the Etsha villages. Some shallow wells may not be included in the survey. Where yields are recorded they are usually in the range 0.5-1.5 l/s, although higher yields are recorded around Maun and Shorobe.

Most water points are used for domestic and/or livestock purposes. The results of the survey are held in a computer database in Maun for DLUPU. This includes information on ownership, location, condition, use; and where available, on depth, yield and water quality.

4.3 WATER QUALITY

4.3.1 Sources of information

DWA commenced a regular programme of water quality monitoring in the Okavango Delta in 1986. The number of samples taken at any location to date is quite small due to limited available resources, and some of the locations selected for the programme have so far received no flow due to prevailing dry conditions. Samples have been taken and analysed at 29 locations throughout the study area since the programme was initiated. Measurements usually include water temperature, pH, alkalinity (mg/l HCO_3^-), of conductivity, total solids, ion concentrations, and hardness (mg/l $CaCO_3$).

Prior to 1986, relatively few data are available. Some samples were tested in association with Anglo-American dredging activities in the Lower Boro (Reavell et al., 1973), and others during the second phase of UNDP/FAO studies (Hutton & Dincer, 1976; UNDP/FAO, 1977). Results have been summarized by SMEC (1987a, Vol.III).

4.3.2 Descriptive

Except in pools which become isolated from sources of inflow, water quality throughout the Delta is good for domestic, agricultural and industrial use.

Total dissolved solids (TDS) of river water entering the Panhandle at Muhembo is between 18 - 66ppm, and usually in the range 25 - 40ppm. Concentrations increase in the seasonal swamps, and at Maun TDS in the Thamalakane River is usually in the range 90 -120ppm, although higher concentrations may develop during recessions. Similar concentrations have been recorded for Khwai Gate and the Kunyere at Toteng. The water is usually slightly alkaline, and chemical composition of dissolved solids is dominated by bicarbonates of calcium and sodium. Chloride content is low.

Water temperatures of inflowing Okavango water are in the range 18 - 29°C, varying seasonally. Temperatures are rather higher at the distal end of the Delta, with usual range approximately 22 - 32°C.

The salt balance of the Delta has been modelled (SMEC, 1987a, Vol.III). An implication of the modest increase in salts concentration between the proximal and distal ends of the Delta is that large quantities of incoming salts remain within the Delta (McCarthy et al., 1986b). Presumably because of the seasonal flux to groundwater and transpiration by vegetation fringing the swamps, this leads to an increase in soil salinity within islands, infertility, and sometimes to surface encrustation of salt.

4.4 HYDROLOGICAL MAPPING

4.4.1 Method

In the first instance mapping was done on overlays of DSL maps at scale 1:50 000. These were subsequently reduced to scale 1:100 000. All channels of significant length which could be clearly identified on 1983 aerial photography - also at scale 1:50 000 - were mapped. Only madiba with clear open water surfaces were mapped. Others evident but which appeared overgrown or covered with aquatic vegetation were not included. No attempt has been made to map very small madiba which would not show clearly at scale 1:100 000.

Hydrological zones which indicate susceptibility to flooding in general terms were interpreted from the 1983 aerial photography and available satellite imagery between 1979 and 1987. A shortcoming of the available satellite imagery was that it did not provide a good range of floods from which to evaluate frequency and extent of flooding. Although years of high and low flood were included in the sets available, there were no years which approached average flooding conditions through the Delta. Reference was also made to DWA hydrometric records, although these usually measure water level in channels and provide little information on more general flooding conditions.

4.4.2 Classification

The hydrological classification of the study area comprises five categories of susceptibility to flooding. No attempt has been made to discriminate zones less than about 2km^2 in extent.

The five categories of susceptibility to flooding are:

1) perennial flooding (PF) - subject to inundation throughout the year in all or most years.

2) regular seasonal flooding (RSF) - subject to inundation on a seasonal basis in most years.

3) occasional seasonal flooding (OSF) - subject to inundation on a seasonal basis in some years, but not in most years.

4) high flood only (HFO) - subject to incursions of flooding from the swamps only during higher floods.

5) dryland (DL) - not susceptible to flooding from the swamps.

The distinction between PF and RSF categories is intended to distinguish between areas which are usually flooded throughout the year and areas which are usually flooded on a seasonal basis. The reader is referred to Appendix E, which provides more detailed descriptions of susceptibility to flooding in the five categories. Any user of the map is also referred to the cautionary notes which follow in Section 4.4.3.

4.4.3 Limitations to interpretation

Mention has already been made of the fact that the range of flooding on available satellite imagery is not good for purposes

of classification. Consequently the reliability of interpretation varies within the study area.

Difficulties encountered in mapping may be summarized as follows:

i) Limitations of scale. No attempt has been made to map discrete zones less than about $2km^2$ in extent. Because of difficulties in assimilating mapped information at a scale of 1:100 000, sinuous boundaries between zones have been avoided. Users of mapped information should be aware that boundaries shown are not precise and that mapped units probably contain smaller areas with different susceptibility to flooding.

ii) Data limitations. The data available are inadequate for accurate determination of frequency, duration or depth of flooding. The size and complexity of the study area ensure that these difficulties cannot be easily overcome. Cycles of high flood years and low flood years in recent times, and the dynamics of the Delta with frequent shifts in distribution of flow and flow regimes, serve to compound these difficulties. Users of mapped information should be aware that estimates of susceptibility to flooding are based upon limited analysis and local knowledge, and upon much interpretation.

iii) Ground Truth Limitations.

Time and resources available for checking visual interpretation of imagery in the field was very limited in this study. Considerable time and expense would be necessary to do this properly and would involve field inspections at different times of the year. Misinterpretation of aerial photography and satellite imagery therefore remains a possibility, but based upon field visits that were made this should not be widespread.

4.4.4 Channels

Channels clearly visible on 1983 aerial photography were mapped. These were classified as perennial, seasonal, or as functioning only during high flood. This interpretation is subject to similar limitations as the interpretation of hydrological zones.

Except in the zone of perennial flooding, the frequency of flow in channels will always be greater than the frequency of flooding in the surrounding zone. This is because inundation occurs only after the (often limited) capacity of channels has been exceeded.

Perennial channels which appear blocked by vegetation have been so identified. Where any doubt arose concerning the integrity of a channel, it has not been mapped. In areas of swamp without dense aquatic vegetation it is particularly difficult to detect the presence of small channels, for example. The actual channel network is undoubtedly more extensive than is indicated.

Field inspection revealed that the channels parallel to but to the north of the Nambopi channel, for example, originated as a network of fine channels within some open swampland about 3-4km

from Letetenetso Island. It conveys a small but significant flow through to the Mburoka and is navigable throughout most of its length. Many kilometres of the upper reaches of this channel were not readily identified as a continuous channel system on aerial photography, and have not been mapped. This channel system has a distinctive role in distribution of flow subsequent to development of the Nqoga blockage, and yet it remains unnamed. For hydrological purposes it is extremely useful to have names by which to refer to extensive channel systems. This and certain other channel systems should be assigned names, and it is recommended that this be done as a separate sub-project.

4.4.5 Madiba

Lakes or madiba (singular: lediba) are a prominent feature of the Okavango Delta swamps. These are areas of open water, with depths (2.5 - 4.5m) greater than that of the surrounding swamps, possibly due to subsidence associated with past peat fires (SMEC, 1987b). While in some instances they may provide a focus for drainage of local swamps, they do not appear to have an important hydrological role, and evaporation from the open water surface is of the same magnitude as evapotranspiration from flooded swamps (SMEC, 1987b).

5. VEGETATION

5.1 INTRODUCTION

Analysis of records of authenticated plant specimens held at those international herbaria containing major collections of Botswana material (viz. Gaborone, Harare, Kew, London, Pretoria), supplemented by references in botanical literature, show that 1061 different species of plants occur within the project area in the Okavango. Many of the remoter parts of the Delta have still to be explored botanically. Some of the plants collected just outside the project area, but not yet within it, will need, in time, to be added to the Okavango inventory. The final total, therefore, will eventually approach 1200 at least - possibly more.

5.2 SPECIES/AREA RELATIONSHIPS

Assuming the project area to be approximately 22 000km² this gives a species/area ratio of 0.0545 which seems to compare favourably with results recently reported by Gibbs - Russell (1985, 1987) as follows:

	Ratio	Taxa	km²
Major southern African biomes:			
Savanna	0.0092	5 788	632 034
Nama-Karroo	0.0108	2 147	198 468
Desert	0.0120	497	41 292
Grassland	0.0339	3 788	111 888
Succulent Karroo	0.0420	2 125	50 616
Fynbos	0.1997	7 316	36 628
Larger regions:			
Europe	0.0011	-	-
Sudan	0.0013	3 200	2 505 800
Eastern N. America	0.0014	4 425	3 238 000
Tropical Africa	0.0015	30 000	20 000 000
W. Tropical Africa	0.0016	7 300	4 500 000
Australia	0.0032	25 000	7 716 000
Tropical Asia	0.0041	20 000	4 885 280
Brazil	0.0047	40 000	8 456 500
Southern Africa	0.0078	20 000	2 573 000

The higher ratio for the Okavango when compared with all other parts of the sub-continent except fynbos must of course be expected seeing that it contains a significantly extensive area of perennial swamp. Wetlands elsewhere in southern Africa are rarely large enough to be mapped as separate vegetation types but their plant species are usually included in checklists for the biomes within which they are situated. Plants of rivers and lakes, especially those perennially inundated, are relegated to special, azonal sections in phytosociological reports. Probably the instability of Okavango hydrological regimes has not encouraged much diversity or speciation among aquatic and

wetland plants (as proven by the almost complete lack of regional endemics). The richness of the Okavango flora is about one order of magnitude greater than for the nation as a whole (0.0052; 582 000km²; 3000 estimated number of spp.).

5.3 PLANT LIST FOR THE STUDY AREA

After adding 17 subspecies, varieties and formae infra-specifically, the total number of plant taxa accepted for the Okavango project area becomes 1078 and these are listed in Appendix F. Although some information is available on mosses (Bryophyta), stoneworts (Charophyta) and liverworts (Hepaticae), it is considered insufficient to present in check list form at this stage. All the Botswana specimens at Pretoria and Harare and most of those at Gaborone have been examined by the author, while at Kew all grasses, sedges, legume and water plant families were seen and at British Museum (Natural History) grasses (Eragrostideae) and some sedges. A small herbarium maintained at Maun comprising many of the major collections gathered in the Okavango was consulted during preparation of the plant list particularly for label information on habitat and associated species.

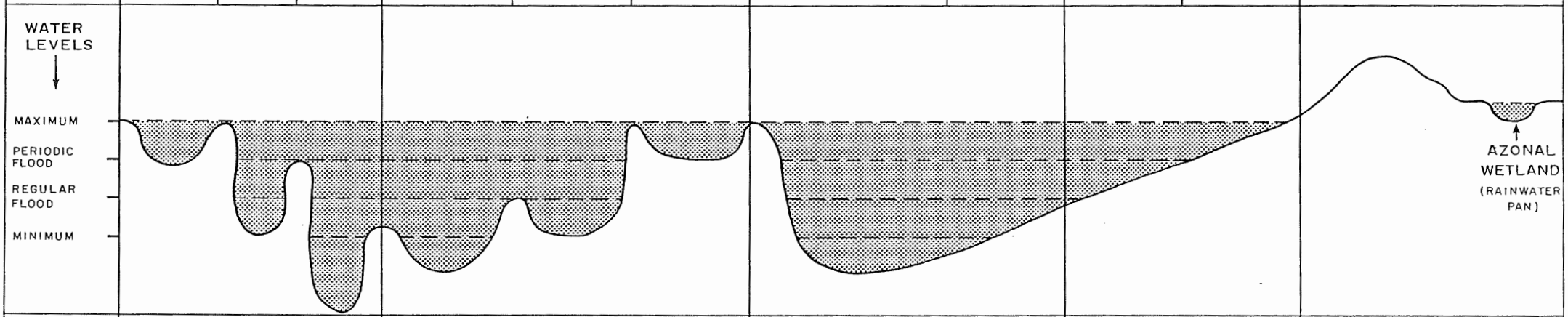
5.4 HABITAT CLASSIFICATION

The wetland habitat classification followed in this report is based on Cowardin et al. (1979) and illustrated in Figure 5.1. Whereas boundaries between riverine, lacustrine and palustrine ecosystems can be laid down in theory easily enough, they are so inextricably interwoven in the Okavango as to make separation very difficult. For example some unconfined channel sections of the mid-Boro river are barely distinguishable from the surrounding swamp. There are also unconfined channel sections which resemble madiba and could be interpreted as lacustrine. To overcome the problem, and to reduce repetition, the perennial sections of all three ecosystems will be treated below in one group - "perennial swamp", and the seasonally inundated sections under "seasonal swamp". The other wetland sections are "flooded grassland" and "rainwater pan" habitats. Deepwater habitats are devoid of vegetation and need not be considered further beyond stating that in most of the upper perennial swamp channels, flow velocities are too high, or waters too turbid, to permit plant growth let alone considering depth as a factor by itself.

The main vegetation types in the dryland follow the classification of White (1983) except that use of the term "savanna" is revived to encompass, in one unit, wooded grassland, bushland, thicket and shrubland - a treatment which is considered justifiable in the semi-arid environment of north western Botswana where grasses predominate, and bushland, thicket and shrubland as defined by White (1983) do not cover sufficiently discrete, large areas excepting perhaps in mosaics. Another difference concerns seasonal swamp included by White (1983) under grassland but here considered to be extensive and distinctive enough to merit recognition as a subtype on its own. White (1983) does not separate forbs from grasses because of their "purely local significance". Although forblands, admittedly, seldom form homogeneous stands of great individual extent, nevertheless they occur in such a widespread "patchwork" distribution pattern throughout Okavango drylands - especially the Delta periphery - it is felt they warrant mention

FIGURE 5.1 VEGETATION HABITAT CLASSIFICATION

ECOSYSTEM	RIVERINE			LACUSTRINE			PALUSTRINE		TERRESTRIAL WETLAND – DRYLAND		TERRESTRIAL DRYLAND
MAJOR HABITAT DIVISION	INTERMITTENT	SEASONAL	PERENNIAL	PERENNIAL	SEASONAL	INTERMITTENT	PERENNIAL SWAMP	SEASONAL SWAMP	SEASONALLY FLOODED GRASSLAND	INTERMITTENTLY FLOODED GRASSLAND	FOREST / WOODLAND SAVANNA / GRASSLAND FORBLAND
TOPOGRAPHIC UNIT	CHANNEL			LEDIBA (LAKE)			SWAMP		FLOODPLAIN		SAND PLATEAU ISLAND / MAINLAND
MAPPING CATEGORY	(DELINEATED ON HYDROLOGICAL MAPS)						PERENNIAL SWAMP PS	SEASONALLY INUNDATED AREAS SIA		INTERMITTENTLY FLOODED AREAS IFA	DRYLAND ASSOCIATION DA



as another subtype. Their significance is being accentuated by livestock grazing effects on grasses during drought cycles and also the role they play in vegetating heavy sand areas and former swamplands that are reverting to dryland - albeit as a transitional phase.

5.5 HABITAT ANALYSIS

An analysis of the distribution of plants by habitat is made in Table 5.1:

It will be noted from Appendix F that some plants grow in two or three different habitats. It is only possible to show a meaningful distribution between habitats if a plant is counted as a separate species each time it occurs in more than one habitat. Then the total number of species can, for this purpose, be taken as 1 428 and analysed thus:

	No.	%
Swamps: Perennial	205	14
Seasonal	240	17
Total	445	31
Flooded Grasslands	213	15
Rainwater Pans	66	5
Drylands	686	48
Miscellaneous (Parasites & Epiphytes)	18	1

5.6 LIFE FORM ANALYSIS

An analysis of the life form of Okavango plants is made in Table 5.2.

5.6.1 Woody species of the Swamps

As perhaps is to be expected in a semi-arid, sub-tropical environment, only a small proportion (18%) of the total flora is woody. In marked contrast to temperate and equatorial wetlands, there are no forested or wooded swamps in the Okavango except for limited patches of Phoenix palm and Syzygium trees at island/mainland fringes or on termitaria. The lower reaches of channels in the perennial swamps are frequently lined by the shrubby Ficus verruculosa which can vary from a spindly plant 1m tall to a wide-branched bowl-shaped thicket 5m high. Declining velocities in narrow channels towards the limits of the perennial swamp permit this fig to grow into and over the channel, forming blockages. The other aquatic, or semi-aquatic, shrubs: Vernonia amygdalina, Myrica serrata, Ficus pygmaea and the bramble, Rubus exsuccus, are common throughout the swamps but seldom form stands that dominate areas of significant extent. The prickly Mimosa pigra is thinly present in a narrow riverine strip between the border and Muhembo. Incidentally, this plant has become a rampant weed causing severe problems when introduced in Australia and its presence in the Okavango will need to be monitored.

TABLE 5.1 ANALYSIS OF OKAVANGO DELTA PLANT SPECIES BY HABITAT

	Total	Dicots	Monocots	Ferns
Terrestrial Ecosystems				
Dryland Habitats (all)	578	436	142	-
Dryland Riverine Woodland	40	36	4	-
Dryland Forest	1	-	1	-
	619	472	147	-
Riverine/Lacustrine/Palustrine Ecosystems				
Perennial Swamp	4	-	4	-
Perennial and Seasonal Swamp	176	81	90	5
Seasonal Swamp	10	3	7	-
	190	84	101	5
Other Wetland Ecosystems (Partly terrestrial, partly riverine/ lacustrine/palustrine)				
Rain Water Pans	32	5	23	4
Flooded grasslands	77	31	45	1
Intermittently flooded grasslands	2	-	2	-
Flooded grasslands and Rainwater pans	19	11	8	-
	130	47	78	5
Plants distributed over more than one major ecosystem				
Perennial and Seasonal Swamp and Flooded grassland	15	6	9	-
Perennial and Seasonal Swamp and Rainwater pans	8	5	3	-
Seasonal Swamps and flooded Grassland	25	6	19	-
Seasonal Swamp, flooded Grassland and rainwater pans	4	1	3	-
Flooded grassland and dryland	63	39	24	-
Flooded grassland, Dryland and Rainwater pans	3	2	1	-
Intermittently flooded grassland and dryland	3	-	3	-
	121	59	62	-
Miscellaneous				
Parasites (holoparasites, hemiparasites etc.) and Epiphytes	18	17	1	-
Total	1078	679	389	10

TABLE 5.2 ANALYSIS OF OKAVANGO DELTA PLANT SPECIES BY LIFE FORM

	Total	Dicots	Monocots	Ferns
AQUATICS (AND SEMI-AQUATICS):				
Emergents: Grasses	25	-	25	-
Sedges	36	-	36	-
Other herbs	76	55	19	2
Shrubs/shrublets	7	7	-	-
Trees	3	2	1	-
	147	64	81	2
Submerged: Sedges	2	-	2	-
Other herbs	19	5	14	-
	21	5	16	-
Emergent and submerged herbs	2	1	-	1
Creepers (herbs)	4	4	-	-
Creepers(woody)	1	1	-	-
Free-floating (herbs) (on surface or submerged)	16	7	7	2
Floating-leaved herbs	12	9	3	-
Floating-stemmed: grasses	1	-	1	-
other herbs	4	4	-	-
Total Aquatics	208	95	108	5
NON-AQUATICS:				
Herbs: Forbs	383	328	50	5
Grasses	168	-	168	-
Sedges	60	-	60	-
Creepers	64	63	1	-
	675	391	279	5
Ground creepers (Partly woody, partly herbaceous)	14	14	-	-
Woody plants				
Shrublets (including woody Herbs)	32	31	1	-
Shrubs	53	53	-	-
Plants occurring commonly as either shrubs or trees	18	18	-	-
Plants occurring commonly as shrubs but rarely (at least in Okavango) as trees	10	10	-	-
Shrubs, sometimes developing into woody climbers	4	4	-	-
Climbers, creepers, lianes	4	4	-	-
Trees	60	59	1	-
	181	179	2	-
Total	1078	679	389	10

5.6.2 Woody Species of the Dryland

Even among the 88 species of dryland trees, only 57 (65%) can be considered to be widely spread throughout the mainland edge and on islands of the Okavango. 18 of the trees listed intrude riverine woodlands at the mainland edge because they are common in Baikiaea/Burkea sandveld savanna communities that abut the Magwegqana or Panhandle and include species such as Pseudolachnostylis maprouneifolia, Dialium engleranum and Erythrophloeum africanum. The remaining 13 trees are either rarities or restricted to minor localities - for example, only a single specimen of both Cassine matabelica and Manilkara mochisia are known to exist in the Okavango. Salvadora persica var. persica may only be encountered on the edge of the project area between Tsao and Toteng and is nowhere common even there.

5.6.3 Herbaceous Species

Herbaceous plants predominate in both dryland and wetland habitats. Annuals (therophytes) contribute significantly to dryland savanna community biomass during the summer months. A feature of the Kalahari flora - the abundance of geophytes- extends partly into the Okavango where 27 representatives of this life form can be found (mostly among the Liliaceae).

5.6.4 Aquatic Plants

There appears to be a paucity of aquatics particularly among the submerged, free-floating, floating-leaved and floating-stemmed forms but there are little published data on other African wetlands with which to make a comparison. A study of neighbouring floras reveals that there are not many other species of these forms which could easily spread to the Okavango. It is likely that despite the quantity and velocity of waters that are available in the Okavango, their low TDS/conductivity status indicate that nutrient values per unit volume are low. So far the floods from the catchment areas in Angola and Namibia are relatively unpolluted and do not carry a heavy sediment load compared with other systems such as the Zambezi. So long as the influent waters remain of high chemical purity, the diversity of Okavango aquatics is likely to remain seemingly rather impoverished. The present balance could easily be changed by perturbations caused by impoundments etc. or by the influence of irrigation schemes on groundwater quality.

Only recently (1986) has the notorious free-floating fern (Salvinia molesta) invaded the Okavango and it is currently the subject of an intensive control campaign. So far it is being contained within or close to the Mogogelo river system but there is a very real danger that it may spread throughout the whole Okavango. A long term biological control measure is available and is already being implemented. Until an equilibrium stage is reached in this weed's population level, it could have a profound influence in the short term on swamp plant communities by stifling competition from other free floating, floating leaved and submerged aquatic forms and in various indirect ways.

5.7 FLORISTIC ANALYSIS

Okavango vegetation is derived from plant genera and families as follows:

	Total		Dicots	Monocots	Ferns
Families	120		93	21	6
Genera	489		343	140	6

This gives an average of just over 2 species per genus, or 9 per family. Families with 15 or more species are ranked in Table 5.3.

TABLE 5.3 THE IMPORTANT FAMILIES OF OKAVANGO PLANTS

			GENERA	TAXA
1.	POACEAE	(Monocot)	68	194
2.	CYPERACEAE	(Monocot)	20	98
	FABACEAE	(Dicot)	40	98
3.	ASTERACEAE	(Dicot)	42	70
4.	ACANTHACEAE	(Dicot)	16	33
5.	EUPHORBIACEAE	(Dicot)	16	31
6.	MALVACEAE	(Dicot)	7	27
	LILIACEAE	(Monocot)	15	27
7.	AMARANTHACEAE	(Dicot)	14	22
	CONVOLVULACEAE	(Dicot)	6	22
8.	SCROPHULARIACEAE	(Dicot)	14	21
9.	ASCLEPIADACEAE	(Dicot)	14	19
	RUBIACEAE	(Dicot)	8	19
10.	LAMIACEAE	(Dicot)	12	17
11.	CUCURBITACEAE	(Dicot)	9	15
			301	713

The above 15 families account for two thirds (66%) of all plants (and 62% of their genera). It will be noted that the grasses (Poaceae) are by far the most varied and that the sedges (Cyperaceae) legumes (Fabaceae) and composites (Asteraceae) also have large numbers of species though in the case of the latter a fifth (14) are not indigenous but naturalised ruderals or weeds of foreign origin.

The 365 plants not ranked above are contained in 188 genera (or 78 families) - an average of just under 2 species per genus and almost 5 per family. The overall pattern of distribution between families corresponds with analyses reported for savannas in adjacent countries, allowing in the case of the Okavango for the influence of wetland habitats boosting the proportions of grasses and sedges.

5.8 PLANT COMMUNITY COMPOSITION

Within each major habitat division, one or more plants tend to dominate and outcompete others, by virtue of their height, abundance or some other attribute, at sites where environmental factors (soil type, microclimate, depth/duration of flooding, etc.) match most closely their particular requirements. Invariably most plants can tolerate a range of conditions on either side of their preferred optimal needs and it is often possible to identify gradients along which they will be found to grow. Where key gradients are shallow, the vegetation will form a continuum where one type passes almost imperceptibly into another and no two types are repeated exactly. Plant communities develop around and are usually named after dominants - the degree of association being dependent upon the similarity between their physiognomy, anatomy, nutrient requirements and a host of factors many of which are not always easy to ascertain, and at least some of which may operate quite randomly. Some plants have a very narrow range of requirements and will only be found at a particular landform facet or soil type, etc. and they serve as useful indicators of specific sites or conditions. Therefore, although dominants may form large homogeneous stands, the communities with which they are associated will vary with every change in the environment. If all plant species within a community are to be taken into account, the range of variation in community composition will be found to be almost infinite when dealing with vegetation types covering areas of many square kilometres.

The phytosociological work carried out in the Okavango so far has been limited to three areas. Heemstra (1976), who was the first to apply Braun-Blanquet techniques, has described plant communities between the edge of perennial swamp and island centres along the Xudum/Xwaapa interfluve. Biggs (1979) dealt with the vegetation of the Chief's Island extension of the Moremi Wildlife Reserve, from dryland savanna to perennial swamp. K. Ellery (1987) and W.N. Ellery (1988) have given details of perennial swamp communities on the Mwanachira river. Smith (1976) has provided an overview of all Delta communities with an emphasis on floristics.

5.8.1 Plant Communities: Perennial Swamp

By definition, perennial swamp habitats are inundated by water throughout the year, and from one year to another but are not necessarily **permanently** inundated. The water level may drop temporarily to the level of the substrate but not below it. All plants in the perennial swamp are, of course, aquatics, the major

dominants being as follows:

Emergents (tall)	Emergents (medium - short)
Cyperus papyrus	Cyperus articulatus
Phragmites australis	Schoenoplectus corymbosus
P. mauritianus	Pycreus nitidus
Typha capensis	Vossia cuspidata
Cladium mariscus ssp. jamaicense	Eriochrysis pallida
Pennisetum macrourum	Echinochloa pyramidalis
Miscanthus junceus	
Ficus verruculosa	

Floating leaved

Nymphaea caerulea	(lacustrine/palustrine)
Brasenia schreberi	(" ")
Nymphoides indica	(" ")

Submerged

Najas pectinata	(lacustrine/palustrine)
Rotala myriophylloides	(riverine)

The following plants occasionally occur in large, fairly homogeneous stands and would qualify for inclusion above except that, taking the perennial swamp in the Okavango as a whole, they are not sufficiently extensive or widespread and some must be better classified as associates:

Thelypteris interrupta	(emergent, riverine margin & palustrine)
Trapa natans ssp. bispinosa	(floating - leaved, palustrine)
Ottelia ulvifolia	(submerged, lacustrine)
Ottelia muricata	(submerged, riverine)
Eleocharis acutangula	(emergent, riverine)
E. dulcis	(emergent, riverine margin)
Pycreus mundii	(emergent, palustrine)
Cyperus pectinatus	(emergent, palustrine)
Eichhornia natans	(submerged, lacustrine)

The most typical community of the perennial swamp is formed around papyrus. The growth habit of this giant sedge is such that little competition from other plants is possible and usually over 90% of the biomass of this community is comprised of the single dominant. It is only at the interface with channels or madiba that associated plants are more noticeable and they include:

Polygonum pulchrum	Cyperus halpan
Ludwigia abyssinica	Leersia hexandra
Commelina diffusa ssp. scandens	Ipomoea rubens
Vossia cuspidata	Vigna luteola
Mikania cordata	

Communities belonging to the two reeds (Phragmites australis, P. mauritianus), the bulrush (Typha capensis), Miscanthus junceus and in the Panhandle only, Echinochloa pyramidalis also cover extensive areas with large stands and a much wider range of associates. However probably the major portion of the perennial swamp is the area where many co-dominants thrive side-by-side. This is in part a reflection of the variability of hydrological regimes and the instability of some river systems besides being a function of water depth, quality, turbidity, level amplitude, substrate and factors which govern the distribution of these plants under normal conditions.

A feature of the perennial swamp is that the output of such highly productive plants as papyrus is revealed in a rapid build-up of peat overlying the substrate, a process which is of almost as great importance in the Okavango as the flow of water and sediment. A typical community of the shallower perennial swamp where peat is formed is the Eriochrysis pallida bogland near the Mwanachira river. A surprisingly greater diversity of plants is evident in these bogs as listed in the following selection:

Drosera madagascariensis
Sebaea microphylla
Neohyptis paniculata
Rotala filiformis
Ottelia ulvifolia (diminutive form)
Xyris capensis
Ficus verruculosa
Miscanthus junceus
Lipocarpha atra
Pycreus aethiops
Utricularia spp.
(various mosses)
Epilobium salignum
Eulophia tanganyikensis
Habenaria chlorotica
H. filicornis
H. ichneumonea
H. schimperana
Rhynchospora candida
Scleria dregeana
S. unguiculata
Pycreus unioloides

5.8.2 Plant Communities: Seasonal swamp

Many of the Okavango aquatics span both perennial and the deeper parts of the seasonal swamps thus many of the species listed above, including especially the dominants, also extend into the seasonal swamps with the notable exception of papyrus. Those parts of the seasonally inundated areas of the Okavango which are sufficiently regularly and deeply flooded to support the growth of all life forms of aquatics (especially submerged species) can be defined as seasonal swamp. It is the presence/absence of these aquatics, besides the depth/duration of flooding, which determines the seasonal swamp boundary with the next wetland category: flooded grassland. Seasonal swamps are flooded deeper and for longer periods than grasslands.

The most widespread community is that dubbed SICA with two co-dominants: Schoenoplectus corymbosus (formerly Scirpus inclinatus) and Cyperus articulatus.

Typical seasonal swamp species include the following:

Hygrophila pobeguinii
Alternanthera sessilis
Hydrocotyle verticillata
Eclipta alba
Ethulia conyzoides
Aeschynomene indica
Ludwigia octovalvis ssp. brevisepala
L. palustris
Polygonum limbatum
P. senegalense
Ceratophyllum demersum
Limnophila indica
Potamogeton thunbergii
Paspalidium obtusifolium
Panicum subalbidum
Acroceras macrum
Echinochloa jubata
Paspalum scrobiculatum
Digitaria eylesii
D. debilis
Hemarthria altissima
Cyperus digitatus ssp. auricomus
Rhynchospora holoschoenoides
Scleria veseyfitzgeraldii
Lagarosiphon cordofanus

5.8.3 Plant Communities: Flooded Grassland

Some 77 species occur exclusively in this habitat and in addition from either flank, 136 species intrude from adjacent swamp, dryland or rainwater pan habitats. The most important dominants are as follows:

Wetter

Sorghastrum nudipes
Eragrostis inamoena
E. lappula
Panicum dregeanum
Panicum repens
Brachiaria humidicola
Setaria sphacelata
Imperata cylindrica
Eulalia aurea
Trachypogon spicatus
Andropogon huillensis
A. eucomus
A. laxatus
Cyperus longus
Fimbristylis bisumbellata

Drier

Hyperthelia dissoluta
Cymbopogon caesius
Aristida junciformis
Eragrostis rigidior
E. tricophora
Cynodon dactylon
Panicum coloratum
Vernonia glabra

It is interesting to note here that the ratio of grasses/sedges in flooded grassland is 63/40 (1.58:1) while the corresponding figure in the perennial and seasonal swamps is 34/62 (0.55:1) almost the complete opposite, which is only natural considering that the sedge family, world-wide, is more aquatic than the grass family.

5.8.3.1 Species tolerant of high Salinity/Alkalinity

A special mention may be made of species tolerant of high salinity/alkalinity because they occur on island beaches, a habitat of minor extent but major importance in the Okavango Delta where a large part of the excess salt load of the waters is deposited by evaporation.

At least 8 grasses and sedges occur here:

Cyperus laevigatus	Cyperus palmatus
Sporobolus spicatus	Odyssea paucinervis
S. acinifolius	Chloris gayana
S. tenellus	Juncus rigidus

5.8.4 Rainwater Pan Communities

The area covered by rainwater pans (whether perennially or seasonally) must be miniscule when compared to the swamps and flooded grassland. Despite their small size, this habitat is richer floristically than the other wetlands no doubt because of the higher nutrient status of the run-off waters, their higher sediment load and the higher proportion of clays/silts in the pan substrates. The following species can be seen exclusively at pans - at least in the Okavango:

Oryza breviligulata	Aponogeton junceus ssp. rehmannii
Elytrophorus globularis	Schoenoplectus maritimus
Diplachne fusca	S. senegalensis
Panicum impeditum	Kyllinga albiceps
P. pilgerianum	Cyperus difformis
P. repentellum	Courtoisia cyperoides ssp.africanus
P. schinzii	Heteranthera callifolia
Echinochloa colona	Wolffiella repanda
Oryzidium barnardii	W. hyalina
Pycreus chrysanthus	Marsilea macrocarpa
Lagarosiphon muscoides	M. minuta
Commelina subulata	M. nubica
	M. vera

5.8.5 Plant Communities: Dryland Terrestrial Ecosystems

The full range of vegetation types in this major category containing the mainland edge and all island and (dry) land masses within the Okavango spans forests, woodlands, savanna, forblands and grasslands. The term savanna itself is an omnibus one and covers mixed stands of trees, shrubs (bush, thicket, scrub) forbs and grasses in varying proportions and spacings - either clumped, regular or random distribution patterns or mosaics. The dryland flora consists of:

Trees	59
Plants occurring commonly either as a shrub or a tree	18
Plants occurring commonly as a shrub but rarely - at least in the Okavango - as a tree	9
Plants occurring mostly as a shrub but sometimes developing into a woody climber	4
Shrubs	48
Shrublets (including woody herbs)	32
Woody creepers	4
Herbs: grasses	109
sedges	18
forbs (including 58 climbers and 13 ground creepers)	385
	686

5.8.5.1 Forest

True forest (tall trees with canopies overlapping, with two or three layers of smaller trees, shrubs, a sparse ground layer of shade herbs, lianes, epiphytes, etc.) is extremely rare in the Okavango but a few patches of relict forest can be found on the mainland edge of the Panhandle especially in the Samochima area where, in addition to the usual components of riverine woodland, trees such as Cassine aethiopica, Excoecaria bussei, Oncoba spinosa and the creepers Dioscorea asteriscus, Tinospora caffra, etc. can be found and nowhere else in the Okavango. As in riverine woodland, nearly all trees are deciduous. Only a few, e.g., Garcinia livingstonei, are evergreen.

5.8.5.2 Riverine woodland

Riverine woodland forms a linear fringe bordering most island/mainland edges with the wetlands/swamps. In some places it is only one or a few trees wide but it can thicken to a dense band of trees and shrubs up to 200m wide-seldom more. The composition of riverine woodlands is always very varied. Typical components include the following:

Trees:
Sclerocarya birrea ssp. caffra
Kigelia africana
Garcinia livingstonei
Combretum hereroense
C. imberbe
Diospyros mespiliformis
Euclea divinorum
Croton megalobotrys
Acacia erioloba
A. nigrescens
A. galpinii
A. sieberana var. woodii
A tortilis (both subspp.)
Albizia harveyi
Colophospermum mopane
Peltophorum africanum
Lonchocarpus capassa
Ficus sycomorus
F. thonningii
Berchemia discolor
Hyphaene petersiana
Zizyphus mucronata ssp. mucronata

Shrubs:
Rhus tenuinervis
Maytenus senegalensis
Combretum albopunctatum
Ximenia americana
Grewia schinzii
Rhus quartiniana
Phyllanthus reticulatus

Grasses:
Aristida adscensionis
Panicum maximum
Enteropogon rupestris
Sporobolus fimbriatus
Brachiaria deflexa
Setaria verticillata

Occasionally, some associations persist over wide areas (e.g., Acacia nigrescens/Croton megalobotrys in the Moremi Wildlife Reserve) and stands of a single species, notably the palm Hyphaene petersiana, may take over whole islands - especially in the mid-lower Delta.

Apart from the ground layer, the lowest vegetation under-storey frequently consists of semi-woody, broad-leaved shade herbs of the families Acanthaceae and Amaranthaceae such as Hypoestes forskaolii, Achyranthes aspera, Pupalia lappacea, Ruspolia seticalyx, etc.

The riverine woodland habitat is plainly an important one for many forms of life providing shade, cover, protection and a source of many edible fruits. Unfortunately because of the relative thinness of its extent, it is not mappable except at a large scale.

5.8.5.3 Other Woodlands

In contrast to the riverine woodlands, those occurring on the larger islands and land masses are extensive and mostly comprise stands of a single or few species. Mophane (Colophospermum mopane) woodlands predominate in the land mass between the Mwanachira/Khwai/Mababe and Mogogelo Rivers, on the southern part of Chief's Island and in small parts only of the Sandveld tongue between the Matsebi and Karongana/Potae/Xene rivers. Close to the wetland edges, mophane woodlands are relatively dense, closed and contain very tall "cathedral" or gallery forms. In drier situations mophane woodlands become much more open and of uniform medium height. Woodlands of Acacia (especially A. erioloba and A. tortilis ssp.) often associated with Combretum and Terminalia spp. are the next most important and extensive type and are to be found in the sandier areas, especially former floodplains. The upper terraces of the relict Thaoge floodplains contain a large block of Acacia woodland stretching from south of Gumare through to Lake Ngami. Two features of this block are of interest. Firstly in the vicinity of where the Mapeno and Maputle distributaries take off from the Thaoge, long avenues of large Acacia erioloba trees can be noted on the airphotos radiating eastwards from points on the Thaoge river bed. It is almost certain that these avenues follow the paths made by cattle trekking regularly from their grazing grounds to watering points. Livestock are known to relish Acacia erioloba pods and their dung piles would form an excellent medium for undigested seeds to germinate in.

The old waggon routes from Ghanzi to Lake Ngami and from north of Shorobe to the Mababe Depression can be traced in parts quite easily by following Acacia tree avenues on the 1951 airphotos. Those Thaoge woodlands established by livestock must have been seeded between 1896 (the date of the rinderpest pandemic) and the early 1940's, i.e. when there were no tsetse. The other feature is that these woodlands contain much Acacia karroo, a species which extends to the eastern side of the Sandveld Tongue but is completely absent from the whole of the NE sector of the Delta.
Acacia tortilis ssp. heteracantha woodlands prefer soils with a higher clay/silt content such as floodplain sumps and are significant in the vicinity of Lake Ngami, the Mababe Depression and part of northern Chief's Island.

5.8.5.4 Grasslands

Grasslands (other than those subject to direct inundation) are rare except at island inner depressions where perhaps woody competition is suppressed either by the high water table or high alkalinity/salinity of the substrate. In addition to those already mentioned above in the list of salinity/alkalinity tolerant species under 5.8.3.1, grasses such as Aristida stipoides, Chloris virgata, Sporobolus ioclados, Wilkommia sarmentosa, Cynodon dactylon, Bothriochloa bladhii, B. insculpta and Schizachyrium jeffreysii and herbs (Epaltes gariepina, Sphaeranthus spp.) are typical of this type.

5.8.5.5 Forblands

Forblands are common in small patches of a few hectares extent but are usually of an ephemeral nature and rarely extensive. The fields of Sesbania, Xanthium and Gomphocarpus which appear irregularly at Lake Ngami are exceptional but these lie just outside the project area. Within the Okavango, if the sumps and depressions of flooded grasslands dry out sufficiently during the summer, temporary and sometimes massive invasions of forbs (e.g., Sida cordifolia, Hibiscus cannabinus, Heliotropium ovalifolium) will take place and flourish until the arrival of the next flood. Two herbs: Gisekia africana (probably the most widespread and common dryland herb of the Okavango) and the weed Tribulus terrestris (a primary coloniser of overgrazed areas) take most advantage of this "flush" habit. There are also two Crotalaria species (C. sphaerocarpa and C. platysepala which are important constituents of forblands.

5.8.5.6 Savanna

In terms of areal extent, this is probably the most important vegetation type complex in the Okavango, and certainly the most difficult to map as it occurs in an intricate mosaic with the mophane and Acacia/Combretum woodlands just described. A sample of some of the more important sub-types is as follows:

a) Mophane shrubland/scrub: known locally as "gumane", this vegetation is of remarkably even height and is dominated by a stunted, shrub-form of mophane. It covers large areas interdigitating mophane woodland. Grass and forb cover is thin close to the mophane but flourishes in the innumerable open patches between the shrubs.

b) Grewia shrubland: shrubs of Grewia flava, bicolor and flavescens (both subspp.) mixed with occasional trees (Acacia/Combretum/Boscia albitrunca) and other shrubs (Rhus, Maytenus, Ximenia, Croton and Dichrostachys cinerea) also cover wide areas but in soils more sandy than those in "gumane". Thus they form a mosaic in the Acacia/Combretum woodland zone.

c) Pluchea forbland: there are two composite herbaceous plants which produce annual stems from a woody base. Being highly aromatic, they are seldom grazed by livestock and their perennial rootstock is immune to damage by fire. Their windblown seeds germinate readily thus they are widespread in disturbed areas such as fallow lands, and roadsides. But

when competition is reduced by overgrazing in the more open savanna areas, they soon achieve dominance in these sites too. The larger and more numerous of the two is Pluchea leubnitziae, and the smaller and more herbaceous Blumea gariepina. Their associates are frequently other weedy or ruderal species and grasses of Aristida, Stipagrostis, Dactyloctenium, Schmidtia spp.

d) Terminalia sericea/Lonchocarpus nelsii/Combretum collinum shrubland. This subtype is to be found mainly on fossil river levees winding through mophane woodland/shrubland mosaics and usually indicates a heavy, loose sandy soil. Mostly the dominant plants are shrubs or small trees, occasionally developing into tall specimens in clumps. Associated species include Grewia avellana, Ochna pulchra, Acacia ataxacantha, A. fleckii.

5.8.5.7 Dryland vegetation altered by man

At towns and villages and in agricultural lands cultivated in the periphery of the Delta, the natural vegetation has been much altered by human activity: gathering firewood, cutting poles for fencing, bridge-making or house-building, sheer-felling for roadmaking and human settlement, clearing for agricultural and horticultural activity, etc. All such sites are shown in the land use maps and described in Section 7.
Mention must also be made of the activities of the Tsetse Fly Control Department in the 1950's and 1960's when vast tracts of Acacia woodland and savanna were treated to halt the spread of the fly. To protect the villages of Tsao, Nokaneng and Gumare mile-wide barriers were sheer-felled, i.e. stripped of all tree growth. Between Sepupa and Makakung in the west, along the Nxaraha Valley and on the lower interfluves between the Matsebi, Xudum, Xwaapa, Shashe and Boro Rivers and from Matlapaneng to Shorobe and Simiti on the Mogogelo various Acacia spp. believed to harbour tsetse were either chopped down by hand axe, sawn mechanically, ring-barked or poisoned by arboricides. These measures were fortunately abandoned in 1966 and the scars of these destructive operations have largely been healed but can still be noted on the airphotos.

5.9 VEGETATION MAPPING

In the vegetation map overlays, boundaries are shown between the following four zones:

1) Perennial Swamp (PS)
2) Seasonally Inundated Areas (SIA)
3) Intermittently Flooded Areas (IFA)
4) Dryland Associations (DA)

The perennial swamp and the boundary between the mainland and intermittently inundated areas were determined by stereoscopic examination of physiognomic vegetation characters on the 1:50 000 scale vertical airphotos of the Okavango taken May 1983. The seasonally inundated areas were plotted from 1:250 000 scale LANDSAT images taken in July - September 1984. Originally it was planned to use LANDSAT imagery from 1978 (or earlier) to plot the intermittently flooded area boundary because the swamps were

known to reach their maximum areal extent during that year but unfortunately no images are available at all from either CSIR, Pretoria or NASA, USA for that year.

Thus the only vegetation types mapped which coincide directly with the plant community descriptions are the perennial swamp and the mainland section of drylands, i.e. the wettest and driest boundaries. It is considered that because seasonal flooding patterns are so variable the best way to map in the intervening area (i.e. to separate intermittently and seasonally flooded grasslands and seasonal swamp) is by checking plant distribution at a variety of carefully selected sites in each river system throughout the Delta. Once reliable extrapolation techniques have been developed mapping can then proceed using airphotos and satellite imagery. Such an exercise would take at least two years and obviously could not be undertaken for this project.

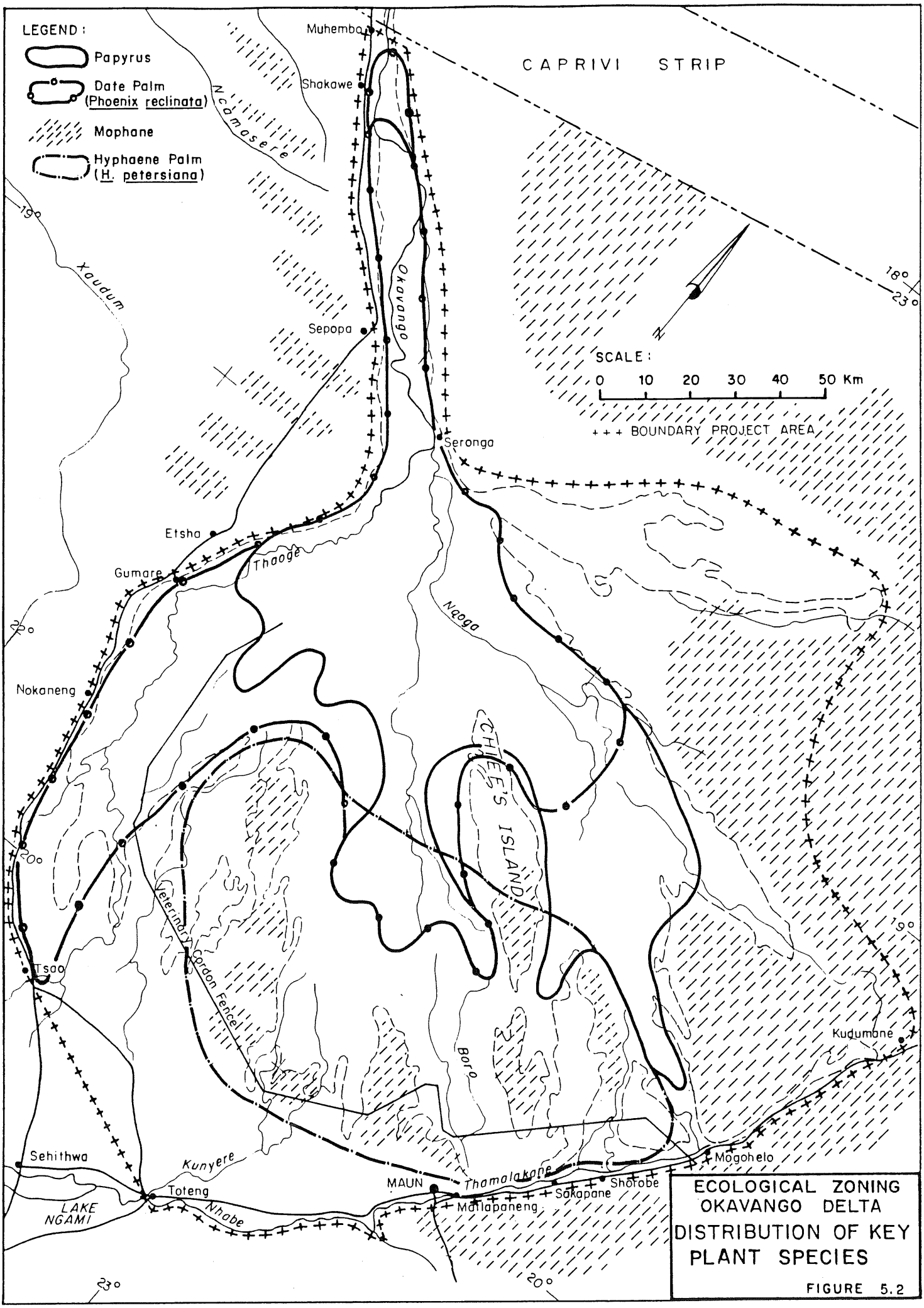
The seasonally-inundated areas (SIA) shown on the vegetation map overlays should be taken strictly as the limits of the floodwater in the Okavango as at 20 July 1984 for all river systems except the lower Santantadibe, Gomoti and Mogogelo rivers for which LANDSAT images of 21.8.84 and 22.9.84 were used. The SIA area therefore covers both seasonal swamp and seasonally flooded grassland - and possibly, even part of the intermittently flooded grasslands seeing that the Muhembo inflow was apparently more than sufficiently above average during the 1983/4 hydrological year to compensate for the local rainfall shortfall.

It should be pointed out that for reasons of scale and time availability, most small islands could not be shown in any of the swamp or grassland units and only the boundaries of the significantly large ones were checked. However the interpretation of islands within the Delta on the 1969 photomaps is generally quite reliable and as these maps were used as working maps for vegetation this gap is not felt to be of any importance. On the working maps, the water limit as revealed by the May 1983 air photography has been plotted so this "back-up" information is readily available in case of need, seeing that it has not been shown on the overlays. For similar reasons as for islands, small areas of seasonal swamp within the perennial swamp have not been mapped but again, these show up reasonably well as the lighter blue areas in the coloured photomaps.

The approximate distributions of four important plant species in the Delta are indicated on Figure 5.2 This shows the limits of papyrus (excluding relict populations), date palm (*Phoenix reclinata*), mophane (*Colophospermum mopane*) and *Hyphaene petersiana* concentrations.

5.10 VEGETATION CHANGES

Changes in the hydrological regimes of river systems in the Okavango are well known, and current investigation by DWA staff and consultants and by researchers from the University of the Witwatersrand into the causes of change are beginning to shed light on some of the important processes and mechanisms responsible. A study of vegetation boundaries also provides



ECOLOGICAL ZONING
OKAVANGO DELTA
DISTRIBUTION OF KEY
PLANT SPECIES

FIGURE 5.2

useful indicators of where change is taking place. This current study has revealed a number of interesting changes which may have an important bearing on future trends within the Delta.

Gomoti River: The perennial swamp has retreated from Haforudithu (where it ended in 1976) to as far upstream as the vicinity of Bokadoro, where a peat fire is currently raging and hastening the demise of the upper Gomoti which has been heavily blocked in this region since Ellenberger's visit in 1931. Despite the disappearance of the perennial swamp in the Central and lower Gomoti, the river has been rejuvenated as a seasonally flowing stream all the way through to even beyond Haforudithu. Although beheaded from its former headwaters at the end of the Mburoka channel, the Gomoti is now receiving flow from a tributary at Mpoka island which appears to correspond with a channel called Guekha (Guega on Stigand's 1925 map), in addition to seasonal flow from the Mogogelo river in the Abaqao district (referred to by some as the Chukuroro channel). A *Ficus verruculosa* blockage is developing on the Mogogelo just above Abaqao and this may be diverting Mogogelo water via the Chukuroro links into the Gomoti. This would explain why the Gomoti has rejuvenated while the lower Mogogelo swamps are reducing in extent.

Mwanachira - Sekiri (Third Bridge) Channel

The only instance where the 1983 airphotos show that perennial swamp has extended into an area marked as mainland on the 1969 photomaps lies just to the south of Magwegqana on the floodplain fed by the channel from Sekiri. Lower on the same floodplain towards Bodumatau seasonal swamp extensions into mature mophane and *Acacia* woodland were noted and confirmed by examination in the field.

NE Sector of the Delta

It is clear that the changes that began with the blocking of the Nqoga river below Hanamozeyo island in the 1930's and 1940's are continuing to rumble on and that the thrust of perennial swamp expansion is being directed towards the TsamTsam molapo and the "Four Rivers" area north of Xugana. To the west of TsamTsam almost as far as Kabamukuni Island, and to its east as far as north of Dombo, flooding in recent years has consistently reached to close to the mainland/intermittently flooded grassland boundary, i.e. approaching its limit. The additional flow apparently being received by the Mwanachira is not being passed mostly to the Khwai/Mababe as may normally have been expected but to TsamTsam and floodplains lying north of the Mwanachira. Floodplains between Dombo and North Gate appear to have shrunk although flow has remained perennial in the Khwai channel itself as far as the gate.

Santantadibe River

Concomitant with the expansion of the Mwanachira has been the reduction of swamp along the Santantadibe. The July 1984 LANDSAT images show little spill of seasonal flooding beyond the perennial swamp boundary. At first it was thought this may be merely due to the late arrival of new waters in this area so further LANDSAT images were ordered for August and September, 1984. However, again very little seasonal flooding was shown so it is clear the this river system is declining rapidly. Proof of this is readily obtained by

showing that the river flow between Daonara and the Thamalakane has been greatly reduced since 1979.

Chief's Island: North End. A large block of **new** perennial swamp is developing in the area between Mombo and Sazita and draining towards Nambopi. During the process many trees have drowned and died. A helicopter survey was necessary to confirm the airphoto interpretation of this area.

5.11 PLANTS AND VEGETATION TYPES DESERVING SPECIAL CONSIDERATION

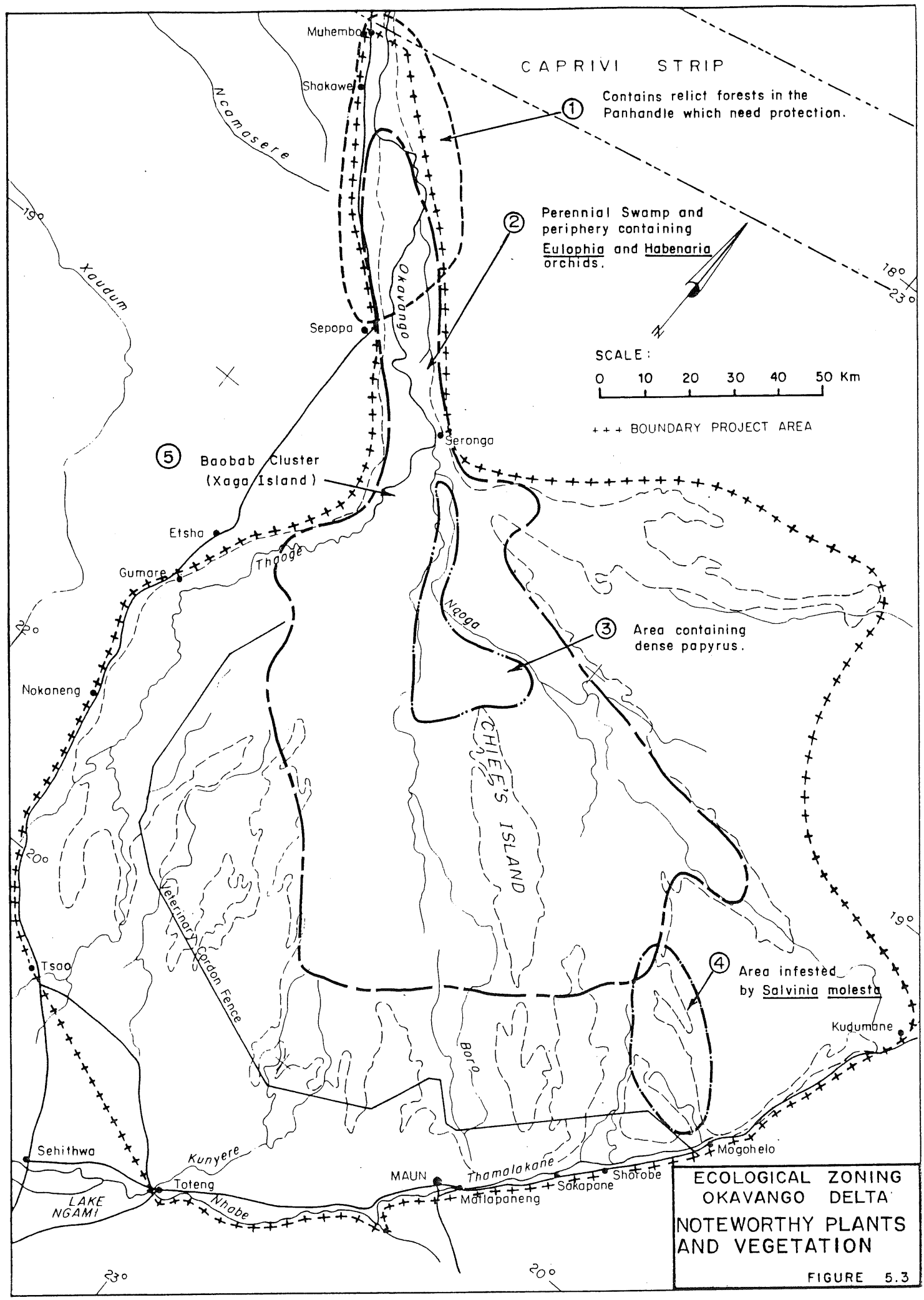
In the Delta it would be unwise to single out any one or more particular plant community or vegetation type as deserving special attention except for relict forest. Vegetation forms perhaps the most important component of scenery and plants provide a very important function in the Delta in dampening the effects of flooding and binding the substrate to prevent erosion in addition to their usual role in energy conversion and nutrient transfer and as a food source for many other organisms. While it may be argued that the expanses of papyrus in the perennial swamp appear dreary and monotonous, it should be remembered that this plant community, among many other functions, is the protector of the water reserves of last resort which enable practically all other forms of life to counter the frequent drought cycles occurring in northern Botswana. Similarly beneficial roles can be ascribed to all other plant communities and vegetation types of the Delta and it is therefore considered best to treat the vegetation of the Delta not as consisting of so many different parts but as a single unit for conservation purposes.

The areas affected by some of the following comments are shown on Figure 5.3.

There are two large, showy orchids that grow in peaty ground in perennial and seasonal swamp. They are *Eulophia latilabris* and *E. angolensis*. They are in danger of being picked out by well-meaning but thoughtless collectors. Fortunately they come into flower in late October to December outside the peak of the tourist season, nevertheless it is felt they should be legally protected. Another orchid, *Zeuxine africana*, is extremely rare in southern Africa and is known from one limited site in the Moremi Wildlife Reserve. It is a small unattractive saprophyte which is easily overlooked but it should be treated specially because of its rarity.

Yet another orchid, *Habenaria pasmithii* is so far the only plant known to be endemic in the Okavango in Botswana. Although it has a wide range (Samochima - Ncamasere - Piajio (Chief's Island) - Khianadiandavhu River), it will need protection.

The epiphytic orchid, *Ansellia gigantea* var. *nilotica*, which is found throughout the Delta (often on *Hyphaene* palms) is a species which local habitants have often removed and transplanted to decorate trees in their gardens and at lodges, etc. This practice is seriously depleting numbers of this attractive plant in the wild and should be made illegal - a problem here will be how to deal with specimens that have already been collected.



ECOLOGICAL ZONING
OKAVANGO DELTA
NOTEWORTHY PLANTS AND VEGETATION

FIGURE 5.3

Two sedges are named after the Okavango (Eleocharis cubangensis and Pycreus okavangensis). The Eleocharis has so far only been found in Namibia. The Pycreus, a nondescript little plant, is widespread in NW Botswana occurring throughout the lower Delta, on the Chobe river and even near a pan in the Kalahari.

The relict forests on the Panhandle contain a most interesting flora and it is strongly recommended that they be given special protection.

There are some very large, magnificent specimens of baobab trees scattered throughout the Delta and particularly in the northwest sector. Xaga islands contain a dense cluster of these trees (and were visited by Prince Charles in 1985). Perhaps this site can be considered for protection although it is very inaccessible; at present it can only be reached by mokoro or by helicopter. If anything can be done to prevent the vandalism of some tourists who carve their initials on trees, and baobabs are a particular prey of such unwelcome visitors, then this should be considered.

It should be pointed out that the Moremi Wildlife Reserve contains no extensive thick papyrus swamp. It is suggested that the apex of the reserve at the top end of Chief's Island be extended north-westwards to include all swamps lying between the Jao (upper Boro) and Nqoga rivers to as far as their junction near Xeshabe Island.

The Department of Water Affairs must be urged to curtail the spread of Salvinia molesta and monitor the Delta continuously to ensure that if this and other noxious weeds such as Eichhornia crassipes (Water Hyacinth) invade or spread in the Okavango, control measures can be implemented immediately.

The cultivation of alien plants such as bananas , Melia azederach, gauvas, pawpaws, bamboo, cassava, etc. should be discouraged at sites within the Delta and should certainly be prohibited in the Moremi Wildlife Reserve, though this should not prevent use of small herb gardens and vegetable patches for local consumption.

5.12 PERCEIVED GAPS AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.12.1 Vegetation

Now that this project has laid down the framework for classifying major vegetation types and mapped the two boundaries (perennial swamp and mainland dryland), it is recommended future mapping efforts be directed towards delineation of the boundaries between seasonal swamps and the two types of flooded grassland, and to determining further subdivisions within these major habitats. Extrapolation techniques should be developed to make full use of airphotos and satellite imagery. Any survey projects to supplement our scanty knowledge of contour levels around and within the Delta, particularly where hydrological change is anticipated should be strongly supported as this would be a most useful aid in vegetation mapping as well. A "bank" of Okavango satellite imagery should be kept in Maun and continuously updated by acquisition of more LANDSAT/SPOT images at regular intervals - at least quarterly. It would be useful perhaps to start further mapping in the Moremi Wildlife Reserve as this area is in need of a management plan.

A checklist and guide to the plants of the Okavango is required.

Certain plant genera important in the Okavango are in need of taxonomic revision. It may be possible to interest post-graduate students to work on them at institutions such as Kew, Missouri or New York Botanic Gardens. The families to which these genera belong are Nymphaeaceae, Menyanthaceae and Cyperaceae.

5.12.2 Vegetation - Wildlife Interactions

Measures to control Salvinia in the Okavango are being hampered by a lack of knowledge of hippo feeding habits, movement patterns etc. This animal is an important species in the Delta wetlands for other reasons as well and it is hoped a project may be devoted to its study.

Base line data should be gathered on the impact of elephants on the vegetation of the Moremi Wildlife Reserve before it reaches such alarming proportions as in the Chobe National park.

5.12.3 Limnology and Sedimentology

Little work has been done on the algae, phytoplankton, zooplankton, periphyton, benthic fauna, bacteria and fungi and other micro-organisms - all of which are important in wetland processes - especially in plant decomposition and peat production. Also much more work needs to be done on water chemistry/quality - nutrient status, chemical composition, dissolved oxygen, pH, sediment load, turbidity, etc. Sediment transport and deposition is a most important process in the Okavango and work such as that performed by Prof. McCarthy and his team from University of Witwatersrand needs to be given much support and widened to cover all river systems in the Delta.

6. FAUNA

6.1 WILDLIFE

6.1.1 Introduction and Sources of Information

This section concerns itself with those animals popularly regarded as "game" - the larger mammals (i.e larger than a fox), together with two important and prominent non-mammals, the ostrich and the crocodile. These animals are characterised mainly by their value to the hunting and tourist industries. For the sake of completeness the antbear (Orycteropus afer) is included here, since it cannot be considered as a small mammal, having a body mass often exceeding 50kg.

Different workers have stated that the Okavango Delta contains between twenty-one (UNDP/FAO, 1977) and "over thirty" (Robbel and Child, 1976) large mammal species. This study recognises thirty-two, giving a total of thirty-four species to be considered in this section. All other mammals recorded from the Delta are dealt with in section 6.2.

Apart from the general text "Mammals of Botswana" (Smithers, 1971), the field survey reports of Moremi Wildlife Reserve (Tinley, 1966; Robbel and Child, 1976) and the Chief's Island study (Biggs, 1979), there has been no large scale, systematic recording or regular monitoring of the Delta's wildlife. Aerial census and survey data are limited to sporadic, patchy attempts to provide seasonal distribution data and very crude population estimates for major species between 1975 and 1987. (UNDP, 1976; KCS, 1984/5; DWNP, 1979/82/87; SMEC, 1987). Detailed work on the ecology of individual species is even more limited and consists of studies on buffalo (Patterson, 1979), lechwe (Biggs, 1979) and baboon (University of California project, various authors supervised by Professor W.J. Hamilton, 1976-present). Data on hunting activities has been collated since 1985 by Ngami Data Services (Pty) Ltd for KCS. These data have been amplified by interviews and discussions with local personnel, whose observations have been evaluated in the light of the author's extensive field experience in the study area.

This section will therefore attempt to describe the use made of the Okavango Delta by those species mentioned below. Animal habitats and their relationship to ecological zones will be described. Relationships between species in the various habitats will be mentioned. Critical areas will be highlighted wherever possible and throughout, the effect of possible land use options will be taken into consideration.

Most animals are highly mobile and therefore may occur in more than one ecological zone, often being found in a variety of habitats. In this sense they may be regarded as users of ecological zones rather than as components of the zones. The concept of "indicator species" as in botanical studies, for example, also falls away. For instance, one would hardly look for the presence of sitatunga to indicate that a particular habitat qualified as perennial swamp; whereas having defined the

area as perennial swamp, one might justifiably expect to find sitatunga there.

6.1.2 Classification of Large Animals

Class **MAMMALIA:** this is represented by six Orders:

1.	PRIMATES	containing one family
2.	CARNIVORA	containing three families
3.	TUBULIDENTATA	containing one family
4.	PROBOSCIDEA	containing one family
5.	PERISSODACTYLA	containing two families
6.	ARTIODACTYLA	containing four families

Class **AVES:** Order STRUTHIONIFORMES
Family Struthionidae
Struthio camelus — Ostrich

Class **REPTILIA:** Order CROCODILIA
Family Crocodilidae
Crocodylus niloticus — Nile Crocodile

6.1.3 Species of Large Mammals

Primates:	CERCOPITHECIDAE	Papio ursinus	Chacma Baboon
Carnivora:	HYAENIDAE	Hyaena brunnea	Brown Hyaena
		Crocuta crocuta	Spotted Hyaena
	FELIDAE	Acinonyx jubatus	Cheetah
		Panthera pardus	Leopard
		Panthera leo	Lion
	CANIDAE	Lycaon pictus	Wild Dog
Tubulidentata:	ORYCTEROPODIDAE	Orycteropus afer	Antbear
Proboscidea:	ELEPHANTIDAE	Loxodonta africana	Elephant
Perissodactyla:	RHINOCEROTIDAE	Ceratotherium simum	White Rhino
	EQUIDAE	Equus burchelli	Zebra
Artiodactyla:	SUIDAE	Phacochoerus aethiopicus	Warthog
	HIPPOPOTAMIDAE	Hippopotamus amphibius	Hippopotamus
	GIRAFFIDAE	Giraffa camelopardis	Giraffe

BOVIDAE	Sylvicapra grimmia	Duiker
	Ourebia ourebi	Oribi
	Raphicerus campestris	Steenbok
	Tragelaphus strepsiceros	Kudu
	Tragelaphus spekei	Sitatunga
	Tragelaphus scriptus	Bushbuck
	Aepyceros melampus	Impala
	Redunca arundinum	Reedbuck
	Kobus ellipsiprymnus	Waterbuck
	Kobus leche	Lechwe
	Oryx gazella	Gemsbok
	Hippotragus niger	Sable
	Hippotragus equinus	Roan
	Taurotragus oryx	Eland
	Syncerus caffer	Buffalo
	Connochaetes taurinus	Wildebeest
	Alcephalus busephalus	Hartebeest
	Damaliscus lunatus	Tsessebe

6.1.4 Wildlife Population Counts

For various reasons mentioned in the literature, wildlife population estimates derived from aerial census techniques are usually inaccurate. Some of the reports referred to above stress that in the case of systematic distribution surveys such as have been carried out in the Okavango Delta they are of little use other than to make crude comparisons between similar surveys. Nevertheless, since strict censuses of the Delta's wildlife have never been carried out, some of the survey flight estimates are presented here, with appropriate comments.

TABLE 6.1 WILDLIFE POPULATION ESTIMATES FOR THE OKAVANGO DELTA

	1975/76(UNDP)		1984/85(KCS)	1987(DWNP)	
Species	wet	dry		wet	dry
Buffalo	18 700	34 900	26 600	12 500	41 700
Elephant	200	4 100	4 700	1 500	7 900
Giraffe	2 200	2 200	2 400	2 200	3 200
Hartebeest	-	-	-	120	2
Hippo	2 700	2 700	820	1 600	500
Impala	24 200	24 200	11 000	24 000	24 300
Kudu	1 100	1 100	680	1 800	1 300
Lechwe	36 600	36 600	16 000	25 400	35 000
Ostrich	700	1 800	1 000	1 500	3 000
Reedbuck	2 400	2 400	540	1 500	2 100
Roan	-	-	120	60	480
Sable	100	2 400	2 800	200	1 000
Sitatunga	-	-	770	1 300	1 100
Tsessebe	9 200	9 200	4 600	6 300	12 000
Warthog	5 600	5 600	2 000	3 600	6 400
Waterbuck	-	-	200	-	260
Wildebeest	9 100	14 400	6 500	7 700	12 600
Zebra	10 900	14 100	9 100	6 200	17 100

Notes:

1. KCS surveys were carried out in a wet October and a dry April, so average estimates are shown.

2. No statistical qualification of the estimates is included. These are discussed briefly by species below (Section 6.1.9).

6.1.5 Movement and migration

Movements may vary in scale, periodicity, direction and speed. At one extreme are large scale annual migrations, while in contrast to these, several species exhibit only local, regular, diurnal movements between habitats e.g. from woodland cover during the day to open floodplain at night. Many species are territorial, sometimes only during part of the year e.g. the rut, while others may wander throughout the Delta and even far beyond.

The reasons for movements are equally varied; they may depend on local changes in conditions e.g. water levels and availability of food, or they may be in response to remote events such as rainstorms. They may be triggered by day length or temperature, or be the result of disturbance by man. The latter may be short term in nature e.g. chasing or other harassment, or it may be permanent e.g. the construction of fences or the manipulation of water supplies.

The Okavango Delta is foremost a source of water in the driest part of the year in an otherwise very dry region. This is without doubt the main reason for any large scale movements linking the Delta with surrounding areas. Natural movements have been more or less curtailed in various sectors of the Delta's periphery. Along the western edge the increase in human population along the Tsao to Shakawe road, together with its attendant livestock and agricultural activities, reduced wildlife movements outwards during the rainy season. Populations virtually cut off from the Delta have dwindled markedly over the past 20 years and CHA's 15 and 16 now support only relics of former wildlife herds.

Knowledge of this development was taken into consideration before construction of the veterinary cordon fence was agreed to. This fence obviously created a more definite barrier and curtailed movements of certain species in the sandveld tongue area, particularly zebra, wildebeest and buffalo. Challenge by wildlife to the fence (completed in 1983) has in fact been surprisingly little, despite the fact that this decade has been exceptionally dry. Survey results suggest that populations within the fence have not been reduced significantly.

The northern extension of the fence has been the subject of much debate regarding alignment and it now appears as if the originally selected line will be followed. Although some movement of wildlife will obviously be affected by the new fence, there is no evidence to suggest that this will be significant. The benefits of limiting cattle intrusion into the Magwegqana should more than offset these effects, although local management of

hunting in the area will require negotiation and adjustment to avoid conflicts.

6.1.6 Biomass

Estimates of large wild animal biomass have been attempted for the Okavango, the results best indicate just how crude and imprecise the aerial survey data sometimes are. It has been shown that in many parts of Africa there is a strong correlation between average rainfall and large animal biomass (Coe et al., 1976). For the Okavango Delta, the predicted biomass is 2 830kg/ km^2.

Comparisons of wet season and dry season estimates for the Okavango Delta (i.e. when many species are dispersed and when concentrated respectively) for UNDP (1976) and DWNP(1987) surveys are given below:

	kg/km^2	
Survey	Wet season	Dry Season
1976	2690	3348
1987	1050	2658

When one considers that a considerable proportion of the Delta is inundated, especially during the "dry" season, the 1976 figures must be considered wildly optimistic and questionable. This is further accentuated by the fact that the lower 1987 figures include many more elephants which markedly increase the biomass figures.

A more careful interpretation of the available data suggests that during the wet season when many species have dispersed (e.g. buffalo numbers are reduced by approximately half), the standing biomass of large wild animals in the Delta approaches the theoretical prediction. During the winter months the influx of large numbers of animals from the dry surrounding areas raises the biomass above the predicted level, probably far exceeding sustainable levels. This situation is ideally suited to the exploitation of the immense wildlife resource in a number of ways. Apart from the high revenue tourism and safari industries supported by the Delta, a 10% harvest of the major components of the wildlife population, properly managed, could yield approximately 2 000 tonnes of lean meat per annum (approaching an average month's production from BMC).

Table 6.2 indicates the most important fractions of the total wildlife biomass at different times of the year.

TABLE 6.2 PROPORTIONS OF BIOMASS REPRESENTED BY DIFFERENT SPECIES DURING THE WET AND DRY SEASON (% of total biomass).

Species	Wet season	Dry season
Buffalo	30	40
Elephant	14	29
Giraffe	10	5
Zebra	7	7.5
Lechwe	10	5
Wildebeest	5	3
Impala	5	2
Tsessebe	3	2.5

This clearly indicates the difference between species which move into the Delta in large numbers on a seasonal basis (buffalo and elephant) and those which are normally resident all year round. As buffalo move in, the proportion of the total biomass represented by resident species, e.g. lechwe, is reduced.

6.1.7 Ecological Classification

Table 6.3 attempts to separate the species we are concerned with according to their dependence on available surface water. As with all living things, large animals display varying degrees of adaptation to their environment. They are also capable of adapting to changing circumstances e.g. completely water independent animals like gemsbok will drink if given the opportunity and predominant grazers like buffalo will occasionally turn to browse if forced by circumstances. In this regard the categories are not to be regarded as hard and fast.

TABLE 6.3 WATER UTILISATION BY ANIMALS OF THE OKAVANGO DELTA.

Aquatic/semi-aquatic	Water Dependent	Water Independent
Crocodile (C)	Buffalo (G)	Antbear (I)
Hippo (G)	Baboon (O)	Cheetah (C)
Lechwe (G)	Bushbuck (B+G)	Duiker (B)
Sitatunga (G)	Elephant (B+G)	Eland (B+G)
	Impala (B+G)	Gemsbok (G)
	Oribi (G)	Giraffe (B)
	Reedbuck (G)	Hartebeest (G)
	White Rhino (G)	Brown Hyaena (C)
	Roan (G)	Spotted Hyaena (C)
	Sable (G)	Kudu (B)
	Tsessebe (G)	Leopard (C)
	Warthog (G)	Lion (C)
	Waterbuck (G)	Ostrich (G)
	Zebra (G)	Steenbok(G+B)
	Wildebeest (G)	Wild Dog (C)

NOTE:
G = Grazer
B = Browser
C = Carnivore
I = Insectivore
O = Omnivore

6.1.8. Animal Habitats

The Okavango Delta is a complex mosaic of habitat types which defies mapping at any convenient scale; for instance, riverine woodland (an extremely important animal habitat) is often reduced to the width of a pencil line at 1:100 000. The smallest unit of land ever sampled during systematic aerial wildlife surveys is 6.25km^2 (SMEC, 1987d, Vol.II), even then many units contained up to seven habitat types. Most surveys have used units of 25 or even 100km^2.

Only two surveys have attempted to record the habitat type occupied by each animal sighting (UNDP, 1976 & SMEC, 1987). Unfortunately, analysis of the data was not carried out in the former and has since been lost. In the case of the SMEC survey a limited area of the Delta was covered. In most other surveys the lack of trained observers ruled out the collection of such data.

Although large animals are highly mobile, especially at a local scale, and may occupy several different habitats during a season or even a day, they nevertheless display preferences for certain habitat types. The following section describes the commonly occurring major habitat types in the Okavango Delta. To avoid confusion, the habitat types are described as sub-divisions of the mapping categories suggested by the vegetation specialist where possible.

1. Perennially Inundated Areas

   Madiba (lakes)
   River channels
   Perennial swamp

2. Seasonally Inundated Areas

   Semi-perennial swamp
   Seasonal long grass/sedge floodplains (wet and dry)
   Seasonal short grass floodplains (wet and dry)

3. Intermittently Flooded Areas

   Grassland

4. Dryland Associations

   Riverine Woodland
   Island grassland
   Scrub communities
   Mixed deciduous woodland
   Mophane woodland
   Terminalia woodland
   Pan (wet and dry)

Detailed descriptions of the vegetation associations contained in these various categories can be found in Heemstra (1976), SMEC (1987d, Vol.II) and the vegetation section of this report (section 5). Very brief descriptive notes are provided here for convenience.

1. Madiba

Perennial open water lakes; may exceed 100ha in area and be up to 4.5m in depth; found mainly in the Panhandle and perennial swamp; usually fringed with papyrus or Phragmites: e.g. Gadikwe, Gcobeha and Cakanaca in Moremi Wildlife Reserve.

2. River channel:

Perennially flowing channels; up to 150m wide in upper Panhandle and Delta; open water fringed by similar vegetation as madiba. e.g. Okavango, Nqoga and Mwanachira rivers.

3. Perennial swamp:

Perennially inundated; characterised by either papyrus, Phragmites or Miscanthus dominated vegetation. e.g. Panhandle and along major distributaries.

4. Seasonal long grass/sedge floodplain:

Invariably floods; average water depth at height of flood is approximately 25cm.; sedges dominate; mean vegetation height is 75cm.

5. Seasonal short grass floodplain:

Invariably floods; near margins of floodplains; average water depth at height of flood is <5cm.; Panicum repens, Eragrostis inamoena and Setaria sphacelata are common grasses.

6. Occasionally inundated grassland:

Dry throughout most years, but floods often enough to prevent woody encroachment; Sporobolus spicatus (island fringe) or Cynodon dactylon (drier areas e.g. centres of small islands) are important grasses.

7. Riverine woodland:

Thin strip of tall trees around islands and land masses; dense canopy and shrub layer; important trees include Acacia nigrescens, Diospyros mespiliformis, Lonchocarpus capassa, Garcinia livingstonei and Croton megalobotrys.

8. Island grassland:

Dry grasslands on larger islands; often dominated by Cynodon dactylon, the presence of the forb Pluchea leubnitziae, indicating an absence of flooding.

9 Scrub communities

Common in large areas of the dry land masses and on larger islands; most commonly Colophospermum mopane or Terminalia

spp, though often mixed with Acacia spp.; rarely exceeds 120cm. in height.

10. Mixed woodland/savanna

Usually Acacia dominated savanna woodland on sandy soils; common shrubs include Dichrostachys cinerea, Rhus and Grewia spp. Good grass cover.

11. Mophane woodland/savanna

Often a pure stand of Colophospermum mopane; may be closed canopy or savanna, mainly annual grasses e.g. Aristida spp. Covers extensive areas; wet season forage area.

12. Terminalia woodland/savanna

Sandy soils; low woodland dominated by Terminalia sericea; good herb and grass layer for wet season grazing.

13. Pans:

Occur on land masses and larger islands; short grassland with semi aquatic vegetation fringing seasonal rainwater; up to 100m in diameter; especially common in mophane woodland (habitat 11).

The use of the above habitats by the wildlife species of the Delta is summarised in Table 6.4.

SMEC (1987d, Vol.II) stated that, in a study area comprising most of the Delta which lies west of the Boro River, almost 90% of animals, accounting for 80% of the total biomass, is made up of six major grazing species: buffalo, lechwe, tsessebe, wildebeest, zebra and impala. The less intensive DWNP surveys (1987), covering the whole Delta, indicate that these species account for slightly over 60% of the total large wild animal biomass. A major reason for this apparent discrepancy is that nearly all the elephants occur east of the Boro River. In fact the figures produced by the SMEC surveys are generally much more accurate than any others for the Delta and if extrapolated indicate that populations of many important species have been underestimated by most surveys.

Considering the relative preponderance of these major grazers, it is not surprising that the floodplain grazing habitats are most heavily utilised, and SMEC (1987d, Vol.II) concludes that the availability of winter floodplain grazing, especially the sedge communities, is the major limiting factor to the Delta's wildlife populations.

TABLE 6.4 THE USE BY OKAVANGO WILDLIFE SPECIES OF DIFFERENT HABITAT TYPES

Species	1 Madiba	2 River Channel	3 Perennial Swamp	4 Seasonal F.P. Long	5 Seasonal F.P Short	6 Occasionally Inundated grassl.	7 Riverine Woodland	8 Island Grassland	9 Scrub	10 Mixed Woodland/savanna	11 Mophane Woodland/savanna	12 Terminalia Woodland/savanna	13 Pans
Ostrich					X	X		X	X	X		X	X
Crocodile	X	X	X	X	X								
Baboon				X	X	X	X	X	X	X	X	X	X
Brown Hyaena									X	X	X	X	X
Spotted Hyaena				X	X	X	X	X	X	X	X	X	X
Cheetah				X	X	X		X	X	X	X	X	X
Leopard				X	X	X	X	X	X	X	X	X	X
Lion				X	X	X	X	X	X	X	X	X	X
Wild Dog				X	X	X		X	X	X	X	X	X
Antbear					X	X	X	X	X	X	X	X	
Elephant		X	X	X	X	X	X	X	X	X	X	X	X
White Rhino				X	X	X		X	X	X	X	X	X
Zebra				X	X	X		X	X	X	X	X	X
Warthog				X	X	X		X	X	X	X	X	X
Hippo	X	X	X	X	X	X		X					X
Giraffe							X		X	X	X	X	X
Duiker								X	X	X	X	X	
Oribi				X	X	X							
Steenbok						X		X	X	X	X	X	
Kudu				X	X	X	X	X	X	X	X	X	X
Sitatunga		X	X			X	X						
Bushbuck						X	X	X	X				
Impala				X	X	X	X	X	X	X	X	X	X
Reedbuck				X	X	X							
Waterbuck				X	X	X	X	X					
Lechwe			X	X	X	X							X
Gemsbok									X	X		X	X
Sable					X	X		X	X	X	X	X	X
Roan					X	X		X	X	X	X	X	X
Eland									X	X	X	X	X
Buffalo	X	X	X	X	X	X	X	X	X	X	X	X	X
Wildebeest				X	X	X		X	X	X	X	X	X
Hartebeest										X		X	
Tsessebe				X	X	X	X	X	X	X	X	X	X

Table 6.5 (adapted from SMEC 1987d, Vol.II) indicates the use made of some of the major habitat types on a year round basis by important species. Unfortunately there is a gap in the data during the rainy season (January - March).

Overall, the importance of the seasonal floodplains is obvious; almost two thirds of all animals sighted were in this habitat, with just over half on sedgeland; allowance must be made for the different visibility for different habitats in interpreting these data.

TABLE 6.5 ANIMAL DENSITIES (per km^2) BY MAIN HABITAT TYPES

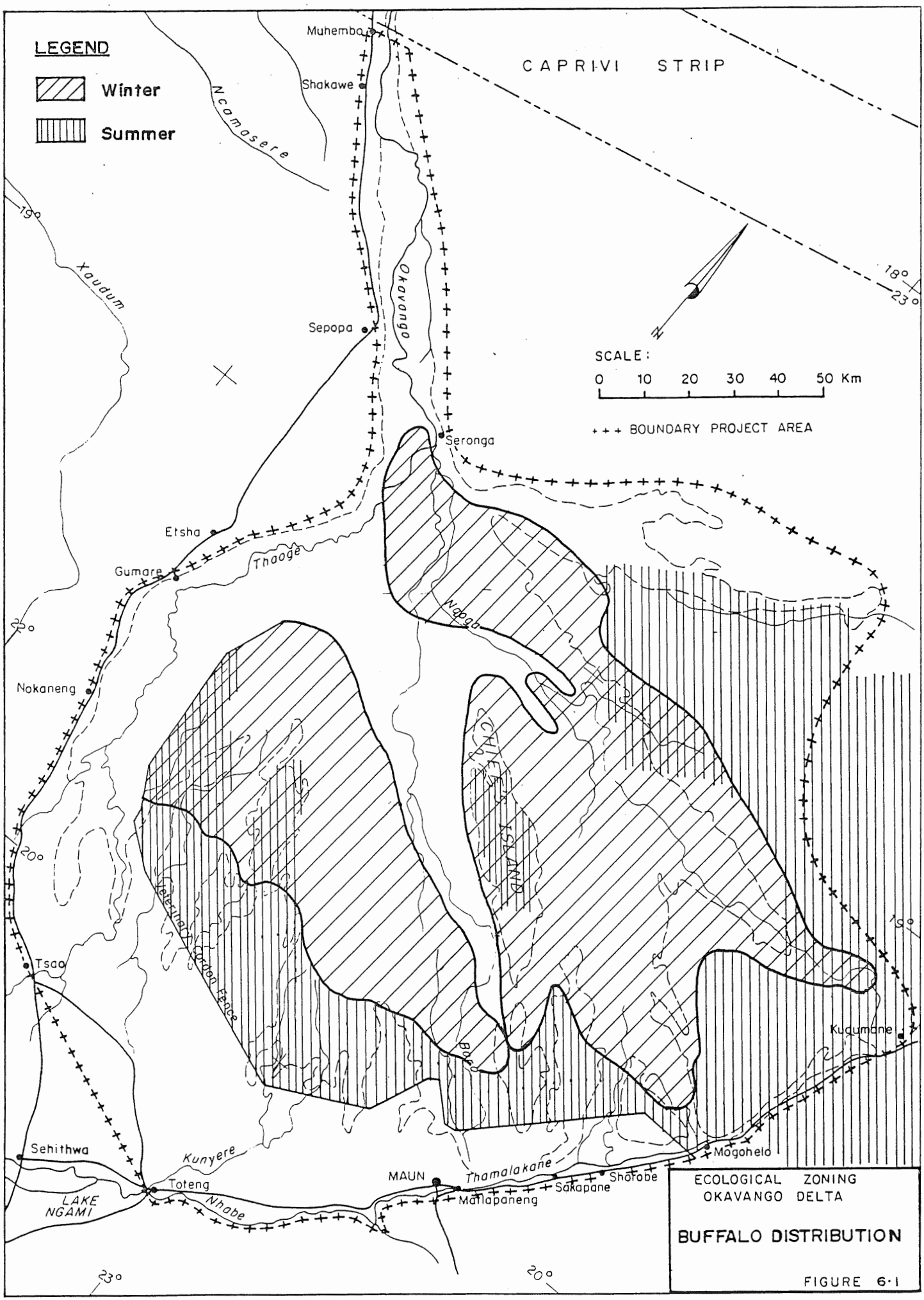
	PERENNIAL SWAMP	FLOODPLAIN Sedgeland	FLOODPLAIN Grassland	ISLAND Grassland	SAVANNA Woodland
SPECIES					
Overall	**.09**	**12.60**	**3.46**	**2.83**	**5.58**
Buffalo	0	2.02	.42	.04	1.07
Giraffe	0	.03	.03	.03	.40
Impala	0	.18	.33	.41	.93
Kudu	0	.03	.03	.03	.18
Lechwe	0.05	6.04	.44	.82	.19
Sitatunga	.01	.08	0	0	0
Tsessebe	0	.65	.56	.59	.37
Warthog	0	.46	.13	.12	.05
Wildebeest	0	1.24	.71	.41	.73
Zebra	0	.46	.64	.35	1.27

6.1.9 Species Descriptions

This section contains brief notes on each species, its status and distribution in the Okavango system, ecological requirements and its utilisation by man.

6.1.9.1 Buffalo

Occurs in large numbers and is highly mobile; movements between the Okavango and Hwange National Park, Zimbabwe have been recorded (Patterson, 1979). Common throughout most of the Delta (Fig. 6.1) and still found in the lower Panhandle, especially at low water. Large aggregations of up to 2 000 individuals may occur towards the end of the dry season (October), particularly along the northern fringes of the Delta (Mwanachira/Khwai) and less so on Chief's Island. Normal herd sizes average between 60 and 200.


LEGEND
Winter
Summer
CAPRIVI STRIP
Muhemba
Shakawe
Ncamasere
Xaudum
Okavango
Sepopa
Seronga
SCALE:
0 10 20 30 40 50 Km
BOUNDARY PROJECT AREA
Etsha
Gumare
Thaoge
Nqoqb
Nokaneng
CHIEF'S ISLAND
Veterinary Cordon Fence
Tsao
Boro
Kuqumane
Sehithwa
Kunyere
Mogoheld
MAUN
Thamalakane
Shorobe
Toteng
Sakapane
LAKE NGAMI
Nhabe
Matlapaneng
ECOLOGICAL ZONING
OKAVANGO DELTA
BUFFALO DISTRIBUTION
FIGURE 6·1

Its clumped distribution makes it a difficult subject for aerial census methods, but estimates for the Okavango are in the region of 25-30 000 and possibly considerably more in very dry periods. It is the single most important contributor to large animal biomass.

Almost exclusively a grazer, it prefers and thrives on the annual grasses of the sand veld savannas (including scrub) during the rainy season, retreating to the floodplain grazing during the winter, when significant loss in body condition occurs. Most grazing occurs at night and early morning, especially on floodplains. It spends the heat of the day lying up in dense woodland. Water dependent and must drink daily.

The vast majority of calves are born January to March.

Bachelor bull groups, usually fewer than eight individuals and often comprised of older bulls, live a more sedentary existence, lying up near or in water during the day and grazing at night.

At present it is undoubtedly the most important animal from a utilisation standpoint. It is a major attraction for the hunting safari industry. In Zimbabwe the economic viability of most game ranching operations depends heavily on the availability of this trophy animal. Photographic tourist operators also rate it as a major attraction. In and around the Okavango it is also the most popular quarry for citizen hunters due to the large quantity of high quality meat obtained from the carcass. In this case the female is preferred above the male which is sought by trophy-hunting safari clients.

6.1.9.2 Elephant

A protected species since 1983; before that its range was largely restricted to Moremi W.R. (especially the mophane tongue), where outside hunting pressure had greatly increased normal dry season concentrations to the detriment of some woodland habitat elements (c.f. Chobe and Linyanti). During the last five years it has re-extended its range throughout the Delta, occasionally sightings having occurred outside the buffalo fence. Large dry season concentrations still occur in the eastern corner of the study area (6 000 in June 1987), and given the high rate of population increase calculated for Botswana's elephants (6-7% per annum, (Calef, 1987) they still pose management problems.

Elephants are grazers and browsers, and also eat many fruits, e.g. Acacia pods (especially A. erioloba) and the "vegetable ivory" of the palm Hyphaene petersiana. For such plants they play an important role in distribution and germination of seeds. They also play an important ecological role in forming game trails, excavating water holes and salt licks and modifying vegetation, often to the benefit of other species either directly or indirectly, e.g. via fires.

It goes without saying that they are of paramount importance to the tourist industry and potentially of immense commercial value for ivory, skins and meat.

6.1.9.3 Lechwe

This species is highly visible in good light and the high population estimates for the Delta are probably not too far out. Almost exclusively confined to floodplains containing some water, it prefers feeding at between 15 and 60 cm water depth (Biggs, 1979), although it can utilise permanently inundated areas up to 1m deep. Very widespread throughout the perennial and seasonal floodplain system, including the lower Panhandle. Its characteristic seasonal movements are closely linked to the annual flooding pattern (Fig. 6.2).

It is exclusively a grazer and competes with many other species for the floodplain margins at high flood levels. Its general condition and apparently poor calving rate gave rise to some concern about the species' 'fitness' in the late sixties and this was heightened by the simultaneous decline of the large population on the Chobe floodplains (Robbel and Child, 1976). Recent censuses in the Delta however, indicate that the species has not declined. The Okavango population is undoubtedly of major international importance and Moremi W.R. is the only protected area in southern Africa containing significant numbers.

6.1.9.4 Giraffe

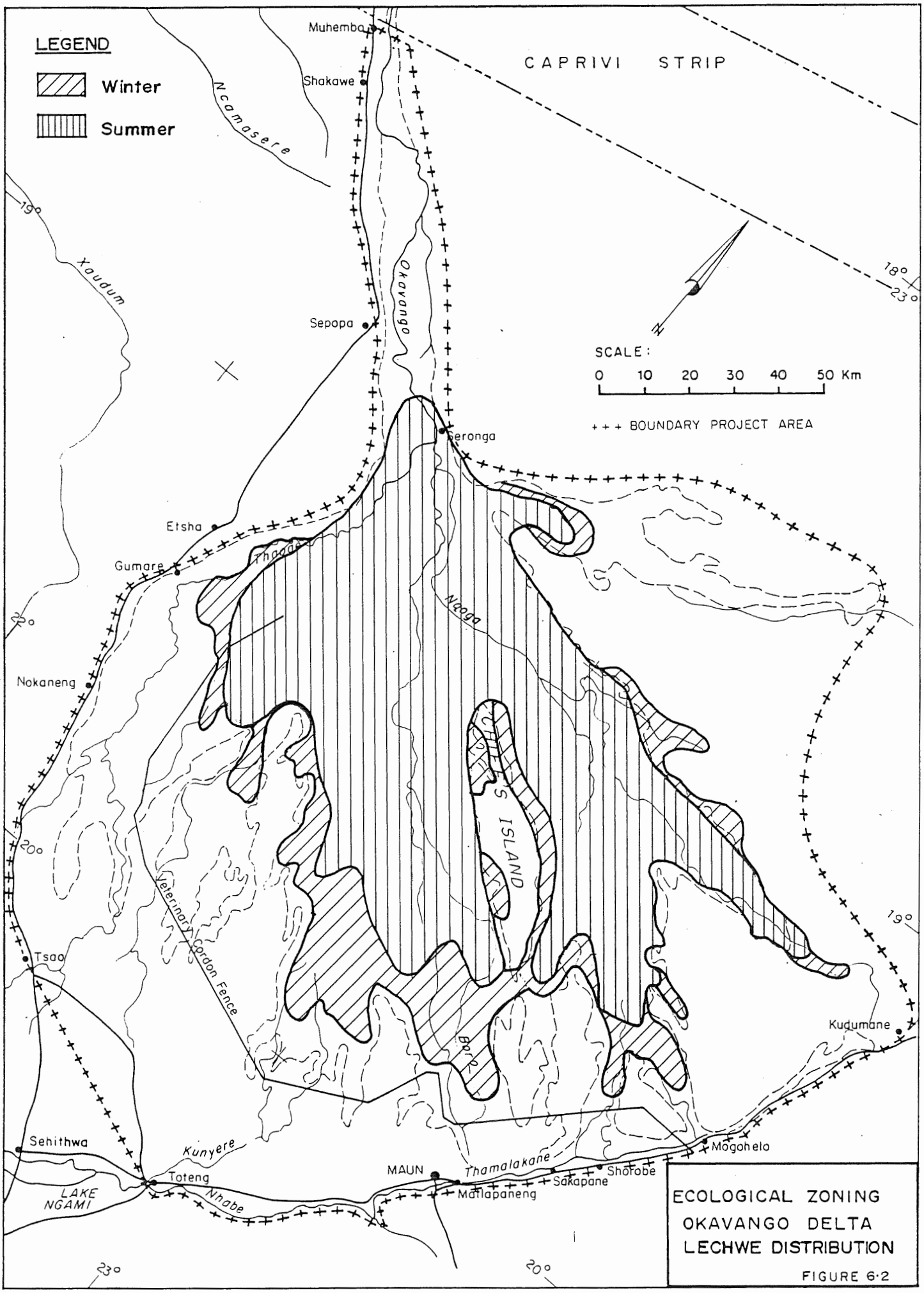
This species forms another major component of the large mammal biomass. It is widespread and common, enjoying protected status. It is almost exclusively a browser, seeming to prefer Acacia woodland and scrub, but also frequenting drainage lines and utilising riverine woodland, especially in the dry season when many deciduous trees are bare. It will also eat dry mophane leaves at this time. Biggs (1979) rates its habitat preferences as 45% Acacia woodland or savanna, 20% riverine woodland and 15% other woodland types. It is also frequently recorded in transit on dry and wet floodplains and will happily cross water up to 75 cm deep.

6.1.9.5 Hippopotamus

Its habitat requirements during daylight are confined to madiba, deeper channels and occasionally pans, which render it unsuitable to multi-species systematic surveys. Although it is fairly widespread in suitable habitat associations throughout the perennial and seasonal swamp, it is more numerous in some localities, e.g. Mogogelo and Khwai river systems. The suspected decline in its numbers during the 1960's appears to have halted, though a suitably designed census is required to establish its status at present. It is a protected species, but where it comes into conflict with man either through aggression or crop raiding, it is frequently destroyed.

The hippo is an important grazing species and will travel long distances from water during the night for feeding. It also feeds during the day on waterlily tubers in deep water.

Important ecological functions include enrichment of water bodies by defaecation to the benefit of local fish populations and channel clearing enhancing water flows. A prominent feature of



ECOLOGICAL ZONING
OKAVANGO DELTA
LECHWE DISTRIBUTION

FIGURE 6·2

seasonally inundated floodplains are hippo paths radiating from central depressions, often ensuring that off-channel depressions receive floodwater. It has been suggested that a special relationship between hippo and lechwe occurs in which the closely grazed floodplains cropped by hippo are preferred habitat for lechwe (Robbel and Child, 1976).

6.1.9.6 Impala

Very common and widespread, aerial census figures are certainly underestimates; it prefers light open woodland and scrub, and is very prominent along ecotones between woodland and floodplain. Many observers have suggested that there is an overpopulation, especially in Moremi W.R. where they compete successfully for grazing at the floodplain edges with other, perhaps more valuable, species such as tsessebe. They move away from the ecotones into the dryland communities in large numbers during the rains. They appear to be less common where floodplain inundation is deeper and penetrates closer to the riverine woodland, Biggs (1979) reporting that densities on the Boro edges of Chief's Island are twice those on the opposite, wetter Mburoka system.

It is a browser and a grazer, very adaptable according to local conditions and the time of the year. It is often seen in the company of baboons, which while preying on young impala, are thought to benefit their companions by acting as lookouts.

They are strictly seasonal breeders, calving in November after a conspicuous rut in May.

There is a pressing need to investigate the impala population and its competitive role in the ecology of floodplain grazing species, especially in the Moremi W.R.

6.1.9.7 Warthog

Very common and widespread except in inundated areas. Aerial survey results are almost certainly vastly under-estimating the actual population. They are associated with floodplains and are mainly grazers, although they spend much time rooting for grass rhizomes and sedges on damp floodplains. These excavations, which may be quite extensive, are about 15 cm deep and form quite important microhabitats for birds, etc., when inundated. They graze predominantly during the rainy season, often in the dryland woodland associations, but depend heavily on rooting behaviour during the drier winter months.

The warthog population appeared to be vigorous and expanding in the late sixties according to Robbel and Child (1976) but they were concerned that the effects of this population on its habitat and those of other herbivores should be carefully monitored. These authors also suggested that the species might be in close equilibrium with its environment and be expected to demonstrate quite marked population fluctuations according to changing conditions such as drought cycles.

6.1.9.8 Zebra

Zebra probably number about 10 000 residents in the Delta with an influx in the east, from the Mababe during the dry season. The vast majority of the Delta's resident population is to be found associated with the Matsebi Sandveld Tongue, where a marked seasonal movement occurs (Fig. 6.3). During the dry winter the animals are closely associated with the floodplains of the major melapo around the apex of the Sandveld Tongue, but they move south to the buffalo fence at the base of the Tongue during the rains. Before the fence was constructed these animals centred their wet season range on the Setateng area which is richly supplied with pans, but is now otuside the buffalo fence and therefore inacessible. The resulting intense grazing pressure against this section of the fence is clearly evident, even on remote sensing imagery. The large concentration shown west of the main road between Tsao and Nokaneng on the DWNP January 1987 survey is hard to explain unless it has been displaced from the Sandveld Tongue during data collation.

Zebra are bulk grazers preferring dry floodplains and savanna habitats. They avoid open water except for drinking purposes but are attracted to recent burns with vigorous green growth.

6.1.9.9 Wildebeest

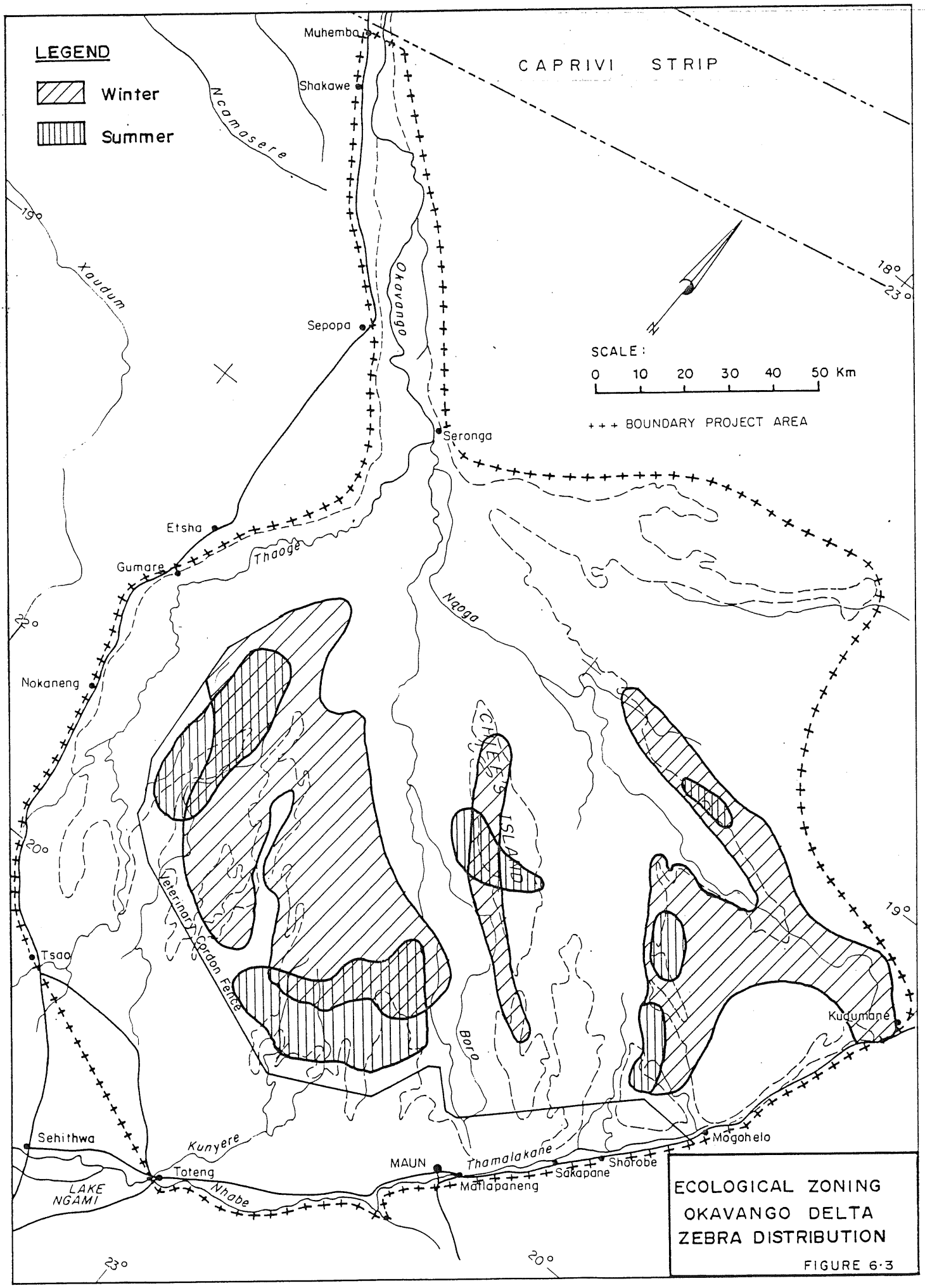
Occurring in similar numbers to zebra, the Okavango wildebeest appear not to have suffered the catastrophic decline of the Kalahari populations in recent years. They are widely distributed and common throughout the Delta, except in perennial swamp and other areas when inundated (Fig. 6.4). They are perhaps most numerous in the western Delta on a permanent basis, but dry season influxes into the eastern Moremi W.R. can occur on a significant scale, probably from the Mababe Depression.

They are specialist grazers and their preferred habitat is dry floodplains with short grass and open savanna. Like most of the Delta's larger grazing species they make more use of the woodland grasses during the rainy season. They are attracted to fresh growth on recent burns and movements are often in response to rainfall distribution.

Breeding is highly synchronised and calves are born usually in November in the Delta.

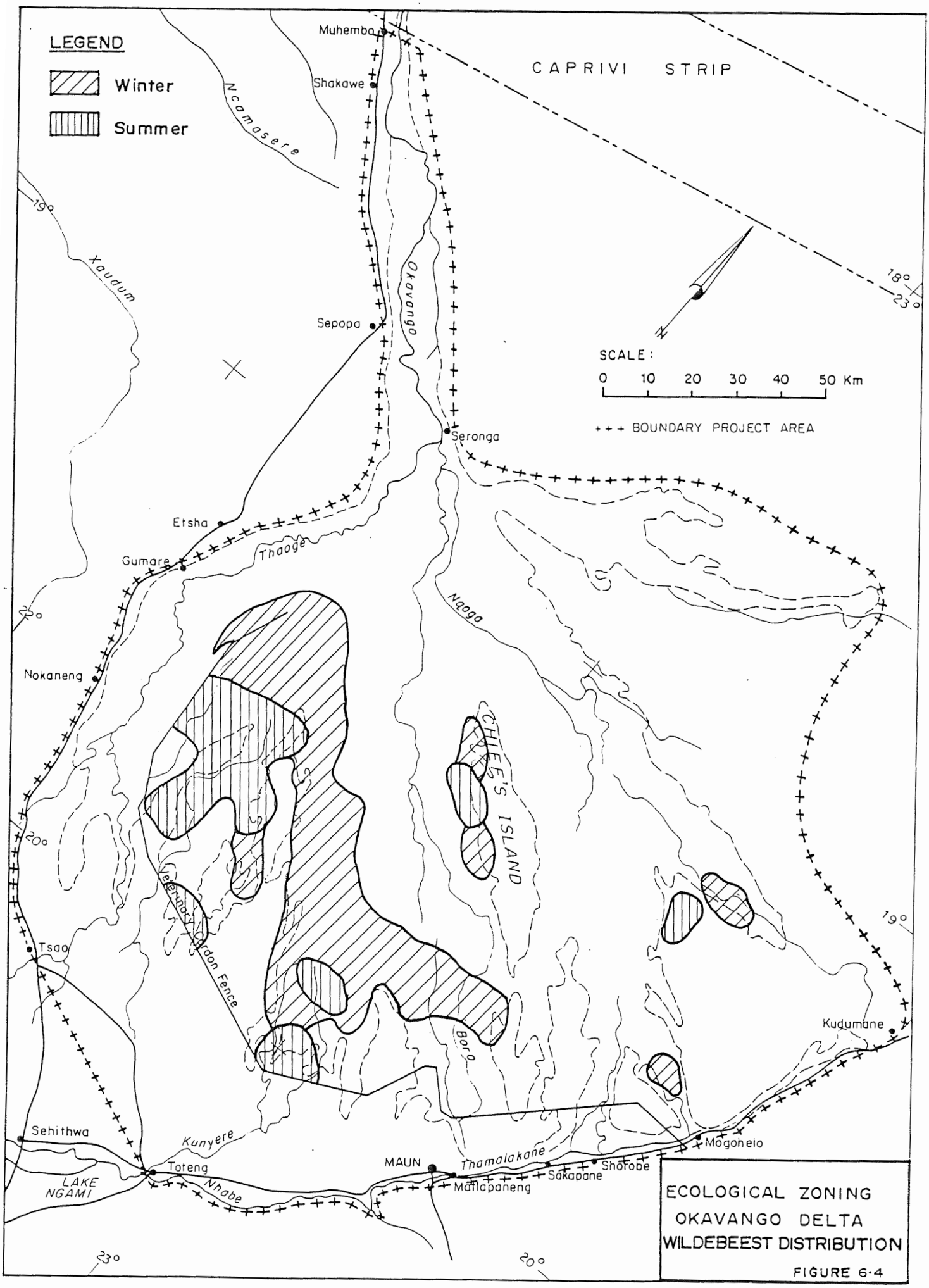
6.1.9.10 Tsessebe

This sensitive grazing species is very widespread in small groups throughout the seasonal swamp zone and larger islands, and is common in the dryland savannas and scrub particularly during the rains (Fig. 6.5). They prefer dry floodplains, particularly the edges near the ecotone with woodland, where they compete (reportedly unsuccessfully) with impala (6.1.9.6) and other species such as warthog. In savanna habitats bush encroachment is also particularly detrimental to this species. Their range in southern Africa has declined markedly in historical times, due partly to biological reasons as mentioned above, but also because their curiousity makes them susceptible to hunting, especially with firearms.



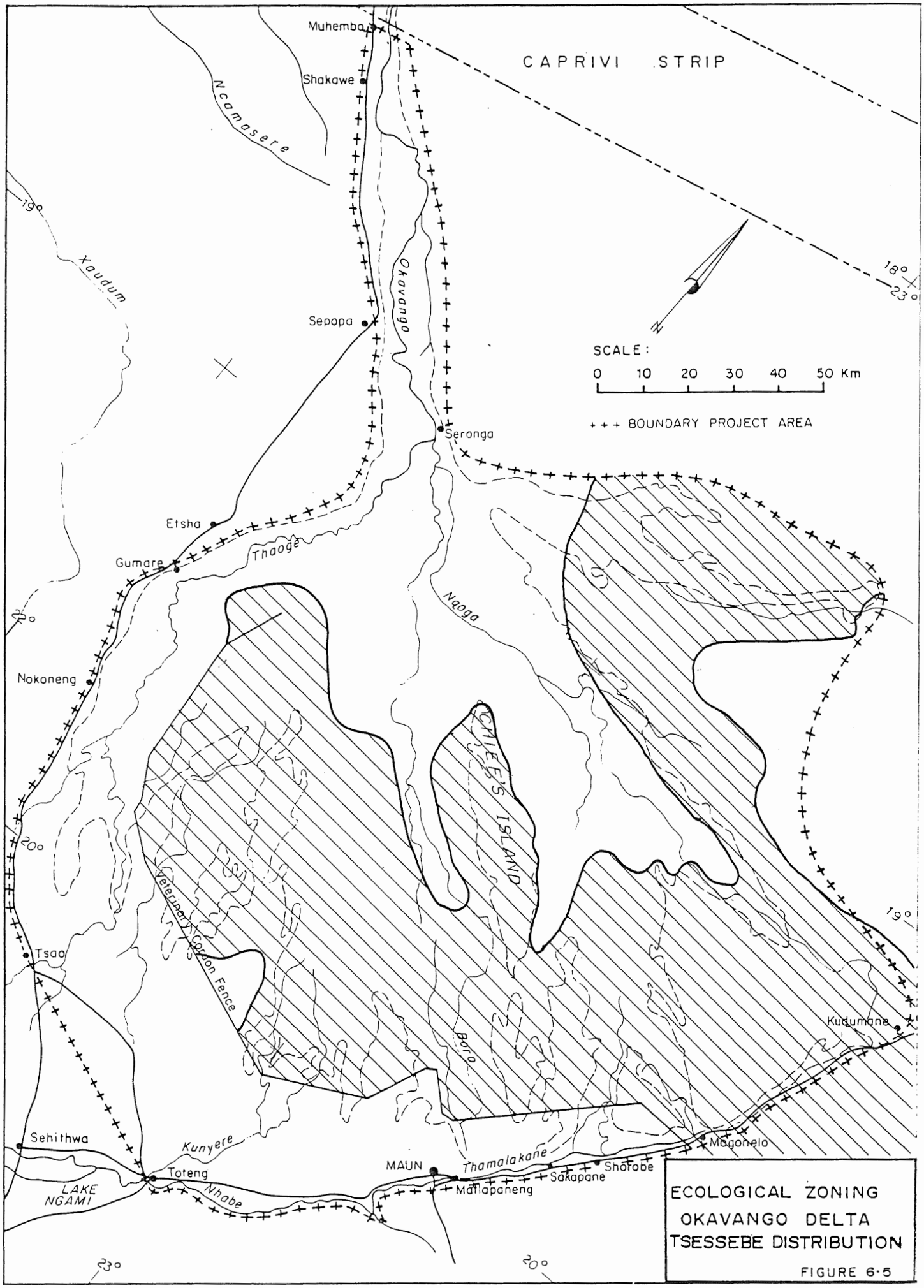
ECOLOGICAL ZONING
OKAVANGO DELTA
ZEBRA DISTRIBUTION

FIGURE 6·3



ECOLOGICAL ZONING
OKAVANGO DELTA
WILDEBEEST DISTRIBUTION

FIGURE 6·4



ECOLOGICAL ZONING
OKAVANGO DELTA
TSESSEBE DISTRIBUTION

FIGURE 6·5

They are particularly attracted to recently burned floodplains and commonly use termitaria as resting/lookout places.

The Okavango population is of considerable international significance and careful monitoring leading to appropriate management is required.

6.1.9.11 Kudu

Although common and widespread in and around the Delta, there is no useful estimate of numbers. Its cryptic nature and habitat preference for dense woodland make the aerial estimation of population size meaningless. Correction factors of between 10 and 20 have been suggested for riverine woodland but no work has been done for other habitat types. The Delta's population is obviously considerable and hunting success rates confirm the species' resilience.

In the Delta they are most common in the island woodland communities within the floodplain system, even when quite heavily inundated. They are also found in the dryland areas. Agricultural activities often enhance kudu populations but they have a high nuisance value. Biggs (1979) ranks their habitat preferences in the Chief's Island area as: Acacia savanna/ woodlands 34%; riverine woodland 27%; mophane woodland 13%; and other mixed woodlands 8%.

They are almost exclusively browsers, and are fairly common throughout most of Botswana.

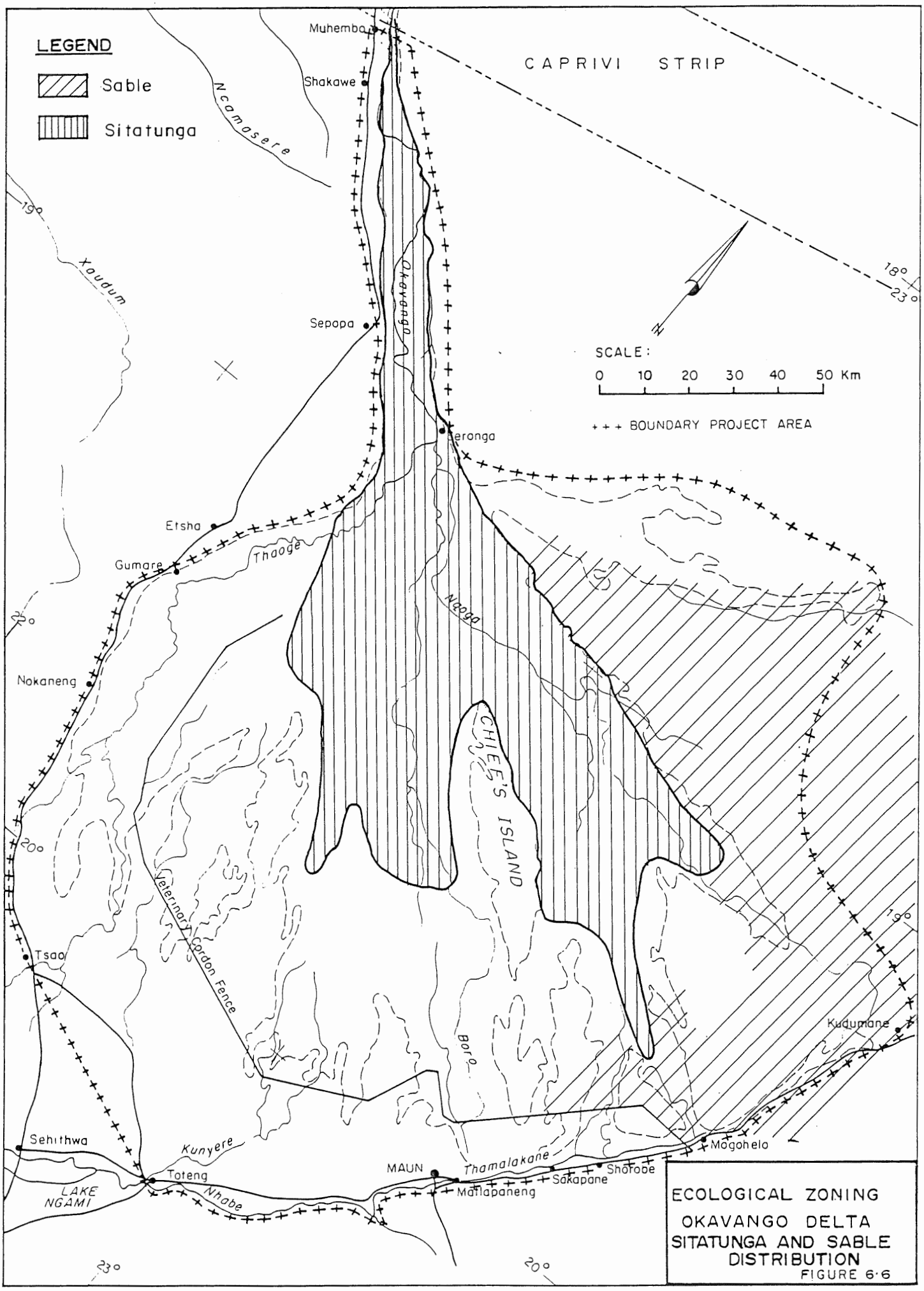
6.1.9.12 Sitatunga

These semi-aquatic antelope are confined to the perennial swamp and prefer dense papyrus and reed beds where water levels are of the order of 0.5 m. They are locally quite common in the Panhandle and other permanently flooded areas, and move down the system with increasing flood levels, retreating with the receding water levels. They have occasionally been recorded as far east as Santawane, but only rarely further south than the southern tip of Chief's Island (Fig. 6.6).

In a wider context, the species occurs in scattered pockets throughout Zaire and less commonly in a number of other central and west-central African countries, but the Okavango must be regarded as the major surviving stronghold and is therefore of paramount importance.

Numbers are unknown due to the difficulty of censusing their preferred habitat. Helicopter surveys in the early morning and late evening would provide better results; however there is no evidence that they are in decline and such an expense is difficult to justify at present.

They are grazers, eating mostly the tips of papyrus and Phragmites in the water during the day, but island grasses during the night. During high floods they are often driven out of their usual habitat on to dry higher land. Games (1983) noted that at high flood levels only 45% of their diet consisted of papyrus umbels



ECOLOGICAL ZONING
OKAVANGO DELTA
SITATUNGA AND SABLE
DISTRIBUTION
FIGURE 6·6

compared with nearly 100% at low flooding levels. Burning the papyrus and reed beds provides superior grazing opportunities but is too often used as a hunting strategy.

6.1.9.13 Bushbuck

This cryptic species is confined largely to the fringes of the Delta, although it has been recorded from Chief's Island and professional hunters report occasional sightings along most of the dry land fringes. They occur near Maun (Matlapaneng) and are probably more numerous than generally thought, though still uncommon. Recorded localities are listed in Appendix G.

They are confined to dense undergrowth, usually in riverine woodland, but will move away from permanent water when rainwater is available in pans. They are mixed browsers and grazers depending on circumstances. Where fresh green grass is available they happily graze, but under more common conditions they are predominantly browsers.

The bushbuck found in the Delta is the sub-species known as the Chobe bushbuck (Tragelaphus scriptus ornatus), a much more colourful animal than other types, which lends it some extra degree of importance, particularly when numbers along the Chobe and Linyanti are thought to be in decline due to modification of the riverine habitat by high elephant densities.

6.1.9.14 Reedbuck

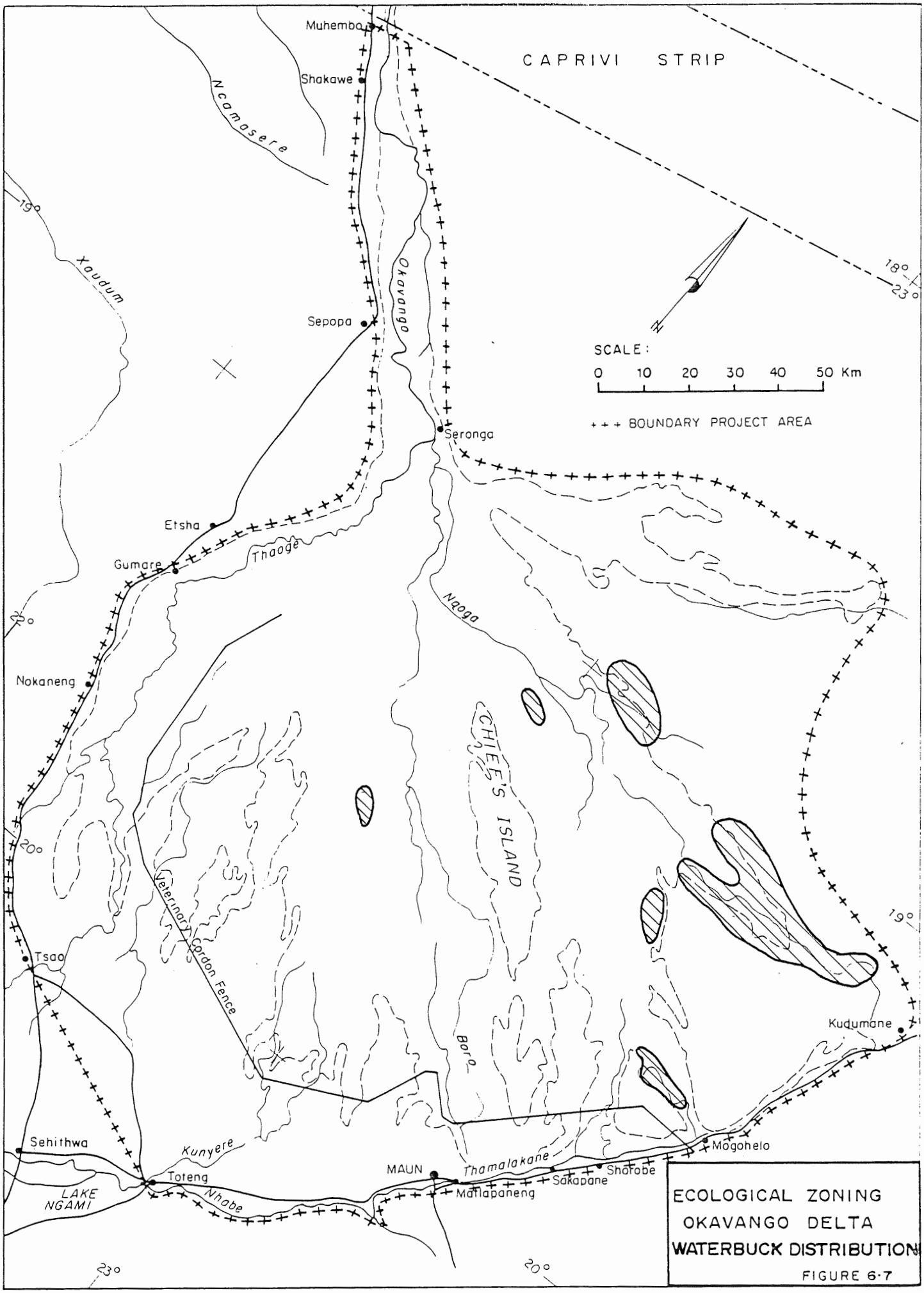
This species is closely confined to floodplains where it prefers a mixture of long and short grassland; the former for cover and the latter for grazing. They are particularly active in the evenings and may become largely nocturnal where disturbance is a problem. They have been displaced from many of the floodplains in the lower Delta, e.g. the Boro valley outside the buffalo fence, due to human activity. In most of the Delta below the perennial swamp they are fairly common and widespread.

The repeated aerial census population estimates in the region of 2 000-3 000 animals are almost certainly very conservative due to their habit of lying low in clumps of long grass, making observation difficult.

6.1.9.15 Waterbuck

Only two of thirteen aerial wildlife surveys conducted in the Delta have recorded this species. It is regularly seen along the Khwai floodplain and associated grassland, less often in the lower Mogogelo system and almost nowhere else. Odd sightings of a few individuals or small groups have been reported from Nxabega in the central Delta and from the mid-Boro area (Fig. 6.7).

Waterbuck are sensitive grazers and are seldom found more than a few hundred metres from surface water. They appear to be easily out-competed where grazing pressure is excessive, e.g. due to impala and warthog, and this may explain their absence from most of the Delta. They are protected by law and would be a fruitful subject for study.



ECOLOGICAL ZONING
OKAVANGO DELTA
WATERBUCK DISTRIBUTION
FIGURE 6·7

Despite the name they do not normally utilise inundated areas like the congeneric lechwe.

6.1.9.16 Sable

This species is confined to the northern and eastern fringes of the Delta (Fig. 6.6). It has not been recorded from Chief's Island or west of the Mburoka-Santantadibe system. It occurs throughout the woodlands and savannas to the north and east of the Delta and quite large numbers may be associated with the southern Magwegqana and the Xugana/TsamTsam area, particularly during drier periods.

It is predominantly a grazing animal but browses when the grass becomes excessively dry.

Its choice of habitat is open savanna or scrub, but it will also make use of dry floodplains. According to the literature it requires to drink daily, but observations of sable in the northern teak woodlands of Botswana seem to contradict this.

6.1.9.17 Roan

This occurs much more widely in the Delta than its smaller relative above. It is often seen singly or in small groups and never in big herds as sable may be. It is uncommon, except in the north east. The species is protected and there are indications that it is more common throughout its range in northern Botswana than it was 20 years ago.

Again, it is a sensitive grazer, preferring longer grasses up to 1.5 m. It is found mostly in dry scrub or savanna with open patches of grassland and is sensitive to bush encroachment restricting its available habitat.

6.1.9.18 Eland

This species has never been resident in the Delta proper although it occurs all around and throughout the Kalahari. Occasionally it is sighted in the lower Khwai and Mogogelo vicinities but is probably just a visitor from the Mababe Depression.

6.1.9.19 Hartebeest

This species would not be expected to occur in the Delta, but the lower Sandveld Tongue was the extreme limit of its range in Botswana. Very few individuals occurred there but obviously a few were confined by the erection of the buffalo fence. They still are seen in low numbers, but it remains to be seen whether or not they will continue to survive. They occur nowhere else in the Delta.

6.1.9.20 Gemsbok

Although the species' range virtually surrounds the Delta they have only been recorded from the western edges of the Sandveld Tongue, where, like the hartebeest, a few have been 'fenced in'.

6.1.9.21 Steenbok

This small antelope occurs on the larger islands and dry land masses, throughout the lower Delta, but not in large numbers. It is far more numerous around the fringes of the Okavango and throughout most of the rest of the country. It is occasionally seen on dry floodplains. It grazes and browses.

6.1.9.22 Duiker

These are widespread but uncommon in the Delta. They occur mainly on the larger islands and land masses and seem to prefer scrub areas to open grassland. They are less often seen during aerial surveys than steenbok but that may be due to differences in behaviour. They are also mixed feeders.

6.1.9.23 Oribi

This small grazing antelope prefers open grassland and floodplains near water. Previously thought to be absent from the Delta, it has recently been reported repeatedly from the northern fringe near the eastern edge of the Magwegqana (I McFarlane, pers. comm.).

6.1.9.24 Lion

Lions are widespread and common, occurring throughout the Delta, even in very wet areas, where lechwe are the favourite prey species. They are more in evidence in Moremi W.R., being wary of vehicles and people in areas where they are hunted. Like the elephant and buffalo, they are a major attraction for tourists and safari hunters.

6.1.9.25 Leopard

Information collected from hunters suggests that they are widespread in the Delta. They are perhaps more common in the seasonal swamp area in association with riverine woodland. They are very shy, especially where hunted, but are commonly seen in Moremi W.R. They are another important trophy animal.

6.1.9.26 Cheetah

Sparse but widespread, particularly in the drier floodplains, larger islands and dry land masses. It will not cross deeply inundated areas. This is another protected species.

6.1.9.27 Spotted Hyaena

Very common and widespread except in perennially inundated areas. The species has a wide habitat tolerance and is almost entirely nocturnal. They are very active hunters as well as scavengers, and indicate their presence by their distinctive vocalisations. They are a nuisance at established campsites where control measures are necessary.

6.1.9.28 Brown Hyaena

This secretive species has only been recorded rarely from the western fringes of the Delta, with even fewer sightings in northeast Moremi W.R.

6.1.9.29 Wild Dog

The status of this species is currently the subject of a study being conducted by personnel from the University of California, based in Maun. At present the study is in its infancy and very little data exist.

From reports it would seem that the species is fairly common in the Delta and occurs in all habitat types except deep water. It is assumed to be highly mobile. It is protected officially but commonly destroyed in defence of stock. Numbers are unknown.

6.1.9.30 Baboon

This conspicuous species is numerous and widespread. It has a wide range of foods, mainly vegetarian, and utilises most habitat types at some time or other, with the exception of deeply inundated areas. For instance it occurs most commonly in mophane woodland during early spring when it eats the scale insects from the mophane leaves. It roosts mainly in the riverine woodland and usually drinks at midday. It utilises the floodplains more during the dry season, foraging in the savanna woodlands more during the rains. The species is a nuisance around established campsites and tourist facilities. Large numbers may have detrimental effects on nesting birds.

The baboons on the western edge of Chief's Island have been the subject of long-term observations by a team of researchers from the University of California.

6.1.9.31 Antbear

Seldom seen because of its nocturnal nature, this animal is nevertheless fairly common and widespread. It occurs in most habitats except inundated floodplains. Its distinctive burrows are well known and utilised by a large number of other species.

6.1.9.32 White Rhino

This species was considered to be extinct in Botswana since the turn of the century. A number was reintroduced into Moremi W.R. from Zululand in 1975. They were released near Cakanaca. Since then individuals and sometimes small groups with young have been seen occasionally by tourists and during aerial wildlife surveys. They are probably still largely confined to the Moremi and Maqwee areas.

6.1.9.33 Ostrich

This bird is widespread and common, especially in the lower Delta, the fringes and the larger islands and land masses. It does occur in the seasonal swamp and is frequently seen on floodplains, even crossing shallow water. It is absent from the perennial swamp.

6.1.9.34 Crocodile

This species is fairly common throughout the Delta, but exploitation in the Panhandle has led to a reduced population in that area. Population estimates of about 5 000 crocodiles in the Panhandle and 1 600 in the rest of the Delta have been made (Simbotwe, 1988b) but these are based on few survey data. Considering the size/age structure of crocodile populations these figures should be used with caution when setting hunting and egg collecting quotas. For further details see sections 6.4.2.1 and 6.1.10.5.

6.1.10 Wildlife Utilisation

Up to the present time wildlife utilisation in the Delta has been limited largely to hunting and game-viewing. Intermittent crocodile hunting enterprises have recently given rise to a crocodile farm near Maun, still heavily dependent on collecting both eggs and adults from the wild, mainly the Panhandle area.

Before 1980 hunting was by far the dominant form of land use in the Delta. This took the form of semi-commercial and subsistence hunting by citizens and safari hunting by non-residents, with a small and decreasing element of sport or 'biltong' hunting by resident non-citizens. During this decade however, the growth of the photographic safari industry has outstripped other forms of land use to the point of becoming a major threat to the integrity of the Delta. The conflicts between hunting and tourism are discussed in section 8.

6.1.10.1 Controlled Hunting Areas

Botswana is divided into some 40 or so Controlled Hunting Areas (CHAs). Nine of these cover the Delta and link it with the surrounding areas. An attempt has been made to illustrate the relevant CHA boundaries on a 1:250 000 scale map. Unfortunately, there have been many changes, both administrative and physical, since the CHAs were defined in the 1960s. The gazetted boundaries are impossible to find in many cases and this situation has obviously led to conflicts between lessees and made the efficient control of hunting activities even more difficult. It should be a matter of priority to redefine the CHAs in a modern land use context. This exercise can only be adequately carried out with a thorough knowledge of ecological factors and processes which obtain in the area. Where distinct natural or man-made boundaries are lacking it will be necessary to delineate these with cut lines, beacons or other suitable and unmistakable features.

6.1.10.2 Hunting Quotas

Each CHA is allocated a quota of animals of the various species which may be hunted. At the present time neither the monitoring of wildlife populations nor the system of recording hunting activities and success rates is good enough to calculate hunting quotas with any degree of confidence. A major shortcoming of the present system is the transferring of licences between individuals and the practice of re-allocating licences to a new area should

the hunter claim to be unsuccessful initially. It is estimated that up to 75% of quotas allocated to some peripheral areas have been re-assigned to CHAs in the Delta towards the end of recent hunting seasons. Clearly, for the quota system to function at all it will be necessary to adhere rigidly to allocations which have been arrived at by scientific monitoring of the animal populations and hunting activities.

The quotas allocated to each CHA are divided between the various categories of hunters. In the Delta this usually means between citizen and non-resident hunters, although two areas on the western fringe also have a small quota for residents. An important aspect of newly designed CHAs should be to separate citizen and non-resident hunting. The data suggest that present resident hunting activities are so insignificant that they do not justify a separate administrative burden and should be absorbed in the other allocations.

Table 6.6 summarises the hunting quotas and success rates (recorded kills) for the Okavango and related areas in 1988. It can be seen that only approximately one third of the overall legal quota is recorded as killed, although these data are calculated from files of hunting returns at rates of 92% for non-residents and 60% for citizens (only six animals were recorded as killed by the resident sector). Citizen hunting records indicate that just over one quarter (26%) of the legal quota was harvested, though many would regard this as a gross underestimate. In the non-resident sector approximately half of the meaningful quota was utilised. This proportion drops to 45% if species such as genet and porcupine are included in the calculations although no licences were sold. The inclusion of such species in the quota is questionable, particularly as they are completely nocturnal, and hunting at night is illegal.

6.1.10.3 Valuable Wildlife Species

The demand to hunt certain species varies according to its actual value in terms of meat, skin and other products (commercial value), or its perceived value as a trophy, which may depend on size or scarcity usually. To the citizen hunter the commercial value is most important, while non-resident safari clients generally seek trophy animals. This fundamental difference demands that management strategies for the two sectors of the hunting industry be separately defined to achieve maximum benefits from the country's wildlife resource.

TABLE 6.6 HUNTING QUOTAS AND SUCCESS RATES FOR THE OKAVANGO AND RELATED CHA'S IN 1988

	Citizens		Non-residents		Residents		TOTALS	
	Quota	Kill	Quota	Kill	Quota	Kill	Quota	Kill
Baboon	-	2	40	8	10	-	50	10
Buffalo	456	209	293	172	30	1	779	382
Bushbuck	-	-	23	1	-	-	23	1
Crocodile	-	-	42	11	-	-	42	11
Duiker	-	12	80	1	20	-	100	13
Eland	25	2	53	3	-	-	78	5
Gemsbok	50	-	12	5	15	-	77	5
Genet	-	-	40	-	10	-	50	0
Hartebeest	-	-	8	1	-	-	8	1
Impala	895	204	285	140	5	1	1185	345
Jackal	-	-	40	2	10	-	50	2
Kudu	314	46	103	63	10	-	427	109
Lechwe	150	44	228	163	-	-	378	209
Leopard	9	1	20	9	-	-	29	10
Lion	5	1	35	21	-	-	40	22
Monkey	-	1	40	1	10	-	50	2
Ostrich	198	17	74	14	25	2	297	33
Porcupine	-	-	40	-	10	-	50	0
Reedbuck	42	14	132	76	-	-	174	90
Sable	-	-	49	32	-	-	49	32
Sitatunga	46	2	109	65	20	-	175	67
Steenbok	-	44	80	23	-	-	80	67
Hyaena	-	-	40	14	6	-	46	14
Springbok	100	8	-	1	10	-	110	9
Tsessebe	-	-	184	126	-	-	184	126
Warthog	400	41	220	99	10	-	630	140
Wildcat	-	-	40	2	10	-	50	2
Wildebeest	350	70	185	75	10	-	545	145
Zebra	345	224	233	109	30	2	608	335
Totals	3385	942 (28%)	2728	1237 (45%)	251	6 (2%)	6364	2185 (34%)

Table 6.7 lists the ten species which generate most revenue in licence fees in ranked order. With the present fees for licences this indicates only the most valuable species as far as Government is concerned. Buffalo are easily the most valuable resource in these terms (although the situation would probably differ if elephant hunting were allowed). Other key species include those which the Okavango Delta supports in useful numbers (in contrast to most other areas), e.g., tsessebe, lechwe and sitatunga.

TABLE 6.7 REVENUE GENERATED BY LICENCE FEES FOR THE MOST VALUABLE (>P10 000) WILDLIFE SPECIES FROM THE OKAVANGO DELTA AND RELATED CHA'S IN 1988

Species	Licence Fees (1988)	
	Pula	%
Buffalo	75 340	18.0
Tsessebe	44 100	10.0
Lechwe	32 983	7.5
Zebra	29 340	7.0
Lion	21 350	5.0
Kudu	21 230	5.0
Sable	17 600	4.0
Sitatunga	16 406	3.8
Reedbuck	15 236	3.5
Impala	14 591	3.4
Total	P288 176	67.0%

The commercial value which may be placed on an animal has been calculated according to BGI's 1988 prices for skins and other by-products, e.g., horns. To this has been added the value of the meat produced from the average adult carcass, dried and valued at P4 per kg. Table 6.8 lists the most valuable species according to these criteria and the value of the 1988 harvest. Again, the buffalo is clearly the most important species. Zebra meat is not usually eaten in Botswana and so no value has been placed upon it. Its value would make zebra equal to buffalo if it were utilised. Any commercial enterprise culling zebra would find a ready market for zebra meat, e.g., in Zimbabwe.

TABLE 6.8 COMMERCIAL VALUE OF MOST VALUABLE SPECIES (>P10 000)

Species	Commercial Value (1988)	
	Pula	
Buffalo	153 200	
Zebra	100 500*	
Wildebeest	16 848	
Kudu	16 100	
Impala	15 180	
Lechwe	12 816	
Tsessebe	10 332	
Total	P324 976	(90%)

* No figure included for zebra meat.

6.1.10.4 Income from the Controlled Hunting Areas

Table 6.9 gives a breakdown of the revenue generated by individual CHA's in 1988 and the licence fees accruing from each sector of hunting activities. Non-resident hunting is responsible for 95% of licence fees, citizen hunting 3.5% and residents 1.5% from allocations of 43%, 53% and 4% respectively of the overall quota.

TABLE 6.9 REVENUE GENERATED FROM CHA'S (1988)

CHA	Licence Fees Citizens	Licence Fees Residents	Licence Fees Non-Residents	Concession Fees	Total
5	1702	-	80298	7920	89920
7	3513	-	91770	16180	111463
8	1512	-	9027	9504	20043
9	2070	-	73840	17820	93730
15	796	3460	25522	3150	32928
16	1728	2710	-	-	4438
17	1071	-	45380	9000	55451
20	1235	-	41928	3000	46163
21	1490	-	40027	11400	52917
Total	15117	6170	407237	77974	507053

Note: Non-resident licence fees are adjusted to allow for endorsements for more than one CHA.

The revenue generated directly from the various sectors of hunting activity together with the commercial value of the harvest in 1988 was therefore approximately P830 000.

6.1.10.5 Crocodile Ranching

Crocodile utilisation takes the form of sport hunting by a few non-residents, with an annual quota of 50, and live capture by Botswana's two crocodile ranches, for which the quota is 1 600 over three years. In addition, 12 000 eggs are on collection quota during the same three-year period.

The majority of crocodile utilisation activities occur in the Panhandle, but capture of live crocodiles is scheduled to end in 1989. Returns filed up to February 1988 are as follows:

Ranch	Crocodiles Caught	Eggs Collected	Live Crocodiles Exported
Okavango Swamps Crocodile Farm (Maun)	795	5930	3443
Wildlife Services Crocodile Farm (Kasane)	258	3013	1044

No sales of live crocodiles are to be allowed after 1989 when the ranches are expected to export skins and by-products only, at the levels of 1 500-2 000 and 1 000 annually from the Maun and Kasane

ranches respectively. 'Well grown' crocodiles of ranched stock, amounting to 5% of the number of eggs collected are to be returned annually to the wild in Moremi W.R. and Chobe N.P. No record of this having taken place to date could be found.

6.2 SMALL MAMMALS

A comprehensive list of smaller mammals recorded from the Delta is given in Appendix G. These records, taken from the literature, cover 72 species (i.e. all mammals not covered in section 6.1 plus the bushbuck, wild dog and antbear). The records are limited to 42 grid squares of one quarter of a degree, covering the Panhandle and the Delta proper. Most of the information is drawn from either Smithers (1971) or Biggs (1979). Because so little systematic recording has taken place there are major gaps in the distribution data which favour certain collecting localities, e.g. Shakawe, Maun, Chief's Island and Khwai. Many species are most certainly more widely distributed than the data indicate.

Scientific names of all confirmed records are included in Appendix G; the short description given here uses common names as far as possible to facilitate reading.

The majority of small mammals is represented by three orders: CARNIVORA (23 spp.), RODENTIA (24 spp.) and CHIROPTERA (12 spp.)

6.2.1 Carnivora (carnivores)

Viverrids are represented by eight mongoose species, two genets and the civet. The last three are common throughout the Delta and its environs, but only the small spotted genet is common and widespread in the rest of Botswana.

Of the mongoose, the five diurnal species are fairly widespread and common in Botswana, although less so in the Kalahari proper. The three mainly nocturnal species (Selous, white tailed and water mongoose) occur mostly in well watered areas and are thus limited largely to northern Botswana. The white tailed mongoose has only been recorded from the Moremi W.R. on the Khwai and Gomoti rivers although it does occur in southern Angola and the Caprivi Strip.

Mustelids include both the clawless and spotted necked otters which occur throughout the wetter parts of the Delta and in the Chobe system. The former is less confined to true aquatic habitat and will wander on dry land in the vicinity of rivers. Honey badgers are common and have a wide habitat tolerance, as does the striped polecat.

Canids include two foxes and two jackals. The bat-eared fox is fairly common throughout the country except in the heavily populated east. In the Delta it is associated with open dry savanna and floodplains mostly and is absent from the wetter parts. The Cape fox has been recorded from the eastern and southern fringes of the Delta only and cannot really be considered resident. The side-striped jackal occurs throughout the northern half of the Delta, particularly in the Moremi W.R. It may be more widespread but is shy and much quieter than the black backed

jackal which is far more numerous and widespread in the Delta and beyond.

Three small cats occur in the Delta: the African wildcat, the caracal and the serval. The last appears to be mainly limited to the Okavango and Chobe systems whereas the first two are more widespread.

The last carnivore recorded from the Delta is the aardwolf, which is associated with drier floodplain grassland and open scrub savanna. It is absent from the perennial swamp.

6.2.2 Rodentia (rodents)

Rats and mice account for 17 out of 24 species of rodents. The Angoni vlei rat, water rat and creek rat are pretty much confined to the wetter areas of the upper Delta and Chobe. Common widespread species include the pygmy mouse and the multimammate mouse, both of which are subject to population explosions. Shortridge's mouse, a close relative of the multimammate mouse, has been recorded from the Panhandle. The tree rat occurs throughout the Delta in association with Acacia woodland and appears to be a distinct sub-species, Thallomys paedulcus herero.

Two gerbils (Tatera spp.) have been recorded, with T. leucogaster more widespread. The pouched mouse and the grey pigmy climbing mouse are common, whereas the chestnut climbing mouse has only been recorded from the Gomoti River. The fat mouse, red veld rat and Namaqua rock rat are common around the Delta's fringes and the single striped mouse and Woosnam's desert rat have also been recorded occasionally.

Other rodents include the dormouse, Damara mole rat and the cane rat, which is found in the Panhandle, Moremi W.R. and near Maun where suitable riverine habitat exists.

The bush squirrel is very common and a sub-species Paraxerus cepapi maunensis is recognised. The ground squirrel is limited to the dry fringes of the Delta, especially between Lake Ngami and Nokaneng.

The spring hare is very common wherever sandy soils suitable for burrows occur. They frequent dry floodplains for grazing and avoid harder soils, e.g. mophane scrub or woodland.

Porcupines are common and widespread in all dryland habitat types and dry floodplains.

6.2.3 Chiroptera (bats)

12 species of bats have been recorded from the Delta. The most conspicuous, because of its call, is Peter's epauletted fruit bat which is common and widespread in association with riverine woodland. All the other species are insectivorous and their detailed ecology is largely unknown. Many prefer to feed in the vicinity of water. They comprise one slit-faced bat, two free-tailed bats and eight vesper bats.

6.2.4 Insectivora

These are represented by the short-snouted elephant shrew and four species of true shrew. They occur in suitable habitats throughout the Delta, except the giant musk shrew, which appears to be limited to the northern parts.

6.2.5 Primates

Apart from the baboon, the vervet monkey is conspicuous and widespread, preferring riverine woodland but also commonly seen in drier woodland and savanna. The night ape (lesser galago) is also common and is associated mainly with riverine woodland, in particular with Acacia spp.

6.2.6 Other Small Mammals

The pangolin is probably more common in the Delta than elsewhere in the country. They have been recorded from a variety of habitats from floodplains to dry land.

The bush pig has been recorded from near Sepupa, but is very uncommon.

The scrub hare is common throughout the Delta and is found in a wide variety of habitats.

6.3 BIRDS

This section was reviewed and adapted for the report after lengthy discussions with T N Liversedge and M J Muller.

6.3.1 Species Occurring in the Study Area

Approximately 450 species have been recorded from the Delta and its environs. Plowes in SMEC (1987d, Vol II) used the Botswana Bird Club's atlas to list them in his Appendix D and indicated the use made by each species of habitat types which occur in the Delta. His Appendix C lists and describes these ornithological habitat types. As with mammals, these habitat types cannot be equated with ecological zones but obviously relate to them. To avoid confusion these appendices are reproduced in full with some additions as Appendix H of this report.

In a Botswana context, several species occur only in the Okavango, although they may be more or less widespread regionally or internationally. These are listed in Table 6.10.

Penry (1985, in SMEC 1987d, Vol II) lists 45 species which occur in the Okavango and are classified as 'threatened' in South Africa. About half of them are dependent on wet habitat and highlight the importance of the Delta in a regional context. Here too, it is worth stressing that the Okavango system represents a southern intrusion of tropical habitats into the Kalahari, extending the range of many species.

TABLE 6.10 BIRD SPECIES RECORDED FROM THE OKAVANGO AND NOT ELSEWHERE IN BOTSWANA

Common name	Scientific name	Map reference
Pintail	Anas acuta	2022B
Blue quail	Coturnix adansonii	1923B
Ross' lourie	Musophaga rossae	1822C
Boehm's spinetail	Neafrapus boehmi	1821B
African broadbill	Smithornis capensis	1923A
Black sawwing swallow	Psalidoprocne holomelas	1821B
Rufous bellied tit	Parus rufiventris	1821B
Whinchat	Saxicola rubetra	1923C
Pale crowned cisticola	Cisticola brunnescens	1923A
Locust finch	Ortigospiza locustella	1923A

6.3.2 Species Meriting Special Consideration

Details of the ecology of all recorded species are clearly beyond the scope of this study. However, a number of birds deserve special note because of their importance in a local, regional or international context.

Pink backed pelican (Pelecanus rufescens)
Apart from the Delta, this species has only been recorded breeding in southern Africa at Lake St. Lucia. It requires trees for nesting and in the Delta uses Ficus spp. and Phoenix reclinata. Approximately 100 birds regularly nested in Xhamu Lediba, but in recent years progressive desiccation has allowed easier human access, with resultant fires and cattle driving the birds away. Smaller numbers still breed at Gadikwe Lediba, Xo Flats and west of Nqoga Island in colonies dominated by marabou and yellow billed storks.

Marabou stork (Leptoptilus crumeniferus)
The breeding colonies on Ficus verruculosa stands in various madiba represent the largest breeding population in southern Africa. Localities needing special protection from tourist disturbance are in Gadikwe and Gcobeha Madiba in Moremi W.R.

Yellow billed stork (Mycteria ibis)
This species breeds in colonies associated with the Marabou stork and Pink backed pelican; the Okavango is the only area except for Lake St. Lucia where breeding occurs in southern Africa.

Open bill (Anastomus lamelligerus)
A mainly tropical species, it occurs in large numbers when attracted by lowering flood levels exposing wet grass plains where it feeds on snails. It breeds at Gadikwe and Gcobeha Madiba.

Saddlebill stork (Ephippiorhynchus senegalensis)
Although not rare, this spectacular bird is not common anywhere and the Delta's population, estimated at about 2 500 (UNDP/FAO, 1977) is very significant. It requires shallow flooded areas for feeding and usually nests in large trees.

Slaty egret (Egretta vinaceigula)
This is the rarest heron in the world and is limited to the Okavango, Chobe and Lake Bangweulu in Zambia. It has only been recorded breeding in the Okavango, also using F. verruculosa. Little is known of its ecology or the details of its habitat requirements, though it appears to favour broad, shallow flooded, short grass fringes for feeding. It is fairly widespread in the Delta, especially in the north, but is nowhere common. Its rarity makes it probably the most important bird in the Delta and it requires a detailed study in order to safeguard its status because it may well be susceptible to unknown changes in the environment.

Rufous bellied heron (Butorides rufiventris)
This bird is uncommon throughout its range and the Okavango population is perhaps the greatest anywhere.

White backed night heron (Gorsachius leuconotos)
This rare heron is one of many significant species found mainly in the Panhandle. For feeding it requires dense vegetation overhanging permanent water, preferably with well defined banks.

Pygmy goose (Nettapus auritus)
This highly attractive and protected species is entirely dependent on waterlily bulbs and usually nests in dead hollow trees. The Okavango population is probably the most significant in southern Africa.

Spurwing goose (Plectropterus gambensis)
This large goose is particularly numerous in the Panhandle when overwintering (e.g. near Ncamasere). It has the potential to become a pest on irrigated crops in the area.

N.B. The Delta is not a particularly important area for most waterfowl, especially dabbling ducks, but very large numbers of Red billed teal (Anas erythrorhyncha) sometimes occur and there are notable numbers of White backed ducks (Thallassornis leuconotus) which share similar habitat with the pygmy goose. The protected status of the Fulvous tree duck (Dendrocygna bicolor) is not considered justified. The enormous, if intermittent, importance of Lake Ngami with regard to waterfowl must be noted, even though it falls outside the study area.

Long-crested eagle (Lophaetus occipitalis)
This distinctive eagle is one more example of the importance of the Panhandle. It also occurs less commonly in the Delta and Chobe.

Western banded snake eagle (Circaetus cinerascens)
This rare species occurs and breeds in the Panhandle and has been recorded from Chobe. It appears to require large trees in undisturbed areas near permanent water. The small 'islands' of riverine forest which occur only in the Panhandle are very important habitat for this and other uncommon species.

Cuckoo hawk (Aviceda cuculoides)
There are records of this species breeding in the Panhandle. Its habitat requirements are similar to those of the preceding and next species.

Pel's fishing owl (Scotopelia peli)
Requiring open water with adjacent riverine forest, this species has its stronghold in Botswana, also in the Panhandle. It is nevertheless quite widespread, but uncommon and shuns areas of human habitation. The Okavango probably contains Africa's largest population.

Blue quail (Coturnix adansonii)
Recently collected from the Khwai River, it is thought to be a more significant record than the next species.

Ross's lourie (Musophaga rossae)
This species has only been recorded once from the lower Panhandle and is considered a rare vagrant.

Wattled crane (Grus carunculatus)
Considered to be highly endangered in South Africa, it is quite numerous in the Delta and also occurs seasonally in he Makgadikgadi area when wet. The Delta's population, which has been estimated at between 500 and 5 000 birds is possibly the most important, although fair numbers occur in suitable wetlands in Zambia. The extent of movement between Zambia and the Delta (if any) needs investigation before a definite statement on its status can be made.

Its preferred habitat is large, shallowly-inundated floodplains, mainly in the seasonal swamp, but it also occurs in parts of the perennial swamp, e.g. Xo Flats. Consequently it is fairly widespread but thinly scattered, normally occurring in pairs or occasional threes. Large concentrations (>100 birds) have been recorded from the lower Delta and Makgadikgadi under certain conditions. Its sensitivity to disturbance by human activities and its uncertain status have led to considerable international concern. Recent initial attempts to study the species in the Okavango should be continued and augmented.

Narina trogon (Apaloderma narina)
A seldom seen but beautiful bird that is confined to the Panhandle. It is also recorded from the Linyanti area.

African skimmer (Rynchops flavirostris)
A breeding migrant which utilises exposed sandbanks, particularly in the Panhandle, for nesting sites. The species is a popular tourist attraction. Its nesting colonies are very prone to disturbance and damage, particularly by people and motor-boat wakes. Important breeding areas are marked on the zoning map.

Carmine bee-eater (Merops nubicoides)
Another tourist attraction due to its spectacular breeding colonies in early summer. It colonises exposed cliffs in the Panhandle but also uses suitable flat sandy areas in the Delta as long as these are free from disturbance, e.g. near Four Rivers. Known nesting sites need protection, especially in the Panhandle.

Coppery-tailed coucal (Centropus cupreicaudus)
Common in the Okavango, but not found further south.

6.3.3 Game Birds

Local interest in shooting birds for sport or food was insignificant until safari companies began to market 'bird safaris' in the late 1970's. These have become very popular, although the prime area is Lake Ngami and that water body is unreliable. Sought after species are doves (especially the Cape turtle dove Streptopelia capicola), sandgrouse (Pterocles spp.), francolin, guinea fowl and waterfowl, probably in that order during recent dry years.

6.3.3.1 Quotas

Quotas for all CHA's seem to be set arbitrarily and equally. The 1988 figures for non-residents are given below:

Doves/Pigeons	1 500	per CHA
Francolin	1 000	" "
Guinea fowl	150	" "
Sandgrouse	800	" "
Ducks	250	" "
Geese	150	" "

Citizens and residents are allowed unlimited shooting. No data exist on how many birds were actually shot, but the non-resident quotas were considerably reduced from previous years because of concern about reported bag sizes and the drought situation.

It is unfortunate that factors such as breeding seasons are not taken into account, particularly for Yellow throated sandgrouse (Pterocles gutturalis) which are mainly shot at a crucial stage of their nesting season, resulting in high mortality of chicks. Conflicts have also occurred between agricultural practices and game bird habitat, e.g., Shorobe molapo development area.

Other important areas for commercial bird shooting are the Khwai/Mababe area and the Boteti River. It is primarily an activity of the Delta fringes and the edges of the sand veld intrusions.

A study is urgently required in order to ascertain the optimum management strategy for the valuable bird shooting industry.

6.3.4 Potential Pests

The Red billed quelea (Quelea quelea) can be a major pest of small-grain crops and is the subject of rigorous control methods. It favours Acacia tortilis thickets for breeding and vast numbers have been recorded from the Khwai/Mababe and Lake Ngami areas. In problem years they are commonly seen using the large reedbeds near the Delta's fringes for roosting, e.g. Thamalakane and Boteti Rivers.

The Cape turtle dove and Spurwing goose also have the potential to be major pests on irrigated or flood recession crops.

In conclusion, it should be stated that the Delta's ornithological importance is restricted neither to its status as a refuge for rare species, nor to its potential for commercial exploitation; it is a unique combination of habitats, most notably wetlands, which provides various requirements for a vast number of resident and migratory species. As such its role is of crucial international importance and must be respected, protected and above all well managed.

6.4 AMPHIBIANS AND REPTILES

6.4.1 A Checklist for the Study Area.

Based on the distribution records of Auerbach (1987) a checklist of amphibians and reptiles of the study area has been drawn up, the localities checked by team members, and by Dr D G Broadley (National Museum, Bulawayo). The list has 95 species/subspecies of amphibians and reptiles recorded in the study area of which 28 are frogs, 7 tortoises and terrapins, 22 lizards, 4 amphisbaenians, 33 snakes and 1 crocodile. There are a further 14 species which may occur in the study area.

6.4.2 Species Meriting Special Consideration

Some of the 96 species, because of past and present exploitation, or the importance of the Okavango Delta to their Botswana or southern African distribution, have been singled out for further discussion.

6.4.2.1 The Nile Crocodile

The history of exploitation of the Okavango Delta crocodile population dates back to 1957 when hunting of crocodiles for their skins commenced. Between 1957 and 1969 a large number of crocodiles was shot; the actual figure is controversial. Pooley (1981) estimates it as 50 000, but this is based on quotas rather than actual numbers (Graham and Simbotwe, 1988). Graham and Simbotwe (1988) estimate the number as 12 000 for the same period. The latter figure is supported by the apparent sensitivity of the population to hunting. For example, one of the concessionaires only managed to obtain the quota (2 000) in 1957; the figures for the following two years were 800 and 500 respectively (Blomberg, 1976). The pattern was repeated in 1973/4 when annual quotas of 500 were set for one concessionaire. The quota was obtained in 1973, but, reduced to shooting animals of 1.5m length and less in 1974, the hunting was abandoned with only 239 crocodiles shot (Blomberg, 1976).

Exploitation was resumed in 1983 when crocodile ranching operations commenced (Simbotwe, 1988a). Eggs, hatchlings, subadults and adults are collected from the wild based on a quota system administered by the Department of Wildlife and National Parks (Simbotwe and Matlhare, 1988). There are currently two established crocodile ranches in Botswana, one on the Thamalakane south west of Maun and the other near Kazungula. Another may open shortly at Shakawe (Simbotwe, 1988a), and enquiries have been received by Ngamiland DLUPU about another at Chanoga. Further details of ranching activities have been given in section 6.1.10.5.

Crocodiles are distributed throughout the Okavango Delta in permanent swamp, rivers, madiba and seasonal swamp. The apparent distribution of nesting sites is markedly different, however, with nearly all sites found between 1975 and 1987 being in the Panhandle between Shakawe and Seronga (Graham and Simbotwe, 1988). Only five sites have been found elsewhere on the Delta, two on the Santantadibe, one at the Santantadibe/Thamalakane junction and two

on the Kiri near Bobo island. These represent only 2.5% of all nest sites in the study area.

Aerial surveys of nesting on the Panhandle indicate that there are about 100 nests (Simbotwe, 1988a), which might be expected to yield 5 600 eggs if all nests are found on ground searches. The problem arises in that it appears that the Panhandle is the main breeding area. It is also an area of the Delta that supports a large human and livestock population (on both banks). With the inevitable conflicts between crocodiles and humans (Skjonsberg and Merafe, 1987, p.40) it is not safe to assume that the Panhandle will remain prime crocodile breeding habitat in perpetuity. This will threaten the existence of crocodile ranches and may threaten the Okavango crocodile population as a whole, if it is found that the rest of the Delta is unsuitable crocodile nesting habitat. Key nesting areas in the Panhandle are indicated with P_W modifiers on the zoning maps.

An important research project would be to assess the nesting in the rest of the Delta and to study the movement of juveniles and adults between the Panhandle and the Delta.

6.4.2.2 Other Reptiles

The Pelomedusidae (terrapins) show an interesting diversity in the study area, four of the five Botswana species are recorded from the Okavango Delta. Limnophis bicolor bangweolicus (Eastern Striped Swamp Snake) is an Angola/Zambian species recorded from Maun and Xugana lediba. Crotaphopeltis barotseensis (Barotse Water Snake) is confined in Botswana to the study area (Sepupa, Xugana lediba and Magwegqana). Rhamphiophis oxyrhynchus rostratus (Eastern Rufous Beaked Snake) - four of the five Botswana records are from the study area. Although Philothamus angolensis has a wide distribution in Africa, it is confined, in Botswana, to the Okavango and Kasane areas.

The Nile Monitor (Varanus niloticus) is reported (Blomberg, 1976) as being an important predator on crocodile nests on the Panhandle, as it is elsewhere in Africa. There is no way of knowing how widespread V. niloticus is in the Panhandle or the size of its population though Auerbach (1987) records it from Shakawe and Sepupa only.

6.4.2.3 Amphibians

Bufo lemairii has been collected at Shakawe and Xugana Lediba. These are the only records for southern Africa south of the Cunene/Zambezi line.

The records of Ptychadena guibei from Gumare, Hyperolius benguellensis (Xo Flats) and Phrynobatrachus parvulus (Khwai river) are the only ones for each species from Botswana. Of these only Bufo lemairii and Hyperolius benguellensis are likely to be important, representing southward extensions of predominantly tropical species.

6.4.3 Implications for Ecological Zoning

The inventory of amphibians and reptiles and what is known of their distribution highlights the importance of the Panhandle and the distributary systems towards the east and south east. The Okavango river and the Nqoga which is the main distributary (section 4.1.3) therefore become of major importance in the conservation of crocodiles and the little-known amphibians and reptiles. It is quite possible that papyrus swamp is the preferred habitat of Crotaphopeltis barotseensis, lending support to the plea for protection of thick papyrus swamp (section 5.11).

6.5 FISHES AND FISHERIES

6.5.1 Introduction

The Okavango Delta is one of the largest floodplain systems in Africa. Its actual size is approximately 16 000km^2, although various authors differ considerably in their estimates, e.g. 10 000km^2 (Gilmore, 1976) and 17 000km^2 (Marshall in SMEC, 1987d, Vol II). Obviously the fisheries potential of the system is correlated to the surface area of water. This is emphasised by the statement of Wilson and Dincer (1976) that the increases in area covered by water during the flood are in the order of 1:2 in the northern perennial swamp and 1:10 in the southern seasonal areas of the Delta. This project has mapped the areas of perennial inundation and potential inundation of the Delta with unprecedented accuracy. Planimetric calculations of these areas are not yet available; in the meantime the estimates given by Ringrose (1985) and Dincer (1986) obtained by remote sensing techniques are probably the most useful. In August 1983 these authors respectively estimated the total area of inundation to be 8 446 and 7 453km^2.

Merron and Bruton (1988) estimated the more productive perennial water area to be approximately 4 000km^2 and using Welcomme's (1979) formula, proposed a sustainable annual yield of 5 000-7 000 tonnes of fish for the Delta. At present the commercial fishery is estimated to harvest 1 200 tonnes, the traditional fishermen approximately 8-900 tonnes and the recreational sector 600 tonnes, although data are lacking to confirm the last two estimates (Merron and Bruton, 1988).

Different opinions exist regarding the possible effects of various natural and man-induced phenomena on the fish stocks of the Delta. The most important factor is obviously the amount of available water and this is largely governed by the annual inflow at Muhembo, which varies between 7.4 and 16 x 10^9m^3 and averages 10.5 x 10^9m^3 (UNDP/FAO, 1977). This largely determines the extent of flooding in the seasonal swamp, in whose flood-plains many important species reproduce. The timing of the flood is also important; many floodplain breeders time their spawning with the higher temperature experienced from September to December. Excessively cold periods are known to cause significant fish mortality, particularly in shallow water.

Many workers (Reavell et al., 1973; Thompson, 1976; Hart, 1986) have commented on the low levels of available nutrients in the Okavango system. This has led to speculation about the apparently low productivity of the system when compared with other floodplain systems in Africa and elsewhere.

Diurnal fluctuations in dissolved oxygen levels occur, probably due to accumulations of organic matter which have a high biological oxygen demand, and have also caused natural die-offs in certain areas of the Delta (Merron and Bruton 1988).

The large scale aerial spraying programme to control tsetse fly has resulted in repeated applications of insecticide to much of the Delta. While ultra-low volume applications have been used, nevertheless significant toxic effects on fish have been demonstrated, especially where human error has led to accidental over application to an area (Merron, 1986). Adequate monitoring of the effects of the spraying on non target species, particularly in aquatic communities has been lacking.

The various sectors of the fishing community are convinced that the activities of the others are detrimental to their own. While there is no doubt that commercial fishing has expanded through promotion by Government and may have had significant effects on some species, the increasing activities of the recreational sector must be affecting the bream and tiger fish populations in many areas. At the present time the traditional harvest is almost completely unknown and research on the interactions of the three sectors would be a fruitful field for further study.

6.5.2 Species composition and distribution

At the present state of knowledge there are 68 species of fish in the Okavango system within Botswana. According to Skelton et al., (1985), there are 8 major habitat types between the Angolan Highlands and Lake Xau/Mopipi Dam. The major swift-flowing upper riverine systems are richest in species diversity (>60 spp) while the sump communities of Lake Ngami and Lake Xau/Mopipi are poorest (47 and 27 spp. respectively). The reasons for this are that the upper habitat types are more stable than the lower ones. Taken to extreme, the species composition of Lake Ngami just before it last dried up in 1982 was reduced to only two species of catfish.

The vast majority of Okavango fishes falls into 13 families which are detailed in Table 6.11. A full species list for the Okavango system (after Skelton et al., 1985) is given in Appendix J.

6.5.3 Habitat types

Merron and Bruton (1988) recognise 5 major divisions of the Okavango Delta ecosystem which apply to the fish fauna. These are:

i. Riverine Panhandle
ii. Upper swamp
iii. Lower swamp
iv. Drainage rivers
v. Sump lakes

TABLE 6.11 THE IMPORTANT FAMILIES OF OKAVANGO FISHES

FAMILY	SPECIES	POPULAR NAMES
Mormyridae	6	Parrotfish/Bulldog/Bottlenose
Characidae	3	Robbers & Tigerfish
Hepsetidae	1	African pike
Distichodontidae	3	Citherines
Cyprinidae	16	Barbs
Bagridae	2	Grunter & Catlet
Schilbeidae	1	Silver catfish
Clariidae	4	Catfish
Mochokidae	5	Squeakers
Poeciliidae (cyprinodontids)	3	Topminnows
Cichlidae	17	Bream
Anabantidae	2	Climbing perch
Mastacambelidae	1	Spiny eel

Many of the species are found distributed throughout the study area. A few are confined to the panhandle and permanent swamp (e.g. Hydrocynus forskahlii and Aplocheilichthyes johnstoni), a few to the rivers of the lower seasonal swamp (e.g. Hepsetus odoe and Serranochromis thumbergi) while others (e.g. Barbus paludinosus and Tilapia ruweti) are peripheral in their distribution.

6.5.4 Species caught by gillnetting

Collections were made regularly throughout a 3-year study at all of these sites (except sump lakes, which were dry throughout the study) using gill nets of various sizes. An analysis of the catch by mass contributions in each habitat was made for nine selected commercially and ecologically important species which together accounted for approximately 80% of the total mass. The results are presented in Table 6.12

TABLE 6.12 PERCENTAGE CONTRIBUTION BY MASS TO CATCHES IN DIFFERENT HABITATS

	HABITATS			
SPECIES	Drainage rivers	Lower swamp	Upper swamp	Riverine Panhandle
Marcusenius macrolepidotus	5	3	2	2
Brycinus lateralis	7	6	3	2
Hydrocynus forskahlii	0	0	29	28
Hepsetus odoe	18	21	2	4
Clarias gariepinus	21	17	22	20
Schilbe mystus	23	24	6	7
Oreochromis andersonii	16	11	14	15
Serranochromis angusticeps	3	9	14	17
Tilapia rendalli	7	6	8	5

It can be seen that the percentage mass composition of the selected species is identical in the Panhandle and the upper swamp (Cakanaca lediba). It is characterised by major contributions of the tigerfish (H. forskahlii), catfish (C. gariepinus) and the cichlids (O. andersonii and S. angusticeps).

In the lower swamp (Nxaraha lediba), marked changes occur in the catches; the tigerfish disappears and the catches are dominated by the silver catfish (S. mystus) and pike (H. odoe). Catfish and cichlids decrease their mass contributions.

In the drainage rivers (Thamalakane and Boteti) silver catfish, pike, catfish and the cichlid O. andersonii dominate in fairly even proportions by mass.

6.5.5 Other species.

These are mainly smaller fish, which do occur in very large numbers in some habitats. Approximately 10% over all habitat types represent juveniles of the large cichlid species. They were sampled at 10 localities by means of seine nets and rotenone poisoning. A summary of the findings is given in Table 6.13.

This analysis demonstrates the marked differences which exist between fish populations in different areas of the Okavango. Overall the most numerous fishes are the barbs (Cyprinidae), topminnows (Cyprinodontidae), "sardines" (characins) and some of the cichlid species, especially T. sparrmanii.

In terms of biomass, the cichlids, especially T. sparrmanii and T. rendalli contribute most (30%). Important non-cichlids are the pike (H. odoe), bulldog (M. macrolepidotus), barbs and the silver catfish (S. mystus).

Cyprinids are especially predominant in river channels and madiba in the upper habitats but also in the lower seasonal floodplains. Generally, in floodplains and drainage rivers they give way to cichlid species.

Characids, especially B. lateralis, are prominent in the madiba associated with the panhandle and upper swamp.

6.5.6 Seasonal movements.

According to Merron and Bruton (1988), seasonal movements may be divided into two types:

i. Lateral migration, e.g. movement from the floodplains to the main channels in response to receding water levels, and the reverse. This is exhibited by many cyprinids, cyprinodontids and certain size classes of tigerfish (H. forskahlii), silver catfish and bulldog.

ii. Longitudinal migration, up and down main channels e.g. larger tigerfish and catfish move downstream in response to the low water movement of laterally migrating prey species back into the channel.

TABLE 6.13 RELATIVE NUMBERS AND BIOMASS OF SMALLER FISHES SAMPLED AT DIFFERENT SITES IN THE OKAVANGO DELTA

	Number %		Biomass %	
1. Riverine Panhandle:				
a. Mainstream	Distichodontidae	21	Cichlidae	57
	Cyprinidae	21	Mochokidae	7
b. Floodplain	Cyprinidae	38	Cichlidae	42
	Cyprinodontidae	29	Clariidae	18
c. Floodplain madiba	Cichlidae	24	Cichlidae	66
	Characidae	21		
	Cyprinidae	16		
	Cyprinodontidae	14		
2. Upper Swamp:				
a. Madiba	Characidae	30	Cichlidae	35
	Cyprinodontidae	24	Cyprinodontidae	23
	Cyprinidae	13	Characidae	22
b. Floodplain	Cichilidae	62	Cichlidae	60
	Characidae	8	Clariidae	11
			Hepsetus	6
c. Rain pools (mainly unconnected)	Cichlidae	52	Cichlidae	68
	Cyprinidae	34	Cyprinidae	12
			Clariidae	7
3. Lower Swamp:				
a. Boro/Nxaraha lediba	Cyprinidae	33	Cichlidae	74
	Cichlidae	21	Hepsetus	4
	Cyprinodontidae	19	Clariidae	3
b. Floodplain	Cyprinidae	38	Clariidae	75
	Cyprinodontidae	37	Cichlidae	15
	Cichlidae	12		
4. Drainage Rivers:				
a. Thamalakane	Cichlidae	30	Cichlidae	55
	Cyprinidae	26	Cyprinidae	6
			Hepsetus	6
			Mormyridae	6
			Schilbe	4
b. Chanoga lediba	Cichlidae	49	Cichlidae	65
	Cyprinidae	14	Cyprinidae	12

A third group of fish react to lowering water levels by residing in floodplain madiba e.g. pike (H. odoe) and certain sizes of silver catfish and bulldog.

On a far greater and less specialised scale there is huge annual movement of fish from the central swamp into the lower newly flooded/seasonal swamp and drainage rivers to repopulate areas.

6.5.7 Trophic relationships

The annual inundation of the shallow floodplains results in a nutrient pulse into the aquatic system from detritus, animal dung etc. This is probably the most important factor influencing fish productivity in the Okavango. Floodplains grazed by wild or domestic ungulates are highly productive, in terms of reproduction, although because of the preponderance of juveniles, fishing yields may actually be lower than in permanent water bodies. A related phenomenon is the observed higher fish stock in lagoons populated by hippo and the high yields obtained from Lake Ngami when it is inundated (Fox, 1976).

The vast majority of fish in the Okavango are either detritivores, epiphytivores/insectivores or piscivores. Only one species, the red-breasted tilapia (T. rendalli) is truly herbivorous (Merron & Bruton, 1988).

These food preferences are also reflected in seasonal movements. Detritus feeders move from the floodplains into the mainstreams at low water, whereas piscivores, like the tigerfish, tend to move longitudinally and more extensively. Omnivorous fish like the squeakers (Synodontis spp.) show little, if any seasonal movements.

6.5.8 Breeding

It appears that the major influence on breeding season for most species is the flood cycle. Apart from directly stimulating spawning, it also provides seasonally inundated littoral areas for nurseries.

In the lower swamp and drainage rivers spawning takes place mainly between September and December which coincides with suitable water levels and high temperatures.

In the upper swamp and panhandle many species, especially non-cichlids, synchronise spawning with increased water levels in February and March e.g. catfish. Many cichlids and the tigerfish however, retain their warm water spawning pattern in these habitats regardless of the flood. Tigerfish in particular have a truncated spawning season from September to December.

6.5.9 Fisheries

Different species of fish are of varying importance to each sector of the fishery. A brief summary of the most important in each

category is given below:

a. COMMERCIAL

Brycinus lateralis
Barbus poechii
Schilbe mystus
Clarias gariepinus
C. ngamensis
Oreochromis andersonii
O. macrochir
Serranochromis angusticeps
S. robustus jallae
Tilapia rendalli

b. RECREATIONAL

Hydrocynus forskahlii
C. gariepinus
C. ngamensis
O. andersonii
O. macrochir
S. angusticeps
S. robustus jallae
T. rendalli

C. TRADITIONAL (little known, probably several others are taken)

H. forskahlii
B. poechii
C. gariepinus
C. ngamensis
O. andersonii
O. macrochir
S. angusticeps
S. carlottae
S. codringtoni
S. giardi
S. robustus jallae
S. thumbergi
T. rendalli

Knowledge of the ecology of the important fish species and their environment is of the utmost importance in the management of the fishery. Maximisation of sustainable yields, avoidance of conflict between the sectors by zoning, and the imposition of fishing seasons are examples. Great care should be taken, in any exploitation of the fishes of the Okavango, that adequate research and record-keeping, aimed at preventing over-fishing, is initiated and maintained.

The tigerfish is essential to the recreational sector. It is limited almost entirely to the Panhandle and upper swamp habitats. Recent data (Merron and Bruton, 1988) show that tigerfish sizes are declining. This, coupled with the knowledge of the species

short breeding season is enough to institute protective measures such as a closed season and the compulsory returning of all except the largest trophy fish by the recreational sector.

Current information suggests that commercial fishing could be developed more successfully in the drainage rivers and associated lagoons. In this respect, careful thought needs to be given to the possible effects of proposed water extraction schemes and the possibility of incorporating fish farming (Marshall in SMEC, 1987d, Vol II).

Experiments with netting techniques during recent surveys have shown a great potential for commercial exploitation of certain under utilised species, especially the silver catfish. This should be encouraged in order to relieve pressure on more popular species such as some of the cichlids. The development of fishing techniques using longlines to crop some of the larger catfish is also recommended (Merron and Bruton, 1988).

Finally, there is a serious shortage of basic limnological data for the Okavango. Before a full understanding of such a complex system can lead to adequate management, this shortcoming must be redressed.

6.6 HYDROBIOLOGY

Information on the hydrobiology of the Okavango Delta waters is the most significant gap in our knowledge of the Delta's biota and processes of ecosystem functioning. Though Thompson (1976) studied the primary productivity of macrophytes, there was no counterpart on the FAO/UNDP team studying algal primary productivity. Reavell et al. (1973) and Reavell (1977) report upon a limited series of water analyses and algal investigations undertaken from March 1972 to September 1974 in association with the Anglo-American dredging on the lower Boro River. Although no precise locality details are given by Reavell (1977) it appears that the studies were confined to the Boro and Thamalakane Rivers and extended to the Boteti and Mopipi outside the study area.

During the flowing-water (i.e. flood) period the phytoplankton was dominated by diatoms (Melosira and Synedra) with blue-green bacteria (Lyngbya and Gleotrichia) subdominant. In a backwater of the Thamalakane an euglenophyte, Lepocinclis, was dominant. During the stagnant water period of February - May 1983 diatoms were still dominant, but green algae (Chlamydomonas) became important in enriched pools.

In the perennial channels the diatoms Eunotia, Diatoma and Cyclotello were important, whereas in seasonal channels the desmids Micrasterias, Staurastrum and Cosmarium were predominant. Based on his studies Reavell (1977) concluded that phytoplankton growth (as assessed by chlorophyll extraction) was primarily limited by phosphorus, with nitrogen as a secondary factor. It is likely that more data is available in Reavell's thesis (Reavell, 1982) which has not been available to the team.

As part of the studies on the effects of endosulfan sprayed against tsetse fly, a COPR team studied zooplankton in some of the waters of the lower Delta - Boronyane stream (Russell-Smith, 1976) and Maphaneng and Manxunyane Pans (Douthwaite et al., 1981). All of these sites are close to Maun. Seasonal fluctuations in the densities of all zooplankton, Cladocera, Copepoda and Rotifera in the two pans are given as well as invertebrates associated with the macrophyte Najas pectinata broken down into Oligochaeta, Chironomidae, Trichoptera, Ephemeroptera, Copepoda, Cladocera and Ostracoda over a three month period (Douthwaite et al., 1981). These studies form a useful basis for further work, which should however be a longer term study undertaken with greater taxonomic precision. In the Boronyane stream Russell-Smith (1976) recorded the freshwater shrimp, Caridina africana as a component of the invertebrate drift, as well as larvae of Trichoptera (Oecetis sp.), Ephemeroptera, Simuliidae and Chironomidae. Other fragmentary information on aquatic invertebrates is available from various feeding studies of fish (Gilmore, 1979; Merron and Bruton, 1988) but once again, identification is to Order or Family.

The only hydrobiological study undertaken in the Panhandle is the six-day study of Hart (1986) at Seronga. The Okavango River, Seronga back-channel and Dungu Lediba were studied. In contrast with Reavell's findings in the lower Delta, PO_4^- - phosphorus values were high (range 61-110 $\mu g l^{-1}$). Phytoplankton was sparse in the river, but the diatom Melosira and the desmid Closterium were found. In Dungu Lediba the blue-green bacterium Microcystis was dominant. Zooplankton was sparse in the river, but diverse in Seronga back-channel (Diaphanosoma, Bosmina and an unidentified diaptomid being dominant). In Dungu lediba the zooplankton was dominated by a diaptomid and Diaphanosoma. Benthic invertebrates were also collect were also collected, and the shrimp Caridina africana was noted.

The paper by Cholnoky (1966) on the diatoms of the Okavango has not been available to the team. Judging by the length of the paper and the reputation of the author it is probably an important basis for the study of this group of algae.

It would seem that a thorough hydrobiological investigation of the perennial swamp is a most urgent need and should take into account primary production, algal and zooplankton communities and benthic invertebrates and the relationships between these.

No systematic surveys of the mollusc fauna of the Okavango appear to have been undertaken. Clarke (in SMEC 1987d, Vol I) recorded the following snails during a brief investigation of the snail hosts of schistosomes:

Biomphalaria pfeifferi
Bulinus (Physopsis) globosus
Bulinus (Bulinus) sp.
Bulinus (Bulinus) forskalii
Lymnaea natalensis
Gyraulus sp.
Lanistes sp.
Pila sp.

6.7 INVERTEBRATES

6.7.1 Tsetse Fly

The tsetse fly, Glossina morsitans, has long affected the ecology of the Okavango Delta, preventing the spread of domestic livestock and arable agriculture into the Delta proper from its margins. The history of tsetse and its control in Botswana has been reviewed by Davies (undated), and only a brief summary is given here. After the rinderpest epizootic in 1896, the death of large ungulates had reduced the tsetse fly in the Okavango area to two residual foci - one on Chief's Island and the other in the Kudumane area. By the time of Stigand's 1921 journey, tsetse had recolonised the whole Delta except for the western fringes and Panhandle (Davies, undated). By the 1960's the whole of the Delta was affected, including Tsao, Nokaneng and Etsha in the west and almost as far as Sepopa and Seronga in the north west (Fig. 6.8). This had resulted in considerable losses of rangeland previously used by cattle. Despite such control measures as game destruction and bush clearing (see section 5.8.5.7), by the mid 1970's the area affected by tsetse was not markedly reduced (Davies, undated).

After environmental impact studies and spraying trials (Davies and Bowles, 1979) ultra-low volume application of insecticides started in 1980 with the objective of eradication of tsetse from the Delta by annual clearance operations (Bowles, 1984). By September 1988 the limits of fly had been reduced substantially to those shown in Fig. 6.9, which is based on information obtained from Dr J Bowles, Chief Tsetse Officer, TFC, Maun. It is evident that eradication from remaining foci centred on Chief's Island will have to take place unless an expensive holding operation (which may be more damaging to the environment over the years than rapid eradication) is to be maintained.

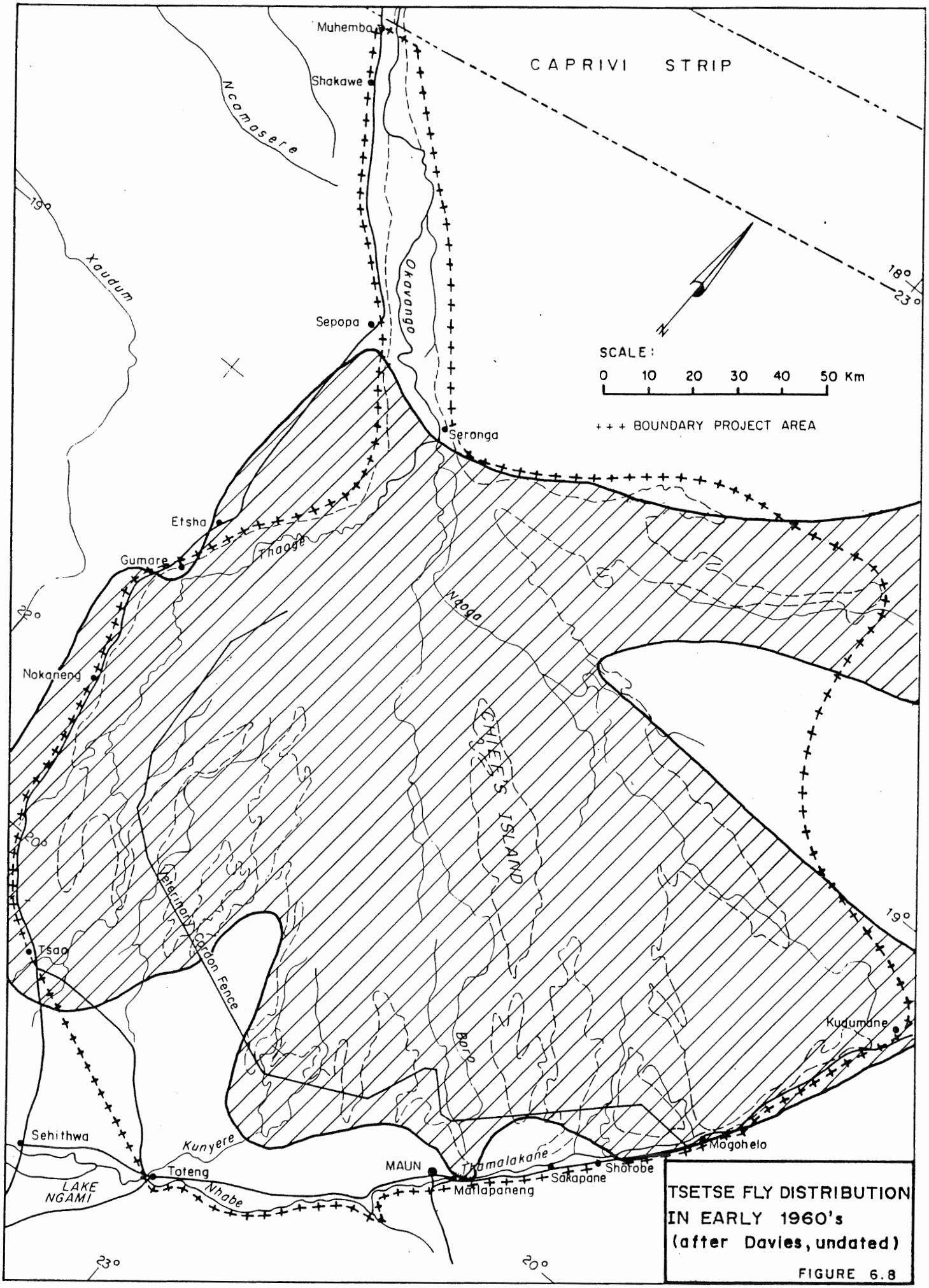
6.7.2 Non-target Invertebrates

In conjunction with studies aimed at assessing the environmental impact of ultra-low volume aerial applications of endosulfan against tsetse fly on fish and bird populations, a team from COPR studied the effects of spraying on non-target invertebrates (mainly arthropods). The results of these studies are contained in reports by Ali (1977), Ali et al. (1976) and Davies (1980). The results of the COPR team are summarised in UNDP/FAO (1977). The study sites in grassland or mophane woodland were all on the Delta margins with seven sites between Maun and Maqwee, one at Xene on the Sandveld Tongue and one at Ikoga south of Sepupa.

Monitoring of later spraying programmes was carried out by Games (1981, 1982). Although perfectly adequate for short term impact assessment purposes, the arthropods (insects and spiders) were only identified to Order or Family which renders these studies of little use as a basis for a resource inventory or for long-term monitoring purposes.

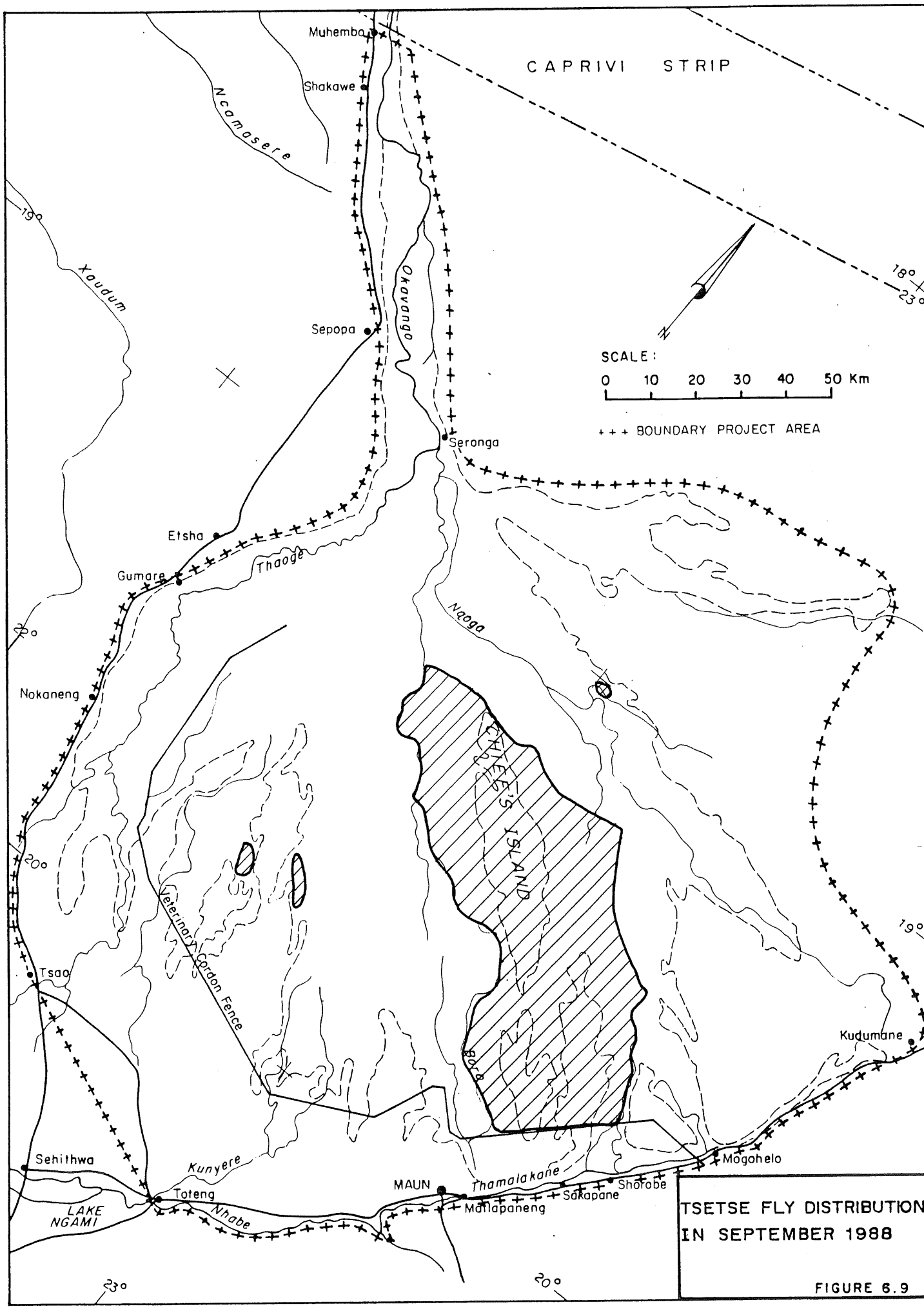
6.7.3 Insects of Agricultural Importance

UNDP/FAO (1977) list several insect pests affecting grain crops in



TSETSE FLY DISTRIBUTION IN EARLY 1960's (after Davies, undated)

FIGURE 6.8



TSETSE FLY DISTRIBUTION IN SEPTEMBER 1988

FIGURE 6.9

the Okavango area. These are American bollworm (Heliothis armigera), Spotted stalkborer (Chilo partellus), Army Worm (Spodoptera spp.) and Sorghum midge (Continaria sorghicola). In March-June 1988 localised outbreaks of Red locust (Nomadacris septemfasciata) and African migratory locust (Locusta migratoria migratorioides) were controlled by ground and ultra-low volume aerial spraying in various areas to the south west of the Delta (Mr Madwala, Crop Protection Officer, DOA, Maun, pers. comm.). These areas include Habu, Tubu and the Nxaraha Valley. Little appears to be known about these outbreaks, the species involved and the environmental impact of control measures instituted.

6.7.4 Invertebrates of Medical Importance

A summary of disease vectors and intermediate hosts of medical importance in the Okavango Delta has been recently made by Clarke in SMEC (1987d, Vol. I). The most important of these are undoubtedly the malaria vectors thought to be Anopheles gambiae (s.l.) and A. funestus (s.l.). As Clarke has pointed out a detailed investigation of the true identity of the species complexes of mosquito involved are necessary before sensible control measures can be instituted.

Both species of trematode causing bilharzia, Schistosoma haematobium and S. mansoni, are known to occur in the people of the Delta (Clarke in SMEC, 1987d, Vol. I). At present the prevalence of S. haematobium is low in the Maun area whilst the prevalence of S. mansoni is as high as 80%. Clarke found Biomphalaria pfeifferi (the intermediate snail host for S. mansoni) to occur throughout the Delta, but especially in the Thamalakane River, while Bulinus (Physopsis) gloposus (the intermediate snail host for S. haematobium) was found only in the upper Delta.

A thorough summary of other medico-ecological problems affecting or of potential importance to the Okavango Delta is given by SMEC (1987d, Vol. I). These problems include trypanosomiasis, hookworm, amoebiasis, trachoma, plague, leishmaniasis, filariasis, anthrax and echinococcosis.

6.7.5 Butterflies and Moths (Lepidoptera)

Pinhey (1968, 1971, 1974, 1976a) has produced a checklist of the butterflies of Botswana from which it has been possible to select several that seem to be of importance to the Okavango Delta study area. Eurema hapale (Pieridae), which has been collected in thick bush at Muhembo, shows an interesting disjunct distribution with the nearest populations being in east Zimbabwe extending northwards from there into East Africa. Acraea acerata (Acraeidae) has only been collected at Victoria Falls and Shakawe/Muhembo south of the Zambezi - Cunene, while Acraea onerata is only known from the type on the Okavango River. Sallya amulia intermedia (Nymphalidae) has been collected at Shakawe, a southward extension of its range in forest in Katanga and the Mwinilunga District of Zambia. The Marsh swift, Borbo micans (Hesperiidae) from Shakawe and Sepopa would appear to be an insect of swampy areas. Another butterfly associated with the swamps proper is Mylothris bernice attenuata, found in association with papyrus where its larvae

probably feed on Polygonum (see section 5.8.1). Some unusual butterfly records have been made in Maun in 1988 (T Liversedge, pers. comm.). Papilio nireus lyaeus is a range extension from Chobe and Pseudacraea boisduvali trimeni a range extension from south eastern Africa.

The mophane worm, the larva of Gonimbrasia (Acanthocampa) belina (Saturniidae) is locally important as a human protein supplement. It has even been suggested (UNDP/FAO, 1977) that a small rural industry based on the export of dried mophane worms could be developed in the Okavango region.

6.7.6 Dragonflies (Odonata)

Owing to the interest of two of the foremost taxonomists of the southern African Odonata (B I Balinsky and E C G Pinhey), this order is better known for the study area than any other group of invertebrates of similar numbers. According to Pinhey (1976b) 114 species of dragonflies are thought to occur in Botswana of which 84 (73.7%) are to be found in the study area. There are 29 species of damselflies (Zygoptera) from five families and 55 species of Anisoptera from four families, giving rise to the statement that the Delta is "one of the richest and most interesting Odonata ecosystems in southern Africa" (Pinhey, 1976b, p.526). Pinhey (1967) earlier hypothesised that the Okavango may have been the epicentre of the distribution of the group B species of the genus Pseudagrion, having all 11 species of group B and none of group A. Later discoveries of Pseudagrion fisheri, a group A species, from Xugana have detracted only slightly from this hypothesis, which could be fruitfully tested by students of evolutionary ecology.

6.8 PERCEIVED GAPS AND RECOMMENDATIONS

6.8.1 Wildlife

6.8.1.1 Aerial Monitoring programme

a) Systematic aerial monitoring of major large mammal distributions (approx 15 spp.) over the entire Delta at least twice yearly for a minimum of two consecutive years out of every five is suggested. The survey years should be decided according to local conditions, especially Okavango inflow and rainfall. The surveys should be conducted at the equivalent flood phase each time and all parameters standardised. Survey intensity should approximate the SMEC 1986 level of 20% cover, and each would take approximately 15 days' flying.

b) Smaller scale systematic survey flights covering selected habitats at much higher intensity should be conducted at certain phases of the flooding regime (four times a year). Each survey would take approximately six days' flying.

c) Stratified random censuses of important species should be flown annually. Bias correction flights for each species to be flown for varying conditions.

Surveys (a) and (b) are to provide long term information on area and habitat utilisation under different conditions. this is essential for basic management and land use planning; (c) is essential for useful population estimates and trends, and in particular for adequate management of hunting, e.g. quotas, culls, etc.

To properly carry out the above functions, a monitoring unit of pilot, biologist and three/four observers would expect to spend half of a working year based in Maun.

6.8.1.2 A Management Plan for Moremi Wildlife Reserve

A detailed practical management plan is urgently required. Careful consideration needs to be given to the terms of reference to ensure that it meets DWNP's immediate needs and is not aimed at unattainable goals. Main emphasis to be on tourist management (in the light of the new park entry fees), protection of sensitive areas, e.g. Gadikwe heronries, development of infrastructure (roads, fire-breaks, etc.), patrolling schedules, zoning and ecological monitoring.

6.8.1.3 Elephant-Habitat Interactions

A much vaunted but sadly neglected and badly needed long term study of elephant densities and their effects on the woodland in the tourist areas of 'old' Moremi in terms of biological conservation and amenity value. This should form part of a wider study covering other types of habitat in the elephant's recently expanding range and have a bearing on future elephant management strategies.

6.8.1.4 Species Studies

There is a need for studies to be made of a number of species of uncertain status, puzzlingly low density or limited distribution.

a) Sable - status, habitat requirements, population trends and seasonal movements.

b) Roan - as for sable. A potentially valuable trophy animal, at present officially protected for inapparent reasons.

c) Warthog - its role in seasonal floodplain ecology.

d) Waterbuck - status, distribution and habitat requirements.

e) Giraffe - justify its protected status or utilise it as a major meat producer. Population biology c.f., buffalo study in 1970's.

f) Impala - population trends and whether management is required in some areas, e.g. Moremi.

g) Bushbuck - status and distribution.

h) Sitatunga - population status, hunting and habitat burning pressure, seasonal movements, possible enhanced protection of core habitat areas.

6.8.1.5 Management Projects

a) A pilot game cropping feasibility study should be undertaken, aimed at meat production initially and involving RAD cooperatives (e.g., Kudumane). Potential species to be considered include lechwe, impala, warthog, giraffe, kudu, buffalo and elephant.

b) A detailed study of seasonal floodplain/herbivore habitat requirements as a possible bottleneck in the Okavango system's carrying capacity should be made. Species studies on impala, warthog, sable, roan and giraffe listed under 6.8.1.4 could form components of this major study.

c) A comprehensive ecological monitoring database should be developed at Ngami Data Services/Maun Wildlife Training Centre to be incorporated eventually in the proposed research station (UB). Initially this could be a natural extension of the present KCS Computer Licensing Project.

d) Okavango WMA Safari Operations and monitoring/management should be developed along the lines of the Matetsi Safari Area in north west Zimbabwe.

6.8.2 Birds

a) Studies on all aspects of the biology (breeding, feeding, migration, habitat requirements) of the Slaty egret and the Wattled crane are important priorities.

b) Management-orientated studies of the game bird species with a view to suggesting hunting seasons, quotas and bag limits consonant with numbers and biology.

c) A study of the importance of Panhandle relict forests to bird populations would be of great value.

6.8.3 Amphibians and Reptiles

6.8.3.1 Crocodile Movement and Breeding

As has been pointed out in section 6.4.2.1 the majority of the crocodiles nest in the Panhandle. If true, this means that there is a marked dispersal movement of hatchlings and juveniles, and an annual movement of females (perhaps males as well) to the Panhandle for breeding. This could be studied by radiotelemetric techniques and is most important in relation to the exploitation of the Panhandle nests by crocodile ranching activities in Botswana.

6.8.3.2 Surveys

Field surveys of amphibians and reptiles of any area in the Delta would add greatly to knowledge of distribution and biology. Suggested target study areas are the Panhandle and Moremi W.R., particularly the perennial swamp areas. Relative abundance and habitat specificity according to the vegetation types described in section 5.8 would also be useful data.

6.8.3.3 Breeding Biology of Frogs

Most arid-zone amphibians in Africa and elsewhere have their breeding cued by the first soaking rains. It would be interesting to examine the timing of breeding of Okavango frogs in relation to the progress of the flood through the Delta (Fig. 4.2) and again in relation to the onset of the rains.

6.8.3.4 Niche Overlap in Okavango Terrapins

With four species of terrapin occurring in the Delta it would be useful to know more about distribution, feeding, breeding and habitat requirements of these animals, especially in areas of sympatry.

6.8.4 Fish

a) Monitoring the effects of tsetse fly spraying activities on fish species and populations in various habitats is needed.

b) Detailed surveys of recreational, traditional and commercial fishing activities, interrelationships, effects on the stocks, management planning, e.g. separation by zoning or closed seasons, etc. would be useful.

c) The potential for commercial exploitation of the fish stocks needs to be carefully assessed in different parts of the Delta, preferably before there is any more expansion of the fishing industry.

6.8.5 Hydrobiology and Physicochemical Limnology

Lack of knowledge about the physicochemical limnology and hydrobiology of the Delta is arguably the most important gap in the current state of knowledge of the Delta. Apart from the work reviewed in section 6.6 nothing is known about phytoplankton, periphyton, zooplankton, benthic fauna and the bacteria and fungi of the swamps. Attention should be focussed on processes such as primary production, nitrogen fixation, decomposition and peat formation. Much remains to be learned about the chemical limnology, and even such a straightforward question as whether the primary production of Okavango waters are phosphorus or nitrogen limited, seems unclear. DWA has started to collect water quality data, but their programme needs to be supplemented to cover sites away from the main channels. In this connection it is encouraging to note that a group of scientists from the Universities of Lund (Sweden) and Botswana are seeking funding for a project covering chemical, phytoplankton and microbiological limnology, which should be encouraged.

6.8.6 Invertebrates

6.8.6.1 Surveys

It is obvious that much remains to be done in the Delta and its environs by way of collection, identification, taxonomy and zoogeographical work on all invertebrate groups. The insects are the most important of these, but annelids, nematodes (free-living and parasitic), molluscs and arachnids are all neglected. Traditionally these activities are undertaken by museums and it is suggested that collecting trips by museums such as the National Museum of Zimbabwe be supported until such time as the activities of the National Museum and Art Gallery are strengthened in this area.

6.8.6.2 Work on Termites

It seems invidious to single out one insect Order above all others, yet mound-building termites have been hypothesised to play an important role in the evolution of landforms and in Delta dynamics. It is suggested that work on termites start at a survey level before focussing on the above question.

6.8.6.3 Side Effects of Tsetse Spraying

Previous work on the environmental impact of tsetse spraying did not allow for identification of invertebrates to species level. As pointed out before (section 6.7.2) valid comparisons can be made between sprayed and unsprayed sites, but for longitudinal studies identification to species level is vital, and consideration should be given to the use of easily identifiable 'indicator' species of terrestrial and aquatic invertebrates.

7. PRESENT LAND USE

7.1 INTRODUCTION

Present land use (PLU) in the areas surrounding the Okavango Delta focuses on livestock rearing and subsistence field and garden crops. Land use within the Delta proper is extensive in nature and is dominated by tourism activities with minor intrusions, particularly in the recent drought, for agricultural purposes. Utilisation of the Delta's other natural resources such as non-resident safari hunting, citizen hunting, fishing and collecting and gathering activities as well as tourist safari operations are the prime determinants of land use patterns within the Delta.

The major objective of the present land use component of the Ecological Zoning was to update previously available data and compile a set of comprehensive maps at a scale of 1:100 000. The distribution of land use on these maps records the 1987/88 situation. If the present drought is followed by a cycle of wetter years (Tyson, 1986) the maps may, in effect, represent the maximum recent intrusion of agricultural land use into the Delta. The 1:100 000 present land use maps also include tourism-related infrastructure (e.g.safari and hunting camps, access tracks and mekoro trails) so that a land use data base is readily available for comparison with the ecological zoning maps. However, tourism is discussed separately in section 8 of this report.

When preparing the present land use maps, data were gathered on use of natural resources in the project area. These data, including comments on topics such as livestock grazing, use of plant resources (e.g. building materials and edible plants) fishing, citizen hunting and arable lands are summarised in tabular format.

7.2 ACKNOWLEDGEMENTS

The project was fortunate in having Ms H Bendsen, the District Agricultural Land Use Planning Officer, Maun, seconded to the project. Her knowledge, integrity and contribution are directly responsible for the completeness of the present land use maps and the resource utilisation data. An acknowledgement is extended to the Regional Agricultural Officer and the Ministry of Agriculture for permitting Ms Bendsen's participation in the project on behalf of not only the project team but also the project Steering Committee.

7.3 LAND USE DATA

7.3.1 Availability of Data

Detailed data of recent origin is available on land use in the Land Use Planning Zones surrounding the Delta. These data

include the following:

- Present Cultivation Practices in the Molapo of the Shorobe Area (Hopkinson et al., 1983)

- An Exploratory Survey of the Ngamiland Agricultural Development Project (Merafe and Bendsen, 1985)

- Land Use Planning - Ngamiland Communal First Development Area (CFDA) (Bendsen and Gelmroth, 1983)

- Land Use Trends and Problems in the Shorobe Area (Bendsen H, 1987)

- Land Use and Sociological Aspects of the Southern Okavango Integrated Water Development Study (SMEC, 1987d)

- Thaoge River Project - Evaluation Mission (Bendsen H et al., 1988)

- Land Use Planning Report for the Eastern Panhandle Areas prepared for the Ministry of Local Government and Lands (Bendsen, 1988)

In addition to these reports which provide coverage of land use practices, population data, historical perspectives and information on distribution of infrastructure, there are several references which provide insight into the culture of a variety of communities in the project area. These include:

- Pastoral Identity and Reluctance to Change: The Mbanderu of Ngamiland (Almagor, 1982)

- Grass Roots Land Tenure Among Yeyi of North Western Botswana (Sutherland, 1982)

- Traditional Use of the Okavango Delta (Campbell, 1976)

- Mokola Palm Experimentation and Extension Activities (Terry, 1987)

- A Survey of Plant Resource Utilisation by the Botswana Basket Industry in the CFDA, Ngamiland (Cunningham and Milton, 1982)

- Field Investigation into the Mokoro Industry (Murray-Hudson, 1988)

There are also numerous reports relating to specific land use situations/problems in the Delta. These are contained in the files of the DOL, Ngamiland District (L van der Heiden, pers. comm.). These files, although confidential in status, can be consulted at the discretion of the DOL for background data for land use planning purposes.

7.3.2 Data Presented on 1:100 000 Present Land Use (PLU) Maps

Considerable effort has been made to make the PLU Maps prepared for the Okavango Delta Ecological Zoning Project as comprehensive as possible. This includes the insertion of a direct reference to the facilities and services provided in individual villages through use of coded annotation. These data are summarised in Figure 7.1.

A copy of the legend included on each 1:100 000 map sheet is given as Figure 7.2. This illustrates the range of data on the PLU Maps.

7.3.3 Utilisation Modifiers

In order to facilitate subsequent land use planning and zoning for the Delta including the potential for direct comparison with ecological zoning maps between traditional use or specific purpose use, 'utilisation modifiers' have been mapped. These utilisation zones include the following aspects:

- bird viewing
- cultivation
- subsistence, recreational or sport fishing
- gathering of plant products
- water resource development
- tourist activities
- game viewing and consumptive uses of wildlife.

7.4 RESOURCE UTILISATION

Following the advice of the Steering Committee, as much data as possible on Present Land Use have been prepared in the form of tables. The major items in this respect are Tables 7.1-7.5 entitled 'Okavango Delta - Natural Resource and Land Utilisation'. These tables are based on the DLUPU Land Use Planning Zones in the project area and include point form data and comments relating to livestock (Item 1, each Table), use of plant resources (Item 2), fishing (Item 3), citizen hunting (Item 4) and arable land use (Item 5) for the particular DLUPU Land Use Planning Zone. Comments on areas used, the access and linkages with communities using these resources and notes on critical resource management problems, are made.

It is anticipated that Tables 7.1-7.5 will be supplementary to the PLU Maps.

Additional tables relate to the following:

Table 7.6 - List of Setswana and scientific names for trees and other plants referred to in Tables 7.1-7.5.

Table 7.7 - Summary of cattle distribution (i.e. population) by DLUPU Planning Zones. The comparative figures for August 1986 and September 1988 which illustrate the general effects of the recent drought on cattle population were obtained from MOA (1987-88).

FIGURE 7.1 FACILITIES AND SERVICES

Sector	Group	Facility / Service	Code	BEETSHA	ETSHA 6	ETSHA 13	GUMARE	GUNITSHUGA	HABU	IKGOGA	KAUKWI	KOMANA	MABABE	MATLAPANENG	MAUN	MOGOTLHO	NCAMASERE	NGARANGE	NOKANENG	NXARAHA	SANKUYU	SEHITHWA	SEPUPA	SERONGA	SHAKAWE	SHOROBE	TOTENG	TSAO	TUBU	XAKAO	XAOGA
AGRICULTURE	Veterinary Extn.	Principal Veterinary Officer	PVO												X																
		Senior Veterinary Officer	SVO												X																
		Veterinary Officer	VO												X																
		Livestock Officer	LO				2								4				X			–			X			–			
		Veterinary Assistance	VA				2			–					3							X	X	X	X	X		X			
		Stock Inspector	SI																								X				
	Facilities	Rural Training Center	RTC																	X											
		Botswana Agricultural Marketing Board	BAMB												X																
		Marketing Cooperation	MC		X																										
		Botswana Livestock Devl. Corporation	BLDC												X				X				X								
		Botswana Meat Commission	BMC												X																
		Livestock Advisory Centre	LAC				X								X										X						
	Agric. Extn.	Regional Agricultural Officer	RAO												X																
		District Agricultural Officer	DAO				X								X																
		District Agricultural Supervisor	DAS				2								2																
		Agricultural Demonstrator	AD	X	–		X					X		X	X		X		X	3		X	X	X	X	X	X	X		X	
		Agricultural Demonstrator (Fisheries)	AD(F)																					X	X						
		Permanent Field Assistant	PFA												X	X		X													
		Permanent Field Asst. (Fisheries)	PFA(F)			X				X	X				X			X													
HEALTH		Hospital	H												X																
		Health Centre	HC				X																								
		Clinic	CL		X										X				X			X		X	X						
		Health Post	HP	X		X		X		X	X	X		X	2		X	X			X		X			X	X	X		X	X
		Family Welfare Educator	FWE	X	2	X	2	X		X	X	–		X	7	X	–	X	X		X	2	X	2	2	X	X	X		X	
EDUCATION		Primary School	PS	X	X	X	X	X	X	X	X	X	Pr	X	10	Pr	X	X	X		X	X	X	X	X	X	X	X	X	X	
		Community Junior Sec. School	CJSS				X								2 + 1 Pl							X			X						
		Secondary School	SS												X																
		Brigade	B												X										X						
		Vocational Training Centre	VTC												X																
	Trans-port	Central Transport Organisation	CTO				X								X										X						
		Airstrip - Dept. Civil Aviation	A-DCA				X								X				X					X	X			X			
		Airstrip - non Dept. Civil Aviation	A	X	X												X														
GENERAL	Comm. Dev.	Community Dev. Officer	CDO				X								X																
		Ass. Community Devl. Officer	ACDO		X		X								X							X	–	X	X			X			
		Community Devl. Assistant	CDA												X				X							X					
		Water Reticulation System	WRS	X	X	X	X	X	X		X	X	Pl	X	X		X	X	X		X	X	X	X	X	X	X	X	Pl	X	
		Post Office	PO		Pl		X								X							X			X						
		Police Station	P				Pl								X							X		X	X						
		Local Police	LP	2	1		5	2	2	2	2	2		2	17		2	2	2		1	4	2	2	5	2	2	2		2	
	Tribal Admin.	Paramount Chief (Regent)	PC												X																
		Senior Chief Representative	SCR				X								X							X			X			X			
		Chief Representative	CR																X				X	X		X					
		Headman of Court of Record	HCR	X	X	X		X		X	X	X		X		X	X	X			X						X			X	
		Headman of Arbitration	HA				X						X		X							X		X	X						

Note:- Pl: Planned, Pr: Private, X: Existing, 2: No. Officers, —: Discontinued

LEGEND AND REFERENCE

1. INFRASTRUCTURE

- Major Village - GUMARE
- Villages - SAKAPANE
- Paved Road
- Unsealed Roads
- Access Tracks
- Bridges (not labelled)
- Pontoon (labelled)
- Ferry (CTO)
- Airstrip/airport (labelled)
- Trek Route (existing or proposed)
- Veterinary Cordon Fence/Drift Fence
- Cutline or Firebreak

2. LAND STATUS AND USE

- Wildlife Reserve National Park or Game Sanctuary Boundary
- Ngamiland Statelands Boundary
- Crush (62) - Dept. Animal Health Foot and Mouth Vaccination Crush with Sept. 1988 Figures
- Cultivated Fields - 1987/88
- Abandoned Fields - 1987/88
- Irrigated Fields - 1987/88
- BH - Borehole
- W - Well
- DWNP or DAH Camp/Campsite boats
- DWA Camp/Campsite
- DWA Hydrological Installation
- Trek Routes on Floodplains (position approximate)

3. TOURISM FACILITIES AND RELATED USE

- Tourist Lodge/Safari Camp with Chalets/Rondavels
- Safari Camp - Permanent Tents or Reed Huts on Concrete Slabs
- Safari or Hunting Camp - Temporary Tents
- DWNP or other Public Campsite
- Casual Campsite (known to be used)
- Channel Permanent Blockage
- Channel Temporary Blockage
- Traditional Mekoro Route (position approximate)
- Horseback Trail Route (position approximate)

4. UTILISATION MODIFIERS

- (U) - Landscape Unit utilised extensively for purpose indicated by modifier.
- U_b - Area utilised for bird observation and/or hunting by safari camp operators.
- U_c - Area traditionally used for cultivation of field crops.
- U_f - River, lediba, channel section used for subsistence, recreational or commercial fishing.
- U_g - Area utilised for gathering of plant products particularly, thatching grasses, sedges and/or reeds.
- U_h - Area developed or designated for water resource (hydrological) development.
- U_t - Area extensively used for tourist activities, particulary game viewing using 4-wheel drive vehicles, boats or mekoro.
- U_w - Area specifically used for game viewing or utilization.

5. ABBREVIATIONS FOR FACILITIES AND SERVICES

5.1 AGRICULTURE

PVO	Principal Veterinary Officer
SVO	Senior Veterinary Officer
VO	Veterinary Officer
LO	Livestock Officer
VA	Veterinary Assistance
SI	Stock Inspector
RTC	Rural Training Center
BAMB	Botswana Agricultural Marketing Board
MC	Marketing Cooperation
BLDC	Botswana Livestock Devl. Corporation
BMC	Botswana Meat Commission
LAC	Livestock Advisory Centre
RAO	Regional Agricultural Officer
DAO	District Agricultural Officer
DAS	District Agricultural Supervisor
AD	Agricultural Demonstrator
AD(F)	Agricultural Demonstrator (Fisheries)
PFA	Permanent Field Assistant
PFA(F)	Permanent Field Asst. (Fisheries)

5.2 HEALTH

H	Hospital
HC	Health Centre
CL	Clinic
HP	Health Post
FWE	Family Welfare Educator

5.3 EDUCATION

PS	Primary School
CJSS	Community Junior Sec. School
SS	Secondary School
B	Brigade
VTC	Vocational Training Centre

5.4 TRANSPORT

CTO	Central Transport Organisation
A-DCA	Airstrip - Dept. Civil Aviation
A	Airstrip - non Dept. Civil Aviation

5.5 COMMUNITY DEVELOPMENT

CDO	Community Development Officer
ACDO	Ass. Community Development Officer
CDA	Community Development Assistant

5.6 TRIBAL ADMINISTRATION

PC	Paramount Chief (Regent)
SCR	Senior Chief Representative
CR	Chief Representative
HCR	Headman of Court of Record
HA	Headman of Arbitration

5.7 OTHER

WRS	Water Reticulation System
PO	Post Office
P	Police Station
LP	Local Police

ECOLOGICAL ZONING
OKAVANGO DELTA

LEGEND FOR PRESENT LAND USE AND TOURISM MAPS

FIGURE 7.2

Table 7.8 - Detailed cattle populations by crush locations on individual map sheets including totals for each map sheet and comparative population figures for August 1986 and September 1988 (obtained from MOA, 1987-88).Table 7.9 - Summary of human populations in DLUPU Land Use Planning Zones comparing 1981 census figures with 1988-89 projected populations.

Table 7.10 - Numbers of FAP assisted fishermen in various DLUPU Land Use Planning Zones.

Separate documentation on tourism land use is included as Section 8. This section includes a series of tables (Tables 8.1 - 8.8) summarising data collected in the tourist camp survey. These tables, particularly Tables 8.3, 8.4, 8.7 and 8.8 contain information relating to land use by the Delta's safari operations. It is suggested that, together with Tables 8.2 - 8.8, Tables 7.6 - 7.10 are used as direct references when interpreting PLU Maps, particularly when considering specific DLUPU Land Use Planning Zones or specific locations (e.g. in utilisation zones in vicinity of safari camp development clusters).

7.5 SUGGESTIONS FOR RESEARCH ON PRESENT LAND USE OR LAND USE PLANNING

Numerous suggestions are made in Tables 7.1-7.5 under the right-hand column 'Special Comments Relating to Resource Use, Depletion and/or Management'. Most of these comments have implied existing or potential land use management conflicts or specific problems.

7.5.1 Panhandle Area - SCDA Zone 1

Present land use investigations for the project show that the Panhandle is a priority area for a comprehensive investigation relating to land use planning, allocation policy and areas requiring special measures to protect ecological resources.

Additional comments in respect of this aspect and included in Section 9 relating to 'pressure points' for ecological zoning and subsequent planning for the Delta.

The suggestion in Table 7.1 (Item 3) about a fisheries resource inventory and management plan for the Panhandle Area is strongly recommended (see also Section 8.12.2(c)) referring to recreational fishing research).

7.5.2 Western Fringe Area - CFDA Zone 2

One of the more important problems relating to scarcity and potential long term resource depletion of mokolwane palms and sources of plant material for dye-making associated with the CFDA's basket-weaving industry will be investigated in detail under a bilateral aid project sponsored by the Government of the Netherlands over the next two to three years.

It may be noted that completion of the ongoing Thaoge River Flow Restoration Project (DWA - Government of the Netherlands) may change present land use downstream of Gumare to some extent.

7.5.3 Ngami - Zone 3

No specific land use research is required for this zone. The individual problems indicated in Table 7.3 should, however, be considered in land use planning/zoning projects for the Delta and in preparation of a management plan for the proposed WMA's covering this section of the project area. In this respect it is to be noted that the proposed Maun Reservoir, to be implemented by DWA, will have an outlet to supply water to Lake Ngami and possibly for cattle watering in that area.

7.5.4 Maun Area - Zone 4

Land use and zoning projects in the Maun area which are referred to in Table 7.4 and are considered to be priority items include:

a) Conservation/management requirements for firewood and sources of poles in the Maun area and other major villages in the Maun/Shorobe corridor.
b) A detailed investigation into thatching grass and reed collection, including areas used, economic structure of the commercial aspects (e.g. role of middleman), conflicts over burning practices (see Item 4, Table 7.4) and needs for zoning commercial vs traditional gathering areas in the context of accessibility to benefit traditional users.
c) Land use planning, land use allocation and protection needs in areas to be affected by proposed water resource developments, i.e. Maun Reservoir, Matlapaneng Storage Scheme and Lower Boro River Works areas. (It should be noted that there are ongoing discussions (i.e. March 1988) on these matters involving DLUPU, MLGL, DWA and SMEC as consultants to DWA for these projects.)

7.5.5 Delta Zone

The priority items requiring specific inputs in respect of land use problems in the Delta Area - Zone 8 as indicated in Table 7.5 are the following:

a) A resource inventory and investigation of the ecological significance of the extensive Hyphaene palm belt between the Boro and Santantadibe Rivers (south of Chief's Island and including the Chitabe/Gabadum area) noted as a P_v area on the Ecological Zoning Maps.
b) Thatching grass/reed collection and needs for land use planning for village purposes in the Khwai area, particularly as this area could receive additional pressure for campsite development or from indiscriminate use subsequent to the increase in entrance fees to Moremi W.R. as noted in Section 8.11.
c) Investigations into the existing or potential land use conflicts in the Daonara/Ditshipi area between traditional agricultural use and increasing use of the area for tourism (particularly mobile safari operators). This area would also be affected by increased pressure due to changes in the entrance fees for Moremi W.R. as noted in (b) above and Section 8.11.

TABLE 7.1 - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

PANHANDLE - SCDA ZONE 1

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
1. LIVESTOCK			
1.1 Livestock Trekking	a) Okavango River floodplain Dongu to Ikgoga corridor	Cattle from Mokgatsha to Beetsha on eastern side are trekked to markets. Trek involves at least 10 km floodplain crossing (3 channels) and 20 or 80 km trek to Sepupa or Nokaneng cattle markets (BCU).	Stock losses common due to predation; local communities want local buying at Seronga.
	b) Eastern floodplain Mokgatsha to Muhembo East	Cattle trekked on floodplain, then trucked via Muhembo ferry to Sepupa BCU.	
	c) Jao/Jedibe floodplain grazing	From east Seronga-Etsha-Jao and from west Sepupa/ Ikgoga-Saboro-Jao over distance of 40-60 km.	Seronga crossing used infrequently but Sepupa-Jao trek route used heavily in past 2 years.
1.2 Floodplain Grazing	a) West Bank - Ikgoga Area	Mainly used on a seasonal basis	Seasonal cattle movement between dryland and floodplain is 25 km depending on availability of water and grass.
	b) East Bank - Muhembo-Beetsha	" " " "	
	c) Kabamukuni and nearby islands	Cattle originate mainly from Seronga-Beetsha on a mafisa basis.	Proposed veterinary cordon fence from Duba Island to Sandoroka Lediba will limit potential intrusion into the Delta. Total cattle in zone are 24,000, of which 9,000 are on west bank and 15,000 on east bank. Tsetse fly eradication has resulted in grazing areas being extended back to east of Seronga as far as Matswee and south to the bigger floodplain islands.
2. PLANT RESOURCES			
2.1 Firewood	Immediate vicinity of local villages except at Shakawe.	Mainly collected by ox and donkey drawn sledges.	Only scarcity in immediate vicinity of Shakawe and Kauxwi where travel of 5-10 km is common.
2.2 Building Materials			
2.2.1 Poles	Mophane used at Ikgoga, Mogotho, Seronga /Beetsha for fencing and building. Mogonono, motsiara, mukwa, mukusi, motswiri and mogotho in all other areas.	Generally collected within 5 km radius of village.	No known shortages but potential conflict if planned forest concession areas extend too close to villages, particularly for mukwa and mukwsi.
2.2.2 Mekoro	Mukwa, mukusi and mpororo are preferred species with mokutshumo and moporota as secondary choice in Shakawe/Ikgoga area.	Preferred species sought up to 20 km inland from river front villages.	Old mekoros used as sledges. Scarcity not yet obvious but increased demands for mekoros for tourism and sub-sistence fishing could create shortages in selected areas (e.g. east bank with 200 subsidized fishermen).
2.2.3 Reeds	Generally abundant locally.	Harvested by mekoro in immediate vicinity at local lediba or river bank.	No shortages likely to occur.
2.2.4 Thatching Grass/ Sedges	Mokamakama is preferred if local rains abundant. Motsigitsane is second choice. In dry years tall floodplain grasses/ sedges (moxaa and moxaxa) used for thatching.	Go into dryland as far as Tsodilo Hills (30 km). Floodplain grasses collected from perennial swamp.	In dry years, tall sedges are substituted and are readily available locally (i.e. within 3-5 km of most villages).

TABLE 7.1 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

PANHANDLE - SCDA ZONE 1

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
2.3 Edible Plants			
2.3.1 Mongongo nut	Harvested from dryland woodlands.	Widely used by villagers in Panhandle area.	No shortage known or anticipated.
2.3.2 Mochope root	Tree root pulverised and mixed with meat during sparse times.	Dryland bushes common to village margins and accessible areas.	" " " "
2.3.3 Morotologa wakgomo	Grape size berry eaten raw	" " " " " "	" " " "
" wapudi	" " " " "	" " " " " "	" " " "
2.3.4 Mokgomphata moretlwa, mogwana	Small berries eaten raw or to brew kadi (beer).	" " " " " "	" " " "
2.3.5 Morula fruit	Eaten raw, brewing beer and nut crushed for oil.	Trees common in riverine fringe areas. " " " " "	" " " " " " " "
2.3.6 Tsaro palm dates	Fruit eaten raw.	" " " " "	" " " "
2.3.7 Mowana nut pulp	Dry pulp chewed.	" " " " "	" " " "
2.3.8 Motsaudi fruit	Eaten raw.	" " " " "	" " " "
2.3.9 Mogorogoroana	Monkey orange pulp	" " " " "	" " " "
2.3.10 Motshaba	Fruit eaten raw	" " " " "	" " " "
2.3.11 Mokutshumo	Raw fruit eaten.	" " " " "	" " " "
2.3.12 Koma	Papyrus roots eaten as vegetable	Aquatic plants collected from floodplains.	" " " "
2.3.13 Tswii/nxoma	Water lily bulb and stems eaten as vegetables	" " " " "	" " " "
2.3.14 Makongara bulb	Crushed and mixed with meat	" " " " "	" " " "
2.3.15 Thepe and morogo	Used as spinach.	Collected from around villages.	" " " "
2.3.16 Honey and tobo	Honey collected from hives in trees; tobo from mophane bees.	Infrequently found and collected as incidental activity.	" " " "
2.4 Handicraft Materials			
2.4.1 Mokolwane	Collected only from west side of Panhandle.	Generally local or obtain leaves on trips to suitable areas.	Special use of mokolwane by people of Gunitsuga from island in Kabamukuni area to make hats.
2.4.2 Dye Making Sources	Collected locally as required.	No key areas or villages.	No shortage of dye materials.
2.4.3 Papyrus and Reeds	Used for sleeping mats and mabinda mats.	Both commonly used and occasionally sold in Maun or to safari camps as decorative linings for ceilings, walls, etc.	Definitely no shortage of materials.

TABLE 7.1 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

PANHANDLE - SCDA ZONE 1

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
2.4.4 Wooden furniture (mukwa mukusi)	Chairs, tables, beds, pots and carvings.	Sold locally.	No shortage of materials.
3. FISHING	Back channels and madiba are preferred areas, with most households involved to some extent. More developed on east bank and based on bream and barbel.	Using mekoro from village or stored at lediba and nets set twice per day.	Mainly subsistence but surplus salted, dried and sold through Fisheries Unit to Drought Relief. East bank has 115 subsidised fishermen and west bank has 66 with an additional 8 commercial and 2 fishing groups. Resource inventory and fisheries management programme needed for Panhandle area to cater for subsistence recreational and commercial long term demands.
4. HUNTING			
4.1 Muhembo East to Seronga	Dryland hunting in CHA5 and 7. CHA7 is preferred as it is good for buffalo, zebra, kudu and other antelope.	Travel by donkey or horse on 7-10 day trip, often covering 60-70 km.	Zebra skins sold to BGI. Delays in distribution of hunting licences are a common complaint.
4.2 Muhembo West to Ikgoga	Villagers use mainly CHA15 for wildebeest and zebra and CHA5 for buffalo, lechwe and kudu. Sepupa and Ikgoga residents use CHA15 for zebra and travel to Jao for buffalo.	Use donkeys to hunt CHA15, and mekoro and by foot to CHA5. Mekoro trips Ikgoga to Jao area involve some 30-40 km.	Only zebra skins are sold. Meat dried at hunting camp and transported as biltong.
4.3 Seronga to Xamxwe	Use mainly CHA7 for hunting with buffalo, wildebeest, kudu and zebra.	Donkeys mainly used as transport.	" " " " " "
5. ARABLE LANDS Total Cultivated Area for SCDA is 13,000 ha all of which is dryland cultivation. Scattered molapo cultivation at Kabamukuni and other islands again since 1986.	Shifting cultivation around Shakawe and Kaukwi/Xakao has shifted 1-2 km inland due to crop damage by livestock.	Fields are located up to 20 km from villages in old dune valleys on both sides of Panhandle. Ploughing only possible after extended rain when water is available for draught animals and humans from local pans.	Group participation for fencing, ploughing, destumping, etc is commonly practised by Hambukushu. Availability of new lands not a restriction unless areas close to roads and villages are incorporated into forest concessions.

TABLE 7.2 - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

WESTERN FRINGE CFDA - ZONE 2

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
1. LIVESTOCK			
1.1 Trekking to Delta	a) Tubu Island to Jao area.	Taken via Nxara Island around cordon fence to Jao and Guda - 40-50 km.	Trekking from 1986-1988 during drought period and cattle under mafisa agreements.
	b) Etsha 4 and 5 to Jao area.	From Etsha 4 via Qoromoxe and from Etsha 6 via Qaaxhwa/ Weboro madiba corridor to Jao and Guda- 35-45 km.	" " " " "
1.2 Floodplain grazing	Habu, Nokaneng and Gumare floodplain areas.	Traditional communal grazing areas along Thaoge flood plains with heavy stock increases in Xara/Jao area in past 2 years (e.g., up to 3,700 cattle in 1988).	Overgrazing; subject to severe soil erosion by wind; heavy stock losses during drought as evident from crush figures of 46,100 in 1985 vs 21,200 in 1988; for CFDA Zone 2 (i.e. a 54% decline in cattle numbers over three years). Potential conflict exists due to cattle intrusion into Delta around cordon fence in dry years.
2. PLANT RESOURCES			
2.1 Firewood	Around local communities	Up to 10 km into dryland areas via ox drawn sledge.	Gumare area experiencing depletion of local firewood resources.
2.2 Building Materials			
2.2.1 Poles	Mainly mogonono and mogotlho from dryland areas.	Generally up to 10 km plus, but no more than 20 km. from village.	Shortage of fencing poles in molapo areas so cattle damage to crops through poorly constructed fences made from ALDEP and ARAP provided materials.
2.2.2 Mekoro	Primarily in northern Etsha area using mopororo.	Obtain from local riparian fringe woodlands.	Mekoro not now prevalent due to drought and only last 5-7 years.
2.2.3 Reeds	Etsha communities have sources in close proximity.	Transported via ox sledge or carried.	No problem now or likely to occur.
	Gumare area source depleted so collected from Xara, Ngojo (east of Thaoge/Tubu north) and Mawashire and Qhego areas (betweenThaoge bypass and river).	" " " " "	Resource is scarce due to drying up of Thaoge River.
	Nokaneng source mainly in Karongana area.	Generally found within 8-12 km.	Minor problems of supply during drought but basic resource judged sufficient for long term needs.
2.2.4 Thatching Grass/ Sedges	Mokamakama is preferred species. Motsigitsane is second choice and Motoshzo is third choice for use during drought.	Collecting area for Etsha outside cordon fence but for Gumare and Nokaneng collection in Karongana area is both outside and inside cordon fence as far as Matsebi if using vehicles. Usually within 15-20 km using ox sledges from village to near fence.	Mainly for domestic use; not exploited commercially.
2.3 Edible Plants			
2.3.1. Mokolwane palm	Mokolwane palm pericarp used as fruit and stem core used as vegetable (gau).	Collected from Tubu area incidental to other activities (e.g., cultivation of fields).	No shortage at Gumare and Nokaneng but depletion of palms in Etsha area (see below).
2.3.2 Tsaro palm	Dates eaten raw.	Sasanawenda, Shadishadi, Qabaga and Ngojo areas.	No shortage known.

TABLE 7.2 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

WESTERN FRINGE CFDA - ZONE 2

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
2.3.3 Morula	Used as a fresh fruit and for making wine, and nuts used for oil	Floodplain and riverine areas.	No shortage known.
2.3.4 Tswii/nxoma	Water lily bulbs (tswii) cooked, crushed and mixed with meat dishes and stamen of flower is used as vegetable (koma).	Collected from madiba and channels.	" " "
2.3.5 Tsita	Roots of reed eaten as a vegetable.	Occurs in blocked Thaoge channels and wet floodplains.	" " "
2.3.6. Motsintsila	Fruit eaten fresh or dried.	Occurs in riverine fringe vegetation.	" " "
2.4 Handicraft Materials			
2.4.1 Mokolwane palm	New growth leaves used for basket-making. Etsha area - Wabe Lediba and Qoroga Island.	Travel by foot and/or mekoro by groups of women and often over 10 km into permanent Delta areas.	Estimated 1500 basket makers in Etsha area making on average 7 baskets annually using three leaves per basket. Depletion of local palm a problem.
	Gumare area - Tubu, 25-35 km Mawashire, Qhego - 15 km Qabaga Lediba - 25 km Quwa - 20 km, Ngojo - 35 km.	Basket materials collected in conjunction with other activities (e.g. cultivation and grazing areas).	Estimated 400 basket makers in Gumare area. Botswanacraft spends P250,000/year for purchase (wholesale price) of baskets in CFDA Zone 2.
	Nokaneng and Habu area.	Collected from Karongana area as a secondary activity and limited commercial sale of baskets.	No shortage in Gumare and Nokaneng areas.
2.4.2 Dye Making Sources			
a) Motsintsila b) Mothakola c) Mohetsola bark and roots as dye	Etsha area - Xgara and Qgoro Gumare area - Quwa and Ngojo	Up to 6 hours walk from Etsha. Distances of 20-35 km common and generally in association with other activities.	Local women involved in basket making consider obtaining of dye materials as a constraint and sources to be scarce. Situation warrants further investigation.
3.0 FISHING	Etsha area - Wabe and Weboro Lediba. Gumare and Nokaneng areas important only in years of high flood - Thaoge and adjacent madiba.	Walking to mekoro left at lediba 5-10 km.	Fishing very much oriented to domestic consumption as opportunities arise. Only 3 FAP subsidised fishermen and one fishing group at Etsha 13.
4.0 HUNTING	Main hunting areas used are CHA15 and 16 (west of buffalo fence) and CHA9 (flood-plain). Main animal sought are buffalo, zebra and kudu.	Distance generally travelled is 30-40 km by foot and donkey using Nokaneng, Habu and Sasanawenda gates.	Floodplain hunting areas preferred. Zebra commercially exploited and also eaten by 2/3 of population. Buffalo biltong also sold commercially. Small game (steenbok) and birds (spurwing, egyptian goose, guinea fowl) also hunted. Ostrich exploited commercially.

TABLE 7.2 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

WESTERN FRINGE CFDA - ZONE 2

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
5. ARABLE LANDS			
5.1 Nokaneng Area	Potae River floodplains inside veterinary cordon fence.	Donkeys used for access and ploughing via Nokaneng Gate.	Nokaneng and Gumare Sub-Land Boards have policy of not allocating "ploughing lands" inside cordon fence to control poaching.
5.2 Total Cultivated Areas for CFDA Zone 2 are - Dryland - 4000 ha - Molapo - 3200 ha	Molapo cultivation shifts considerably year to year based on seasonal flooding pattern.	Distances of 15-35 km are common and most (98%) located outside cordon fence.	Overall shift of some 90% in location of cultivated melapo in past 5 years. General shift northwards of Tubu to permanent blocked Thaoge and eastwards to Karongana area.

TABLE 7.3 - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

NGAMI - ZONE 3

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
1. LIVESTOCK			
1.1 Livestock Trekking	Shakawe - Moshu Trek Route, well away from veterinary cordon fence.	Proposed trek route's closest point to fence is 3 km at Kunyere River crossing.	Trek route not yet cleared and used.
1.3 Livestock Grazing	Scattered cattle posts immediately south of fence using private water points (wells).	Cattle remain year round in the area.	No known associated intrusion of small stock or cultivation inside veterinary cordon fence.
2. PLANT RESOURCES			
2.1 Building Materials			
2.1.1 Poles	Mogotlho collected up to 8-10 km from villages such as Tsao, Sehithwa & Toteng.	Collected by donkey carts.	No shortage apparent.
2.1.2 Reeds and Thatching	Collected inside cordon fence in Matsebi floodplains (mokamakama & motsigitsane).	Collected by donkey cart and on a small commercial scale using vehicles, up to 40 km into Matsebi area.	Shortage experienced during drought but can be found in seasonally flooded areas.
3. FISHING	Lake Ngami when flooded.	One fishing group and 3 small individual commercial fishermen located at Pelican Point (Tololamoro)	Occasional resource only when Lake Ngami fully flooded.
4. HUNTING	Use mainly CHA9 but also CHA15 and 16 for buffalo, zebra, kudu, wildebeest, impala and ostrich. Small antelope and warthog also hunted.	Hunting mainly done by donkey or on horse back via Habu or Matsebi gates.	Hides of zebra and ostrich sold to BGI while other species hunted for meat only. Eastern boundary of CHA15 and 16 uncertain to many parties and is a source of local conflict e.g. commercial hunters vs citizen hunting. Ostrich a main species, with feathers as well as hides sold. Problem exists with inter-zonal meat removal permits due to need to obtain these at the VA's office rather than at cordon fence gates at time of entering.
5. ARABLE LANDS	Cultivation in Tsao area focuses on Thaoge valley, but limited primarily to Kunyere valley elsewhere. Tsao area - approximately 1000 ha cultivated (Tsao - Toteng).	Fields generally within 0-5 km of villages.	Arable land use does not occur in proximity to veterinary cordon fence.

TABLE 7.4 - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

MAUN AREA - ZONE 4

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
1. LIVESTOCK			
1.1 floodplain Grazing	Excessive grazing pressure on communal pastures south of cordon fence from Shashe to Shorobe (i.e. "Maun Front").	Cattle moved into Delta edges during drought from Hainaveld ranches and Makalamabedi (e.g. 660% increase to Shorobe area in 1975-85 period)	Coincidence of tsetse eradication, construction of fence and overstocking resulted in heavy grazing pressure and stock losses during 1987 and 1988.
	Small stock grazed in the Boro and Santantadibe corridor intrude through cordon fence.	Intrusions limited to less than 1 km inside fence.	Not a serious problem.
2. PLANT RESOURCES			
2.1 Firewood	Serious depletion in a radius of 10-15 km around Maun and to lesser area around Matlapaneng.	Commercial firewood collected by trucks and on a small scale using donkey carts and sold in Maun area.	Conservation of mophane woodlands as fuel havesting zones under consideration but local response limited. Needs attention as potential long term problem.
2.2 Building Materials			
2.2.1 Poles	Mophane is main species used some of it coming from dryland areas between Shorobe and Shokomokwa/Tsatsabaga and between Maun and Goroku.	10 km around sources and 20-30 km from source into Maun using donkey carts locally and lorries for transport to Maun.	Radius of cutting is being extended to obtain good quality poles for construction and for increased demands. No obvious intrusion into Delta, yet.
	Motswiri and mogotlho	Collected from riverine areas, e.g. Shashe area.	No shortage at present.
2.2.2 Mekoro	Use riverine species from molapo areas; mainly mopororo and motsaudi.	Collected from Boro and Santantadibe floodplains and inside cordon fence and Thokatsebe and Gorokwe (i.e. 30 km inside fence). Also collected from fringe areas along the Boteti River.	Shortage of good straight trunks fast becoming a constraint to long term demand in Maun area, particularly with proposed Maun Reservoir.
2.2.3 Reeds/Thatching Grasses	Collected from:		
	- Daonara/Ditshipi area	Inside cordon fence using Daonara Gate and commercially sold in Maun.	Main grasses collected are mokamakama, motsigitsane and kwenjama (red grass). Main reed (lethaka) is Phragmites.
	- Xwaapa and Kiri-Boro area	Inside cordon fence Khurunxaraga Gate to Xwaapa, Goboxo, Xabarachang and Xamochoo and sold commercially in Maun.	Thatching grass scarcity occurred during drought causing further intrusions into delta almost to Cacaba (see map 1923C).
	- Boteti madiba (Xobe and Dauga) - Reeds only	On periphery of project area and to be inundated by Maun Reservoir.	Communally owned resource is being exploited commercially without benefits to TLB and Council. Needs investigations re: long term policy, zoning of commercial vs communal use, etc.
	- Khwai area	Grasses collected and sold on a commercial basis in Maun and to Delta safari camps.	
2.3 Edible Plants			
2.3.1 Mokolwane palm	a) Sap is tapped, collected and distilled into alcoholic beverage (muchema)	Done mainly in Shorobe area.	Preburning and slashing for tapping destroys trees: No shortage yet occurring.
	b) Core of stem used as a vegetable (gau)	Widespread use in Shorobe, Daonara, Ditshipi and Makoba areas.	Also kills individual palms.
	c) Mokolwane nuts collected and eaten raw.	" " " " " " " "	No effect on trees. Traditional user rights exist and are recognised in areas close to main villages.

TABLE 7.4 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

MAUN AREA - ZONE 4

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
2.3.2 Tree Fruits	Mochaba (fig); motsaudi (fruit) motsintsila (fruit); morotologa (berries); morula (fruit); Mokutshumo (fruit) and motsotsjane.	Found throughout Maun area as riverine or island fringe trees and exploited as available.	No shortages known.
2.3.3 Vegetable	Morogo le keta and Morogo thepe (wild spinach); tswii/nkoma (water lily); koma (shoot of papyrus).	Found locally alongside main channels and in madiba.	No shortages known.
2.3.4 Mophane Worms and Honey	Collected as available in mophane belts in association with other activities.	Collected both inside and outside cordon fence. (mainly outside).	No shortages known.
2.4 Handicraft Materials			
2.4.1 Basket Making	Centred on Shorobe-Motsaudi using local resources.	Mokolwane leaves for weaving and motsintsila bark collected as convenient or as needed. Mothakola bark and roots also used.	No shortage of mokolwane trees but convenient sources of dye materials are diminishing. Baskets marketed directly to tourists travelling Maun-Kasane road and also sold to agents in Maun.
2.4.2 Sleeping Mats	Mokotsi leaves for sleeping mats and for binding from Tsanakona, Thamalakane area.	Collected and hand carried to villages.	No shortage known.
3. FISHING	Qoroqwe Lediba, Thokatsebe, Boro I and II areas and Boteti madiba (Daoga, Xobe and Dikathong) and at Xwapa lediba.	Mainly mekoro used but small boats used on big lagoons along Boteti River.	20 small scale commercial and 22 subsistence fishermen in Zone 4 were subsidised by FAP between 1982 and 1987. Fisheries resource potential will alter considerably with Maun Reservoir and needs to be investigated in detail after Matlapaneng Scheme completed. Dried fish collected at cordon fence/river crossings by Fisheries Unit for Drought Relief use.
4. HUNTING	Chitabe area CHA20 used by Shorobe residents for buffalo and other floodplain hunting. CHA24 used by Shorobe residents for zebra. Maun area residents use CHA9, CHA21, CHA20 and CHA7 for hunting kudu, buffalo zebra. CHA25 used mainly for zebra, wildebeest, gemsbok and springbok.	Chitabe (CHA20) accessed via Daonara Gate CHA21 accessed via Khurunuxaraga Gate CHA9 accessed via Matsebi Gate CHA7 accessed via Kasane Road Gate or Santawani Gate. Maun residents tend to use vehicles for access for hunting whereas donkeys are used in outlying areas.	Hunting and collecting reeds/thatching grass often undertaken as joint activities. Veld fires in Daonara/Ditshipi; Cacaba and Khwai areas (set by hunters) frequently destroy thatching grass immediatley prior to harvesting time (i.e. August). Conflict requires further study.
5. ARABLE LANDS Total cultivation area is about 4500 ha, of which 2500 ha is molapo and 2000 ha is dryland.	Molapo areas outside cordon fence are Xhwaa, Shorobe, Mazanga, Goroku, Boro, Motsaudi and Matlapaneng and along Nhabe and Boteti Rivers. Molapo areas inside cordon fence are Daonara, Ditshipi and Gamodao.	Lands areas inside cordon fence are accessed through all gates and all donkeys checked by veterinary authorities.	During past 8 years, molapo production limited due to drought conditions and intrusions by outside livestock, causing excessive crop damage. Molapo development and Matlapaneng scheme will seriously alter molapo potentials and requires detailed study.

TABLE 7.5 - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

DELTA AREA - ZONE 8

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
1. LIVESTOCK	Delta Zone is a stock free zone. Daonara/Ditishipi area has regular intrusion by cattle under permit for ploughing.	Cattle taken into Delta for limited period only.	No problem if controlled.
	Jao/Jediba area has mafisa cattle since 1986 mainly coming from western fringe areas during recent drought.	Details of cattle trekking given in Tables 7.1 and 7.2.	Trend is towards increasing numbers (i.e. presently 780 head). This use is recognised by Veterinary Department through establishment of crush at Jao. Main danger occurs in drought years as cattle could spread to inner Delta. Status of situation needs clarification and policy decision.
	Donkeys commonly used for transport and ploughing in Delta villages such as Mababe, Sankuyu, Khwai, Cacaba/ Delta Camp area and all along southern fringe.	Donkeys remain most viable means of transport for local villagers using Delta resources.	Use of donkeys somewhat incongruous with Wildlife Management Area concept.
2. PLANT RESOURCES			
2.1 Firewood	Firewood generally collected in close proximity of safari camps or villages.	Transport by mekoro or vehicles.	Shortage being experienced in safari camps along the mid Boro and in vicinity of regular overnight stops along tourist mekoro trails.
2.2 Building Materials			
2.2.1 Poles	Mostly mophane used and others imported if necessary.	Hauled to camps by tractor/trailers as required.	Local use not considered as problem.
2.2.2 Mekoro	Mekoro and polers come from southern Panhandle area. Main species used locally are mukwa, mukusi & mopororo.	Extensive mekoro travel routes exist and special tourist mekoro trails are located in vicinity of main camps, particularly along Boro and Santantadibe.	Mekoro preservation needs to be promoted due to resource depletion of riverine vegetation. Refer study on mekoro by Murray-Hudson (1988).
2.2.3 Reeds and Thatching Grass	Reeds are readily available but thatching grass of good quality is scarce, particularly during drought periods. Moxaa is preferred species.	North Moremi area camps get grass from Khwai area Boro area camps get grass locally or import via Maun. Reeds are collected for central Delta from as far away as Jao.	Conflict between burning off for hunting and thatching grass collection warrants attention as described in Table 7.4.
2.3 Edible Plants	Collection of edible plants is important to remote area dwellers and temporary communities located in the Delta.	Plants collected as and when available using mekoro or on foot, particularly during fishing and hunting trips.	Low population density in the Delta Zone indicates no likely problems.
2.4 Handicrafts			
2.4.1 Basket Making	Mokolwane used as available with main areas being Sankuyu and Mababe collected from Mogogelo River channel.	Sold to passing tourists and/or safari camps. Baskets from Ikgoga/Etsha 13 area are marketed by polers to the camps in the Delta.	Mokolwane resource not endangered. Applications for furniture production from Mokolwane wood are pending and represent a threat to large remaining stands of mokolwane, which have other ecological values. Area of concern is between Boro and Santantadibe, south of Chiefs Island (i.e., Gabadum area).

TABLE 7.5 (Contd.) - OKAVANGO DELTA - NATURAL RESOURCE AND LAND UTILISATION

DELTA AREA - ZONE 8

ACTIVITY OR RESOURCE UTILISATION	AREAS USED FOR ACTIVITY OR RESOURCE UTILISATION	LINKAGES FOR ACCESS, MEANS OF TRANSPORT AND DISTANCES INVOLVED	SPECIAL COMMENTS RELATING TO RESOURCE USE, DEPLETION AND/OR MANAGEMENT
3. FISHING	Primarily main channels and adjacent madiba and mainly for subsistence. Surplus dried, salted and sold through Fishieries Unit for Drought Relief. Some smoking of fish also done as temporary preservation measure.	Fishing follows flood flow through the Delta and is traditional; using mekoro and nets provided under FAP.	32 subsistence and 3 small scale commercial fishermen suubsidised under FAP. Most fishing done in lower Boro and Santantadibe upstream or Qoroqwe Lediba. No problems or conflicts known.
4. HUNTING	Preferred areas by Maun residents are CHA 20, 21, 9 and 7 for buffalo, kudu zebra and water antelope species. CHA35 has access problems in years of medium to high flood and has limited game.	Hunting mainly by donkey from traditional villages but increasingly use of 4-wheel drive vehicles or trucks on basis share-hunting or selling of licences obtained by ballot.	Some conflicts exist over use of access tracks and CHA boundaries, use of campsites and general relations between subsistence (citizen) and commercial hunting. Additional comments are included in Section 6 relating to Wildlife.
5. ARABLE LAND	Scattered around remote area villages such as Mababe, Sankuyu, Ditishipi, Daonara, Thokatsebe, Jao and Gombo.	Ploughing done by donkey and harvested on a subsistence basis only.	Crop damage by wildlife, particularly elephants in Mababe and Sankuyu is a problem. Some assistance under ARAP but fencing not generally adequate for exclusion of bigger game species.

TABLE 7.6 LIST OF SETSWANA AND SCIENTIFIC NAMES FOR TREES AND OTHER PLANTS REFERRED TO IN TEXT AND TABLES 7.1 THROUGH 7.5 INCLUSIVE

Tswana Name	Scientific Name
TREES	
mogonono	Terminalia sericea
mogotlho	Acacia erioloba
mokola	Hyphaene petersiana
mokolwane	Hyphaene petersiana (tree)
mokutshumo	Diospyros mespiliformis
mongongo	Ricinodendron rautanenii
mophane	Colophospermum mopane
mopororo	Lonchocarpus capassa
moporota	Kigelia africana
morula	Sclerocarya birrea
mothakola	Euclea divinorum
motsaudi	Garcinia livingstonei
motshaba	Ficus sycomorus
motsintsila	Berchemia discolor
motswiri	Combretum imberbe
mowana	Adansonia digitata
mukusi	Baikiaea plurijuga
mukwa	Pterocarpus angolensis
tsaro	Phoenix reclinata
SHRUBS	
mokgomphata	Grewia flavescens
moretlwa	Grewia flava
morotologa	Ximenia americana
morotologa/wa/kgomo	Ximenia caffra
GRASSES, SEDGES, HERBS AND AQUATIC PLANTS	
koma	Cyperus papyrus
lethaka	Phragmites sp.
mohetola	Indigofera sp.
mokamakama	Cymbopogon sp.
molgotsi	Sansevieria sp.
motsigitsane	Stipagrostis uniplumis
moxaa	Miscanthus junceus
moxaxa	Vetiveria sp.
tswii	Nymphaea caerulea

TABLE 7.7 SUMMARY OF CATTLE DISTRIBUTION BY DLUPU PLANNING ZONES IN AREAS SURROUNDING OKAVANGO DELTA

MAP SHEETS	DLUPU PLANNING ZONE	NUMBER OF CATTLE VACCINATED AUG. 86	SEPT. 88	PERCENTAGE CHANGE 1986-1988
1821B & C, 1822A) 1922C) 1822D)	Zone 1 Second Communal Development Area (SCDA)	8 159 12 335 2 359	8 858 12 246 3 488	
	Total	22 853	24 592	+8%
1922A) 1922C)	Zone 2 CFDA	20 936 23 285	13 257 8 902	
	Total	44 221	22 159	-50%
2022A) 2022B)	Zone 3 Ngami	5 478 11 611	3 478 5 250	
	Total	17 089	8 737	-49%
2023A) 1923D) 1923C)	Zone 4 Maun	11 950 7 286 4 392	5 973 7 008 1 707	
	Total	23 628	14 688	-38%
1922B	Zone 8 Delta	-	780	
	Total	-	780	-
TOTAL		107 845	70 956	-34%

TABLE 7.8 LIVESTOCK DISTRIBUTION IN AREA SURROUNDING OKAVANGO DELTA

MAP SHEET	CATTLE CRUSH LOCATION	NUMBER OF CATTLE VACCINATED AUG 86	SEPT 88
1821B & C 1822A west side of Panhandle (SCDA1)	Muhembo	862	499
	Shakawe	611	787
	Samochima	644	622
	Xhaoga	754	492
	Khongo	446	540
	Setutu	610	658
	Kgomokgwana	444	265
	Kauxwi	912	1 315
	Xakao	1 108	1 012
	Sekondomboro	632	810
	Ngarange	636	764
	Tobera	-	440
	Hongwa/Sekanduku	500	654
	Sub total	8 159	8 858
1822C east side of Panhandle (SCDA1)	Shauwe	335	612
	Letsao	763	942
	Mawana	987	1 221
	Dungu	1 214	1 308
	Seronga	768	1 077
	Teekai	896	886
	Ncamasere	1 375	1 300
	Kajaja I	763	581
	Kajaja II	765	948
	Sepupa	507	334
	Mowana	757	357
	Ikgoga	885	1 043
	Thamatsha	636	341
	Xaanxana	1 684	1 296
	Sub total	12 335	12 246
1822D east side of Panhandle (SCDA1)	Gunutsoga	1 591	2 095
	Beetsha	768	1 393
	Sub total	2 359	3 488

TABLE 7.8 (cont.) LIVESTOCK DISTRIBUTION IN AREA SURROUNDING OKAVANGO DELTA

MAP SHEET	CATTLE CRUSH LOCATION	NUMBER OF CATTLE VACCINATED AUG 86	SEPT 88
1922A Western Fringe (CFDA Zone 2)	Etsha 13	-	532
	Etsha 10	1 114	566
	Etsha 4	635	710
	Qurube	1 101	1 352
	Bodumatau	983	877
	Mathlamodimo	409	235
	Thamma	1 278	748
	Gumare	762	364
	Thale	1 795	825
	Nxabexau	2 059	886
	Tubu	2 482	482
	Kandadiangodi	3 292	1 426
	Danega	2 410	560
	Xara	2 586	2 733
	Tjaa/Kandadiangodi East	-	961
	Sub total	20 936	13 257
1922C Western Fringe (CFDA Zone 2)	Majwana	842	481
	Nokaneng	1 237	566
	Thige	1 632	573
	Khubuga	2 655	1 016
	Xwee	3 649	1 206
	Boajankwe	2 597	901
	Nxweree	1 917	906
	Habu	2 015	807
	Kakanaga	2 058	894
	Masamo	3 512	571
	Khubukhubuga	-	78
	Thafi	193	146
	Tshelojamotswana	645	457
	Konde	333	300
	Sub total	23 285	8 902

TABLE 7.8 (cont.) LIVESTOCK DISTRIBUTION IN AREA SURROUNDING OKAVANGO DELTA

MAP SHEET	CATTLE CRUSH LOCATION	NUMBER OF CATTLE VACCINATED AUG 86	SEPT 88
2022A Ngami (Zone 3)	Matsiara	348	319
	Kaure	407	409
	Senxaxumo	1 283	581
	Maporota	1 474	517
	Tsao	573	859
	Dobe	1 393	802
	Sub total	5 478	3 487
2022B Ngami (Zone 3)	Tholoamoro	2 481	950
	Legothwane I	1 751	274
	Legothwane II	783	679
	Toteng I	483	106
	Toteng II	992	241
	Moumo	395	94
	Teemane	307	228
	Kgomotswana	469	304
	Makola	667	227
	Makgwelekgwele	750	161
	Tswelenyane	1 133	198
	Mogapelwa I	429	139
	Mogapelwa II	971	222
	Sookgwe	-	1 177
	Morula	-	250
	Sub total	11 611	5 250

TABLE 7.8 (cont.) LIVESTOCK DISTRIBUTION IN AREA SURROUNDING OKAVANGO DELTA

MAP SHEET	CATTLE CRUSH LOCATION	NUMBER OF CATTLE VACCINATED AUG 86	SEPT 88
2023A Maun Front (Zone 4)	Phatswe	923	662
	Tsetseku/RTC	294	120
	Matsebe	1 166	428
	Marula	1 098	191
	Nxaraga/Mashu	1 235	507
	Shashe	521	67
	Thamalakane W.	215	235
	Komana	271	164
	Haka	238	201
	Makgalo	1 024	673
	Sedibana	664	337
	Makokong	277	234
	Lediba	307	319
	Gwexwa	318	154
	Kantsang	244	309
	Dikgathong	465	110
	Daoga	294	99
	Patikwe	352	147
	Metsemasweu	173	0
	Somelo	68	154
	Maun East	171	69
	Mapororo	227	74
	Tsanakuna	495	181
	Thamalakane	34	5
	Dairy S. Paul/ Sec. School	64	186
	Xobe I	580	195
	Xobe II	232	152
	Sub total	11 950	5 973

TABLE 7.8 (cont.) LIVESTOCK DISTRIBUTION IN AREA SURROUNDING OKAVANGO DELTA

MAP SHEET	CATTLE CRUSH LOCATION	NUMBER OF CATTLE VACCINATED AUG 86	SEPT 88
1923D Maun Front (Zone 4)	Makoba	292	352
	Gabomochaa	933	667
	Sukapane	912	635
	Shorobe	992	469
	Sexaxa	436	385
	Daonara mobile	-	956
	Nxarachaa	424	122
	Legakabe	102	107
	Dinao	204	276
	Mopako	91	113
	Boiteko	286	285
	Shokomokwa	204	553
	Xhomxwa	219	91
	Nanogaonne	153	820
	Nxinikwe	1 009	530
	Tsatsbaga	446	89
	Bodumatau	-	68
	Phefodiafoka	303	282
	Tshipidi	280	208
	Sub total	7 286	7 008
1923C Maun Front (Zone 4)	Daonara Gate	945	304
	Boro	230	298
	Matlapana	109	294
	Goroku	304	104
	Marophe	519	285
	Maun West	320	149
	Maphane	262	78
	Xaraxao	614	0
	Gogomoga	614	47
	Tsutsubega	186	0
	Komkogo	289	148
	Sub total	4 392	1 707
1922B Delta Area (Zone 8)	Jao	-	780
	Sub total	-	780

TABLE 7.9 POPULATION DISTRIBUTION BY DLUPU PLANNING ZONES IN AREAS SURROUNDING OKAVANGO DELTA

DLUPU PLANNING ZONE	1981 CENSUS POPULATION	1988-89 PROJECTED POPULATION	PERCENTAGE CHANGE 1981-89
Zone 1 Panhandle Area (SCDA)			
East side	8 234)		
West side	8 190) 16 424	20 500	25%
Zone 2 Western Fringe (CFDA)	11 103	14 300	29%
Zone 3 Ngami Area	3 269	4 100	25%
Zone 4 Maun Front Area	21 364	30 000	40%
Zone 8 Delta Area	1 883	2 300	23%
TOTALS	54 000	71 200	32%

Note: Population projections based on 5%/year increase in major villages such as Maun and Gumare, 3.5%/year in medium size villages and 2.6%/year in small villages and rural communities.

TABLE 7.10 SUMMARY OF DISTRIBUTION OF FAP FISHERMEN - OKAVANGO DELTA AREA 1982-87

ZONE	SUBSISTENCE FISHERMEN	COMMERCIAL FISHERMEN	TOTAL
Zone 1 Panhandle (SCDA) East side West side	 122 66	 7 1	 129 67
Panhhandle sub total	188	8	196
Zone 2 Western Fringe (CFDA)	3	-	3
Zone 3 Ngami Area Maun Area	- (22)	(3) (21)	(3) (43)
Zone 8 Delta Area	32	3	35
TOTALS	245	35	280 (70%)

Note: Bracketed figures represent fishermen assisted by Financial Assistance Policy (FAP) residing in the Lake Ngami or Maun areas whose fishing activities depend very much on flooding levels in individual areas.

8. TOURISM

8.1 PERSPECTIVE

Growth of the Okavango Delta's tourism industry has been spectacular between 1978 and 1988. This is reflected in the growth rate of fixed safari camps from 14 in 1978 to 32 safari/fishing camps in 1988. In addition there has been considerable expansion of mobile safari operators utilising the Delta, either from Maun or as internationally based operations. This trend in tourism growth is also reflected in the increase in landings at Maun's DCA controlled airstrip which have increased in annual total over the past five years from 3 700 in 1983 to some 10 800 in 1988, a 280% increase (see Fig. 8.1).

Investigations into tourism for the Ecological Zoning Project - Okavango Delta have concentrated on an inventory of the infrastructure and services available and determining the capacity and areas utilised by the Delta's safari camps. A detailed inventory/survey form was completed for each of the 33 safari camp operations. An example of the inventory form is given in Appendix K. Tabulated summary information derived from the inventory are presented in Tables 8.1-8.8.

Documentation in this section summarises the findings of the inventory and outlines the current nature of the Delta's evolving tourist industry. This analysis includes comments on existing use patterns and areas used, indicated and/or potential conflicts relating to tourism activities, areas used and/or associated resource allocation conflicts. Extensive use is made of tables and point form summaries in order to present the diversity of data and comments. Suggestions relating to additional follow-up investigations on the Delta's tourism resources and activities are included in the final sub-section.

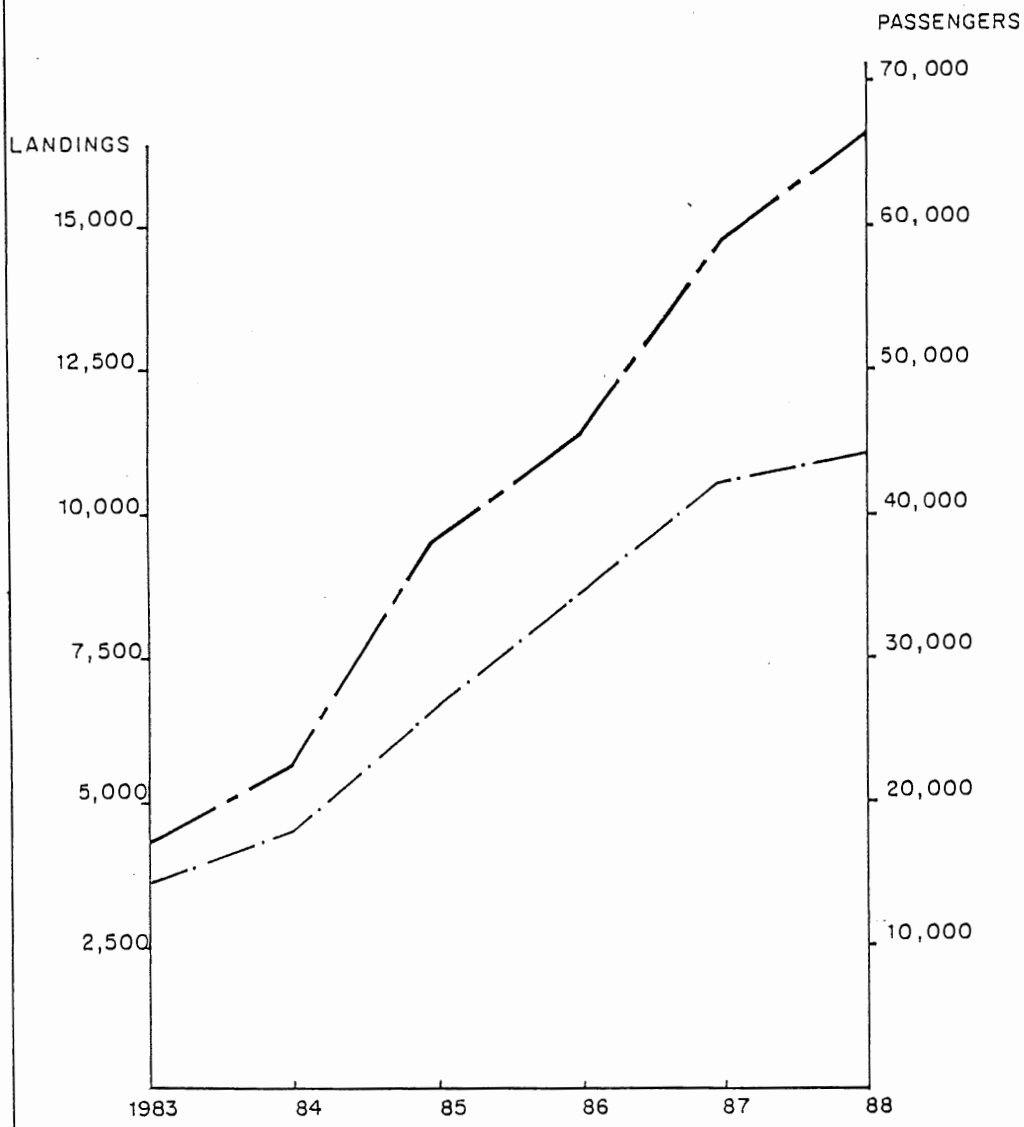
8.2 AVAILABILITY OF DATA AND LIAISON WITH AUTHORITIES

8.2.1 Availability of Data

Data specific to the tourist industry of the Okavango Delta is lacking. The most comprehensive reports relating to Botswana's tourist industry as prepared by Fowkes (1985) and others such as Bayne, et al. (1985), Ingram, et al. (1985) and Roberts (1985) include some specific data relating to the Delta or parts thereof, such as Moremi Wildlife Reserve.

Other references are largely general in scope, including either descriptions of attractions and facilities (e.g. Main et al., (1987) and Ministry of Commerce and Industry (1988)) or relate to the role of tourism in development or use of the Delta and associated resources (e.g. Campbell and von Richter (1976), Johnson (1976), and SMEC (1987d).

The location, access to and associated areas used in the vicinity of safari camps in the Delta, have been mapped on the 1:100 000 'Present Land Use and Tourism' maps for this project. Locations



LEGEND:

—·— Aircraft Landings

— — — Total Number Of Passengers

ECOLOGICAL ZONING
OKAVANGO DELTA

GROWTH IN AIR TRAFFIC THROUGH MAUN AIRPORT - 1984 - 1988 PERIOD

FIGURE 8.1

of camps and access tracks and other information relating to tourism infrastructure and use (e.g. navigable status of channels) have been assembled and are presented on a 1:250 000 map entitled 'Tourism Infrastructure'.

It should be noted that, as this is the first attempt at comprehensive locating and mapping of tourism related infrastructure, and because of the dynamic nature of the ongoing tourism development in the Delta, errors and omissions have possibly occurred. Responsibility for these is accepted by the Consultant, but it is felt that substantial information has been provided, which can be updated as required by DLUPU and other parties concerned.

8.2.2 Liaison with Authorities

Close liaison has been maintained with Mr Lejo van der Heiden, District Officer Lands for Ngamiland District, who has been extensively involved in the tourist camp survey and data processing. His assistance in this respect and guidance in compilation of this section is gratefully acknowledged.

Courtesy visits to explain the objectives and the approach to the tourist camp survey and the documentation of tourism aspects of the Okavango Delta - Ecological Zoning Project have been made to the following parties:

- Ministry of Commerce and Industry (Tourism Division), Principal Tourism Officer (Mr U S Mpolaka) and the Division's Marketing Adviser (Mr S J W Mashi)

- HATAB representatives in Gaborone and Maun, particularly Mr P Sandenberg

Discussions with these parties and an exchange of ideas, in particular with the Tourism Division, has led to modification of the approach to the inventory and analysis used in deriving the results described in this chapter. The Consultant recommends that liaison with these parties should be maintained during the land use planning activities stemming from this report. On the other hand, certain information shown on the 1:250 000 Tourism Infrastructure map may be useful for future planning by the Tourism Division.

8.3 SCOPE AND DISTRIBUTION OF THE DELTA'S TOURISM ATTRACTIONS

The Delta's main attractions relate to its complex mosaic of dryland, island, island fringe and wetland habitats, and associated wildlife including 'big game', birds, fishes, reptiles and amphibians. The seasonal changes associated with the wet season and annual progression of flood flows through the Delta add to the diversity of both fauna and vegetation distribution. The Okavango Delta is unique as an inland delta ecosystem, both in the African and world-wide contexts.

Due to the diversity of landscapes, madiba and linking channels and the problems which are often associated with access, development of tourism has evolved around safari camps based near

attractions and multi-functional access (i.e. tracks, airstrips and boatable sections of channels). Although large groups of various wildlife species are atypical, the frequent occurrence of small groups of a diversity of species in scenic habitats (e.g. island fringe and floodplain areas) is a key feature of the Delta's tourist attractions.

With over 400 species of birds having been recorded the opportunity to observe rare species and/or large numbers of particular bird species is an integral part of most Delta visitors' experience. Similarly, fishing opportunities, particularly for tigerfish, are specific attractions and are the basis of the safari camps located in the Panhandle and Western Fringe zone.

Other major attractions associated with the Delta include opportunities for short duration or two to four day camping trips by mekoro, associated day trips to nearby attractions, e.g. Tsodilo Hills rock art sites and opportunities to observe local community lifestyles. The ranking and priorities for participation in activities associated with individual camps and summary comments relating to these are included in Table 8.4 and relevant comments are outlined in section 8.7.

The uniqueness of the Okavango Delta, combining the attributes of desert grassland with seasonal and permanent wetlands and an accompanying diversity of flora, fauna and landscapes, is a tourism resource base which warrants careful planning for tourism development and use.

8.4 TYPES AND DISTRIBUTION OF SAFARI CAMPS - 1988

The general types and distribution of safari camps are presented on the 1:100 000 Land Use and the 1:250 000 Tourism Infrastructure maps.

Location of safari camps is historically linked to a number of factors including:

- Availability of water for domestic use.

- Site selection in the Maun Area based on access to the Boro and Thamalakane Rivers during high water level periods during the mid to late 1970's.

- Utilisation of sites with multiple means of accessibility and proximity to permanently navigable waters (e.g. North Moremi camps).

- Utilisation of sites formerly used for wildlife exploitation activities (e.g. crocodile shooting camps).

- Site selection based on administrative constraints such as restrictions on development and use of access tracks in Moremi W.R. and/or suitable campsite locations within Controlled Hunting Areas (CHA's) allocated to individual safari companies.

- Site selection to capitalise on key resources and attractions (e.g. fishing camps in Panhandle Area located at larger madiba with access to back channels with abundant fish resources).

Analysis of data from the inventory and discussions with safari camp operators indicate that there are four general areas with similar tourist attractions, facilities and services provided and similar modes of operation. These four tourist areas or zones of the Delta have been used in summarising data (e.g. Tables 8.1-8.8) to provide a framework for discussion purposes and are:

- Panhandle and Western Fringe Area centred on Shakawe;
- North Moremi and Khwai Area including the Cakanaca and Xugana clusters;
- Central Delta Area including the Santawani Safari Lodge and the emerging Ditshipi area used by mobile safari operators;
- Maun Area with the cluster of safari camps in the Matlapaneng area.

8.4.1 Safari Camps

Data summarising the number and type of tourist accommodation provided in the major zones are presented in Items 1 and 2 of Table 8.1 and in Table 8.2 and indicate:

- A total of 33 camps with the greatest number located in the North Moremi/Khwai Area (11) and the Panhandle/Western Fringe Area (9).
- A dominance of reed huts and permanent tents (i.e. on concrete slabs) in the Panhandle/Western Fringe Area; permanent tents in the North Moremi/Khwai Area; reed huts and campsites in the Central Delta Area and brick chalets/ rondavels/hotel rooms and campsites in the Maun Area.

It is to be noted that Island Safari Lodge and Riley's Hotel (and to a lesser extent other camps in the Maun area) have a high percentage of guests who are not tourists (i.e. they are business visitors to Maun). This aspect has been taken into account in projections of occupancy rates by assuming that 50% of Island Safari Lodge and 70% of Riley's Hotel occupants are non-tourist visitors.

Over 90% of the safari camps in the Delta have guest dining rooms and guest bars. However, the number of public bars is limited (i.e. 13 in total with eight of these in the Maun Area).

8.4.2 Campsites

Determination of the total number of campsites available to the travelling public in and around the Okavango Delta is complicated

TABLE 8.1 DISTRIBUTION OF SAFARI CAMPS WITH INDICATED CAPACITIES, OCCUPANCY RATES, STAFF NUMBERS, ACTIVITIES BY PRIORITY RANKING AND PROJECTED VISITOR NUMBERS

	TOURIST AREA	PANHANDLE AND WESTERN FRINGE	NORTH MOREMI AND KHWAI AREA	CENTRAL DELTA AREA	MAUN AREA	TOTALS FOR DELTA
1	No. of camps	9	11	6	7	33
2	Accommodation Types					
2.1	rondavels/rooms	17	18	8	63	106
2.2	reed huts	25	-	22	11	58
2.3	perm. tents	18	56	6	13	93
2.4	temp. tents	6	15	-	-	21
2.5	Area Total	66	89	36	87	278
3	Capacity/Occupancy					
3.1	beds	116	178	74	219	587
3.2	annual bed nights	40 630	56 730	28 820	79 940	206 120
3.3	estimated occupancy					
3.3.1	beds	24%	28%	34%	20%	26%
3.3.2	accom. units	34%	46%	56%	42%	46%
3.3.3	max. monthly	60%	65%	72%	66%	66%
4	Public Campsites					
4.1	No. of campsites	65	210(1)	135(2)	390	800
4.2	annual camper nights	22 100	73 500	45 900	141 300	282 800
4.3	est. occupancy	12%	16%	21%	10%	14%
4.4	max. monthly	38%	45%	62%	40%	44%
5	Staff Numbers					
5.1	office/mgmt.	16	22	13	20	71
5.2	waiters/barmen	13	18	13	39	83
5.3	kitchen staff	25	38	17	31	111
5.4	housekeeping	19	35	20	29	103
5.5	drivers/guides	14	27	70	21	132
5.6	labourers	40	37	15	34	126
5.7	Area Total	127	177	148	174	626
6	Activities by Priority					
6.1	1st priority	fishing	game viewing	mekoro trails	mobile safaris for game viewing	game viewing and mekoro trips
6.2	2nd priority	birdwatching	boat trips and birdwatching	nature walks and birdwatching	boat trips	birdwatching and fishing
6.3	3rd priority	trips to Tsodilo Hills and boat trips	fishing and nature walks	boat trips for game viewing and game flights	birdwatching, fishing and game flights	boat trips, nature walks and trips to Tsodilo Hills
7	Projected 1988 Annual Bednights					
7.1	in acc. units	9 600	14 800	9 200	13 000(3)	46 600
7.2	campers	2 400	10 300	8 100	10 800	31 600
7.3	others (10%)	1 200	2 500	1 700	3 600(4)	9 000
7.4	Area Total	13 200	27 200	19 000	27 400	87 200

Notes:
(1) All 210 campsites in North Moremi/Khwai Area are located within Moremi Wildlife Reserve and administered by DWNP (i.e. North Gate, Third Bridge and Cakanaca).
(2) 25 campsites in the Central Delta Area are located within Moremi Wildlife Reserve and administered by DWNP (i.e. South Gate).
(3) Based on 30% tourists at Riley's Hotel and 50% tourists at Island Safari Lodge.
(4) Based on 15% as additional bed nights at Maun rather than 10% as for other areas.

by the facts that:

- No individual camping places are designated in most campsites, including the DWNP campsites situated in the Moremi W.R., which comprise the majority of these facilities in the North Moremi/Khwai Area.

- Safari campsite operators have tended to overestimate the number of campers which can be catered for at their campsites (i.e. based on casual observation at these sites and facilities provided for campers).

- Assuming large capacities to cater for campers and extended seasons (i.e. 365 days/year) tends to overestimate both the capacity and projections of annual bed nights and visitor numbers even though occupancy rates at campsites are low.

It is indicated in Table 8.1 that there is total of 800 camping places available in the Delta area, almost 50% of which are located in Maun. It is suggested that realistically the total number is of the order of 600 and that of the Maun Area may be closer to 200-225 than 390, as indicated (see section 8.8 relating to projections of visitor numbers).

With impending changes in the fee structure for entry to Botswana's National Parks and Game Reserves, the number of camping-based visitors to the Delta, particularly the campsites in the Central Delta, North Moremi/Khwai and Maun Areas will probably decrease substantially (see section 8.11).

8.5 ACCOMMODATION CAPACITY, SEASONALITY AND OCCUPANCY RATES

Specific data relating to occupancy rates at individual camps is sparse and some gross estimates provided during the tourist camp survey are probably over optimistic. Specific data have been provided by some safari camp operators and this is classified as confidential out of respect for these parties' willingness to provide this information.

However, the information has been used to extrapolate the estimated occupancy rates presented in Table 8.1. These data have been supplemented by discussions on occupancy rates with other parties such as safari camp owners/managers, HATAB representatives in Maun and other consultants engaged in tourism development feasibility studies of the Delta (i.e. Price Waterhouse, pers. comm.).

8.5.1 Accommodation Capacity

Generally, most accommodation units in the Delta are two-bed units, regardless of the type of accommodation unit (e.g. reed hut, rondavel or permanent tent). The total capacity of fixed accommodation units for the Delta in 1988 is indicated as 587 beds with an annual capacity (based on operator-indicated seasons) of 206 000 bed nights/year.

Accommodation capacity appears to be dominated by the Maun Area, but when adjustments are made for business visitors to this area's two major facilities (i.e. Island Safari Lodge and Riley's Hotel) the annual number of tourist bed nights for the Maun Area is equivalent to that of the North Moremi/Khwai Area (i.e. 55 000 bed nights/year or approximately 150 'tourist beds' out of the 219 bed total for Maun Area).

Table 8.1 item 3.1 shows that the Panhandle/Western Fringe Area has about 30% greater accommodation capacity than the Central Delta, but the indicated total occupancy numbers of tourists staying in fixed accommodation for the two areas are about equal (see Item 7.1 in Table 8.1).

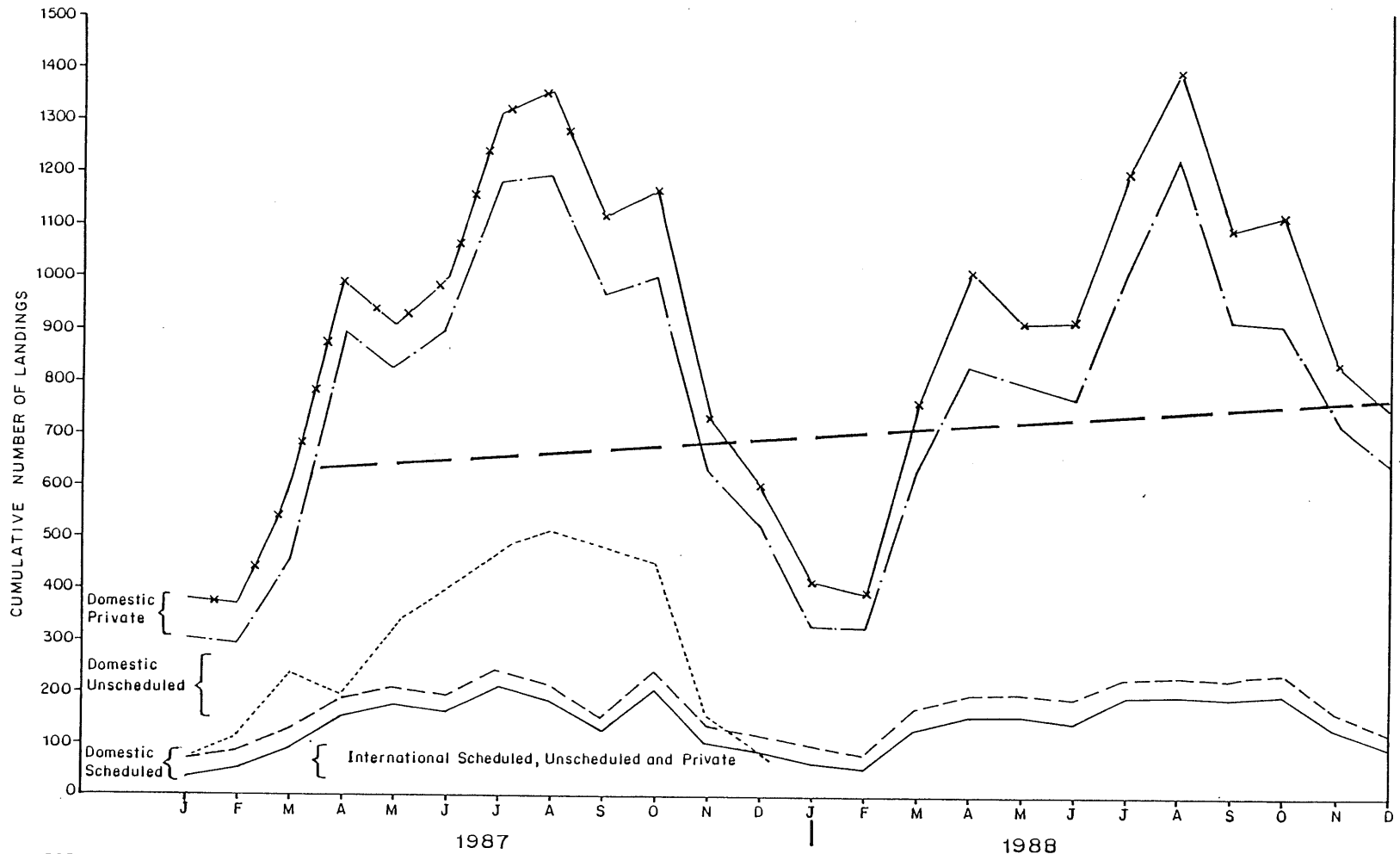
8.5.2 Seasonality of Tourism Use

Seasonality of tourism use in the Okavango Delta is very pronounced and the problem of 'peaking' appears to be growing with increasing visitor numbers and occupancy rates. Seasonality is illustrated by Figures 8.2 and 8.3 showing monthly landings of aircraft and the monthly occupancy levels based on eight safari camps in the Delta, respectively.

Evidence of the increasing peaking is indicated in Figure 8.2 comparing the 1983 landings with those of 1987 and the apparent increase in landings directly related to tourism (i.e. unscheduled domestic or charter aircraft) between 1987 and 1988.

Figure 8.3 illustrates the variation in peaking by accommodation type including the gradual build-up to the peak season for fixed accommodation in the August to October period and its rapid drop off in use over the December to January period. The pronounced peaking in April, August, September and December for the campsites reflects the influence of school holiday periods in respect of tourist arrivals from the Republic of South Africa. The July/August peak also probably reflects the presence and use of camping facilities during this period by independent travellers from Europe and North America (e.g. students on summer vacation) and peak numbers of arrivals of mobile operators with similar clients to the Delta coinciding with the northern hemisphere summer holiday period.

The seasonality of the tourism use is a problem for safari camp operators, particularly those in the Central Delta which is best visited in association with the passing of the annual floods in this area in the June to August period. Constraints on use during the wet season which coincides with the Christmas/New Year holiday period are pronounced, particularly in wet years. Although many safari operators indicate they operate on a 'year-round' basis, they have extremely low occupancy rates during the December to February periods. This could be a major factor influencing indicated occupancy rates. The occupancy rates could be higher than claimed due to this 'casual approach' to operating camps adopted by some operators during the December to February period. (This is not intended as criticism but reflects the nature of the tourist visit patterns and the uncertainty associated with operating during the wet season/annual holiday period.)



LEGEND:

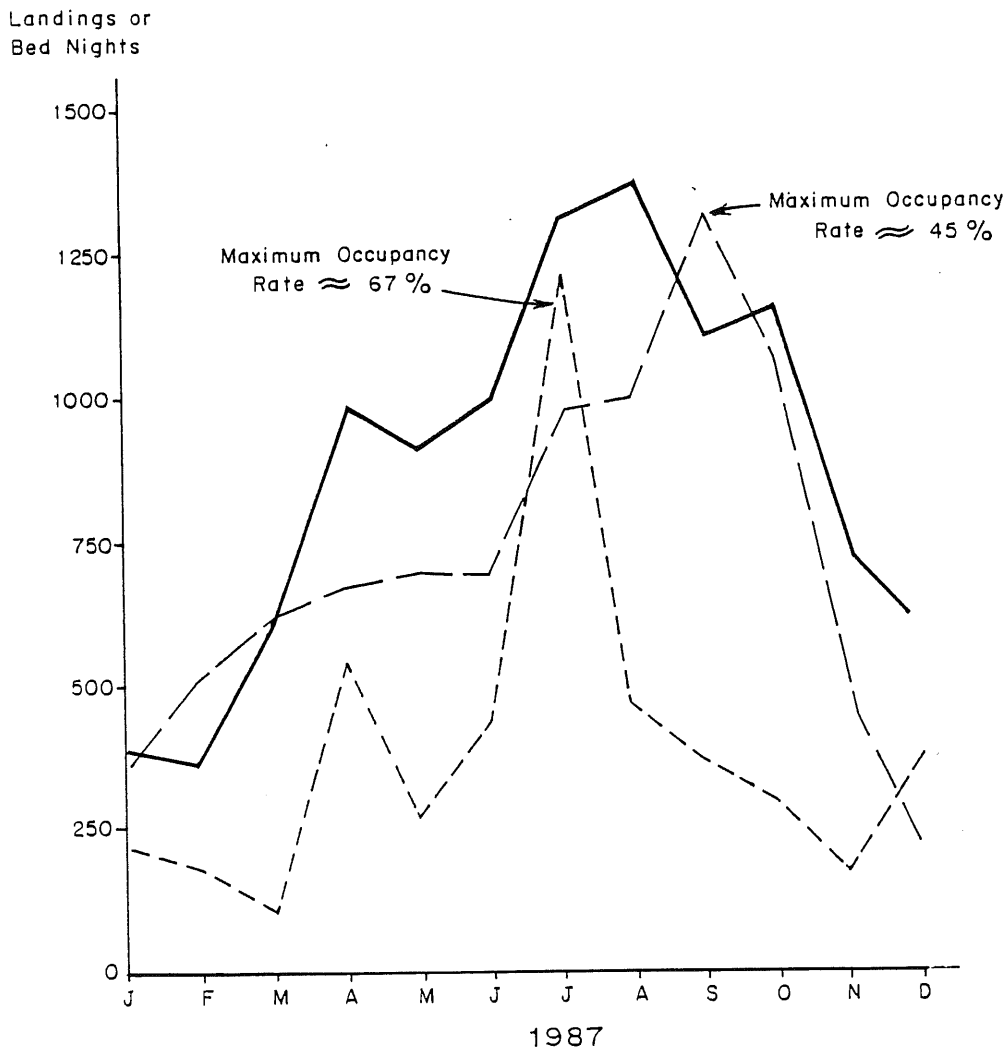
- Total International Aircraft Landings
- Domestic Scheduled Aircraft Landings
- Domestic Unscheduled (Charter) Aircraft Landings
- Domestic Unscheduled (Private) Aircraft Landings
- 1983 Total Landings
- Trend Line For Annual Rate Of Growth

NOTE: Graph Is Cumulative Number Of Landings/Month

ECOLOGICAL ZONING
OKAVANGO DELTA

SEASONALITY AND DISTRIBUTION OF AIRCRAFT LANDINGS 1987 AND 1988

FIGURE 8.2



LEGEND:

——— Aircraft Landings at Maun Airport.

— — Occupancy Rate of 8 Safari Camps in the Delta with Average Capacity of 2840 Bed Nights/Month.

— — — Occupancy Rate of a Single Campsite in the Delta with Average Capacity of 1800 Bednights/Month.

ECOLOGICAL ZONING
OKAVANGO DELTA

INDICATED SEASONALITY OF TOURISM RELATED ACTIVITIES - 1987

FIGURE 8.3

8.5.3 Occupancy Rates for Safari Camps and Campsites

As implied above, determination of occupancy rates based on the data readily available is difficult. Additional detailed data gathering and research of monthly returns (confidential information) lodged by safari camp operators with the Ministry of Commerce and Industry and other secondary information sources would be required. Such investigations were beyond the scope of this project.

Basic calculations and estimates of occupancy rates have been made based on the data available and extrapolation from other sources, e.g. Fowkes (1985), Ingram, et al. (1985), and SMEC (1987d Vol. I and II).

a) Safari Camps
Fowkes indicated an overall occupancy rate of 20.4% for the Maun area facilities based on 1984 information. The data gathered for this project indicates an overall annual occupancy bed-night rate of 26% for fixed accommodation and 14% for campsites. Occupancy rates in the peak season based on accommodation unit occupancy are 65-75% on a monthly basis and would be even higher for shorter periods, particularly at the more popular and accessible lodges in the Central Delta and Cakanaca Areas.

b) Campsites
The annual overall occupancy rate of 14% for campsites is considered to be a realistic figure based on the data available. As noted above, some uncertainty exists in respect to the capacity of individual campsites, particularly in the Maun Area. The overall capacity for the Delta is judged to be of the order of 600 camping places and the annual capacity to be approximately 210 000 camper nights. The indicated occupancy rates for the various tourist areas are confirmed with specific data relating to one Central Delta private campsite and the extrapolation from gate receipt data analysed for Moremi W.R. (Ingram, et al., 1985). Based on these data there were 16 000-20 000 visitors/ year to Moremi Wildlife Reserve in 1983-84. It is estimated that this has increased to 22 000-25 000 visitors in 1988, approximately 40-50% of whom would be campers staying in the estimated 235 DWNP camping places located in Moremi W.R.'s campsites.

Tourist use patterns including duration of stay, origin of visitors, areas utilised, activities pursued and expenditure patterns of casual campers using both DWNP provided campsites and private campsites is considered to be a priority aspect of the Delta's tourism requiring additional investigation. It is unfortunate that an adequate data base is not now available so that detailed evaluation of campsite occupancy rates and visitor numbers (i.e. user days) and expenditure patterns can be compiled for the camper component. This is particularly relevant to the monitoring of the likely economic effects of the impending increase in entry fees to Moremi W.R. A recommendation to undertake additional investigations relating to this aspect is outlined in section 8.12.

8.6 STAFF NUMBERS AND BENEFITS FROM WAGES

There are an indicated total of 626 employees for the 33 safari camp operations surveyed. This is equivalent to approximately one employee per bed provided; possibly an appropriate 'rule of thumb' to be applied for tourism and economic planning for the Delta.

Variations in the distribution of employees reflect the modes of operation characteristic of the tourist areas as evidenced by the following:

Approximately 30% of all employees are found in the seven Maun Area operations.

The distribution of job categories is:

- office/reception/managerial - 71 (11%)
- waiters/barmen - 83 (13%)
- kitchen staff - 111 (18%)
- housekeeping/laundry staff - 103 (16%)
- drivers/safari guides - 132 (21%)
- gardeners/labourers - 126 (21%)

Disproportionately high percentages of guides (i.e. mekoro polers) occur in the Central Delta Area and waiters/barmen in the Maun Area where there are several public bars (see Table 8.1).

Detailed data on employment in the non-resident hunting sector of the safari industry have not been collected but it is indicated by Fowkes that altogether some 87% of casual employment in the tourism sector is generated by the Ngamiland operations. With a total wages payment of P3.2 million for Botswana in 1984 for 1 032 employees, the average employee was paid P3 100. Using an inflation rate of 8%/year and an indicated total of 626 employees in 1988, the employee wages benefits (based on an average 1988 wage of P4 200) is estimated at P2.7 million for the Delta.

Secondary and/or multiplier benefits in terms of tourist purchases in local transit centres such as Maun, casual employment, purchase of supplies and equipment by safari operators and safari company employees and their dependants and promotion/advertising expenditures are not possible to delineate with the data available to this project.

Detailed economic analyses of costs and benefits including management costs (e.g. DWNP operating costs) should be undertaken in order to obtain a more realistic appreciation of the net social benefits to the Delta area's citizens and to Botswana as part of any further tourism related studies for the Okavango Delta.

8.7 ACTIVITIES AND LAND AND WATER USE FOR TOURISM

The patterns of land use associated with tourism operations in the Okavango Delta tend to be site selective and linearly oriented along main access tracks and navigable sections of river

channels. This pattern is reflected in the tourism utilisation zones (i.e. U_t units) indicated on the 1:100 000 maps. Actually the zones are much narrower than delineated on the maps, being predominantly the access track, river or floodplain margins in the centre of most U_t units.

8.7.1 Activity Patterns

The dominant activities relevant to each of the Delta's four tourist zones are summarised in Item 6 of Table 8.1. Additional details relating to activities and their priorities for individual safari camps are presented in Table 8.4. In summary, the main activities associated with the four tourist areas are as follows:

- Fishing, boat trips, bird watching and day trips to Tsodilo Hills characterise activities in the Panhandle/Western Fringe zone.

- Game viewing using four-wheel-drive vehicles and walking from boat trips dominate activities in the North Moremi/ Khwai Area with bird watching, fishing and mekoro trips (i.e. one day) being the main secondary activities. Boat trips to the Gadikwe/Gcobeha lagoons to view heronries in this area are also undertaken by most safari camps in the North Moremi/Cakanaca area and are a source of concern due to their effects on the heronries.

- Mekoro trails (two-three day trips) to Moremi W.R. or other floodplain margin areas coupled with game viewing and bird watching by walks from overnight camps are the basic activities for most camps located in the Central Delta except for Santawani Safari Lodge which has game viewing by four-wheel-drive vehicles as its dominant activity.

- The Maun Area safari camps tend to concentrate on providing short duration (e.g. three-four day) mobile safaris using either vehicular trips to Moremi Wildlife Reserve or boat access up the Boro River.

Based on the inventory data, brochures for various companies and general knowledge, it is thought that the complete range of tourism activities possible for the Delta is being adequately catered for but that cluster development of safari camps centred on attractions and access (e.g. Cakanaca, Xugana, Khwai, Matlapaneng, Shakawe and Cacaba-Delta areas) has created both perceived and actual overcrowding due to several operators using the same area. This situation is further complicated in the Cakanaca and Khwai areas where mobile operators and independent tourists using DWNP campsites use the same access tracks and/or river sectors as safari camp operators.

Future planning and location of safari camps catering for photographic safari clients will need to consider this aspect in respect of individual applications and for zoning for development and long term tourism use of the Delta. This is particularly applicable if the basic concept of tourism promotion for the

Delta is to continue to focus on the 'wilderness experience' and to be based on 'high price/low volume' guided safari type operations.

8.7.2 Land Use/Management Aspects

The status and tenure situation in respect of individual camps is confidential information. However, responses by safari operators indicated a general dissatisfaction with the existing situation. With the increasing tourist numbers, the limited number of safari camps (and in most cases some physical limitations as to site capacity) and the resulting increase in value of 'lessees' interest' in safari camps, the security of tenure for both safari camp leases and CHA's needs to be addressed promptly. Future investment decisions relating to the Delta's safari camp and CHA based non-resident hunting operations now involve, in effect, substantial financial commitments.

It is realised that the Ministry of Local Government and Lands (MLGL), DWNP and the Tawana Land Board are aware of the problem and are considering the future policy in respect of this matter. The tourist camp survey has confirmed the concern of safari camp operators and it is hoped that the growing value and benefits of tourism outlined below (i.e. now a P16 million industry based on the Delta's resources growing at 10-12%/year) will assist in highlighting the importance of completing a management plan for the Okavango Delta including long term policies and strategies of tourism development and definitive land use and wildlife management plans.

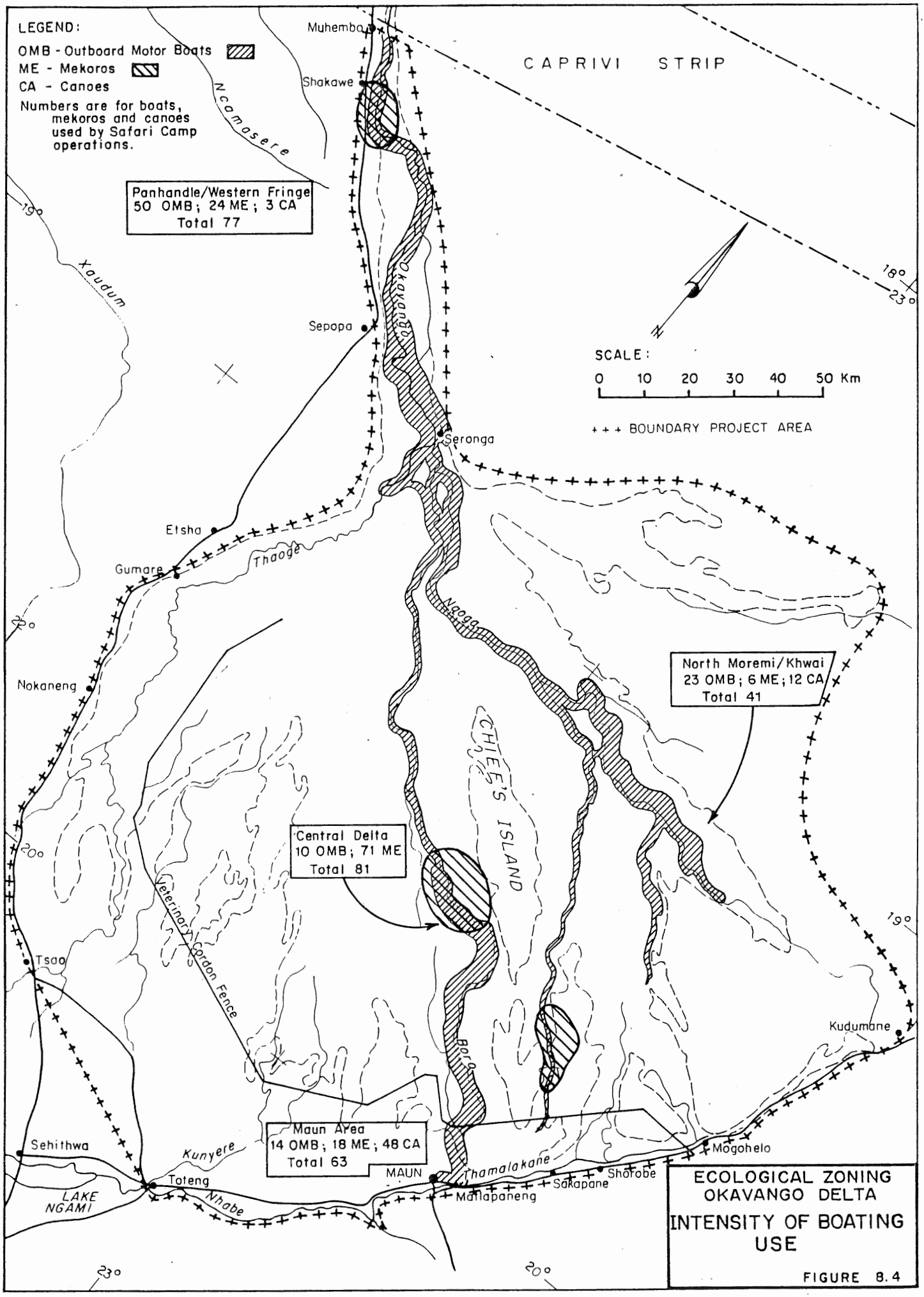
8.7.3 Water Use by Tourism Related Activities

The safari camp survey indicated that there was the following distribution of motor boats, mekoro and canoes owned and utilised by the Delta's safari camp operators:

Area	Motor boats	Mekoro	Canoes	Total
Panhandle/Western Fringe	50	24	3	77
North Moremi/Khwai	23	6	12	41
Central Delta	10	71	-	81
Maun	14	18	48	80
Total	97	119	63	279

The above distribution illustrates the high proportion of motor boats in the Panhandle/Western Fringe Area (i.e. 5.5/camp) and the dominance of mekoro travel in the Central Delta (i.e. 12/camp) with the two safari campsite operations (i.e. Oddballs and Ntswi) using 50 mekoro in total. Recent proliferation of unauthorised operations in the lower Santantadibe has given rise to concern about degradation of the environment.

The 97 motor boats registered to safari camp operations in the Delta represent approximately 17% of the total boats registered by the DWA for the Okavango region. Figure 8.4 attempts to illustrate the relative intensity of motor boat use on the Delta's various waterways. Preliminary investigations into the data held in DWA files in Maun relating to boat and motor


LEGEND:
OMB - Outboard Motor Boats
ME - Mekoros
CA - Canoes
Numbers are for boats, mekoros and canoes used by Safari Camp operations.
CAPRIVI STRIP
Muhembo
Shakawe
Ncamosere
Panhandle/Western Fringe
50 OMB; 24 ME; 3 CA
Total 77
Xaudum
Okavango
Sepopa
SCALE:
0 10 20 30 40 50 Km
+ + + BOUNDARY PROJECT AREA
Seronga
Etsha
Gumare
Thaoge
Nqoga
Nokaneng
North Moremi/Khwai
23 OMB; 6 ME; 12 CA
Total 41
CHIEF'S ISLAND
Central Delta
10 OMB; 71 ME
Total 81
Veterinary Cordon Fence
Tsao
Kudumane
Boro
Maun Area
14 OMB; 18 ME; 48 CA
Total 63
Sehithwa
Kunyere
Toteng
Nhabe
LAKE NGAMI
MAUN
Thamalakane
Mogohelo
Shorobe
Sakapane
Maitapaneng
ECOLOGICAL ZONING
OKAVANGO DELTA
INTENSITY OF BOATING USE
FIGURE 8.4

registrations and inter-zonal transfer of boats indicate that a good data base exists for a separate study to delineate boat distribution by ownership (i.e. private, safari operators, Government Departments) boats' probable location and extent of annual boat movements into and out of the Delta waters. A suggestion for this study is included in section 8.12.

Conflicts between boat users and other tourists are an indicated problem. Conflicts exist in respect of:

- Outboard motor boats (OMB) vs mekoros in the Central Delta Area.

- Erosion hazards created by the wash from larger OMB's in the Panhandle sections of the Okavango River.

- Outboard noise disturbance to other camps, wildlife on floodplains and birds at heronries and sandbank or riverine nesting and floodplain staging areas throughout the Delta.

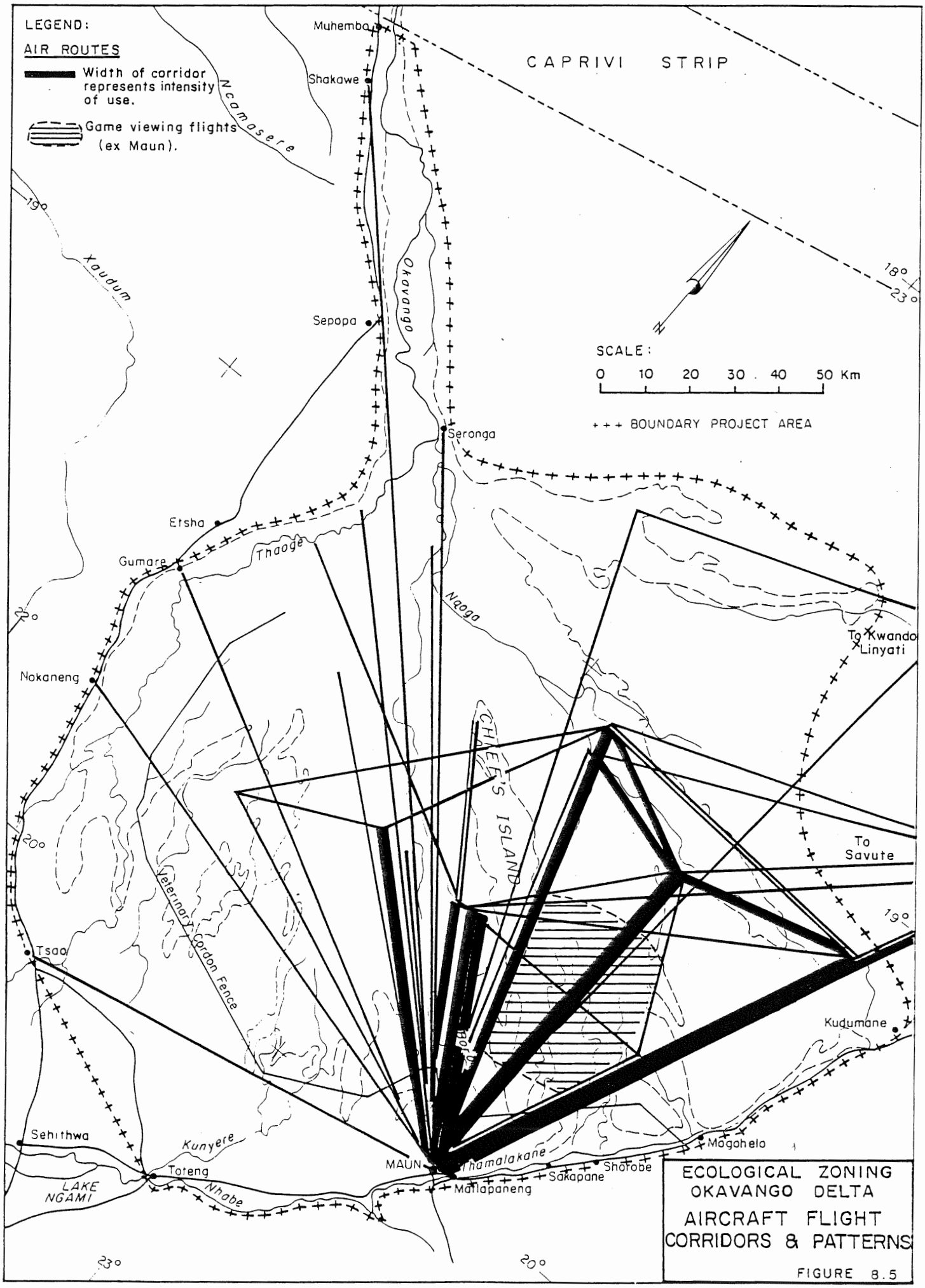
It is reported that controls on the size of outboard motor sizes using waters in Moremi Wildlife Reserve are to be invoked by DWNP. A review should be undertaken of this aspect in the context of legitimate requirements by Government Departments undertaking field investigations (e.g. DWA and TFC) and also for requirements by safari camps relying on boat access either traditionally or due to seasonal flooding.

8.7.4 Use of Aircraft for Tourism Related Activities

The substantial growth in and importance of the charter aircraft operations associated with tourism in the Delta is shown on Figures 8.2 and 8.3. All 26 of the Delta's safari camps located outside the Maun area indicate that part, and in some cases, all, supply servicing to the camp is undertaken using charter or the camps' own aircraft. A situation has developed in which certain Delta air routes are extremely busy at certain times of the year. Figure 8.5 attempts to illustrate the most heavily utilised 'corridors'.

Some 25% of safari camps listed game viewing flights as an activity for their operation and it is probable that actual participation in this activity is higher, particularly if the trips to and from camps are included. As with boating and other activities it is difficult to obtain specific details of the extent of this activity within the time allocated for tourism investigations.

Aircraft noise and disruption to on-ground game viewing activities was a commonly indicated conflict noted during the tourist camp survey. Game viewing flights seldom, if ever, conform to standing Air Navigation Regulations regarding heights above National Parks and Game Reserves. Flight paths to some camps overfly other camps and/or key activity zones. Disturbance by aircraft to heronries and other bird colonies or feeding/ staging bird groups is another tourism related impact which warrants further investigation.



ECOLOGICAL ZONING
OKAVANGO DELTA
AIRCRAFT FLIGHT CORRIDORS & PATTERNS

FIGURE 8.5

It is suggested that a study be undertaken into numbers and locations frequented for game viewing flights, and that flight frequencies on regular routes between Maun Airport and camps by charter aircraft should be an integral part of the proposed follow-up land use/tourism planning study for the Okavango Delta.

8.7.5 Non-resident Hunting Safari Use

Data relating to the Delta's non-resident hunting safari operations was not reflected in the tourist camp inventory. In 1988 there were basically four major companies providing hunting opportunities for non-resident hunters. These included:

- Safari South Limited
- Hunter's Africa
- Vira Safaris
- Buffalo Trails

Data available from one of these operations responsible for approximately one-third of the camps operated indicated a utilisation (i.e. occupancy) rate of some 1 600 hunter days/season (i.e. from April to September). Based on the total number of camps operated by all hunting safari operators, the total utilisation rate in 1988 for the CHA's located within and around the Okavango Delta could approximate 4 200-4 800 hunter days/year. This would involve some 400-450 individual non-resident hunters. With high occupancy rates and high daily fee revenues generated, non-resident hunting safaris account for a substantial proportion of the gross tourist benefits from the Delta (i.e. 42% as noted in Fowkes, 1985). This is confirmed by the estimates included in section 8.9, and the licence fees paid by non-resident hunters (section 6.1.10.2).

Conflicts between safari hunting operators over CHA boundaries, illegal hunting in other parties' territories and use of access tracks and other infrastructure do exist. Similarly, there are conflicts over the 'exclusivity' assumed and implied in areas designated for non-resident hunting and use of these areas by other parties, either for tourist activities or other traditional or legal uses (e.g. citizen hunting, poaching, gathering reeds and thatching grass and field work by Government agencies such as DWA and DWNP). Additional comments relating to these conflicts are provided in section 6 - Wildlife and the Land and the Resource Utilisation tables included in section 7 - Present Land Use.

8.7.6 Mobile Safari Operations

The Fowkes report based on 1984 data indicated that there were 33 mobile operators operating in Botswana, 19 of which were Botswana registered companies. Mobile safari operations in 1984 accounted for less than 15% of gross tourist revenue (in terms of foreign exchange) and provided less than 10% of the total tourist numbers and less then 5% of the Batswana employment opportunities in the tourist industry (Fowkes, 1985).

In 1988, it estimated that there are 37 mobile safari operators using the Delta (some involving only one trip/year). Of these 37

mobile operators, some 24 have offices or agents located in Maun and/or Gaborone (Main, et al. 1987). The extent of foreign ownership and the frequency and patterns of use of the Delta's tourism resource base are difficult to determine wihout extensive research. Based on published literature and brochures, it would seem that:

- Larger trans Africa and South Africa based mobile safaris are comprised of approximately ten tourists/safari group.

- Mobile safari operators comprise a significant component of the campsite users and generally spend two to three days in Moremi Wildlife Reserve.

- Mobile safari groups are comprised largely of European and South African residents (e.g. 75-80%).

- Mobile safari operators make extensive use of guided mekoro trails in the Central Boro and Chief's Island areas.

Conflicts associated with mobile safari operators relate to illegal camping within Moremi Wildlife Reserve, use of access tracks provided by CHA based safari operators and operating of semi-permanent camps or activities (e.g. in the Ditshipi/ Santantadibe/south Chief's Island area) without official approval and/or appropriate permits. The latter situation is being investigated and the necessary remedial action invoked by MLGL through the District Commissioner's Office. However, explicit policies and guidelines are required to effectively control this situation which is a recurring problem. The situation warrants a specific study into these activities and the devising of long term objectives in respect of mobile safari operators in the proposed land and tourism use development and management plan for the Delta.

8.8 BASIC PROJECTIONS OF OCCUPANCY AND TOURIST NUMBERS

Projections of visitor numbers based on the estimated occupancy rates have been undertaken in order to obtain a preliminary indication of the relative numbers utilising the four tourism areas or zones of the Delta. These projections are basic estimates but tend to be confirmed by those of other parties i.e. Price Waterhouse (pers. comm.) and HATAB representatives.

The total annual tourist occupancy of the Delta is estimated at 85 000-90 000 bednights/year. This is equivalent to 25 000-30 000 individual tourists, giving due recognition to other tourists (not included in the inventory), such as safari company hunting clients, those staying with friends and those using casual campsites outside DWNP and private campsites. The average projected annual bednights are included as Item 7 in Table 8.1 and indicate an annual total of some 87 000. The indicated minimum number of bednights and use of adjusted campsites capacities is 73 000 bednights/year. The indicated maximum number of visitors, using the excessive campsite capacities previously referred to, extended seasons of safari camps and a 12% adjustment for casual visitors is 99 000 bednights/year.

These figures correspond to an estimated minimum annual estimate of 24 000 visitors and an estimated maximum of 33 000.

Based on these figures it would appear that annual visitor numbers to the Delta are roughly equivalent to 50% of the annual total of aircraft passenger arrivals and departures at Maun Airport (i.e. 66 000 in 1988 - see Figure 8.1). As with other aspects of the Delta's tourism resource and use, additional research is definitely required to confirm the preliminary projections of tourist numbers, as outlined above.

The estimated annual rate of bednight occupancy of 46 600 for the Okavango Delta in 1988 (i.e. Item 7.1 in Table 8.1) compares realistically with the estimated total bednight occupancy of 39 700 indicated for 1984 for all fixed safari camps in Botswana (Fowkes, 1985). This fact and the comparison of Fowkes' total of 17 000 clients who booked with all Botswana safari companies offering fixed accommodation compares generally with the estimated annual total of 15 000-18 000 individual tourists staying at fixed safari camp accommodation in the Delta in 1988.

Although direct comparisons are not possible, extrapolation and comparison of data based on relative distribution of safari lodges indicate that the annual bednights spent in the Delta from Fowkes' data would have been approximately 30 000 in 1984. Comparing this with the 1988 estimate of 46 600 indicates a growth rate of approximately 10-12%/year for the Delta's tourist safari industry.

8.9 BASIC PROJECTIONS OF ECONOMIC BENEFITS FROM THE DELTA'S TOURIST INDUSTRY

Detailed analyses and projections of the economic benefits associated with safari camp and campsite operations are beyond the scope of this project. However a basic indication of the relative significance of the primary benefits of the tourism industry can be summarised as follows (these are considered minimum estimates):

- safari camp fixed accommodation operations
  47 000 visitor nights @ P160/night = P7.5 million

- public (DWNP) and private campsite operations
  32 000 visitor nights @ P50/night = P1.6 million

- non-resident hunters using services of the three major companies with allocated CHA's in the Delta 4 500 hunter days @ P1 500/day = P6.8 million

- casual visitors staying with friends and visiting the Delta on a day-use or short term visit basis 4 500 visitor days @ P40/day = P0.2 million

Thus the estimated minimum annual benefit for the Okavango Delta's tourism industry is estimated at P16.1 million, with non-resident hunting accounting for some 40% of the total, as was also the case in 1984 (Fowkes, 1985).

8.10 ACTIVITY CONFLICTS AND AREAS INDICATED AS REQUIRING PROTECTION

8.10.1 Tourism Activity Related Conflicts

Open ended responses from safari camp operators were sought and recorded in respect of perceived or actual conflicts and of the protection or land resource management requirements relating to areas used by them (see Items 20.3 and 20.5 on Questionnaire Form in Appendix K). Due to difficulties in coding responses and with maintaining confidentiality, this information has not been included in summary tables.

8.10.2 Activity or Land Use Conflicts

There was substantial agreement on the conflicts indicated for the four tourist activity zones. In summary these were (in order of most frequent responses):

a) Panhandle/Western Fringe Area

- Conflict over commercial vs recreational fishing in terms of policy, net sizes, locations, etc., and resource depletion of tigerfish.

- Policy and activities relating to harvesting of crocodile eggs and/or catching of hatchlings and adults.

- Burning of reeds and papyrus during recent drought periods.

- Cattle encroachment into lower Panhandle/Delta floodplains during recent drought periods.

- Other conflicts include too many lodges in Shakawe area, too many boats, noise disturbance due to night time use of boats and irrigation pumps, sitatunga hunting vs game viewing in lower Panhandle and loss of riverine forest due to land clearing.

b.1) North Moremi/Cakanaca Sub-Area

- Needs for additional game viewing roads.

- Poor maintenance of DWNP campsites, particularly problems of litter, baboons and hyaenas.

- Needs for controls on motorboats (numbers and activities), litter and general disturbance to heronries in the Gadikwe/Gcobeha lagoon area.

- Conflicts between hunting safari operators and photo safari operators in use of access tracks and burning of floodplains and/or papyrus.

- Illegal casual camping and/or day use of areas in proximity to safari camps and at key activity zones (e.g. hippo pools) located outside designated campsites and within Moremi W.R.

- Other conflicts include lease property border disputes at Cakanaca and Xugana camp clusters; concern at long term allocation of CHA 17 (i.e. better used for tourism); controls required on hiring of boats to casual campers; general inefficiency/problems in dealing with DWNP game scouts.

b.2) Khwai Sub-Area

- Need for controls on hunting activities in proximity to lodges and areas used for game walks.

- Need for initiating effective land use controls in and around Khwai village.

- Illegal hunting and poaching activities in Khwai area (i.e. within 5 km of Moremi W.R.).

- Land allocation conflict between CHA and use of areas (the north side of Khwai River) by non-hunting tourists.

- Other conflicts or management issues include need for longer hours of access through Moremi W.R. during peak season; additional management required for Moremi W.R. during peak season; misuse of Drought Relief Hunting Permits by Khwai villagers; and illegal camping by mobile operators in CHA areas.

c) Central Delta Area

- Conflict over use of OBM's vs mekoro in central Boro area.

- Boat and aircraft noise and interference with mekoro trail game viewing activities.

- Illegal use of Ditshipi and Santantadibe areas by mobile operators for camping and bases for mekoro trail safaris.

- Other conflicts or resource management problems relating to controls required on crocodile operations; policy relating to subsistence permits for polers; and timing of aircraft flights over central Delta (i.e. early morning disturbance).

d) Maun Area

- Generally conflict situations indicated were minimal and of minor significance but included:

  - concern over boat traffic on lower to mid Boro area in terms of numbers, conflicts with mekoros and needs for security of tenure for boat landings/depots inside veterinary cordon fence;

  - indicated need for designated individual campsites for Maun based mobile safari camp operators;

  - concern that proposed increased entrance fees should be used to improve campsite facilities in Moremi Wildlife Reserve;

- concern over firewood shortage in Matlapaneng area;
- indicated need for provision of training of personnel Maun Area because of the extensive tourism developments in the immediate vicinity.

8.10.3 Areas Requiring Protection Based on Responses by Safari Camp Operators

As with the activity and land/resource use conflicts there was considerable consistency among the response received relating to the four areas by safari camp operators in those areas. The areas indicated as warranting protection in the tourist zones are as follows.

a) Panhandle/Western Fringe Area

- Red Cliffs area, because of the African skimmers and Carmine bee-eaters
- Ncamasere Valley, for its diversity of bird species
- Filipo (Eastern) Channel and controls on over - exploitation of fish and crocodile resources
- Etsatsa/Pepere/Duba Island zone as a wildlife sanctuary, due to its value for game and bird nesting (e.g. Wattled cranes)
- remaining riverine forest zones to protect both scarce plant resources, bird habitat and unresearched importance to other fauna, e.g. invertebrates
- Ngquma Lediba area for its fish and bird life
- special protection status for entire Panhandle floodplain/ riverine fringe so that an effective resource management programme can be devised and implemented.

b) North Moremi/Khwai Area

- protection status and controls on boating activities required in the Gadikwe/Gcobeha area
- gazetting and enforcing of special protection zone (i.e. non-hunting zone) around Khwai safari camps and village
- Maqwee area due to its significance as game and bird habitat
- protection status for the area between north end of Chief's Island and the Nqoga River due to wildlife movements through the area,

c) Central Delta Zone

- protection policy and policing of destructive uses of palms in the Daonara/Chitabe Island/south Chief's Island area
- south end of Chitabe/Mogogelo Channel because of its importance as habitat for eland, roan and reedbuck
- protection of the Xigera Lagoon area for its bird life
- possible inclusion of other protection status for the Mombo area due to its significant undisturbed tree cover and its wildlife diversity, as fringe area to permanent Delta.

d) The areas indicated by Maun based safari camp operators as requiring protection were limited but did include:

- need to reduce degradation in vicinity of Third Bridge campsites
- need to provide some protection status to Boro River from veterinary cordon fence to Cacaba.

8.11 COMMENTS ON PROPOSED CHANGES TO ENTRANCE FEES TO DWNP ADMINISTERED AREAS AND POTENTIAL EFFECTS ON DELTA TOURISM

The proposed changes in fee structure for entrance to Botswana's National Parks and Wildlife Reserves could have a substantial effect on tourism patterns of use in the Okavango Delta in both the short and long term. By raising the daily entrance fee rate from P5 to P50, it is probable that

- Some loss in bookings to safari camps using Moremi W.R. for game viewing activities will occur on both a short and long term basis.

- It could create an incentive to avoid paying fees and encourage indiscriminate camping in the Moremi W.R. fringe areas or alternatively accessible areas (e.g. lower Xudum/Xwaapa areas).

Existing pressure areas where increased casual camping could occur might include the following:

- Khwai area outside the Moremi Wildlife Reserve boundaries;
- Santawane/Daonara area due to improved and additional access tracks constructed during the 1983-87 drought period;
- Lower Boro area particularly if improved access is provided to the Boro/Kiri junction in conjunction with the Lower Boro River improvement works;
- Xudum/Xwaapa/Khurunxaraga area through existing access tracks via gates in the veterinary cordon fence;
- Panhandle area, in the medium term, as road access from Maun to Sehithwa and north from Nokaneng to Shakawe is improved.

High daily entrance fees will tend to discourage visits to the most accessible parts of the Delta (i.e. Moremi W.R.) by young individual tourists who tend to be conservation oriented and could eventually return as high paying safari camp clients and who could possibly assist in supporting future conservation issues relating to the Okavango Delta.

The above potential implications are given as examples of how the proposed changes in entrance fees could have a pronounced effect on the camper component of the Delta's tourists. This component accounts for an estimated 36% of the total visitor days (i.e. bednights) and an estimated 10% of the indicated P16 million revenue derived from the Delta's tourism activities.

Increases in entrance fees to Moremi W.R. will also have management implications in respect of that Reserve's existing DWNP administered and maintained public campsites. With

increased fees, expectations of facilities and services provided will be greater and upgrading of these facilities should be a priority item. Unfavourable comparisons with facilities and services available in national parks of adjacent countries, particularly Zimbabwe, would possibly influence the choices of some potential international tourists. It is also suggested that in the medium term additional management inputs will be required at DWNP public campsites, in order to control activities by users and reduce environmental degradation of these campsites.

Several options may be available in respect of development of alternative areas for campsites outside Moremi W.R. if it is a long term objective to reduce visitor pressure on the Reserve. These options include the following:

- Provision of designated campsites on an annual permit basis for mobile operators who would be required to notify intended use and held responsible for campsite maintenance. Standards to be guaranteed by an annual bond registered with DWNP or other authorities.

- Permit private campsite development by CHA lease holders, with planning authorities having inputs to plans for development and/or expansion of facilities.

In summary, it is suggested that the proposed changes in entrance fee structures will probably cause an upset in the current status, use patterns and numbers of tourists opting to visit the Delta as independent campers. Due consideration will need to be given to this aspect during the follow-up land use and tourism management plan preparation. As noted above (section 8.7) it is also considered important that some feed-back from the camper segment of the Delta's tourist population should be obtained as an input to the management plan development.

8.12 SUGGESTIONS FOR INVESTIGATIONS ON TOURISM USE OF THE DELTA

The following suggestions are made as the priority items for further investigations, most of which are required as inputs to the proposed land use and tourism and management plan.

8.12.1 Non-organised Visitor Use Patterns

Gaps in the information available on non-organised use by tourists of the Delta are extensive. Particular gaps exist in relation to:

a) Actual capacity and numbers of people utilising DWNP campsites and user perceptions and attitudes of this experience as it relates to campsites at South Gate, Third Bridge, Cakanaca and North Gate.

b) Areas used and extent of use by casual campers camping outside the boundaries of Moremi W.R. and in other areas of the Delta accessible by four-wheel-drive vehicles (e.g. Daonara/Ditshipi, Lower Boro, Khurunxaraga/Xudum and Sepupa/Shakawe/Muhembo zones).

c) Visitor profile (i.e. origin, means of transport, length of stay, areas visited, expenditure pattern and user satisfaction and perceptions/attitudes towards organised tourism use of the Delta through a survey of users of campsites/services provided by (i) Maun based operators (e.g. Island Safari); (ii) Oddballs; (iii) parties using DWNP campsites; and (iv) independent/casual campers staying in road accessible camps in the Panhandle area.

The information to be gathered is considered to be most important and of some priority. In particular it would be beneficial to obtain some information on attitudes to the park entrance fee structure. To cover the range of tourists/campers likely to be involved and have a valid sample for analysis at least 25 (and preferably 50) interviews must be collected at each of the four DWNP campsites pre and post change in fee rates.

Item 8.12.1 has been subdivided according to possible sub-projects which could be undertaken as topics, but if this is done collaboration would be required in respect of questionnaire format.

8.12.2 Other Possible Research or Sub-Studies

Other data gaps, relating to tourism use, that would be suitable as projects by individual researchers and which would be of limited duration include:

a) Length of stay, activity participation, user satisfaction and attitudes towards tourism development and conservation of the Delta by organised tourists staying at safari lodges. This type of information can be gathered by self-administered questionnaires left with and returned from camp operators. (A small questionnaire of this nature is already administered by Oddballs.) This sub-project would be suitable as an honours or masters thesis project. The researcher would possibly require assistance with formatting and analysis of the self-administered questionnaire for computer. Extensive literature is available on use of self-administered questionnaires in national parks and recreation areas in USA, Canada, Australia, etc.

b) Investigations into secondary benefits associated with tourism particularly as it relates to the Maun business community (which should possibly assist financially with this project). Data is required in respect of length of stay in Maun; relative expenditure for accommodation, meals, souvenir purchases, joy flights; vehicle rentals; purchase of camping supplies, petrol, etc. This project could possibly also be sponsored and/or supervised by one of the larger accounting firms involved in the tourism industry in Botswana and/or through HATAB.

c) A 'creel census' type survey with numbers and species caught, etc., comparing recreational fishing and commercial activities at three locations, say, Shakawe, Sepupa and Seronga. The objectives of this study would be to obtain information not only on the relative scope and fish

resources utilised but also to complement this with information relating to areas used and user satisfaction by recreational fishermen. Ideally, additional interviews could be undertaken at more remote fishing camps through the cooperation of those camp owners (e.g. Akukwe, Ngquma Lediba and Etsatsa). As with 8.2.1 above, extensive information is available on techniques from overseas parks and wildlife authorities.

d) Analyses of data available and preparation of a small report on use of aircraft by Delta tourist operators. Preliminary data available from this Project relating to airstrip locations, total flights, destinations and air flight frequency. Noise disturbance is an indicated problem and appears to be related to conflicts in timing and overflying of camps. This needs to be investigated in more detail. The assistance of air services companies based in Maun would be essential.

e) Boating use in the Delta re: ownership, distribution of boats, areas used, compliance with licensing and spraying regulations, etc. A certain amount of information is already available in DWA's data base at Maun.

TABLE 8.2 OKAVANGO DELTA - TOURIST CAMP SURVEY - ADMINISTRATION

Number	Area Code	Camp Name	Owner	Address	Present Manager
PANHANDLE AREA AND WESTERN FRINGE					
2	A1	Akukwe Island	J. Seaman	P. Bag 47, Maun	J. Seaman
7	A1	Drotsky's Cabins	Fish Eagle Lodge	P. Bag 1, Shakawe	J. & E. Drotsky
8	A1	Etsatsa	Hunters Africa	Box 119, Maun	G.D. Randall
11	A1	Jedibe	Jao Safaris	Box 1, Maun	H. Rawlinson
17	A1	Mxamaseri	P.J. Bestelink	P. Bag 23, Maun	P.J. Bestelink
24	A1	Shakawe Fishing C.	Okavango F. Saf.	Box 12, Shakawe	B.E. Pryce
29	A1	Xaro	Okavango Expl.	P. Bag 48, Maun	J. Stacey
9	A2	Guma Lagoon	P.J. Bestelink	P. Bag 23, Maun	G. Ramakolodi
21	A2	Qhaaxwa	Xaxaba Camp (Pty)	Box 147, Maun	G. Kamutati
NORTHERN MOREMI/KHWAI AREA					
1	B1	African Skimmer	Okavango Expl.	P. Bag 48, Maun	G. Brits
4	B1	Camp Okavango	Desert & Delta Saf.	P. Bag 10, Maun	Changu
25	B1	Shindi	KDS Botswana (Pty)	Box 40, Maun	D. Balfour
33	B1	Xugana	Okavango Expl.	P. Bag 48, Maun	A. W. Pirie
3	B2	Camp Moremi	Desert & Delta Saf.	P. Bag 10, Maun	C. Mlazie
20	B2	Okuti	R.K. Schleipfer	P. Bag 49, Maun	R.K. Schleipfer
31	B2	Xaxanaka (Mor.Saf.)	Tsaro PhotoSafaris	P. Bag 26, Maun	D. Bristow
32	B2	Xaxanaka (Saf.Unl.)	Safaris Unlimited	Box 253, Maun	P. Enee
12	B3	Khwai River Lodge	Gametrackers (Pty)	Box 100, Maun	J. Matengu
14	B3	Machaba	KDS Botswana (PTY)	Box 40, Maun	B. Cantle
28	B3	Tsaro Lodge	Tsaro PhotoSafaris	P. Bag 26, Maun	D. Hunter
CENTRAL DELTA AREA					
15	C1	Mombo	Jao Safaris	Box 1, Maun	
6	C2	Delta Camp	N/W Holdings (Pty)	Box 39, Maun	M. Dwyer
16	C2	Ntswi	Trans Okavango	P. Bag 33, Maun	M.J. Gunn
18	C2	Oddballs	N/W Holdings (Pty)	Box 39, Maun	
23	C2	Santawani	Gametrackers (Pty)	Box 100, Maun	T. Read
30	C2	Xaxaba	Xaxaba Camp (Pty)	Box 147, Maun	K. Motsamai
MAUN AREA					
5	D	Crocodile Camp	Croc. Camp Safaris	Box 46 Maun	K.H. Gimpel
10	D	Island Safari L.	Island Safaris	Box 116, Maun	T.J. Graham
13	D	Kubu Camp	Okavango	Box 487, Maun	P. Fox
19	D	Okavango River L.	P. TavaresDaSilva	Box 32, Maun	P. TavaresDaSilva
22	D	Rileys Hotel	Cresta Marakanelo	Box 1, Maun	N. Pryce
26	D	Sitatunga Camp.Saf.	J. Seaman	P. Bag 47, Maun	J. Seaman
27	D	Thamalakane S.L.	Koro Safari Lodge	P. Bag 22, Maun	C. Blomstrand

TABLE 8.3 OKAVANGO DELTA - TOURIST CAMP SURVEY -SERVICES AND FACILITIES

Number	Area Code	Camp Name	Type	Accommodation	Facilities	Services
PANHANDLE AREA AND WESTERN FRINGE						
2	A1	Akukwe Island	S. Camp	8 reed huts	GDR, GB	None
7	A1	Drotsky's Cabins	S. Camp	3 BC/R, 3 RH	GDR, GB	CCS, CS, B/C
8	A1	Etsatsa	S. Camp	1 RH, 6 tp.tents	GDR, GB	None
11	A1	Jedibe	S. Camp	6 perm. tents	GDR, GB	L
17	A1	Nxamaseri	S. Lodge	4 BC/R. 1 RH	GDR, GB, SS	L
24	A1	Shakawe Fishing C.	S. Lodge	10 BC/R, 6 pm.tents	GDR, PB, SS, SP	CCS, CS, L, VR, B/R, FT
29	A1	Xaro	S. lodge	6 perm. tents	GDR, GB, SS	None
9	A2	Guma Lagoon	S. Camp	4 reed huts	GDR, GB	CCS, L, B/C, CE, HR
21	A2	Qhaaxwa	S. Camp	8 reed huts	GDR, GB	None
NORTHERN MOREMI/KHWAI AREA						
1	B1	African Skimmer	R. Boat	4 temp. tents	GDR, GB	None
4	B1	Camp Okavango	S. Camp	11 perm. tents	GDR, CB	None
25	B1	Shindi	S. Camp	6 perm. tents	GDR, GB	None
33	B1	Xugana	S. Lodge	8 perm. tents	GDR, GB, SS, SP	None
3	B2	Camp Moremi	S. Camp	11 perm. tents	GDR, GB	None
20	B2	Okuti	S. Camp	7 perm. tents	GDR, GB	B/C
31	B2	Xaxanaka (Mor.Saf.)	S. Camp	3 perm. tents	GDR, GB	B/C
32	B2	Xaxanaka (Saf.Unl.)	S. Camp	11 temp. tents	GB	VR, B/C
12	B3	Khwai River Lodge	S. Lodge	13 BC/Rondavels	GDR, GB, PB, SS, SP	None
14	B3	Machaba	S. Camp	6 perm. tents	GDR	None
28	B3	Tsaro Lodge	S. Lodge	6 BC/Rondavels	GDR, GB, PB, SS, SP	None
CENTRAL DELTA AREA						
15	C1	Mombo	S. Camp	6 perm. tents	GDR, GB	None
6	C2	Delta Camp	S. Lodge	8 reed huts	GDR, GB, SS	None
16	C2	Ntswi	S. Camp	4 reed huts	GB, PR, PB, SS	CCS, CS, L, SF, B/C, CE
18	C2	Oddballs	C. Site	Campsite	PR, PB, SS, Sh	CCS, CS, L, SF, B/C, CE
23	C2	Santawani	S. Lodge	8 BC/Rondavels	GDR, GB, PB, SS	None
30	C2	Xaxaba	S. Lodge	10 reed huts	GDR, GB, SS, SP	CS, L, B/C
MAUN AREA						
5	D	Crocodile Camp	S. Lodge	7 reed huts	GDR, GB, PB	CCS, CS, L, SF, B/C, MS
10	D	Island Safari L.	S. Lodge	20 BC/Rondavels	GDR,GB,PR,PB,SS,SP,Ci	CCS,CS,L,SF,VR,B/C,CE,MS
13	D	Kubu Camp	S. Camp	Campsite, 1 R.H.	SP	CCS,CS,L,SF,VR,B/C,CE
19	D	Okavango River L.	S. Lodge	9 BC/Rondavels	GDR, 2PB, SS, BS, SP	CCS, CS, L, B/C, CE
22	D	Rileys Hotel	Hotel	34 hotel rooms	GDR,GB,PR,3PB,SS,BS,SP	L
26	D	Sitatunga Camp.Saf.	S. Camp	8 perm. tents	GDR, GB, SS	CCS, CS, L, SF, VR, B/C
27	D	Thamalakane S.L.	S. Lodge	3 RH, 5 pm.tents	GDR,GB,PR,PB,SS,SP	CCS, CS, L, CE, MS

Accommodation
- tp = temporary
- pm = permanent
- BC = Brick Chalets
- R = Rondavels
- RH = Reed Huts

Facilities
- GDR = Guest Dining Room
- GB = Buest Bar
- PR = Public Restaurant
- PB = Public Bar
- SS = Souvenir Shop
- Sh = General Shop
- SP = Swimmingpool
- Ci = Cinema

Services
- CCS = Casual camping sites
- CS = Camping Showers
- L = Laundry
- SF = Sale of firewood
- VR = Vehicle Rental
- B/C = Boat/Canoe Rental
- CE = Camp. Equip. Rental
- MS = Mobile safaris
- H = Horse Riding
- FT = FishingTackle Rental

TABLE 8.4 OKAVANGO DELTA - TOURIST CAMP SURVEY - CAMP CAPACITY AND AMENITIES

Number	Area Code	Camp Name	Season	Capacity	Activities	Priorities
PANHANDLE AREA AND WESTERN FRINGE						
2	A1	Akukwe Island	YR	16/5840/-/-	GV/BR/FI/BW/ME	1FI/2ME+BW/3GV
7	A1	Drotsky's Cabins	YR	18/6570/20/7300	W/BR/FI/BW/TT	1BW/2FI/3TT
8	A1	Etsatsa	YR	12/4380/-/-	W/BR/FI/BW/MC	1FI/2BW
11	A1	Jedibe	M-D	12/3650/-/-	W/BR/FI/BW/ME	1ME/2BW/3FI
17	A1	Nxamaseri	F-N	8/2430/-/-	W/BR/FI/BW	1FI/2BW+W
24	A1	Shakawe Fishing C.	YR	14/5110/35/12775	W/BR/FI/BW/TT	1FI/2BW/3TT
29	A1	Xaro	YR	12/4380/-/-	GV/BR/FI/BW	1BR/2FI/3BW
9	A2	Guma Lagoon	F-N	8/2430/6/1820	W/BR/FI/BW/ME/HO	1FI+BR/2HO/3BW
21	A2	Qhaaxwa	YR	16/5840/-/-	W/BR/FI/BW	1FI/2BR/3BW
NORTHERN MOREMI/KHWAI AREA						
1	B1	African Skimmer	M-N	8/2190/-/-	W/BR/FI/BW	1W/2BR/3FI/4BW
4	B1	Camp Okavango	M-D	22/6650/-/-	W/BR/BW/MC	1BR/2BW
25	B1	Shindi	M-D	12/3670/-/-/	GV/W/BR/FI/BW/ME	1GV/2BW+BR/3FI
33	B1	Xugana	YR	16/5840/-/-	GV/W/BR/FI/BW/ME/GF	1BR+W/2GV/3BW/4FI
3	B2	Camp Moremi	M-D	18/5470/-/-	GV/BW	1GV/2BW
20	B2	Okuti	YR	14/5110/-/-	GV/W/BR/BW/MC	1GV/2BR/3W
31	B2	Xaxanaka (Mor.Saf.)	YR	16/5840/-/-	GV/BR/FI/BW	1GV/2FI/3BR
32	B2	Xaxanaka (Saf.Unl.)	A-D	22/6030/-/-	GV/W/BR/FI/MC/GF	1GV/2BR/3FI/4W/5GF
12	B3	Khwai River Lodge	M-D	26/7900/-/-	GV/W/FI/BW/GF/	1GV/2W/3GF
14	B3	Machaba	M-D	12/3650/-/-	GV/BW	1GV/2BW
28	B3	Tsaro Lodge	YR	12/4380/-/-	GV/W/FI/BW	1GV/2W/3FI
CENTRAL DELTA AREA						
15	C1	Mombo	M-D	14/4250/-/-	GV/W/FI/BW	1BW/2GV/3W
6	C2	Delta Camp	YR	16/5840/-/-	W/FI/BW/ME	1ME/2W
16	C2	Ntswi	YR	16/5840/40/14600	W/BR/FI/BW/ME	1ME/2BR/3W/4FI
18	C2	Oddballs	YR	-/-/60/21900	W/FI/BW/MC	1ME/2W
23	C2	Santawani	M-D	16/4860/-/-	GV/W/FI/BW/MC/GF	1GV/2W/3FI/4GF
30	C2	Xaxaba	YR	22/8030/11/4020	W/BR/FI/BW/ME/GF	1BW/2ME+W/3BR+W/4GF
MAUN AREA						
5	D	Crocodile Camp	YR	16/5840/60/21900	GV/BR/BW/MC/GF	1MS/2BR
10	D	Island Safari L.	YR	72/26280/200/73000	GV/BR/FI/BW/MC/GF	1BR/2MC
13	D	Kubu Camp	YR	-/-/50/18250	GV/W/BR/FI/BW/MC/GF	1MS/2BR/3ME
19	D	Okavango River L.	YR	24/8760/60/21900	BR/FI/MC/GF	1BR/2MC
22	D	Rileys Hotel	YR	68/24820/-/-	NONE	NONE
26	D	Sitatunga Camp.Saf.	YR	22/8030/100/36500	W/FI/BW/ME	1MS/2BW/3W/4FI
27	D	Thamalakane S.L.	YR	17/6210/20/7300	GV/BR/FI/BW/ME/HO	1ME/2MS/3FI

Capacity

1/2/3/4

1 = total guest beds
2 = no bednights per year
3 = visitors cap. campsite
4 = no campers per year

Activities

GV = Game viewing
W = Walking
BR = Boat rides
FI = Fishing
BW = Bird Watching
ME = Mekoro trails
MC = Mekoros/Canoes
HR = Horse riding
MS = Mobile Safaris
TT = Daytrips to Tsodilo

Priorities

Abbreviations see Activities

TABLE 8.5 OKAVANGO DELTA - TOURIST CAMP SURVEY -- ACCESS AND EQUIPMENT

Number	Area Code	Camp Name	Accessibility	Airstrip	Equipment
PANHANDLE AREA AND WESTERN FRINGE					
2	A1	Akukwe Island	W: Seronga	Seronga/DCA/55	MB4/ME8
7	A1	Drotsky's Cabins	R + W: Shakawe	Shakawe/DCA/60	V2:2LC/MB4
8	A1	Etsatsa	W: Seronga	Seronga/DCA/55	V1:1LC/MB7/ME2
11	A1	Jedibe	W: Jedibe	Jedibe/own/45	MB2/ME8
17	A1	Nxamaseri	adj. airstrip	Nxamaseri/own/60	MB4/CA2/AC1
24	A1	Shakawe Fishing C.	R + W :Shakawe	Shakawe/DCA/60	V6:4LR+1F250+1BF/MB12/AC1/TR
29	A1	Xaro	R + W :Shakawe	Shakawe/DCA/60	V2:1HI+1F250/MB3
9	A2	Guma Lagoon	R: Etsha/adj. airstrip	Guma/own/45	MB4/ME6/CA1
21	A2	Qhaazwa	R: Etsha/adj. airstrip	Qhaazwa/own/40	MB4
NORTHERN MOREMI/KHWAI AREA					
1	B1	African Skimmer	W: Xugana airstrip	Xugana/KDS/35	MB2
4	B1	Camp Okavango	adj. airstrip	Camp Oka./own/35	MB6/CA4/AC1
25	B1	Shindi	W: Xugana airstrip	Xugana/KDS/35	V3:2LC+1LR/MB2/ME4
33	B1	Xugana	W: Xugana airstrip	Xugana/KDS/35	V1:1LC/MB4/AC1/TR1
3	B2	Camp Moremi	adj.Xak.airst./R: Maun	Xakanaka/DWNP/30	V3:3LC
20	B2	Okuti	adj.Xak.airst./R: Maun	Xakanaka/DWNP/30	V2:2LC/MB2
31	B2	Xaxanaka (Mor.Saf.)	adj.Xak.airst./R: Maun	Xakanaka/DWNP/30	V5:1LR-FC+2LR+1LC/MB4
32	B2	Xaxanaka (Saf.Unl.)	adj.Xak.airst./R: Maun	Xakanaka/DWNP/30	V6:2LR+2LC+2BF/MB3/ME2/CA8/AC3
12	B3	Khwai River Lodge	adj. airstrip/R: Maun	Khwai/Gametr./30	V5:4LC+1LR/TR1
14	B3	Machaba	R: Khwai airs./R: Maun	Khwai/Gametr./30	V2:2LC
28	B3	Tsaro Lodge	R: Khwai airs./R: Maun	Khwai/Gametr./30	V5:2LC+2LR+1UN
CENTRAL DELTA AREA					
15	C1	Mombo	adj. airstrip	Mombo/own/40	V2:2LC/MB1
6	C2	Delta Camp	adj. airstrip	Delta/own/20	ME10
16	C2	Ntswi	W+R: Maun/adj. airstrip	Ntswi/own/20	MB3/ME20
18	C2	Oddballs	adj. airstrip	Delta/own/20	V1:1LR-FC/ME30
23	C2	Santawani	adj. airstrip/R: Maun	Santawani/own/20	V3:3LC
30	C2	Xaxaba	adj. airstrip	Xaxaba/own/20	V1:1LC/MB6/ME11/AC2
MAUN AREA					
5	D	Crocodile Camp	R: Maun	Maun/DCA/-	V5:1LC+3LR+1UN/MB5/ME3/CA9
10	D	Island Safari L.	R: Maun	Maun/DCA/-	V6:6HI/MB4/CA23
13	D	Kubu Camp	R: Maun	Maun/DCA/-	V3:3LR/MB2/ME15
19	D	Okavango River L.	R: Maun	Maun/DCA/-	V2:2LR/MB2/PB2/CA6
22	D	Rileys Hotel	R: Maun	Maun/DCA/-	V1:1minibus
26	D	Sitatunga Camp.Saf.	R: Maun	Maun/DCA/-	ME10/CA10/TR
27	D	Thamalakane S.L.	R: Maun	Maun/DCA/-	V5:2LC+3LR/MB1

Accessibility	Airstrip	Equipment
R: Road access from	1/2/3	V3 = total no. vehicles
W: Water access from	1 = Name	LC = LandCruiser
adj. = adjacent to	2 = Owner	LR = LandRover
	3 = flying time in min. from Maun	LR-FC = LandRover Forward Control
	DCA = Dept. of Civil Aviation	HI = Hilux
	DWNP = Dept. of Wildl. Nat. Parks	F250 = Ford Custom 250
	KDS = Kerr, Downey and Selby	BF = Bedford 5 ton tr.
		UN = Unimog
		MB = Motorboats
		ME = Mekoros
		CA = Canoes
		AC = Aircraft
		TR = Tractors

TABLE 8.6 OKAVANGO DELTA - TOURIST CAMP SURVEY - STAFFING

Number	Area Code	Camp Name	Staff	Staff accommodation
PANHANDLE AREA AND WESTERN FRINGE				
2	A1	Akukwe Island	OR2/WB1/KS3/HL2/DS2/GL3/T13	13/0/0/0
7	A1	Drotsky's Cabins	OR2/WB2/KS2/HL2/DS0/GL6/T14	4/0/10/0
8	A1	Etsatsa	OR2/WB1/KS3/HL2/DS2/GL2/T12	12/0/0/0
11	A1	Jedibe	OR2/WB3/KS3/HL3/DS4/GL2/T17	8/0/9/7
17	A1	Nxamaseri	OR2/WB1/KS3/HL2/DS1/GL2/T11	8/3/0/8
24	A1	Shakawe Fishing C.	OR2/WB2/KS2/HL1/DS0/GL4/T11	2/0/9/0
29	A1	Xaro	OR1/WB1/KS3/HL4/DS1/GL3/T13	1/0/12/0
9	A2	Guma Lagoon	OR1/WB0/KS2/HL1/DS0/GL15/T19	2/17/0/0
21	A2	Qhaaxwa	OR2/WB2/KS4/HL2/DS4/GL3/T17	17/0/0/10
NORTHERN MOREMI/KHWAI AREA				
1	B1	African Skimmer	OR1/WB0/KS1/HL0/DS0/GL1/T3	3/0/0/0
4	B1	Camp Okavango	OR2/WB3/KS3/HL5/DS7/GL4/T24	25/0/0/0
25	B1	Shindi	OR2/WB2/KS4/HL4/DS2/GL4/T18	16/0/0/0
33	B1	Xugana	OR2/WB1/KS4/HL4/DS4/GL2/O1/T18	18/0/0/5
3	B2	Camp Moremi	OR2/WB3/KS3/HL5/DS1/GL1/T15	15/0/0/0
20	B2	Okuti	OR2/WB1/KS2/HL1/DS2/GL0/T8	8/0/0/0
31	B2	Xaxanaka (Mor.Saf.)	OR3/WB2/KS2/HL2/DS3/GL1/T13	13/0/0/0
32	B2	Xaxanaka (Saf.Unl.)	OR1/WB0/KS6/HL0/DS3/GL3/T13	13/0/0/0
12	B3	Khwai River Lodge	OR4/WB5/KS4/HL6/DS3/GL9/O4/T35	35/0/0/30
14	B3	Machaba	OR1/WB1/KS4/HL4/DS1/GL2/T13	13/0/0/0
28	B3	Tsaro Lodge	OR2/WB0/KS5/HL4/DS1/GL4/O1/T17	2/13/2/0
CENTRAL DELTA AREA				
15	C1	Mombo	OR1/WB2/KS2/HL4/DS1/GL1/T11	11/0/0/0
6	C2	Delta Camp	OR2/WB2/KS4/HL2/DS10/GL4/T24	6/18/0/80
16	C2	Ntswi	OR3/WB2/KS2/HL1/DS20/GL0/T28	3/25/0/40
18	C2	Oddballs	OR2/WB1/KS0/HL1/DS30/GL2/T36	4/32/0/0
23	C2	Santawani	OR2/WB3/KS4/HL4/DS2/GL6/T21	21/0/0/20
30	C2	Xaxaba	OR3/WB3/KS5/HL8/DS7/GL2/T28	28/0/0/8
MAUN AREA				
5	D	Crocodile Camp	OR2/WB2/KS5/HL3/DS3/GL10/T25	2/0/23/0
10	D	Island Safari L.	OR3/WB8/KS8/HL4/DS9/GL8/T40	5/0/35/0
13	D	Kubu Camp	OR1/WB0/KS1/HL0/DS5/GL2/T9	2/0/7/0
19	D	Okavango River L.	OR1/WB3/KS4/HL3/DS0/GL3/T14	1/0/13/0
22	D	Rileys Hotel	OR11/WB20/KS9/HL16/DS1/GL5/T62	8/0/54/0
26	D	Sitatunga Camp.Saf.	OR1/WB5/KS3/HL2/DS2/GL3/T16	16/0/0/20/Sanakona
27	D	Thamalakane S.L.	OR1/WB1/KS1/HL1/DS1/GL3/T8	2/0/6/0

Staff	Staff Accommodation
OR = Office, Reception and Management	1/2/3/4
WB = Waiter, Barmen	1 = No of staff provided with onsite accommodation.
KS = Kitchen staff	2 = No. of staff living in associated self-prov. camp.
HL = Housekeeping and Laundry staff	3 = No. of staff travelling from nearby village.
DS = Drivers, Safariguides	4 = No. of family living at camp.
GL = Groundsmen, Labourers	
O = Other	
T = Total number	

TABLE 8.7 OKAVANGO DELTA - TOURIST CAMP SURVEY - SUPPLY SOURCES AND TRANSPORT

Number	Area Code	Camp Name:	Supply Sources	Energy Sources	Supply/Transport
PANHANDLE AREA AND WESTERN FRINGE					
2	A1	Akukwe Island	Ser./Sep./Ser./Ser./RDO	DB/PA/GA/PE	Road+Boat/Air +Boat
7	A1	Drotsky's Cabins	1+2nearby farm/L/L/RDO	DB/GA/PA+GA/PE	Road/Air+Road
8	A1	Etsatsa	Seronga/L/L/-/RDO	DB/GE/GA+GE/PE	Road+Boat/Air+Boat
11	A1	Jedibe	L/L/Jedibe/Jedibe/RDO	DB/PA+GA/GA/PE	Air+Boat/Air+Boat
17	A1	Nxamaseri	L/Sepopa/L/RedCliffs/RDO	DB/GE/GE+GA/GE+PE	Road/Air
24	A1	Shakawe Fishing C.	L/RSA/L/-/RDO	DB/GA/GE/PE+DI	Road/Air+Road
29	A1	Xaro	L/RSA/Shakawe/Khwai/RDO	SO/PA+SO/GA+GE/PE	Road/Air+Road
9	A2	Guma Lagoon	L/Etsha/L/-/LDO	DB/GE+PA/GE+GA/GE	Road/Air
21	A2	Qhaaxwa	L/RSA/L/-/LDO	DB/PA/GE/PE	Road+Boat/Air
NORTHERN MOREMI/KHWAI AREA					
1	B1	African Skimmer	None	GA/GE/GE/GE	-/Air+Boat
4	B1	Camp Okavango	L/RSA/Kachikau/Khwai/RDO	DB/GE/GE/PE	Road+Boat/Air
25	B1	Shindi	L/-/L/-/LDO	DB/GE/GE/GE	Road/Road+Boat+Air
33	B1	Xugana	L/RSA/Shakawe/Khwai/LDO	SO/GE/GE/GE	Road/Air+Boat
3	B2	Camp Moremi	L/RSA/Kachikau/Khwai/LDO	DB/GE/GE/PE	Road/Air
20	B2	Okuti	L/Shor./Chanoga/Daon./RDO	DB/PA/GA/PE	Road/Air
31	B2	Xaxanaka (Mor.Saf.)	L/DWNP/Maun/Khwai/RDO	DB/PA/PA/PE	Road/Air
32	B2	Xaxanaka (Saf.Unl.)	L/Maun/Shorobe/Khwai/RDO	SO/PA/PA/PE	Road/Road+Air
12	B3	Khwai River Lodge	L/RSA/Kavimba/Maun/BH	DB/GE/GE/GE	Road/Air
14	B3	Machaba	L/-/-/-/Well	DB/GA/GA/GE	Road/Air+Road
28	B3	Tsaro Lodge	L/L/Maun/Khwai/RDO	DB/GE/GE/PE	Road/Air+Road
CENTRAL DELTA AREA					
15	C1	Mombo	L/Maun/Maun/Maun/Well	DB/GE/GE/PE	Road+Air/Air
6	C2	Delta Camp	L/Maun/Nxaragha/-/RDO	DB/SO/GA/PE	Road+Air/Air
16	C2	Ntswi	L/Maun/L/-/RDO	DB/SO/GA/PE	Road+Boat/Air
18	C2	Oddballs	L/Maun/Nxaragha/-/RDO	DB/SO+GA/GA/PE	Road+Air/Air
23	C2	Santawani	L/RSA/Shorobe/L/Well	DB/GA/GA/DI	Road/Air
30	C2	Xaxaba	L/RSA/Kiri/Kiri/RDO	DB/GE/GE+GA/PE	Air/Air
MAUN AREA					
5	D	Crocodile Camp	L/L/Daun./Daun./NWDC	DB/GE/GA/PE	Road/Road
10	D	Island Safari L.	L/-/-/-/Well + RDO	DB/GE/GE/EL+PE	Road/Road
13	D	Kubu Camp	L/L/Daun./Daun./NWDC	DB/GE/GA/PE	Road/Road
19	D	Okavango River L.	L/L/L/L/Well	DB/GE/GE+GA/GE	Road/Road
22	D	Rileys Hotel	-/-/-/-/DWA	EL/EL/EL/EL	Road/Road
26	D	Sitatunga Camp.Saf.	L/L/Sep.-Ser./Sep.-Ser./BH	DB/GE+PA/GA/DI	Road/Road
27	D	Thamalakane S.L.	L/L/Ditshipi/Ditshipi/RDO	DB/GE/GE/DI	Road/Road

Supply Sources		Energy Sources		Supply/Transport
1/2/3/4/5		1/2/3/4		1/2
1 = Firewood	Shor. = Shorobe	1 = Hot water	DB = Donkey Boilers	1 = fuel and construction mat.
2 = Constr. poles	Daun. = Daunara	2 = Lightning	SO = Solar	
3 = Reeds	DWNP = provided by Dep.	3 = Cooling/Refridg.	GA = Gas	
4 = Thatching grass	RDO = River Draw Off	4 = Waterpump	PA = Paraffine	2 = light goods and perishables
5 = Water supply	LDO = Lagoon Draw Off		EL = Electricity (mains)	
	BH = Borehole			
L = Local	NWDC = Council water supply		PE = Petrol	
Ser. = Seronga	DWA = Maun water supply		DI = Diesel	
RSA = Imported from RSA				

TABLE 8.8 OKAVANGO DELTA - TOURIST CAMP SURVEY - SANITATION AND WASTE DISPOSAL

Number	Area Code	Camp Name	Sanitation	Waste Disposal
PANHANDLE AREA AND WESTERN FRINGE				
2	A1	Akukwe Island	5 PL, 5 SB	PL/O/P&B/5
7	A1	Drotsky's Cabins	8 FT, 8 SB	STD/C/P/400
8	A1	Etsatsa	6 FT, 7 SB	STD/C/P&B/75
11	A1	Jedibe	6 FT, 6 SB	ST/C/P&B/100
17	A1	Nxamaseri	9 FT, 8 SB	STD/C/P&B/30
24	A1	Shakawe Fishing C.	10 FT, 8 SB	STD/C/P&B/450
29	A1	Xaro	7 FT, 7 SB	ST/C/P&B/150
9	A2	Guma Lagoon	6 FT, 6 SB	STD/C/P&B/20
21	A2	Qhaaxwa	11 FT, 8 SB	STD/O/P&B/75
NORTHERN MOREMI/KHWAI AREA				
1	B1	African Skimmer	1 FT, 2 CT	ST/see Xugana
4	B1	Camp Okavango	11 FT, 11 SB	STD/C/P&B/100
25	B1	Shindi	7 FT, 7 SB	STD/O/P&B/2000
33	B1	Xugana	9 FT, 9 SB	ST/C/P&B/300
3	B2	Camp Moremi	11 FT, 11 SB	STD/C/P&B/75
20	B2	Okuti	4 FT, 4 SB	STD/C/P&B/80
31	B2	Xaxanaka (Mor.Saf.)	4 FT, 3 SB	STD/O/P&B/60
32	B2	Xaxanaka (Saf.Unl.)	2 FT, 2 SB	STD/C/P&B/30
12	B3	Khwai River Lodge	14 FT, 14 SB	STD/C/P&B/400
14	B3	Machaba	7 FT, 7 SB	STD/O/P&B/40
28	B3	Tsaro Lodge	11 FT, 9 SB	STD/C/P&B/200
CENTRAL DELTA AREA				
15	C1	Mombo	6 FT, 8 SB	STD/C/P&B/80
6	C2	Delta Camp	10 FT, 10 SB	ST/C/P&B/300
16	C2	Ntswi	4 FT, 10 SB, 4PL	STD/C/P&B/100
18	C2	Oddballs	5 FT, 12 SB	STD/C/P&B/250
23	C2	Santawani	8 FT, 4 SB	STD/C/P&B/200
30	C2	Xaxaba	22 FT, 22 SB	ST+STD/O/P&B/150
MAUN AREA				
5	D	Crocodile Camp	11 FT, 12 SB	STD/C/P&B/100
10	D	Island Safari L.	34 FT, 30 SB	STD/C/NWDC/-
13	D	Kubu Camp	4 FT, 6 SB	STD/O/P&B/100
19	D	Okavango River L.	9 FT, 9 SB	STD/C/NWDC/-
22	D	Rileys Hotel	42 FT, 34 SB	STD/C/NWDC/-
26	D	Sitatunga Camp.Saf.	12 FT, 8 SB, 4PL	STD/C/P&B/4000
27	D	Thamalakane S.L.	4 FT, 4 SB	PT/ST/P&B/30

Sanitation

FT = Flush toilets
PL = Pit Latrines
SB = Shower/ Bathrooms
CT = Chemical toilets

Waste Disposal

1/2/3/4

1 = Sewerage system
  PL = Pit Latrines
  ST = Septic tank
  STD = Septic tank with drainfield
2 = Waste water disp.
  O = Open
  C = Closed
3 = Refuse disposal
  P = Pit and burried
P&B = Pit and burned
NWDC = refuse coll. by District Council
4 = distance of pit from open water (meters)

9. ECOLOGICAL ZONING

9.1 DATA AND METHODOLOGY

The data used for the process of ecological zoning comprised the 1:50 000 photomaps with the four vegetation units drawn by the vegetation specialist (section 5.9), the 1:50 000 transparent hydrological maps with five units drawn by the hydrologist (section 4.4.2), and the 1:250 000 terrain units map drawn by the geomorphologist (section 2.10). Each hydrological map was overlain on the appropriate vegetation map and the correspondence of the boundaries was checked and discussed between hydrologist, vegetation specialist and geomorphologist before a new boundary was drawn on a fresh sheet of transparent film and the code for hydrological, vegetation and soils unit entered in the zone.

As has been previously pointed out (sections 4.4.3 and 5.9) the original maps did not include very small units (less than about $2km^2$) and it was often necessary to indicate mosaic categories denoted, for example, as RSF/OSF; SIA/IFA; 2b/3b. The first zoning exercise led to the classification of ecological zones presented in Table 9.1 and shown diagrammatically in Figure 9.1. With 15 terrain units, five hydrological units and four vegetation units the theoretical number of combinations is 300. However, six of the terrain units cover about 80-85% of the study area. The likelihood of some combinations occurring is very low but the large number of mosaic categories increases the number of combinations to approximately 60.

Obviously the large number of zones required rationalisation and a simplified system based on correlation of classification systems was used for ecological zoning; see Table 9.2. This scheme employs five mapping units, I-V, which were indicated on the 1:100 000 Ecological Zoning Maps together with the original zoning classification. It was also felt that it was important to map areas of particular importance with ecological status/protection modifiers (Table 9.3). These modifiers were evaluated as a team effort before indicating their boundaries on the 1:100 000 Ecological Zoning Maps. On the 1:250 000 scale Ecological Zoning Map, included with this report, only the five mapping units (Table 9.2) are shown, together with the ecological status/protection modifiers (P modifiers).

9.2 NOTES ON THE AREAS LABELLED WITH P MODIFIERS

It should be pointed out that the Consultant's team considers the whole of the Okavango Delta an ecological area of such importance that it merits conservation. The Government of Botswana is, therefore, urged to consider declaring the Delta a World Heritage Site. This observation notwithstanding, the team has been requested to indicate smaller areas of particular concern, and the following is a brief account of each of these areas.

TABLE 9.1 CLASSIFICATION OF ECOLOGICAL ZONES

SOILS/GEOMORPHOLOGY	HYDROLOGY	VEGETATION
Unit 1 - PERENNIAL SWAMP	PERENNIAL FLOODING (PF)	PERENNIAL SWAMP (PS)
Unit 2a - SEASONAL FLOODING (2 Sub-units)	REGULAR SEASONAL FLOODING (2 years out of 3) (RSF)	SEASONALLY INUNDATED AREA (SIA) (Sub-units: swamp, floodplain
Unit 2b - OCCASIONAL FLOODING (3 Sub-units)	OCCASIONAL SEASONAL FLOODING (one year out of 4) (OSF)	
	HIGH FLOOD ONLY (one year out of 10) (HFO)	INTERMITTENTLY FLOODED AREAS (IFA)
Unit 3a - SAND PLATEAUX (Sub-units $3a^1$ - $3a^2$) Unit 3b - ISLANDS AND RIVERINE FRINGES Unit 3c - FOSSIL TERRACES AND FLOODPLAINS (Subunits $3c^1$ - $3c^5$)	DRY LAND (DL)	DRYLAND ASSOCIATION (Sub-units: Woodland, Savannah, Grassland) (DA)

FIGURE 9.1 CORRELATION OF CLASSIFICATION SYSTEMS FOR ECOZONING

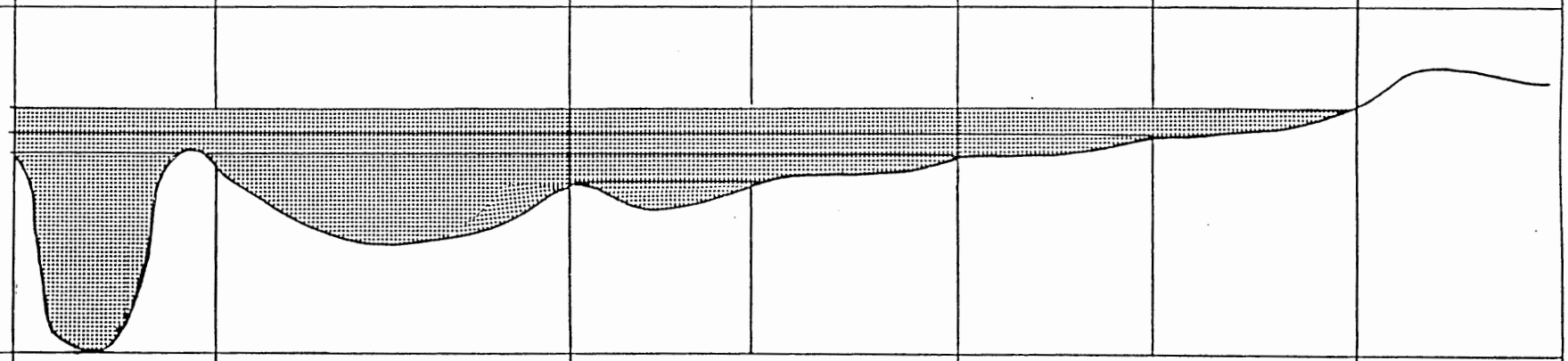
ECOSYSTEM:	RIVERINE	LACUSTRINE	PALUSTRINE		TERRESTRIAL WETLAND — DRYLAND		TERRESTRIAL DRYLAND
MAJOR HABITAT DIVISION:	PERENNIAL SEASONAL INTERMITTENT	PERENNIAL SEASONAL INTERMITTENT	PERENNIAL SWAMP	SEASONAL SWAMP	SEASONALLY FLOODED GRASSLAND	INTERMITTENTLY FLOODED GRASSLAND	FOREST/WOODLAND SAVANNA/GRASSLAND FORBLAND
WATER LEVELS* 1 2 3 4							
TOPOGRAPHIC UNIT:	CHANNEL	LEDIBA	SWAMP		FLOOD PLAIN		SAND PLATEAUX ISLANDS FOSSIL FLOODPLAINS
VEGETATION MAPPING CATEGORY:	(DELINEATED ON HYDROLOGICAL MAPS)		PERENNIAL SWAMP PS	SEASONALLY INUNDATED AREAS SIA		INTERMITTENTLY FLOODED AREAS IFA	DRYLAND ASSOCIATION DA
HYDROLOGY MAPPING CATEGORY	PERENNIAL BLOCKED SEASONAL-CONFINED -UNCONFINED HIGH FLOOD CHANNEL	NOT DIFFERENTIATED BUT INCLUDES PERENNIAL SEASONAL INTERMITTENT	PERENNIAL FLOODING PF	REGULAR SEASONAL FLOODING RSF	OCCASIONAL SEASONAL FLOODING OSF	HIGH FLOOD ONLY HFO	DRYLAND DL
TERRAIN UNIT MAPPING CATEGORY	← 1 PERENNIAL SWAMP →			← 2 — LIABLE TO FLOODING → 2a & 2b		2a, 2b and some 3a	3 NOT LIABLE TO FLOODING → ←3a, 3b & 3c →
ECOZONE MAPPING UNITS	I			II	III	IV	V

TABLE 9.2 ECOLOGICAL ZONE MAPPING UNITS

Mapping Unit	Description of Unit and Associated Landscape, Flooding and Vegetation Categories	Dominant Mapping Categories Included	
I	Perennially flooded swamp including Papyrus, Phragmites, reed swamps, mixed grass/sedgelands	PF/PS/1	
II	Seasonally flooded swamp inundated on a regular basis and including mixed grass sedgeland characterised by SICA (see section 5.7.3 p. 42/43) and subject to deep flooding.	RSF/SIA/1 RSF/SIA	(2a (2b
III	Seasonally flooded grasslands inundated on a less frequent basis and tall and short grassland communities and characterised by shallow flooding and absence of aquatic plants.	OSF/SIA	(2a (2b
IV	Intermittently flooded areas inundated in high floods only and characterised mostly by tall grassland and encroaching woody species at the dryland margins.	HFO/IFA	(2a (2b (3a
V	Dryland (sand plateau, island and fossil floodplain) areas not subject to inundation and characterised mainly in extent by savanna but also riverine woodland, forest and grasslands.	DL/DA	3

TABLE 9.3 ECOLOGICAL STATUS/PROTECTION MODIFIERS

Note: Modifiers indicate areas of particular importance. Multiple listing of modifiers is possible.

P_v - Area known or indicated to have vegetation communities or occurrence of specific species warranting protection measures.

P_b - Areas of known or indicated significance in terms of bird habitat for nesting, breeding, refuge, as seasonal feeding areas, staging areas during migration or other special reasons.

P_w - Area of known or indicated significance as wildlife habitat as home range or associated with seasonal migrations.

P_s - Areas with existing or possible significance for scientific interest or ecological related purposes significant to the Delta including geomorphology, hydrology, resource exploitation and landscape change, as well as the vegetation communities, birdlife, wildlife, fish resources or other living resources.

P_h - Areas of known hydrological importance including major blockage areas and areas of unstable regime or exhibiting signs of change.

P_r - Areas of known or anticipated risk in terms of erosion, pollution or specific land use conflicts.

9.2.1 Areas Indicated as Being Important for Birds (P_b)

- Map sheet 1821 A/B/D. Red Cliffs are an area on the east bank of the Panhandle where Carmine bee eater colonies regularly nest.

- Map sheet 1822C. The back channels of the Okavango River between Ncamasere and below Sepupa (the Filipo or eastern Channel) and where the Okavango splits into Nqoga and Thaoge distributaries contain sandbanks where African skimmers nest.

- Map sheet 1922A. Xhamu Lediba, a nesting site for Pink backed pelican.

- Map sheet 1922B. Both banks of the Nqoga River upstream of Nqoga Island and the left bank downstream of Nqoga Island are nesting areas of Yellow billed stork and Marabou stork.

- Map sheet 1922B. In the Nxabega-Xo Flats area are two sites used for nesting by Yellow billed stork, Marabou stork and Pink backed pelican.

- Map sheet 1923A. Gcobeha, Gadikwe and Cakanaca Madiba have heronries in Ficus verruculosa of importance to many water birds including Slaty egret.

- There are, in addition, various vegetation types (listed under P_v below) which have important bird communities in association.

9.2.2 Areas Indicated as Being Important for Hydrology (P_h)

From a hydrological viewpoint the Delta is by definition a sensitive area. Potential reasons for changes, man-made and natural, are discussed in section 4. One of the changes recently proposed is the Lower Boro River Channel Improvement Works which will affect the lower Boro River over a distance of about 26km within the veterinary cordon fence. The recommendation that no other channel improvement works will ever be undertaken within the Delta, i.e. within the veterinary cordon fence and its extension, has been accepted by the Government of Botswana when it approved the implementation of the Southern Okavango Integrated Water Development. This in fact should protect the Delta from any future man-made changes.

However, there are a number of areas which are particularly susceptible to man's interference with the hydrology of the Delta. Attention is drawn to these areas on the Zoning Maps with the modifier P_h.

- Map sheet 1922C. The start of the alluvial fan of the Delta proper, where there is an increase in grade.

- Map sheets 1922C, D and 1922B. The entire length of the primary Nqoga channel, where there is a lateral water surface gradient away from the aggrading bed, and resistance to lateral spill by thick papyrus.

- Map sheets 1922A and B. The perennial swamp above the Xene, Mathabanelo, Potae and Karongana distributaries.

- Map sheet 1822D. Sources of the Magwegqana and constrictions in channels leading to it. Two areas between Gau and Kabamukuni Island to the east of Kabamukuni Island and northeast of this, and an area at Kwexao.

- Map sheet 1922B. At Qokao along the edge of the perennial swamp; sources of the Matsebi and Xudum.

- Map sheet 1922B. Xo Flats where water from the Jao is redistributed to the Boro, Kiri and Xudum.

- Map sheet 1922B and 1923A. Between Sazita and Nambopi, the source of an unnamed river joining the Mburoka.

- Map sheet 1922B. Two constrictions in channels at the north end of Chief's Island leading to the Nambopi.

- Map sheet 1922B. A constriction at Nxabega.

- Map sheet 1923A. Two locations east of Chief's Island are restrictions on the Nambopi channel.

- Map sheet 1923A. A swampy area south of Dxaaba, the source of the Santantadibe.

- Map sheet 1923A. Near Gcobeha Lediba, headwaters of the Mogogelo, and two constrictions in this distributary on the west side of Mboma 'Island'.

- Map sheet 1923A. The source of the Guekha.

- Map sheet 1922D. A source of the Matsebi and a constriction in its channel.

- Map sheet 1922D. Thapagadi, a constriction through which much of the Xudum water flows.

- Map sheet 1923C. The Kiri north of Bobo Island where a slight restriction occurs.

- Map sheet 1923C. A gap in Lion Island and another between Lion Island and Beacon Island through which much of the water of the Xwaapa system flows.

- Map sheet 1923C. The source of the Shashe River above the Kunyere faultline.

9.2.3 Areas of Known or Anticipated Risk of Erosion (P_r)

- Map sheets 1922A and C. The $3c^3$ soils of the Thaoge terminal floodplain north and southeast of Nokaneng are known to be prone to wind erosion.

- Map sheets 1923C and D. The $2b^3$ soils between Maun and Shorobe, bounded by the Kunyere and Thamalakane faultlines, and in an area northwest of Maun above the Kunyere faultline are similarly erosion prone.

- Map sheet 2023A. A triangle of $3c^5$ soils bounded on two sides by the Thamalakane and Nhabe Rivers at their junction with the Boteti and on the third by the Maun-Toteng road are also at risk from erosion.

9.2.4 Areas of Significance for Scientific Interest (P_s)

- Map sheet 1821A/B/D. Red Cliffs are the only place in the study area where the layers of alluvium laid down by the Okavango are exposed.

- Map sheet 1922B. Dxherega Lediba which is the site of T S McCarthy's studies of sediment deposition and where pegs have been placed for further research (marked Dobe Lediba on the 1:50 000 maps).

9.2.5 Areas Known to Have Vegetation Communities Warranting Protection (P_v)

In the Delta it would be unwise to single out any one or more plant community or vegetation type as deserving special attention except for relict forest. Vegetation forms perhaps the most important component of scenery and plants provide a very important function in the Delta in dampening the effects of flooding and binding the substrate to prevent erosion, in addition to their usual role in energy conversion and nutrient transfer, and as a food source for many other organisms. While it may be argued that the expanses of papyrus in the perennial swamp appear dreary and monotonous, it should be remembered that this plant community, among many other functions, is the protector of the water reserves of last resort which enable practically all other forms of life to counter the frequent drought cycles occurring in northern Botswana. Similarly beneficial roles can be ascribed to all the other plant communities and vegetation types of the Delta, and it is therefore considered best to treat the vegetation of the Delta not as consisting of so many different parts, but as a single unit for conservation purposes.

This statement notwithstanding, attention is drawn to some areas warranting protection primarily for their vegetation.

- Map sheet 1821 A/B/D contains several areas of relict riverine forest which should be afforded protection. These include Wilmot's Plot, Xaro Camp and an island to the east of Xaro Camp and near the centre pivot irrigation plot, all in the Samochima area. Also, a group of islands north of Shakawe and west of Xakao. A useful and important project would be to survey the whole Panhandle to map and inventory this vegetation type and its associated fauna.

- Map sheet 1922C. Xaga Island on which grows a group of large baobabs.

- Map sheet 1922B (and just extending onto 1822D). From the tip of Chief's Island north to the Nqoga and west to the Jao, then following these rivers to Xeshabe. This is an area of thick papyrus and it is suggested that it is incorporated into Moremi W.R

- Map sheet 1922B. The Mombo-Sazita area with well developed Acacia woodland, mainly for reasons of game concentrations and also denoted P_W area (see 9.2.6).

- Map sheet 1923C. A large area south of Chief's Island between the Boro and Santantadibe Rivers for protection of Hyphaene palms.

9.2.6 Areas of Significance as Wildlife Habitat (P_W)

- Map sheet 1821 A/B/D. A large area of back-channels in the Samochima known to be a crocodile nesting area.

- Map Sheet 1822C. Crocodile nesting areas off Ncamasere, Dungu, Ikgoga and to the west of Ikgoga Lediba.

- Map Sheet 1823C. A large area along the Magweggana Valley, extending out of the project area to the northeast. This area is critical to game as a source of water during the dry months and in droughts.

- Map sheets 1922A, B, C and D. A large area at the tip of the Sandveld Tongue and on both sides of it - Matsaudi and Xene - known for the diversity and biomass of game animals.

- Map sheet 1922B. An island near Xhamokwe Lediba known for its albino lechwe.

- Map sheet 1922B. Mombo and the northwest end of Chief's Island for game concentrations.

- Map sheets 1923 A, B and D. Santawane area known for its game concentrations, particularly in the dry season.

- Map sheets 1923A and B. North Moremi known for its game concentrations.

- Map sheet 1923B. Khwai area for its game concentrations, especially in the dry season.

- Map sheet 1922B. Pompom area for its game concentrations.

9.3 AREAS OF CONFLICT BETWEEN STATUS/PROTECTION AND UTILISATION

The TOR asks for an indication of 'pressure points', and these have been identified by overlaying the 1:100 000 Land Use Maps on the 1:100 000 Ecological Zoning Maps. A list of these follows.

- In the Panhandle, dry season grazing and burning of cover for hunting and grazing threatens the nesting activity of crocodiles (see also section 8.10.2).

- An indiscriminate programme of crocodile egg collection threatens recruitment into the population (see section 6.4.2.1).

- There is enormous development of tourist facilities (see section 8.10.2) and agricultural activities in the Samochima/Shakawe area which must threaten the integrity of the relict riverine forest and its associated fauna.

- Agricultural activity above Red Cliffs and tourist pressure may threaten the Carmine bee eater colony at this site.

- The use of the Filipo or Eastern Channel by motor boats causes a wash which destroys African skimmer nests and chicks on the low sandbanks.

- There is the potential for disturbance of breeding birds at Xhamu Lediba due to its proximity to Qaaxhwa Camp, which should be monitored.

- There are many fields in the $3c^3$ soils south of Gumare and north of Nokaneng; most prevalent along the relict Thaoge Channel. Cultivation of these soils exposes them to wind erosion.

- The important dry season and drought watering points along the Magweggana are to be bisected by the proposed veterinary cordon fence. Although this is not anticipated to cause problems (section 6.1.5) the situation should be monitored after the fence has been built.

- Seven camps within a small area at Cakanaca, and thus within the Moremi W.R., is an incongruous situation. Serious consideration should be given, when a management plan for Moremi W.R. is drawn up, as to whether this kind of development is desirable.

- The heronries at Gcobeha, Gadikwe and Cakanaca madiba are a tourist attraction. With tourist use comes the danger of disturbing breeding birds, a danger acknowledged by at least some opeators (section 8.10.3). Research and guidelines for a code of conduct are needed.

- Third Bridge campsite in Moremi W.R, is crowded at times, with litter problems, firewood shortages, etc. (section 8.10.2). The situation needs monitoring after the introduction of the new entry fee structure.

- There is obvious pressure on the vegetation in and around Maun/Matlapaneng for firewood, poles and grazing. This has been articulated by at least some tourist operators as a shortage of firewood. Widespread use of electric power is the only long-term solution for centres such as Maun.

- Agricultural activity in the $2b^3$ soils north and northwest of Maun. These fine soils are prone to wind erosion.

- Similarly there are fields in the triangle between the Thamalakane and Nhabe Rivers at the Boteti junction where there are $3c^5$ soils prone to erosion.

- Dense agricultural activity in the Shorobe/Matlapaneng melapo on $2b^3$ soils.

10. PERCEIVED GAPS IN THE DATA AND RECOMMENDATIONS FOR FUTURE RESEARCH

As requested (TOR, Appendix A) the Consultant has indicated in each section the gaps in the data base and suggestions for future research. This section is a summary of those suggestions with cross-references to the other section or sections from which they originate.

10.1 GEOMORPHOLOGY AND SOILS

a) Sedimentation rates within the Delta (sections 2.9, 4.1.9 and 5.12.3).

b) Channel evolution in the upper Delta (sections 2.9 and 5.12.3).

c) Wind erosion studies (section 2.9).

d) Tectonic and seismic studies (section 2.9).

10.2 CLIMATE

a) Improving climate records from Kwihum (especially) and Xugana and Tubu. Rainfall most important (section 3.4).

10.3 HYDROLOGY

a) Research on groundwater resources, particularly on the northern and eastern sides of the Delta (section 4.1.9).

b) Aquisition of colour satellite imagery for hydrological, geomorphological and vegetation studies. Four sets of images per year are suggested (sections 4.1.9, 2.9 and 5.12.1).

10.4 VEGETATION

a) Mapping the boundaries of the seasonal swamp and the two types of flooded grassland (section 5.12.1).

b) A checklist and guide to the plants of the Okavango (section 5.12.1).

c) Taxonomic revision of key plant genera (section 5.12.1).

d) Study of hippopotamus in the Okavango, in particular feeding and movement in relation to their role in the spread of Salvinia (section 5.12.2).

10.5 FAUNA

10.5.1 Wildlife

a) Aerial monitoring of large mammal numbers and distribution (section 6.8.1.1).

b) A management plan for Moremi W.R. (section 6.8.1.2).

c) Management projects including game cropping, floodplain/herbivore inter-relationships, an ecological monitoring computer bank and the scientific management of WMA's (section 6.8.1.5).

d) Species studies of wildlife whose biology is poorly known in the Okavango Delta (section 6.8.1.4) and elephant-habitat interactions (sections 6.8.1.3 and 5.12.2). The hippopotamus study suggested in 5.12.2 can also be mentioned here.

10.5.2 Birds

a) Studies of the biology of rare or endangered species (e.g. Slaty egret and Wattled crane - see section 6.8.2).

b) Management orientated projects on game birds (section 6.8.2).

c) An ecological study of the importance of Panhandle relict forests to birds, butterflies, reptiles and amphibians (sections 6.8.2, 6.8.3.2, 6.8.6.1 and 9.3).

10.5.3 Amphibians and Reptiles

a) Study of crocodile movement between and breeding in Panhandle and Delta (section 6.8.3.1).

b) More academic studies of species distribution and biology of frogs and reptiles (e.g. sections 6.8.3.2, 6.8.3.3 and 6.8.3.4).

10.5.4 Fish

a) Management orientated studies on the fisheries potential of the Delta (sections 6.8.4, 7.5.1 and 8.12.2).

b) Side effects of anti-tsetse spraying on fish (section 6.8.4), birds and non-target invertebrates (section 6.8.6.3).

10.5.5 Hydrobiology and Physicochemical Limnology

a) Any serious and relatively long-term study on the hydrobiology of the Delta (particularly the perennial swamp)

would contribute significantly to the scanty knowledge available (sections 6.8.5 and 5.12.3).

10.5.6 Invertebrates

a) Surveys of virtually any group (section 6.8.6.1) and studies of the biology of mound-building termites (section 6.8.6.2).

10.6 LAND USE

a) Research on gathering activities in Planning Zone 2 (section 7.5.2), Planning Zone 4 (section 7.5.4) and Planning Zone 8 (section 7.5.5).

b) Research on shortages or potential shortages of poles and firewood in the Maun/Shorobe area (sections 7.5.4 and 9.3).

c) Research on conflicts, existing or potential, between land use practices and the Delta's natural resources (e.g. burning practices) and the effects of development schemes on land use (sections 7.5.4 and 7.5.5).

d) Investigations of hunting or game cropping as a form of land use in WMA's (section 7.5.3) involving RAD's (section 6.8.1.5).

10.7 TOURISM

a) Research on non-organised visitor use patterns to start as soon as possible to gather information on attitudes towards the new park entrance fee structure (section 8.12.1).

b) Research on organised tourism (visitors to safari lodges (section 8.12.2(a)).

c) Investigation of the secondary benefits of tourism (section 8.12.2(b)).

d) A census of recreational fishing, perhaps to be undertaken in conjunction with research on commercial fisheries (sections 8.12.2(c) and 6.8.4).

e) Aircraft use for tourist purposes in the Okavango Delta (section 8.12.2(d)).

f) Boating in the Delta (section 8.12.2(e)).

10.8 ECOLOGICAL ZONING

a) It has become increasingly evident that the Panhandle is an important but little-known component of the Okavango Delta, having unique flora and fauna, perhaps in association with the relict forest. It is strongly recommended that a survey of all the relict forest patches be undertaken, together

with a resource inventory and suggestions for their conservation (e.g. by the creation of small nature reserves).

b) Research should be undertaken to discover the importance of the disturbance at the various heronries in the Delta. The objectives should be essentially management-orientated to discover how close an approach can be made by boatloads of tourists before disturbance occurs. Other features of disturbance could include noise and the horse-power of OBM's. Guidelines should then be laid down to prevent disturbance.

10.9 GENERAL

The Delta must be recognised as a unique ecosystem without parallel anywhere else in the world. Changes in the regimes of its principal rivers render it so dynamic that all forms of life (plants, animals, birds, insects, etc.) are given little opportunity to diversify and speciate. Endemics are rare. The uniqueness of the area derives from the juxtaposition of a variety of wetland habitats each of considerable extent in a semi-arid environment and beset with a rich wildlife that is becoming increasingly endangered everywhere else on the continent.

Consideration should be given to the establishment of a scientific research institute for the Okavango. This body would be responsible for supervision, monitoring and in some instances, initiation of research activity in the region. It should have affiliations with the University of Botswana and relevant Government Departments, but should be sufficiently autonomous to seek and administer independent sources of funding in the pursuit of agreed management objectives.

The Consultant strongly recommends that Government give serious consideration to joining the World Heritage Convention by nominating the Okavango Delta for inclusion in the World Heritage List. Apart from acknowledging the universal value of this outstanding natural asset, inclusion of the Okavango Delta in the World Heritage List would permit appropriate development for the benefit of Botswana, while at the same time providing international legal safeguards for the Delta's conservation. Very few natural areas in Africa have been selected for inclusion in the World Heritage List, and the almost certain acceptance of the Delta by the World Heritage Committee would confer deserved prestige, echoing Government's own frequently-stated claims for the region, and would provide a useful fillip to international tourism.

The Okavango Delta also eminently qualifies for inclusion on the Ramsar List for Wetlands of International Importance. Its socio-economic significance allied to its outstanding scientific and scenic merits place it among the foremost wetlands in the world.

Small annual contributions as signatories to these Conventions would assist Botswana gaining sympathetic international consideration in its endeavours to reconcile sustainable development with conservation of the Okavango's unique assets. In return, funding from these international organisations could be sought to further relevant research objectives and for official travel to overseas meetings to enable exchange of ideas and experience.

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