

Ecological Investigations of the UNDP in the Okavango Delta

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UNDP/FAO Project "The investigation of the Okavango Delta as a Primary Water Resource for Botswana," Maun

Mr Graham and I are ecologists working in a multidiscipline team which has been studying various aspects of the Okavango Delta. We were invited to this Symposium to talk on the secondary productivity of African wetlands with particular reference to the Okavango Delta. Rather than attempt to do this in any detail we decided to describe our work in the Delta from its start in July 1974 and to give an outline of our preliminary conclusions. Our Final Report will be available to Government by December 1976 and we anticipate that our research findings will in due course be offered for publication to the relevant scientific journals.

We would now like to thank members of the Organising Committee for permitting us to make this change.

There were three main reasons why we requested to change the subject of our talk.

- (1) the realisation that much of what we could usefully say on the requested topic is being said by other contributors.
- (2) our field programme is incomplete and analysis of our results to date would have involved some waste of time, and perhaps most importantly,
- (3) the realisation that the organisation of this type of joint UNDP/Government Project is not often fully, or indeed partially, understood.

There are numerous potential future competing demands for Okavango water. The principal present and potential uses are:

- (a) domestic water supplies,
- (b) livestock watering,
- (c) irrigated agriculture,
- (d) industrial development,
- (e) mining development,
- (f) wildlife and fisheries,
- (g) tourism and recreations.

Each of these demands has an impact on each other; these demands may be complementary or competitive.

The Okavango Project was established as a joint Government/FAO Project to undertake hydrological and ecological studies in the Delta and its environs. The ecological team commenced work in July 1974. Prior to this date various ecological surveys and studies had been carried out or were currently underway in the region, the most important of the latter category being those of Smith, Patterson, Biggs and Reavell, all of whom will be presenting papers at this Symposium. The aid from FAO was designed to either assist these on-going studies, or to establish new lines of investigation in accordance with the overall objectives of the Project.

We decided that a systematic repetitive aerial survey programme was required in order to monitor both habitat factors and large mammal populations.

This programme has been carried out over approximately 90% of the Delta, the 10% to the south being covered only once as it did not contain significant numbers of large mammals (map 1). The design of the system was such that it required approximately 45 hours of flying time; individual observations could be assigned to

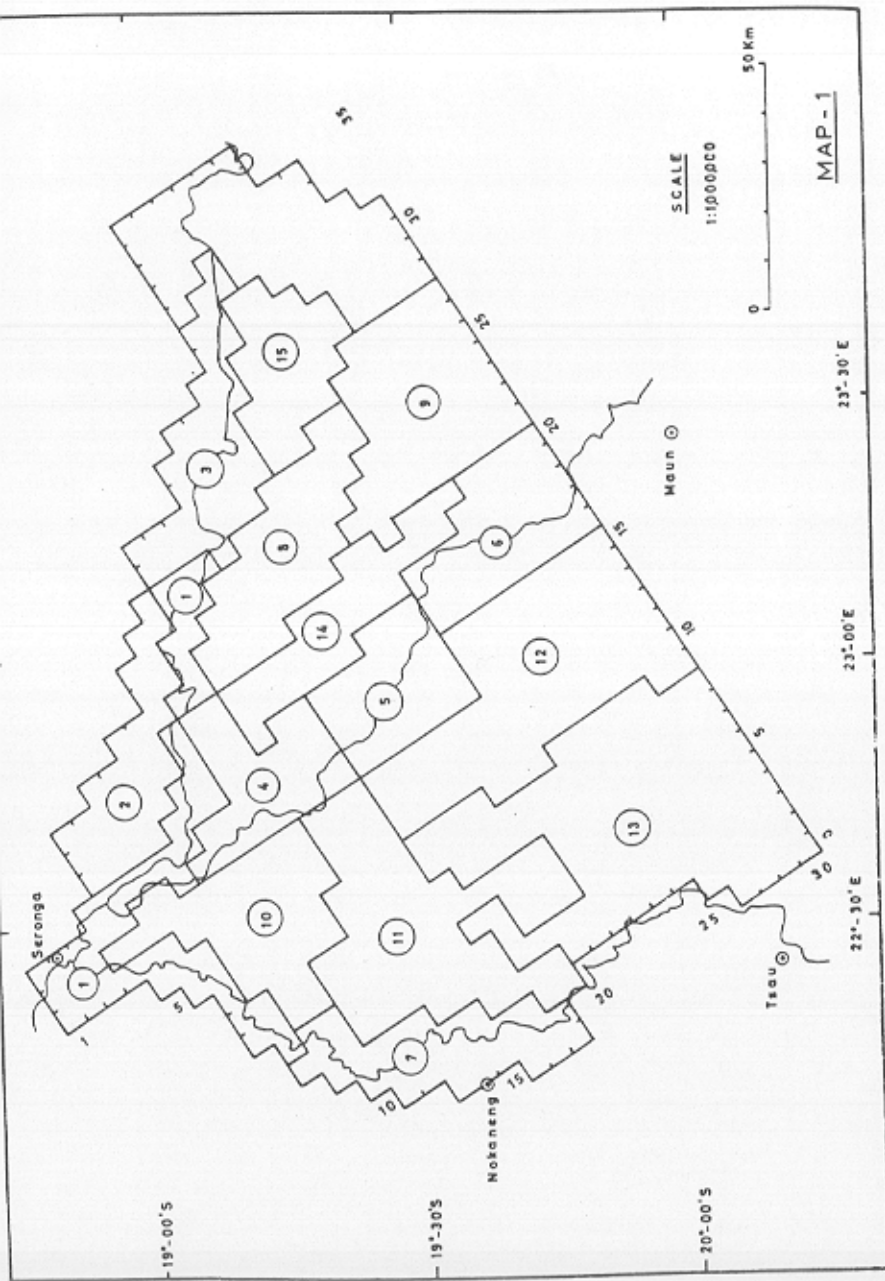


TABLE 1

Animal type	Species	Average weight of individuals kg	Biomass	Wet meat yield in kg Biomass \times 4	Value as wet meat (Yield \times Rand 3)	Value as skin (Rand)
Terrestrial Water-dependent	buffalo	400	8 214 400	3 285 760	985 728	114 755
	zebra	175	1 137 850	455 140	136 542	165 151
	wildebeeste	150	738 900	295 560	88 668	22 522
	impala	47	1 081 000	432 000	129 600	35 052
	elephant	1 800	2 892 600	1 157 040	347 112	156 740
	tsessebe	130	1 023 430	411 372	123 412	40 132
Sub-total			15 093 180	6 036 872	1 811 062	534 352
Terrestrial Water-independent	giraffe	600	1 615 200	646 080	193 624	102 565
	kudu	150	300 000	120 000	36 000	4 064
	warthog	58	174 000	69 600	20 880	6 096
	sable	130	130 000	52 000	15 600	4 064
	ostrich	50	37 500	15 000	4 500	17 145
Sub-total			2 256 700	902 680	270 804	133 934
Aquatic	lechwe	79	1 646 123	658 449	197 535	31 756
	sitatunga	70	105 000	42 000	12 600	2 286
	hippo	600	900 000	360 000	108 000	30 480
	crocodile	40	80 000	32 000	9 600	12 192
Sub-total			2 731 123	1 092 449	327 735	76 714
Grand total			20 081 003	8 032 401	2 409 720	745 000

Rough estimates of biomass, meat yield, meat value, and skin value of the Okavango Delta wild animal herds. Skin values from Wildlife Department and Botswana Game Industries statistics. Meat value based on Maun price of R1,20/kg dry game meat.

one of a grid of 741,5×5 km cells, the grid being constant in that the flight lines were accurate and repetitive for each grid flight.

The observations are compiled and analysed by a computer programme specially written for the Project, hence Government ecologists will be able to continue monitoring.

The programme was designed to yield information on:

- numbers,
- distribution by cell and habitat,
- biomass, and
- productivity,

for 20 species of large animal, covering some 18 500 km². Preliminary estimates for each species covered is shown in the Tables 1 and 2.

During each distribution flight a set of observations was made on the following habitat parameters within each cell:

- greenness of the herbaceous layer,
- herbaceous ground cover,
- distribution of free water,
- extent of burning.

These parameters were selected as they were considered to be the major ones influencing animal distributions.

The background paper prepared for this Symposium by Patterson describes the main ecological zones of the Delta. A more detailed interpretation of the zones was prepared under the well-known Land system survey method of Terrain Evaluation, (Aste, et al).

TABLE 2

Animal type	Species	Population by aerial census	Estimate by guesswork	
Terrestrial Water-dependent	buffalo	20 536	23 000	
	zebra	6 502		
	wildbeeste	4 926		
	impala	1 609		
	elephant	7 911		
Terrestrial Water-independent	giraffe	2 692	2 000	
	kudu			
	warthog			3 000
	sable			1 000
	ostrich			750
Aquatic and Semi-aquatic	lechwe	20 837	1 500	
	sitatunga			
	hippo			1 500
	crocodile			2 000

Tentative population estimates, derived from Grid 2, or guessed at using aerial observations and circumstantial evidence.

Ecological zones of the Delta

The recognised major zones are:

- The Okavango River with its associated floodplain and terraces between Moembo and Nxamasere. This has been called the "Upper Okavango Panhandle."
- Downstream areas of *permanent swamp* occupy the floodplain and terraces of the Okavango River and the upper reaches of the major distributaries.
- Downstream from the permanent swamp is an area of *seasonal swamp* within which are islands and discontinuous areas of dry land.
- On the west of the Delta there is an extensive area of former floodplain and river terraces associated with a former main distributary. This area is now much drier than it apparently was in the past — this is the "Nokaneng Flats" zone.
- The Okavango drainage system terminates in four sinks, Lake Xau, Mababe Depression, intermittently the Savuti Marsh, and the one in our area, *Lake Ngami*.
- The *surrounding woodlands* together with Chief's Island.

The approximate boundaries of these zones are shown on map 1.

Following stereoscopic examination of photo pairs, various landscape units, land facets, were recognised in the area. However, the variation in topography, island size and vegetation is such that mappable units could not be recognised. Accordingly an artificial zoning system has been used, this system is based on the 5 km×5 km grid used during the animal distribution flights.

The recognised artificial zones are:

- Permanent swamp
- Nggokha Flats,
- Khwai Flats,
- Upper Boro Drainage,
- Mid Boro Drainage,
- Lower Boro Drainage,
- Nokaneng Flats,
- Upper Santantadibe Drainage,
- Lower Santantadibe Drainage,
- Jau Flats,
- Jau Flats North,
- Matsebe-Xudum Drainage,
- Sandveld Tongue,
- Chief's Island,
- Moremi Wildlife Reserve.

A particular land facet may occur in more than one of the fifteen artificial zones, for example the facet "small island" occurs in twelve of the fifteen zones, Table 3.

The land facets within the grid

The following are summaries of the facet descriptions:

(1), *Upper Main Channel* — perennial flow; 20-25 m wide; appreciable sediment load along the Nggokha only, elsewhere clear; velocity 0,61 m/sec seasonally variable; vegetation typically fringed by *Cyperus papyrus*, umbels up to 4 m above water level, usually as a pure stand with fern *Cyclosorus interruptus* in the understorey; the Papyrus zone forms a mat, parts of which are occasionally broken off; where Papyrus is absent, *Phragmites* spp., *Typha* sp. or *Miscanthidium* occurs. *Phragmites* is restricted to more sluggish waters, *Miscanthidium* is rooted on the seasonally-flooded levees. *Vossia cuspidata* often forms a fringe zone along the Papyrus zone. The width of the Papyrus

	Permanent Swamp	Nggokha Flats	Khwaai Flats	Upper Boro Valley	Mid Boro Valley	Lower Boro Valley	Nokaneng Flats	Upper Santatadibe Valley	Lower Santatadibe Valley	Jau Flats North	Jau Flats South	Matsibe-Xudum Valley	Sandveld Tongue	Chief's Island	Moremi
Upper Main Channel	P	P	P	P											
Lower Main Channel															
Major Lediba	5		2	3	2	1		2	1	2	2	2			
Minor Lediba	5	5	5	5	5	2	5	1	1	4		1			
Termitaria wooded	5														
Permanently inundated areas	5	2	2	5	1			2	2	1					
Molapos	5	5	5	5	5	5		5	5	5	5	5			
Abandoned main channels								5							
River Terraces		1	1					5							
Islands															
(a) Small	3	5	5	5	5	5	1	5	5	5	5	5			
(b) Intermediate		5	5	5	5	5		5	5	5	5	5			
(c) Large		1	2	1	2	5		5	5	5	5	5			
Lineated Ridges					5	5		1	1						
Land Masses		1	1										5	5	5

P = Present

Frequency from 1 (occasional) to 5 (frequent).

zone varies, typically up to 15 m wide.

(2), *Lower Main Channel* — 3-20 m wide, lesser sediment load, variable fringe of papyrus, Phragmites, Vossia, Echinochloa, the shrub *Ficus verruculosa*, wide range of aquatics forming local communities especially where channel flow is reduced in those areas where it widens to form ledibalike stretches; aquatics are listed under (3).

(3), *Major ledibas* — variously-shaped semi-circular, oval digitate; larger ones over 100 ha, Cadikwe 125 ha, Xobega 136 ha, Guma 100 ha, restricted mainly to permanent swamps; flanked by beds of Papyrus, Phragmites, Typha, and *Ficus verruculosa*, which may also form islands within the Lagoon. (These islands are apparently fairly stable as only in one lagoon amongst those studied has there been any change since 1969). Open water surface with beds of *Vossia* around the fringe and aquatic communities throughout, the major aquatics are *Brasenia schreberi*, *Naja Pectinata*, *Caratophyllum demersum*, *Nymphaea caerulea*, *Trapa natans*, *Ottelia muricata* and *O. ulvifolia*, *Rotala myriophyllodes*, *Polygonum* and *Ludwigia* spp., *Utricularia* spp. and many sedges (*Cyperus*, *Eleocharis*, *Paspalum*, etc. spp.).

(4), *Minor Ledibas* — Variously-shaped, down to 0.5 ha smaller ones assumed to be seasonally dry in extreme drought, occur throughout the swamps, plant species as for major lagoons but more variable.

(5), *Termitaria Islands* — small mounds occur in molapos throughout the swamp, up to 40 m diameter, relief up to 10 m; carry dense thicket or tree vegetation; along the western edge of the Upper Thaoge distinct termitaria sub-zones occur, these consist of densely-wooded termitaria up to 40 m diameter, separated by narrow grass/sedge-covered channels.

(6), *Permanently Inundated Areas* — Extensive beds of the reed *Phragmites* spp. occur on the Upper Thaoge (the Thaoge blockage) and smaller ones scattered throughout the swamps, only one large bed of Papyrus (over 100 ha) is known to exist in the study area, the Nggokha cross-channel blockage; beds of mixed Papyrus/Phragmites/*Miscanthidnum* occur throughout the swamps and merge with molapos.

(7), *Seasonally Inundated Areas, Melapo* — These make up the major part of the non-woody area of the seasonal swamps and merge gradually into the permanent swamp. On the aerial photographs they appear as wide plains, up to 1 000 m wide, with a very low relief, the water regime varies with the degree and extent of the flood and with the local rainfall, typically there is a woodland/molapo ecotone which is seasonally dry and the central molapo which is seasonally wet to a greater or lesser extent. Small seasonal lagoons and termitaria are common in the molapos.

(8/9), *Abandoned Main Channels* — the Nokaneng Flats are made up of former river terrace systems together with a complex of abandoned channels and present channels, up to 100 m wide, short to medium grassland, variable species composition, heavily grazed, scattered tree communities, (*Acacia* spp.), small raised stands within the terrace, village sites.

(10), *Islands* — Variously-shaped, variable in size from 10 m diameter to 100 × 3 000, typical island in NW up to 5 km × 8 km, relief up to 3 m, gentle slopes, very fine to coarse-grained sands almost certainly of polygenetic origin. Very broadly classified on vegetation cover and distribution of vegetation on the islands: **Wet** — (a) *Hyphaene ventricosa* fringed with *Phoenix reclinata*; (b) Riparian fringe, often single tree wide, with centre of the island covered by short grassland. This type of island occurs in both wet and dry zones; (c) saline areas, short grassland distinguished by a crust of white salts, common plants are *Sporobolus spicatus*, *S. tenellus*, *Solanum Panduriformis* and *Cynodon dactylon*. **Drier** — (d) *Terminalia sericea*/Mopane woodland intermixed with *Acacia* spp. savanna.

Wet: (a) *Hyphaene ventricosa* fringed with *Phoenix reclinata*,

(b) Riparian fringe, often single tree wide, with centre of the island covered by short grassland. This type of island occurs in both wet and dry zone.

(c) Saline areas, short grassland distinguished by a crust of white salts, common plants are *Sporobolus spicatus*, *S. Tenellus*, *Solanum Panduriformis* and *Cynodon dactylon*.

Drier: (d) *Terminalia sericea*/Mopane woodland inter mixed with *Acacia* spp. Savanna.

(11), *Lineated Ridges* — especially prominent on the divide between the Boro and Kiri systems but also occurring in the Santantadibe system, 20 m × 50 m × 200 m — 800m gentle slopes, relief up to 3 m, fine to coarse sand, vegetation *Terminalia sericea* woodland intermixed with Mopane and/or *Acacia* woodland and woodland savanna, occasional large expanses of grassland with scattered shrubs and trees, saline areas present.

(12), *Land Masses:*

(a) *Chief's Island*, perimeter 461 km, area 709 km²:

(i) Woodland interflues up to 5 000 m wide, Mopane or *Acacia* woodland with lineated strips of *Terminalia sericea* woodland c. 100 m wide;

(ii) Pans, 60 m diameter, seasonally waterlogged, short grassland, heavily grazed;

(iii) Seasonal water courses, seasonally inundated short grassland.

(b) *Sandveld Tongue* — perimeter 857 km, area 2 792 km²:

- (1) Flat extensive interfluvies, vegetation *Terminalia sericea* woodland, Mopane scrubland, Mopane woodland, Acacia woodland, dense riverine woodland especially prominent along the eastern boundary;
- (ii) Mosaic of ancient flood channels in the south-west lineated north-south up to 30 m wide, very low relief, seasonally inundated, short grassland;
- (iii) Seasonal water courses, seasonally inundated short grassland;
- (iv) Pans, up to 60 m diameter, short grassland, seasonally waterlogged.

(c) *Moremi Peninsula* — Not described here, adequately described in Tinley.

During the course of the photographic interpretation it became obvious that the area of the Delta covered by dry land was very much greater than one would gather from a review of earlier reports on the ecology. As the relative proportions of dry land, areas susceptible to flooding and permanently wet areas in any particular zone have a major influence on the ecology areas of that zone, it was decided to measure these land categories.

Initially it was hoped to distinguish eight categories, based on tree cover and wetness factors, but because of tonal variation on the photographs it was not possible to do this with confidence. Accordingly eight categories were summed as follows:

- A. *Dryland* (1) Woodland and woodland savanna,
(2) Grassland.
- B. *Area susceptible to flooding*
(3) Very wet,
(4) Wet,
(5) Drainage channels within woodland,
(6) Saline patches.
- C. *Open water*
(7) *Lediba*,
(8) *Channels*.

The percentage cover of each category was converted to hectares per 25 km² cell and the total for the cells within each zone calculated, the results are shown in Tables 4 and 5, and the frequency of dry land in Table 6.

Error figures are given for some of the results, this has been done in order to illustrate the degree of accuracy of the method used.

It should be realised that the accuracy of the photo interpretation is likely to be much less than the mathematical expression of the method used.

TABLE 5
(Totals from table 4)

LAND MASSES	Grand Total	23%	2%	0.03%
	385 000 ha 3 850 km ²	356 184 ha	28 302	514
DELTA MINUS LAND MASSES (SWAMP)	1 207 500 ha 12 075 km ²	373 962	817 663	15 875
TOTAL	1 592 500 ha 15 925 km ²	730 146 ha	845 965	16 389

NOTE: Area of Chief's Island 70 985 ha
Area of Sandveld Tongue 279 221 ha

TABLE 4
Areas of dryland (ha). Land susceptible to flooding and open water within each zone

Zone Number	DRY			WET					Open Water
	Woodland	Grassland	Total	Very Wet	Wet	Drainage channel in woodland	Saline patches	Total	
1 130 000 ha	14 960	8	14 968	109 856	713	699	731	111 999	3 041 ±216
2 72 500 ha	14 460	0	14 460	54 502	2 158	84	865	57 609 ±427	431
3 85 700 ha	30 252	3 998	34 250 ±508	41 672	6 424	1 974	1 670	51 740 ±500	1 510 +186
4 70 000 ha	12 690	257	12 938	53 029	1 694	240	1 041	56 003 +129	1 059 +129
5 70 000 ha	9 526	1 470	10 996	49 042	6 503	28	1 914	57 487 +128	4 677 +128
6 77 500 ha	18 815	4 853	23 668	39 365	6 210	94	3 486	49 155 300	43 387 +67
7 50 000 ha	6 289	24 ±19	6 313 +276	40 691	1 288	1 180	228	43 267 +421	15 174 ±28
8 247 500 ha	227 996	4 271	232 267	7 781	2 169	5 205	1 999	15 174 +421	59 ±28
9 9 500 ha	24 088	2 248	26 336	60 025	3 898	59	3 339	67 304 ±134	1 360 ±134
10 120 000 ha	54 093	10 741	64 834	30 593	22 576	107	1 766	55 042 812	55 042 ±109
11 97 000 ha	14 462	430	14 892 ±431	61 785	17 268	22	2 721	81 796 ±430	81 796 ±109
12 160 000 ha	60 595	6 918	67 513 ±707	59 390	26 147	2 722	3 987	91 796 ±502	691 ±100
13 177 500 ha	71 707	11 096	82 803	75 396	13 165	2 547	3 237	94 345 ±73	352 ±73
14 72 500 ha	61 767	2723	64 490	5 277	680	1 389	428	7 774 ±203	236 ±59
15 65 000 ha	59 426	835	59 427 ±209	1 732	1 733	1 801	88	5 354 ±203	219 ±55

TABLE 6
Frequency distribution of dryland

% of Dry land per cell	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
1	64	15	13		2	4		2			Permanent Swamp
2	7	55	14	14		10					Ngokha Flats
3	11	26	12	6	26	8		3	8		Khwai Flats
4	18	39	21	10	4	8					Upper Boro Drainage
5	11	44	33	4		4	4				Mid Boro Drainage
6		21	21	22	22	6	6		2		Lower Boro Drainage
7	45	35		10	10						Nokaneng Flats
8						SANDVELD TONGUE					
9	8	36	24	18		11	3				Upper Santantadibe Drainage
10		10	22	8	6	10	20	12	6	6	Lower Santantadibe Drainage
11	23	46	23	8							Jau Flats North
12	5	11	19	17	11	12	9	16			Jau Flats South
13	1	4	13	17	15	10	6	14	13	7	Matsibe-Xudum Drainage
14						CHIEF'S ISLAND					
15						MOREMI					
Total	15	24	17	12	8	8	5	6	3	2	

The papers presented at this Symposium cover most aspects of man's utilisation of the Delta. We would like to believe that the results of our surveys will help government to frame rational land-use plans for the whole Delta. Following our surveys we have come to the following tentative conclusions.

- (1) The inherent instability of the system should mean that any land-use plans be flexible.
- (2) The proposed enlargement to the existing Moremi Game Reserve will result in a Reserve containing all the major habitats within the Delta with the important exception of Papyrus swamp.
- (3) Game Management Areas could form viable economic units around the Reserve. Management of these Areas would involve more intensive and rational utilisation of existing game stocks but not in any large scale habitat alteration.
- (4) The proposed scale of water extraction is not likely to have any catastrophic effect on the Delta as a whole but of course there will be drastic local changes.
- (5) The so-called Sandveld Tongue in the south-west of the Delta is a land mass of approximately 2 800 km², shore line of approximately 857 km. This area could be managed for either game utilisation or domestic stock range should the Tsetse eradication campaign be successful. Our preliminary indications are that a better economic return could be expected from wildlife rather than from domestic stock in this area.
- (6) We believe that the best way to prevent *ad hoc* human disturbance of the Delta is for domestic range improvement schemes to be implemented in the presently inhabited areas.