

# Preface

The data available on the Caprivi cover the region from the 21° E line of longitude, i.e. the Caprivi (Liambezi) Region described in Proclamation 6 of 1992.

The data were collected from various sources and using different methods. Copies of the data are available in unprojected latitudes and longitudes in ArcView shape files (\*.shp). Other data are available as MS Excel files (\*.xls). Besides these digital data, there are satellite images, aerial photographs and a bibliography available on the Caprivi. The data can be obtained from the Environmental Profiles Project in the Directorate of Environmental Affairs either copied on to regular 1.4 Mb disks, written to CD, or sent by e-mail. We hope to make the data available at a web/ftp site in the near future.

Information compiled by the Environmental Profiles Project is freely available while that derived from other sources can be used after getting permission from those organizations. The information is available at no cost in the spirit that human development is stimulated by the unrestricted flow of information.

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# Climate

In the North-East, the Namibian Meteorological Service has first-order weather stations at Katima Mulilo and Rundu; in addition, rainfall data are collected at Andara. Other weather data were collected from the meteorological services in Botswana and Zambia for places around Caprivi so that isohyet maps could be interpolated for the Caprivi region.

Data collected include monthly rainfall figures and the number of days on which rain fell (raindays), minimum, maximum and average temperatures, daily relative humidity and daily evaporation figures.

The data are stored in the \climate folder. The folder is divided into four other folders:

- \availdata which contains MS Excel files describing the evaporation, rainfall, humidity and temperature data that are available
- \botswana which contains files of weather data for places in Botswana
- \namibia which contains files of weather data for places in Namibia
- \zambia which contains files of weather data for places in Zambia
- \summary which contains files of summary data for all places pertinent to the Caprivi and gives the geographic co-ordinates of the places for which data are available.

The original data from the three weather bureaux are in various formats but are of a file name consisting of uppercase letters, for example, RAINANDARA.wk1. The data were imported into MS Excel for manipulation. These files all have file names written in lowercase, for example, rainandara.xls. The filenames used are as descriptive as possible, i.e. rainandara gives the rainfall data collected at Andara.

Charts in \climate\availdata show what data are available for which places within and near Caprivi. A list of place names for which data are available and their co-ordinates is also given (\climate\summary\gazeteer.xls).

## Data manipulation

### Rainfall and rain variance maps

The long-term rainfall averages and the variance in rainfall (co-efficient of variance) were calculated for a number of places in Namibia, Botswana and Zambia. These values, calculated using a rain season running from October to September of the following year, and the co-ordinates of each place were saved as a Dbase file (isohyet\comprain.dbf) and imported into ArcView. The values were interpolated (using the spline method) to produce rainfall and rain variance maps.

### Graphs and charts

The long-term seasonal values for rainfall, raindays, and millimetres of rain per rainday were plotted for Katima (using the data in \climate\namibia\rainkatima.xls). The monthly averages and standard deviations were also calculated and plotted. Each season ran from October to September of the following year.

# Meteorological services

- Republic of Zambia Meteorological Department  
PO Box 30200  
10101 Lusaka  
Zambia  
Tel: 00 260 1 251889  
Fax: 00 260 1 251795  
E-mail: zmd@zamnet.zm  
Contact: Head of Processing (Mr Biemba Mutti)
- Botswana Meteorological Services  
PO Box 10100  
Gaborone  
Botswana  
Tel: 00 267 356281  
Fax: 00 267 356282  
Contact: Penny Lesolle or Russell Mothupi
- Windhoek Weather Bureau  
Private Bag 13226  
Windhoek  
Tel: 208 2176  
Fax: 208 2197  
Contact: Lorinda

# River levels, flow volumes and flooding

Data were obtained from the Department of Water Affairs (DWA) and permission from that department must be obtained for the use of this data before the Profiles Project will give it out. In the directory \rivers, we have ASCII files provided by the DWA for several different gauging stations. The files contain daily records of river levels and flow volumes (when collected). The files also have header lines which clearly explain the data.

## Flooding on the eastern floodplain

The Profiles Project requested the International Institute for Aerospace Survey and Earth Science (ITC) in the Netherlands, to have a student investigate flooding regimes on the eastern floodplains. This work was completed towards an MSc thesis: *Binzouli, F. 1997. Assessment and zonation of the 1989 flood along the Zambezi River for environmental management in eastern Caprivi (NE Namibia) using multi-temporal remote sensed imagery and GIS. MSc thesis, International Institute for Aerospace Survey and Earth Sciences, The Netherlands.*

A copy of this publication is available in the Directorate of Environmental Affairs' library, and copies of the processed LandSat images showing the distribution of flood waters are available from the Profiles Project. Because of their large size, they have not been included in the set of data in \finaldat.

# Vegetation and soils

The Environmental Profiles Project compiled a map of vegetation types in Caprivi. Information on the main plant species was collected for each vegetation type. The mapping attempted to achieve two goals. The first was to describe and map units which other people might recognize as real and relevant in Caprivi, while the second was to have units which reflect patterns and differences in the availability of important plant resources. A total of 36 different units were described and mapped.

## Sources and processing

The units are based largely on an interpretation of TM (Thematic Mapping) images taken in 1994, and processed by the National Remote Sensing Centre (NRSC) in Windhoek. Three Landsat TM images taken in June and July 1994 were processed to enhance bands four, five and three. The three images excluded the eastern tip of the eastern floodplains and information for this area was added separately to the maps and databases using existing 1:50 000 SPOT (Système Probatoire d'Observation de la Terre) xs false colour composites from June 1992. Enhancements were made using intensity, hue and saturation decorrelation, and the three decorrelated layers were combined into a normal red, green and blue image. Lastly, photographic images were printed at scales of 1:150 000 retaining a pixel size of 30 by 30 metres. The boundaries of apparently homogenous units were digitized off these images.

The digitized units consisted of some 3 600 polygons and about 270 distinctly coded mapping units, and it was clear that these data had to be corrected and simplified. Accordingly, the polygon units were overlaid on the photographic print of the TM images, and many units were merged based on colouration, pattern and a knowledge that many of the image colours were due to the effects of fire. Further field work showed the need to remove and merge many more units and, in a few cases, new units were added. The final product provides an approximation to what we believe to be the main vegetation units in the Caprivi. This approximation should provide a basis for others to check, add and to elaborate on the units.

## Description of databases

Sample data on soils and vegetation taken at 137 sites (see relevé data, p9) were overlaid on the units and additional descriptive information was provided by aerial and ground surveys. The main vegetation and soils map is available as an ArcView 3 data set: theveg.shp, theveg.shx and theveg.dbf. They are stored in the directory \vegetation\veg and soils. The attribute fields of the data set are described below.

### theveg.dbf

CODE acts as a unique linking field to other attribute data

SOIL\_PH gives the soil pH derived from data collected by NRSC staff during field visits; not all units were sampled, hence the gaps in the database.

SOIL\_TEXT gives a descriptive name of the soil type derived from data collected by NRSC staff during field visits and from data collected by Chris Hines (Environmental Information Services).

VEG\_STRUC gives the vegetation structure, based on the descriptive system for structural groups proposed by Edwards (*Edwards, D. 1983. A broad-scale structural classification of vegetation for practical purposes. Bothalia 14(3): 705-712*); an additional unit, wetlands, was added to the system; where the vegetation unit may comprise two structural groups, this is indicated, for example, code MM is high closed woodland or wetland.

ARABLE classifies the vegetation unit according to its potential (poor, moderate or high) for arable agriculture. The rating is based largely on a subjective assessment of the production potential of the soils, flooding frequency, saline accumulation and 'workability' (i.e. how easy is it to plough and work) of the soils.

LIVESTOCK classifies the vegetation unit according to its potential (poor, moderate or high) for livestock farming. The rating is based on a general understanding of forage quality related to soil nutrient status, species composition (palatability) and biomass production potentials.

COMM\_RES classifies the vegetation unit according to the non-agricultural values (poor, moderate, high) of the vegetation unit for the local communities. This is a subjective assessment of the value of the vegetation resources for construction wood, thatching grass, medicinal and food purposes.

DIVERSITY classifies the vegetation unit according to the overall diversity (low, medium, high) of plants and animals likely to be supported in the system. This assessment is made based on an extensive knowledge of the area and general patterns of biodiversity observed in other studies.

CONS\_VAL classifies the vegetation unit according to its conservation value (low, medium, high) relative to its biodiversity and importance on local, regional, national and international levels. The degree to which the units are threatened by development or degradation and the degree to which they are conserved elsewhere was also used in the assessment of these values.

AREA gives the area (m<sup>2</sup>) as calculated from an Albers Conical Equal Area projection, with standard parallels at 17° S and 19° S, a central meridian at 23° E and a latitude of origin at 19° S.

LEGEND gives the name of the unit as used in the publication *An environmental profile and atlas of Caprivi*.

Information on plant species is provided in four files for each of the 36 mapping units: frequency.xls, stratum.xls, cover.xls and sum\_species.xls. Species in all these files are given an eight-character code, this being made up of the first four letters of the generic name and the first four of the species name. A complete listing of species names and codes is given in species list.xls.

### frequency.xls

Provides ratings per plant species on a five point scale which indicates the likelihood of finding any one species in a given vegetation unit or sample within a unit (1 = 1–20%; 2 = 21–40%; 3 = 41–60%; 4 = 61–80%; 5 = 81–100%).

## stratum.xls

Provides information for all plant species on the height (in metres) of the stratum in which any one species makes its most important contribution to a vegetation unit. This is an attempt to characterize the structure of the vegetation. For example, in unit BaD, *Baikiaea*, *Pterocarpus* and *Ricinodendron* make up a distinct tree layer at 18 m. Most grasses are indicated as contributing only to a ground layer of one metre, although some may be 1.5 m to 2.0 m in height.

## cover.xls

Provides a broad assessment of the cover-abundance of any species expressed as a percentage of aerial cover within the stratum in which it is most important in a unit. These are approximate modal values for a species within a unit. The range of cover values is not reflected in the value given.

## sum\_species.xls

This file provides frequency, stratum and cover values, as per the files described above, for a number of 'more important' species. Data for these species have simply been copied and merged into this file for ease of use. The fields are coded for each species, with the last letter of each species code being 'f' for frequency data, 's' for stratum data, and 'c' for cover information.

## Relevé data

Data for 137 relevé samples were collected by National Remote Sensing Centre staff in 1996. Data for these sample sites are available in six MS Excel files in the directory \vegetation\releve data.

## coverdat.xls

The data on vegetation cover and image colours for the 137 sample sites is stored in this file.

SITE gives the sample number

MAIN LANDSCAPE gives a code and a name of the main landscape of the site

LAND ELEMENT name

TREE gives total tree cover of the site ( $t_1+t_2$ ), where  $t_1$  and  $t_2$  are two tree levels

SHRUB gives total shrub cover of the site ( $s_1+s_2+dh$ ), where  $s_1$  and  $s_2$  are the two shrub levels and  $dh$  is the dwarf shrubs

WOODY gives the cover value for woody all woody species (TREE + SHRUB)

GRASS gives the cover value of all perennial (gp) and annual (ga) grasses

H+G gives the cover value of grasses (g) and herbs (h)

ALL VEG gives the total cover value of the vegetation (TREE + SHRUB + H + G)

COVER OF STRATA gives the % cover of the various different strata:

t1 & t2 (tree strata)

s1 & s2 (shrub strata)  
dh (dwarf shrubs)  
gp (grasses perennial)  
ga (grasses annual)  
h (herbs)

GROUND COVER VALUES OF:

basal (% cover of growing vegetation as it emerges from the ground)  
bare soil (% cover of open soil)  
litter (% cover of litter)

HEIGHTS OF STRATA gives the heights of various strata:

t1 (tree stratum 1)  
t2 (tree stratum 2)  
s1 (shrub stratum 1)  
s2 (shrub stratum 2)  
dh (dwarf shrubs)  
gp (grass perennial)  
ga (grass annual)  
hh (herbs)

## terrain2.xls

Data on lithology, slope features and erosion are stored in this file.

SITE gives the sample number of the relevé

MAIN LANDFORM gives the code and name of the landform

LAND ELEMENT gives the code and name of the land element

LITHOLOGY gives the main geological formation, as recorded in the field, within the following categories:

kalahari sands  
alluvial material  
alluvial+calcrete

SLOPE TYPE gives one of three types of slope:

straight  
convex  
irregular  
concave

SLOPE LENGTH gives the length of the slope in metres

STEEPNESS gives the slope steepness as a %

EXPOSURE gives the compass orientation of the exposed slope

EROSION TYPE gives the type of erosion as:

none  
sheet (whole surface)  
splash (surface disturbed by rain drops)  
aeolic (wind) or  
rill (small gully)

AREA gives the percentage of area affected by erosion

WATER SOURCE gives the source of water in the soil (ponding or flooding), as:

rain  
river

## soildat.xls

Gives the data on soils collected from each relevé.

SITE gives the sample number.

MAIN LANDSCAPE gives the code and name of the landscape.

EFFECTIVE DEPTH gives the effective depth of the soil in centimetres. This is the depth to which the soil augur could be turned into the ground. In some cases, underlying rock restricted the augur, or loose sand collapsed causing the hole to cave in and prevent further drilling, or thick clay prevented further turning. In these cases, the effective soil depth would be greater than that recorded. This field is thus of no value in indicating actual soil depth.

GW DEPTH gives the ground water depth (cm).

OM TOP gives the organic material on the soil surface, coded as:

- (none)  
+ (present)

The presence or absence of organic material should provide an indication of nutrient availability. When organic material is present there should also be surface sealing of sandy soils.

Depth features are given for colour, ph, texture and mottling in decimetre layers up to 100 cm. The thickness of each stratum is given by changing values for colour, pH, texture and mottling. For example, if strata 1, 2 and 3 share identical values for colour, pH, etc., the first stratum would be 30 cm deep. Soil colours, both for surface and strata are of doubtful value. There should be no relation between quality and colour. The colours are given using munsell colour codes.

COLOUR/depth

PH/depth

TEXTURE/depth

PH gives in ph values, using "Herbige" field list

MOTTLING No mottling was recorded for most records; these are not missing data. Mottling results from changing water levels. These data should be aggregated for analysis purposes into one field with '0' for those sites with no mottling and the upper depth of 10, 20, 40, etc., for the layer where mottling starts for other records. White mottling is an indication of calcrete layers deeper in the profile.

TEXTURE given by following codes:

S (sandy)

L (loamy)

C (clayey)

Si (silt)

g (gravelly)

cc (calcrete)

Om (organic matter)

(lower case letters in parentheses reflect a minor content; S+SC reflects two layers within the ten-centimetre band)

SURFACE SEAL gives the percentage of bare surface sealed. Most records are okay, but some are missing data and for some others only 'yes' is reported. Surface sealing is associated with lots of organic matter on sands. Sealing tends to cover large areas, whereas capping is more localized, especially on clays where it appears as cracked blocks. Both sealing and capping lead to water erosion.

CAPPING gives the percentage of surface capped sealed; most records are okay, but some are missing data, and for some others only 'yes' is reported.

SALINITY reports on saline deposits; this is of no value, since only one record of 'light' is given.

SURFACE COLOUR gives the munsell colour code; of little or no value.

REMARKS

## plantdat.xls

Gives data on cover percentages of each species.

## sample.xls

Gives the co-ordinate positions for the samples:

SITE  
SDEG  
SMIN  
SSEC  
EDEG  
EMIN  
ESEC

## erosion.xls

Gives the following data on erosion features:

SITE  
EROSION TYPE  
AREA  
WATER SOURCE

# Fire

The Profiles Project commissioned a study of NOAA images taken in 1996 to map fire scars. The report on this study is available: *Simon Trigg. 1997. Fire Monitoring in the Caprivi Strip for the Environmental Profiles Project.*

Copies of the images of fire scars and some active fires are available from the Profiles Project, but are not included in the final data series because they are so large.

# Fauna

## Game counts

The Profiles Project analysed aerial counts of large game, cattle and settlements done in 1995. This was the most recent and most complete aerial survey, and covered the whole of the Caprivi except for the area west of Mahango Game Reserve. The survey strips were at five- or one-kilometre intervals. All the original data are stored in the Profiles databases, but permission to use these data should be obtained from the Division of Specialist Support Services, Ministry of Environment and Tourism, Windhoek (Attention: Dr Malan Lindeque). The Profiles Project estimated game densities from these data for grids five kilometres by five kilometres in size. These estimates are also available.

Information from an aerial survey in 1994 is also available. The 1994 survey was less complete than the 1995 survey and the codes used for species differ from those used in 1995. Results from the 1994 survey are summarized and compared with previous surveys by Rodwell, Tagg and Grobler. (*Rodwell, Tagg and Grobler (1995). Wildlife Resources in the Caprivi, Namibia: The Results of an Aerial Census in 1994 and comparisons with past surveys. Directorate of Environmental Affairs, Research Discussion Paper No. 9. Available from the Directorate of Environmental Affairs.*)

## Processing the game count data

Pauline Lindeque (Specialist Support Services, Ministry of Environment and Tourism) provided the 1995 gamecount data; Tim Rodwell (Boyce Lab, University of California, Davis) provided the 1994 data. Species codes used in the 1995 count differed from those used in 1994. Following this, species codes in the field 'species' were transformed into new codes (given in 'species1') to standardize them for 1994 and 1995. Codes were as follows:

BABOO	baboon	IMPAL	impala
BUFF	buffalo	KUDU	kudu
BUSHB	bushbuck	LECHW	lechwe
CATT	cattle	LION	lion
CROC	crocodile	ORYX	gemsbok
DONK	donkey	OSTR	ostrich
DUIK	duiker	REEDB	reedbuck
ELAND	eland	ROAN	roan
ELEPH	elephant	SABLE	sable
ELE_D	dead elephant	SITAT	sitatunga
GIRAF	giraffe	STEEN	steenbok
GNUS	wildebeest	TSESS	tsessebe
GOAT	goat	VILL	village
HIPPO	hippo	WARTH	warthog
HONEY	honeybadger	W_DOG	wild dog
HYAEN	hyaena	ZEBRA	zebra

The 1994 data were appended to the 1995 data in three files. In the first, games1.dbf all the original data are present except for way-points with no species, or where altitude only was

recorded. In the second, games2.dbf, records were added together when the same species was recorded at the same place within the same strip width (either 250 m or 500 m); records on the left and right sides of the plane are therefore pooled. In the third, games3.dbf, all records of the same species at the same place were pooled, irrespective of the strip width or side of the plane. The number of records in each file varies: games1.dbf has 2225 records, games2.dbf has 1973, and games3.dbf has 1805 records.

The structure for the database of each of these three files is:

YEAR	(19)94 or (19)95
SESSION	counting session
BLOCK	area block
TRNO	transect number
IDNT	way-point number
DATE	date of flight
SIDE	left or right side of the aircraft
STRIP	strip width (m)
SPECIES	old code for species
NO	number counted
NOTES	
LATITUDE	latitudinal position
LONGITUDE	longitudinal position
SPECIES1	new code for species (see above)

## Notes on the estimation of densities from 1995 game census data

- A five-kilometre by five-kilometre grid was drawn up covering the whole region.
- A file showing the GPS track of the aircraft during the census was obtained and a buffer area of 250 m on either side of the track was created. This buffer area represented the area counted, and was overlaid on the grid. From this we could calculate what proportion of each grid block had been sampled, i.e. a sampling frequency factor.
- The file showing positions of all sightings was then overlaid on the grid and the total number of each species was summed per grid block. The sampling frequency factor was then applied to the total count for each species per grid block to obtain an estimated total number per grid block. Note that for elephants and buffalo the sampling frequency factor was doubled since these animals were counted over a distance of 500 m either side of the aeroplane. The estimated total number per block was then divided by 25 to obtain a density estimate per square kilometre.
- The polygon file of grid blocks was then rasterized into 500 m x 500 m pixels or grids and that was then overlaid on a 500 m x 500 m grid for the whole Caprivi. This allowed parts of the five-kilometre by five-kilometre grid that jutted over the border to be cut off.

## Other files in \fauna\game

- cens95.shp is a point file for each sighting
- gamesum.shp has density estimates for all species per five-kilometre by five-kilometre square

- the five-kilometre by five-kilometre square grid is in g5kmsht.shp
- the flight lines are in flight95.shp

## Bird diversity

Using data collected for the Southern Africa Bird Atlas Project, Tony Robertson and Alice Jarvis (Directorate of Environmental Affairs, Ministry of Environment and Tourism) calculated an index on the diversity of bird species. The basic unit area for the atlas work and the index are quarter degree squares, each square being 15 minutes of latitude by 15 minutes of latitude and longitude.

The index of diversity calculated is the Shannon Index described in Harrison and Martinez (*Harrison, JA and Martinez, P. 1995. Measurement and mapping of avian diversity in southern Africa: implications for conservation planning. Ibis 137: 410-417*).

The database (fauna\birdiv\birdive.dbf) for quarter degree squares contains the following fields:

MAPNAME gives a code for each square

INDEX gives the Shannon Index value (indices were only calculated for squares with five or more field cards because lower reporting rates do not provide useful measures of numbers of species)

RANK gives a rank number for each square ranging from the lowest to highest diversity values

SABAP\_CARD gives the number of field cards recorded for each square

# Settlements and household counts

These data give the numbers of households counted throughout Caprivi in 1996. They are stored in the directory \hhcounts. The data were collected to provide accurate indices of the number of people in different areas.

## Sources and processing of data

- Most data were obtained from 1:20 000 aerial photographs taken in 1996. Groups of photographs were assembled into montages. All households on the photographs were marked and counted. The montages were mounted on a digitizing tablet and aggregations of households were mapped as polygons with the number of households recorded as an attribute for each polygon. For ease and speed of data analysis, each polygon was later assigned a point object, with the point approximating the centre of the area covered by a group of households.
- Most households were easily identified as a grouping of two or more structures enclosed by a fence, and this definition agreed with local definitions of households and those used in population censuses and surveys. Structures not enclosed by fences were usually ignored as grain storage or bachelors' huts. However, households in some areas are also not fenced and each aggregation of several small huts was designated as a household.
- The 1:20 000 photographs covered the following areas: the whole of eastern Caprivi (east of the Kwando River) and the whole area along the Okavango River from 21° E to Mohembo. For other areas, household counts were obtained as follows:  
**Western Caprivi** Bushman settlements at Omega, Bwabwata, Guiga, Dodge City, Dwarspan, Borila, Ntane-ca, Doppies, Susuwe, Nova, Xharnxhois; all from estimates given by Dr Matthias Brenzinger (Institut für Afrikastik, University of Köln) and Simon Mayes (IRDNC, Susuwe). These estimates were provided as the number of people in each village. Other western Caprivi households at Bagani and Mutjiku were counted from the 1:20 000 aerial photos.  
**Villages south of the tar road and west of the Okavango River** were counted off photographic slides taken by Environmental Profiles staff. A few small villages right next to the tar road were counted from the ground; GPS positions were recorded for all these villages.
- The data were overlaid with a map of enumeration areas used in the 1991 Population and Housing Census. For each enumeration area, the average number of people per residential household was calculated; these average household sizes were applied to each point count of households. Note that for the western Caprivi 'Bushman' villages, the number of people were those estimated by Brenzinger and Mayes, and numbers of households in the database are estimates derived by dividing the number of people by average household size.
- The database contains one other figure for average household size. This is a figure which takes the 1991 Population Census average and inflates it by 12.5%. The adjustment was made because the 1991 population census average of 4.8 people per household was probably an underestimate, while the 1993/94 Income and Expenditure Survey average of 5.4 people (12.5% higher) is considered more representative. (Note:

the 1994/95 Agricultural Census gives a figure of 6.1 people for farming households in rural areas.) Thus, to estimate numbers of people, the adjusted average household sizes were multiplied by the number of households.

- The data set includes households just across the Kavango–Caprivi border. These were included because they were needed for estimating population density.
- In the Environmental Profile publication, *An environmental profile and atlas of Caprivi*, a total population within the Caprivi is given as 110 704, this being the sum total of numbers estimated by multiplying numbers of households by adjusted average household sizes. In retrospect, there might be a slight error here because they ignore institutional residents – people in hostels, hospitals and prisons. In the 1991 census there was also an institutional population of 3 146 i.e. 3.45% of the total population. An additional 3.45% should thus perhaps be added to the total estimated derived from household counts, giving a total population in 1996 of 114 523. Most of the institutional residents would have been in Katima Mulilo and this would have boosted the estimated population for the town. For interest, Research Triangle Institute in North Carolina produced some population projections for each region in Namibia, based on 1991 Population Census parameters, for the Ministry of Basic Education and Culture. Their estimate for Caprivi in 1996 was 108 140 people. The 1996 Intercensal Demographic Survey puts the population at about 107 900 people, this being an estimate provided verbally by the Central Statistics Office. It was based on a data set that was complete, but some small errors detected during further cleaning and checking of the data might lead to a slightly different estimate.

## Description of database

The data are stored in the ArcView database: \hhcounts.dbf. The following fields are available:

HH gives the number of households counted

SOULS gives the estimated number of people:  $HH * AVGHH$

GEO is the code for the enumeration area from 1991 Population and Housing Census

COUNT gives the number of people in residential households in enumeration area

HHCOUNT gives the number of residential households in each enumeration area

AVGHH is the average household size:  $COUNT / HHCOUNT$

ADJSOULS is the adjusted estimate of number of people:  $HH * ADJ\_HH$

ADJ\_HH is the adjusted estimate of average household size:  $(AVHGG * .125) + AVGHH$

## 1943 data

To compare the number of households in 1996 with those in 1943, old aerial photographs (1:36 000) were obtained for five areas in Caprivi representing different landscapes (see section on *Cultivated areas*, p19, too). The households were mapped and counted in each area. Each hut is stored as a point object in \hhcounts\huts43.shp. The numbers of huts in each area are found in huts43.dbf. The sample areas are available as shape files (sample.shp) in the directory \fields.

# Cultivated areas

- Areas that had been cleared for cultivation were mapped off the 1996 set of 1:20 000 aerial photographs. This covered all of eastern Caprivi. For the western area (west of the Kwando River), areas cleared for cultivation were mapped off the 1:80 000 surveyor-general's 1996 aerial photographs. These data are available in fields\fields.shp. The attribute data in \fields.dbf gives the area (m<sup>2</sup>) and perimeter (m) of the fields.
- No attempt was made to distinguish between areas that were actively cultivated and those that were fallow or abandoned. Cleared areas were obvious in woodland habitats, but in floodplain areas the mapped units probably represent only more recently cultivated areas. This is because old fields are probably obliterated by periods of high floods.
- To compare areas cleared in 1996 with those in 1943 and 1972, prints were obtained for five sample areas representing different landscapes. The areas are shown in the Profile publication and are available as shape files (sample.shp). The size of each area (m<sup>2</sup>) is given in sample.dbf. Photographs taken in 1943 were at a scale of 1:36 000 and those in 1972 at 1:70 000. Cultivated areas in the eastern floodplains were not compared because older fields were no longer visible after flooding.
- Geo-referencing of the 1943 and 1972 prints was done by adjusting the scale and rotation of the digitized maps to align with prominent features on other digital maps, e.g. roads and rivers.
- Cultivated areas from 1943 and 1972 are in the data sets fields43.shp and fields72.shp, respectively. The area of each field (m<sup>2</sup>) and the sample block from which it comes are given in the dBase files.

# Infrastructure

The directory \infrastructure contains data on airstrips, police stations, cattle crushpens, boreholes, clinics, the position and names of villages and towns, schools, telephone and power lines, and roads.

## **airstrip.shp**

This file contains rough positions of airstrips and airports known to the Environmental Profiles Project. In many cases the positions are accurate because the strips are at known locations which were determined off topographic maps or using global positioning systems.

## **bigtowns.shp**

This is a simple file showing the positions of a set of larger villages or towns. The selection of what is a larger village or town was arbitrary. The attribute data (bigtowns.dbf) consists only of the names of larger villages.

## **borehole.shp**

These data should only be used with the permission of the Directorate of Water Affairs. The single point file shows where boreholes are located and has a set of data attached to it as follows:

STATION gives a unique code number for each borehole generated for the Profiles Project.

SOURCE gives the source of data: either from recent UNICEF drilling project (unicef) for jetted holes, from the drilling project by Carr, Barbour and Associates (carr), from recent Chinese government funded project (chinese p), or from the Department of Water Affairs database (DWA). The original Department of Water Affairs database provided to the Profiles Project had to be cleaned in several ways, including the removal of duplicate records and deletion of records that were attributed to Caprivi but were from elsewhere based on their co-ordinates.

WW\_NO gives the Department of Water Affairs database internal code number

LAT gives the decimal latitude degrees

LONG gives the decimal longitude degrees

YIELD gives the yield of the borehole when tested (m<sup>3</sup>/hr)

RWL gives the rest water level (m)

TDS gives the level of total dissolved solids

TYPE gives the type of hole

FU – unknown

COLLAR – unknown

DEPTH is the depth drilled (m)

## **clinics.shp**

This file gives the locations and types of health facilities. The positions of the facilities were determined by matching their names with those of names of villages and schools. This is a

fairly safe approach since all facilities are in bigger and well-known villages. The single point file shows where the facilities are located and has a set of data attached to it as follows:

NAME gives the name of the village where the clinic is

TYPE gives the type of clinic: clinic (primary health care facilities), hospital (beds and doctors) or health centre (some beds)

### crushes.shp

The locations of crushpens were mapped by the Environmental Profiles Project using global positioning systems. The locational information is thus available for anyone to use. Counts of cattle per crushpen belong to the Directorate of Veterinary Services and permission must be obtained to use those counts. The single point file shows where crushpens are located and has a set of data attached to it as follows:

NAME gives the name of each crushpen/village

CODE gives a unique code number to each crushpen generated for the Profiles Project

JUNE\_1996 gives the number of cattle counted in June 1996

### phones.shp

This is a file of the rough positions of telephone lines copied off roads along which they run, as indicated by Mr Pritzen (Otjiwarongo Telecom office) on a faxed copy of a road map.

### police.shp

This gives the rough positions of police stations and border posts known to the Environmental Profiles Project. In many cases the positions are accurate because the stations/posts are at known locations which were determined off topographic maps or using global positioning systems.

### power.shp

This is a file of the rough positions of electricity lines as supplied by Mr Wagner of NamPower. Positions of lines copied off roads along which the lines run. Where lines do not follow the roads their positions were estimated off maps shown to us by Mr Wagner.

### roads.shp

These roads and tracks were assembled from various sources, largely by the National Remote Sensing Centre (NRSC). The NRSC's permission should be obtained to use the data. The data file (roads.dbf) gives a code roughly indicating the type of road (RDTYPE).

### schools.shp

This file gives the locations and types of schools. The data set attached provides the following information.

CSCHOOL is a unique code number used for each school by the Ministry of Basic Education and Culture. Those schools without numbers are not on the Ministry's database.

LAYER gives information on how the school was mapped: GPS (mapped with a global positioning system), SCHMAP (position found and digitized off a topographical map) and SCHOOLS (position estimated from a knowledge of where the school is).

SCHNAME gives the name of the school.

TYPE gives the type of school: prim (primary offering all or some primary grades), sec (offers all or some secondary grades), comb (combined school offering both primary and secondary grades), and other (vocational or tertiary institution).

LEARNERS gives the number of pupils or students in 1996 Annual Education Census.

TEACHERS gives the number of teachers in 1996 Annual Education Census.

### village.shp

This is a simple file showing the positions of a set of villages for which names were available or known. The attribute data (village.dbf) consists only of the village name.

# Land uses and administration

The \landuse directory gives information on the size and position of constituencies, conservancies, government farms and forests and parks in Caprivi.

## govtfarm.shp

Government farms are state controlled farms. The boundaries of Shadikongoro, the Katima tobacco farm, the prison farm and cultivated part of Omega were copied from cleared areas on the 1:20 000 photos. Boundaries of the quarantine farm were estimated from a paper map provided by Veterinary Services. The rest of the Omega farm was mapped from co-ordinates on a surveyor's plan provided by National Development Corporation. Boundaries of Sachinga were copied off boundaries from the LandSat image digitized by National Remote Sensing Centre for the vegetation maps where Sachinga stands out as a separate unit. The attribute data in govtfarm.dbf give the name of each farm and its area (m<sup>2</sup>).

## forest.shp

A rough map derived from faxed maps from Peter Ries (Directorate of Forestry, Katima Mulilo) show cut lines and main roads demarcated as forest reserve. However, the quarantine camp was separated from the forest reserve; the reserve's boundary being on the Golden Highway, according to Mike Jurvelius (Forest Fire Control Specialist, Directorate of Forestry). The area of the state forest is given in forest.dbf.

## parks.shp

These are boundaries of the nature reserves and parks under the administration of the Ministry of Environment and Tourism obtained from National Remote Sensing Centre (NRSC). The boundaries are not particularly accurate. Those of Popa Falls were copied off the government gazette descriptions of the boundaries. The name and area (m<sup>2</sup>) of each park is given in parks.dbf.

## conserva.shp

These are very rough boundaries of areas that are being developed or proposed as conservancies, as per maps in the tourism development plan for Caprivi and discussions with Mathew Rice (IRDNC, Caprivi) and Jo Tagg (Directorate of Environmental Affairs, Ministry of Environment and Tourism).

## constit.shp

Boundaries and names of political constituencies, digitized by NRSC by interpreting the boundaries in the government gazette. Attribute data in constit.dbf are arranged:

AREA gives the size of each constituency (m<sup>2</sup>)

PERIMETER of each constituency (m)

NAME of each constituency

AREASQKM area in km<sup>2</sup>

# Satellite imagery

For purposes of the Profiles Project, three Landsat Thematic Mapper images were acquired by the National Remote Sensing Centre to cover Caprivi: 174-072, of 14 June 1994; 175-072, of 7 July 1994; and 176-072, of 28 June 1996.

The resulting coverage just excluded the very eastern tip of the eastern Caprivi floodplains and Impalila Island. Information from this area was added separately to the maps and databases using existing 1:50 000 SPOT xs false color composites from June 1992.

The imagery was received from Satellite Application Centre, South Africa, with radiometric corrections made. To get the best fit with the topographic data, about 40 points per scene were selected for the geometric corrections. Re-sampling was done using nearest neighbour classification. The geometrically corrected scenes were pasted together using 'mosaicing' option in the Imagine software. Subsequently a buffer of 250 metres outside the international border was created to mask the Caprivi region from the areas in surrounding countries. An Albers Conical Equal Area projection was used, with standard parallels at 17° S and 19° S, a central meridian at 23° E and a latitude of origin at 19° S.

For further processing and image enhancement the bands 4, 5 and 3 were selected. Band 4 represents the near infrared (NIR) reflection, band 5 the middle infrared (MIR) and band 3 the visible red. This band combination gives the maximum differentiation in land cover (vegetation) and soil surface characteristics.

Enhancements were made using intensity hue saturation (IHS) decorrelation, programmed by staff of the Image processing laboratory (IPL) at ITC, Enschede. The three decorrelated layers were again combined into a normal red, green and blue image.

Lastly, map compositions were made in scales of 1:150 000 retaining a pixel size of 30 m by 30 m, and in 1:300 000 whereby the pixel size was increased to 100 m by 100 m. Metric co-ordinates and text were added. The films were produced on an optronix film writer at IPL, ITC, after which the photographic enlargements were produced. All image processing was done on Unix workstations using Erdas Imagine and Arcinfo software.

The three images are housed by the National Remote Sensing Centre. Copies of five other Landsat images of the eastern floodplains are also housed at the NRSC. These were purchased by the International Institute for Aerospace Survey and Earth Sciences (ITC) in Holland for work on flooding regimes on the floodplains.

# Aerial photography

This reviews and provides information on aerial photography of Caprivi. It does not presume to provide a complete picture of all aerial photography for the region, but is offered in the hope that it may make life easier for those who need information on what photographs are available. It is clear that many aerial photography jobs are commissioned without people finding out what is already available.

Many aerial photographs were taken of the Caprivi for different purposes over the years: production of topographic maps, design of roads, planning of water schemes, etc. Some of the jobs cover small tracts of land, for example, a few kilometres on either side of a road, whereas other jobs cover the whole of the eastern or western Caprivi. The scale at which the photographs were taken also vary: between 1:10 000 and 1:70 000. It is also clear that the South African Defence Force had aerial photographs taken, but information on these was not collected by the Profiles Project.

Copies of photographs can be obtained once the negatives have been traced (usually with the institution that commissioned the photography or with the photography company that carried out the job), and permission by the commissioning institution has been granted. Quite a number of contact prints for various areas were purchased by the Caprivi Profile Project and these are stored at the Directorate of Environmental Affairs.

## Available photography

1996/97 entire Caprivi

1:20 000

The Environmental Profile Project of Caprivi added to the stock of photographs by arranging for a complete set of 1:20 000 photographs to be taken. These were taken in 1996 (the whole of the area east of the Kwando River and two strips along the Okavango River) and in 1997 (the whole area west of the Kwando River and a small area of the Chobe Swamps (that were missed in 1996). The photography was done in October, 1996, and in July, 1997. The work was paid for jointly by the Finnish-supported forest fire and forest inventory projects, the LIFE (USAID-supported) project and the Environmental Profiles Project. Aircraft Operating Company (AOC), South Africa, did the photography in conjunction with Walter Volkmann (Windhoek-based land surveyor). Contact prints are stored in the Directorate of Environmental Affairs, while the negatives are stored at the Office of the Surveyor General.

Centre-point co-ordinates are stored in the files: photos 1996.txt (1996 photos of eastern Caprivi); photos 1997.txt (1997 photographs of western Caprivi); and Okavango River.txt (two strips along the Okavango River, 1996).

1996 entire Caprivi

1:80 000

Surveyor General, Windhoek

1995 Kalambasa Junction to Ngoma

1:12 500

Department of Transport

Photographers: Fotogrammensura

- 1995 Katima to Wenela  
 1:12 500  
 Department of Transport  
 Photographers: Fotogrammensura
- 1995 Divundu to Mohebo  
 1:25 000  
 Department of Transport  
 Photographers: Fotogrammensura
- 1995 Linyanti, Bukalo and Mukwe  
 1:10 000  
 Directorate of Regional and Local Government  
 Photographers: Photosurveys
- 1993 Central western East Caprivi  
 1:30 000  
 negatives at AOC, commissioned by the Directorate of Water Affairs  
 Photographers: AOC
- 1993 Central western East Caprivi  
 1:50 000  
 negatives at AOC, commissioned by the Directorate of Water Affairs  
 Photographers: AOC
- 1990 Takwasa to Divundu along road  
 1: 25 000  
 Department of Transport  
 Photographers: Fotogrammensura
- 1988 Katima and eastwards as far south as Bukalo  
 1:10 000  
 negatives at Directorate of Water Affairs  
 Photographers: Fotogrammensura
- 1978 Most of eastern Caprivi  
 1:35 000  
 job FT 784/78  
 negatives housed at Water Affairs  
 Photographers: AOC
- 1972 Western Caprivi – Mukwe and Bwabata (blocks 1821 and 1822)  
 1:70 000  
 job 709/72  
 negatives housed at Surveyor General, Cape Town
- 1972 Eastern Caprivi – Kongola and Katima (blocks 1823 and 1824)  
 1:60 000  
 job 710/72  
 negatives housed at Surveyor General, Cape Town
- 1968 Along the Okavango River East of Mukwe  
 1:19 000 and 1:40 000  
 job FT 668/67  
 negatives housed at Water Affairs  
 Photographers: EIRA, Pretoria

1943 whole of the Caprivi  
1:36 000  
jobs 31/43 to 36/43  
negatives housed at Surveyor General, Cape Town

## Photography obtained

The following contact prints were made by the Environmental Profiles Project and is available from the Directorate of Environmental Affairs.

1996 entire Caprivi  
1:20 000 (some still being photographed 27 Nov 1996)

1995 Kalambesa Junction to Ngoma  
1:12 500

1995 Katima to Wenela  
1:12 500

1995 Divundu to Mohembo  
1:25 000

1995 Linyanti, Bukalo, Mukwe  
1:10 000

1993 East Caprivi  
1:30 000

1993 East Caprivi  
1:50 000

1990 Takwasa to Divundu  
1:25 000

1972 Selected areas in Caprivi  
1:70 000 or 1:60 000 (some still on order 27 Nov 1996)

1968 Okavango River  
1968

1943 Selected areas in Caprivi  
1:36 000 (some still on order 27 Nov 1996)

## Companies and contacts

### Surveyor General

Ministry of Lands, Resettlement and Rehabilitation  
Tel: 245054/6/7/8  
(Immanuel Khoeseb, Uzo Okafor)

### Department of Water Affairs

Ministry of Agriculture, Water and Rural Development  
Tel: 2963091  
(Klaus Lieske)

### Department of Transport

Ministry of Works, Transport and Communications  
Tel: 2082050  
(Mr Trumper)

Directorate of Regional and Local Government: Towns and Villages Administration  
Ministry of Regional and Local Government and Housing  
City Centre

Aerial Photography Section  
Chief Directorate: Surveys and Land Information  
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Attn: Walter Volkman

# Literature

Bibliographies of publications on Caprivi were compiled in the literature directory as follows: caprivi.doc (literature specifically on Caprivi); general.doc (general publications with some relevance to Caprivi); and kavango.doc (literature on Kavango but relevant to Caprivi with the redefinition of the region's boundaries in 1992).

In addition, the Profiles Project obtained copies of many publications and these are available for use in the Directorate of Environmental Affairs library.

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*see also, General (p40) and Kavango (p52) references*

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