PRODUCTION OF AN AGRO-ECOLOGICAL ZONES MAP OF NAMIBIA (first approximation)

PART I: CONDENSED METHODOLOGY

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INTRODUCTION

This article is a summary of the methodology for creating an agro-ecological zones map, applied during the Technical Co-operation Project (TCP/NAM/6611) between the Food and Agriculture Organization (FAO) and the Namibian Ministry of Agriculture, Water and Rural Development (MAWRD). This is an edited extract from *AGRO ECOLOGICAL ZONES OF NAMIBIA. First Approximation. Technical Report 1. TCP/NAM/6611 (A)*, by E De Pauw, Consultant Land Use Planner, August 1996. The intention of this article is to highlight methodological steps explained in the Technical Report, for interested parties who do not have the opportunity or time to read the original report.

DEFINITION

In this study, agro-ecological zones are considered to be land entities that are sufficiently uniform in terms of climatic, landform and soil features for broad planning objectives and are unique by the specific combinations of these land attributes.

The zones are fully described in terms of their component attributes and can be easily linked to land use or farming system patterns, thereby forming a useful framework to assist agricultural development planning, land use harmonization and environmental management.

METHODOLOGY

Mapping of growing period zones

The methodology of growing period analysis is simple in principle, but complex in execution. In general, the growing period is the time during a growing season when both air temperature and soil moisture permit crop growth (FAO, 1983). The length of growing period is formally defined as the number of days during which precipitation exceeds half the potential evapotranspiration, plus the number of days to evapotranspire an assumed 100 mm (or less, if not available) of water from excess precipitation. There is also a prerequisite that the average air temperature during the whole period must exceed 6.5 °C. (FAO, 1978). Further details of the scientific background of the method are supplied in Nachtergaele and De Pauw (1985) and De Pauw (1989).

Records from 52 weather stations (Table 1), with long enough records of monthly rainfall (Source: AgroMet Databank) and average potential evapo-transpiration (Source: FAO), calculated according to the Penman-Monteith method, were analyzed with a computer programme developed by E de Pauw (De Pauw, 1989).

TABLE 1: WEATHER STATIONS USED FOR GROWING PERIOD ANALYSIS.

Station	Latitude	Longitude	Altitude	Rainfall record		
	° South	° East	m	From	To	Missing
Andara	-18.04	21.28	1100	1951	1990	
Aranos	-24.08	19.07	1200	1961	1990	
Arbeidsgenot	-19.35	16.55	1400	1961	1990	
Ariamsvlei	-28.07	19.50	774	1951	1990	
Aroab	-26.47	19.39	1000	1951	1991	
Aus	-26.41	16.19	1421	1951	1989	
Berseba	-25.29	17.47	1064	1951	1989	
Bethanien	-26.30	19.09	1150	1951	1989	
Buitepos	-22.18	19.57	1300	1961	1990	
Bunja	-17.52	19.21	1050	1953	1991	
Diaz Punt	-26.38	15.06	15	1951	1990	
Dordabis	-22.56	17.41	1500	1951	1990	
Gibeon	-25.08	17.45	1059	1951	1991	
Gobabeb	-23.34	15.03	407	1963	1991	

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TABLE 1 (CONTINUED)

Gobabis	-22.28	18.58	1445	1951	1990	
Gochas	-24.51	18.48	1150	1951	1991	
Grootfontein	-19.34	18.06	1400	1951	1991	
Hochfeld	-21.39	17.52	1550	1951	1991	
Huttenhof	-19.29	17.11	1300	1961	1990	
Kalkfeld	-20.53	16.11	1516	1951	1990	
Kamanjab	-19.38	14.51	1200	1951	1990	
Karasburg	-28.02	18.45	1013	1951	1991	
Karibib	-21.56	15.50	1171	1951	1991	
Katima Mulilo	-17.29	24.17	950	1945	1975	
Keetmanshoop	-26.32	18.07	1067	1951	1991	
Khorixas	-20.23	14.58	900	1956	1991	
Koes	-25.57	19.09	900	1951	1990	
Leonardvile	-23.31	18.49	1350	1951	1990	
Maltahohe	-24.50	16.59	1400	1951	1991	
Mariental	-24.37	17.58	1099	1961	1990	
Okahandja	-21.58	16.55	1337	1951	1990	
Okaukuejo	-19.11	15.55	1102	1961	1990	
Omaruru	-21.25	15.56	1211	1961	1990	
Omatjenne	-20.24	16.26	1200	1951	1991	
Ombalantu	-17.31	15.01	1000	1951	1991	
Oniipa	-17.57	16.05	1100	1951	1991	
Oranjemund	-28.34	17.26	30	1951	1991	
Otjimbingwe	-22.22	16.08	1100	1951	1991	
Otjozondu	-21.16	17.53	1400	1961	1990	
Outjo	-20.07	16.09	1272	1951	1991	1973-74
Rehoboth	-23.19	17.05	1386	1951	1991	
Rundu	-17.55	19.46	1102	1951	1991	
Sesfontein	-19.08	13.39	750	1957	1985	1972-73
Stampriet	-24.21	18.26	1100	1951	1985	
Swakopmund	-22.41	14.31	12	1951	1991	1973-74
Tses	-25.53	18.08	962	1951	1990	
Tsumeb	-19.14	17.43	1311	1951	1989	1985
Tsumkwe	-19.35	20.32	1000	1966	1991	
Usakos	-21.59	15.35	873	1951	1991	
Warmbad	-28.27	18.44	750	1951	1990	
Windhoek	-22.29	17.28	1700	1951	1990	
Witvlei	-22.25	18.29	1455	1951	1990	

For each station the computer programme generated a growing period matrix that contains the most relevant information for analyzing the growing period characteristics at each station. On the basis of these growing period matrixes a summary table was prepared and used for grouping stations, with sufficiently similar attributes, into zones with growing period characteristics that are significantly different from other zones.

Eleven growing period zones were mapped on a 1:2 000 000 scale by manual interpolation between the positions of these 52 stations. The accuracy of the interpolation was enhanced by a regression relationship between average annual rainfall and average growing period ($AGP = -20.64 + 0.23459\ RAIN$; $r^2 = 0.96$). That meant that an additional twelve stations, which could not be used in the original analyses, due to too short or patchy record lengths, could be assigned to particular growing periods (Table 2).

TABLE 2: ADDITIONAL WEATHER STATIONS USED FOR INTERPOLATION.

Station	Latitude ° South	Longitude ° East	Altitude m
Ganab	-23.07	15.31	
Hardap	-24.32	17.36	1108
Kalkrand	-24.03	17.36	
Nkurenkuru	-17.37	18.37	
Okandjose	-21.37	17.04	1400
Otavi	-19.38	17.20	1420
Otjiwarongo	-20.27	16.40	1455
Otjovazandu	-19.13	14.29	1050
Otjovazandu	-19.40	15.52	
Sandveld Proefplaas	-22.01	19.09	
Sitrusdal	-19.56	16.23	
Wilhemstal	-21.55	16.19	

Mapping of agro-ecological zones

This study was basically a compilation of existing information on landforms, soils and climate, which has been re-interpreted for the mapping of agro-ecological zones at the scale of 1:1 000 000. The steps in define agro-ecological zones were:

- definition of zone boundaries;
- characterization of zones.

Definition of zone boundaries

Zone boundaries were based on a re-interpretation of the FAO Land Type Map (FAO, 1984) overlaid with the Growing Period Zones Map. The FAO Land Type Map was prepared in 1984 by the FAO Remote Sensing Centre in Rome, under FAO Project NAM/78/004, from LANDSAT images. (FAO, 1984; Travaglia & Schade, 1981) The results were a report and two map sheets at 1:1 000 000 scale, dividing Namibia into 4 Land Divisions, 20 Land Provinces and 66 Land Regions. Vegetation and land use were also indicated to some extend.

The FAO Land Type Map suffers from some shortcomings:

- As no ground truthing was done, there are obvious mistakes, which causes a lack of confidence;
- the definitions of terms and classes are not precise;
- there is mixing of terms related to land cover with structural landforms and geology, causing a lack of systematic description and confusing legend;
- the map colour scheme is confusing;
- the map projection is not known, making it difficult to incorporate into a geographical information system.

Despite these flaws, the Land Type Map was still useful as a starting point for the AEZ map, as these terrain units defined by remote sensing show a good relationship with agro-ecological zones.

The AEZ team, under guidance of Dr De Pauw, spent two weeks in the field to check boundaries, to provide ground truth. Further boundary checking was done by comparing the Land Type Map with the 42 1:250 000 scale topographical map sheets of Namibia (Director-General of Surveys, 1978). These exercises resulted in the identification of 53 distinctly different land systems, based on different landforms, soils and geology.

The overlaying procedure of the Growing Period Zones (GPZ) Map over the Land Systems (LS) Map was manual and flexible. The boundaries of the GPZ Map, based on interpolation of 64 station points, are far less accurate than those of the Land Systems Map, based on remote sensing. Consequently, boundaries of the GPZ Map were stretched to coincide with boundaries of the LS map, where possible. This was done to prevent meaningless boundaries. Furthermore, where a particular growing period zone occupied only a very small portion of a land system, it was mapped as an inclusion within the main growing period zone.

With these precautions, it was possible to differentiate 69 agro-ecological zones on the basis of growing period patterns, landforms and soils.

Characterization of zones

The scale of this study limited the differentiating components to growing period patterns and land systems. At the 1:1 000 000 scale it was not realistic to further subdivide the land systems, but the growing period pattern and soil pattern were specified in each agro-ecological zone in terms of a distribution, defined by:

- the dominant component, occupying more than 50 % of the AEZ;
- the associated components, each occupying 15 - 50 % of the AEZ;
- the included components, each occupying less than 15 % of the AEZ.

A dominant component is not necessarily present. Sometimes two or more components form an association without clear dominance of one or the other. Included components, while occupying less land, are sometimes the most interesting and cannot be ignored. These may, in fact, be of higher agricultural potential, due to better soils or water availability.

Land Systems

Land systems have been described in terms of the following attributes:

- broad landform;
- SOTER[1] landform classes (FAO, 1993);
- regional slope classes;
- altitude range;
- relief intensity;
- drainage pattern;
- geological substrata;
- SOTER geology codes.

- The *broad landform* provides an overall label for the land system, e.g. dunefield, hill, mountain, plain, pan, etc.

- The *regional slope class* refers to the predominant slope range within the land system. The following classes have been distinguished:
  1) 0 - 2 %;
  2) > 2 - 5 %;
  3) > 5 - 8 %;
  4) > 8 - 15 %;
  5) > 15 - 30 %;
  6) > 30 - 60 %;
  7) > 60 %;

When a single slope class was insufficient to characterize a land system in full, both the minimum and maximum slope ranges within the system were specified. The scale of the study and the use of 1: 250 000 scale topographical maps, lead to generalization that could cause very misleading results. In future refinements of the AEZ map at larger scale, the 1:50 000 scale topographical maps and a sufficiently detailed digital terrain model in a geographical information system (GIS) will be used for this activity.

- The *general altitude range* was specified as detailed as feasible at the particular scale (1:250 000) and as narrow as the particular land system allows for. This may range from 3 m, for the coastal salt plains, to 2000 m for the rocky hills and mountains.

- The *relative relief* refers to the difference in altitude between locally adjacent higher and lower parts of the land surface, normally the interfluve crest and the valley floor. The following classes have been distinguished:
  1) < 10 m : very low relative relief;
  2) 10 - 30 m : low relative relief;
  3) 30 - 100 m : moderate relative relief;
  4) 100 - 300 m : high relative relief;
  5) > 300 m : very high relative relief.

- The *drainage pattern* describes the extent to which drainage lines or ridge crests show linear orientation. The following classes have been differentiated:
  1) no preferred orientation;
  2) weakly oriented;
  3) strongly oriented, parallel;
  4) strongly oriented, radial;
  5) mature river system.

- The *geological substrata* were derived from the Geological Map of Namibia (Geological Survey of Namibia, 1980; Geological Survey of Namibia, 1982) at a scale of 1:1 000 000. Fairly detailed stratigraphy has been summarized into general stratigraphic/ lithological labels.

- The *SOTER lithological codes* (FAO, 1993), a standardized way to classify geological substrata, provide a more detailed assessment of the lithology of land systems. In this study, SOTER lithological codes have been specified up to the third level.

Soils

Information on the soils of Namibia was too scanty to use soil types in the basic delineation of agro-ecological zones in this study. In future, reconnaissance and semi-detailed soil surveys of the country will enable the AEZ team to use soils as one of the basic differentiating components for drawing up larger scale AEZ maps. For this study, various literature sources, aerial photograph interpretation and limited fieldwork were applied to give an overall view of soil patterns. This study was not a soil mapping exercise and, consequently, cannot establish the relative importance of the described patterns and types.

Soils have been described in terms of the Revised Legend for the FAO-UNESCO Soil Map of the World (FAO-UNESCO, 1990), which was found to be appropriate for the scale of the study.

SUMMARY

The aim of this article was to introduce, in very general terms, the methodology applied to produce the first draft of a 1:1 000 000 scale Agro-ecological Zones Map of Namibia, to be used for national and regional planning. For further information, the reader is referred to the list of References.

The results of the study are discussed in *PRODUCTION OF AN AGRO-ECOLOGICAL ZONES MAP OF NAMIBIA (first approximation); PART II: RESULTS*, also in this issue of the Agricola.

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[3] The SOTER (World Soils and Terrain Digital Database) landform classes are the product of a joint project of UNEP, ISSS, ISRIC and FAO to standardise and simplify terminology used for describing soils and landforms world-wide. In this study, the SOTER landform classes were specified up to the second level.

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