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Land Use Planning
For Rational Utilization of Land and Water Resources

SWAZILAND

AGRO-CLIMATIC CHARACTERIZATION OF SWAZILAND

Explanatory Note to the Moisture Zones Map and Thermal Zones Map

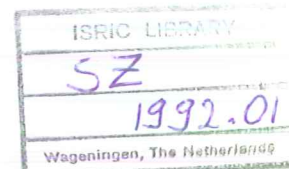
The Kingdom of Swaziland
Food and Agriculture Organization of the United Nations
United Nations Development Programme

Mbabane, 1992

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Explanatory Note to the Moisture Zones Map and Thermal Zones Map

By:

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The conclusions given in this report are considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

The definitions employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of the country, territory or sea area or concerning the delimitation of frontiers.

Van Waveren, E.J. and J.V. Nhlengetfwa. 1992. *Agro-climatic Characterization of Swaziland. Explanatory Note to the Moisture Zones and Thermal Zones Map.* FAO/UNDP/Govt. of Swaziland. Land Use Planning for Rational Utilization of Land and Water Resources Project SWA 89/001. Field Document 2. 15pp, 2 Maps

ABSTRACT

A rainfall and growing period analysis was carried out using longterm climatic records of 41 meteorological stations in Swaziland. The growing period analysis follows the methodology of the FAO Agro-ecological Zones Project and is based on a simple water balance using rainfall, potential evapotranspiration and soil moisture storage capacity.

The rainfall and length of growing period were statistically analyzed in order to be able to express the rainfall and length of growing period at different levels of probability.

The length of growing period and rainfall distribution were mapped at scale 1:500.000. The Moisture Zones Map gives the minimum expected length of growing period and annual rainfall in 80% of the years (dependable LGP and dependable rainfall).

Annual temperatures and temperatures during growing period were analyzed and correlations between temperatures and altitude were established. The temperature - altitude relationships were used to map the thermal zones at scale 1:500.000.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

The Moisture Zones Map and the Thermal Zones Map form part of the agro-climatic characterization of Swaziland for agricultural planning purposes.

The Moisture Zones Map gives information on the distribution of the length and character of the growing period for dryland farming. The growing period analysis is based on a simple water balance using evapotranspiration, rainfall and soil moisture storage capacity. In addition the Moisture Zones map depicts the total annual rainfall distribution.

The Thermal Zones Map indicates mean temperatures during growing period and mean annual temperatures.

Generally the methods as reported in the Agro-Ecological Zones Project (FAO, 1978) are followed. Agro-ecological zoning has been an on-going activity in Swaziland and the maps presented here are a further refinement of earlier work (Vilakati, 1985; Vilakati & Nkambule, 1985).

The results of the growing period and rainfall analysis presented in this report are given for different probability levels in order to indicate the minimum LGP and minimum rainfall that can be expected in a certain percentage of the years. The legend to the Moisture Zones Map gives the dependable LGP and the dependable rainfall, i.e. the minimum length of growing period and minimum rainfall that can be expected in 8 out of 10 years (0.8 probability).

The methodology and statistical methods employed are described in detail in (Van Waveren & Nhlengetfwa, 1992).

This report only presents summarized results of the climatic analysis. The decadal climatic data records and growing period analysis tables for each of the stations used, are available from the Land Use Planning Section of the Ministry of Agriculture and Cooperatives.

2. THE CLIMATIC DATABASE

For the agro-climatic zonation of Swaziland climatic records of in total 41 stations were collected and stored in a database. The stations, their locations, the length of the rainfall records, and the information available for each station are listed in Table 1. Note that all data is on decadal (10-day) basis, unless stated differently. The geographic distribution of the stations is depicted in figure 1.

Table 1. Climatic stations and rainfall stations. Location, length of record and information available.

| Station | Lat. | Long. | Alt. | Record | Available information |
|-------------------------------|-------|-------|------|--------|--|
| Big Bend | 26 51 | 31 52 | 98 | 60-90 | Rainfall |
| Malkerns | 26 33 | 31 09 | 740 | 60-90 | Estimated reference |
| Mananga | 26 00 | 31 45 | 230 | 60-90 | evapotranspiration |
| Matsapha | 26 32 | 31 18 | 642 | 69-90 | Length of growing period |
| Mbabane | 26 20 | 31 09 | 1145 | 60-90 | Temperatures |
| Mhlume | 26 08 | 31 49 | 250 | 79-90 | |
| Nhlangano | 26 06 | 31 12 | 1036 | 60-90 | |
| Bulembu | 25 57 | 31 08 | 1167 | 60-89 | Rainfall |
| Hlatikhulu | 26 59 | 31 19 | 1186 | 60-85 | Length of growing period |
| Mpaka | 26 24 | 31 47 | 335 | 69-79 | Temperatures |
| Mpisi | 26 23 | 31 32 | 394 | 60-88 | |
| Piggs Peak | 25 58 | 31 15 | 1012 | 60-87 | |
| Usutu D4 | 26 35 | 31 57 | 1456 | 70-87 | |
| Lavumisa | 27 19 | 31 54 | 135 | 60-89 | |
| Foyers | 26 12 | 31 32 | 381 | 60-87 | Rainfall |
| Mankayane | 26 40 | 31 04 | 1009 | 60-90 | Length of growing Period |
| Mayiwane | 25 55 | 31 28 | 457 | 60-89 | |
| Mbuluzi | 26 14 | 31 12 | 1097 | 60-88 | |
| Mlilwane | 26 29 | 31 12 | 707 | 60-89 | |
| Ngonini | 25 47 | 31 24 | 835 | 60-86 | |
| Nsoko | 27 04 | 31 57 | 173 | 79-87 | |
| San Roy | 26 38 | 31 28 | 312 | 69-89 | |
| Siphofaneni | 26 40 | 31 41 | 200 | 60-86 | |
| St Josephs | 26 27 | 31 29 | 518 | 60-84 | |
| St Phillips | 26 51 | 31 46 | 183 | 60-87 | |
| Tambuti | 26 45 | 31 45 | 190 | 71-86 | |
| Dwaleni | 27 10 | 31 16 | 975 | 60-82 | Rainfall (annual totals) |
| Hluti | 27 12 | 31 35 | 640 | | |
| Johannesloop | 27 01 | 31 02 | 1067 | 60-81 | |
| Kubuta | 26 53 | 31 29 | 533 | 60-84 | |
| Malalotja | 26 09 | 31 08 | 1526 | 86-90 | |
| Mpala | 26 10 | 31 45 | 339 | 60-75 | |
| Poponyane | 26 55 | 31 35 | 305 | 60-76 | |
| Usutu A1 A3 A6 C1 E3 stations | | | | | |
| Siteki | | | 653 | | Rainfall (annual Totals) Temperatures |
| Manzini | | | 608 | | Temperatures |

Fig 1. Approximate locations of climatic stations and rainfall stations used



3. THE MOISTURE ZONES MAP

The moisture zones map gives the dependable length of growing period (LGP) in days/annum for soils with an available water holding capacity of 100mm, and the dependable annual rainfall.

The dependable length growing period is the minimum total length of growing period that can be expected in 80% of the years. The total length of growing period is not necessarily continuous and may include one or more dry periods. Therefore where discontinuous growing periods occur the dependable length of the first continuous growing period occurring after 20 September is also indicated.

The dependable annual rainfall is the minimum total rainfall that can be expected in 80% of the years. Note that the annual rainfall refers to the period 1 August - 31 July.

The average decadal rainfall totals of stations of which longterm records (more than 20 years) were available are given in Table 2.

3.1. Moisture Determined Growing Period

The growing period analysis is based on a simple water balance using rainfall, potential evapotranspiration and soil moisture storage capacity.

The moisture determined growing period begins when the rainfall is equal to, or greater than, half the potential evapotranspiration. The growing period ends when rainfall is less than half the potential evapotranspiration and the available soil storage water has been evapotranspired (FAO, 1978).

The growing period may include minor dry periods (up to 20 days), which is more or less comparable with the 50mm rainfall deficit used by FAO.

A Normal growing period must exhibit a Humid period, i.e. a period with an excess of precipitation over potential evapotranspiration. A growing period without a humid period is called an Intermediate growing period.

The potential evapotranspiration was estimated using the reference evapotranspiration formula (Combination or Penman-Monteith Formula) recommended by FAO (Smith, 1991). The reference evapotranspiration (ET_o) is defined as:

'The rate of evapotranspiration from a hypothetical crop with an assumed crop height of 12cm, a fixed canopy resistance of 70 s m⁻¹ and an albedo

Table 2. Average decadal rainfall totals (mm).

| Station | J1 | J2 | J3 | F1 | F2 | F3 | M1 | M2 | M3 | A1 | A2 | A3 | M1 | M2 | M3 | J1 | J2 | J3 | J1 | J2 | J3 | A1 | A2 | A3 | S1 | S2 | S3 | O1 | O2 | O3 | N1 | N2 | N3 | D1 | D2 | D3 |
|-------------|----|----|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Bulumbu | 74 | 65 | 100 | 91 | 77 | 64 | 56 | 41 | 46 | 37 | 32 | 21 | 10 | 16 | 13 | 6 | 9 | 5 | 10 | 6 | 6 | 6 | 5 | 17 | 17 | 15 | 36 | 32 | 51 | 52 | 60 | 66 | 64 | 63 | 88 | 61 |
| D4 | 65 | 87 | 96 | 87 | 46 | 55 | 45 | 34 | 36 | 27 | 27 | 9 | 4 | 14 | 9 | 4 | 3 | 4 | 10 | 4 | 5 | 10 | 7 | 15 | 22 | 19 | 28 | 34 | 50 | 45 | 63 | 58 | 63 | 56 | 60 | 51 |
| Mbabane | 72 | 69 | 109 | 97 | 66 | 62 | 65 | 40 | 45 | 40 | 32 | 18 | 9 | 15 | 9 | 10 | 4 | 5 | 10 | 4 | 6 | 7 | 7 | 20 | 16 | 14 | 39 | 35 | 52 | 53 | 66 | 63 | 68 | 71 | 66 | 76 |
| Piggs Peak | 63 | 56 | 106 | 105 | 64 | 47 | 52 | 33 | 34 | 35 | 24 | 17 | 6 | 14 | 9 | 5 | 8 | 6 | 9 | 4 | 5 | 4 | 10 | 16 | 14 | 11 | 32 | 27 | 36 | 46 | 49 | 50 | 56 | 64 | 67 | 60 |
| Mbuluzi | 70 | 52 | 83 | 67 | 54 | 49 | 54 | 40 | 42 | 27 | 25 | 17 | 8 | 11 | 9 | 5 | 7 | 6 | 8 | 2 | 2 | 6 | 3 | 13 | 5 | 8 | 30 | 24 | 44 | 37 | 50 | 49 | 49 | 55 | 52 | 62 |
| Hlathikulu | 57 | 51 | 66 | 60 | 43 | 38 | 38 | 36 | 26 | 34 | 22 | 18 | 10 | 14 | 7 | 3 | 10 | 4 | 8 | 5 | 5 | 4 | 6 | 19 | 7 | 12 | 30 | 26 | 39 | 37 | 44 | 54 | 47 | 43 | 52 | 43 |
| Milwane | 59 | 49 | 72 | 73 | 49 | 52 | 40 | 32 | 29 | 30 | 26 | 17 | 7 | 12 | 5 | 6 | 6 | 2 | 8 | 3 | 4 | 6 | 2 | 12 | 9 | 11 | 27 | 28 | 39 | 40 | 49 | 61 | 57 | 50 | 50 | 50 |
| Foyers | 34 | 35 | 59 | 65 | 35 | 23 | 31 | 29 | 21 | 24 | 15 | 13 | 7 | 12 | 4 | 2 | 7 | 3 | 6 | 1 | 7 | 6 | 1 | 11 | 5 | 5 | 25 | 20 | 29 | 23 | 35 | 38 | 46 | 40 | 35 | 44 |
| Malkerns | 50 | 53 | 62 | 68 | 39 | 43 | 39 | 30 | 26 | 29 | 21 | 12 | 5 | 10 | 4 | 5 | 2 | 3 | 8 | 2 | 2 | 6 | 3 | 13 | 9 | 9 | 28 | 24 | 36 | 38 | 43 | 44 | 47 | 42 | 47 | 46 |
| Mayiwane | 38 | 46 | 50 | 53 | 45 | 35 | 31 | 33 | 24 | 23 | 21 | 15 | 4 | 11 | 6 | 2 | 5 | 3 | 5 | 2 | 4 | 5 | 2 | 10 | 6 | 11 | 18 | 20 | 33 | 31 | 37 | 37 | 50 | 58 | 38 | 54 |
| Mankayane | 48 | 39 | 60 | 67 | 39 | 28 | 36 | 31 | 23 | 22 | 18 | 14 | 5 | 10 | 3 | 6 | 8 | 3 | 10 | 2 | 2 | 4 | 3 | 11 | 7 | 7 | 23 | 20 | 35 | 32 | 44 | 40 | 41 | 36 | 49 | 38 |
| Matspaha | 43 | 35 | 60 | 69 | 35 | 40 | 46 | 27 | 31 | 35 | 23 | 8 | 5 | 10 | 3 | 4 | 1 | 3 | 7 | 3 | 2 | 6 | 4 | 15 | 10 | 10 | 38 | 26 | 44 | 39 | 44 | 38 | 54 | 39 | 46 | 31 |
| Ngonini | 46 | 41 | 71 | 62 | 43 | 44 | 32 | 33 | 26 | 22 | 23 | 15 | 7 | 8 | 4 | 7 | 6 | 3 | 7 | 2 | 2 | 4 | 4 | 8 | 7 | 5 | 23 | 18 | 28 | 32 | 35 | 40 | 52 | 47 | 53 | 51 |
| Nhlangano | 32 | 35 | 71 | 60 | 36 | 31 | 37 | 26 | 21 | 28 | 16 | 14 | 5 | 10 | 5 | 6 | 8 | 4 | 9 | 2 | 3 | 6 | 3 | 13 | 7 | 6 | 28 | 23 | 35 | 34 | 41 | 41 | 41 | 40 | 38 | 39 |
| San Roy | 34 | 38 | 71 | 54 | 30 | 27 | 27 | 19 | 22 | 25 | 18 | 8 | 3 | 4 | 2 | 2 | 1 | 2 | 3 | 1 | 4 | 2 | 1 | 2 | 5 | 12 | 21 | 21 | 39 | 23 | 40 | 22 | 61 | 42 | 43 | 29 |
| St Josephs | 47 | 32 | 56 | 41 | 30 | 34 | 26 | 23 | 28 | 25 | 17 | 12 | 7 | 10 | 3 | 2 | 6 | 3 | 9 | 1 | 3 | 6 | 3 | 12 | 5 | 6 | 23 | 22 | 28 | 28 | 34 | 35 | 45 | 31 | 45 | 44 |
| Mananga | 40 | 33 | 62 | 59 | 36 | 21 | 29 | 22 | 23 | 23 | 12 | 12 | 5 | 10 | 4 | 5 | 5 | 3 | 7 | 1 | 4 | 3 | 2 | 7 | 6 | 4 | 19 | 14 | 28 | 22 | 29 | 28 | 38 | 35 | 38 | 38 |
| Mpisi | 32 | 25 | 45 | 39 | 32 | 24 | 23 | 15 | 21 | 21 | 17 | 10 | 5 | 7 | 5 | 5 | 3 | 2 | 5 | 2 | 2 | 3 | 2 | 9 | 6 | 4 | 19 | 16 | 29 | 25 | 27 | 20 | 37 | 30 | 40 | 27 |
| Big Bend | 31 | 23 | 47 | 42 | 26 | 19 | 23 | 18 | 20 | 17 | 13 | 11 | 6 | 10 | 3 | 4 | 4 | 2 | 6 | 3 | 1 | 3 | 3 | 8 | 4 | 3 | 21 | 16 | 22 | 22 | 21 | 34 | 30 | 29 | 24 | 23 |
| Lavumisa | 35 | 20 | 40 | 35 | 28 | 14 | 27 | 19 | 16 | 14 | 11 | 12 | 5 | 11 | 6 | 4 | 4 | 5 | 5 | 2 | 2 | 5 | 2 | 11 | 5 | 6 | 17 | 16 | 19 | 21 | 18 | 24 | 23 | 26 | 23 | 20 |
| St Philips | 34 | 25 | 41 | 47 | 23 | 16 | 25 | 25 | 17 | 17 | 12 | 11 | 6 | 10 | 2 | 3 | 4 | 3 | 3 | 3 | 0 | 1 | 1 | 10 | 2 | 6 | 12 | 19 | 28 | 20 | 23 | 26 | 28 | 22 | 28 | 24 |
| Siphofaneni | 41 | 28 | 51 | 51 | 25 | 17 | 31 | 24 | 23 | 27 | 22 | 9 | 4 | 10 | 2 | 2 | 6 | 2 | 6 | 3 | 2 | 3 | 1 | 13 | 3 | 4 | 14 | 16 | 18 | 14 | 20 | 35 | 29 | 28 | 28 | 20 |
| Tambuti | 40 | 33 | 64 | 60 | 24 | 23 | 22 | 20 | 20 | 11 | 19 | 10 | 6 | 9 | 4 | 4 | 2 | 2 | 7 | 1 | 7 | 3 | 1 | 3 | 4 | 5 | 17 | 16 | 18 | 16 | 33 | 38 | 37 | 22 | 33 | 33 |

of 0.23, closely resembling the evapotranspiration from an extensive surface of green grass of uniform height, actively growing, completely shading the ground and not short of water'.

Classification of Length of Growing Period

The length of growing period was classified following the FAO 'Climate Classification for Rainfed Agriculture'. The available data justified a further subdivision of the FAO Moist Semiarid and Subhumid zones.

| | | |
|----------------------|---|---|
| Dry Semiarid (DSA) | : | LGP 90-119 days. |
| Moist Semiarid (MSA) | : | LGP 120-179 days. Subdivided in MSA1 (120-149 days) and MSA2 (150-179 days) |
| Subhumid (SH) | : | LGP 180-269 days. Subdivided in SH1 (180-224 days) and SH2 (225-269 days) |
| Humid (H) | : | LGP >270 days. |

The legend further indicates for each of the zones the occurrence of dry periods during the rainy season and the start of the growing period.

3.2. Soil Moisture Storage Capacity

The moisture storage capacity of the soil (STo) affects the length of growing period. This is most prominent in moisture zones which have a considerable humid period. During a humid period rainfall exceeds evapotranspiration and the excess water is stored in the soil. In the Semiarid moisture zones (DSA, MSA1, MSA2) the STo is of comparatively minor influence on the LGP, as the excess water produced during the short humid periods is seldom sufficient to bring the soil moisture level at field capacity.

Table 3. shows the influence of the STo on the LGP in the Humid and Subhumid moisture zones. From the table it can be concluded that the dependable growing period increases on average 2-3 decades on soils with a high STo (200mm). A low STo (50mm) reduces the growing period with on average 2-3 decades. In the Humid moisture zone (H) the influence of the soil on the LGP is of little relevance, as the growing period is limited by the occurrence of low temperatures, rather than moisture deficits.

Table 3. The increase and decrease of the dependable LGP (in decades) for soil moisture storage capacities of 200mm and 50mm as compared the 100mm used in the Moisture Zone Classification.

| Zone | Station | STo (mm) | Dependable LGP |
|-------------------|------------|-------------|-------------------|
| Humid (H) | Bulembo | 200 | +3 |
| | | 50 | -1 |
| | Mbabane | 200 | +4 |
| | | 50 | -5 |
| | Usutu D4 | 200 | +3 |
| | | 50 | -5 |
| | Piggs Peak | 200 | +2 |
| | | 50 | -1 |
| Subhumid (SH2) | Mbuluzi | 200 | +3 |
| | | 50 | -3 |
| | Hlathikulu | 200 | +1 |
| | | 50 | -2 |
| | Mlilwane | 200 | +3 |
| | | 50 | -3 |
| Subhumid (SH1) | Malkerns | 200 | +3 |
| | | 50 | -1 |
| | Matsapha | 200 | +2 |
| | | 50 | -2 |
| | Mayiwane | 200 | +2 |
| | | 50 | -1 |
| | Nhlangano | 200 | +2 |
| | | 50 | -1 |

3.3. Map Construction and Reliability

The map was constructed on basis of the LGP and rainfall analysis of 24 stations for which longterm decadal rainfall data records were available, and on rainfall analysis of 8 additional stations which had longterm records of annual totals. A summary of the results is given in Table 3. Information of 5 Usutu forest stations in Pallet (1990) was used to further verify the southwestern Highveld area.

The orographic character of the rainfall distribution allowed a further positioning of the isolines on basis of major relief features as shown on the 1:500.000 Topographic map. The limited amount of stations, approximately 1 per 450 km², does not allow a more detailed map scale.

3.4. Moisture Zones

In the following the moisture zones are briefly characterized. Additional information is given in Table 4. This table lists the results of the LGP and rainfall analysis per station at 80%, 60%, 40%, and 20% confidence levels (0.8, 0.6, 0.4 and 0.2 probability).

H - Humid (area: 558 km²; 3% of Swaziland)

A normal growing period with a substantial humid period. The length of the dependable moisture determined growing period is 270-290 days (STo=100mm). Soil moisture storage capacities of 200mm and 50mm, respectively increases and decreases the LGP with 3 decades. The dependable rainfall is 1000-1200mm. The probability of occurrence of dry periods of more than 30 days during the growing period is very low. The start of growing period occurs in 80% of the years between 21 August and 10 October. The humid moisture zone is confined to the northern Highveld.

SH2 - Subhumid (area: 2517 km²; 15% of Swaziland)

A normal growing period with a substantial humid period. The length of the dependable moisture determined growing period is 225-289 days (STo=100mm). Soil moisture storage capacities of 200mm and 50mm, respectively increases and decreases the LGP with 3 decades. The dependable rainfall 850-1000mm. The probability of occurrence of dry periods of more than 30 days during the growing period is very low. The start of the growing period is between 11 September and 31 October in 80% of the years. SH2 represents the dryer parts of the northern Highveld located in the rainfall shadow of moisture zone H, and the wetter parts of the southern Highveld.

SH1 - Subhumid (area: 4666 km²; 27% of Swaziland)

A normal growing period. The humid period is often discontinuous in southern Highveld. The length of the dependable moisture determined growing period is 180-224 days (STo=100mm). Soil moisture storage capacities of 200mm and 50mm, respectively increases and decreases the LGP with 2 decades. The dependable rainfall is 700-850mm. The probability of occurrence of dry periods of more than 30 days during the growing period is low, but increasing towards the south to up to 25% in Nhlangano. The start of growing period occurs in 80% of the years between 11 September and 10 November. SH1 comprises the northern Upper Middleveld, the wetter parts of the Lubombo Range, and the dryer parts of the southern Highveld.

Table 4. Growing period analysis and rainfall totals for the individual stations at 4 probability levels and average values.

| Station | Minimum LGP (decades) | | | | | 1st continuous | | | | | Dry Period % Occ. | Minimum Annual Rainfall (1st Aug - 31st July) | | | | |
|---------------------------------|---|----------------|----|----|----|----------------|----|----------------|----|----|-------------------------|--|------|------|------|------|
| | Total .8 .6 .4 .2 Av | .8 .6 .4 .2 Av | | | | | | .8 .6 .4 .2 Av | | | | | | | | |
| H - Humid | | | | | | | | | | | | | | | | |
| Bulembu | 31 | 31 | 31 | 31 | 33 | n/a | | | | | 0 | 1200 | 1400 | 1500 | 1700 | 1419 |
| D4 | 28 | 31 | 31 | 31 | 31 | n/a | | | | | 0 | 1100 | 1200 | 1300 | 1500 | 1249 |
| Mbabane | 27 | 31 | 31 | 31 | 31 | n/a | | | | | 0 | 1100 | 1300 | 1500 | 1700 | 1451 |
| Piggs Peak | 27 | 29 | 31 | 31 | 29 | n/a | | | | | 0 | 1000 | 1100 | 1200 | 1500 | 1242 |
| SH2 - Subhumid | | | | | | | | | | | | | | | | |
| Mbuluzi | 25 | 28 | 30 | 31 | 29 | n/a | | | | | 0 | 950 | 1150 | 1200 | 1400 | 1124 |
| Hlathikulu | 23 | 29 | 31 | 31 | 27 | n/a | | | | | 0 | 725 | 950 | 1100 | 1250 | 1017 |
| Mlilwane | 22 | 24 | 26 | 30 | 25 | n/a | | | | | 0 | 850 | 1050 | 1150 | 1250 | 1074 |
| SH1 - Subhumid | | | | | | | | | | | | | | | | |
| Matsapha | 19 | 23 | 24 | 27 | 23 | n/a | | | | | < 10 | 700 | 850 | 1000 | 1200 | 932 |
| Malkerns | 18 | 22 | 24 | 26 | 22 | n/a | | | | | < 10 | 750 | 900 | 1050 | 1150 | 965 |
| Mayiwane | 19 | 22 | 24 | 27 | 22 | n/a | | | | | < 10 | 775 | 875 | 1000 | 1100 | 864 |
| Mankayane | 18 | 21 | 25 | 28 | 22 | n/a | | | | | < 10 | 700 | 825 | 925 | 1050 | 859 |
| Nhlangano | 19 | 22 | 24 | 28 | 22 | 15 | 19 | 22 | 25 | 20 | 20 | 700 | 775 | 850 | 1000 | 848 |
| Siteki | | | | | | | | | | | | 700 | 775 | 825 | 850 | 820 |
| Joh'loop | | | | | | | | | | | | 725 | 900 | 975 | 1075 | 914 |
| MSA2 - Moist semiarid | | | | | | | | | | | | | | | | |
| Ngonini | 17 | 20 | 22 | 25 | 21 | | | | | | | 675 | 800 | 975 | 1075 | 908 |
| Foyers | 17 | 20 | 23 | 25 | 20 | 11 | 17 | 21 | 25 | 17 | 25 | 600 | 700 | 900 | 975 | 793 |
| San Roy | 16 | 18 | 20 | 23 | 19 | 6 | 13 | 17 | 20 | 13 | 30 | 525 | 600 | 800 | 900 | 755 |
| St Josephs | 16 | 20 | 22 | 24 | 20 | 6 | 12 | 20 | 22 | 16 | 25 | 600 | 700 | 825 | 925 | 779 |
| Mpaka | (insufficient data; available records comparable to San Roy) | | | | | | | | | | | | | | | |
| Dwaleni | | | | | | | | | | | | 625 | 700 | 800 | 875 | 745 |
| Kubuta | | | | | | | | | | | | 675 | 750 | 800 | 975 | 817 |
| Hluti | (insufficient data; available records comparable to Kubuta) | | | | | | | | | | | | | | | |
| MSA1 - Moist Semiarid | | | | | | | | | | | | | | | | |
| Mhlume | 12 | 17 | 19 | 23 | 17 | 3 | 9 | 18 | 23 | 13 | 25 | 500 | 650 | 750 | 900 | 726 |
| Mananga | 12 | 17 | 19 | 23 | 17 | 3 | 9 | 18 | 23 | 13 | 25 | 500 | 650 | 750 | 900 | 726 |
| Mpisi | 14 | 17 | 20 | 23 | 17 | 4 | 9 | 15 | 21 | 12 | 25 | 475 | 575 | 675 | 800 | 632 |
| Mpala | | | | | | | | | | | | 475 | 625 | 800 | 850 | 678 |
| Poponyane | | | | | | | | | | | | 475 | 550 | 650 | 825 | 630 |
| DSA - Dry semiarid ¹ | | | | | | | | | | | | | | | | |
| Big Bend | 10 | 12 | 16 | 19 | 15 | 3 | 5 | 8 | 14 | 8 | 40 | 425 | 500 | 550 | 700 | 590 |
| Lavumisa | 11 | 16 | 19 | 21 | 16 | 3 | 6 | 13 | 16 | 10 | 40 | 425 | 500 | 600 | 700 | 574 |
| St Philips | 10 | 14 | 18 | 21 | 15 | 3 | 6 | 10 | 16 | 9 | 45 | 425 | 525 | 600 | 700 | 566 |
| Sipofaneni | 11 | 14 | 21 | 24 | | 4 | 7 | 9 | 17 | | 50 | 475 | 575 | 675 | 800 | 630 |
| Tambutu | 11 | 15 | 16 | 21 | | 3 | 4 | 11 | 19 | | 40 | 475 | 575 | 650 | 850 | 648 |
| Nsoko | (insufficient data; available records comparable to Lavumisa) | | | | | | | | | | | | | | | |

MSA2 - Moist Semiarid (area: 3608 km²; 21% of Swaziland)

A normal growing period. The humid period is short and often discontinuous. The length of the dependable total moisture determined growing period is 150-179 days. Soil moisture storage capacity has only a limited effect on LGP (<10

¹ Siphofaneni and Tambutu are transitional to MSA1, but classified as DSA on basis of their growing period characteristics.

days). Dry periods of 3-4 decades occur in 25% of the years, more frequently in January and February than during other parts of the growing period. The length of the dependable first continuous growing period occurring after 20 September is 60-150 days. The dependable rainfall is 550-700mm. The ratio total P/total Eto over the growing period exceeds 0.6 in 80% of the years and 0.75 in 60% of the years.

The start of the growing period occurs in 80% of the years between 21 September and 10 November. MSA2 includes the Lower Middleveld, the dryer parts of the Lubombo Range and the southern Upper Middleveld.

MSA1 - Moist Semiarid (area: 4031 km²; 23% of Swaziland)

A normal growing period in most years, with a very short discontinuous humid period. Intermediate growing periods (characterized by the absence of a humid period) occur infrequently. The length of the dependable total moisture determined growing period is 120-149 days. The soil moisture storage has only a limited effect on the LGP (<10 days). Dry periods of 3-6 decades occur in 25% of the years, more frequently in January and February than during other parts of the growing period. The length of the dependable first continuous growing period occurring after 20 September is 30-60 days, but on a 60% confidence limit at least 90 days. The dependable rainfall is 450-550mm. The ratio total P / total Eto over the growing period exceeds 0.5 in 80% of the years and 0.65 in 60% of the years.

The start of the growing period occurs in 80% of the years between 21 September and 20 November. MSA1 comprises the northern and south-western Lowveld.

DSA - Dry Semiarid (area: 1978 km²; 11% of Swaziland)

A normal growing period in most years, with a very short discontinuous humid period. Intermediate growing periods (characterized by the absence of a humid period) occur infrequently. The length of the dependable total moisture determined growing period is 100-119 days. The soil moisture storage capacity has a very limited effect on the LGP: it may slightly reduce the length and occurrence of minor dry periods during the growing season. Dry periods of 3-6 decades occur in 40% of the years, more frequently in January and February than during other parts of the growing period. The length of the dependable first continuous growing period occurring after 20 September is 20-30 days, increasing to 50-60 days on a 60% confidence limit. The dependable rainfall is 400-450mm. The ratio total P / total Eto over the growing period exceeds 0.45 in 80% of the years and 0.55 in 60% of the years.

The start of the growing period is highly scattered over the period August-March but in 80% of the years between 21 September and 31 November. DSA represents the driest part of Swaziland and is confined to the southern Lowveld.

4. THE THERMAL ZONES MAP

The classification of the thermal zones is based on mean temperature characteristics during the growing period, and in accordance with the FAO 'Climate Classification for Rainfed Farming'. The map delineates the following thermal zones:

| Thermal Zone | | Mean Temperature growing period (°C) | Area (km ²) (% of Swaziland) | |
|----------------------|-----|---|---|-----|
| Moderately Warm (MW) | MW1 | 22.5 - 25 | 9787 | 56 |
| | MW2 | 20 - 22.5 | 3076 | 19 |
| Moderately Cool (MC) | MC1 | 17.5 - 20 | 3465 | 20 |
| | MC2 | 15 - 17.5 | 887 | 5 |
| Cool (C) | C | 12.5 - 15 | 20 | 0.1 |

The map legend gives a further characterization of the thermal zones, as well as their approximate altitudes.

MW2w was distinguished as a subzone of MW2. This small subzone (95 km²) is confined to the eastern part of the country (Lubombo Plateau) and is characterized by milder temperatures during the winter due to a comparatively large maritime influence.

The thermal zones map is based on the temperature records (on decadal basis) of 16 stations (see Table 1). The temperature characteristics of the stations are given in Table 5 (mean annual temperatures) and Table 6 (mean growing period temperatures). In order to construct the map, correlations between mean annual and growing period temperatures and altitude of the stations were established using regression analysis.

The mean annual temperature (°C) decreases with increasing altitude (in m.a.s.l.) according to the following equation:

$$T_{\text{mean (annual)}} = 23.2 - 0.0055 * \text{Alt} \quad (R^2 = 0.96; \text{Std. Error} = 0.5)$$

The mean temperature during the growing period is obtained from:

$$T_{\text{mean (GP)}} = 26.5 - 0.0069 * \text{Alt} \quad (R^2 = 0.96; \text{Std. Error} = 0.6)$$

The high correlation coefficients (R) combined with the reasonable standard errors show that for mapping purposes on small scales the simple linear relationships are sufficiently accurate to estimate mean annual and mean

growing period temperatures on basis of altitude, although the equations should not be used to estimate temperatures at altitudes below 250m. In the lower parts of the Lowveld temperatures are no longer increasing with decreasing altitudes, and differences between the various climatic stations seem to be more determined by the physiographic position of the station.

The decrease of the mean growing period temperature with altitude is more pronounced than the decrease of the mean annual temperatures due to the fact that the length of growing period is not constant, but varies according to the moisture zone and generally increases with altitude (see Table 4).

Mean Maximum and Minimum Temperatures

Mean decadal maximum and minimum temperatures are given in Table 5 and 6. It should be realized that daily extremes can be considerable higher or lower than the mean decadal data presented in the tables.

Table 5. Annual mean, maximum and minimum temperatures: Averages and highest and lowest mean decadal values.

| Thermal Zone | Station | Tmean Av Hi Lo | Tmax Av Hi Lo | Tmin Av Hi lo | Altitude (m.a.s.l.) |
|--------------|------------|-------------------|------------------|------------------|------------------------|
| MC2 | Usutu D4 | 15 18 11 | 20 22 16 | 9 13 5 | 1456 |
| MC1 | Hlatikhulu | 17 19 14 | 21 24 19 | 12 16 6 | 1186 |
| | Bulembu | 18 20 13 | 23 25 19 | 12 16 6 | 1167 |
| | Mbabane | 17 20 12 | 23 25 19 | 11 15 4 | 1145 |
| | Nhlangano | 18 21 14 | 24 26 20 | 12 16 6 | 1036 |
| | Piggs Peak | 17 20 13 | 23 25 20 | 11 15 6 | 1012 |
| MW2 | Malkerns | 20 24 15 | 25 28 22 | 14 19 8 | 740 |
| | Matsapha | 20 24 15 | 26 29 22 | 14 19 8 | 642 |
| | Manzini | 20 24 16 | 26 29 23 | 14 19 8 | 608 |
| MW2w | Siteki | 20 23 17 | 25 28 22 | 15 18 11 | 653 |
| MW1 | Mpisi | 21 25 16 | 28 31 25 | 14 20 6 | 394 |
| | Mpaka | 22 25 18 | 28 31 24 | 16 20 10 | 335 |
| | Mananga | 22 26 18 | 28 31 24 | 16 21 10 | 230 |
| | Lavumisa | 22 26 19 | 30 34 26 | 14 18 10 | 135 |
| | Ubombo | 22 27 17 | 28 33 25 | 16 21 8 | 108 |
| | Big Bend | 22 27 17 | 28 33 25 | 16 21 7 | 98 |

The minimum temperatures given in Table 5 and 6 should be interpreted with extreme care as the minimum temperature is strongly influenced by physiographic position, vegetation and moisture conditions. Consequently

considerable differences can occur over short distances which are not necessarily related to altitude.

Frost occurs in June and July in the Cool (C) and Moderately Cool (MC1, MC2) zones (Van Waveren & Nhlengetfwa, 1992). However, very low night temperatures (below 0°C) may incidentally occur during the winter in any of the other zones as well, especially in low positions (valleys and depressions) due to the inflow of cold air.

Table 6. Mean, maximum and minimum temperatures during growing period: Averages and highest and lowest mean decadal values.

| Thermal Zone | Station | Tmean (GP) | | | Tmax (GP) | | | Tmin (GP) | | |
|--------------|------------|------------|----|----|------------|----|----|-----------|----|----|
| | | Av | Hi | Lo | Av | Hi | Lo | Av | Hi | lo |
| MC2 | Usutu D4 | 16 | 18 | 15 | 21 | 23 | 20 | 12 | 14 | 8 |
| MC1 | Hlatikhulu | 18 | 20 | 16 | 22 | 23 | 21 | 13 | 15 | 10 |
| | Bulembu | 19 | 21 | 17 | 24 | 26 | 22 | 14 | 16 | 9 |
| | Mbabane | 18 | 20 | 16 | 24 | 25 | 22 | 13 | 15 | 8 |
| | Nhlangano | 20 | 22 | 17 | 25 | 27 | 22 | 14 | 16 | 10 |
| | Piggs Peak | 18 | 21 | 17 | 24 | 26 | 22 | 13 | 16 | 9 |
| MW2 | Malkerns | 22 | 23 | 20 | 27 | 28 | 25 | 17 | 19 | 14 |
| | Matsapha | 22 | 24 | 20 | 27 | 29 | 25 | 17 | 18 | 15 |
| | Manzini | 23 | 25 | 21 | 28 | 29 | 26 | 18 | 20 | 14 |
| MW2w | Siteki | 22 | 23 | 20 | | | | | | |
| MW1 | Mpisi | 24 | 26 | 22 | 30 | 31 | 28 | 18 | 20 | 16 |
| | Mpaka | 25 | 26 | 22 | 30 | 31 | 28 | 19 | 20 | 16 |
| | Mananga | 24 | 26 | 22 | 29 | 31 | 27 | 19 | 21 | 17 |
| | Lavumisa | 25 | 27 | 22 | 32 | 34 | 30 | 18 | 20 | 16 |
| | Big Bend | 25 | 27 | 23 | 30 | 32 | 29 | 19 | 21 | 16 |

5. THE AGRO-CLIMATIC UNITS

Overlaying the Thermal Zones Map with the Moisture Zones Map results in 15 Agro-climatic units with unique combinations of thermal and moisture conditions. Table 7 lists the Agro-climatic units and the area they cover.

Table 6. Agro-climatic units (overlay of Moisture and Thermal Zones)

| Unit | | Area (km ²) (%) | | Unit | | Area (km ²) (%) | |
|------|------------|--------------------------------|-----|------|------------|--------------------------------|-----|
| 1 | MW1 - DSA | 1969 | 11 | 9 | MC1 - MSA2 | 24 | 0.1 |
| 2 | MW1 - MSA1 | 4021 | 23 | 10 | MC1 - SH1 | 1665 | 10 |
| 3 | MW1 - MSA2 | 3095 | 18 | 11 | MC1 - SH2 | 1465 | 8 |
| 4 | MW1 - SH1 | 713 | 4 | 12 | MC1 - H | 305 | 2 |
| 5 | MW2w - SH1 | 95 | 0.5 | 13 | MC2 - SH2 | 654 | 4 |
| 6 | MW2 - MSA2 | 473 | 3 | 14 | MC2 - H | 232 | 1 |
| 7 | MW2 - SH1 | 2177 | 13 | 15 | C - H | 20 | 0.1 |
| 8 | MW2 - SH2 | 404 | 2 | | | | |

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MOISTURE ZONES

Scale 1:500.000

Food & Agriculture Organization of the UN
United Nations Development Programme
Kingdom of Swaziland

Length of Growing Period

| Zone | Dependable Total (days) | LGP 1st (days) | Dry Period Occ. (%) |
|------|-------------------------------|----------------------|---------------------------|
| H | 270-360 | - | - |
| SH2 | 225-270 | - | - |
| SH1 | 180-225 | - | - |
| MSA2 | 150-180 | 60-150 | 25 |
| MSA1 | 120-150 | 30- 60 | 25 |
| DSA | 100-120 | 20- 30 | 40 |

Dependable Total GP:
Minimum LGP in 80% of years.
May include Dry Period.

Dependable 1st GP:
Minimum length of 1st
continuous GP after
20 September in
80% of years

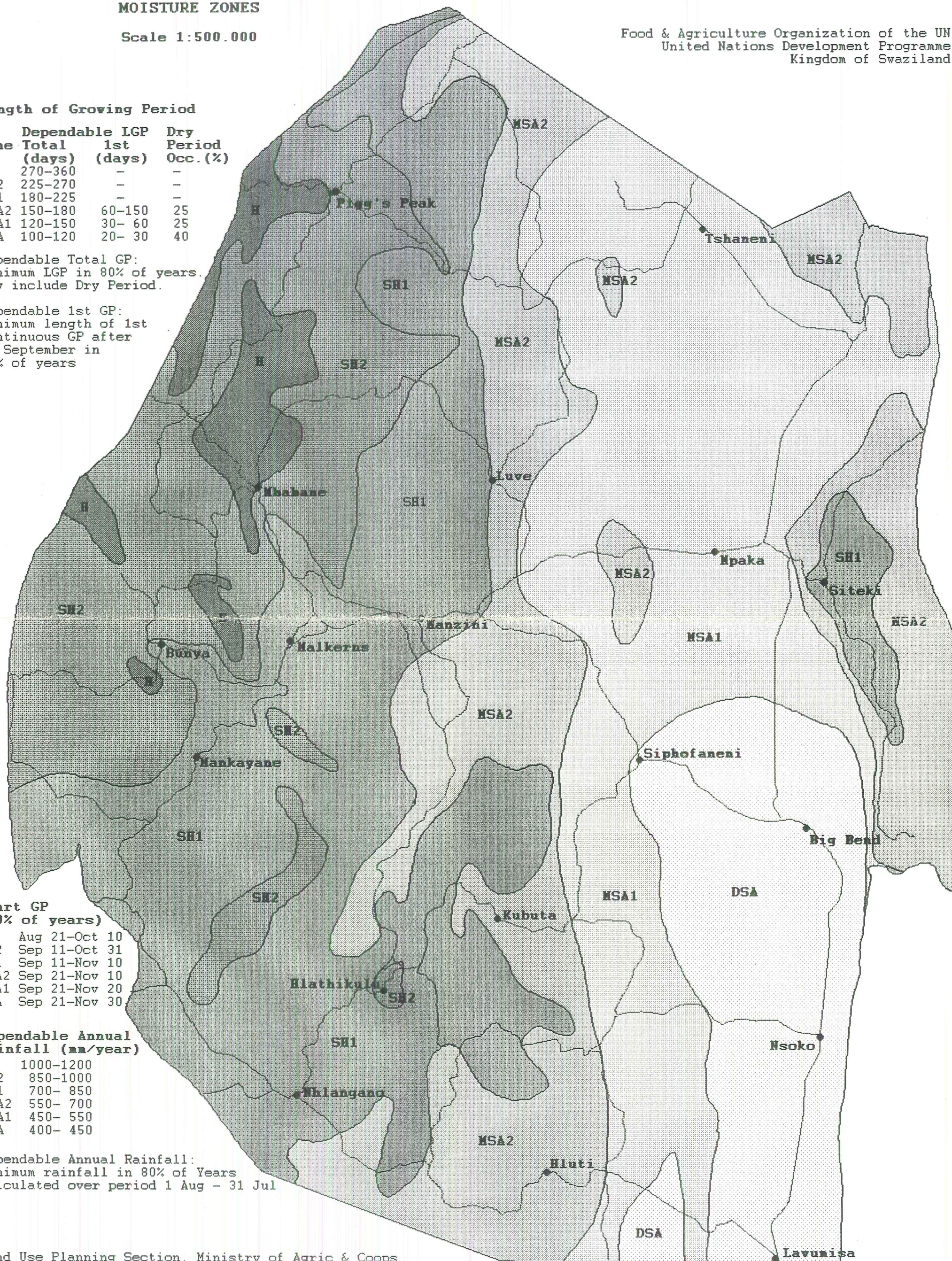
Start GP
(80% of years)

| | | | |
|------|-----|--------|----|
| H | Aug | 21-Oct | 10 |
| SH2 | Sep | 11-Oct | 31 |
| SH1 | Sep | 11-Nov | 10 |
| MSA2 | Sep | 21-Nov | 10 |
| MSA1 | Sep | 21-Nov | 20 |
| DSA | Sep | 21-Nov | 30 |

Dependable Annual
Rainfall (mm/year)

| | |
|------|-----------|
| H | 1000-1200 |
| SH2 | 850-1000 |
| SH1 | 700- 850 |
| MSA2 | 550- 700 |
| MSA1 | 450- 550 |
| DSA | 400- 450 |

Dependable Annual Rainfall:
Minimum rainfall in 80% of Years
Calculated over period 1 Aug - 31 Jul



AGRO-CLIMATIC CHARACTERIZATION OF SWAZILAND

SWA 89/001 Land Use Planning for Rational
Utilization of Land and Water Resources

THERMAL ZONES

Scale 1:500.000

Food & Agriculture Organization of the UN
United Nations Development Programme
Kingdom of SwazilandMean Decadal Temperatures (degr.C)
During Growing Period

| Zone | Average | Highest | Lowest |
|------|---------|---------|---------|
| MW1 | 22.5-25 | 25-27.5 | 20-22.5 |
| MW2 | 20-22.5 | 22.5-25 | 17.5-20 |
| MW2w | 20-22.5 | 22.5-25 | 17.5-20 |
| MC1 | 17.5-20 | 20-22.5 | 15-17.5 |
| MC2 | 15-17.5 | 17.5-20 | 12.5-15 |
| C | < 15 | < 17.5 | < 12.5 |

Altitude (m.a.s.l.)

| | |
|--------|------------|
| MW1 | < 625 |
| MW2(w) | 625 - 950 |
| MC1 | 950 - 1300 |
| MC2 | 1300-1700 |
| C | >1700 |

Mean Decadal Temperatures
(annual)

| Zone | Average | Highest | Lowest |
|------|---------|---------|---------|
| MW1 | 20-22.5 | 25-27.5 | 15-20 |
| MW2 | 17.5-20 | 20-25 | 12.5-15 |
| MW2w | 17.5-20 | 20-25 | 15-17.5 |
| MC1 | 15-17.5 | 17.5-20 | 10-15 |
| MC2 | 14-16 | 15-17.5 | 10-12.5 |
| C | < 14 | < 15 | < 10 |

