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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

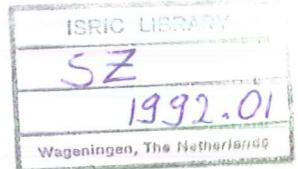
The Kingdom of Swaziland
Food and Agriculture Organization of the United Nations
United Nations Development Programme

Mbabane, 1992

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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.

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Van Waveren, E.J. and J.V. Nhlezengetfwa. 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.

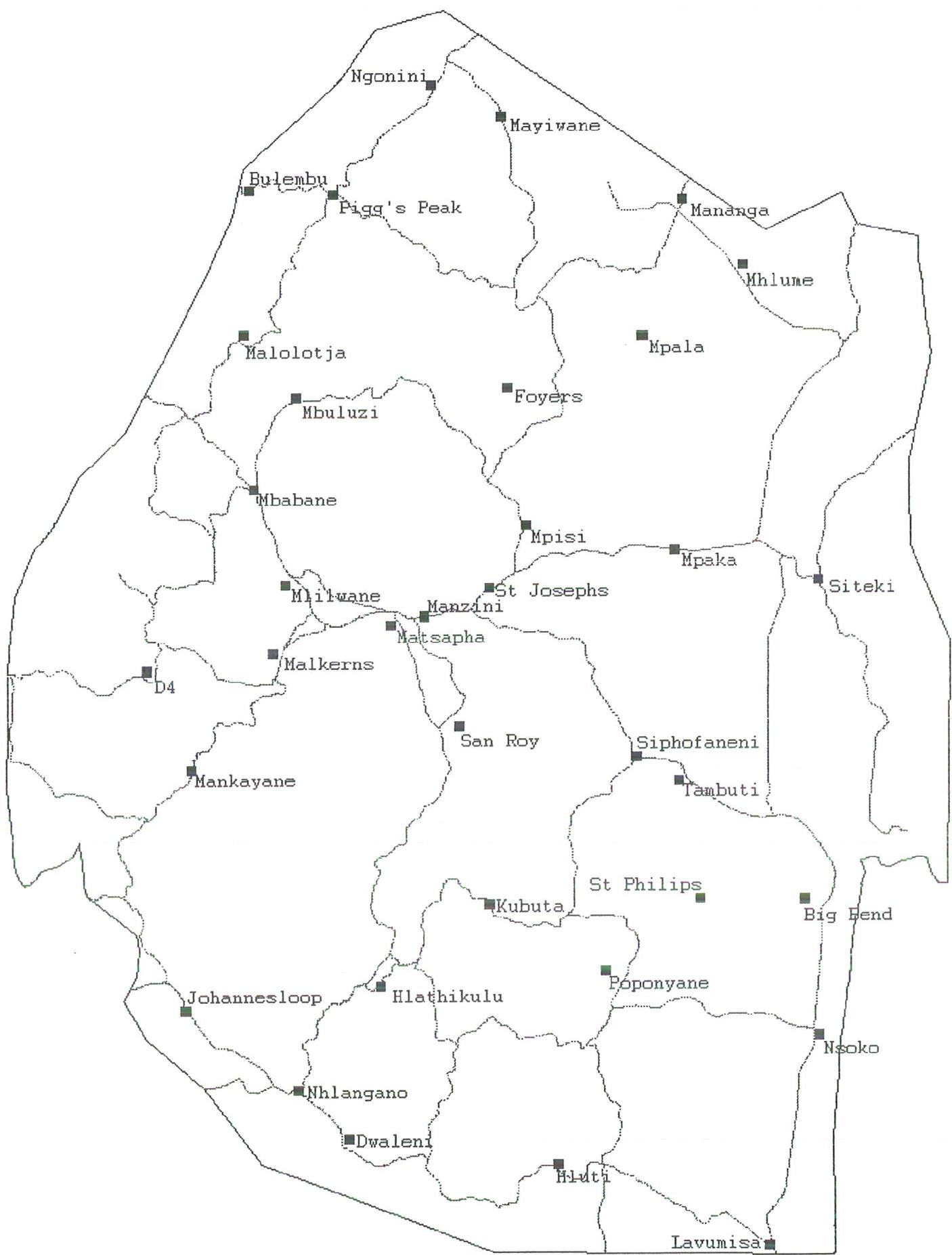
2. THE CLIMATIC DATABASE

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 Malkerns Mananga Matsapha Mbabane Mhlume Nhlangano	26 51	31 52	98	60-90	Rainfall
	26 33	31 09	740	60-90	Estimated reference
	26 00	31 45	230	60-90	evapotranspiration
	26 32	31 18	642	69-90	Length of growing period
	26 20	31 09	1145	60-90	Temperatures
	26 08	31 49	250	79-90	
	26 06	31 12	1036	60-90	
Bulembu Hlatikhulu Mpaka Mpisi Piggs Peak 	25 57	31 08	1167	60-89	Rainfall
	26 59	31 19	1186	60-85	Length of growing period
	26 24	31 47	335	69-79	Temperatures
	26 23	31 32	394	60-88	
	25 58	31 15	1012	60-87	
	26 35	31 57	1456	70-87	
	27 19	31 54	135	60-89	
Foyers Mankayane Mayiwane Mbuluzi Mlilwane Ngonini Nsoko San Roy Siphofaneni St Josephs St Phillips Tambuti	26 12	31 32	381	60-87	Rainfall
	26 40	31 04	1009	60-90	Length of growing Period
	25 55	31 28	457	60-89	
	26 14	31 12	1097	60-88	
	26 29	31 12	707	60-89	
	25 47	31 24	835	60-86	
	27 04	31 57	173	79-87	
	26 38	31 28	312	69-89	
	26 40	31 41	200	60-86	
	26 27	31 29	518	60-84	
	26 51	31 46	183	60-87	
	26 45	31 45	190	71-86	
	Usutu A1 A3 A6 C1 E3 stations			Rainfall (annual totals)	
Siteki	653			Rainfall (annual Totals)	
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 (ET₀) is defined as:

'The rate of evapotranspiration from a hypothetic crop with an assumed crop height of 12cm, a fixed canopy resistance of 70 sm^{-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	01	02	03	N1	N2	N3	D1	D2	D3		
Bulembu	74	65	100	91	77	64	56	41	46	37	32	21	10	16	13	6	9	5	10	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	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		
Mlilwane	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			
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		
Walkers	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		
Mayiware	38	46	50	53	45	35	31	33	24	23	21	15	4	11	6	2	5	3	5	2	4	5	2	10	5	2	10	20	33	31	37	37	50	58	38			
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	3	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	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	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			
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	4	5	2	2	5	1	1	10	2	6	12	19	21	18	24	23	26	23	20		
St Philips	34	25	41	47	23	16	25	25	17	31	24	23	27	22	9	4	10	2	2	6	3	1	3	2	3	1	13	3	4	14	16	18	14	20	35	29	28	20
Siphofaneni	41	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		
Tambuti	40	33	64	64	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)					Dry Period	Minimum Annual Rainfall (1st Aug - 31st July)				
	Total	1st continuous				% Occ.	.8	.6	.4	.2	Avg
	.8	.6	.4	.2	Avg	.8	.6	.4	.2	Avg	
H - Humid											
Bulembu	31	31	31	31	33	n/a		0	1200	1400	1500
D4	28	31	31	31	31	n/a		0	1100	1200	1300
Mbabane	27	31	31	31	31	n/a		0	1100	1300	1500
Piggs Peak	27	29	31	31	29	n/a		0	1000	1100	1200
SH2 - Subhumid											
Mbuluzi	25	28	30	31	29	n/a		0	950	1150	1200
Hlathikulu	23	29	31	31	27	n/a		0	725	950	1100
Mlilwane	22	24	26	30	25	n/a		0	850	1050	1150
SH1 - Subhumid											
Matsapha	19	23	24	27	23	n/a		< 10	700	850	1000
Malkerns	18	22	24	26	22	n/a		< 10	750	900	1050
Mayiwane	19	22	24	27	22	n/a		< 10	775	875	1000
Mankayane	18	21	25	28	22	n/a		< 10	700	825	925
Nhlangano	19	22	24	28	22	15 19 22 25 20		20	700	775	850
Siteki									700	775	825
Joh'loop									725	900	975
MSA2 - Moist semiarid											
Ngonini	17	20	22	25	21				675	800	975
Foyers	17	20	23	25	20	11 17 21 25 17		25	600	700	900
San Roy	16	18	20	23	19	6 13 17 20 13		30	525	600	800
St Josephs	16	20	22	24	20	6 12 20 22 16		25	600	700	825
Mpaka											925
Dwahleni									625	700	800
Kubuta									675	750	800
Hluti									675	750	975
MSA1 - Moist Semiarid											
Mhlume	12	17	19	23	17	3	9	18	23	13	25
Mananga	12	17	19	23	17	3	9	18	23	13	25
Mpisi	14	17	20	23	17	4	9	15	21	12	25
Mpala											
Poponyane											
DSA - Dry semiarid ¹											
Big Bend	10	12	16	19	15	3	5	8	14	8	40
Lavumisa	11	16	19	21	16	3	6	13	16	10	40
St Philips	10	14	18	21	15	3	6	10	16	9	45
Sipofaneni	11	14	21	24		4	7	9	17		50
Tambuti	11	15	16	21		3	4	11	19		40
Nsoko											

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 Tambuti 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:

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

The mean temperature during the growing period is obtained from:

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

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 & Nhlelengetfwa, 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
				14	MC2 - H	232	1
6	MW2 - MSA2	473	3	15	C - H	20	0.1
7	MW2 - SH1	2177	13				
8	MW2 - SH2	404	2				

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AGRO-CLIMATIC CHARACTERIZATION OF SWAZILAND
MOISTURE ZONES

Scale 1:500,000

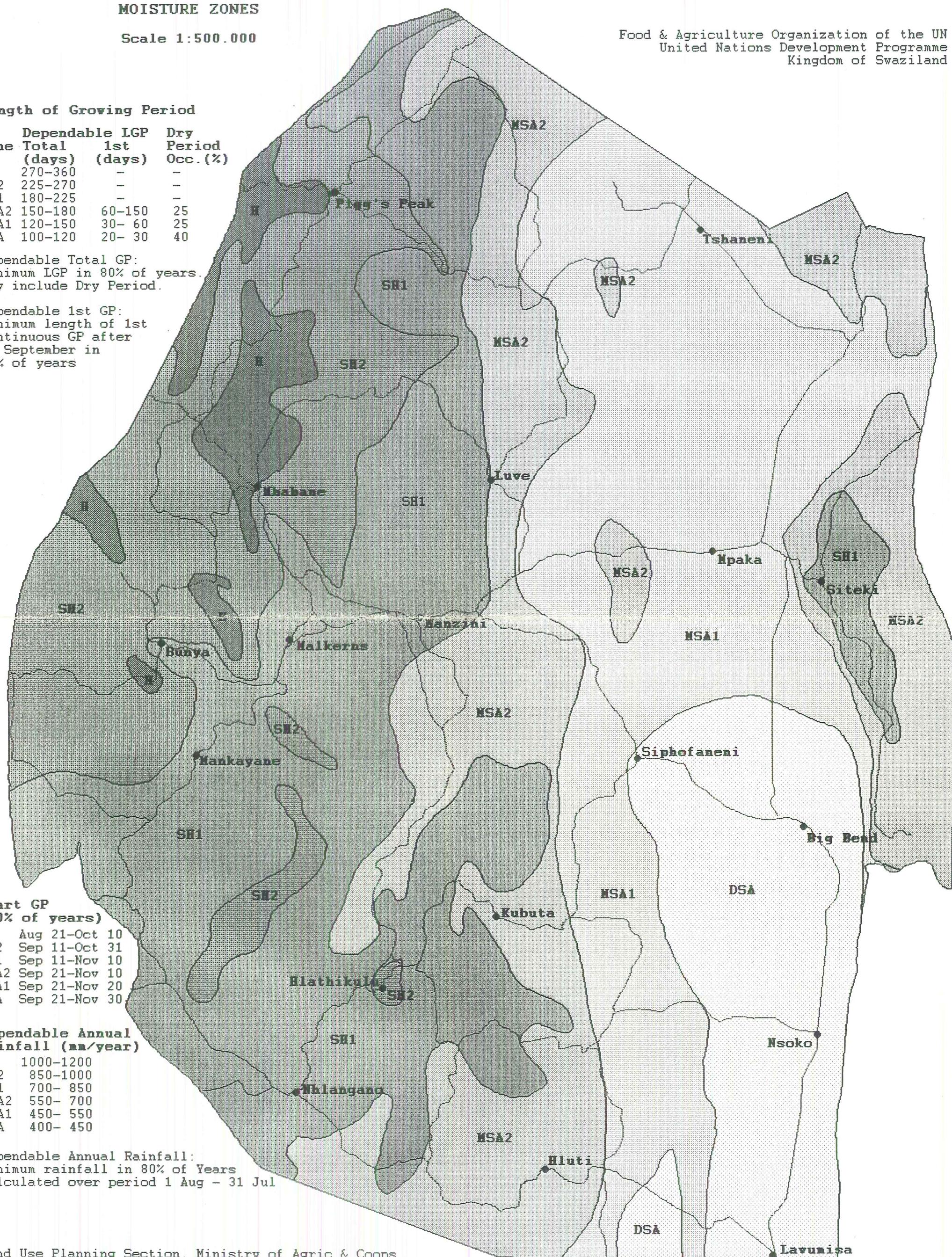
SWA 89/001 Land Use Planning for Rational
Utilization of Land and Water ResourcesFood & Agriculture Organization of the UN
United Nations Development Programme
Kingdom of Swaziland

Length of Growing Period

Zone	Dependable Total (days)	Dependable 1st Period (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 IGP 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

THERMAL ZONES

Scale 1:500.000

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

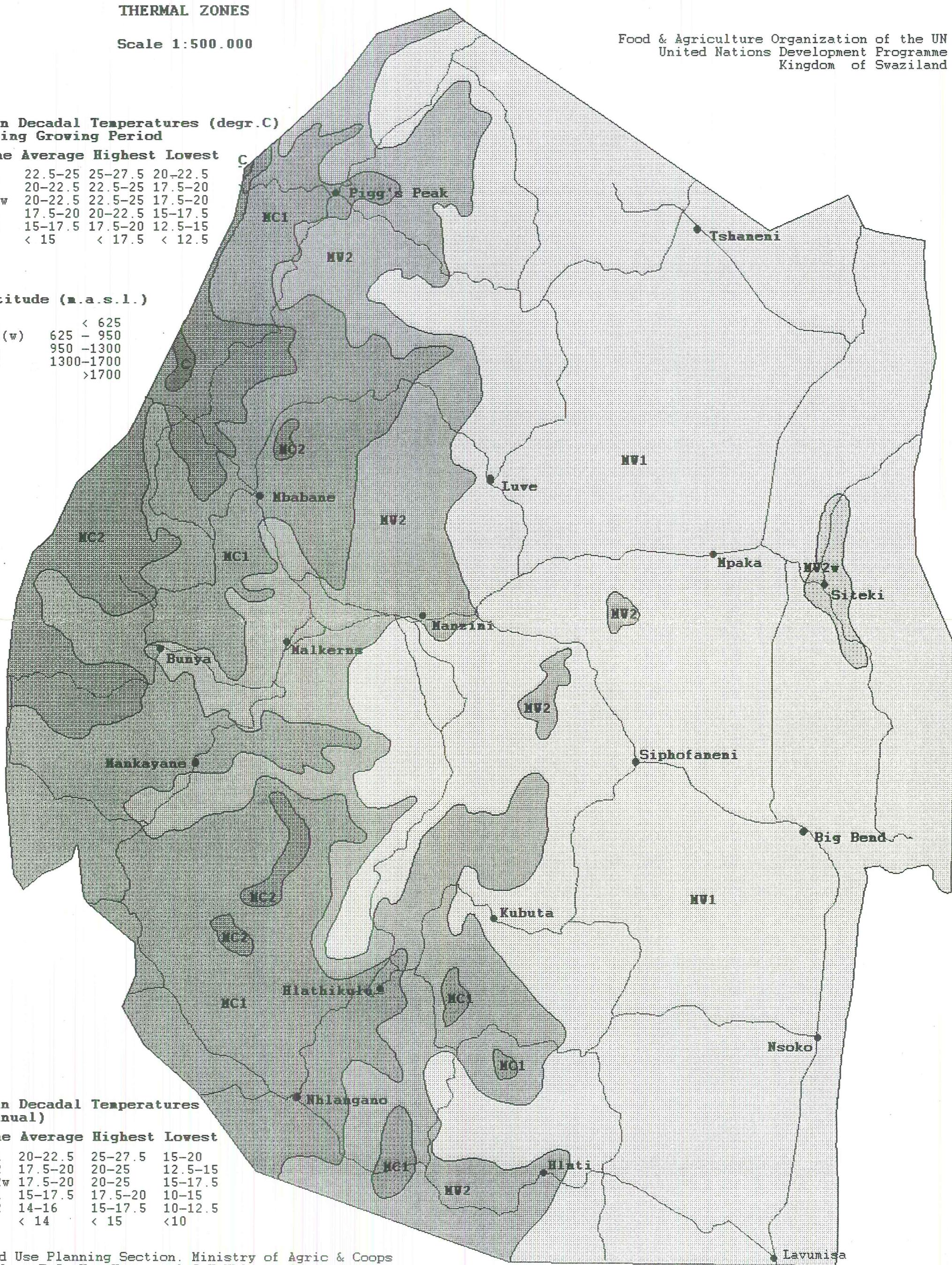
Food & Agriculture Organization of the UN
United Nations Development Programme
Kingdom of SwazilandMean Decadal Temperatures (degr.C)
During Growing Period

Zone Average Highest Lowest

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