A SUMMARY OF

RAINFALL, PAN EVAPORATION and TEMPERATURE DATA

at PAN EVAPORATION STATIONS in

MALAŴI

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RAINFALL, PAN EVAPORATION and TEMPERATURE DATA at PAN EVAPORATION STATIONS in MALAWI.

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INTRODUCTION

The examination of climatic observations, namely rainfall, pan evaporation and temperature, was originally initiated to determine design criteria for existing and future irrigation schemes in Malawi and to assist in the selection of the crops to be grown. Before the observations could be examined the bulk of climatic data had to be processed so that the data woul be more easily accessible. Since computer processing was not a likely possibility in the near future, the data were processed by hand. In order to eliminate calculation errors most of the calculations were done twice. All the meteorological observations were expressed in units from the imperia system and had to be converted into units of the metric system for this report.

In order to limit the volume of data it was decided to process only the data from those evaporation stations at which both an open evaporation pan and a raingauge are installed. Unfortunately the evaporation stations with long periods of records are not well distributed over the country. In recent years an effort has been made to relocate and to increase the number of evaporation stations resulting in a better network of observation points. In 1970 about 70% of the stations were situated in the Southern Region while in 1978 this was about 50%.

This report consists of a series of tables and graphs presenting the basic information from the evaporation stations which can be used for further analysis. The tables present the 10-day values of rainfall and pan evaporation for each year of data recording. The graphs are designed by arranging the data according to different levels of probability of occurrence

Because of the importance of the rainfall distribution, not only is the total rainfall for 10-day periods calculated and processed, but also the dry spell durations, the number of raindays and the depth duration frequency of daily rainfall. These are presented graphically at different levels of probability of occurence. The temperatures, which are measured at about 30 evaporations stations are also processed and the absolute and the mean maximum and minimum monthly temperatures are presented in graphs at different probability levels.

An accurate probability can theorically only be determined from a very large set of data, but this of course is not available and therefore an estimate of probability must be made from a sample. The accurancy of this estimate of probability will depend on the length of records and the variability of the phenomenon concerned. The longer the record the closer will the observed relative frequency of occurence approach the theoretical one. With a short record certain rare events may even not occur during the period of observation. Therefore one must be carefull in determining probabilities from a short period of record, particularly of events which occur infrequently.

For the processing of the climatic data it is assumed that a period of 10 years is the minimum length required for the determination of probabilities. The maximum number of record years for any station in Malawi is 27 years.

Probability may be expressed as a percentage of the total number of occurrence with 100% for all occurrence. If an event occurs with a probability of 20% it is also true that the probability that it will not occur is 80%. The probability may also be expressed in terms of a return period of the probable number of times an event will recur in a given length of period.

The spatial distribution of the evaporation stations with long periods of records was found inadequate for the design of climatic maps for the different climatological characteristics. The 4 maps included in this report show for a number of evaporation stations some of their main climatic characteristics.

Summary of the data presented in this report

climatic parameter	description of the presentation	levels of exceedance probability of occurrence	presented at
Rainfall	10 days totals	- recorded values	Tables A
		- 20, 50 & 80%	Graphs C
	Onset & end of rains	10, 20, 50, 80 & 90%	Graphs C
	Length of rainy season	10, 20, 50, 80 & 90%	Graphs C
	Nov.-Apr rainfall	10, 20, 50, 80 & 90%	Graphs C
	Nov.-April No. raindays	20, 50 & 80%	Graphs D/E
	Dry spell duration *)	20, 50 & 80%	Graphs D/E
	Number of raindays *)	20, 50 & 80%	Graphs D/E
	Depth duration frequency of daily rainfall	return periods of 2, 10 & 20 years.	Graphs D/E
Pan evaporation	10-day averages	- recorded values	Tables B
		- 20% & 80%	Graphs C
Temperature	Abs. monthly Max. & Min.	20% and 80% respectively	Graphs E
	Mean monthly Max. & Min	50%	Graphs E

*) for half month periods

For each of the three Regions the graphs and tables are presented in a seperated annex. In each annex the stations are arranged in alphabetical order and the available data for one station are put together. On the lists of the evaporation stations (tables I, II and III) is indicated which information is available from each station. The letters indicated under report number in these tables correspond with the letters mentioned after tables and graphs in the summary above.

Evaporation stations

Details of location, altitude, length of record and the meteorological office number of each of the evaporation stations is given in Tables I, II and III. These tables list all stations opened between 1950 and 1978. The total number of stations is 76 but 19 of these stations had been closed by the end of 1978. The location of the 76 stations is indicated on Map 1. The distribution of the stations is not very uniform, since half of the stations are located in the Southern most of the three regions of Malawi. Only 24 of the present stations have records from before 1960.

The first evaporation stations were established by the Water Development Branch of the Ministry of Works. At present these stations are run and supervised by the Water Resources Department of the Ministry of Agriculture and Natural Resources. The standard equipment at the evaporation stations is an evaporation pan and a raingauge.

A limited number of the evaporation stations are equipped for the measurement of other meteoroligical variables temperature, humidity, windrun, radiation and sunshine). These synoptic stations are in most cases equipped and supervised by the Meteorological Services since they are usually the stations at the airports. However the observers at these stations send copies of the pan evaporation and rainfall data to the Water Resources Department.

The daily observations at the evaporation stations are done by local people who receive a compensation for their work. The data sheets are sent to the district offices where the data are checked before the data are sent to the Water Resources Division where the data are stored. The stations are regularly visited by the district officers for inspection.

Rainfall

Because of the variability of rainfall, monthly figures are of limited value for agricultural practice, particularly for irrigated agriculture. In this paper the rainfall is therefore expressed as total rain during a 10-day period. The amount of rainfall for the same corresponding period of 10-days over several years is calculated. For each period of 10-days the rainfall is ranked in either ascending or descending order and a serial rank number is attached to each value, the highest value being P_1, the lowest P_n. Then the rank number (r) is divided by the total number of observations plus 1 in order to obtain the frequency of exceedance as $F\ (P\ P_r) = r/(n + 1)$ in the case of descending data ranking. A normal frequency distribution has been assumed of all the observations presented in this paper. The rainfall estimates were abstracted at three different levels of probability (20%, 50% and 80%).

The graphs presenting the rainfall probability levels connect points of equal probability for each period of 10-days disregarding the year of recording. It is therefore very unlikely that these graphs are representative of any particularly year. The actual rainfall pattern will be much more variable. In order to quantify the effective rainfall, the total amount of rain between the 1st November and 30th April is calculated for each year. The total rainfall during these 6 months is indicated at 5 levels of probability of occurrence.

The onset and the end of the rains are very important parameters for agricultural planning purposes. The date of the "onset of the rains" is defined as the first occasion after the first of October, in which 12mm or more rain occur in two days or less. The date of the onset is when the 12mm has accumulated and when the next rain exceeding 5mm/day is within 20 days after this date.

The "end of the rains" is defined as the last date on which 10mm or more falls in a period of 2 days or less, followed by a period of more than 20 days during which the amount of 5mm/day does not occur. The probable dates of the onset and the end of the rains are indicated at 5 levels of occurrence.

The "length of the rainy season" is the number of days between the onset and the end of the rains, as defined above. The length of the rainy season is also expressed at 5 levels of probability of occurrence.

Map 2 shows the mean annual rainfall (in mm) and the mean length of the rainy season (in days) for the evaporation stations with more than 10 years of records. It is obvious from this map that the mean annual rainfall is very much related to the topography. The areas with high mean annual rainfall (more than 1500 mm/year) are on and near the high Plateaux. The lowest mean annual rainfall (less than 700 mm/year) occurs in the Shire Valley and the upper catchment of the Dwangwa river. In most of the evaporation stations the average length of the rainy season varies between 120 days and 175 days.

The duration of the "dry spell" is defined as the number of consecutive days during which the daily rainfall does not exceed 3mm. The maximum duration of the dry spell is calculated for each half month period during rainy season. A dry spell commencing in a particular half of a month is allocated to this half of the month regardless of whether it persists into the next half of the month or not. From the sequence of maximum dry spell periods for each half month of every year of record a frequency distribution was drawn up and the maximum dry spell duration estimates were abstracted at 3 probability levels (20%, 50% and 80%). Between mid December and mid March the dry spell duration with a 50% exceedance probability of occurrence is in general about 5 days. An exception is the Lower Shire Valley where this duration is about 7 - 8 days.

The "number of raindays" is calculated for each half month and gives an impression of the distribution of the rainfall during the rainy season. A day is considered as a "rainday" if the daily rainfall is more than 3mm. A frequency distribution was drawn up in a similar fashion as above and then the raindays were abstracted at the 3 probability levels. These levels are presented as a graph.

A depth duration frequency relation of rainfall is worked out for all the evaporation stations. The rainfall data used were daily observation and not the 24 hours rainfall. The frequency distribution of 1, 2, 3 and 5 day rainfall is determined according to the Gumbel's probability distribution. From this analysis 1, 2, 3 and 5-day rainfall with return periods of 2, 10 and 20 years were selected and plotted. This relation can, for example, be used for the calculation of the design discharge for a surface drainage system. At only a limited number of evaporation stations was the maximum rainfall intensity for one day more than 150mm/day. The stations with high daily rainfall were all situated along the Lakeshore or near the high Plateaux.

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Pan Evaporation

The evapotranspiration is an essential element of the water balance and it is therefore important to quantity this element. The evapotranspiration cannot be measured directly and must be estimated. The evaporation from a free water surface of an open pan is an indicator of the evaporative demand of the atmosphere. Empirical correlations are required to convert the evaporation rate measured by the pan into the potential or actual evapo-transpiration. The disadvantage of the pan evaporation is its variable behaviour due to local climatic conditions and to the different dimensions and exposure of the pan.

The pan evaporation is measured once a day and normally at 8 hours in the morning. The observations are recorded for the previous day. The evaporation is measured by counting the number of cups required to fill the pan till the top of a fixed hook gauge. The volume of each cup corresponds with an evaporation of 0.05 inches. In case the pan overflows due to heavy rainfall the average pan evaporation value for that month is calculated and used as observation of the pan evaporation for that day.

For the observation of evaporation from open water two different types of evaporation pans are used: the Kenya type pan and the American Class A pan. Initially only the Kenya type pan was installed but at present mainly Class A pans are used. The main difference between the evaporation pans is the water depth in the pan; the three different standard pans used in Malawi are:

Kenya type pan	diameter 48"	depth: 17"	freeboard: 3"
Kenya type pan	diameter: 48"	depth: 14"	freeboard: 2"
Class A pan	diameter: 48"	depth: 10	freeboard: 2"

In six station locations pairs of pans have been maintained for a shorter or longer period, in order to compare galvanised with black and Class A with Kenya type. The relation between these two types of pans has not been worked out for this paper. For these six stations the evaporation data from the Class A pan have been used in this report.

The pans are constructed locally and this might be the reason that the freeboard is not always according to the standard design. Other variations have been introduced into the records over the years because of inconsistencies in maintenance. The pans are painted black inside others remain galvanised. Screening is inconsistent and undocumented changes in locations have also occured.

Evaporation pans at 19 locations in Malawi are operated in association with fully instrumented meteorological stations. Monthly potential evaporation using Penman equation is routinely calculated and pan coefficients could be derived. These data are readily available in published form since 1972.

The pan evaporation data is summed over each perio 10-day period, and expressed as an average daily rate in mm/day for that period. It was found that monthly mean evaporation rates resulted in an underestimation when predicting evaporation demand for the design of irrigation and drainage projects. For each corresponding period of 10-days for every year of record a frequency distribution was drawn up. From this ranked data the estimates of evaporation was abstracted at two levels of probability (20% and 80%).

Map 3 shows the mean annual and yearly maximum values of the pan evaporation (20% exceedance probability) at the locations where these data have been measured for more than 10 years. The yearly maximum pan evaporation is found from a sequence of the annual maximum 10-days pan evaporation and from this serie the pan evaporation with a 20% probability of occurrence is estimated. It is obvious from this map that the topography strongly influenced the pan evaporation. The variation in pan evaporation between adjacent and similar stations is difficult to explain, therefore interpolation between the stations should be done very carefully.

Along the lakeshore and in the Shire Valley the mean annual pan evaporation is the highest and varied between 2000mm and 2200mm. Mean annual pan evaporation values below 1500mm. are found in areas of high and prolonged rainfall (Mulanje, Zomba and Nkhata Bay). The pan evaporation values for the Chileka stations are probably strongly influenced by non-climatic circumstances, since this station is adjacent the platform for the aeroplanes and therefore not very reliable.

Temperature

At 32 evaporation stations in Malawi the daily maximum and minimum temperatures have been observed during a long enough period to justify processing these data. The frequency of occurrence of minimum and maximum temperatures are very important criteria for the selection of crops; extreme temperatures can result in growth disturbance. Since the temperature data collected at these stations have never been processed a first attempt has been made and the results are presented in this paper.

For each month the sequence of daily maximum temperatures was taken. The mean of those values is defined as the mean monthly maximum temperature and the highest of these values is defined as the absolute monthly maximum temperature. The minimum temperatures are processed in the same way. The variations in temperature are relatively limited and therefore the monthly data are found adequate for processing.

From the sequence of annual mean temperatures a frequency distribution was drawn up and the mean monthly temperatures were estimated at the 50% probability level. Frequency distributions were also drawn up for the absolute monthly minimum and maximum temperatures and from these distribution the 80% and 20% exceedance probability levels respectively were found. A normal distribution of the temperature data was assumed. For each station the monthly estimates were plotted and presented as a graph.

The spetial variations of the absolute monthly maximum and minimum temperatures can be seen from Map 4. The absolute maximum temperature is apparently very much related to the topographical situation. Absolute maximum temperatures (20% exceedance probability) above 40°C are only observed in the Lower Shire Valley, while on the high Plateaux this value is below the 30°C. As for the absolute minimum temperatures the effect of the proximity of Lake Malawi to the stations on the lake shore is very pronounced.

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This bibliography is far from exhaustive. It includes works referred to in this paper along with other publications with information on the climate in Malawi.

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Table I. List of EVAPORATION STATIONS (closed and open) situated in the NORTHERN REGION.

Meteo. office nr.	Station name	Lat. (S)	Long. (E)	Grid ref.	Start year	End year	Alt. (m)	Pan type	Report nr.
721	Chelenya				1978			A	1
721 01	Chelinda	10°37'	33°50'	WD 885 303	1976		2300	A	2
711	Chilumba	10°26'	34°15'	XD 370 470	1952		495	K	3 ABCD
731 08	Chintheche - hospital	11°50'	34°11'	XB 27 92	1952	1958	475	A	4 AB
731	Chintheche - lake	11°50'	34°10'	XB 280 922	1976		475	A	4 AB
701 06	Chitipa	09°42'	33°16'	WE 290 277	1975		1295	K	5 ABCE
741	Chisumuluu Island	12°02'	35°38'	XB 670 700	1976		490	A	6
731 07	Chombe Tea Estate	11°38'	34°12'	XC 312 120	1959		560	K	7 ABCE
722	Euthini	11°27'	33°25'	WC 465 342	1978		1145	A	8
722	Jenda	12°20'	33°33'	WB 598 342	1978		1435	A	9
711 05	Karonga	09°56'	33°56'	XE 034 024	1952	1955	480	K	10
711 05	Karonga	09°56'	33°56'	XE 032 022	1955	1968	485	K	10
711 05	Karonga	09°57'	33°54'	WD 981 999	1968		535	K	10 ABCE
731	Mazamba Tea Plot	11°41'	33°55'	WC 990 072	1960		1280	K	12 ABCD
741	Likoma Island	12°04'	34°44'	XB 892 659	1952	1960	495	K	11 AB
701	Misuku	09°39'	33°32'	WE 591 322	1978		1525	A	13
722 06	Mzimba	11°54'	33°36'	WB 652 842	1951		1355	K	14 ABCE
722 09	Mzuzu	11°26'	34°01'	XC 103 353	1951		1270	K	15 ABCE
731 06	Nkhata Bay	11°36'	34°18'	XC 416 168	1952		485	K	16 ABCE

Table II. List of EVAPORATION STATIONS (closed and open) situated in the CENTRAL REGION.

Meteo. office nr.	Station name	Lat. (S)	Long. (E)	Grid ref.	Start year	End year	Alt. (m)	Pan type	Report nr.
742	Chipoka	13°59'	34°11'	XV 641 533	1952		475	A	21 ABCD
751 05	Chitedze	13°59'	33°38'	WV 692 546	1954		1095	A	22 ABCE
752 07	Dedza	14°22'	34°20'	XV 44 10	1956	1957	1585	K	23
752 04	Dedza - Chongoni	44°19'	34°16'	XV 362 167	1957		1615	K	23 ABCE
742 01	Dwangwa	12°33'	34°06'	XB 23 16	1971		490	A	24 AB
751	Kamuzu Dam	14°10'	33°29'	WV 692 334	1975		1095	K	25
731 13	Kasungu	13°02'	33°29'	XA 526 598	1961		1310	A	26 ABCD
731	Lifupa	13°03'	33°09'	WA 16 58	1978		1010	A	27
751	Lilongwe	13°59'	33°47'	WV 83 53	1951	1961	1035	K	28 AB
751 03	Lilongwe Airport	13°59'	33°42'	WV 754 565	1969		1135	A	29 AB
751	Lilongwe - Capital	13°57'	33°48'	WV 854 582	1974		1105	A	30
741	Malomo	13°09'	33°50'	WA 907 471	1978		1080	A	31
741 03	Mchinji	13°49'	32°52'	VV 874 748	1976		1190	A	32
772 01	Ntcheu	14°49'	34°38'	XU 765 613	1956		1130	A	33 ABCE
741 01	Nkhota Kota	12°56'	34°1[illegible]'	XA 389 712	1952		475	A	34 ABCE
742 02	Salima	13°47'	34°28'	XV 5 7	1951	1961	500	A	35
742 02	Salima Airport	13°45'	34°35'	XV 712 792	1961		510	A	35 ABCE
77	Tsangano	15°04'	34°36'	XU 728 218	1978		1675	A	36

Table III. List of EVAPORATION STATIONS (closed and open) situated in the SOUTHERN REGION.

Meteo. office nr.	Station name	Lat. (S)	Long. (E)	Grid ref.	Start year	End year	Alt. (m)	Pan type	Report nr.
774 14	Alumenda	16°19'	34°58'	YT 06 90	1951	1954	75	-	51
773 03	Blantyre	15°47'	35°04'	YT 14 54	1951	1960	1055	K	52 AB
771 04	Bvumbwe	15°55'	35°03'	YT 216 386	1955		990	A	53 ABCE
792 01	Chambe Plateau	15°54'	35°31'	YT 722 397	1958		1675	K	54 ABCD
773 10	Chichiri	15°48'	35°02'	YT 188 522	1966		1135	K	55 ABCE
771 06	Chikwawa	16°02'	34°47'	YT 915 279	1951	1977	105	K	56 ABCE
772 12	Chileka	15°41'	34°58'	XT 114 657	1954		770	A	57 ABCE
773 06	Chingala, near Nchalo	16°12'	34°39'	XT 9 0	1965	1972	100	A	58 AB
791 01	Chisombedzi	15°5[illegible]'	35°12'	YT 37 48	1955	1964	-	-	59 AB
792 10	Chitakali	16°01'	35°30'	YT 680 281	1959	1976	700	K	60 ABCE
77	Kasinthula	16°05'	34°50'	XT 952 214	1977		80	A	61
781	K[illegible]ongo (near Mposa)	15°44'	35°37'	YT 85 65	1978		710	A	62
781	Khanda	15°21'	35°30'	YU 694 008	[illegible]60		650	A	63 ABCE
774 06	Limbe	15°49'	35°04'	YT 22 51	1951	1957	1220	-	64 AB
771 09	Makhanga	16°31'	35°09'	YS 326 726	1953		55	K	65 ABCE
781 12	Makoka	15°32'	35°11'	YT 384 832	1968	1977	1035	K	66ABCE
772 05	Mangochi	14°29'	35°15'	YU 449 982	1951		480	A	67 ABCE
772 09	M[illegible]pe	15°23'	34°54'	YT 046 980	1954		465	A	68 ABCD
791 11	Mimosa	16°05'	35°38'	YT 809 203	1957		655	A	69 ABCE
761 03	Monkey Bay	14°04'	34°54'	YV 070 440	1952		480	A	70 ABCE
77	Mudi Dam	15°48'	35°00'	YT 14 5	1955	1960	1065	-	71 AB
772 11	M[illegible]za	15°37'	34°31'	XT 629 751	1977		670	A	72
774 08	Nankhunda	15°50'	35°01'	YT 155 501	1959		1065	A	74 ABCE
792 12	Naming'omba	16°03'	35°04'	YT 234 257	1951		1045	A	73 ABCD
77	Nchalo	16°16'	34°55'	YT 01 01	1960		65	A	75 ABCE
775 02	Ngabu	16°28'	34°54'	YS 019 801	1972		100	A	76 AB
774 01	Njuli (Thyolo)	16°08'	35°08'	YT 281 161	1959		820	A	77 ABCE
761	Nkapa	14°42'	35°34'	YU 769 748	1977		875	K	78
77	Nkhate	16°09'	34°57'	YT 087 137	1965		80	A	79 ABCE

Table III. List of EVAPORATION STATIONS (closed and open) situated in the SOUTHERN REGION (contd.).

Meteo. office nr.	Station name	Lat. (S)	Long. (E)	Grid ref.	Start year	End year	Alt. (m)	Pan type	Report nr.
77	Nkombedzi wa Fodya	16°14'	34°39'	XT 764 037	1965		150	A	80 ABCE
771 11	Nsanje	16°56'	35°15	YS 404 282	1952	1959	50	A	81 ABCE
77	Nsanje	16°55'	35°15	YS 40 28	1977		50	A	81
775	Nyasa Mission	16°07'	35°05'	YT 227 168	1965		900	A	82 ABCE
781	Sombani	16°32'	35°42'	YT 90 77	1954	1958	635	-	83 AB
772 01	Toleza	14°56'	35°01'	YU 15 48	1978		610	A	84
79	Tuchila	15°57'	35°17'	YT 523 394	1978		695	A	85
781 06	Zomba - Town	15°23'	35°19'	YT 495 991	1954	1968	990	A	86 ABCE
782 09	Zomba Plateau	15°21'	35°17'	YU 465 014	1960		1585	K	87 ABCE
781	Zomba - Chancellor	15°23'	35°20'	XT 511 975	1975		895	A	88

RAINFALL and PAN EVAPORATION at the EVAPORATION STATIONS in the NORTHERN REGION- Average Total for 10-day period (in mm).

Station		January			February			March			April			May			June			July			August			September			October			November			December			Total
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Chilumba	R	70	76	70	60	52	50	91	115	117	112	83	88	44	23	18	4	11	10	14	6	4	3	3	0	1	1	1	1	1	1	10	9	24	34	57	71	1335
1953-1978	E	49	45	54	45	45	36	48	46	47	42	44	45	50	51	56	57	56	53	56	59	65	63	67	76	73	77	83	87	88	[illegible]	94	90	82	72	60	60	2224
Chinthече	R	90	111	100	58	59	59	128	180	208	185	139	105	78	66	18	10	37	28	3	12	2	6	7	2	5	1	2	1	4	0	26	37	11	93	72	102	2045
1952-1958	E	41	36	38	32	33	26	35	38	43	34	35	37	37	46	41	43	34	41	40	42	49	44	49	55	50	53	58	59	64	76	64	58	59	45	40	46	1620
Chitipa	R	69	68	59	81	76	56	79	84	64	30	18	10	2	4	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	2	9	17	45	40	66	92	975
1958-1978																																						
Chombe Tea Est.	R	91	70	58	59	71	84	105	114	141	133	114	135	58	26	25	18	26	32	15	19	18	6	9	5	8	13	0	14	8	14	20	68	83	58	64	97	1879
1959-1978	E	38	39	46	38	42	31	39	38	41	40	37	36	35	34	34	31	30	30	30	29	34	35	38	46	48	52	60	61	64	77	61	62	56	54	45	44	1555
Karonga	R	66	57	61	55	51	57	108	111	119	99	97	50	14	13	6	0	4	3	1	1	0	1	0	0	0	0	0	0	0	0	8	8	33	46	66	74	1199
1952-1978	E	50	47	58	51	49	38	49	49	46	48	51	54	54	54	56	57	55	57	55	55	59	60	63	69	74	80	84	91	92	94	92	86	82	66	61	53	2233
Mazamba	R	103	83	74	64	63	67	96	81	103	90	65	70	24	8	7	2	4	6	4	6	4	2	3	2	1	3	1	4	5	9	19	22	43	58	60	78	1334
1960-1978	E	26	27	32	24	29	20	24	25	25	22	23	21	24	26	24	22	21	20	23	20	24	26	24	35	34	37	43	50	53	56	47	46	38	36	32	30	1089
Mzimba	R	90	66	64	76	70	48	64	43	35	21	12	8	3	3	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	3	14	13	28	46	60	63	833
1951-1978	E	39	37	44	36	37	31	39	41	48	42	42	45	48	48	54	48	47	46	47	46	54	55	54	71	69	75	82	86	91	[illegible]	81	79	65	57	42	46	2013
Mzuzu	R	68	67	69	60	65	61	76	68	77	79	76	69	37	12	14	7	11	17	12	3	14	4	8	2	7	5	1	6	8	5	16	27	34	41	65	77	1269
1951-1978	E	39	36	39	37	35	27	37	37	39	32	30	29	31	32	33	30	27	26	28	30	32	34	37	48	49	53	58	65	68	80	71	66	56	48	40	42	[illegible]
Nkhata-Bay	R	102	68	79	71	62	69	106	140	135	88	92	81	51	51	21	20	20	16	11	8	6	1	4	4	3	1	1	6	2	4	23	32	43	61	78	85	1625
1952-1978	E	40	39	46	36	38	27	38	36	41	33	36	36	38	39	38	38	36	38	38	38	43	47	48	57	55	59	64	65	68	78	67	65	57	51	43	46	1662

Table IV

RAINFALL and PAN EVAPORATION at the EVAPORATION STATIONS in the CENTRAL REGION - Average Total for 10-day periods (in mm).

Station		January			February			March			April			May			June			July			August			September			October			November			December			Total
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Chipoka	R	77	80	77	65	90	79	76	43	45	39	8	6	1	1	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	1	10	10	17	38	60	61	888
1952-1978	E	45	42	44	43	39	37	47	49	55	50	52	52	45	48	52	45	44	46	47	47	56	53	55	65	62	65	71	73	78	90	80	76	70	59	53	54	1989
Chitedze	R	83	55	79	65	69	59	48	37	37	34	16	10	4	4	1	1	0	1	0	0	0	0	0	0	1	0	1	1	2	2	18	19	42	56	73	76	894
1954-1978	E	39	40	42	37	36	30	36	39	42	40	38	38	41	38	40	36	36	37	38	42	45	46	56	59	61	66	73	77	83	87	71	69	59	51	42	44	1754
Dedza	R	75	73	107	54	88	53	50	37	34	28	21	8	4	1	5	1	1	4	1	0	1	0	1	0	0	0	1	2	3	2	15	14	28	55	72	70	909
1956-1978	E	38	40	41	34	34	29	37	37	41	37	34	33	36	34	35	33	33	34	35	37	42	45	43	56	59	62	73	70	75	85	66	67	58	53	41	43	1650
Kasungu	R	66	61	66	66	65	39	50	31	20	13	8	4	2	2	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2	5	8	24	46	52	55	688
1961-1978	E	32	31	32	33	31	23	35	36	40	37	36	35	39	36	37	34	35	34	36	35	41	42	44	57	56	55	69	73	78	86	71	67	53	45	39	35	1598
Lilongwe Airp.	R	78	63	83	58	82	70	62	22	34	47	7	9	6	8	0	0	0	0	3	0	0	0	0	0	0	1	0	1	7	1	17	9	32	60	83	63	906
1969-1978	E	44	45	42	48	48	31	48	40	48	39	44	43	43	40	47	42	39	40	43	43	51	54	54	70	71	70	78	85	90	91	85	79	69	55	49	48	1956
Ncheu	R	88	99	98	78	86	63	56	41	39	18	20	6	3	3	2	1	11	2	2	1	0	0	0	1	1	2	0	3	15	7	12	13	40	49	72	76	1008
1956-1978	E	38	35	41	33	32	26	34	40	45	39	38	38	39	39	39	37	32	34	33	35	44	40	44	52	52	53	63	65	65	71	61	59	52	48	41	45	1502
Nkhota-Kota	R	117	95	118	93	97	87	128	107	114	94	73	38	14	14	10	4	2	5	4	1	3	1	0	0	0	2	0	1	1	5	7	11	30	57	95	109	1537
1952-1978	E	44	45	45	41	44	31	45	44	52	47	48	52	50	54	57	52	50	50	52	54	62	58	63	71	68	73	81	86	90	103	89	86	71	69	53	56	2184
Salima	R	104	94	99	87	106	60	98	58	59	38	35	5	3	10	1	2	0	0	0	0	0	0	0	0	0	1	0	1	0	0	16	5	19	58	87	84	1130
1951-1978	E	48	49	50	43	44	36	48	51	60	57	55	57	56	53	57	48	49	51	51	55	64	63	65	72	73	75	81	85	92	107	91	90	79	66	54	57	2232

Table V

RAINFALL and PAN EVAPORATION at the EVAPORATION STATIONS in the SOUTHERN REGION - Average total for 10-day periods (in mm).

Station		January			February			March			April			May			June			July			August			September			October			November			December			Total
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Bvumbwe	R	92	91	89	82	89	35	49	62	49	41	36	19	7	9	4	6	6	8	5	3	8	4	5	3	2	3	1	4	6	13	21	25	47	85	62	81	1152
1955-1978	E	31	35	37	34	31	27	34	32	35	31	31	31	32	29	33	29	27	24	26	30	33	36	38	48	47	52	59	59	63	69	54	48	44	42	35	36	1382
Chambe Plateau	R	209	145	193	145	184	96	106	108	96	46	56	27	13	20	4	2	4	6	8	2	10	3	4	3	2	3	3	13	13	15	51	31	71	118	139	190	2139
1958-1978	E	27	27	23	29	26	26	30	27	32	25	26	30	28	27	37	27	24	23	25	23	26	27	29	35	37	36	44	42	44	44	34	38	33	30	31	27	1099
Chichiri	R	86	93	94	56	81	54	68	85	45	36	24	17	6	7	5	5	5	4	5	3	5	2	2	1	0	1	1	8	8	7	37	26	42	93	65	68	1145
1966-1978	E	40	40	44	44	39	32	46	39	41	37	37	38	42	38	41	38	36	32	32	38	42	47	46	63	66	66	81	83	81	82	70	69	60	53	43	53	1779
Chikwawa	R	77	52	67	49	54	23	27	49	30	21	15	10	7	5	3	4	6	5	5	2	6	3	5	1	2	2	1	5	4	8	13	17	37	43	60	77	795
1951-1977	E	49	49	54	53	46	39	47	44	51	47	42	42	43	39	41	37	35	32	33	37	39	44	48	56	61	66	75	82	86	91	82	77	80	68	55	57	1928
Chileka	R	65	55	76	50	68	34	37	45	33	19	18	6	6	6	1	1	2	1	1	0	1	0	0	0	0	2	0	2	4	12	21	16	39	59	65	83	828
1954-1978	E	55	58	60	58	54	46	60	60	66	61	58	62	62	60	68	61	58	50	57	60	68	68	74	90	91	97	115	114	119	121	100	96	85	75	63	70	2621
Chitakali	R	111	83	118	87	132	56	126	101	81	89	93	55	31	33	17	13	18	37	30	17	24	18	20	5	13	6	7	36	22	20	31	57	46	71	91	107	1902
1959-1976	E	39	39	41	39	34	32	38	37	43	37	36	43	39	39	44	39	43	33	32	39	41	47	46	55	55	57	63	63	69	71	58	55	56	46	46	45	1639
Khanda	R	81	99	72	65	64	51	48	68	52	22	7	11	2	1	3	2	2	3	1	0	2	1	1	0	1	2	0	2	4	3	13	16	49	36	74	94	952
1960-1978	E	43	46	44	38	35	35	43	38	44	42	42	38	37	36	40	32	31	31	32	35	35	41	41	52	50	55	65	65	64	77	68	64	62	54	43	43	1641
Makhanga	R	61	57	61	42	40	32	39	37	26	16	10	9	3	5	7	3	5	7	8	4	8	3	4	2	2	1	1	4	5	7	18	18	34	51	50	72	752
1953-1978	E	57	57	60	57	51	40	55	48	55	47	44	46	44	41	44	38	37	33	35	39	46	48	56	69	71	82	89	91	97	114	98	89	89	73	65	66	2171
Makoka	R	79	80	93	66	75	59	64	47	43	33	16	13	9	4	2	1	2	6	2	0	0	0	1	0	0	0	0	5	3	5	28	13	50	79	62	74	1014
1968-1977	E	42	45	46	46	41	32	44	42	46	34	37	38	36	35	40	36	35	31	36	37	43	47	46	63	65	68	81	77	81	92	71	70	62	53	46	49	1793

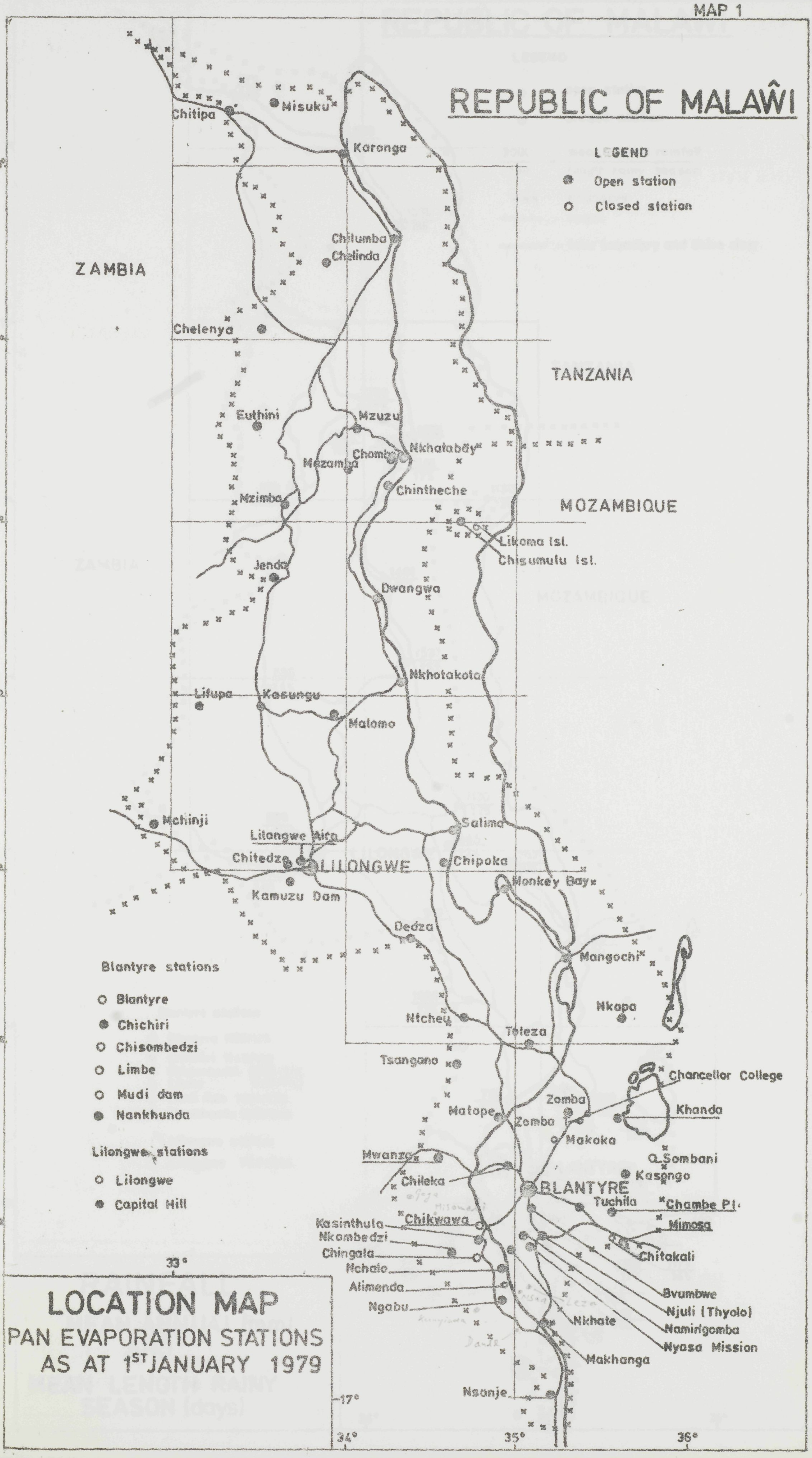
Table VI --

RAINFALL and PAN EVAPORATION at the EVAPORATION STATIONS in the SOUTHERN REGION (contd) - Average Total for 10-day periods (in mm).

Station		January			February			March			April			May			June		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Mangochi	R	73	62	71	68	77	42	47	51	30	21	9	12	3	2	1	4	1	0
1951-1978	E	53	52	60	51	51	43	57	56	65	60	61	56	55	55	57	52	49	48
Matope	R	57	66	67	66	63	29	38	28	25	16	15	10	3	4	2	1	1	1
1954-1978	E	45	47	49	47	44	36	49	49	49	46	46	53	49	46	43	44	40	41
Mimosa	R	102	74	98	90	106	50	102	96	81	76	48	39	20	22	14	14	15	25
1957-1978	E	43	45	46	44	40	30	41	38	40	37	34	33	32	29	32	27	25	24
Monkey-Bay	R	65	64	85	78	96	69	39	35	17	13	7	6	1	1	1	2	0	0
1952-1978	E	56	59	55	52	48	40	53	53	64	58	60	60	56	53	58	50	50	50
Naming'omba	R	96	89	98	92	100	45	71	68	55	54	40	23	17	11	10	10	14	14
1951-1978	E	40	42	47	42	38	32	42	36	38	34	34	31	34	31	33	29	27	27
Nakhunda	R	91	81	79	76	99	41	59	64	60	29	23	14	2	6	1	3	3	3
1959-1978	E	40	42	44	45	38	33	43	38	43	36	39	37	40	38	43	40	36	35
Nchalo	R	72	40	52	39	60	20	30	40	32	15	7	7	5	6	3	3	2	8
1960-1978	E	57	59	65	58	51	43	55	50	57	50	49	45	44	39	41	39	37	33
Njuli	R	71	69	84	70	90	36	67	66	55	40	32	27	8	13	6	7	7	10
1959-1978	E	41	44	48	42	38	33	40	35	38	33	36	33	32	31	28	29	30	24
Nkhate	R	65	49	67	33	62	33	33	64	47	24	15	7	8	12	5	4	8	9
1965-1978	E	50	53	55	52	47	36	48	41	49	43	45	41	42	38	38	35	34	28

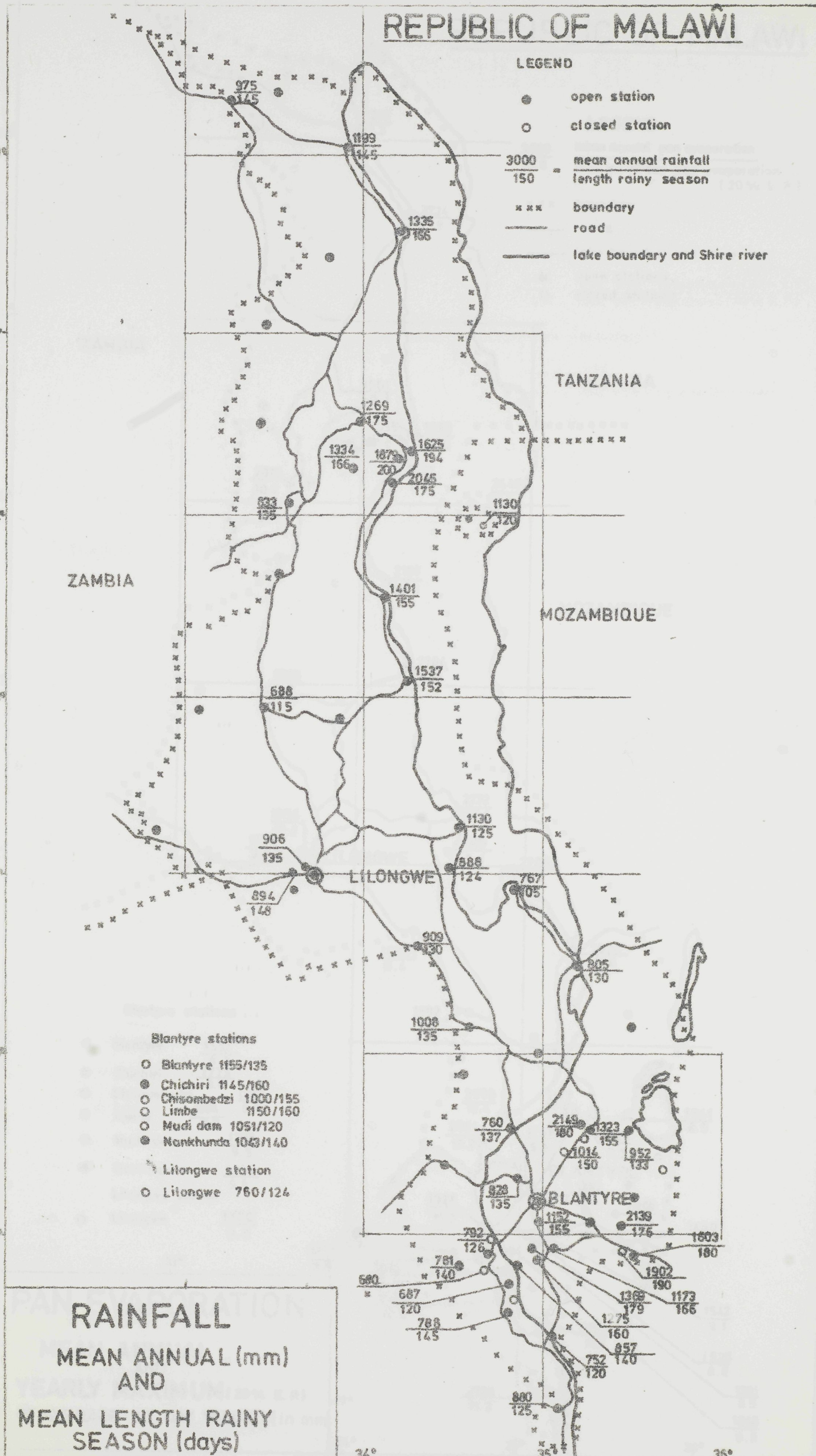
Station		July			August			September			October			November			December			Total
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Mangochi	R	2	0	1	0	1	0	3	2	0	4	4	2	16	11	33	34	51	67	805
1951-1978	E	50	54	62	59	62	71	74	77	84	90	94	108	89	90	78	72	62	63	2320
Matope	R	1	0	1	1	0	0	1	2	2	5	4	7	23	20	39	49	52	61	760
1954-1978	E	42	46	48	53	55	70	69	70	77	89	93	102	75	71	62	59	50	55	2009
Mimosa	R	16	8	14	8	11	5	7	6	11	13	13	16	40	49	54	88	65	107	1603
1957-1978	E	26	28	31	32	33	42	42	49	54	57	61	66	59	54	52	48	43	45	1460
Monkey-Bay	R	0	0	0	0	0	0	0	1	0	1	1	0	10	3	18	38	51	65	767
1952-1978	E	50	50	54	56	57	66	64	67	73	78	84	96	81	79	74	65	65	66	2200
Naming'omba	R	14	6	12	6	8	3	3	5	2	7	13	9	31	29	54	81	74	105	1369
1951-1978	E	27	29	32	37	37	51	50	50	63	63	67	75	60	57	53	49	42	41	1520
Nakhunda	R	3	1	3	1	1	1	1	1	0	1	8	8	24	19	40	68	59	70	1043
1959-1978	E	36	37	44	46	48	60	64	68	82	79	88	93	67	67	57	55	47	52	1800
Nchalo	R	5	4	4	2	2	1	1	1	0	6	3	5	13	11	37	35	49	67	687
1960-1978	E	34	38	43	44	50	59	60	68	73	76	82	95	82	80	79	73	63	67	2038
Njuli	R	13	6	13	5	4	3	3	3	2	8	6	9	29	20	47	76	79	91	1175
1959-1978	E	326	26	31	35	39	50	49	54	62	68	72	77	64	56	57	50	47	45	1543
Nkhate	R	5	4	8	3	4	1	2	1	1	6	5	6	23	22	36	53	64	68	857
1965-1978	E	32	35	43	43	45	57	56	67	69	74	78	82	76	68	70	63	55	60	1848

Table VI (contd)

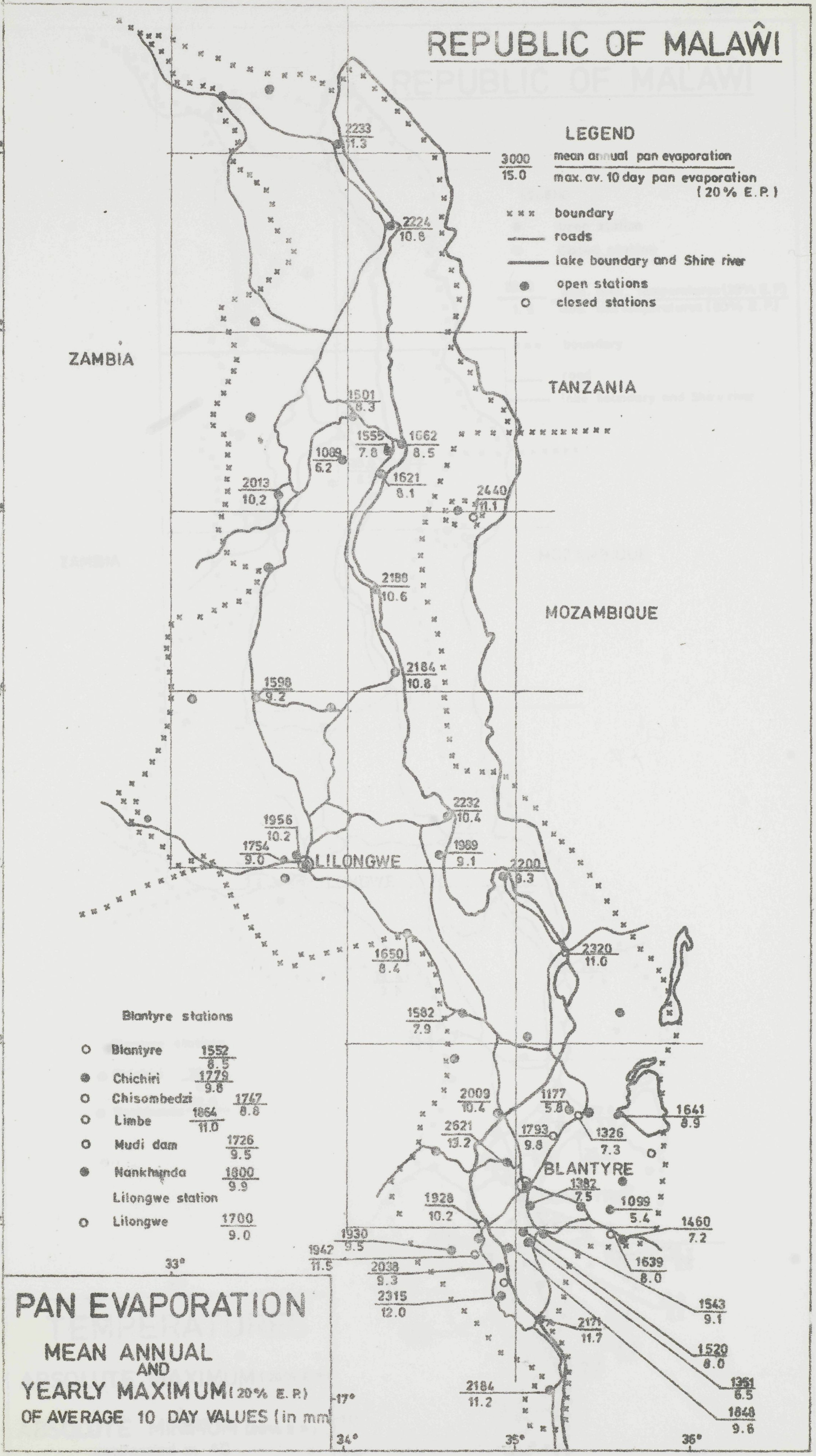


LOCATION MAP
PAN EVAPORATION STATIONS AS AT 1ST JANUARY 1979

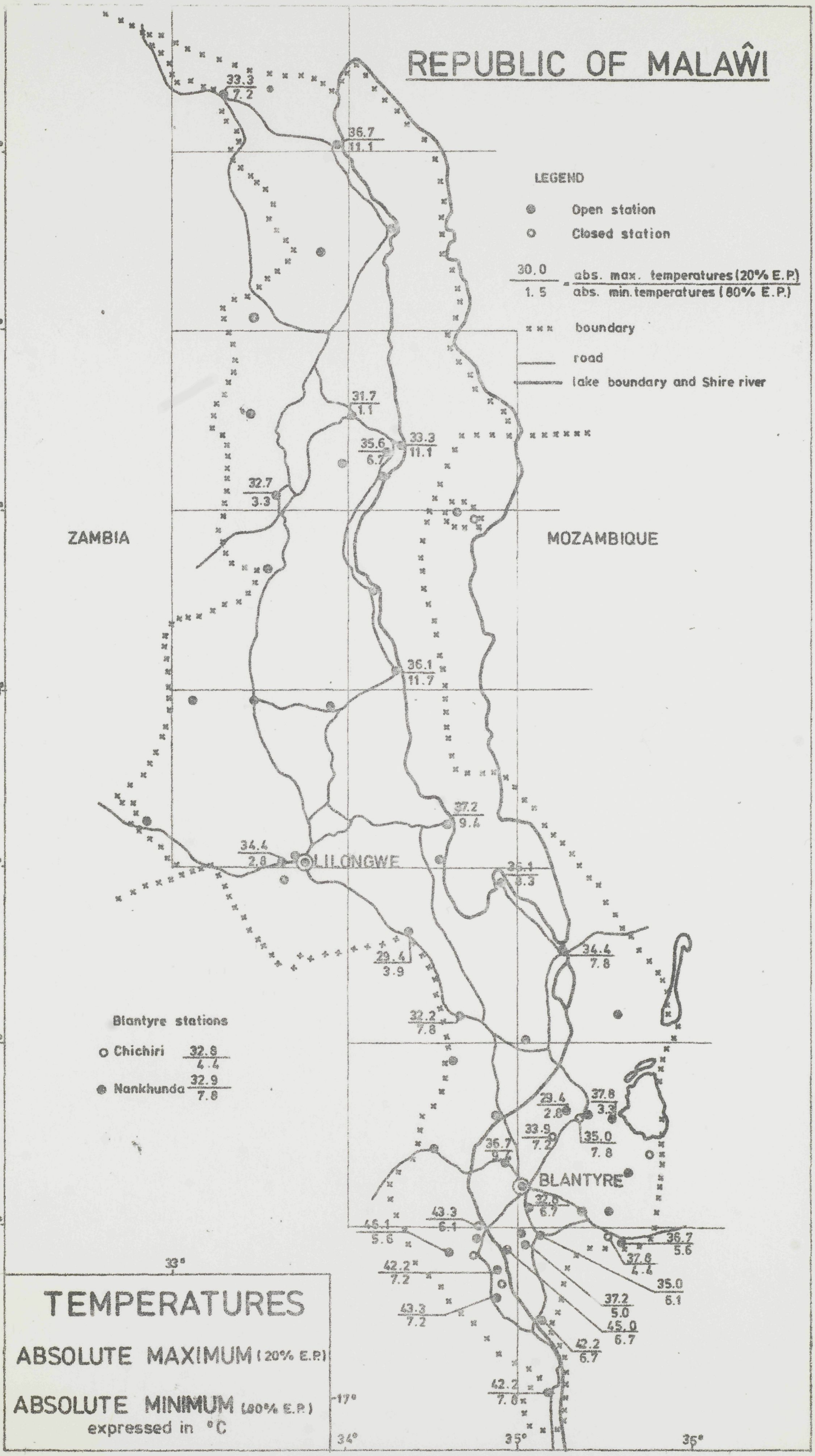
MAP 2


REPUBLIC OF MALAWI
LEGEND
open station
closed station
3000/150 = mean annual rainfall / length rainy season
boundary
road
lake boundary and Shire river
TANZANIA
ZAMBIA
MOZAMBIQUE
LILONGWE
BLANTYRE
Blantyre stations
Blantyre 1155/135
Chichiri 1145/160
Chisombedzi 1000/155
Limbe 1150/160
Mudi dam 1051/120
Nankhunda 1043/140
Lilongwe station
Lilongwe 760/124
10°
11°
12°
13°
14°
15°
16°
34°
35°
36°
RAINFALL
MEAN ANNUAL (mm)
AND
MEAN LENGTH RAINY
SEASON (days)

MAP 3



REPUBLIC OF MALAWI
LEGEND
3000 mean annual pan evaporation
15.0 max. av. 10 day pan evaporation (20% E.P.)
boundary
roads
lake boundary and Shire river
open stations
closed stations
ZAMBIA
TANZANIA
MOZAMBIQUE
LILONGWE
BLANTYRE
Blantyre stations
Blantyre 1552 8.5
Chichiri 1779 9.6
Chisombedzi 1747 8.8
Limbe 1864 11.0
Mudi dam 1726 9.5
Nankhunda 1800 9.9
Lilongwe station
Lilongwe 1700 9.0
PAN EVAPORATION
MEAN ANNUAL AND YEARLY MAXIMUM (20% E.P.)
OF AVERAGE 10 DAY VALUES (in mm)


REPUBLIC OF MALAWÎ
LEGEND
Open station
Closed station
30.0 / 1.5 = abs. max. temperatures (20% E.P.) / abs. min. temperatures (80% E.P.)
boundary
road
lake boundary and Shire river
ZAMBIA
MOZAMBIQUE
LILONGWE
BLANTYRE
Blantyre stations
Chichiri 32.8 / 4.4
Nankhunda 32.9 / 7.8
33.3 / 7.2
36.7 / 11.1
31.7 / 1.1
33.3 / 11.1
35.6 / 6.7
32.7 / 3.3
36.1 / 11.7
37.2 / 9.4
34.4 / 2.8
36.1 / 8.3
34.4 / 7.8
29.4 / 3.9
32.2 / 7.8
29.4 / 2.8
37.8 / 3.3
33.9 / 7.2
35.0 / 7.8
36.7 / 9.7
32.8 / 6.7
43.3 / 6.1
46.1 / 5.6
36.7 / 5.6
37.8 / 4.4
35.0 / 6.1
42.2 / 7.2
37.2 / 5.0
43.3 / 7.2
45.0 / 6.7
42.2 / 6.7
42.2 / 7.8
10°
11°
12°
13°
14°
15°
16°
-17°
33°
34°
35°
36°
TEMPERATURES
ABSOLUTE MAXIMUM (20% E.P.)
ABSOLUTE MINIMUM (80% E.P.)
expressed in °C