Section 6.2

ANNUAL PRECIPITATION

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Mean Annual Precipitation, MAP: Concepts

- The MAP (mm) characterises the long term quantity of water available to a region for hydrological and agricultural purposes.
- Under non-irrigated conditions the MAP gives an upper limit to a region's sustainable agricultural potential in regard to biomass production if other factors (e.g. light, temperature, topography, soils) are not limiting.
- Not only is MAP important as a general statistic in its own right, but it is probably also the one climatic variable best known to hydrologists and agriculturists, and to which they can relate many other things.
- In South African agrohydrological studies MAP has, for example, been used as a variable related to monthly rainfall distribution, to design flood prediction, the number of raindays or to crop and timber production (e.g. Schulze, 1983; Schmidt and Schulze, 1987).
- While simple to calculate and attractive to use, the concept of MAP nevertheless has its weaknesses, in that in South Africa
  - negative departures of annual precipitation (i.e. the low rainfall years) are more numerous than positive ones (i.e. the higher than average years), and therefore annual rainfalls are not distributed normally (i.e. they have a positive skew), and
  - MAPs are frequently inflated by a few very high annual totals from very wet years, especially in areas of low rainfall.

Interesting Findings on Stations with Highest and Lowest Annual Precipitation

The station with the *highest observed long term rainfall* in South Africa from Lynch's (2004) study is Robertsvlei in the southwest corner of the Western Cape (30 completed years of record; 431 completed months of records, i.e. nearly 36 equivalent years; 13 460 daily records, i.e. nearly 37 equivalent years, with a MAP of 2 088 mm, a lowest annual rainfall of 1 294 mm (in 1974) and highest annual total of 3 222 mm (in 1978).

Mapping Mean Annual Precipitation

Lynch (2004), using quality controlled and infilled daily rainfall values from over 9 600 stations each with ≥ 15 years of daily records, applied a Geographically Weighted Regression (GWR) approach with derivatives of altitude, latitude, longitude and slope to generate 1 arc minute (1' x 1' latitude/longitude, ~ 1.7 km x 1.7 km) values of MAP (cf. **Section 2.2**). Station residuals between simulated and observed rainfall were then superimposed over the generated surface of rainfall by interpolative techniques, akin to those used by Dent *et al*. (1989), to adjust the "global" surface to more local conditions.

Comparisons of MAP Between the 2004 and 1989 Rainfall Studies

Perusal of the tables of provincial/country statistics show that for all statistics and across nearly all provinces/countries the 2004 study by Lynch (2004) displays lower values of MAP than the Dent *et al*. study of 1989. This is particularly the case with minimum one arc minute gridded values in the provinces. It is hypothesised that this is an artefact of extrapolations of values lower than the minimum observed station values, and in particular to points lower in altitude than that of the lowest altitude station in a region. This finding warrants further investigation in future.

Mapping Annual Precipitation in the Driest and Wettest Years in Ten

To map annual precipitation values in the driest and wettest years in 10, the 50 year daily rainfall series at those stations selected by Warburton and Schulze (2005) for the South African Quaternary Catchments Database (Schulze *et al*., 2005; cf. summary in **Section 2.2**) were used. The station selection was achieved using the utility developed by Kunz (2004). From those stations' datasets annual precipitations were calculated and the values of the wettest and driest years in 10 determined by frequency analysis.

The station with the *lowest observed long term rainfall* in South Africa according to Lynch (2004) is Vioolsdrift along the RSA/Namibia border in the Orange River valley (43 completed years of record; 546 completed months of record, i.e. nearly 46 equivalent years; 16 675 daily records, i.e. again nearly 46 equivalent years), with a MAP of only 47 mm, a lowest annual rainfall of only 1.7 mm (in 1979) and a highest annual total of 128 mm (in 1997).

Distribution Patterns over South Africa of Statistics on Annual Precipitation

The overall feature of the distribution of MAP over South Africa is that it decreases fairly uniformly westwards from the escarpment across the interior plateau. Between the escarpment and the ocean in both the southern and the eastern coastal margins there is the expected complexity of rainfall patterns induced by irregularities of terrain. According to the Geographically Weighted Regression technique used by Lynch (2004), approximately 20% of South Africa receives less than 200 mm MAP, and 47% receives less than 400 mm per annum (**Figure 6.2.1**), this being the result of the presence of subtropical high pressure cells which inhibit rainfall generation because of predominantly subsiding air. Only about 9% of South Africa receives a MAP in excess of 800 mm (**Figure 6.2.1**). Perusal of the tabulated statistics indicates that KwaZulu-Natal is the wettest of South Africa's nine provinces, while the Western Cape has the highest range of MAP within any of the provinces, and the highest individual point rainfall at an estimated 3 198 mm per annum (Lynch, 2004).

There is a general shift of isohyets of lower value towards the east for the driest year in 10 and higher isohyets westwards for the wettest year in 10 when these respective maps are compared with that of mean annual precipitation.

References (In the sequence in which they appear in this Section, with the full references given in Section 22)

1. Schulze, R.E. (1983)
2. Schmidt, E.J. and Schulze, R.E. (1987)
3. Lynch, S.D. (2004)
4. Dent, M.C., Lynch, S.D. and Schulze, R.E. (1989)

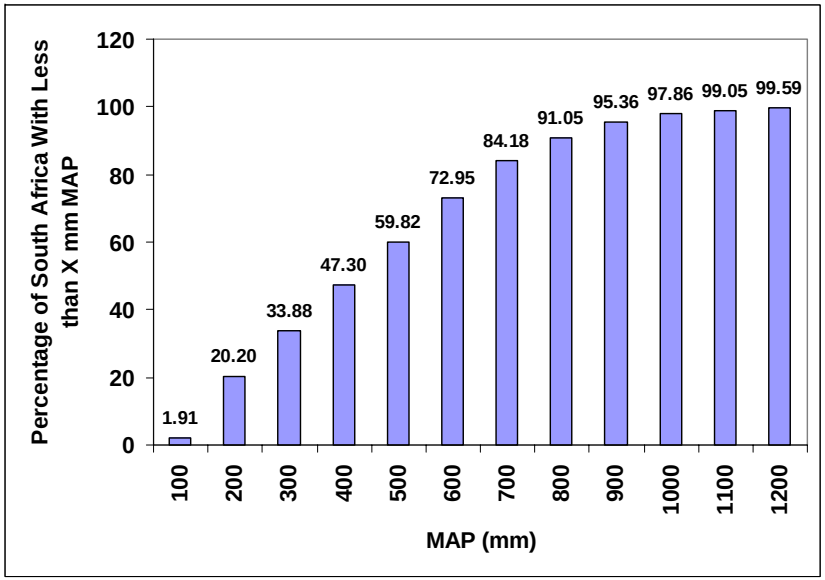

Figure 6.2.1 Percentages of South Africa receiving less than threshold values of MAP (Source: Lynch, 2004)

5. Warburton, M.L. and Schulze, R.E. (2005)
6. Schulze, R.E., Warburton, M.L., Lumsden, T.G. and Horan, M.J.C. (2005)
7. Kunz, R.P. (2004)

Citing from this Section of the Atlas

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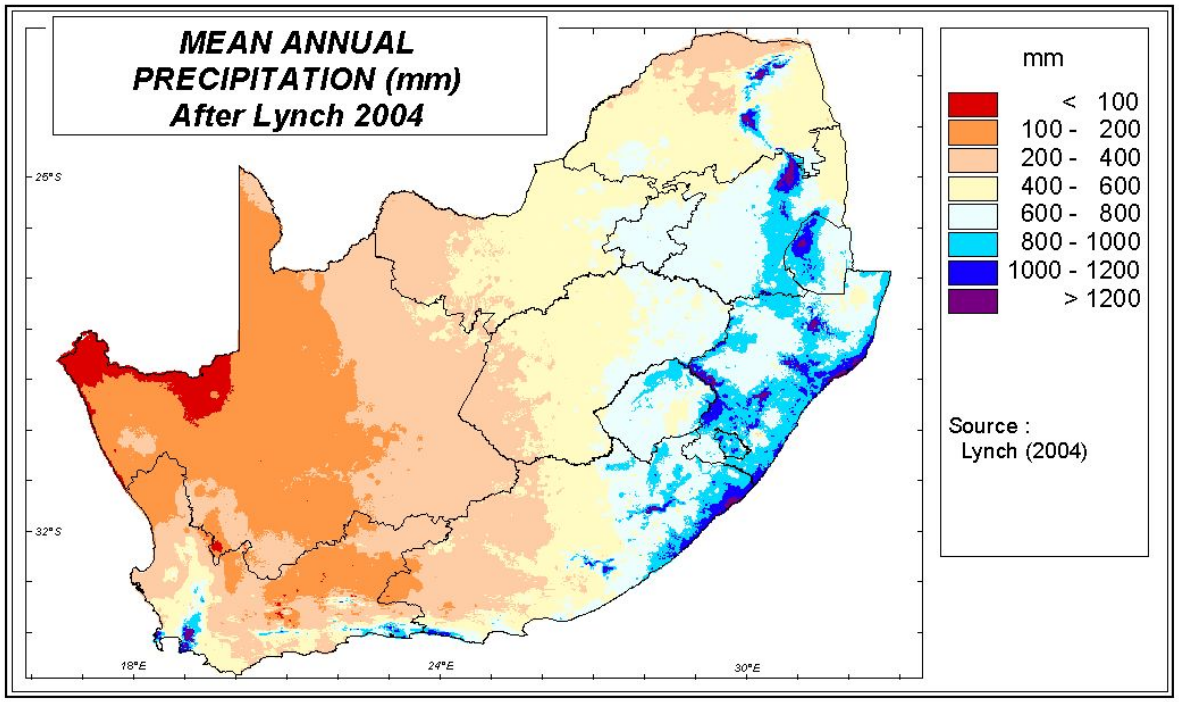
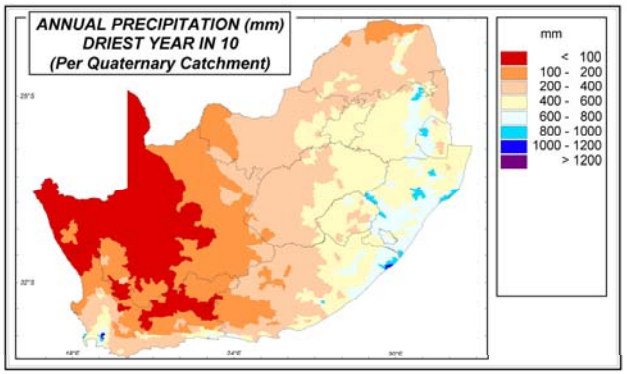
MAP (mm) by Geographically Weighted Regression, 2004 Study by Lynch							
Province / Country	Mean Value	CV (%)	Maximum Value	Minimum Value	Exceedence Probability		
					20%	50%	80%
Limpopo	515	28	1878	129	409	501	584
Mpumalanga	707	21	1648	368	600	673	816
North West	457	22	777	156	356	455	558
Northern Cape	203	39	489	1	138	185	280
Gauteng	647	7	912	358	610	654	682
Free State	514	22	1164	228	405	514	619
KwaZulu-Natal	837	18	1923	255	713	815	952
Eastern Cape	538	43	1493	84	326	503	747
Western Cape	323	61	3198	20	167	265	444
Swaziland	810	19	1385	473	669	787	959
Lesotho	714	15	1795	401	626	709	781

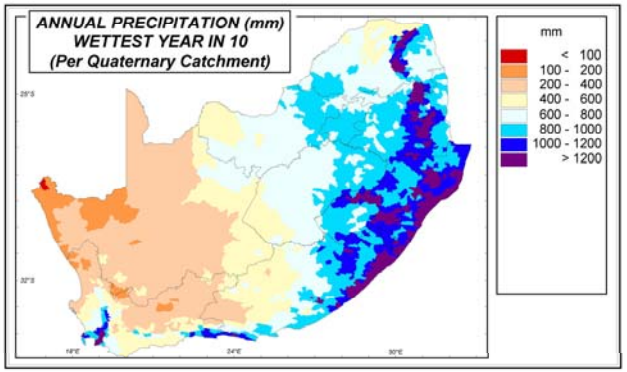
MAP (mm) by Regionalised Regression Analysis, 1989 Study by Dent *et al*.							
Province / Country	Mean Value	CV (%)	Maximum Value	Minimum Value	Exceedence Probability		
					20%	50%	80%
Limpopo	527	28	2031	200	616	517	411
Mpumalanga	736	24	1933	341	851	695	618
North West	481	21	782	246	584	485	377
Northern Cape	202	43	540	20	284	185	129
Gauteng	668	38	900	556	693	670	638
Free State	532	22	1689	275	634	524	422
KwaZulu-Natal	845	20	1967	417	973	819	707
Eastern Cape	552	43	1722	96	768	528	332
Western Cape	348	72	3345	60	477	282	165
Swaziland	860	22	1690	451	997	832	705
Lesotho	701	21	1796	361	791	689	589

Annual Precipitation (mm): Wettest Year in 10, by Quaternary Catchment							
Province / Country	Mean Value	CV (%)	Maximum Value	Minimum Value	Exceedence Probability		
					20%	50%	80%
Limpopo	834.0	30.5	1826.6	463.6	654.6	769.1	936.1
Mpumalanga	988.1	22.9	1799.3	636.6	801.0	910.7	1163.4
North West	748.6	13.7	950.9	453.9	654.6	758.8	835.5
Northern Cape	336.4	38.2	692.4	99.0	226.2	319.5	453.5
Gauteng	833.0	8.2	992.7	662.0	772.6	841.6	882.6
Free State	776.8	21.1	1485.7	439.3	654.3	762.2	860.2
KwaZulu-Natal	1124.9	16.5	1928.7	801.5	960.8	1091.7	1270.7
Eastern Cape	805.7	36.4	1929.7	236.7	523.5	812.7	1043.1
Western Cape	538.0	54.6	2011.3	148.4	315.4	464.9	722.4
Swaziland	1109.4	15.2	1462.3	849.7	951.2	1068.2	1278.3
Lesotho	1015.9	20.9	1729.0	722.9	839.7	962.7	1188.6

Annual Precipitation (mm) : Driest Year in 10, by Quaternary Catchment							
Province / Country	Mean Value	CV (%)	Maximum Value	Minimum Value	Exceedence Probability		
					20%	50%	80%
Limpopo	353.6	30.6	848.2	152.0	266.2	343.5	412.9
Mpumalanga	530.0	24.5	968.1	291.0	423.6	505.5	640.1
North West	349.1	21.9	486.7	171.1	290.6	362.6	415.8
Northern Cape	118.6	51.3	252.7	0.0	59.0	112.8	179.8
Gauteng	446.6	10.0	544.9	333.7	408.5	458.4	479.6
Free State	403.2	26.7	800.3	176.7	309.0	408.9	480.8
KwaZulu-Natal	613.9	17.5	991.1	369.4	529.4	602.6	701.1
Eastern Cape	395.1	44.9	1041.3	66.2	222.5	375.8	558.3
Western Cape	262.5	71.5	1243.6	39.3	118.1	195.2	402.3
Swaziland	583.5	23.2	889.5	364.3	434.8	604.9	701.4
Lesotho	544.2	24.5	991.1	301.8	436.4	536.1	613.1


MEAN ANNUAL
PRECIPITATION (mm)
After Lynch 2004
25° S
32° S
16° E
24° E
30° E
mm
< 100
100 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1200
> 1200
Source :
Lynch (2004)


ANNUAL PRECIPITATION (mm)
DRIEST YEAR IN 10
(Per Quaternary Catchment)
mm
< 100
100 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1200
> 1200


ANNUAL PRECIPITATION (mm)
WETTEST YEAR IN 10
(Per Quaternary Catchment)
mm
< 100
100 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1200
> 1200