DROUGHT MONITORING IN NAMIBIA DURING THE 2001/02 AND 2002/03 SEASONS

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ABSTRACT

This paper describes the methodology used during the 2001/02 and 2002/03 seasons to aid decision-makers in declaring drought and to design a marketing incentive scheme. Two methods were used: calculating the standardized precipitation index for all available rainfall stations at the end of April each season, and calculating the difference between the mean seasonal biomass production and the mean for 17 seasons as calculated using NDVI values from satellite imagery. These gave a clear indication of the spatial variation in drought conditions.

INTRODUCTION

Information on rainfall and biomass production is presented to decision-makers in the agricultural industry at the end of every growing season, particularly for the livestock industry. These decision-makers include the management of the Ministry of Agriculture, Water and Rural Development and the Meat Board, which administers a marketing incentive scheme that can be targeted specifically at drought-affected areas.

The Drought Policy of the Government of Namibia has an upper limit of a one in fourteen year drought (7th percentile of rainfall for the preceding 12 months), before any thoughts of drought aid by Government are entertained. According to this policy, fodder subsidies are out of the question. An incentive scheme to market animals has been suggested, with the aim of taking animals off the land. The Namibia Early Warning and Food Security Unit addresses assessment only. For a fuller approach, the AgroMet section of the Agro-ecological Zoning Programme has two arrows in its quiver. The first is the calculation of standardized precipitation indices (SPI) from monthly rainfall and bringing it into alignment with the drought criterion of the Government. The second is calculation of Estimated Total Seasonal Biomass Production from satellite-obtained Normalized Difference Vegetation Index (NDVI) values. Both these methods were described earlier by Du Pisani (2001a & b).

METHODOLOGY

The standardized precipitation index (SPI) is the difference of the precipitation (P_i) for a specified time period (1 to 72 months) from the mean (P_{mean}) divided by the Standard Deviation (SD) of precipitation for the same time period:
$SPI = (P_i - P_{mean})/SD$.

SPI values are usually calculated for 1, 3, 6, 12, 24 and 48 months. The values are then categorized as shown in Table 1.

Table 1. The different categories of SPI values

SPI Values	
2.0 and above	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-0.99 to +0.99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2.0 and less	Extremely Dry

Using a software programme from the National Drought Mitigation Center in Lincoln, Nebraska, USA, SPI values were calculated for a number of Namibian stations for 3, 6, 12 and 24 month periods (McKee, Doeskern & Kleist, 1993). These gave a clear indication of what had been happening in the short (past 3 or 6 months) or longer (12 and 24 months) term. In evaluating drought for the purpose of ultimately considering drought aid, the 12- and 24-month SPI values are more useful, while the 3- and 6-month SPI values highlight trends within a season. Table 2 shows the cumulative probabilities for various SPI values to occur.

Table 2. The cumulative probabilities for various SPI values

SPI	Cumulative Probability
-3.0	0.0014
-2.5	0.0062
-2.0	0.0228
-1.5	0.0668
-1.0	0.1587
-0.5	0.3085
0.0	0.5000
0.5	0.6915
1.0	0.8413
1.5	0.9332
2.0	0.9772
2.5	0.9938
3.0	0.9986

According to Table 2, the SPI value nearest to the one-in-fourteen-year drought, which is equivalent to the 7^{th} percentile of long-term annual rainfall, would be -1.5. The graph in Figure 1 shows the best fit between rainfall percentiles (in intervals of 10, also known as deciles) and SPI values. A good fit is obtained with a second order polynomial, with r^2 of

0.8041. More work is necessary to see whether the 7th percentile is the best value for identifying crisis drought situations. At the moment it seems that this value is equal to an SPI value of -1.34 only. In all cases the meteorological criteria should be taken only as pointers for personal inspection by drought evaluation personnel, who can determine whether the situation on the ground warrants drought aid in any form. In short, meteorological criteria should not seen as absolute, but rather as indicators of where further investigation is warranted.

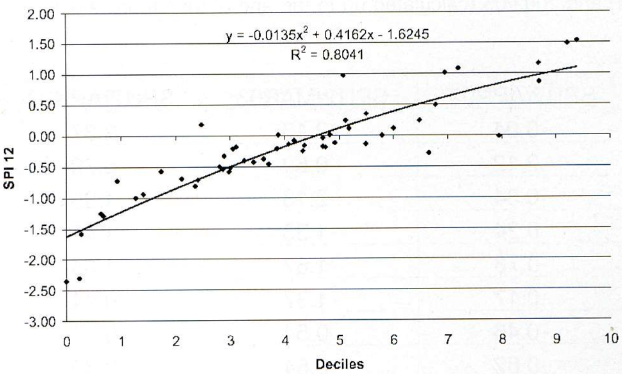

Figure 1. SPI 12 vs Deciles.

This is where the second arrow in our quiver can provide additional information for the decision-makers: the use of a methodology developed in France by *Groupement pour le Développement de la Télédétection Aérospatiale* (GDTA) and tested in Kenya, Zimbabwe and in Namibia (Du Pisani, 2001b).

Ten-day maximum value composites are produced of the Normalized Difference Vegetation Index (NDVI) data from October to May by the Namibian Meteorological Services and the Etosha Ecological Institute. Initially, data from the *NOAA* satellite were used, but at present *SPOT Vegetation* data are being used. The data are processed with the Multiscope and SMAR software packages developed by GDTA to estimate total biomass production accumulated over a growing season according to the Monteith formula:

$$BP\ (season) = \Sigma \varepsilon i . \varepsilon c . \varepsilon b . GR . dt$$

Where

BP (season) = Cumulative seasonal biomass production (kg/ha)

εi = Efficiency of interception of solar radiation by leaves (%)

εc = Fraction of solar energy suitable for photosynthesis (± 48%)

εb = Efficiency of conversion of solar to chemical energy (varies with vegetation type)

GR = Global radiation from the sun (Watts/m²)

dt = Time step (10 days)

RESULTS AND DISCUSSION

The maps in Figures 2, 3 and 4 were produced to assess drought severity in near real-time. They show the percentage deviation of estimated total seasonal biomass production in the 2001/02 and 2002/03 seasons as compared to the 1985/86–2003/04 mean. SPI values are indicated by coloured dots, providing the opportunity to view two types of drought indicator at a glance.

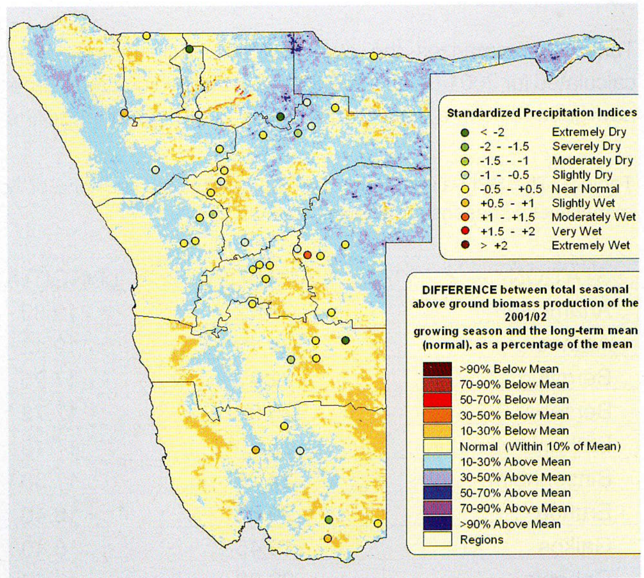

Figure 2. Estimated total seasonal biomass production of 2001/02 compared to the long-term normal, with 2001/02 SPI values.

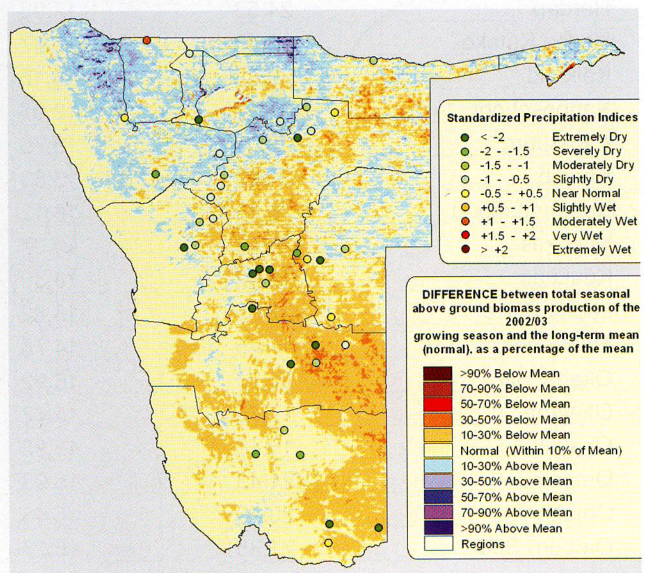

Figure 3. Estimated total seasonal biomass production of 2002/03 compared to the long-term normal, as calculated up to the end of March 2003.

During the 2001/02 season only four stations had SPI values below -1.34 (see Table 3), namely Aranos and Karasburg in the south-east, Okatana in the north-west and Tsumeb in the north-central area. The biomass values did not show extreme deviations from the mean either. Drought did not seem a serious problem during the 2001/02 season.

Long-term forecasts for the 2002/03 season did not bode well, with an El Niño having developed during the austral winter. Indeed, the season did not have an auspicious start and at the end of March, prospects were looking quite bleak.

During the first half of April, however, considerable areas of Namibia, especially in the central high ground, were favoured with good rains and in some places rainfall records for April were broken. What seemed like a disaster drought for virtually the whole country took on a new complexion with these most welcome rains.

Table 3 summarizes the standardized precipitation indices calculated for 2001/02 and 2002/03. The last two columns show how good rains in a single month (April 2003) can change the index (from March until April 2003). The SPI values calculated at the end of March (see Figure 3) and the end of April (see Figure 4) differed considerably in some areas.

Table 3 shows that the SPI 12 values worsened considerably from 2001/02 to the 2002/03 season, except for Tsumeb, Okatana and Aranos. In many cases the SPI values also improved from March to April, so that this rain helped at least some farmers escape a disaster drought, but many were not as lucky.

Table 3. The SPI values during 2001/02 (calculated until end of April 2002) and 2002/03 (calculated up to the end of March and April 2003, respectively) seasons for different stations

STATION	LATITUDE	LONGITUDE	SPI12/APR02	SPI12/MAR03	SPI12/APR03
Ariamsvlei	-28.12	19.83	-0.04	-2.13	-2.37
Aranos	-24.13	19.12	-2.12	-0.69	-0.70
Bergvlug	-22.47	17.25	-0.34	-2.13	-1.39
Berseba	-25.98	17.78	0.24	-1.33	-1.47
Bethanie	-26.50	17.15	0.73	-1.67	-1.65
Binsenheim	-22.78	17.38	-0.17	-1.37	-0.74
Erundu	-20.63	16.40	-0.46	-0.54	-0.11
Gaikos	-19.45	18.40	-0.82	-0.54	-0.60
Gobabis	-22.28	18.58	0.12	-2.34	-2.31
Gochas	-24.51	18.48	0.21	-1.06	-1.34
Grootfontein	-19.60	18.10	-1.00	-2.08	-1.96
Hardap	-24.53	17.93	-0.96	-2.42	-2.35
Hosea Kutako	-22.48	17.47	0.01	-2.07	-1.48
Kalkfeld	-20.88	16.18	-0.16	-0.93	-0.32
Kanonschoot	-22.12	18.07	-0.80	-1.90	-1.88
Karasburg	-28.03	18.75	-1.58	-2.11	-2.11
Karibib	-21.93	15.83	-0.25	-1.31	
Keetmanshoop	-26.53	18.12	-0.50	-1.69	-1.93
Khorixas	-20.38	14.97	-0.58	-1.80	-1.27
Koukuas	-18.92	18.30	-0.72	-1.33	-1.41
Leonardville	-23.52	18.82	0.36	-0.19	-0.21
Mahanene	-17.45	14.78	0.40	1.31	1.80
Okahandja	-21.97	16.92	-0.69	-1.52	
Okatana	-17.75	15.72	-2.35	-0.78	-0.79
Okaukuejo	-19.18	15.92	-0.81	-1.97	-1.33
Omaruru	-21.43	15.93	-0.22	-1.15	-0.38
Omatjenne	-20.40	16.48	-0.42	-1.16	-0.85
Omburo Sud	-21.35	16.23	-1.15	-0.93	-1.46
Otavi	-19.63	17.33	-0.43	-1.01	-0.80
Otjovazandu	-19.13	14.29	1.01	0.36	
Rehoboth	-23.32	17.08	0.37	-2.13	-1.01
Rohrbeck	-24.13	18.47	-0.21	-2.14	-1.99
Rundu	-17.92	19.77	-0.33	-1.25	-1.21
Sandveld Exp Farm	-22.03	19.12	0.04	-1.30	-1.28
Sitrusdal	-19.93	16.38	0.11	-0.52	-0.12
Sonop	-19.05	18.92	0.35	0.08	-0.15
Tsumeb	-19.23	17.72	-2.30	-0.66	-0.65
Usakos	-21.98	15.58	-0.08	-2.07	-2.07
Warmbad	28.45	18.73	0.86	0.45	
Westfalenhof	22.23	16.40	0.01	-2.23	-1.21
Windhoek	-22.57	17.10	0.11	-2.00	-0.67
Witvlei	-22.25	18.29	1.53	0.18	

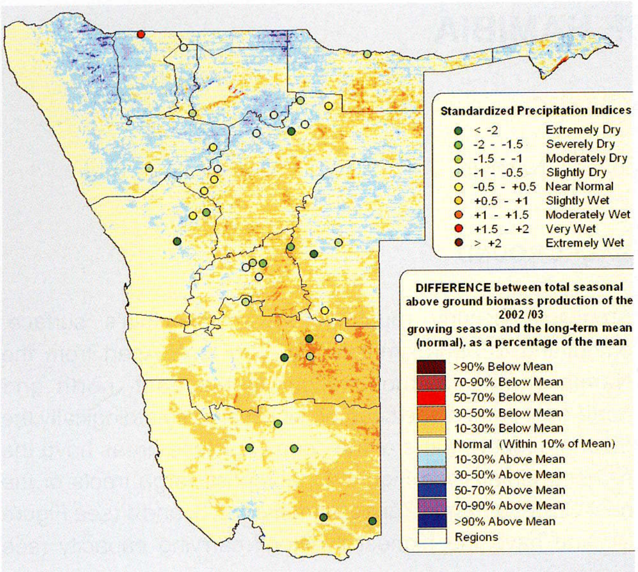

Figure 4. Estimated total seasonal biomass production of 2002/03 compared to the long-term normal, as calculated up to the end of April 2003.

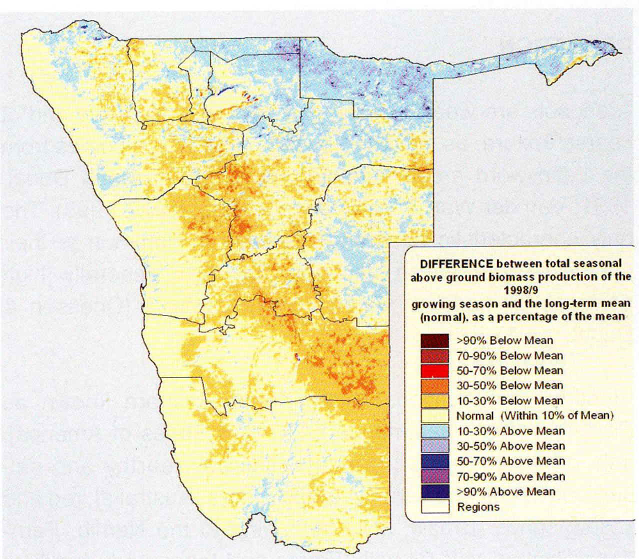

Figure 5. Estimated total seasonal biomass production of 1998/99 compared to the long-term normal.

There seems to be a great similarity between the 1998/99 season (Figure 5) and 2002/03 (Figure 4). Neither were very good seasons. However, nor were they nearly as bad as the 1994/95 season (Figure 6), which was by far the worst season in the 19 seasons for which these biomass production estimations could be calculated. One remarkable phenomenon of the 1994/95 season was the grass that grew in the Namib Desert, especially in the northern part.

CONCLUSION

By making use of both rainfall and satellite imagery, it seems that we are well on our way to supply decision-makers with the necessary information for evaluating drought situations for livestock farming in Namibia. There is a pressing need for near real-time data from more rainfall stations, to calculate SPI values. The software used for calculating SPI values does not handle any breaks in rainfall figures. Furthermore, it is a problem to get the information in real-time, although the NMS telephones about 120 rainfall stations every ten days during the season. An Estimated Total Seasonal Biomass Production map can be produced only after the end of May, when the rainy season is truly over, and there is usually a small delay in obtaining the last of the satellite images necessary for the calculations. Though we obtain most of the satellite imagery free of charge, in order to get the information in real-time we pay approximately N$ 7 000 for the final nine images of every growing season; data older than three months are free.

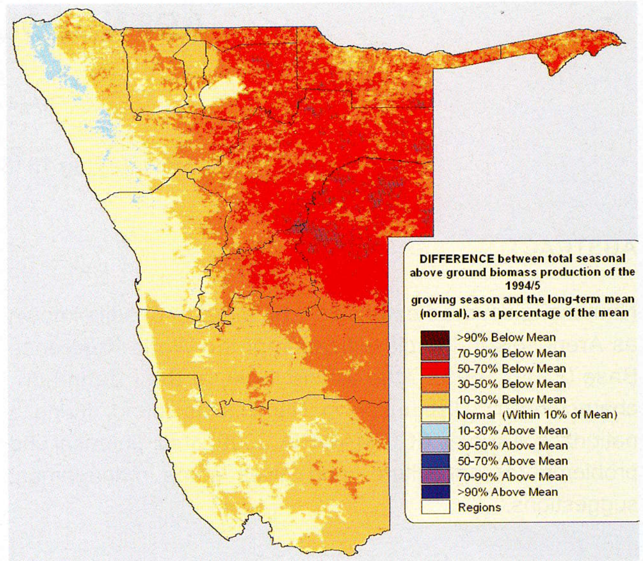

Figure 6. Estimated total seasonal biomass production of 1994/05 compared to the long-term normal.

Despite these small problems, it seems that decision-makers find the biomass maps in combination with the SPI values a good indication of where marketing incentives should be introduced and where field-based evaluations of impending drought should be carried out.

ACKNOWLEDGEMENTS

I wish to acknowledge Marina Coetzee's input in producing the maps in this paper.

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