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DROUGHT FEEDING OF SHEEP

J.G. Cloete

Agricultural Research Insitute for the Karoo Region, Middelburg, C.P.

The severe drought during 1969/70 has again focussed attention on one of the major problems faced by South African farmers. However, the occurrence of drought is nothing new in countries such as South Africa and Australia. Probably one of the most severe droughts to have occurred in South Africa was in 1933/34 when no fewer than 12 million or 25% of the total number of sheep and goats died (Bonsma & Mare, 1942). Similarly one of the most severe droughts in Australia was that of 1895–1903 when the sheep population fell from approximately 106 million to 53 million or 50% (Franklin, 1962). Drought losses should, however, not only be interpreted in terms of the resultant reduction in stock numbers but also take into account their effect on future wool and mutton production. Thus Franklin (1962) suggested that, had it been possible to prevent the losses during the 1945/46 drought, cumulative wool cheques over the following 10 years may have totalled an additional R1 200m in Australia.

The severity of the drought problem provoked Government action in South Africa with the appointment of the Drought Investigation Commission (1920), the Fodder Conservation Commission (1948) and the Drought Investigation Commission (1961). The Drought Investigation Commission (1923) focussed attention on the drying-up of large areas of the country and encroachment of the desert. Although they could detect no significant difference in the total annual rainfall they concluded that its economical value had to a large extent been reduced by changes in the characteristics of the natural grazing for which man had been responsible.

The recommendations of these Commissions coupled with improved drought-feeding methods have apparently induced a stabilising influence on maintaining sheep numbers at a more constant level during the period 1955-1970 than during the preceding period 1910–1954 (Drought Investigation Commission, 1965, Agricultural Statistics, 1970). Variation in total sheep numbers in South Africa is graphically illustrated in Fig. 1.

From Fig. 1 it is evident that total sheep numbers were drastically reduced following the droughts of 1915 1933 and 1945. The object of this article is to examine available knowledge on the drought-feeding of sheep in an attempt to curtail drought losses and also to indicate how droughts could best be combated.

Incidence and Scope of Droughts

The Fodder Investigation Commission (1949) indicated that from 1926 to 1947 more than 55 % of the total area of the Republic was proclaimed drought-stricken for five of the 22 years. They concluded that an average of one out of every four to five years was affected severely by drought. Long-term analyses of metereological records,

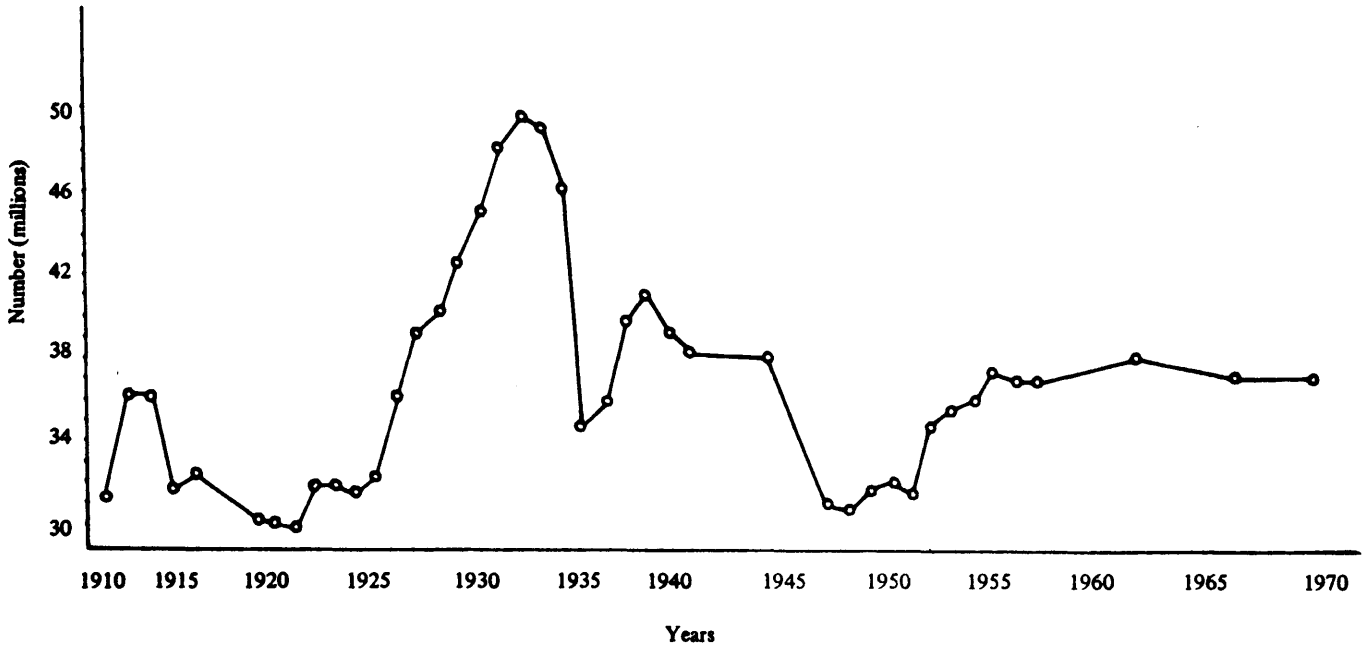

Fig. 1. – *Number of sheep in the R.S.A. from 1911 to 1970.*

however, indicated that the incidence of droughts and dry periods shows no regular rhythm in time of onset, duration or extent of area affected, and that there is little or no prospect of successfully forecasting drought from an assumed occurrence of rainfall cycles (Foley, 1957), which makes the problem of drought control difficult.

In order to indicate the incidence of droughts and their influence on stock losses in South Africa, the Drought Investigation Commission (1965) used as criterion the official proclamation of a district as drought-stricken. On this basis they have for the period 1948 to 1962 grouped districts according to the number of months during which each has been proclaimed drought-stricken. The duration of the proclamations was grouped in periods of 36 months (13,6%) and less, 36 to 59 months, 60 to 95 months and 95 months and more (36%). Unfortunately stock losses due to droughts are only known for certain years and an example of the influence of drought on stock losses is therefore only given for one such a representative period namely, that of 1959/60. (Table 1).

Table 1

Sheep losses due to droughts, 1959/60 (European owned) (Drought Investigation Committee, 1965)

Cape Province	644 279
Natal	3 436
Transvaal	24 308
Orange Free State	35 489
Total for the Republic	707 512

% Months declared drought-stricken			
40,1	and	more	351 572
20,1	to	40	281 351
10,1	to	20	16 972
0,1	to	10	24 209

It is clear from Table 1 that in districts which have been proclaimed drought-stricken for 40% or more of the above-mentioned periods, losses due to drought far exceeded those in areas proclaimed for a lesser percentage of time. In such arid areas the annual precipitation varies from 0–500 mm. In order to give an indication of the proneness of the small stock industry to droughts, the numbers of sheep in districts which have been proclaimed drought-stricken during 1960/61 are presented in Table 2.

It is clear that when compared with the total number of sheep in South Africa those in areas which have been proclaimed drought-stricken for 20% of the 14 year period represent almost 56%. The significance of the latter figure may furthermore be judged when wool production in extensive (arid), semi-intensive (semi-arid) and intensive (grassveld) areas are taken into account (Joubert, 1971). Data are presented in Table 3.

From results presented in Table 3 it is evident that

Table 2

Number of sheep during 1960/61 in districts which were proclaimed drought-stricken during the period 1948 to 1962. (Drought Investigation Committee, 1965

Percentage months declared drought-stricken			Number	% of total number of sheep in the Republic
40,1	and	more	6 178 314	18,12
20,1	to	40	12 903 670	37,83
10,1	to	20	3 515 735	10,31
0,1	to	10	2 222 366	6,52

Table 3

Wool production in extensive, semi-extensive and intensive areas (1968/69)

Province	Extensive %	Semi-extensive %	Intensive %
Cape Province	63,91	21,84	14,25
Transvaal	–	71,07	28,98
Orange Free State	44,77	30,33	24,89
Natal	–	–	–
Mean percentage of total wool production	51,72	30,38	17,89

more than half of the total wool of the Republic is produced in arid areas with a rainfall of less than 500 mm annually. According to the Drought Investigation Commission (1965) the rainfall in arid areas is not only low but also extremely variable and unreliable with, in some instances, a mean percentage deviation from the annual mean precipitation of 50 to 70% .

The results presented here present a rather gloomy picture of the vulnerability of large areas and the majority of sheep numbers to the hazardous effects of droughts. Application of correct and efficient drought-feeding procedures consequently warrants top priority especially when the price of wool is at a low ebb, and cannot be divorced from economical aspects.

Differentiation between Different Types of Drought

Correct application of efficient drought-feeding measures should clearly distinguish between two major types of drought viz. (a) seasonal droughts, which in their scope and duration are reasonably predictable and (b) periodic droughts viz. droughts which exceed the normal seasonal pattern, and which in their scope are unpredictable. Such droughts vary from short-term periodic droughts to long-term or disastrous droughts. From the following presentation of results and discussion it will become obvious that measures imposed to bridge such droughts differ widely.

Measures to Bridge Seasonal Droughts

1. *Veld Management*

It is generally accepted that veld grazing is the cheapest source of feed for ruminants. Notwithstanding this important fact, various reports indicate that the condition of the natural grazing is deteriorating. Tidmarsh (1966) stated that despite the efforts of the Government to get the Soil Conservation Act of 1946 more widely applied, the condition of the soil and veld of the Republic continues to retrogress. Roberts (1969) reported that although approximately 34% of farms have the facilities to apply conservation farming, less than 10% of farmers apply the recommended veld management systems. The Drought Investigation Commission (1923) attributed losses during droughts as being primarily due to overstocking.

South Africa's diverse geological, topographical and climatological conditions give rise to a total of 75 different veld types with another 75 variations (Acocks, 1953). The nutritive value of these veld types varies, like their ecological surroundings, between extremes (Louw, 1969).

Although the Drought Investigation Commission (1965) proposed that the bridging of seasonal droughts should be seen as an integral part of sound farm planning, measures incorporated to counteract nutritional deficiencies during seasonal droughts differ widely between major veld types. These measures will be more specifically discussed for the following regions:

(a) Western and South Western Cape Province;
(b) Grassveld and Savannah in the Cape Province, Orange Free State, Natal and Transvaal and
(c) Karoo

(a) *Western and South Western Cape*

The seasonal dry period in these areas is normally from November to April. That protein, calcium, phosphorus, magnesium, copper, cobalt and molybdenum may be deficient during dry season grazing on natural veld were indicated by Brock (1957), Van der Merwe 1959), Vlok (1963), Terblanche (1966) and Stindt, Celliers, Joubert & Perold (1965). A revolution in livestock farming on these veld types was brought about by supplying various trace element licks (Perold, 1949; van der Merwe, 1959).

This area is fortunate in being an important wheat producing area as well as other cereals and legumes. Chaff and straw are most valuable drought feeds when supplemented (Greeff, van der Merwe & Swart, 1963; Hayward, 1968). The value of lupin seed as a drought feed for sheep was indicated by Van Niekerk and Louw (1959) and Dippenaar & Cronje (1961). In large parts of the area the influence of the normal seasonal dry period is alleviated by the fact that sheep graze the stubble after harvesting. Seasonal droughts in this area probably have a lesser impact on livestock production than in other areas since it is richly endowed with available supplementary feeds.

(b) *Grassveld and Savannah*

Seasonal droughts in these areas normally occur between August and December. In comparison with other areas, less analytical data are available on the chemical composition of plant species in these areas. A very distinctive feature of grassveld is that the chemical composition varies tremendously between seasons. The chemical composition of plant species in grassveld and Savannah was determined by Lesch (1957), van der Westhuizen (1959), and Steenkamp (1967), from the young stage in summer to the dry stage in winter. The crude protein value may reach a minimum of 2,4% during winter on *Themeda Triandra* veld (Swart, van Schalkwyk, Hugo & Venter, 1963), dry matter digestibility may be as low as 43% during the dry period (Smuts & Marais, 1940), while the starch equivalent value of veld grass varies from 56 in November to 15 in June (Theiler, Green & du Toit, 1924). The grassveld areas are characterised by acute protein (Du Toit, Louw & Malan, 1940; Smuts & Marais, 1940; Agenbach, 1958; Louw, 1962) and phosphate (Theiler, 1920; Bisschop, 1964) deficiencies which may cause severe weight losses during winter (Swart *et al.*, 1963; Bishop, 1966) or deaths. Numerous workers indicated that these deficiencies can easily be rectified by non-protein – nitrogen, phosphate and molasses – containing licks (Clark & Quin, 1951; Clarke & Barrie, 1954; Altona, Rose & Tilley, 1960; Pieterse 1961).

The views of the Drought Investigation Commission (1965), namely that seasonal droughts in these areas could be easily bridged by conserving cereal and veld hay during periods of plenty, are fully endorsed, and requires no further elucidation.

(c) *Karoo*

Seasonal droughts in the Karoo are not as well demarcated than in other areas and may consequently be described as being more relative in nature. It varies from approximately August to December but when winter rains fail a seasonal drought may cover the period May to December. The vastness of the Karoo with its diversity of topographical conditions results in a large number of veld types. Louw (1969) indicated that a deviciency of phosphorus is common to the whole of the Karoo. His findings were supported by van der Vyver and van Niekerk (1965a) and Cloete & Rossouw (1970 – unpublished observations). However, Steenkamp (1967) obtained no reaction from phosphorus supplementation at Petrusville and Hopetown with mature sheep. It would appear that the type of animal used in experiments should be carefully considered when phosphorus deficiencies are investigated. From the observations of Louw (1962) Louw, Steenkamp & Steenkamp (1967a), (1967b), (1968a) and (1968b) it is evident that Karoo veld contains excessive

Table 4

*Influence of energy, protein and phosphate supplementation during seasonal and periodic droughts on Karoo Shrub veld (*Pentzia spp*)*

	Energy[1]	Protein[2]	Phosphate[3]	Control[4]
Seasonal droughts				
Body weight changes of sheep				
First 3 1/2 months of pregnancy (kg/sheep)	3,00	1,50	1,00	0,70
Last 6 weeks of pregnancy (kg/sheep)	2,90	1,10	0,20	0,73
Weaning weight of lambs (kg)	14,68	12,40	11,80	9,95
Periodic droughts				
Body weight of ewes after lambing (kg)	43,59	41,09	42,86	39,50
Body weight of ewes after weaning (kg)	40,09	38,77	35,59	33,90
Body weight loss of ewes from mating until weaning (kg)	4,32	5,36	8,32	10,67
Mortality of ewes from lambing until weaning (%)	0	0	5	15
Wool producting (kg)	5,32	5,32	5,32	5,05
Tender Fleeces (%)	63	65	71	94

1. The energy lick consisted of mealiemeal, starch, molasses and salt and was provided at an intake of 1/4 of the daily maintenance requirements (M) for energy 1/12 th M for protein and 1/12 the M for phosphorus.

2. The protein lick consisted of lucerne meal, groundnut meal, molasses and salt and was provided at an intake of 1/4 of the daily maintenance requirements for protein, 1/12 M for energy and 1/12 the M for phosphorus.

3. The phosphate lick consisted of mono sodium phosphate, salt and molasses and was provided at 1/2 M for phosphorus, 1/12th M for energy and 1/12 th M for protein.

4. The control lick consisted of salt and molasses and contributed negligibly towards energy and protein requirements.

calcium and a decidedly unfavourable calcium: phosphorus ratio. It seems possible that the high calcium content in the latter species may cause metabolic disorders such as kidney and bladder stones which annually leads to losses among valuable rams and wethers. The phosphatic source employed in licks thus appears to be of the utmost importance and requires careful scrutiny.

In general wool production and the maintenance of body weight on shrub veld *Pentzia* exceeds that on mixed veld and those on the higher mountain plateaus (Venter, Cloete & Edwards, 1969). Although the chemical composition of hand-plucked samples throughout virtually the whole Karoo area (Henrici, 1935; Louw, 1969) has yielded valuable information on possible nutritional deficiencies during seasonal droughts, lack of information on more comprehensive aspects of the nutritive value of Karoo grazings tends to hamper progress in this field of research. A complete discrepancy regarding quantitative aspects of grazing intake prompted some workers to employ a method of trial and error in obtaining more direct information on animal performance than merely using chemical analysis as a criterion. Van der Vyver & van Niekerk (1965b) used 700 Merino ewes and lambs in a trial in which 227 g lucerne hay, 113 g mealies, 113 g lucerne hay plus 57 g mealies and no supplementary feeding were given daily. Best results were obtained with 113 g mealies. The latter may indicate that an energy deficiency may supervene during seasonal droughts.

The normal method employed by farmers in the Karoo to bridge seasonal droughts namely to use feeds such as maize and lucerne as supplements is open to serious question, since such a method does not promote efficient utilisation of natural pastures and also appears to be decidedly uneconomical. Major criticisms against this practice comprise a substantial reduction in grazing intake (Allden & Jennings, 1962) and inefficient utilization of labour and transport. These criticisms prompted Cloete & Rossouw (1970– unpublished observations) to investigate possibilities of devising a more efficient and cheaper method of combating seasonal droughts. The work which started during 1965 is still in progress. Results obtained with energy, protein and phosphorus supplementation are presented in Table 4.

The results indicated that during the seasonal dry period, the protein content of grazing in these areas is apparently not a limiting factor in the case of dry sheep, but that energy and phosphate supplementation may

improve live weight gain. However, during the last phase of pregnancy and during lactation, when protein requirements are higher, the decrease in body weight may also be improved by protein supplementation. From results obtained both at Grootfontein and Carnarvon, energy appears to be the major nutritional deficiency during seasonal droughts on shrub (*Pentzia*) veld. From Table 4 it is obvious that energy, protein and phosphorus would curtail losses, during periodic droughts. It is significant to mention that rectifying these deficiencies during seasonal droughts with a lick which contains energy, phosphate, salt and molasses was approximately 30–50% cheaper than had feeds such as maize and lucerne been used. Grazing utilization appeared to be improved which calls for judicious grazing management when such licks are used. The incidence of pregnancy toxaemia was eliminated by using the abovementioned lick.

Drought resistant fodder crops may also be utilized to good advantage in combating seasonal droughts in arid areas.

2. *Drought resistant fodder crops*

The value of drought resistant fodder crops such as Spineless cactus (*Opuntia spp*) (Turpin & Gill 1928; Maré 1932; Bonsma & Engela, 1938; Walters, 1951, Terblanche, 1970); Old-man Saltbush (*Artripex spp*)(Bonsma & Engela, 1938; Bonsma & Maré, 1924; Aucamp & Cloete, 1970), bluebush (*Kochia spp*) (Wilson, 1966); American aloe (*Agave americana*) (Bonsma & Engela, 1938) and Noors (*Euphorbia coerulescens*) (Roux, 1953) is well-known but, unfortunately not yet fully appreciated by farmers. The latter is rather surprising since Terblanche (1970) has indicated economical advantages attached to the correct utilization of these fodder crops, particularly Spineless cactus. The nutritional deficiencies of Spineless cactus when utilized in conjunction with shrub veld can be rectified by using a simple salt-phosphate lick (Cloete, 1970). Every effort should be made to propagate the use of these drought resistant fodder crops in arid and semi-arid environments.

3. *Utilization of water during seasonal droughts*

The optimal utilization of water during times of drought is often ignored in drought-feeding studies with sheep since deficiencies of available feed receive priority in investigation. During droughts it is not only the quantity of water available which should be considered but also the quality. For example the supply may be abundant but sheep may refuse to drink it. Steyn & Reinach (1939) attributed this to an increase in the salinity of such water. Buttner (1937) indicated that by the term "brack" is meant water which is rich in minerals such as the chlorides, sulphates and bicarbonates of potassium, magnesium, sodium and calcium. Examples of how severe the latter problem may be on some farms in the Karoo are presented in Table 5 (Vorster, 1970 – unpublished observations).

From this table it is clear that the total salts or the "brack" content of water increases from east to west. The concentrations of calcium, magnesium, sodium, chloride and sulphate in water exhibit a negative relationship with the annual rainfall from the eastern to the western parts of the Karoo. From Table 6 it is clear that only the water in the sour grassveld areas satisfies the requirements proposed by Steyn & Reinach (1939) and which are currently used in the case of water for human consumption in the United States of America. The waters in the North Western Karoo contain far more total solids than the above-mentioned restrictions. It is consequently not surprising that so many instances occur during droughts in these areas where sheep refuse to take water.

Table 5

Mineral composition of water in the Eastern (grassveld), Central (grass and shrub veld) and North Western Karoo (shrub veld)

Constituent		Eastern Karoo	Central Karoo	North Western Karoo
Total salts	(ppm)	877	1758	4296
Calcium	(ppm)	60	109	385
Magnesium	(ppm)	83	120	263
Sodium	(ppm)	105	291	643
Carbonates	(ppm)	0	0	0
Bicarbonates	(ppm)	543	414	374
Chlorides	(ppm)	99	401	1579
Sulphates	(ppm)	91	305	613
pH		7,6	7,7	7,1

The influence of salinity of drinking water on sheep has also been studied under carefully controlled conditions. Additions of sodium chloride to rain water have shown that a concentration of 1,5% was detrimental to a small proportion of the flock and a concentration of 2,0% adversely affected all sheep (Peirce, 1957). Additions of sodium chloride and calcium chloride (Peirce, 1962); sodium chloride, sodium carbonate and sodium bicarbonate (Peirce, 1963, 1966); bicarbonate (Grosskopf & Briel, 1967) and fluorine (Peirce, 1954) have provided valuable information on the influence of salinity of water on wool and mutton production and indicated the adverse effects which some waters in the North Western Karoo may have on sheep during times of drought.

During severe droughts it is, however, not only the quality of drinking water for sheep which is affected but also the quantity Water is the nutrient required in largest amounts. Factors which influence water consumption such as air temperature (Clark & Quin, 1949, Macfarlane, Morris & Howard, 1956, Ross, Moose & McFate, 1964; Erasmus 1967), humidity (Johnston, Ragsdale, Berry & Shanklin, 1963), body weight (Winchester & Morris, 1956; Louw & Bonsma, 1962), and breed differences (Erasmus, 1967) have been sufficiently investigated and although positively linked, are probably of lesser importance than the quantity of water available to sheep

during droughts. The type of veld frequently determines the amount imbibed. When green and succulent, the amount of free water needed will be much less than when it is dry (Stoddart & Smith, 1943; MacFarlane. Dolling & Howard, 1966; van der Merwe & Belonje, 1970). When it is considered that high ambient temperatures (MacFarlane, 1962) and an increase in the salinity of water (Wilson, 1966) during droughts in arid areas will increase water requirements, the availability of water in these areas may magnify drought feeding problems. The latter aspect should therefore be carefully considered since restricted watering or a total lack of water leads to a decrease in grazing intake (Anand, 1961; Erasmus & de Kock, 1965), affects the type of feed the sheep selects (Clark & Quin, 1949) and leads to (a) irreversible circulatory failure (Macfarlane, Morris, Howard, McDonald & Budtz-Olsen, 1961) (b) a decrease in water intake when again available (Clark & Quin, 1949; N.R.C., 1964), (c) a decrease in the secretion of digestive juices (Solovyh, 1959) and substantial losses in body weight and sheep numbers (Macfarlane, 1962). Sheep in these areas should consequently be allowed a sufficient number of watering points.

Methods to Combat Periodic or Protracted Droughts

Decisions to make

When a drought exceeds the seasonal limit or rains fail during the period of normal expectancy one of the following methods are usually considered in alleviating the position:

(i) Moving sheep to grazing in other areas.
(ii) Not to feed at all.
(iii) To get rid of excess sheep
(iv) To apply hand feeding

(i) *Moving sheep to grazing in other areas*

This method of bridging protracted droughts has been a popular one during previous years and has in many cases been successful. The acceptibility of the method of moving sheep to grazing in other areas under prevailing conditions is, however, highly questionable and cannot be recommended due to the following reasons:

(a) It gives the farmer a false impression of a higher carrying capacity of his property which is intimately associated with all the problems of over-stocking.

(b) The properties of other farmers which have been conserved are trampled.

(c) Grazing is not easily obtainable under prevailing circumstances.

(d) In cases where railage facilities are poor, transport costs are high when motor trucks are employed.

(e) Diseases with which farmers who move their stock are not acquainted may lead to heavy losses.

(f) Losses are normally heavy where stock are moved on foot for long distances.

(ii) *Not to feed at all*

This method may have disastrous results as has been proven during the recent severe drought in some Karoo areas. As the drought continues the condition of valuable breeding stock may deteriorate to such an extent that supplementary feeding when eventually started, has little value. Furthermore, the expected rains seldom materialise. Consequently the views of the Drought Investigation Commission (1965) namely that they could not accept a *laissex-faire* attitude of not to feed at all should be fully endorsed.

(iii) *To get rid of excess sheep*

This method is basically sound and has also been proposed by Moule (1949), McClymont (1956) and Cloete, Basson & Hugo (1966). Since mutton prices are highest when veld conditions are poor and many sheep are in poor condition when normally expected seasonal rains have failed, marketing of the sheep from the veld may present problems. The teeth of old sheep which are to be marketed are normally badly worn. Van Niekerk & Mulder (1965) suggested that the relatively rapid degeneration of the mandibular premolars and first molars may have an adverse effect on the ability of the animal to masticate its food properly and can thus partially be responsible for the decrease in body weight and wool production which are known to occur in sheep of about six years old. When sheep are grazed on mixed Karoo veld rapid attrition of the incisors are also known to occur. The latter phenomenon appears to be associated with soil contamination and soil ingestion (Healey & Ludwig, 1965; Cutress & Healy, 1965).

In order to bridge problems of getting old sheep in a marketable condition experiments were conducted at the Agricultural Research Institute for the Karoo Region since 1962. Major results are summarised in Table 6 (Jacobs & Cloete, 1970).

From this table it is clear that old Merino sheep initially weighing 31,8 kg could be marketed economically within a period of four to six weeks on a ration consisting of 27,3 kg maize meal and 18,2 kg lucerne meal both milled through a hammermill with one-quarter inch screen openings. When large numbers of old sheep have to be fattened a similar mixture could also be given in the pelleted form (Cloete & Rossouw, 1970). The reason why when the maize meal content of the fattening ration is increased beyond 60% poorer results are obtained, is in-

vestigated at the moment. Maize meal should, however, be introduced gradually in order to prevent purging.

Table 6

Influence of the length of the feeding period on the fattening of old Merino sheep when a ration consisting of 60 % yellow maize meal and 40% lucerne meal is used

	FATTENING PERIOD			
Initial body weight (kg)	32,27	32,77	32,32	32,36
Final body weight (kg)	45,23	46,05	48,18	49,68
Body weight gain (kg)	13,09	13,27	15,86	17,32
Carcass gain (kg)	6,77	7,68	8,91	10,09
Carcass grading: Prime (%)	10	0	16	26
First grade (%)	74	78	84	69
Second grade (%)	16	5	0	5
Third grade (%)	0	17	0	0
Kg feed per Kg body weight gain	2,75	2,92	2,91	3,64
Kg feed per Kg carcass gain	5,25	5,05	5,19	5,21
Initial carcass value (R)	4,65	4,65	4,65	4,65
Feeding costs (R)	2,11	2,35	2,88	3,34
Profit per sheep (R)	2,24	2,04	2,53	2,62
Profit per sheep (R)	2,24	2,04	2,53	2,62

(iv) *The application of hand-feeding*

Hand-feeding has been successfully practiced in Australia since the experiments of Franklin (1946), Bull, Vasey & Gamble (1951) Franklin & Sutton (1952) Franklin, McClymont, Briggs & Campbell (1955) and Briggs, Franklin & Mc Clymont (1957). With the deterioration of our natural grazing particularly in the arid and semi-arid areas (Acocks, 1953), the large scale construction of drought feeding units on farms comprising a number of small pens should receive priority, in particularly the arid regions. The idea of removing the most valuable stock from the natural grazing during protracted droughts, after old and excess sheep have been marketed, can be motivated as follows:

(a) Protection of the natural grazing against further deterioration

(b) Saving in labour and transport costs

(c) Saving in feed costs. Moule (1949) postulated that "some idea of the amount of feed which can be saved by yarding the sheep as against allowing them to roam the paddock may be gained from the fact that it would require an additional 454 kg of maize per 1000 sheep per week to provide for their walking 9,7 km per day". The Drought Investigation Commission (1965) fully endorsed the idea of hand-feeding the most valuable sheep in small pens or paddocks during protracted droughts. The mechanics of the hand-feeding of sheep under these conditions will consequently be more fully examined.

(i) *When to start hand-feeding in pens.* Research workers agree that hand-feeding should commence before body weight falls to a critical level. Simpson & Robinson (1968) reported that when body weight fell to 30,9 kg when feeding commenced deaths occurred during winter and proposed that sheep weighing 45,5 kg could be allowed to fall to 31,8 kg during summer and 34,1 kg in winter before hand-feeding should start. The C.S.I.R.O. (1958) in summarising the hand-feeding experiments in Australia reported that dry, adult Merino sheep in good store condition can lose approximately 40% of their body weight before mortality becomes serious. Cloete, *et al.* (1966) proposed that hand-feeding should commence when dry, adult Merino sheep in a fair condition have lost approximately 15 to 20% in body weight. The discrepancy between these findings may probably be attributed to the fact that Australian results refer to the commencement of hand-feeding while there was still some grazing available in the paddocks while our recommendation refers to the complete withdrawal of sheep from the natural grazing and the body weight at which hand-feeding should commence in pens. The influence of initial body weight at the commencement of complete hand-feeding on mortality rates of Merinos in the Karoo is presented in Table 7 (Cloete & Basson 1971 – unpublished observations). The experiment has been in progress for 150 days.

Table 7

Influence of body weight at the commencement of pen-feeding on the mortality of Merino sheep in the Karoo

	Average initial body weight		Difference in weight	Mortality (%)	
	Heavy group kg	Light group kg	%	Heavy group	Light group
100% lucerne hay	41,55	34,09	21,9	0	20
50% lucerne + 50% maize	41,77	34,09	22,5	0	10
25% lucerne + 75% maize	41,50	34,32	20,9	0	30
100% maize	41,45	34,23	21,1	0	30

Results presented in Table 7 clearly indicate that a weight loss of approximately 20% before hand-feeding commences may result in losses. In comparison with Australian data, these figures represent a weight loss of approximately 25%.

Once accustomed to hand-feeding it would appear from Table 7 that heavier sheep could lose more than 20 % of their body weight before losses are recorded. Moule (1949) supported a gradual weight loss and mentioned that every 0,45 kg of body tissue catabolised in the process of weight loss provides an amount of energy almost equivalent to that obtained from feeding 1,8 kg maize.

Since no clear pasturalist view is available on the exact stage at which sheep should be withdrawn from the natural grazing without inflicting permanent damage, it is arbitrarily suggested that, when conservation farming is practiced, sheep should be transferred to pens when they have reached a body weight of approximately 38,6 kg. From the available evidence it appears that losses under pen-feeding conditions will be curtailed and damage to grazing reduced when sheep are transferred to feeding pens at the latter body weight. The latter body-weight proposal refers to dry sheep since it is known that dry ewes lose significantly less weight on sparse grazing than lactating ewes (McInnes, 1967).

(ii) *What sheep to feed.* Young breeding ewes are obviously the most valuable to have since when the drought breaks they are then the most difficult and expensive to buy and often the result of years of selective breeding (Moule, 1949; McClymont, 1956). Wethers and aged ewes are the obvious stock to discard (Cloete *et al.* 1966). Weaners have often been found difficult to bring through a drought, but modern knowledge on feeding can virtually eliminate this difficulty. They can survive on considerably less feed than older sheep. Rams should receive preferential treatment since malnourished rams will result in a poor lamb crop. (McClymont 1956). Heavily pregnant ewes are the most susceptible to poor feed since a few weeks of poor feeding during the later stages of pregnancy may lead to

(a) losses of ewes due to pregnancy toxaemia;
(b) birth of under-sized weak lambs;
(c) weak ewes which may die or exhibit poor mothering instincts and poor udder development with a consequent poor milk yield. Feeding of such ewes should commence at least four weeks before lambing.

(iii) *How to feed.* Although van Niekerk, Basson & Mulder, (1967) and to a certain extent Bull *et al.* (1951) have found that daily feeding yielded better results than weekly feeding, no difference could be detected between daily and weekly feeding by Franklin *et al.* (1955) and Briggs *et al.* (1957) or between daily and twice or three times per week feeding (Jordan & Hanke, 1963; Franklin 1967). On the contrary McClymont (1956) reported a decided advantage in weekly fed groups compared with daily fed groups. The losses in the daily and weekly fed groups being 30 and 12 respectively over an experimental period of 343 days. The reason for the fewer losses in the weekly fed group may be attributed to the fact that in this case shy-feeders were also allowed an opportunity to obtain feed after their more robust counterparts have satisfied themselves. Cloete *et al.* (1966) indicated that in the case of heavily pregnant and lactating ewes daily feeding may be preferable owing to their high nutrient requirements. With all other sheep intermittent feeding is better.

(iv) *What to feed.* The decision on what to feed will obviously depend on what feeds are available and their costs per feeding unit. In order to give an indication of the economical value of certain feeds commonly employed for drought feeding, their price have been linked with their energy value. Details are given in Table 8 (Cloete *et al.* 1966).

Although it is commonly accepted that home-produced roughages are the cheapest (Franklin, 1946; Moule, 1949; Jefferies, 1957; McClymont, 1956) it is evident from Table 8 that the position drastically changes when roughages have to be purchased. From this table it is evident that concentrates are the cheapest source of feeding during times of drought and should receive greater attention.

In the higher rainfall regions roughages seldom, if ever, appear to be in short supply. In the arid regions. however, the availability of roughage presents real problems. The most important roughage in these areas, namely lucerne hay, is often unobtainable and, when obtainable, sold at uneconomical prices.

In view of these difficulties the optimal use of maize, which is freely available, was tested out at the Agricultural Research Institute for the Karoo Region and at the Carnarvon Experimental Station since 1968 (Cloete, Cloete & Rossouw, 1970 – unpublished observations). Four groups consisting of 20 aged Merino ewes each were given maintenance rations of 100% maize; 75% maize plus 25% lucerne hay; 50% maize plus 50% lucerne hay and 100% lucerne hay for a period of 365 days. Quantities of the various rations given daily allowed the maintenance of a body weight of approximately 31,8 kg per head. Some of the results are presented in Table 9.

From results presented in Table 9 it would appear that as regards the maintenance of body weight and mortality rates, a drought maintenance ration consisting of 50% maize and 50% lucerne hay (based on a nutritive value basis) appears to yield the best results. When, however, feeding costs are considered, a ration consisting of maize only offers economical advantages. The higher mortality rate in the maize fed group may cause some concern. It should be mentioned, however, that old sheep (± 10 years) were used in the experiment and that pen-feeding may normally not be practised for such extended periods. Mortality rates in the other groups appear not to exceed published figures in Australia (Franklin, 1946; Bull *et al* (1951) Franklin *et al.* 1955).

The more basic aspects of this experiment were investigated at the Research Institute for the Karoo Region. Twenty-four adult Merino wethers were given similar

Table 8

Relative costs (cents per feed unit) of some drought feeds

(A) Roughages

Price per ton (R)	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Groundnut hay	1,18	1,32	1,47	1,62	1,76	1,91	2,06	2,21	2,35	2,50	2,65	2,79	2,94	3,09	3,23	3,38	3,53	3,68	3,82
Oat Hay	1,05	1,18	1,32	1,45	1,58	1,71	1,84	1,97	2,10	2,24	2,37	2,50	2,63	2,76	2,89	3,03	3,16	3,29	3,42
Oat Straw	1,74	1,96	2,17	2,39	2,61	2,83	3,04	3,26	3,48	3,69	3,91	4,13	4,35	4,56	4,78	5,00	5,22	5,43	5,65
Wheat Straw	4,00	4,50	5,00	5,50	6,00	6,50	7,00	7,50	8,00	8,50	9,00	9,50	10,00	10,50	11,00	11,50	12,00	12,50	13,00
Lucerne Hay (good quality)	1,00	1,12	1,25	1,37	1,50	1,62	1,75	1,87	2,00	2,12	2,25	2,37	2,50	2,62	2,75	2,87	3,00	3,12	3,25
Lucerne Hay (poor quality)	1,21	1,36	1,51	1,67	1,82	1,97	2,12	2,27	2,42	2,58	2,73	2,88	3,03	3,18	3,33	3,48	3,64	3,79	3,94

(B) Concentrates

Price per ton (R)	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	38	40
Groundnut meal	1,32	1,38	1,45	1,51	1,58	1,64	1,71	1,78	1,84	1,91	1,97	2,04	2,10	2,17	2,24	2,30	2,37	2,50	2,63
Oats	1,51	1,59	1,67	1,74	1,82	1,89	1,97	2,04	2,12	2,20	2,27	2,35	2,42	2,50	2,58	2,65	2,73	2,88	3,03
Lupins	1,30	1,36	1,43	1,49	1,56	1,62	1,69	1,75	1,82	1,88	1,95	2,01	2,08	2,14	2,21	2,27	2,34	2,47	2,60
Molasses	2,00	2,10	2,20	2,30	2,40	2,50	2,60	2,70	2,80	2,90	3,00	3,10	3,20	3,30	3,40	3,50	3,60	3,80	4,00
Maize	1,28	1,35	1,41	1,47	1,54	1,60	1,67	1,73	1,79	1,86	1,92	1,99	2,05	2,11	2,18	2,24	2,31	2,44	2,56

Table 9

The influence of various drought maintenance rations on body weight changes and mortality rates of sheep under pen-feeding conditions over a period of 365 days

	100% Lucerne	50 % Lucerne 50% maize	25 % Lucerne 75 %Maize	100 % Maize
Initial body weight(kg)	42,09	42,00	41,91	42,00
Final body weight (kg)	32,45	35,14	34,64	32,32
Body weight change over 365 days (kg)	-9,64	- 6,86	-7,27	-9,68
Mortality rate (%)				

maintenance rations for a period of 475 days. The digestibility of dry matter and nitrogen, calcium, phosphorus, sodium retention, plasma vitamin A levels and ruminal pH were determined at three-monthly intervals. During the first three-monthly period no supplementation was given in the case of the maize-fed group. During the rest of the experiment 14 g of a mixture consisting of 16 kg defluorinated lime, 16 kg bone meal and 14,5 kg salt was given per head daily. The various nutritional balances are presented in Tables 10(a), (b), (c) and (d).

Table 10 (a)

Dry matter digestibility of various drought maintenance rations for Merino sheep over a period of 475 days

	Three-monthly periods			
	1	2	3	4
100%Maize	83,4*	93,3	89,7	90,4
75% Maize + 25% Lucerne	80,6	80,2	80,9	80,1
50% Maize + 50% Lucerne	77,9	74,5	82,1	74,2
100% Lucerne	61,9	65,1	59,5	66,7

* No calcium supplement

Table 10 (b)

Retention of nitrogen, calcium, phosphorus and sodium on drought maintenance rations for Merino sheep over a period of 475 days

Component and rations	Three monthly periods – Balances (g/sheep/day)			
	1	2	3	4
Nitrogen				
100 % Maize	– 2,54*	– 0,06	+ 0,59	+ 1,04
75 %Maize	+ 1,83	+ 2,29	+ 2,02	+ 3.60
50 % Maize	+ 1,29	+ 2,32	+ 2,79	+ 4,28
100 % Lucerne	+ 0,90	+ 5,78	+ 2,43	+ 6,49
Calcium				
100 % Maize	– 0,74*	+ 0,07	+ 0,26	+ 0,07
75 %Maize	+ 0,76	– 1,31	– 0,64	– 0,10
50 %Maize	+ 1,02	– 0,22	+ 0,63	+ 0,63
100 %Lucerne	+ 1,81	+ 1,14	+ 0,98	+ 2,01
Phosphorus				
100 %Maize	– 0,20*	+ 0,55	+ 0,06	+ 0,42
75 % Maize	+ 0,16	+ 0,26	+ 0,21	+ 0,35
50 % Maize	+ 0,26	+ 0,07	+ 0,24	+ 0,24
100 % Lucerne	+ 0,27	+ 0,07	+ 0,36	+ 0,79
Sodium				
100 % Maize	– 0,15*	+ 0,21	+ 0,02	+ 0,23
75 % Maize	– 0,15	– 0,23	– 0,05	– 0,01
50 % Maize	+ 0,19	– 0,21	+ 0,04	+ 0,01
100 % Lucerne	+ 0,34	+ 1,33	+ 0,95	+ 1,44

* No Calcium supplement

Table 10 (c)

Mean pH values of rumen contents of Merino sheep on various drought maintenance rations for a period of 475 days

Rations	Hours before and after feeding			
	1 h before	1 h after	3 h after	6 h after
100 % Maize	6,33	5,97	5,92	6,05
75 % Maize + 25 % Lucerne	6,80	6,27	6,17	6,26
50 % Maize + 50 % Lucerne	6,83	6,38	6,34	6,36
100 %Lucerne	7,23	6,47	6,32	6,33

Tabel 10(d)

Plasma vitamin A levels of Merino sheep which were kept on drought maintenance rations for a period of 475 days

Ration	Three-monthly periods (vitamin A palmitate/ 100 ml. plasma)				
	1	2	3	4	5
100 % Maize	112,7	108,3	88,6	83,1	80,3
75 %Maize + 25 % Lucerne	107,4	122,3	85,5	77,1	82,2
50 % Maize + Lucerne	98,6	130,1	95,5	81,9	94,0
100 % Lucerne	99,8	107,3	83,3	71,3	68,6

The dry matter digestibility of maize appears to exceed figures in the literature (Morrison, 1959). As might have been expected calcium balances during the first three-monthly period were negative. Although negative without supplementation during the initial three months, the addition of 14 g of the mineral mixture daily virtually changed all negative balances into positive during the subsequent nine months of the metabolism experiment. Results in Table 10(c) also indicate that pH values of rumen contents were not substantially lower on the sole maize ration than values on other rations when samples were taken six hours after feeding.

Plasma vitamin A levels on the sole maize ration were found to be higher than those recorded on the lucerne ration. No vitamin A deficiency symptoms could be detected. Results of this experiment indicated that when supplemented, sheep can subsist on all grain rations for rather extended periods. This results partially confirms the findings of Briggs, Franklin & McClymont (1956) who found no differences in average body weights and mortality rates of sheep given all-grain rations of wheat, maize, oats, barley or grain sorghum for a period of 180 days. We observed that some sheep on the all-maize ration and also on the 75% maize plus 25% lucerne hay ration pulled-out and consumed the wool of some of their counterparts. Post-mortem observations revealed that the wool thus consumed was changed into solid round balls of compressed and interwoven wool fibres. The latter phenomenon is probably associated with a roughage deficiency compensatory effect.

There are, however, a few very important factors which should be considered when all grain rations are used during extended droughts namely

(a) that such rations should be introduced gradually

in order to prevent purging

(b) that the acute calcium deficiency should be rectified by giving 0,7 kg defluorinated agricultural lime per 45,5 kg grain or licks containing calcium, (Cloete & Rossouw, 1970– unpublished observations).

(c) That feed losses due to birds may be substantial (Bull *et al.* 1951; Cloete and Rossouw, 1970 – unpulished observations) and

(d) that grain should not be fed daily in order to curtail losses due to shy feeders.

(v) *How much to feed.* In determining the maintenance requirements of dry, mature Merino sheep by means of regression analysis, Cloete & Rossouw (1970) found that 0,33 kg digestible organic matter will maintain the body weight of the 31,8 kg sheep. The validity of our estimates may best be judged when they are compared with those of Franklin & Sutton (1952) and Briggs *et al.* (1957). Franklin & Sutton (1952) who fed dry, mature Merino sheep initially weighing 34,5 kg at a level of 1,9 kg starch equivalent (S.E.) per week for 343 days reported little variation in body weight. Briggs *et al.* (1957) reported that body weight varied only slightly and no losses were recorded among dry adult Merino sheep which received 1,8 kg S.E. per head weekly. Since these experiments involved hundreds of sheep over extended periods their results appear to be most applicable to penfeeding conditions during times of drought. The validity of these results becomes even more acceptable when it is linked with the thousands of sheep which have been successfully pen-fed on the levels prescribed. Our estimate differs only slightly from these values.

Since maintaining a body weight at approximately 31,8 kg for an adult sheep under pen-feeding conditions during times of droughts appears to be the accepted level for drought maintenance feeding (Franklin & Sutton, 1952; Briggs *et al.* (1957), it should be kept in mind that when sheep are penned outdoors during cold winters the maintenance requirement may be increased (Bull *et al.* 1951; Lambourne & Reardon, 1963; Simpson & Robinson, 1968) and that allowance for additional feed should be made.

Australian results (C.S.I.R.O., 1958) furthermore indicate that weaners, ewes six weeks before lambing and ewes nursing lambs can subsist on 1,36, 2,3 and 3,2 kg S.E. per head weekly. The exact requirements will, however, vary according to the condition of the sheep.

(vi) *Early weaning of lambs.* Nutritional requirements indicate that a considerable saving in feed costs may be effected if lambs could be successfully weaned at an early stage. Thus McInnes (1966) reported that by weaning lambs at 9 weeks of age and hand-feeding them for 6 weeks, feed costs could be reduced by 30%. When condensing the mass of literature on the early weaning of lambs it is possible to make the following deductions

(a) The lambs can be successfully weaned at between six and eight weeks of age (Bonsma & Engela, 1941; C.S.I.R.O., 1958; Dolling, Moore & Sheaffe, 1963 ; Franklin, Briggs & Mc Clymont, 1964).

(b) The best results are obtained when weaned onto a high protein (± 18%) diet (McInnes & Briggs, 1964; Large, 1965; Nel, Lategan & Mellet, 1970).

(c) Supplementary feeding should start before weaning to prevent weight loss at weaning time (McClymont, 1956; Hyland, 1957).

(d) That a mixture containing equal proportions of concentrates and roughage yields good results (C.S.I.R.O. 1958).

(e) At about eight weeks the lamb can digest herbage with the same efficiency of an adult (Wardrop, 1960).

(f) Early weaning furthermore permits intensification of the sheep enterprise (Jordan, Hanke & Reiner, 1959) and reduces parasites in young lambs (Ross & Lawson, 1961).

(g) The optimal period a weaned lamb should be fed is, however, not well-defined and requires further investigation.

(vii) *Feeding facilities.* The moving and trough space allowed per sheep when penned may jeopardise results when certain principles are not adhered to. At the Burdekin unit sheep were generally concentrated at a rate of 120 per hectare (McClymont, 1956) which amounts to approximately 1,39 sq. m per sheep. Bull *et al.* (1951) allowed 1,67 sq m per sheep while our ratio has been approximately 1,86 sq m (Cloete & Rossouw, 1970 – unpublished observations) in the case of drought feeding. Generally approximately 15 cm of trough space are allowed per sheep (Moule, 1949; McClymont, 1956). It is obvious that over-concentration of sheep in a limited space may lead to disastrous results especially when adequate provision has not been made for the shy feeder.

(viii) *Some economical aspects of pen-feeding.* In order to gain some indication of the feasibility of pen-feeding during protracted droughts results on feed costs, wool production, and mortality rates in an experiment which were conducted at the Carnarvon Experiment Station are presented in Table 11. (Cloete, Cloete & Basson, 1970 – unpublished observations).

Table 11

Some economical aspects of the pen-feeding of Merino sheep on various drought maintenance rations over an experimental period of 365 days

	100 % Lucerne	50% Lucerne + 50 % maize	25 %Lucerne + 75 % maize	100 % maize
Feed costs – unsubsidised (R)	6,48	5,67	5,35	4,86
Feed costs – subsidised (R)	3,24	2,84	2,67	2,43
Wool production (kg/sheep)	3,23	3,50	3,05	3,14
Income from wool sold at 26c/lb (R)	1,85	2,00	1,74	1,79
Mortality (%)	10	10	25	55
Costs to maintain a sheep for 365 days (feed not subsidised) (R)	4,53	3,72	3,61	2,91
Costs to maintain a sheep for 365 days (feed subsidised) (R)	1,29	0,89	0,93	0,48

Maize was purchased at R36 per ton and lucerne at R24 per ton.
Daily maintenance rations were: Lucerne hay = 681 g/sheep; Maize = 340 g/sheep;
50 lucerne plus 50 maize = 340 g lucerne hay plus 170 g maize and 75% maize plus 25 % lucerne = 255 g maize plus 170 g lucerne hay per sheep.

From the data presented in Table 11 it is clear that the drought maintenance ration used has an important influence on economical aspects of pen-feeding. It would appear as if a ration consisting of 50% maize and 50% lucerne hay (170 g maize + 340 g lucerne hay/sheep/day) yielded superior results as regards the maintenance of body weight, wool production and survival rate. Although cheaper, the substantially higher mortality rates in the groups which received the 75 and 100% maize appeared to have made these rations less economical when losses are valued at approximately R4,60 per sheep(Cloete & Rossouw, 1970). The latter refers to the value of the carcasses of drought condition sheep weighing approximately 31,8 kg. It is obvious that when losses have to be replaced after the drought is broken a considerably higher price would have to be paid for replacements.Every effort should consequently be made to solve the problem of shy feeders to which the mortality rates reported in Table 11 could be partially attributed.

From Table 11 it is also clear that when feeds are subsidised during times of drought sheep could be maintained at a fairly low cost under pen-feeding condisions. Pen-feeding thus appears to be, not only a feasible, but also an extremely important method for combating protracted droughts and in some areas it also appears the only solution to stop the retrogression of our natural grazing.

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