

Human response and adaptation to drought in the arid zone: lessons from southern Africa

P.J. O'Farrell^{a*}, P.M.L. Anderson^b, S.J. Milton^c and W.R.J. Dean^c

Human adaptation and response to drought is primarily through evasion or endurance. A review of historical agricultural practices in southern Africa demonstrates evidence of drought evasion response strategies in well-established transhumance routes, where herders move livestock on a seasonal basis in order to exploit resources subject to different climatic regimes. European settlers to the arid regions of South Africa quickly recognised the necessity of these evasion options to survive drought, and adopted the transhumance practices of indigenous farmers. Areas of geographically diverse resource bases became hotly contested by settlers and indigenous farmers. The success of evasion systems are shown to hinge on good social and institutional support structures. When movement is not an option, drought endurance is pursued by attempting to limit the damage to the natural resource base. This is through a number of means such as forage conservation, varying livestock types and numbers, water and soil conservation and taking up alternative livelihood options. State responses to drought over the last century reflect the general South African pattern of racially divided and unjust policies relating to resource access. Historically the state provided considerable support to white commercial farmers. This support was frequently contradictory in its aims and generally was inadequate to enable farmers to cope with drought. Since the advent of democracy in 1994, the state has intervened less, with some support extended to previously disadvantaged and poor communal farmers. Climate change predictions suggest an increase in drought, suggesting that the adoption of mitigating strategies should be a matter of urgency. To do this South Africa needs to build social and institutional capacity, strive for better economic and environmental sustainability, embed drought-coping mechanisms into land restitution policy to ensure the success of this programme, and acknowledge the diversity of the agricultural sector.

Key words: transhumance, drought-proofing, drought endurance, climate change, sustainable agriculture, social and institutional capacity

Introduction

'Everybody talks about the weather, but nobody does anything about it', said Mark Twain.¹ But this famous quote is decidedly inaccurate: people have long contemplated weather modification, and both adapt or adjust to weather conditions, and move towards or away from certain climatic regimes.² Southern Africa generally has a high coefficient of rainfall variation, making droughts a frequent occurrence.^{3,4} The influence of this variable climate on agricultural activities cannot be over-emphasised.⁵ A look at the history of humans in southern Africa confirms this view, and there is considerable evidence that people's lifestyles and livelihoods were and still are closely linked to climate. In arid and semi-arid regions the chief climatic regime requiring a

^aNatural Resources and the Environment, CSIR, P.O. Box 320, Stellenbosch 7599, South Africa.

^bEnvironmental and Geographical Science Department, University of Cape Town, Rondebosch 7700, South Africa.

^cRenu-Karoo Veld Restoration, P.O. Box 47, Prince Albert 6930, South Africa.

*Author for correspondence. E-mail: pofarrell@csir.co.za

Box 1. What is drought?⁷

Meteorological drought: a reduction in rainfall supply compared with a specified average condition, less than a certain amount (e.g. 70 per cent).

Agricultural drought: a reduction in water availability below the optimal level required by a crop during each different growth stage, resulting in impaired growth and reduced yields.

Hydrological drought: the impact of a reduction in precipitation on natural and artificial surface and sub-surface water resources.

Socio-economic drought: the impact of drought on human activities, including both indirect and direct impacts.

response is drought. Vast areas of southern Africa are arid and provide limited options for intensive agricultural production and as a result most of this area is managed as rangeland for extensive livestock production.⁶ Choosing appropriate livelihoods in these arid areas is the first of numerous human responses to climate.

While a lack of rainfall is the underlying cause of drought, diverse socio-economic, biological and agricultural factors determine the severity of its impact.⁷ Drought takes variable definitions depending on the viewpoint of the individual experiencing it. This paper does not attempt to address the issue of defining drought *per se*, but aims rather to make the point that drought can be defined both biologically and socially. Drought can be variously defined as 'meteorological drought', 'agricultural drought', 'hydrological drought' and 'socio-economic drought', each with their own boundary conditions and thresholds (Box 1).⁷ While drought is a climatic event with relatively predictable biophysical repercussions, social perceptions and responses to drought, at individual through community to state level, are highly varied and are the subject of this review.

Responses and mechanisms

Drought has posed a challenge to livestock farmers for centuries,⁸ to which they have adopted diverse responses. Across a temporal scale, responses to drought are variably defined. Coping is considered a short-term response to intermediate decline in access to food.^{2,9} Adjustment is a response that requires more time where people might, for example, diversify their food sources or livestock types.² Adaptation to drought is described as a longer-term response that involves considerable change in lifestyles and livelihoods.^{2,9,10}

Additionally, there is a spatial dimension relating to the mechanisms of response to drought. These mechanisms can be through endurance or evasion, and are sometimes coupled with drought prediction.² Drought response mechanisms are frequently determined by the type of farming practice, for example nomadic and transhumant pastoralists are able to evade drought, while ranchers, sedentary pastoralists and croppers must frequently adopt an endurance strategy.^{8,11} How people respond to drought is a function of a variety of factors typically relating to the severity, frequency and duration of the drought.

Evading drought – historical transhumance

Transhumance, or the seasonal migration of livestock, has long been recognised as an effective means of evading unfavourable climatic effects, such as drought, whereby moving domestic livestock across a landscape allows maximum forage use across a variety of climatic regimes and events.¹² Pastoral grazing strategies of this nature first emerged in northern and eastern Africa, and later moved with herders and livestock to southern Africa.¹³ This climate-driven lifestyle was effectively used by the Khoikhoi in the southern and western Cape for over 2000 years and persists today, although constrained by land ownership patterns and influenced by social norms and current agricultural practices.^{14–18} Transhumance is characterised by yearly movement cycles of livestock, following seasonal shifts in resource availability, coupled with variants in pattern associated with climatic events such as years of drought. A reduction in rainfall or even smaller scale shifts in the timing of rainfall, can result in ecosystem responses such as switches from grass to shrub-cover dominance or the failure of annual plant production.¹⁹ Resource fluctuations are effectively evaded by following various well-established transhumance routes. The entrenched nature of the transhumance routes followed by the Khoikhoi, attests to a familiarity with resource variability and evasion during times of scarcity.²⁰

European settlers to the southern and western regions of South Africa soon realised the significance of access to a diverse and temporally-variable grazing resource base, as well as the benefits of a transhumance lifestyle for effectively exploiting this resource base and evading drought.²⁰ Correspondingly, control of regions encompassing a diversity of climatic regimes was recognised as being highly strategic.²⁰ Control of climatically-diverse regions by European settlers was bitterly contested.²⁰ Conflict continued until these settlers had largely displaced the indigenous Khoikhoi pastoralists.²⁰ Settlers to these regions adopted lifestyle strategies similar to those of the recently displaced Khoikhoi, moving according to resource availability, tracking resources on a seasonal basis, or in response to drought. While the value of this strategy was self-evident for those relying on the rangeland for their livelihood, those in power, the Cape colonial government, did not have the same perspective. They viewed these new transhumant settlers as problematic, their lifestyle as demeaning, their farming strategy as weak, and did not like the freedom they assumed. They moved beyond the established frontiers in their attempts to sustain themselves through periods of scarcity, taking them beyond the reach of those governing.²¹ This sentiment persisted and is reflected in the following quote by E.B. Watermeyer of Calvinia who saw degradation as a direct result of fires and overstocking: '...the great offender is the nomadic trekker, who makes his scherm in the veld and destroys all the surrounding bushes, and trees...'^{21,22} Through imposition of regulations concerning fencing and subsidies for predator control and deep-drilled well points, colonial authorities transformed the transhumance lifestyle to one of settled ranching.^{15,17,18,20,21,23} A clear example of how the transhumance cycle of Khoi pastoralists changed over time in the Namaqualand area, has been identified as changing from a wide range covering the area from the Orange to the Olifants rivers, followed by a restricted transhumance cycle confined to the broader Leliefontein communal area, and finally a constrained 'within-village' movement pattern for current herders.²⁴

Evading drought – current practices

Despite considerable effort to contain pastoralists, reduce wide-ranging transhumance, and to formalise livestock production, vestiges of the movement patterns of climate-based resource

exploitation and drought evasion remain today. Examples of this are found in both the communal and commercial livestock production systems in the arid regions of southern Africa. Some farmers on communal land still use herding strategies to manage environmental variability in conjunction with a variety of socio-economic goals.²⁵ Communal farmers in general have short-distance movement between key resource areas in normal years. In drought years movement is likely to be on a larger scale following general fodder shortage and in severe drought, large-scale transhumance would be practised.¹³ In reality, however, extended movement to evade drought may be constrained by land availability, animal health and social issues, and large numbers of livestock starve to death.²⁶

Movement strategies in association with climate and vegetation responses are also still evident in the commercial farming sector. Farmers move their livestock according to vegetation type in association with rainfall patterns, but strategies are constrained by land ownership, so they must adjust their strategy in accordance to their particular mix of available vegetation types.¹⁶ Some commercial farmers in arid parts of the Karoo own two farms, one at high altitude which they graze in the summer and one at low altitude reserved for cooler weather. Livestock are moved between farms along public roads, either on foot or in trucks.

Landscapes are highly variable, both abiotically and biotically. Thus the drought response of a given plant species may differ with soil type, and different vegetation types respond variably to the timing and amount of rainfall.¹³ These factors drive choices between pursuing cultivation or pastoralism, and more likely the degree of specialisation within each of these land-use strategies.^{13,19} Superimposed on biological considerations are the mosaic of different land uses and the highly fragmented landscape of variable land tenure and access, all of which constrain current drought evasion strategies.

The long history of drought evasion in southern Africa, the rapid adoption of the system by European settlers, and its persistence in current agricultural landscapes clearly highlight the merit of this response strategy to variable climatic regimes and the avoidance of drought.²¹ What facilitates and what constrains a drought-evasion strategy is discussed in more detail below.

Evading drought – facilitating factors

Drought evasion requires the movement of livestock and often entire families. Movement is difficult and requires considerable effort and adjustment. In order to move, farmers need networks and social linkages that extend into other ecological zones not created by drought.¹³ These networks need to be strong, and are often affected through family connections, as securing tenure in distant places can be controversial. The strength of the institutions in place which regulate movement and access to resources is also significant in facilitating this movement.¹³

Drought-evading strategies of this nature have the benefit of cementing social relationships or maintaining social capital with potential reciprocity and interdependence.²¹ In addition to considerations around access to land, the movement of belongings, people and livestock, often requires additional labour, with further social and financial costs: the availability of cash to hire labour or purchase feeds is related to herd survival.¹³ In response to this constraint, people sometimes resort to resource pooling where groups of people come together to aid each other, for example, by joining livestock herds and reducing the number of herders needed or sharing transport and reducing these costs.¹³

A further recorded drought-evasion mechanism among both communal and commercial farmers is through loaning arrangements.¹³ This is where livestock are sent to relatives to lower the stocking rate in the area experiencing drought. This response reduces the herd requirements, lightens the carrying capacity and spreads the risk of losing livestock to drought.¹³ In some instances this may serve as a benefit to the recipients who may not have stock, typically benefiting from livestock products and the births of new animals.¹³ This also has the benefit of cementing social relationships and interdependencies. Drought is immensely stressful and successful evasion is not always possible. Sometimes people have been reduced to illegally foraging on land that is not their own, or even to raiding other people's herds for livestock once theirs have succumbed to drought.^{27,28}

Occasionally people will abandon their land entirely and move to a city. Alternatively, one or two members of the family will move to a city to seek an alternative livelihood depending on the length of and number of droughts experienced.^{9,29}

Enduring drought

Endurance largely translates into the preservation of the ecosystem dynamics to aid recovery after drought.⁸ This in essence means 'sitting it out' without damaging biological resources in the long-term. This strategy is mostly adopted by those who are more closely tied to the land through crop farming or ranching, for whom movement or evasion is not an option, and entails various farm management strategies aimed at compensating for the loss of the ability to evade a drought.⁸

The most obvious ecological aspects to be managed during drought are those systems that give rise to forage. This is particularly relevant to areas that have been overstocked and degraded. The variable response of natural vegetation to the late or early onset of rain, or reduced rainfall is demonstrated in the example where six million sheep died from poisoning in the widespread southern African drought of 1969, after grazing on the available toxic biomass.³⁰ Grazing strategies that rely on fenced paddocks and livestock rotation between these paddocks, are adjusted and managed very closely during droughts to ensure the most effective use of the forage resource, including those species susceptible to drought. Herds are also manipulated, typically reducing stock numbers to minimise the impact on vegetation.¹⁰ This has been described as the best means of preserving ecosystem functioning and aiding recovery after drought.⁸ Reducing stock numbers, through sales or slaughter, to meet drought-driven declines in grazing capacity has the same relative effect on grazing resources as increasing land area of a farm. However, the strategy of reducing stock numbers is unpopular because stock is expensive to replace and because banks regard livestock as collateral for determining increases in the magnitude of loans granted to farmers.¹⁰ Drastic reductions in stock numbers place additional risks on farmers, for example, remaining livestock may be less genetically suitable to drought conditions compared with those sold off.

Other livestock management responses for enduring drought include improving the quality of livestock while reducing quantity, switching to hardier breeds, or changing ratios of animal types.¹⁰ For example karakul, afrikaner, damara and dorper sheep are considered better drought adapted than angora goats and merino sheep.^{8,10} Similarly goats are generally considered more drought-hardy than sheep and farmers adjust the composition of their herds as a means of reducing possible livestock losses.^{8,11} While water requirements for sheep rise considerably with a rise in temperature, goats get most of their water requirements from forage.^{11,31} Similarly, indigenous animals, such as

springbok, eland and gemsbok, are often considered to be better adapted to local conditions and may fare better in drought than domesticated animals.^{8,10}

The effective management and use of available water is critical to drought endurance. Water is acquired through water conservation and harvesting, river diversion, run-off farming and through the establishment of boreholes.^{8,10} Improving water-use efficiency is also a key factor in making limited water go further and gains are mostly achieved through improved irrigation techniques. Water availability is described as the single most important health factor for livestock in drought and is seen as the primary limiting factor of herd size.¹¹ Sheep for example need 1.5 litres water for every 500 g of dry matter consumed, but at elevated temperatures, they may require up to 12 times more.^{11,31}

Farmers respond to the shortage of grazing in times of drought by buying in or producing their own fodder, or renting additional pastures or grazing lands.^{8,10,11} Sometimes money to buy additional fodder is made available through the sale of livestock or through state subsidy schemes. Fodder may be sourced in a variety of ways, for example by harvesting biomass from road verges and by chopping down branches or trees so animals can forage off these trees.⁸ Planting drought-resistant crops or agroforestry are both known drought-endurance strategies. Species such as mesquites (*Prosopis* sp.), saltbush (*Atriplex nummularia*), agave (*Agave americana*), and spineless cactus (*Opuntia* sp.), have all been promoted as drought-tolerant fodder production species,^{8,10} although all these species have a tendency to invade drainage lines where they may compete with indigenous trees and windmills for groundwater. In some cases, species such as saltbush are promoted as ruminant stimulants enabling animals to digest other less palatable species, as might be required when available forage is limited during drought. Moving towards more water-efficient feeds such as millet or sorghum in place of lucerne or maize is a further means of surviving drought.^{8,27} The production of additional fodder on a farm or the purchase of supplementary fodder, as opposed to taking or moving livestock to available grazing, requires financial capital in contrast to the movement of animals.

Improving veld condition, through resting, pasture re-seeding and rehabilitation efforts aimed at preserving and enhancing ecosystem function, is a further drought-endurance strategy aimed at making the resource last, although views on the usefulness of this strategy are widely divergent.¹⁰ In addition to preserving and enhancing grazing, protection and conservation of soil is seen as a key endurance strategy. Soil and water conservation techniques include contour furrowing, pitting, banking, terracing, benching,^{8,10} retaining large amounts of crop residue on the soil surface and increasing the length of fallow periods.³²

Farm-level diversification or the diversification of economic activities that a farmer engages in, is a well-established endurance mechanism.¹⁰ This is typically evident in the diversification of on-farm animal breeds and crop types, as well as the establishment of alternative income-generation strategies such as commercial hunting, tourism or the sale of handcrafts, and off-farm work.^{10,33,34} In the Little Karoo where more than 80% of farmers surveyed kept ostriches, only 17% were totally dependent upon ostrich farming for income, because they kept other types of livestock as well as engaging in tourism-related enterprises.³⁵ The success of such diversification is often linked to government policy and supported through incentives and appropriate legislation.³⁶ Regional trends and national and international fashions play a role too, but variety and diversification reduces risk.³⁶

Financial endurance through drought periods is managed through reductions in resource consumption, self-sufficiency, as

well as risk spreading, examples of these being reducing fuel usage, establishing woodlots, and the spreading of losses across a broader community.¹⁰ Budgeting or planning for losses and accepting losses when they do come, expectedly or unexpectedly, are all noted.¹⁰ Seeking external assistance through the acquisition of loans, either monetary or in the form of natural capital such as pasturage, or through communal efforts in resource pooling and labour sharing, are also evident.^{10,34} Such approaches occur among the Tswana people; communal building and ploughing systems, and a system of sharing cattle and communal herding require a certain degree of community cohesion.⁹ A further more common, cross-cultural request for external assistance is prayer for divine intervention.⁹

Predicting and anticipating

Mark Twain suggests there has never been a shortage of speculation and discussion around the weather and most communities have indicators and signs through which drought is predicted and anticipated. In southern Africa recorded indicators include variation in the timing and sounds of winds and rains, the use of livestock appearance such as the quality of their hair, the appearance of termites and their mounds, birds and their specific colour, the absence of mole hills or the presence of poisonous plants, the flowering of certain tree species, the appearance and size of stars, and higher-than-normal temperatures.^{11,37} More obvious means of prediction are the measurement of lower than usual rainfall or through the use of climate forecast data.³⁸ A variety of meteorological and agricultural indices have been developed to predict and assess drought.^{38,39,40} Perceptions on the accuracy of climate forecasts differ between communal and commercial farmers, with commercial farmers having a far greater trust in and reliance on these.¹¹

It is also important to note that the timing and duration of droughts cannot always effectively be predicted, and while people are surprised by drought, the variety of social responses shows a deep understanding and belief that drought is always possible. Also significant to note is that while a drought may be predicted, the intensity and duration of a drought continues to be elusive, demanding considerable flexibility in adopting coping, adjustment and adaptation strategies and mechanisms.⁴⁰ Current efforts focus on modelling vegetation processes in response to rainfall and drought conditions.⁴¹

A history of response by the state in South Africa

The arrival of European settlers in South Africa, the ensuing period of colonialism, and the subsequent apartheid era, saw significant changes in both land tenure arrangements and social structures. The development of homeland policies, betterment schemes and forced removals saw indigenous people being dispossessed and removed from their land.⁴ Generally this took place coincidentally with the development of considerable support to white farmers, who grew in economic strength in response to these interventions. Infrastructure was built, and strong support services established, including assistance from banks for land acquisition.²¹ This saw substantial increases in output from white farmers. Farmers were protected from foreign competition as subsidies continued.¹¹

Government policy over the past 100 years has acknowledged the significance of drought in South Africa. The Senate Select Committee report titled 'Droughts, Rainfall and Soil Erosion', released in 1914, was the first formal inquiry into drought as a driver in southern Africa.²² This issue was tackled again in greater detail in the 1923 'Drought Investigation Commission', which documented and distilled understanding in this field

from the previous 50 years.⁴² This commission documented the need for a change in livestock management practices and change in natural resource use. Over the next sixty years there were eighty parliamentary acts rendering assistance to commercial farmers in response to drought and drought-related impacts.¹¹ These acts were far-ranging and a great deal of emphasis was placed on soil conservation.

State support for white commercial farmers was initiated in the 1930s and intensified during drought periods.^{11,21} Contradictory government policy was evident from an early stage. Whilst the effects of heavy stocking were being noted by this commission, drought aid was being provided for restocking.²¹ Colonisation of South Africa, followed by apartheid policy and legislation, affected animal movement, notably through veterinary restrictions and fencing acts. These had the effect of disrupting historical approaches to dealing with drought. In particular, evading strategies became those limited, recommended and sponsored by the government.⁴⁰ Subsidies for the mass riling of stock from drought-affected areas to non-affected areas, combined with special credit facilities and tax relief, were an example of this.²¹ The agricultural credit board, established in the 1950s, gave loans to farmers, often following periods of drought, who were no longer found creditworthy by commercial institutions. The failure to incorporate climate variation and drought into commercial agricultural development and practice resulted in greater areas of marginal land being used for agriculture.⁴ The livestock reduction scheme was a further policy tasked with improving rangeland condition, which would in turn facilitate drought recovery. This was a volunteer scheme, which ran from 1969–1978, where farmers in targeted areas were paid to reduce their stocking levels by one third of the Department of Agriculture recommended carrying capacity, thereby resting a third of their land. From the 1980s there was a shift towards more long-term drought assistance focussed on appropriate natural resource use.¹¹ This conservative approach encouraged the adoption of low-risk technology, correct carrying capacities and grazing strategies, with droughts being recognised as natural phenomena.¹¹

The post-1994 stance of the first democratic government towards drought support reflected their greater agricultural support policies. This era, from the mid-1990s to the present, saw a more hands-off approach by government towards the agricultural sector, without the same degree of tax relief and easy finance extended to farmers. This was mirrored in their approach to drought, where farmers have largely been left to fend for themselves. This said, there has been some effort to aid previously disadvantaged, poor, and communal farmers, who have received some drought relief in the form of feed and government loans.

On reflection, state interventions cannot be viewed as having been highly successful. Interventions have largely been reactive, and not enough emphasis has been placed on developing capacity to cope with drought. No collective strategies to combat drought have been developed, and increasingly people respond in their individual capacity. There is historical distrust of the government and political fear of government or institutional response to collective measures. In the past there was greater local and regional alliance where people relied on institutions such as traditional leaders for support, as well as distant relatives. Now people tend to turn to national government for support. Drought remains a stressful and often crippling event for farmers across all sectors in South Africa today.

Coping and adapting into the future

Climate change predictions for the arid zones of southern

Africa include greater climate variability and potentially a greater increase in drought frequency.⁴³ Reflections on past strategies aimed at coping with drought suggest we need to re-view our approach to improve our ability to cope with drought. Our current inability to successfully manage drought, combined with climate change predictions, lends urgency to the need to effectively engage with drought and devise improved approaches.

History tells us that social capital, apparent in social interactions, labour and land loaning or sharing schemes are necessary in coping with drought.³³ Similarly, institutional capacity and structure in supporting larger community-wide efforts has also been shown to be necessary. Emerging research on adapting to climate change lends support to these historical lessons, and points to the need for the development and maintenance of supportive and informative networks and adaptive capacity of communities and individuals.³³

Drought and climatic variability is reflected in our production systems with changing production levels and income variability. This variability needs to be managed, particularly with regard to drought where the economic repercussions can be devastating. For better financial stability, farming strategies need to take cognisance of the constraints imposed by climate and manage with the aim of having systems that are both economically and environmentally sustainable.

Financial stability will dictate responses. Wealthier farmers are better buffered against the impacts of drought.³³ By contrast poor farmers are at greater risk from the impacts of drought as they are more dependent on climatic conditions and have less ability to access other resources that would reduce its impact.³³ Paradoxically, while wealthier farmers are generally better able to endure droughts than poorer farmers, the latter are, in fact, better adapted to drought, often taking a proactive approach in adopting diverse income alternatives in anticipation of drought.³³

Policies relating to land reform, land restitution and redistribution must include drought-coping mechanisms. Putting people on land without these identified drought-proofing strategies will result in a failure to meet restitution and redistribution ends, evidenced in bankruptcy, land sales and degradation.

History shows us there are a number of ways to respond to the spatial and temporal variability inherent in drought stress. Most future scenarios suggest that the South African agricultural landscape is going to become increasingly heterogeneous and variable. For example, gradients in vegetation responses to drought, coupled with grazing, have been found to be intensifying over the long-term in northern Botswana.⁴⁴ Agricultural response strategies to drought need to recognise the social diversity of these landscapes and be flexible enough to incorporate differing objectives, priorities of the farmers and opportunistic patterns of management.¹³

Conclusions

Drought has been around and responded to for as long as people have utilised the resources of southern Africa's arid landscapes. This is reflected in utilisation patterns of the past. Drought highlights social and biophysical connectivity, and coping with and adapting to drought requires acknowledgement and engagement with both these elements. A more recent analysis of drought response by the state reflects South Africa's history of racially-developed, unjust approaches. This era saw considerable reactive support to white farmers during times of drought. While this allowed the continuation of commercial agriculture, it did not encourage pro-active and adaptive developments in terms of enabling farmers to cope with

drought. Future adaptation measures need to acknowledge the importance of social and institutional capacity and be sensitively integrated with current development pathways in order to be sustainable and relevant to local priorities.

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