A decision making model for stable beef production in arid environments

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Abstract

Agricultural activities are depicted as highly dependent on weather conditions. The need to employ risk management strategies is emphasized leading to the aim of the paper stating that a basic qualitative decision making model should be adopted to ensure timely adjustments to weather conditions. Factors affecting production are discussed. Two models adapted to an arid environment as well as their practical application in an actual production scenario are discussed. It is concluded that the incorporation of pro-active decision making models into the management plan contributes towards the stabilization of the production system, while also protecting the grazing resources.

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Introduction

Agricultural production systems are a function of both biophysical and socio-economic conditions (Van de Ven *et al.*, 2003). Producers are increasingly expected to apply production methods that will ensure long-term sustainability of natural resource use and thus also of farming enterprises. Smyth & Dumanski (1993) divided the concept of sustainability into four main pillars, namely; productivity, stability of production, soil and water quality and socio-economic feasibility. Agriculturists, however, concern themselves mainly with the biophysical conditions that affect production systems.

Agriculture has been described as “the most weather dependent of all human activities” (Oram, 1989). Hansen (2002) furthermore stated that year-to-year climate variations pose particular challenges to the management of food production systems and the natural resources on which they depend. This becomes even more challenging in arid regions where the rainfall pattern is erratic. In these regions resources are, apart from being scarce, also vulnerable to degradation (Coetzee, 1971).

Although many agricultural decisions are related to climatic changes, it is often necessary for producers to make these decisions several months before the impact of the climate is realized (Hansen, 2002). The producer must therefore prepare for a range of events that may occur. Due to the scarcity of available resources, the range of possible decisions will inevitably include various tradeoffs to be considered and weighed by the producer (Stoorvogel *et al.*, 2004).

Over the years many mathematical models concerning agricultural enterprises have been developed. The general aim in the development of most of these models was to quantify outcomes based on certain predetermined inputs into the model. Belcher *et al.* (2004) listed many of these models pertaining mainly to crop based agricultural systems. Although most models describing agricultural systems undoubtedly have high academic and scientific merit, it is unfortunately seldom producer friendly. Producers, instead, generally base their decisions on qualitative assessments of vegetation and animal status (Méot *et al.*, 2003). These researchers ascribe this to the fact that the thinking system of producers does not operate on the same knowledge base as that of scientists. Méot *et al.* (2003) also stated that producers make decisions based on two types of information. Firstly, on information relating to the general organization of the farm (layout of the farm and the management of the herd) and secondly on information aiming to adjust to the current year’s condition (weather events, breeding results and opportunities for marketing).

It is often necessary to employ conservative risk management practices that will result in lower average production (Hansen, 2002), but may ensure increased stability of the production system. Extended weather pattern predictions are possible and should be used to reduce climatic uncertainties and to tailor agricultural decisions thereby effectively reducing the adverse impacts of nature (Hansen, 2002).

The aim of this study is to put forward a basic qualitative decision making model. Ideally this model will assist producers to interpret and act on information with the aim to timely adjust to prevailing weather events in an effort to stabilise the production system.

Production situations and factors

Before discussing the model itself, it is necessary to highlight the underlying principles on which an animal production system and thus also the decision making model are based.

Van de Ven *et al.* (2003) identified three basic production situations for an individual animal, namely, potential, limited and reduced production. According to Van de Ven *et al.* (2003) potential production only occurs when all the water and feed requirements (limiting factors) of an animal have been met in the absence of reducing factors such as disease and pollutants.

Cattle have a limited potential to ingest dry matter, and all nutritional requirements must be met from this intake to realize their potential production. The nutritional value of a feed is made up of the various nutrients it contains as well as the availability of those nutrients to the animal (Tamminga *et al.*, 1994).

Growing organisms exhibit a smooth sigmoid growth curve during the growing phase in their lives. A normal smooth sigmoid growth curve is still observed when feed (quantity and quality) and water are limited at a constant rate over the lifespan of the animal. The inflection point in the curve (mature live weight) will, however, be lower and reached at an increased age. If feed and water limitations are sporadically interrupted the sigmoid curve will follow a see-saw pattern (Van de Ven *et al.*, 2003).

In general cattle are kept in herds and not as individuals. Thus decision making at herd level influences the herd dynamics, herd composition and production (Van de Ven *et al.*, 2003). In South Africa most beef herds are kept on pastures. Thus grazing management forms an important and integral part of the production system. Production outputs from these systems are highly dependent on climatic conditions, veld type and stocking rate. Veld type is a relative constant factor at farm level while climatic conditions are dependent on prevailing weather systems and thus both out of the control of the producer. Stocking rate, on the other hand, is solely the result of the management decisions made by the producer.

As grazing pressure is increased through increased stocking rates the competition between animals for available forage increases. When this competition for forage exceeds a certain threshold, the performance of individual animals will decrease, but the production per unit land will increase up to a critical stocking rate (Van de Ven *et al.*, 2003). If this critical stocking rate is exceeded, the production per unit land will decrease.

Factors that the producers can control include the stocking rate, supplementary feeding to the animals and the rotation of cattle between the various camps (Cross *et al.*, 2004). The producer must find a coherent combination of these factors that will ensure optimal production and many satisfactory combinations may exist (Cross *et al.*, 2004). Determination of the best combinations will depend on the available resources as well as labour constraints, and economic targets.

The decision making model

As with any decision making model the main objectives are to initiate active monitoring of the production system and importantly to provide guidelines for actions based on the outcomes of the monitoring actions. The proposed model is intended to serve as a basis that can be adapted to suit individual farming enterprises.

Cross *et al.* (2004) recommended that to maximize production, anticipation of the area to be allocated for grazing, the area to be set aside to cope with weather fluctuations and the quantity of supplementary feeding needed, is required. Thus, the rainfall pattern and the subsequent grass production form the main pillars of this model. The producer must therefore be able to quantitatively estimate fodder production either as the actual weight produced per hectare, the time spent grazing a certain area or any other suitable method.

Although two decision making models are depicted, only the underlying principles will be discussed as it is comparable for both models. In Figure 1 a model based on a weaner marketing production system and in Figure 2 a model based on a 30 month old steer marketing production system, are depicted.

The basis of these models is founded on a regular monitoring of the produced grazing. The outcomes are defined only in terms of mean long-term grass production. The outcome is positive (+) if the grass production is equal to or better than the mean long term grass production and negative (-) if the grass production is lower that the mean long term grass production. It is important not to over-estimate grass production or to ignore the results of the monitoring action in the optimistic hope that the situation will improve. Monitoring should be done at predetermined times of the year. Driving forces that affect grass growth should be used to determine the most suitable monitoring period. These factors include time of the first rain and the duration of the rainy season. The first monitoring action should be conducted at a stage when it can be reasonably expected to have started to rain. The second monitoring action should be done half way through the normal rainy season and for the last time at the end of the rainy season. In the Arid Sweet

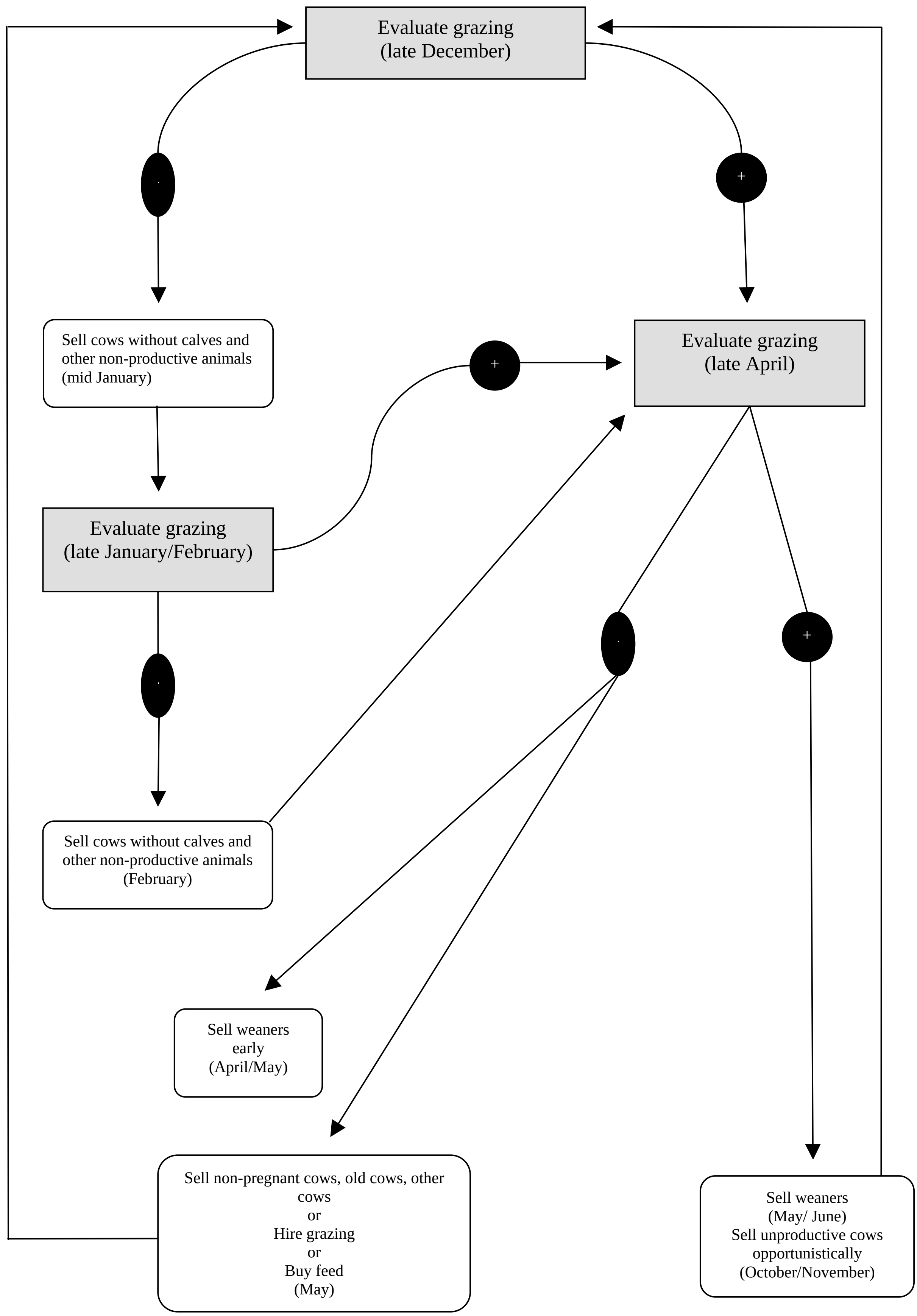

Figure 1 A decision making model for a farming enterprise producing weaner calves

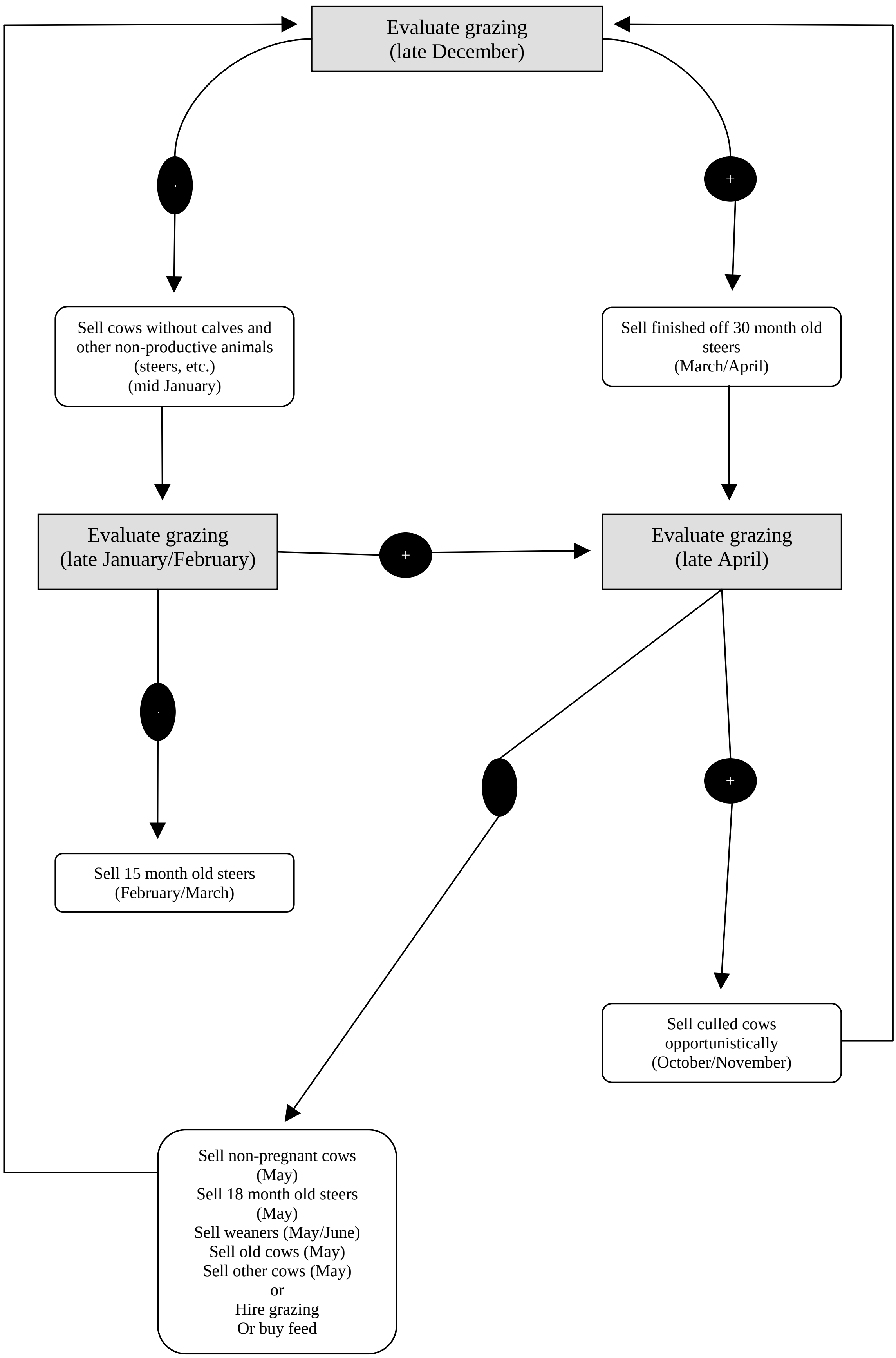

Figure 2 A decision making model for a production beef enterprise producing 30 month old steers

Bushveld these time corresponds with mid December, early February and late April. If the monitoring actions were executed efficiently and the proper actions taken in time, no further monitoring should be necessary until the cycle starts all over again.

Actions should be predetermined, clearly defined both in terms of what the action entails as well as the time frame allowed for each action for the successful implementation of the model. All actions in the proposed models stating that animals should be sold, actually implicate that animals should be removed from the veld. This removal can also include different feeding strategies, and/or various options to enlarge the grazing area. The production system and production objectives will determine the actions that will be needed to adjust to environmental conditions.

Practical application of the decision making model

Figure 3 indicates the number of cattle sold in relation to the rainfall received at the Mara Research Station for the period 1997 to 1999. The trends depicted in Figure 3 are the result of the application of a model similar to the model illustrated in Figure 2. From January to March 1997 high rainfall was experienced resulting in the normal culled animals to be marketed during June to July 1997. However, from November to March 1998 the rainfall was much more erratic and less rain was received than during the early parts of 1997. Consequently animals were sold in November 1997 and again in February 1998. As the rainfall subsided after February 1998 large numbers of animals were sold in June 1998. When the rainfall was normal during the 1998/1999 season, it was not necessary to market animals during the latter parts of 1998 and the early parts of 1999.

The small number of animals marketed at various times of the year was due to animals slaughtered at specific ages for experimental purposes.

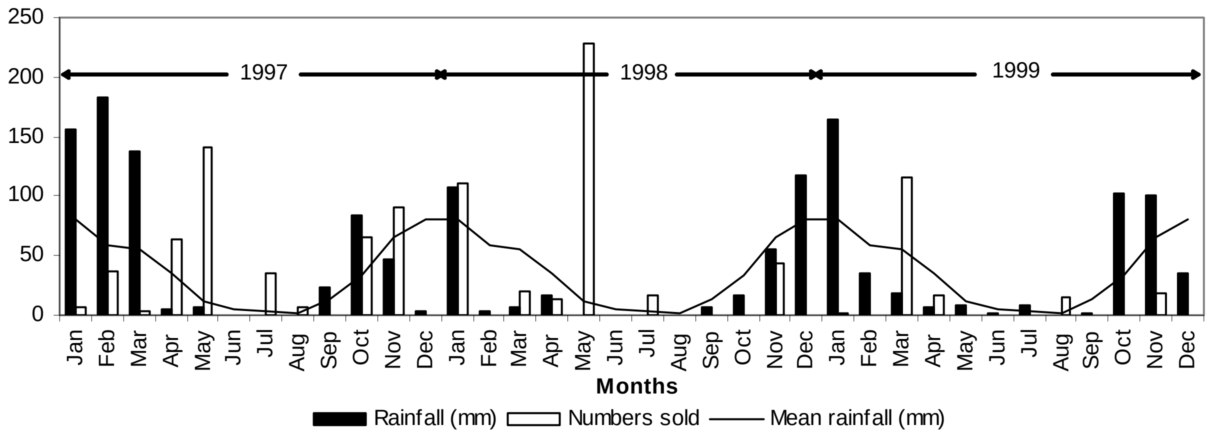

Figure 3 The relationship between rainfall received and the number of animals sold from January 1997 to December 1999

With respect to the total number of animals (as on January 1st of each year) on the Mara Research Station (Figure 4), it seems that the pre-emptive management strategy (applied since 1995) resulted in relatively low fluctuations in animal numbers. Animal numbers dropped to below 600 in 1995 due to sluggish reactions to meagre environmental conditions prevalent during the latter part of 1991 to 1995. Although it is possible, even in arid regions, to circumvent the effects of below average environmental conditions in the short run, the damage inflicted upon the pasture inevitably catches up in the medium term. This is because this circumvention is largely achieved through overgrazing.

The rapid increase in animal numbers in 1996 was due to the relocation of approximately 100 animals from other institutions as well as the commencement of the Mara Veld Bull Club in August 1995. If it was not for this large scale importation of cattle, the recovery period necessary to return to 1994 numbers was projected to be between six and eight years. With a pre-emptive management strategy, animal numbers need not be reduced to the same degree and the recovery period seldom requires more than three to four years. Since 1995 the number of steers and bulls kept at the Mara Research Station was increased while the number of cows was decreased to facilitate rapid adaptations to environmental conditions, hence the lower proportion of calves since 1996.

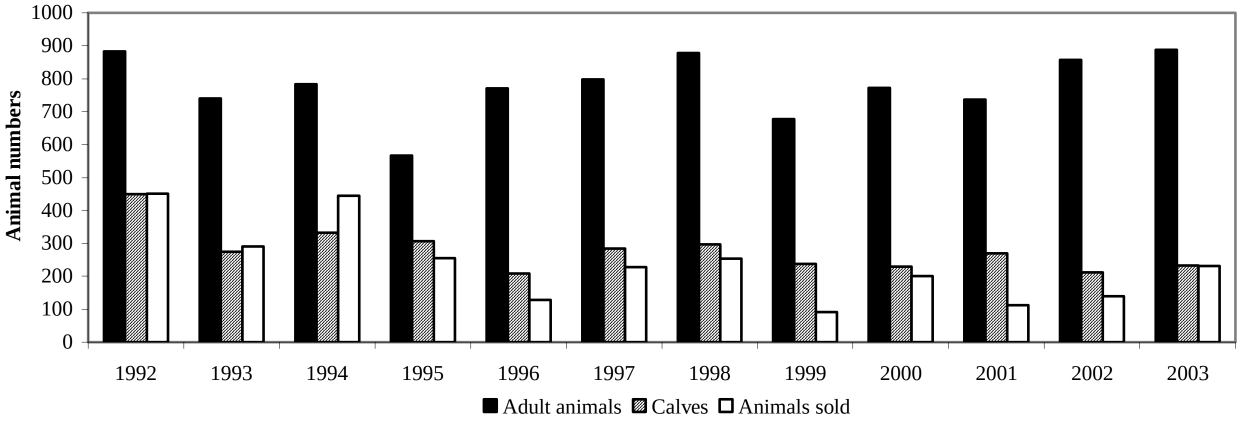

Figure 4 Changes in animal numbers prior (1992 to 1995) and after (1996 to 2003) the adoption of a pre-emptive management strategy

Implementing conservative stocking rates and management practices coupled with a pre-emptive management strategy will limit the expression of the "boom and bust" scenarios as depicted by Hahn *et al.* (1999). "Boom" scenarios occur when animal numbers are allowed to rise to very high levels all through periods characterized by good environmental conditions, while "bust" scenarios occur when animal numbers are not reduced timely during dry periods resulting in very high losses.

Incorporating pro-active decision making models in the management plan of a production enterprise will contribute to limit production losses during adverse climatic conditions and thus to stabilise the production system. Concomitantly grazing resources are protected from over-exploitation.

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