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Determination of Veld Grazing Capacity and Nutrient Potential Using GPS Mapping

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Abstract:
Ten farms from a Smallholder Dairy Sector (SDS) were surveyed based on their nautical location relative to the Marirangwe Milk Collection Centre. Grass samples were taken by randomly throwing a one by one metre quadrant every 40 paces along a transect line on each farm. All the grass that fell within the area of the quadrant was cut at 5cm (approximate grazing level), identified by species and as palatable or unpalatable, bagged and weighed separately. A Global Positioning System (GPS) was used to take coordinates of the points each quadrant was thrown in order to derive a species map based on presence or absence of the species. This was done using moderate resolution imaging spectroradiometer (MODIS) satellite images. After converting the data into binary format, mapping was done using Integrated Land and Water Information System (ILWIS) version 3.3 GIS environment (Enschede, 2005).
It was found that there was a significant relationship between the Normalized differential vegetative index (NDVI) and the presence or absence of four species (P< 0.005) and these were Sporobolus pyramidalis (17% probability of occurrence), Heterogon contortus (18%), Stylosanthes guianensis (5%) and Eragrostis spp (9%).
Calculations of the potential palatable yield showed that the prevailing stocking rate (12 ha per Livestock Unit) of the veld in Marirangwe was under stocked and had a potential of meeting the metabolisable energy needs of 7,285 LSU in January when the veld is in peak nutritional condition.
It was concluded that the natural veld in Marirangwe had the potential of supplying adequate nutrients to the number of milking cows throughout the year, but there was need to harvest and store the grass, manage rampant burning and supplement the cows with other homegrown fodder in order to have a more year-round milk supply pattern.

1. Introduction

Marirangwe is a smallholder dairy farming area in Mashonaland East Province in Zimbabwe. During the period of the study, the average herd size for farmers was 11 livestock units (LSU) and there was a total of 209 dairy cows. Considering that there were 30 active farmers in the area, and using a general stocking rate of one LSU per five hectares, the number of cattle did not appear to pose a serious threat of overgrazing. The estimated pastoral land area shared amongst the dairy farmers was about 2600 ha which therefore allowed for an average herd size of 17 LSUs per household. However, the fact that overgrazing and overstocking are not synonymous terms is generally overlooked (Acocks, 1990).

The overall stocking rate on paper may appear very low, but the actual local stocking rate, as regards the few palatable species or the small patches of veld which are actually being grazed, may be excessively high. If the overall stocking rate is, say one LSU per 5 ha, but the cow grazes only 10% of the vegetation, then the actual stocking rate on this most valuable part of the vegetation is really one cow per 50 ha. The land may not be overstocked, but the best part of the vegetation is overgrazed. Another fact that is generally overlooked is that palatability is not absolute. Palatability of a plant can be affected by a number of factors, for instance, the species and breed of the grazing animal; local variations in soil and climate; the abundance of other species either more palatable or less palatable, and the stage of growth, fresh young growth, as a rule, being more palatable than old woody growth. The overriding factor is, however, intensity of stocking: the greater the number of animals, the less choosy they become and the smaller the proportion of species of plants found to be so unpalatable as to be completely ungrazable. This is an important consideration in the practice of controlled strip grazing or establishment of well defined paddocks. The main focus of the study was to establish the potential carrying capacity of the natural veld of the area during the period of sampling. By so doing, we would be able to know whether the highly seasonal nature of milk production by the SDS is due to insufficient natural veld, and best recommend management practices that would enhance greater veld-use efficiency of this available resource.

2. Materials and Methods

1.1. Data Collection

In the rainy season, the focus of analysis was on the natural veld which accounts for 95% of feed used by the small-scale dairy farmers as gathered from the quantities of concentrates bought from the MCC. Approximately 30% of the farmers (10 farms) with a total area of about 900ha were selected for veld sampling, as an attempt to sample all the farmers would have proved to be a tedious and unpractical endeavor. The ten farms were selected based on the premise that the farms were located within the three areas around the MCC which represented the locality of active milk producers. From each of the northern, southern and western boundaries, three farms were sampled and one farm from the eastern border (as this was the only farmer supplying milk to the centre due to distance constraints). On each farm, the farmers would physically indicate where their cattle grazed. Transect lines were then established so as to systematically sample these natural pastures. These transects were done by establishing the longest diagonal points of a particular grazing area, and thereafter further establishing the opposing diagonal points. By so doing, each of the grazing areas was sampled as a four cornered area with two imaginary diagonal lines along which the sampling was done. Due to the size of most of the grazing areas, physical rope-lines were not used in marking the transects, but rather marks pegged at either end of the field were followed.

Sampling of the grasses was done by pacing forty steps along the predetermined transect lines and throwing a 1m by 1m quadrant behind the sampler's back in an unbiased manner. All the grass species that fell within the quadrant were then cut about 5cm from ground level and identified as palatable or unpalatable species. Classification of species as palatable or unpalatable was accomplished through the aid of a grass identification field book, and through farmers' knowledge as to which grass types the cattle generally grazed willingly, and those which they did not. These different categories were then weighed at the end of sampling from each farm and noted. Each transect was determined by the accessibility and size of the veld area.

1.2. Global Positioning System (GPS) Data

A GPS receiver was used to measure the location of grass species found in the study area. The GPS data collected were converted into a binary format in Microsoft Excel spreadsheet. Where certain grass species were present, the binary representation was one and where it was absent it was given a zero. The GPS data was then converted into a point map in a Geographical Information Systems (GIS) environment.

1.3. Remotely Sensed Data

Moderate resolution imaging spectroradiometer (MODIS) satellite images of the 7th March 2009 were selected and downloaded from, the National Aeronautics and Space Administration (NASA) website; http://www.nasa.gov/ntv. Normalized difference vegetative index (NDVI) was used as a surrogate measure of the grass biomass. NDVI is calculated as follows:

$NDVI = NIR – R / NIR + R$,

Where NIR is the Near Infrared band and R is the red band of MODIS satellite image. MODIS was used in this study because it is cost free and has a near daily temporal resolution coverage, which is relevant for mapping plants which are constantly changing in terms of their biomass. An overlay function of MODIS derived NDVI and the point map derived from GPS points was conducted to get NDVI values for each GPS surveyed point where each grass species was identified in a GIS environment.

1.4. Spatial Logistic Regression

After calculating the NDVI for each species, the grass species were converted into a binary format where each species was given the value 1 where it was present and 0 where it was absent. The binary data were then used in a logistic regression so as to establish whether there is a relationship between the NDVI and the presence of each species using the formula;

$y =\beta 0+\beta 1xi+\varepsilon i$

where y is the probability of occurrence of each grass species, $\beta 0$ and $\beta 1$ are coefficients of the logistic regression equation, and is NDVI. Grass species with a significant relationship between its greenness and its presence were used for mapping in Integrated Land and Water Information System (ILWIS) version 3.3 GIS environment (Enschede, 2005). The results were maps showing the distribution of the probability of occurrence of each grass species. The next step was to extract the areas with a high probability of occurrence of each grass species. Finally, the significant relationships between NDVI and the presence of selected grass species were presented graphically.

1.5. Estimating the Potential Yield, Energy Contribution and Carrying Capacity of the Natural Veld

The total area covered by all the quadrants that were thrown throughout the sampled farms and the weights of the palatable and unpalatable species were used to extrapolate the potential bulk yield of the veld. This was done by converting the total sampled area of the quadrants into hectares using the formula:

Ha covered by quadrants = total area in m^2 / 10 000m^2

Calculations were then made of the veld yield, on dry matter basis, by multiplying the weights of the palatable and unpalatable species by the total area available for grazing. To come up with the potential yield contribution, the veld at that particular period, an average of 8.1 MJ / kg DM basis was used for the grass, as determined through the results from the laboratory analysis.

3. Results

Significant relationships were established on four species identified as predominant in the sampled areas. These were *Sporobolus pyramidalis*, *Heterogon contortus*, *Stylosanthes guianensis* and *Eragrostis curvula*. Other grass species were identified but showed no significant ($P > 0.05$) relationship with the NDVI. All the species identified and the amounts of palatable and unpalatable species for each farm are indicated in Table 1. The weights of both the palatable and unpalatable species were obtained from harvesting the grass that was captured within the quadrants.

Figures 1 to 4 illustrate the derived satellite maps for the four predominant species. Within these maps, the black dots show where the samples were taken. Figure 5 shows the logistic regression graph for the probability of occurrence in relation to the NDVI for each species.

FARM No.	PREDOMINANT SPECIES	PALATABLE (kg DM)	NON PALATABLE (kg DM)
F3	*Sporobolus pyramidalis*, *Heterogon contortus*, *Stylosanthes guianensis, Hyparrhenia* spp.	0.98	0.098
F8	(a) *Dactyloctenium giganteum*, *Digitaria* spp., *Loudetia* spp., *Tristachya leucothrix*	3.43	0.343
	(b) *Digitaria* spp., *Loudetia* spp., *Tristachya leucothrix*		
F14	*Cynodon dactylon*	0.49	0.147
F17	(a) *Hyparrhenia* spp., *Sporobolus pyramidalis*	0.98	0.049
	(b) *Hyparrhenia*/ siratro mix		
	(c) Sedges, *Cynodon dactylon, Hyparrhenia* spp.		
F28	(a) *Sporobolus pyramidalis, Eragrostis* spp., *Loudetia* spp.	0.98	0.147
	(b) *Sporobolus pyramidalis, Hyparrhenia* spp.		
F40	*Cynodon dactylon, Andropogon eucomus, Eragrostis* spp., *Heterogon contortus, Hyparrhenia* spp., *Paspalum scrobitulatum*	0.98	0.147
F45	(a) *Sporobolus pyramidalis, Hyparrhenia* spp.	1.225	0.098
F46	*Sporobolus pyramidalis, Cynodon dactylon, Loudetia* spp.	1.47	0.098
F57	*Sporobolus pyramidalis, Eragrostis* spp.		
F69	*Heterogon contortus, Digitaria* spp.	0.98	0.147
Total		**11.5**	**1.3**

Table 1: Predominant species captured and weight (kg) of species

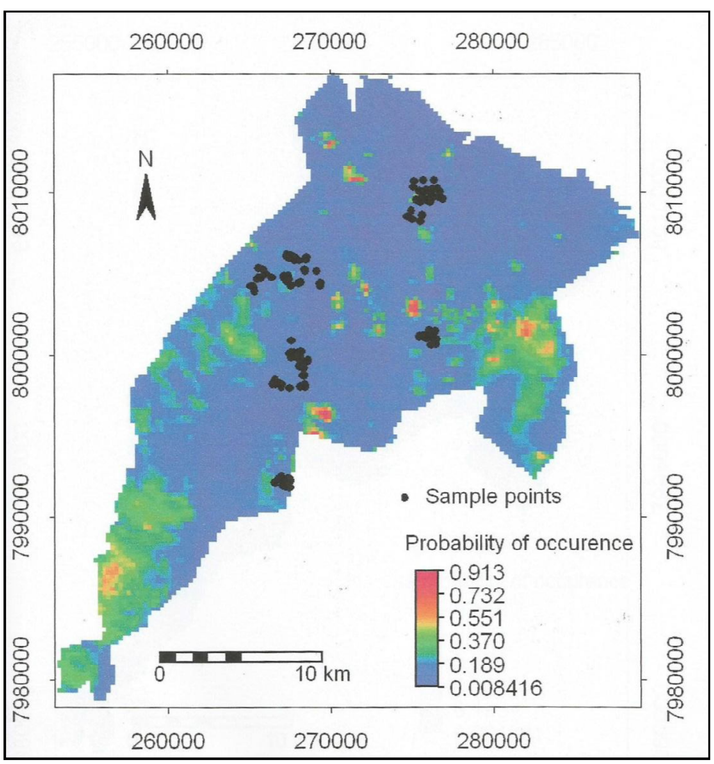

Figure 1: Probability of occurrence of Sporobolus pyramidalis

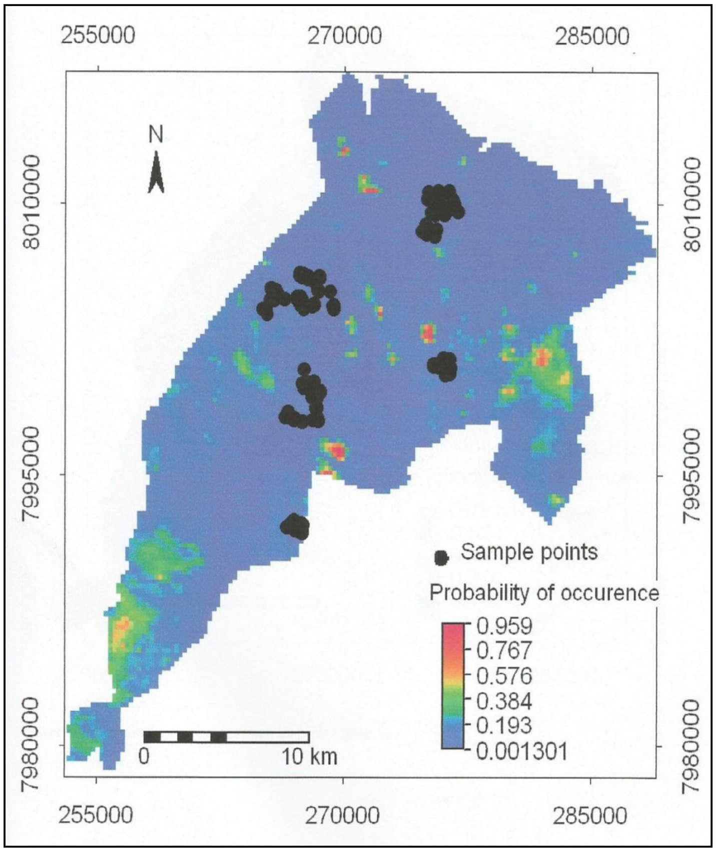

Figure 2: Probability of occurrence of Eragrostis spp.

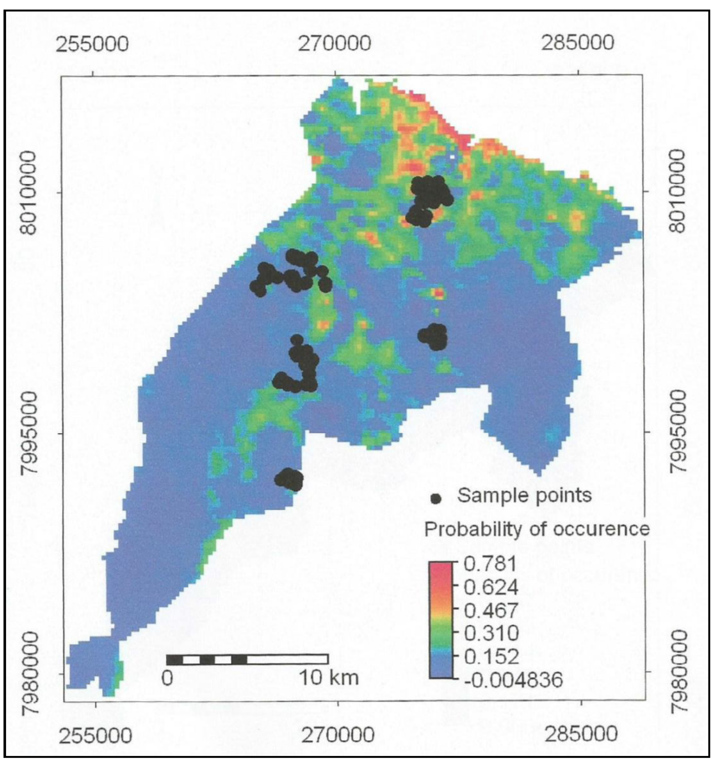

Figure 3: Probability of occurrence of Heteropogon contortus

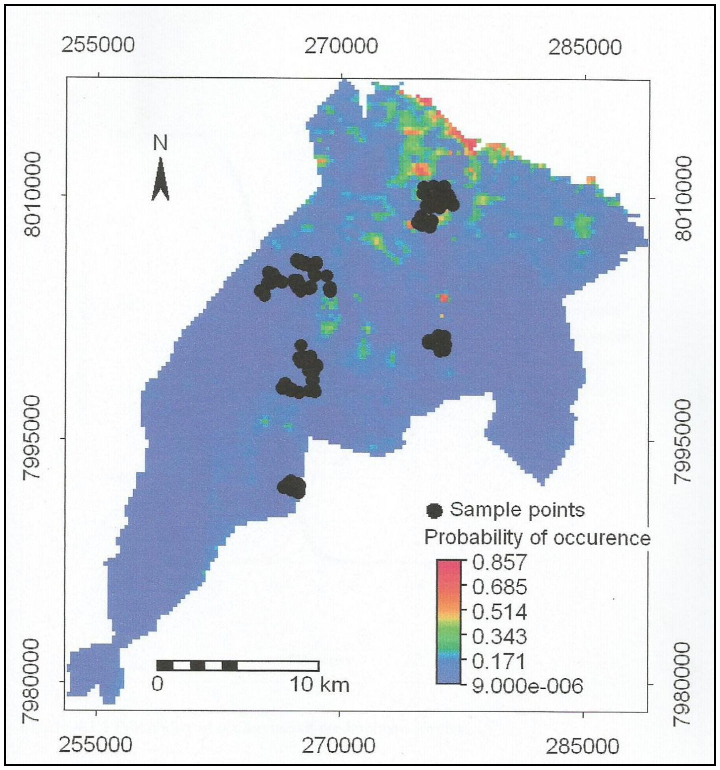

Figure 4: Probability of occurrence of Stylosanthes guianensis.

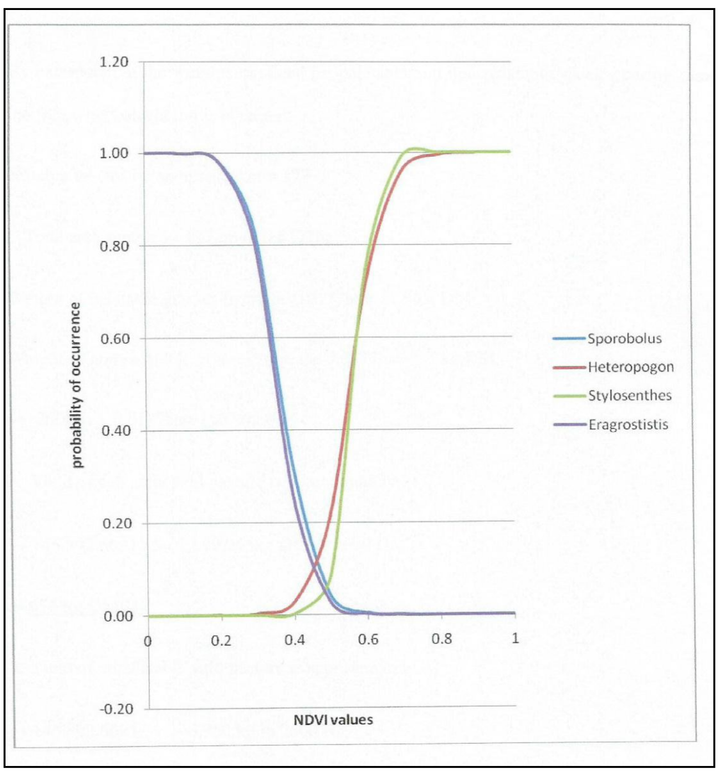

Figure 5: Probability of occurrence of predominant species.

3.1. Available Bulk Veld during the Rainy Season

By extrapolating the weights obtained for palatable and non palatable species during sampling, the following calculation is obtained.

Number of 1m x 1m samples taken = **177**

Hence Total area sampled = 177 m^2 or 0.0177 ha

Weight of palatable grasses from the 0.0177 ha = 11.5 kg DM

Weight of non palatable grasses from the 0.0177 ha = 1.3 kg DM
→2600 ha ÷ 0.0177 ha = 146 892.66
Therefore yield of palatable veld pasture is approximately,
→ 146 892.66 x 11.5 = 1 689 266 kg DM in 2600 ha
= 650kg DM / ha
Yield of unpalatable veld pasture is approximately,
→ 146 892.66 x 1.3 = 190 960 kg in 2600 ha
= 73 kg DM / ha
→ Average ME (MJ/kg) of the natural grasses is 8.1 MJ/kg
Therefore ME available in palatable veld is,
650*8.1 = 5 265 MJ / kg DM /ha
Unpalatable portion: 73*8.1 = 591.3 MJ / kg DM /ha
Therefore since the potential grazing capacity of this veld type is set at 1 LSU / 5 ha (Rattray, 1957), then the 2600 ha available to the Marirangwe farmers can accommodate 520 LSU. If the above calculation holds true, it therefore means that 209 dairy cows in Marirangwe would approximately require the following ME requirements in January (when the grass samples were taken):
→ 1 cow requires 1879 MJ / kg ME DM
→ Veld potential yield = 5 265 MJ / kg ME DM
→ 5 265 * 2600 = 13 689 000 MJ / kg ME DM
→ 13 689 000 ÷ 1879 = 7 285 cows.

4. Discussion

The natural veld available to the farmers of Marirangwe can be classified as *Hyparrhenia* veld type 2a according to classification of Zimbabwean grassveld types (Rattray, 1957). The major threats to the potential of the natural veld are predominance of unpalatable increaser species such as *Sporobolus pyramidalis*. Veld that is characterized by a large presence of such grass species is indicative of a history of overgrazing and or erosion.

From the results obtained from the sampling and the remote GPS analysis, it was likely that *S. pyramidalis* occurred in 17% of the area captured under satellite imagery. With a decrease in the NDVI, which measures the vigour of plant growth (greenness), there was an increase in the probability of occurrence of *S. pyramidalis* and *Eragrostis* spp. Both these species tend to thrive in areas of patchy grasslands that are associated with overgrazing. As the NDVI values increased, the probability of occurrence of these two species reduced. This trend was the opposite of *Heterogon contortus* and *Stylosanthes guianensis* which both tend to thrive in veld types characterized by luxuriant biomass (Tainton, 1999).

Despite the fact that the stocking rate at Marirangwe appears to be acceptable for this veld type, the actual grazing capacity needs to be determined. By extrapolating the weights of the palatable and unpalatable species, an estimate could be made of the approximate yield potential of the grazing area. In essence, this would mean (theoretically) that if the total 2600 ha was allocated only to dairy cows, and the veld nutritional value remained as it was in January, it would have a potential carrying capacity of 7 285 cows. The grazing area would be able to meet the cows' energy requirements at the prevailing level of production. In practice, however, it is not possible due to a variety of factors such as:

The seasonal variation in the nutrient composition of the veld decreases markedly from the rainy to the dry season;

Dairy cows are not the only livestock kept on this area;

Approximately 52% (as attained from satellite imagery) of the area is comprised of vegetation other than that for which a significant NDVI value can be established. This is most likely to be woodlands, water bodies, roads and other infrastructure;

The veld is continuously being grazed and therefore a static biomass yield is impossible;

A significant amount of the veld is lost through burning, trampling, encroachment and/or used for other purposes by man.

If it were postulated that only ¼ of the total veld area were available for milk production, however, the veld (at that time of the year) would still be able to supply adequate energy requirements for 1800 cows, far above the prevailing dairy herd with a potential excess of 1600 LSU. This is of great significance in understanding the huge disparities between the condition and production of cows in the smallholder settings from the rainy to the dry season.

The dry matter, chemical composition and potential stocking rates obtained, tend to conform to findings at Matopos Research Station based on veld recommendations for veld that is being grazed (Gammon, 1976). Gammon, (1976) concluded that veld is most suitable for dairy production in spring and early summer (i.e. up to January, or February, on sweet veld provided it is abundant and intake is not restricted. After January, or February, the levels of digestible crude protein (DCP) and total digestible nutrients (TDN) were too low to be of use for milk production without some form of dietary supplementation (Gammon, 1976). From research such as that conducted at both Henderson and Matopos Research Stations, it was found that the natural veld in Zimbabwe loses approximately 74% of its DCP from September through October (Elliot and Folkertson, 1961). This has a negative impact on voluntary feed intake of the cow as this would mean that the cow would require large amounts of forage that is high in undegradable fibre and would therefore not be able to meet its daily nutrient requirements on the account of limited reticulo-rumen capacity (Campling and Lean, 1983; Mupeta, 2000).

5. Conclusion

At the levels of milk production existing during the period of the study, the natural veld in Marirangwe has the potential to sustain dairy production in the summer season only. The rapid decline in the nutritive value of the veld from January to October makes dependence on the natural veld to meet maintenance requirements and sustain milk production not possible. The cows would literally be milking 'off their backs' in order to produce milk as long as the major portion of their feed is the nutritively low veld, characteristic of the dry season. If, however, the veld was harvested before the nutrient levels diminish and proper veld managements systems adopted, the veld could prove to be a sustainable means of nutrient supply for the cows in Marirangwe and ensure a more annual milk production trend.

6. References

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