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Kenya Agricultural Research Institute

2012

International Journal of Economics and Management Sciences
Vol. 1, No. 12, 2012, pp. 29-43

MANAGEMENT JOURNALS
managementjournals.org

A DEMAND ANALYSIS FOR SAHIWAL BREEDING ANIMALS FROM THE NATIONAL SAHIWAL STUD (NSS) BETWEEN 1971 AND 2007

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ABSTRACT

The main objective of this working paper is to trace the development of demand for Sahiwal breeding stock over the period 1971-2007. Such an analysis will enhance our understanding of what has happened on the demand side within the study period. There is only a handful of Sahiwal breeding farms existing in the country, which implies that a particular market structure exists. This paper thus traces the likely evolution of demand and provides some insights on what has happened over the period since 1971. The year 1971 was upon decided as a starting point for the simple pragmatic reason that data for earlier years may not be available. Demand indicators assembled from the records at KARI-Naivasha are used to establish the trends of demand in order to predict the likely trajectory of demand in the near future. Time series analysis of data shows the probability of demand for bulls to have been on a downward trend while for heifers, it has been increasing over time. Also critical in this result is that the probability for heifer crosses is soon catching up with demand for heifers and bulls and given these trends, this may be the animal in greatest demand. Results for average request sizes are mixed with an increase in the size of requests for bulls and heifer crosses until 1990s and a drop in the size of requests since. Some parts of the country also appear to have dropped off, notably Coast Province while others (North Eastern) are rare demand centres. A second part of the analysis, which involves the estimation of models that explain these trends, provides a framework within which the role of important demand shifting parameters such as prices, production systems and distances is determined in greater detail.

Keywords: *Stock Breeding, Sahiwal, Commercial Dairy Production, Milk Production.*

BACKGROUND INFORMATION

The Sahiwal was introduced in Kenya in 1939 and the National Sahiwal Studies (NSS) was set up in 1963 to develop the breed for use as a dual purpose animal (beef and milk) suitable for the semi-arid environments of Kenya and to develop appropriate management systems for the breed (Mpofu and Rege, 2002). The breed was imported from Pakistan and India. The breeding stock, mainly bulls, were imported, maintained and used for upgrading zebu cattle at thirteen livestock improvement centres, namely: Ngong, Kabianga, Baraton, Maseno, Sang'alo, Chebororwa, Machakos, Ndomba, Chemeron, Katumani, Mariakani, Naivasha and Marimba. The first three bulls were imported from Pusa (India). After 1945, 60 Sahiwal bulls and 10 Sahiwal cows were imported from Jahangirabad (Pakistan) with another importation in 1964 from Karnal (India). The latest importation in 1991 comprised of 1,000 doses of semen from six proven Sahiwal bulls imported from Pakistan. By 1962, there were 2,500 Sahiwal cattle in the thirteen livestock improvement centres (Muhuyi, Lokwaleput and Sinkeet, 1999) and up until 1986, the NSS and El-Karama together held a similar number of Sahiwal animals. The NSS was set up in Naivasha owing to its ecological conditions and size. Following the Swynnerton plan of 1954, commercial dairy production was opened up to indigenous people and part of the plan was therefore to introduce better producing breeds and smallholder herds in medium potential areas were upgraded with the Sahiwal while

European breeds such as the Friesian were used in high potential areas (Ngigi, 2005). Even by 1948, substantial increases in milk yield had been recorded from Sahiwal/Nandi crossbreeds (Smith *et al*., 1996).

In Naivasha, pregnant cows are observed at the lower farm. At the NSS, calves are separated from their dams immediately after birth, weighed and fed with colostrums during the first week and thereafter, whole milk at a rate of 10% of their body weight. They are then weaned at 12 weeks (3 months) at an average weight of 55kg. As weaners (55-125kg), they are rotationally grazed on natural pastures which are adequately supplied with water and mineral licks *ad libitum* when available. At 4 months, males from below-average milk yielding cows and test bulls are castrated and disposed off as fattening steers. Weaners are then branded at 8 months and males and females separated. Heifers (9-36 months) join the dry cow herd (at Ol Magogo farm) and are weighed monthly up to 27 months. Heifers are randomly assigned to test bulls and those that have attained 270kg at 27 months are inseminated and once nearing calving time are ferried to the lower farm where they calve down. Young bulls on the other hand (9-24 months) are transferred to the bull herd (top farm) and weighed monthly up to 24 months after which they are selected for progeny testing on the basis of an index computed from the breeding values of the sire, dam and growth rate of the young bull. Out of 75 bulls from the elite herd, 15 bulls are selected to form a team for progeny testing. Semen is collected and stored at the Central Artificial Insemination Service (CAIS). Bulls are further selected for semen quality and the results used to choose about 10 bulls for progeny testing. Bulls over 24 months are maintained for 6-7 years when progeny test results are available and from the ten bulls, the best two in terms of milk production from their daughters are selected and eventually relocated to CAIS (Kabete) for semen production. Semen from proven Sahiwal bulls is used locally and surplus exported.

The Sahiwal is bred for both milk and meat in an effort to improve the productivity of local breeds (zebu). Among traits considered important by breeders include milk production per lactation, reproductive efficiency, growth potential, adaptability, udder conformation and temperament which are traits that the Sahiwal is credited for (Muhuyi *et al*., 1999). Discussions with pastoralists in Kajiado for instance report substantial tradeoffs between local cattle (zebu) and exotic breeds e.g. Sahiwal which are comparatively less resistant to drought, travel shorter distances, require more forage and can be more susceptible to disease while being more expensive to purchase and these tradeoffs are well understood by the pastoral farmers (Boone *et al*., 2006)[1]. The animal is docile and has been bred for milking without a calf at foot.

STATEMENT OF THE PROBLEM

The NSS is currently composed of 1,200 plus heads of different sex and ages. The supply of Sahiwal to farmers is supplemented by private farms[2], most of which are in the Rift Valley. Breeding material is disseminated through the sale of live stock by the NSS at Naivasha and also through artificial insemination by the Central Artificial Insemination Station at Kabete. The Sahiwal breed has been the *Bos indicus* breed most frequently used in dairy crossbreeding in Kenya. Between 1970 and 2007, out of a total 18,500 records at the NSS, over 6,498 heads have been sold to farmers in order for them to upgrade their local herds. The breed has been somewhat popular with stock keepers mainly from the marginal areas under conditions where some breeds such as Friesians find it difficult to survive. These include districts such as Kajiado, Narok and Transmara. For instance, in 2000, 12% and 8% of households in Kitengela reported owning pure Sahiwal bulls and cows respectively while indigenous/Sahiwal bull and cow crosses were reported in 30% and 26% of the households (Kristjanson *et al*., 2002). Many of the farmers reported in these studies have in great likelihood sourced their Sahiwal breeding stock from the NSS which holds one of the largest herds of pure Sahiwal in the world. In addition, all Sahiwal bulls held at CAIS for the production of semen have been bred from the NSS.

The utilization of AI is still generally low, even for the Central Highlands noted for its lead in dairy production (Bebe *et al*., 2004), where in the late 1990s, AI use was estimated at about 20% (Omiti, 2002). While other estimates put it at 52% among smallholder farmers, it is likely that preference for natural bull service even for the Sahiwal will prevail at least in the short term. Gamba (2006) puts the prevalence of bull service at 70%. In fact, the slow growth of the dairy sector in Malawi, Zambia, Tanzania and Zimbabwe is partly explained by failure or unavailability of AI services.

[1] The Pastoral production system in Kenya occupies 62% of the country with agro-pastoral taking up 20.5% and mixed systems taking up the remainder (Cecci et al., 2009).
[2] The major breeding ranches in Kenya have included El Karama Ranch, Kilifi plantations, Cerdavale, Deloraine and Illkerin Project at varying degree of intensity and have similarly sourced their foundation stock from the NSS over the period.

Artificial Insemination has been in use in Kenya for several decades being the first country in East Africa to use the technique in 1946. In 1986 there was a major policy change, which introduced cost sharing in Artificial Insermination (A.I) service provision that were hitherto subsidized through Kenya National Artificial Insemination Services (KNAIS). This set the framework for privatization of A.I services with Dairy Co-operative Societies, A.I self-help Groups, Private Veterinarians and Private Inseminators providing the services. The performance of KNAIS continued to decline even further and by 1992 the number of inseminations had dropped to 200,000 from 548,000 in 1979. However some improvement has been noted and by 2008, semen distribution was around 550,000 doses from roughly 200,000 in 1999. At the moment, Kenyan imports of bovine semen are estimated to be growing at 11% annually with the US sharing 73% of this market dominated by 5 suppliers viz.; American Breeders Service (ABS), Worldwide Sires Ltd., Cooperative Resource International (CRI), Alpha Genetics, and Sierra Besert Breeders Ltd valued at US$1.6 million (Kamau *et al.*, 2008)[3]. Local semen (20%) is provided by the Kenya National Artificial Insemination Services (KNAIS[4]) and is perceived by farmers to have a high failure rate. Sahiwal semen price ranges between KES 70 and KES 90 at CAIS. Currently, CAIS holds 4 Sahiwal bulls from which they sell (80%) to private A.I service providers who include private veterinarians, private inseminators, A.I self-help groups and Dairy Co-operative societies, private and institutional farms and has about 30 agents spread out in mainly dairy producing areas of the country.

Breeding services account for just under 2% of the total cost of milk at the farm gate with feeding accounting for over 50% (Land 'O Lakes, 2008). Despite this, AI use is still generally low and even for the Central Highlands noted for its lead in dairy production and was estimated at about 37% with the rest using bull service (Bebe *et al*., 2004)[5]. Yet, A.I is credited to have led to the development of the country's dairy herd. However, 54% of households prefer AI and its low use (actual use) is attributed to constraints of low availability and perceived high costs[6]. Others are put off by increasing vulnerability to disease with exotic blood, failures to conceive under A.I deriving from a combination of short oestrus of zebu cows and the unreliability of motorized runs. Usually, the detection of oestrus is crucial and it may be conveniently done during communal grazing under herd conditions (Galloway *et al*., 2003).

Farmer education on heat detection methods, adequate feeding, observation of cows for heat signs, identification of cows truly on heat and recording the time of heat observation and if possible informing the inseminator the time of first heat detection is called for as there exist aids to heat detection such as tail paint, heat mount detectors, teasers and heat synchronisation which may be used under certain economically warranted situations (ibid). In Tanzania, the National Artificial Insemination Centre, established in 1976, has recently been forced to reduce its prices since farmers were not keen on taking up A.I though prices offered are far less than world standards[7]. Among dairy farmers in Uganda, several factors hinder the use of A.I and these include farm level cost of A.I services, farming experience, herd size, and cattle breed (Kaaya *et al*., 2005). In Botswana on the other hand, just as in Kenya, farmers appear to prefer breeding bulls to AI (Makenzi *et al*., 2004). Nonetheless, breeding services are important in maintaining and improving livestock herds. For the Sahiwal, the NSS has been unable to satisfy demand for breeding material.

This paper therefore examines the requests (henceforth reported as 'demand') for Sahiwal breeding stock from KARI-NSS since the 1970s to present. The interest is occasioned by the inability of the NSS to service all requests for Sahiwal breeding animals combined with the feel that natural bull service is a preferred method at present. The 'demand' for Sahiwals over the past is reviewed and various estimations attempted for the future demand projections as well as a proper location of Sahiwal supply points within the country. A brief discussion of these results is made and areas of further work suggested in forecasting future demand.

[3] UN Statistical data however reports a value of no more than US$200,000.
[4] Formed 1966 for the purpose of expanding the coverage of AI service provision in the country to meet the increasing demand
[5] Others estimate usage of bull service at 81% in Kirinyaga, Molo and Rachuonyo Districts where 63% of these actually choose the bull to serve (Baltenweck et al., 2004)
[6] Ouma et.al. in Narok report non use of AI as attributed to its unavailability. In a recent milk shed assessment, farmers from Kericho, Bomet, Sotik, Koibatek, Keiyo, Nandi North, Nandi South and Trans Nzoia indicate prohibitive costs and long distances from the market centres where AI service providers are located as well as few AI service providers.

[7] The Mpwapwa breed (10% Ayshire, 62% Red Sindhi/Sahiwal the rest Zebu) in Tanzania developed 1958 is still not adopted due to absence of a clear policy on their dissemination and an important constraint to the use of AI has been the absence of necessary infrastructure for an extensive AI scheme.

MATERIALS AND METHODS

Description of Data and Data Sources

With no better database on which to base demand projections, data is assembled from the records archived at KARI-National Animal Husbandry Research Centre, Naivasha. Records are in the form of letters written to the NSS from different farmers over the period. These letters detail requests for Sahiwal breeding animals addressed to the NSS. The records were tabulated noting the dates when these requests were made as well as the number of breeding animals requested for, while also noting, where indicated, the proximate location of the requesting farmer and the sex of animal required. The records therefore show that the demand can be classified broadly into 5 viz.; bulls, heifers, heifer/bull crosses and steers. A total of 802 usable individual requests were retrieved from these records from a total 184 different addresses. Several years of data are however unavailable[8].

Some of the letters indicate general requests (no details about whether the animal(s) requested are male or female while others do not mention the number of animals requested. Hence, the details contained (where given) are extracted and the assumptions below made:

a) If breeding animals are requested with no reference to sex, then it is assumed that the request is in reference to breeding bulls.
b) If cows are mentioned in the request, then it is assumed that these are pure breeds (not crosses).
c) Cross breeds are assumed to be Sahiwal crossed with other breed.
d) All steers are assumed to be Sahiwal.
e) No repeat requests are made by individuals i.e. if there are 20 individual requests from address x, then this represents 20 different individuals.
f) All enquiries for animals without specific numbers quoted were also regarded as potential demand but entered as missing data.

All the above data was therefore sorted and entered into a spreadsheet and various SAS procedures used to produce the descriptive statistics presented in the paper.

RESULTS AND DISCUSSION

Description of Size of Demand

From the 802 requests, 5,531 animals were requested from the NSS yielding a rough estimate of 6-7 animals per request. Generally, many of the requests (42%) are for 1-2 animals and an additional 20% are composed of requests for between 3-5 and 13% for requests for 6-10 animals (Figure 1). Looking at demand for specific categories, the trend is the same with the distribution heavily skewed (Figure 2-6). The data shows that of these animals, 2,460 were bulls, 2,064 pure Sahiwal heifers/cows, 356 Sahiwal heifer crosses, 604 steers and 47 Sahiwal male crosses. This represents on average, 5 bulls, 10 cows, 4 crosses, 16 steers and 4 male crosses per request[9]. Looking at the number of requests for specific categories, the data shows that 459 of the requests (those with data) were for pure bred bulls and 199 of these were for cows. On the other hand, 82 of these requests were for heifer crosses, 37 for steers with 11 of these requesting for male crosses. A number of these requests did not specify how many animals were requested i.e. 46, 32, 5 and 6 of the requests for bulls, heifers, heifer crosses and steers respectively. At least 89 (11%) of all the requests were for a combination of either of the categories above. On average, the number of bulls requested was 3.25 and a standard deviation of 8.37 (Table 1). For heifers, heifer crosses, steers and bull crosses, the means were 2.7, 0.45, 0.76 and 0.06 respectively with the standard deviations 10.3, 2.54, 5.47 and 0.66 respectively.

Tests for normality are performed on the number of requests (by category) and the results are presented on Table 2 and plots in the appendix. A normal distribution as well as a kernel density curve has been superimposed on these histograms for comparison and give a good visual impression of the spread of these data which validates the results of the non-normality of the data on Table 2. The data reveals a departure from normality, explaining the large variance between the mean and median and all statistics show this (Table 2). Similarly, the data was split into 4 groups, each representing the date (decade) when the report was made. The resulting distributions are also displayed in the appendix.

[8] These are in reference to the periods December, 1978 – June, 1983 and January 1989 - September 1990.
[9] This is in reference to all requests where the sum of counts is divided by f (where f = frequency of all requests for respective categories) and where request>0.

Sources of Demand and Trends

Sources of these requests are tabulated and displayed in the tables and figures on the appendix. There were about 164 different addresses from where these requests emanated. Cumulatively, of the 2,262 bulls requested (from Kenyan addresses), 47% of these requests came from Rift valley followed by Eastern with 19%. On the other hand of the 1,654 heifers/cows, 46.5% of these requests came from Rift valley and 29.5% from Coast province. Similarly, 344 heifer crosses were requested of which 36.6% was from Rift Valley. Nyanza, Coast and Central had 21.8%, 19.7% and 15.1% respectively.

However, between 1972 and 1978, annual 'demand' was 290 animals per year while between 1984 and 1988, this was around 238 animals. Between 1991 and 1999, this figure stood at 200 animals but which fell further to 50 animals between 2000 and 2007. The average number of requests per year was 44 between 1972 and 1978, 28 for both the 1980s and 1990s and 9 written requests per year since 2000. Generally, Rift Valley province has been the source of most of the requests to the NSS (Table 3) representing a cumulative 48% of all requests followed by a distant Eastern Province with 13% of requests. A small number of requests (6%) have also come from other countries especially from within the COMESA region[10]. Tanzania appears to be a consistent out of country demand for Sahiwal animals (Table 4) although the actual figures are quite small.

Locally, North Eastern and Coast provinces have not been represented in this data since 2000. For the coastal region, this trend is more apparent falling from 12% in the 70s to virtually none since 2000. The same trend appears for Eastern province dropping from 17% in the 1970s to 5% between the years 2000-2007. Nairobi on the other hand appears to be gaining importance as a source of requests with time, the low numbers during the 1990s notwithstanding. Females were requested in 35% of the records meaning that bulls have been the preferred sex forming 65% of the requests. Examining the sex of animals demanded from different provinces, Central and Coast show that of the three categories (bulls, heifers and heifer crosses), 33.9% and 27% were for bulls representing a preference for females unlike the other provinces where bulls represented by over 50% of the animals requested. Central and Coast reveal that unlike most other provinces, heifers and cows (as opposed to bulls) have been the preferred sex particularly in these regions possibly for dairy purposes or where extensive grazing is not tenable. Similarly, requests for heifers have exceeded those for bulls since 2000 unlike in the earlier year when bulls seemed to have been preferred.

The stability of Rift Valley in maintaining demand may be explained by the relative proximity of some districts such as Narok, Kajiado and Nakuru to the NSS. Distance from NSS increases acquisition costs but such may not fully explain the fall in demand over time in some of these provinces e.g. Coast. Changes such as declining land sizes in some of the districts could also have directed both the pace and direction of demand.

The requests were tabulated and summed for each quarter starting 1971 and results used to produce a graph of these requests over time (Figure 7). However, the analysis can be looked at category by category and the resulting distributions are shown on the appendix. The average size of the request has been 5.4 heads for bulls but for the decades 1970s to 2000s, the resulting figures are 4.8, 6.2, 5.4 and 8.3 respectively. This represents a rise in the 1980s, a drop in the 1990s and a subsequent rise for the period 2000-2007. For heifers on the other hand, a typical request would be composed of 10.4 heads.

However, splitting the data and analyzing these requests by decade 1970-2000, the respective figures are 14.1, 11.2, 9.1 and 3.7 respectively, signifying a drop in the average size of a request. One point that is clear here is that on the average, the size of requests for bulls is smaller than that for heifers/cows (see Figure 8). This is expected since one can buy one bull to serve a large herd as opposed to one who buys a cow for dairying purposes i.e. for cows/heifers, the bigger the number, the better. Looking at heifer crosses for these periods, the average has been 4.3 animals. The figures are 3.0, 6.2, 4.3 and 3.7 animals for 1970s, 1980s, 1990s and 2000s respectively. This represents a rise in the 1980s and a drop in the average size of the request for subsequent periods. Steers on the other hand show the figures 40.6, 12.4, 11.9 and 17.0 animals for the respective decades. On average, the size of a request for steers has been 16.3. As expected, steers for fattening imply a farmer with enough space for these (usually large farms). Bull crosses do not have any record since 2000 and not surprisingly, the total number of requests has only been 11 with a mean of 4.3 with only one request in the 1970s. For 1980s and 1990s, the figures are 2.8 and 4.3 respectively.

Figure 8 shows the trends in the average request size over the period for bulls, heifers and heifer crosses. No apparent long-term trends are discernible from this figure save that the average number of heifers/cows is larger

[10] These include Tanzania, Sudan, Uganda, Burundi, Somalia, Rwanda, Zambia, Zaire, Comoros and Mauritius in decreasing order of importance.

than that for bulls more so during the 1970s. A major drop for heifers is discernible around the mid 1980s but recovers at the beginning of the 1990s but the average does not level off to that of the 1970s and possible early 1980s. The trend for heifer crosses since the 1970s has also been haphazard. Collectively however, there appear to be years with higher means than others probably mimicking the drought years. To visualize the trend, two smoothing factors (0.2 and 0.8) are used for each category to come up with the graphs shown (Figures 9-x) below. These show that the average size of requests for bulls has an increasing trend over time while the converse is true for heifers[11]. For heifer crosses, there was an increase in the average size of requests but from 1990s the direction has been southwards.

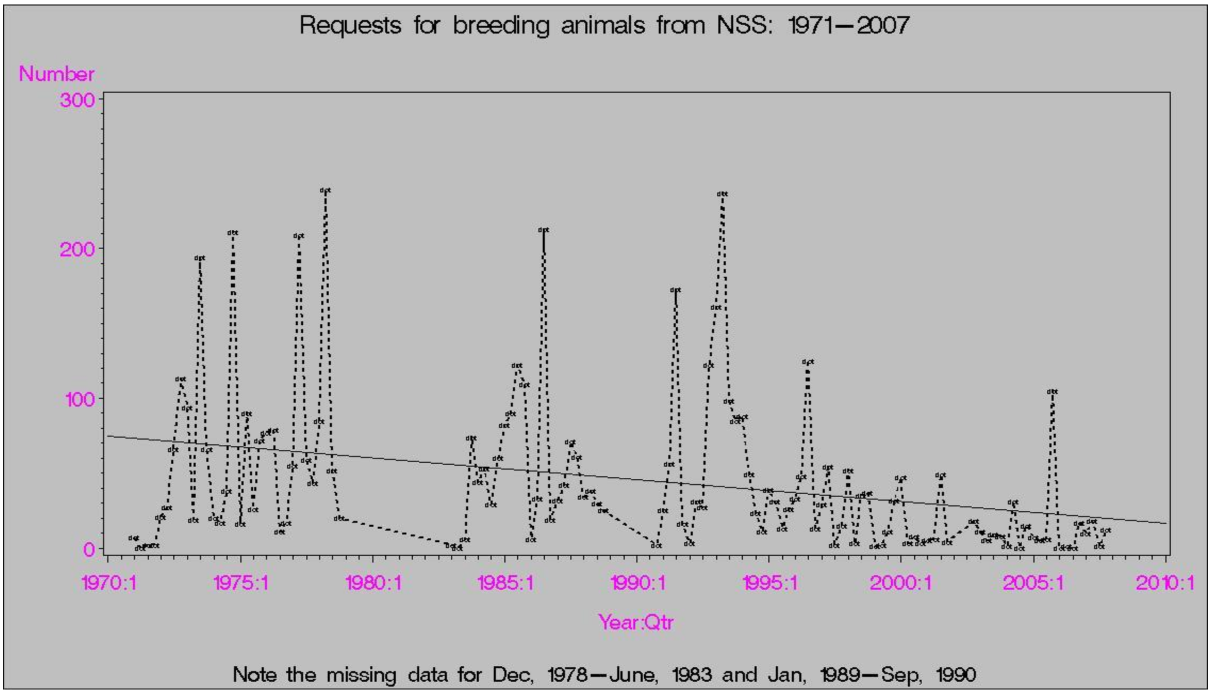


Figure 7: Quarterly 'Demand' for Breeding Animals from NSS over a 37 Year Period

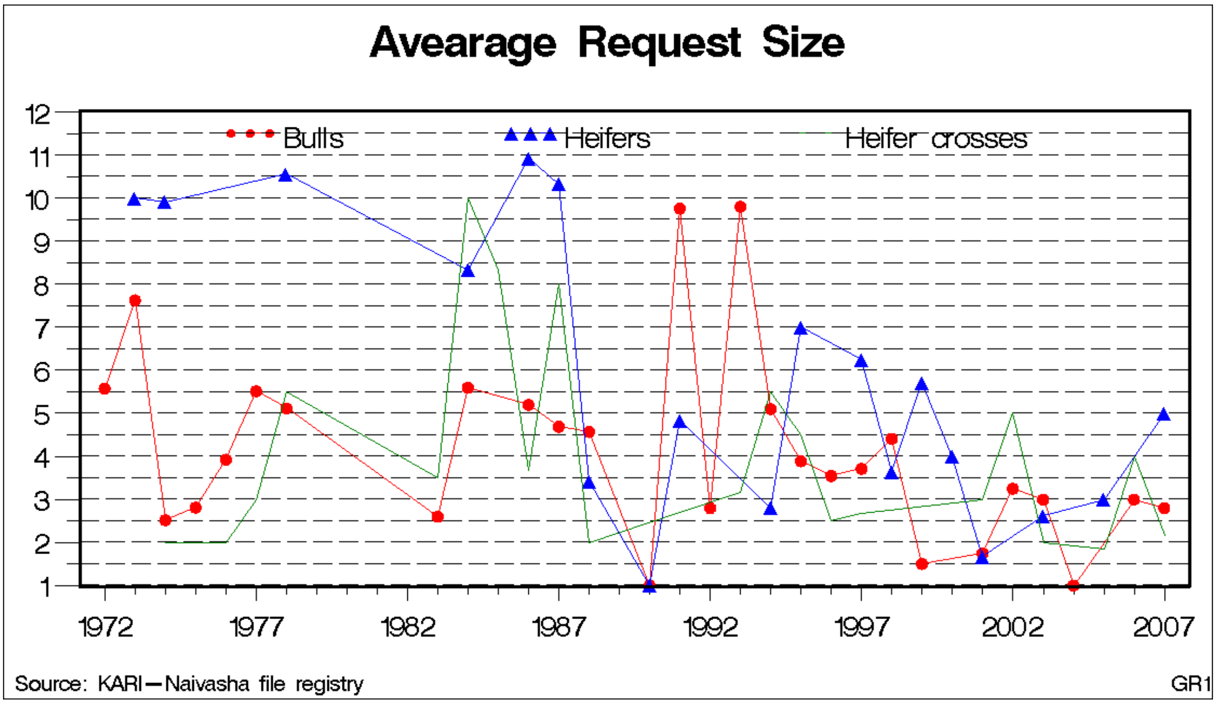
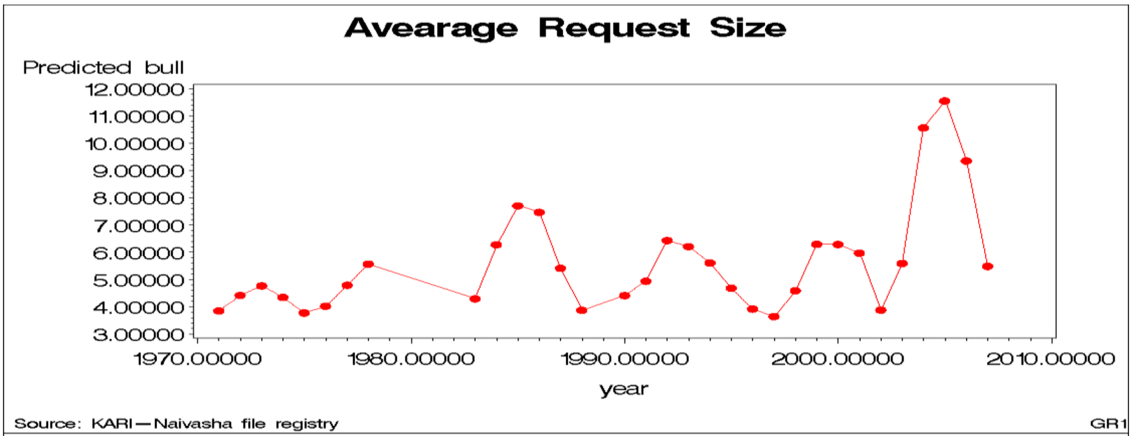
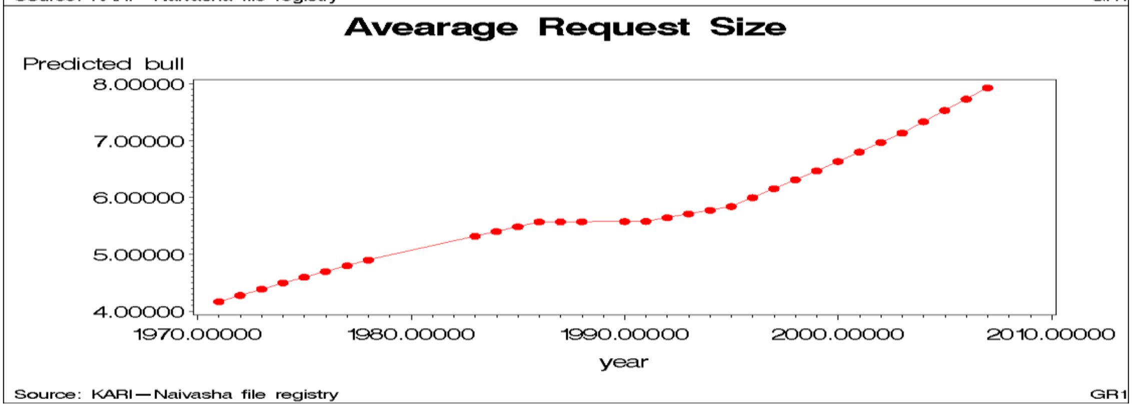
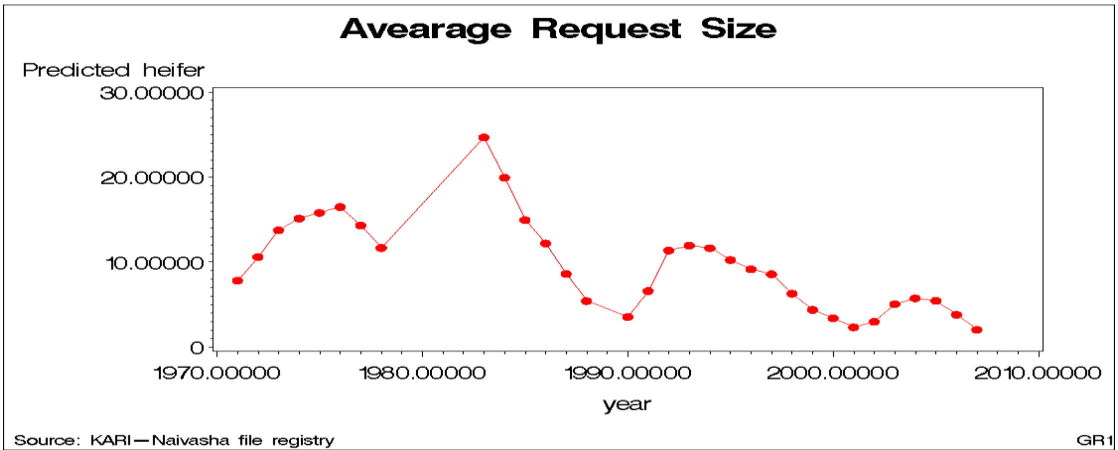


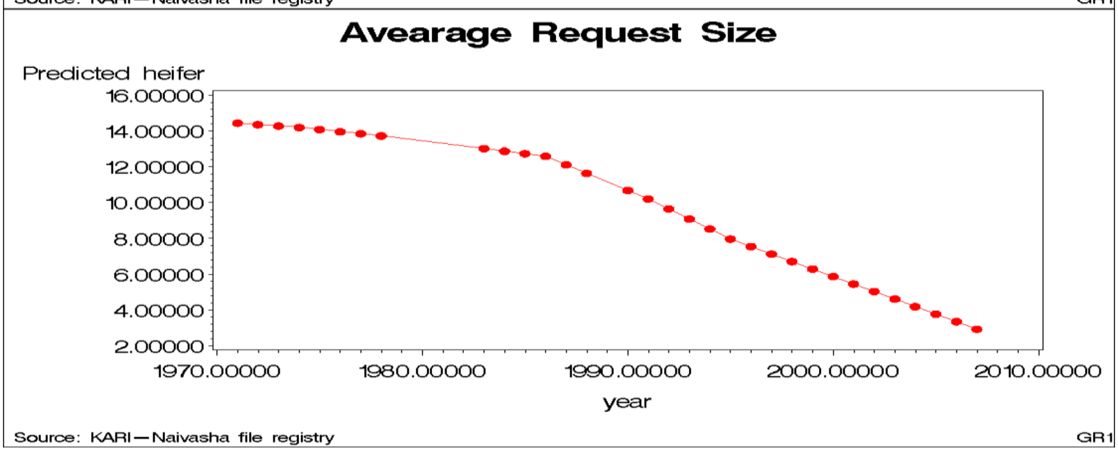
Figure 8: Average Size of 'Demand' for Breeding Animals from NSS over a 37 Year Period

[11] For bulls, one of the outliers is omitted and the slope changes direction and resembles that for heifer crosses with a rise in the 1970s and 1980s a peak at 1990 then a drop since then.


Avearage Request Size
Predicted bull
12.00000
11.00000
10.00000
9.00000
8.00000
7.00000
6.00000
5.00000
4.00000
3.00000
1970.00000
1980.00000
1990.00000
2000.00000
2010.00000
year
Source: KARI—Naivasha file registry
GR1


Avearage Request Size
Predicted bull
8.00000
7.00000
6.00000
5.00000
4.00000
1970.00000
1980.00000
1990.00000
2000.00000
2010.00000
year
Source: KARI—Naivasha file registry
GR1


Avearage Request Size
Predicted heifer
30.00000
20.00000
10.00000
0
1970.00000
1980.00000
1990.00000
2000.00000
2010.00000
year
Source: KARI—Naivasha file registry
GR1


Avearage Request Size
Predicted heifer
16.00000
14.00000
12.00000
10.00000
8.00000
6.00000
4.00000
2.00000
1970.00000
1980.00000
1990.00000
2000.00000
2010.00000
year
Source: KARI—Naivasha file registry
GR1

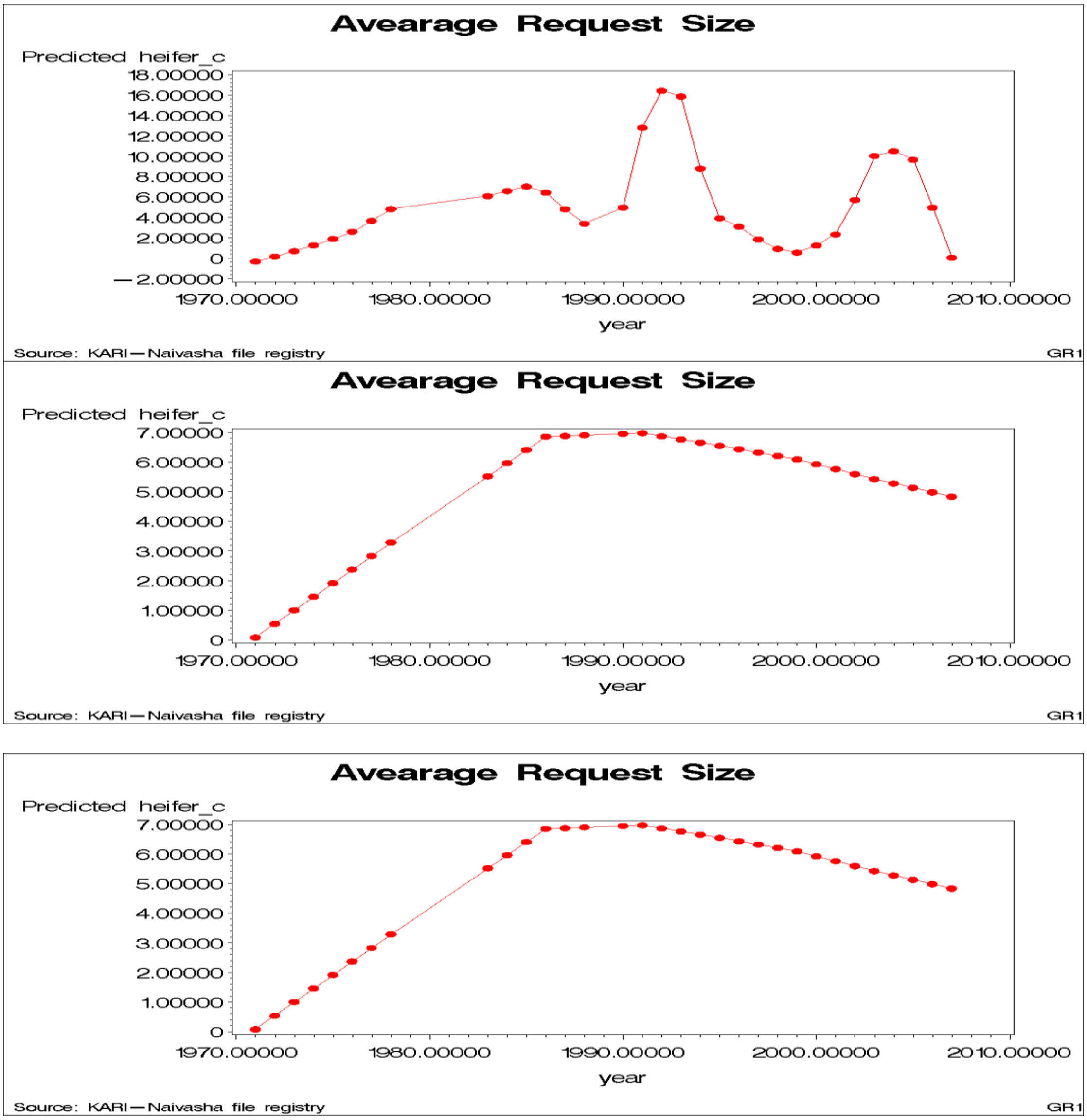


Figure 9-x: Smoothed Graphs Showing Predicted Average Size of Requests.

Probability of Demand across Categories

The probability of request for animals varies with animal type (X^2 = 724.5, P<0.0001). The overall probability of request for bulls, heifers and steers was significantly higher than bull crosses. The probability of a request for heifer crosses and bull crosses did not significantly differ. Across animal categories, the probability of request did no differ significantly between years (time) (X^2 = 0.47, P = 0.4933) and the predicted probabilities of requests over the years for each category is presented in Figure 9.

Separate models were run for various classes where probability (y_j=1) =f (time). Time here was entered as a number stretching from 1971 (=1) to 2007 (37) with the missing years entered in the model so as to account for past time. The models all (with the exception of steers and bull crosses) reveal that the probability of each *j* category being requested differed with time (Table 5). Predicted probabilities are derived from the data and graphed to produce Figure 9 which shows that the probability of a bull being requested has been a declining over the years from about 0.8 in the early 70s to about 0.3 by 2007. On the other hand, the probability of a request being that for a heifer or a heifer cross has been increasing steadily over time. This is from less than 0.2 for heifers and 0.05 for heifer crosses in the early 1970s to 0.4 and 0.3 respectively by 2007. The same, however, cannot be said for steers and bull crosses whose probability has been consistently low.

The number of requests has also tended to show a declining trend with time (Figure 10). From about 40 each year in the 1970s, these have dropped to an average of less than 10 in the 2000s from an average 28 in the 1990s. The role played by alternative communication with the NSS may be a driving force in this decline. However, the mobile telephone boom started about 2001/2 since even by 2000; the number of subscribers per

100 inhabitants was below 2 and below that of fixed line subscribers. Therefore, the fall experienced from 1991, for instance, is unaccounted for nor does this explain the drop from the levels of 1970s. An additional graph with superimposed linear trend lines (per category) was produced (Figure 11) and shows a drop in the number of requests over the years for bulls and heifers and a small increase for heifer crosses.

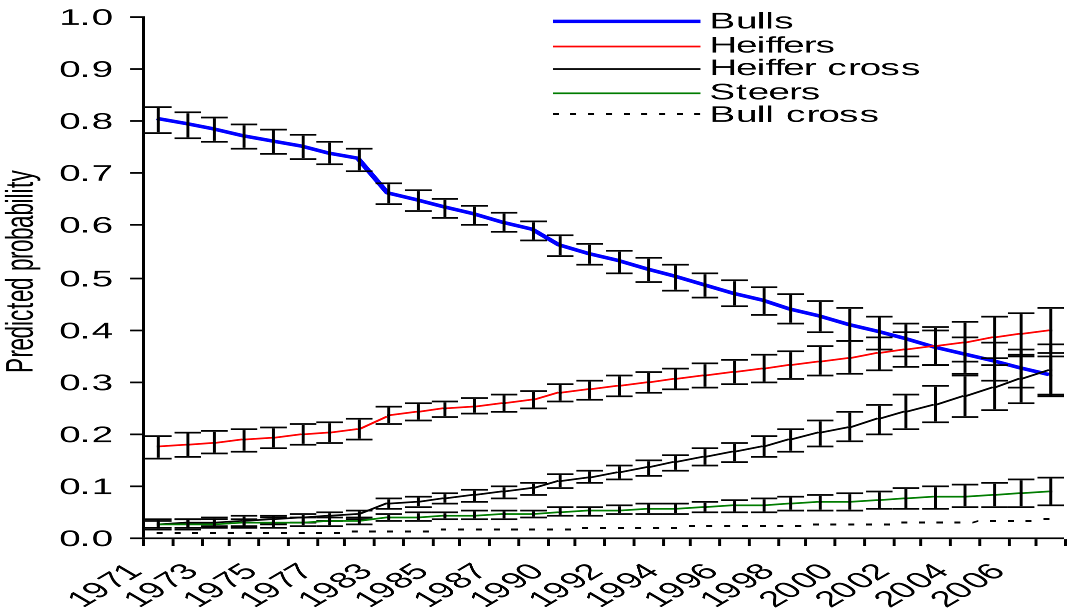


Figure 9: Predicted Probability of Requests for Bulls, Heifers, Heifer Crosses, Steers, and Full Crosses (Vertical Bars Represent Standard Errors)

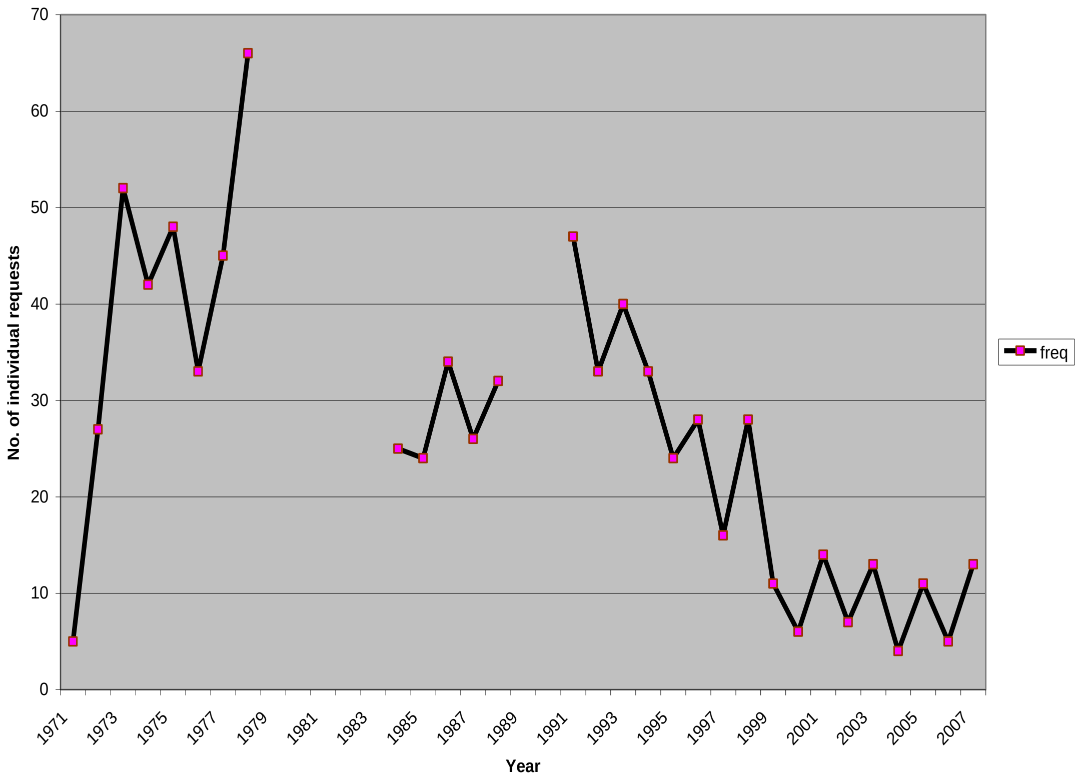


Figure 10: Number of Individual Requests for the Period 1971-2007

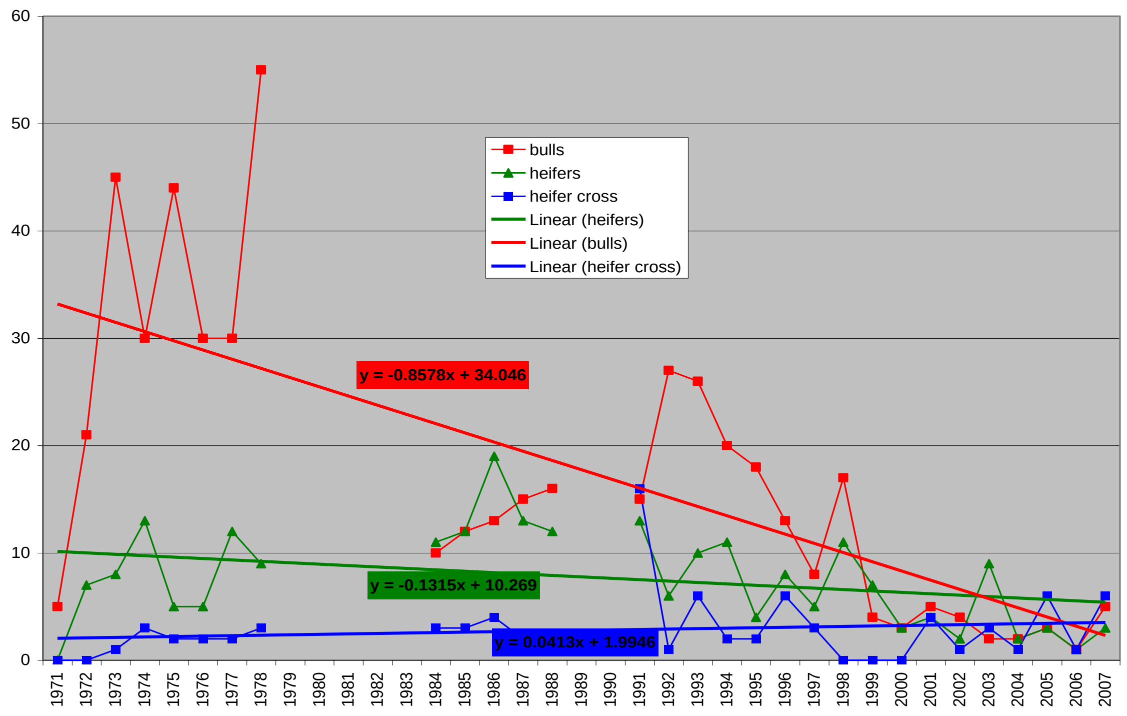


Figure 11: Number of Individual Requests (By Category) Over the Period 1971-2007

CONCLUSIONS

The resulting analysis indicates that the demand for Sahiwal breeding animals may have been falling marginally over time. However, it is clear that since 2000 when communication was made easier using mobile telephony, demand may be expressed differently as opposed to written requests. This may partly explain the low numbers requested in the 2000s. However, the change in curvature at 1990 is not fully supported by this argument. The number of requests has also been falling. This fall in the number of requests and the average size of the respective requests is however apparent signalling a combined drop in the number of Sahiwal demanded. The 1970s represent a period of growth and this could be explained by the healthy growth in the economy during this period.

Despite all these limitations, it is clearly necessary to provide forecasts for demand over the next few years. Therefore, a more detailed and clearer examination of this and additional data needs to be undertaken explaining what may have led to the observed trends. The potential role played by other factors such as the pricing of breeding animals, alternative sources of Sahiwal breeding stock and possible changes at the farm level as possible demand shifters will need to be investigated. This may involve the development of spatial demand models that can be used in estimating demand for Sahiwal breeding material and determining the likely path that this demand will take keeping in mind the evolution of demand shifters accounting too for the presence of competing sources of Sahiwal in the country. These results would go along in the development of a breeding plan for the Sahiwal at the NSS. The same results can also be used in the design of an appropriate pricing structure maximizing on profits to the NSS while at the same time offering a competitive price to farmers interested in the Sahiwal breed.

REFERENCES

Aklilu, Y. (2002a). An Audit of the Livestock Marketing Status in Kenya, Ethiopia and Sudan: Issues and Proposed Measures, Vol II, Community-Based Animal Health and Participatory Epidemiology Unit, (CAPE) PACE Programme OAU-IBAR, June, Nairobi.

Aklilu, Y. (2002b). An Audit of the Livestock Marketing Status in Kenya, Ethiopia and Sudan, Vol I, Community-Bassed Animal Health and Participatory Epidemiology Unit (CAPE) PACE Programme OAU-IBAR, April, 2002, Nairobi.

Baltenweck, I., Ouma, R., Anunda, F., Mwai, O. and Romney, D. (2004). Artificial or Natural Insemination: The Demand for Breeding Services by Smallholders. Paper presented at the 9th KARI Biennial Scientific Conference/Kenya Agricultural Research Forum, 8-12 November 2004, Nairobi, Kenya.

Bebe, B. O., Thorpe, W., Udo, H. M. J. and Mulinge, W. (2000). Breed Preferences and Breeding Practices in Smallholder Dairy Systems of the Central Highlands of Kenya. Paper Presented at the 7th KARI Biennial Scientific Conference, 13-17 November 2000, KARI Headquarters, Nairobi, Kenya.

Boone, R., Burn Silver, S., and Thornton, P. (2006). Optimizing Aspects of Land Use Intensification in Southern Kajiado District, Kenya: Final Report to the International Livestock Research Institute, Nairobi, Kenya. Reto-o-Reto Project, DGIC, December 2006. Available at: www.reto-o-reto.org

EAC (2002). Freeing Cross Border Trade of Agricultural Products: Present Trade and Recommendations for Liberalizing Cross Border Trade, EAC Arusha, EAC; GTZ 2002, pp71.

Galloway, D. and Perera, O. (2003). Guidelines and Recommendations for Improving Artificial Breeding of Cattle in Africa.

Gamba, P. (2006). Beef and Dairy Cattle Improvement Services: A Policy Perspective, Tegemeo Working Paper No 23, 2006.

Ilatsia, E. D., Muasya, T. K., Muhuyi, W. B. and Kahi, A. K. (2007). Milk Production and Reproductive Performance of Sahiwal Cattle in Semi-Arid Kenya. Tropical Science, 47(3): 120-127.

Kaaya, H., Bashaasha, B. and Mutetikka, D. (2005). Determinants of Utilization of Artificial Insemination (AI) Services among Ugandan Dairy Farmers. Eastern Africa Journal of Rural Development, Vol. 21 (1) 2005: pp. 34-43.

Kamau C.N. and Diaby S. (2008) Kenya: Livestock and Products Dairy Genetics Market Brief. 2008 GAIN Report Number: KE8032.

Karanja, A. M., Kuyvenhoven, A. and Moll, H. A. J. (2003). Economic Reforms and Evolution of Producer Prices in Kenya: An ARCH-M Approach. African Development Review, 15(2-3): 271-296.

KARI. (2007). National Sahiwal Stud Bulletin, February 2007, KARI, National Animal Husbandry Research Centre.

Khan, M. S., Bilal, G., Bajwa, I. R., Rehman, Z. and Ahmad, S. (2008). Estimation of Breeding Values of Sahiwal Cattle Using Test Day Milk Yields. Pakistan Veterinary Journal, 28(3): 131-135.

Kristjanson, P., Radeny, M., Nkedianye D., Kruska, R., Reid, R., Gichohi, H., Atieno, F. & Sanford, R. (2002). Valuing Alternative Land-Use Options in the Kitengela Wildlife Dispersal Area of Kenya. ILRI Impact Assessment Series 10. A Joint ILRI (International Livestock Research Institute)/ACC (African Conservation Centre) Report. ILRI, Nairobi, Kenya. pp. 61.

Makenzi, P. M., Timan, M. O., Laltaika, E. and Ubwani, Z. (2004). Livestock Production in Botswana: The So called “Botswana Model”: Privatizing the Commons, A Trade or Trap? Report of a Study Tour to Botswana, 18th -28th January 2004.

Meyn, K. and Wilkins J. V. (1974). Breeding for Milk in Kenya, with Particular Reference to the Sahiwal Stud, available online http://www.fao.org/.

Muhuyi, W. B, Lokwaleput, I. and Sinkeet, S. N. (1999). Conservation and Utilization of the Sahiwal Cattle in Kenya. FAO Animal Genetics Research Information, 26, 35-44.

Muthee, A. (2006). Kenya Livestock Sector Study: An Analysis of Pastoralist Livestock Products Market Value Chains and Potential External Markets for Live Animals and Meat, AU-IBAR &NEPDP, Deloitte, August 2006, Nairobi.

Ngigi, M. (2005). The Case of Smallholder Dairying in Eastern Africa, IFPRI, EPTD Discussion Paper No. 131, Washington D.C.

Nyariki D.M. (2009) Impacts of Policy Reforms on the Livestock Industry in Kenya: The Case of the Dairy Sector, Livestock Research for Rural Development, 21 (10) 2009.

Omiti, J. (2002) Impacts of Liberalisation in Kenya's Dairy Sector. In: Rangnekar, D. and Thorpe, W. (Eds.). (2002). Smallholder Dairy Production and Marketing ‑ Opportunities and Constraints. Proceedings of a South–South Workshop Held at NDDB, Anand, India, 13–16 March 2001. NDDB (National Dairy Development Board), Anand, India, and ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 538.

Scarpa R., Ruto E.S.K., Kristjanson P., Radeny, M., Drucker, A. G. and Rege, J. E. O. (2003). Valuing Indigenous Cattle Breeds in Kenya: An Empirical Comparison of Stated and Revealed Preference Value Estimates. Ecol. Econ. 45 (3): 409-426.

Smith, P. D., Tyler, R. A. and Young E. M. (Eds.) (1996). Review of Kenyan Agricultural Research, (Vol. 1). Kenya Agricultural Research Institute, CAZS, University of Wales, Gwynned, United Kingdom.

Trail, J.M.C. and Gregory, K. E. (1981). Characterization of the Boran and Sahiwal Breeds of Cattle for Economic Characters. Journal of Animal Science 52:1286-1293.

APPENDICES

Table 1: Basic Descriptive Statistics of Requests (Numbers Requested)*

	Mean (Std. Dev.)	Mode	Median	Skewness	Kurtosis	Range	Variance
Bulls	3.25 (8.358)	0	1	6.739	60.545	100	69.851
Heifers	2.68 (10.31)	0	0	6.423	48.223	100	106.278
Heifer crosses	0.45 (2.54)	0	0	12.902	213.443	50	6.456
Steers	0.76 (5.47)	0	0	11.556	166.617	100	29.904
Bull crosses	0.059 (0.66)	0	0	13.664	197.064	10	0.435

NB: *These figures are for all data including those requests where demand for category =0

Table 2: Goodness-of-fit Statistics for Normal Distribution

Test	Statistic	p-value
	Bulls	
Shapiro-Wilk	0.3806	<0.0001
Kolmogorov-Smirnov	0.3485	<0.0100
Kramer-von Mises	28.0044	<0.0050
Anderson-Darling	139.2769	<0.0050
	Heifers	
Shapiro-Wilk	0.27589	<0.0001
Kolmogorov-Smirnov	0.39743	<0.0100
Cramer-von Mises	43.4158	<0.0050
Anderson-Darling	206.6032	<0.0050
	Heifer crosses	
Shapiro-Wilk	0.16142	<0.0001
Kolmogorov-Smirnov	0.46689	<0.0100
Cramer-von Mises	51.4454	<0.0050
Anderson-Darling	239.3237	<0.0050
	Steers	
Shapiro-Wilk	0.12283	<0.0001
Kolmogorov-Smirnov	0.50869	<0.0100
Cramer-von Mises	59.3163	<0.0050
Anderson-Darling	274.1857	<0.0050
	Bull crosses	
Shapiro-Wilk	0.06249	<0.0001
Kolmogorov-Smirnov	0.52169	<0.0100
Cramer-von Mises	64.78306	<0.0050
Anderson-Darling	299.8626	<0.0050

Table 3: 'Demand' for Sahiwal Breeding Animals by Province (1971-2007)

Province	**Percentage**					
	1970s	**1980s**	**1990s**	**2000s**	**Entire period**	**Females**
Importing countries	9.1	7.4	5.3	18.9	7.61	44
Central	4.4	5.4	2.3	6.8	7.98	53
Coast	12.6	10.1	4.2	-	8.60	33
Eastern	16.7	12.8	12.2	5.4	12.72	23
Nairobi	3.1	6.0	2.3	12.2	4.24	62
North Eastern	0.3	2.7	0.8	-	1.50	50
Nyanza	4.7	5.4	8.4	5.4	6.98	43
Rift Valley	48.1	48.3	61.5	48.6	48.56	30
Western	0.9	2.0	3.1	2.7	1.87	67

Table 4: Distribution of Requests for Sahiwal by Country and Trading Bloc

Trading bloc	Country	Frequency	Percentage (%)
Pre-PTA	Burundi	1	0.4
	Cameroon*	1	0.4
	Kenya	230	91.3
	Oman*	1	0.4
	Rwanda	3	1.2
	Somalia	4	1.6
	Sudan	4	1.6
	Tanzania	6	2.4
	Zaire	1	0.4
	Zambia	1	0.4
	Total	252	100.0
	Cameroon*	1	0.3
	Cameroon*	1	0.3
	Kenya	359	97.0
	Sudan	3	0.8
	Tanzania	4	1.1
	Mauritius	1	0.3
	Total	**370**	**100.0**
COMESA	Kenya	95	99.0
	Tanzania	1	1.0
	Total	**96**	**100.0**
EAC	Burundi	1	1.2
	Kenya	77	90.6
	Tanzania	2	2.4
	Comoros*	1	1.2
	Uganda	4	4.7
	Total	**85**	**100.0**

* Not member of trade bloc

Table 5: ANOVA Results for the Probability of Request with Time by Category

Category	Intercept	Year	Log likelihood (df)
Bulls	84.55 <0.0001	58.49 <0.0001	86.42 (30) <0.0001
Heifers	89.81 <0.0001	14.64 0.0001	67.28 (30) 0.0001
Heifer crosses	141.94 <0.0001	37.67 <0.0001	59.43 (30) 0.0011
Steers	99.86 <0.0001	4.60 0.0320	55.53 (30) 0.0031
Bull crosses	53.19 <0.0001	2.31 0.1286	26.47 (30) 0.6510

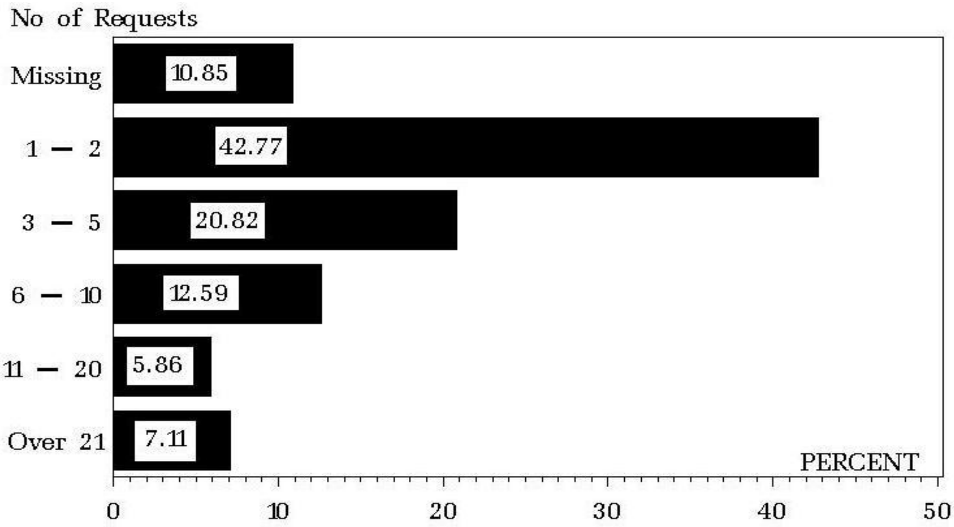


Figure 1: Size of Demand over the 1971-2007 Period (All Categories Combined)

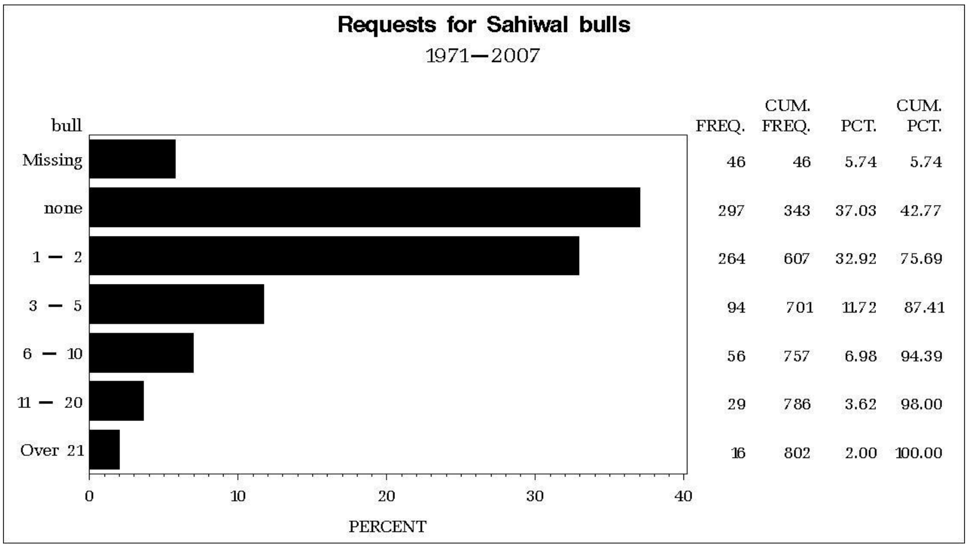


Figure 2: Distribution of Demand Size for Bulls over the 1971-2007 Period.

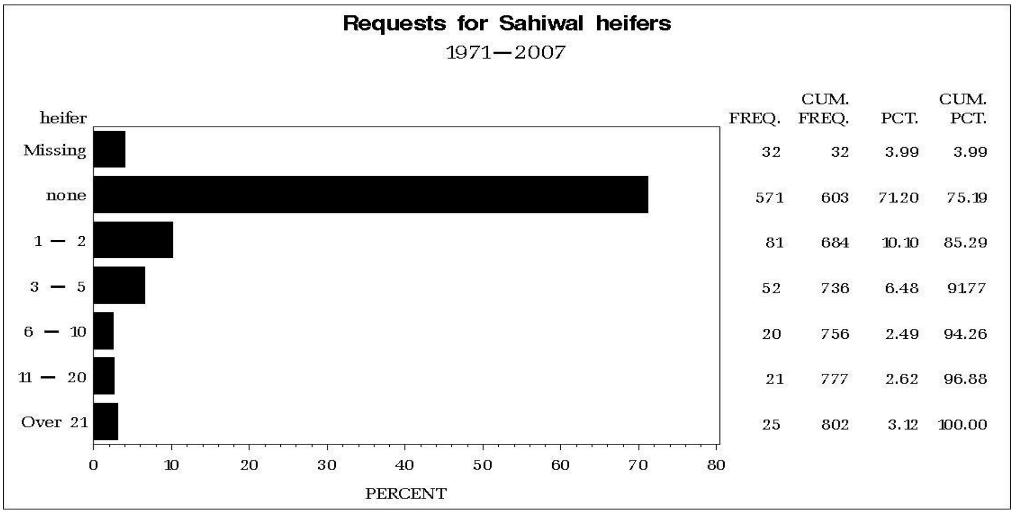
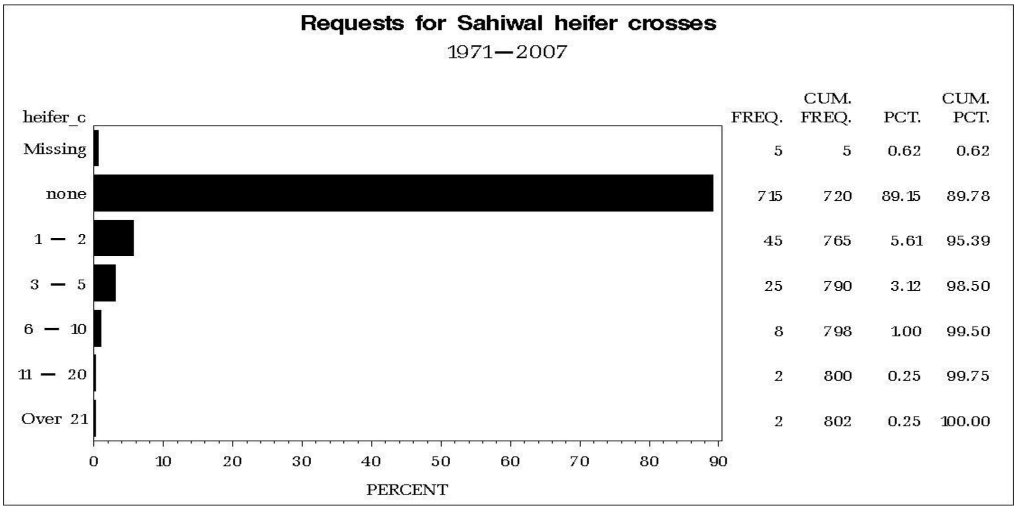
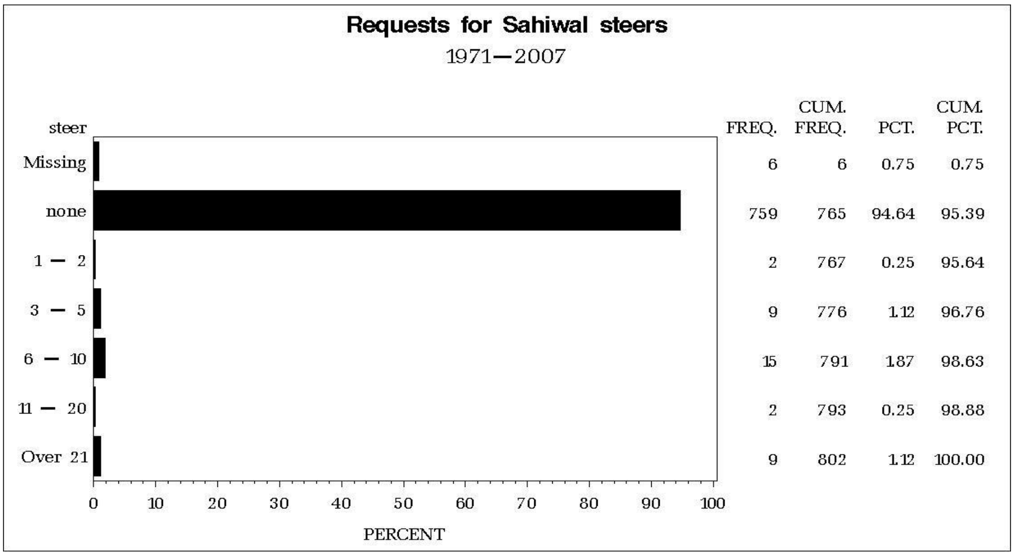


Figure 3: Distribution of Demand Size for Heifers over the 1971-2007 Period



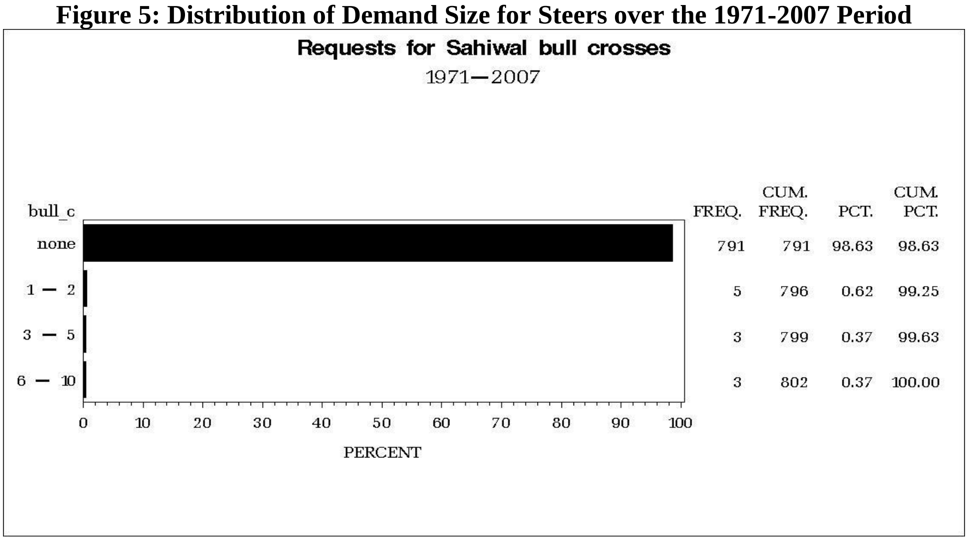
heifer_c	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
Missing	5	5	0.62	0.62
none	715	720	89.15	89.78
1 — 2	45	765	5.61	95.39
3 — 5	25	790	3.12	98.50
6 — 10	8	798	1.00	99.50
11 — 20	2	800	0.25	99.75
Over 21	2	802	0.25	100.00

Figure 4: Distribution of Demand Size for Heifer Crosses over the 1971-2007 Period.



steer	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
Missing	6	6	0.75	0.75
none	759	765	94.64	95.39
1 — 2	2	767	0.25	95.64
3 — 5	9	776	1.12	96.76
6 — 10	15	791	1.87	98.63
11 — 20	2	793	0.25	98.88
Over 21	9	802	1.12	100.00

Figure 5: Distribution of Demand Size for Steers over the 1971-2007 Period



bull_c	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
none	791	791	98.63	98.63
1 — 2	5	796	0.62	99.25
3 — 5	3	799	0.37	99.63
6 — 10	3	802	0.37	100.00

Figure 6: Distribution of Demand Size for Bull Crosses over the 1971-2007 Period.