Rural Agriculture Revitalisation Program

SNV – Netherlands Development Organisation

DAIRY BREEDING STUDY REPORT, *2013*

Conducted by

With support from

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List of abbreviations

ABS	African Breeder Services
ABS TCM	African Breeder Services Total Cattle Management
AFC	Age at First Calving
Agritex	Department of Agriculture, Technical and Extension Services
AI	Artificial insemination
AISP	Artificial Insemination Service Provider
ARDA	Agricultural and Rural Development Authority
BLUP	Best Linear Unbiased Prediction
BPPs	Breeding Programme Pillars
CA	Contagious Abortion
CBF	Cattle Bank Facility
CCI	Calving To Conception Interval
CI	Calving Interval
CLSI	Calving To Last Service Interval
CR	Conception Rate
DA	District Attorney
DBPPs	Dairy Breeding Programme Pillars
DDP	Dairy Development Program
DMB	Dairy Marketing Board
DO	Days Open
DR&SS	Department of Research and Specialist Services
DVS	Department Of Veterinary Services
DZL	Dairibord Zimbabwe Limited
ET	Embryo Transfer
EU	European Union
F1	First Generation
F1	Second Generation
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GoZ	Government of Zimbabwe
HPI	Heifer International Zimbabwe
KII	Key Informant Interviews
LAR	Land and Agrarian Reform
LIT	Livestock Identification Trust
LOL	Land O'Lakes
LPD	Livestock Production Department
MCC	Milk Collection Centre
MOET	Multiple Ovulation and Embryo Transfer
NADF	National Association of Dairy Farmers
NGO	Non Governmental Organisation
NSC	Number of Services per Conception
PD	Pregnancy Diagnosis
SCC	Swedish Co-operative Centre
SNV	Stichting Nederlandse Vrijwilligers (Foundation of Netherlands Volunteers)
SWOT	Strength, Weakness, Opportunities, Threats
TAI	Timed Artificial Insemination
TBDs	Tick Borne Diseases
TLC	Tender Loving Care
TOR	Terms of Reference
UNDP	United Nations Development Programme
US	United States

USD	United States Dollar
ZDSA	Zimbabwe Dairy Services Association
ZESA	Zimbabwe Electricity Supply Association
ZHB	Zimbabwe Herd Book

TERMS OF REFERENCE

The tasks of the intervention were:

1. Thorough desk studies and consultations of key stakeholders, establish the status of dairy sector including that of functional and non-functional MCCs initially to inform the Aide Memoire compilation;
2. Evaluate existing and past breeding models;
3. Determine cattle breed distribution and prevalence of dairy crossbreed and purebred cattle, particularly in areas where MCCs were established and others where there is dairy production potential;
4. Establish constraints to breeding including those affecting AI provision and success such as heat detection and reproductive management;
5. Assess available breeding infrastructure and inputs including semen supply, AI service providers, and geographical distribution of AI services;
6. Evaluate use of breeding technologies, particularly heat-synchronized AI breeding, embryo transfer, genomic bull and sexed semen;
7. Evaluate farmers' breeding skills and knowledge to determine requisite curriculum development and training programmes;
8. Establish availability of AI training facilities and capacity;
9. Assess availability and efficiency of dairy extension and animal health services to support breeding programmes;
10. Establish existing cattle identification and milk production recording programmes and evaluate their adequacy;
11. Identify existing cattle breed societies and determine the Zimbabwe Herd Book status and potential for strengthening;
12. Determine cattle supply, adequacy for herd expansion and potential herd size that could be used for crossbreeding programmes;
13. Review existing GoZ dairy policies and programmes that support breeding programmes and identify policy issues;
14. Identify cattle breeding investments, and financial products targeted or accessible to the dairy sector, in particular those available to smallholder dairy farmers or reasons for non-availability;
15. Review performance and milk testing services, and research and extension programmes on dairy cattle breeding;
16. Establish availability of feed resources and fodder and crop by-products to determine potential for development of feed flow plans for consistent feed supply to support breeding programmes; and
17. Review dairy leadership development and women and youth empowerment programmes to broaden participation in dairy breeding programmes.

Expected Output and Deliverables

1. An aide memoire of not more than 5 pages outlining initial findings based on literature review and consultations with a few stakeholders and experts. This is to be delivered within two weeks of the start of the study.

2. Recommend and rank the most promising dairy breeding models in terms of meaningful smallholder participation and private sector appetite to develop the breeding programme.

3. Develop dairy breeding framework and identify primary/support services and enabling environment precedent to its actualization.

4. Propose a programme design that would address the issues identified in the studies.

EXECUTIVE SUMMARY

We conducted a study which, in summary, was to review the status of breeding programmes in the smallholder dairy sub-sector in Zimbabwe and deliver the following outputs:

- An aide memoire of not more than 5 pages outlining initial findings based on literature review and consultations with a few stakeholders and experts. This is to be delivered within two weeks of the start of the study.
- Recommend and rank the most promising dairy breeding models in terms of meaningful smallholder participation and private sector appetite to develop the breeding programme.
- Develop a dairy breeding framework and identify primary/support services and enabling environment precedent to its actualization.
- Propose a programme design that would address the issues identified in the studies.

Consistent with terms of reference, based on initial visits to Marirangwe Milk Collection Centre and key informant interviews, particularly the Dairy Development Program (DDP), we previously submitted the aide memoire (inception report). We then conducted further work at 6 milk collection centres (MCCs): Guruve, Mushagashe-Hamaruomba, Nharira, Rusitu Mayfield, Tsonzo, and Umzingwane. Rusitu-Mayfield and Tsonzo (in Manicaland Province) were selected from among the best MCCs, Nharira (in Mashonaland East Province), and Mushagashe (in Masvingo Province) were selected from the middle performance tier, while Umzingwane (in Matebeleland South Province) and Guruve (in Mashonaland Central Province) were regarded as least-performing MCCs.

We conducted household surveys, key informant interviews (KIIs) and focus group discussions (FGDs) at each MCC. For the household survey, a questionnaire was distributed to men and women at each MCC. Overall, the respondents comprised 36% women and 64% men. The youth (under 35 years of age) made up 20% of the respondents. The KIIs were also with key government, private sector, and development agents involved in the smallholder dairy subsector.

The household surveys sought data on statistics including membership of MCCs, milk production and sales, cow productivity, cattle breed distribution across the MCCs, extension and financial support services, breeding methods and technologies, current breeding models, and farmer knowledge. The KIIs with senior government representatives explored existing policies on smallholder dairy sub-sector breeding programmes support. Focus group discussions were held at MCCs in order to triangulate the findings from the household surveys and to address other issues of a general nature.

Data was analysed using the Statistical Package for Social Sciences (SPSS). The findings were analysed using the breeding pillars (presented in the inception report) analytical framework.

Based on our findings and analysis, MCCs have low membership that does not provide adequate critical mass for self sustaining breeding programmes. The average number of milking cows across breeds per MCC (440 cows) is not adequate for a viable breeding programme that is AI-based. A cow herd of at least 1000 will be required for economies of scale to engage AI service providers. Milk production per cow is low and it is still below 10 litres per day even for the purebred dairy cows. This demonstrates substantial scope to improve production largely through improved feeding and reproductive management. Feeding is not adequate in most herds with most farmers neither conserving feeds for feeding during the dry season nor having sufficient access to concentrate feeds.

Calving intervals are still too long resulting in about 50% of the cows calving each year. Lactation lengths are still short at 5.3 ± 2.0 months and 8.1 ± 1.9 months for local and purebred cows, respectively. There is a large array of breeds dominated by the local Mashona breed and largely crossbreds of Brahman, Jersey, Red Dane, and Holstein-Friesian. About 90% of the farmers use bulls (natural service) to breed their cows. Unlike in similar dairy schemes in other countries, AI use is low (10% of respondents).

This is probably a consequence of inadequately developed AI infrastructure, lack of knowledge on AI by the farmers, and the relatively high cost of AI. Other breeding technologies including heat synchronized AI have not been widely used, and results from the few cases when it was used were unsatisfactory.

There are virtually no existing or previous well-defined breeding models for smallholder dairy farms, but it is clear that they were largely anchored on bull schemes. Sire cow breeds acquired by smallholder farmers were not chosen by the farmers but depended on availability and what was provided by funding agents. While some cattle acquisition projects partly succeeded, most were criticized for reasons including failure to prescribe the quality of animals distributed, lack of supplied animal records, stringent cattle finance loan repayment conditions, and failure to provide ancillary support services to improve cow survival. Future cattle acquisition programmes should take into account farmer choices and have feasible,realistic repayment conditions.

Key breeding technologies including AI, synchronized AI, sexed semen use, and embryo transfer have not been adequately exploited. In most progressive dairy programmes in developing countries, AI has been the engine for improvement of cow productivity while synchronized AI has been a tool for massive introduction of new genetics in cattle reared under communal grazing systems. Sexed semen can also offer cost-effective opportunities to grow the female cattle herd instead of solely relying on imports. When these technologies are supported through appropriate policies and financing including government subsidies, they can be terminally employed on a large scale and create large dairy herds that provide economies of scale for a sustainable smallholder dairy sector.

To create a basis for implementing the smallholder sub-sector breeding programme, we have developed a breeding framework and programme design that has five components with the overall goal of increasing income of smallholder dairy farmers through cow productivity improvement. The five components are: Developing breeding programme clusters for efficient delivery of breeding services; setting up breeding infrastructure and cattle supply structures; implementing reproductive performance improvement of existing smallholder farmer herds programme; establishing cattle breeding and multiplication farms to enhance dairy cattle supply; and building or strengthening institutions and developing policies for breeding programme support.

In addition, we suggested breeding models that could be applied in the smallholder dairy sub-sector that are developed in the context of available key resources and feasible breeding methods (e.g., synchronized, ordinary AI, or natural breeding). For example, to this end, we propose a model for communal grazed herds in which we recommend synchronized AI using dual purpose and Jersey breeds, and use of the resulting crossbred bulls in future mating programmes.

We have addressed a key concern about breed combination in crossbreeding programmes. In this regard, in our view, the limited availability of dairy cattle does not offer much choice to the farmer other than getting what is available. However, sire breed choice would be feasible with AI. For sire breed choice we would recommend dual purpose and the Jersey breeds for farms in relatively dry areas and with low feed resources. Farms with abundant resources, particularly feed and good support services can use virtually the whole breed range including the Holstein Friesian.

1. INTRODUCTION

Consistent with the terms of reference (ToR), our inception report outlined initial findings from literature and consultations with one milk collection centre (MCC), six farmers, and experts, particularly those from Dairy Development Programme (DDP), gathered during the inception period, 21 November to 5 December, 2012. The report identified large gaps in requirements for setting up robust breeding programmes including vestigial AI services; limited financial products to support dairy and specifically breeding programmes; inadequate participation of women and youth; and lack of a breeding programme enabling environment anchored on a perennial feed supply and viable MCCs. However, the report noted the buoyant demand for milk and potential benefits to farmers, and the existence of potential to transform MCCs into viable units that can support vibrant breeding programmes which in turn can further increase milk volume.

In order to validate our initial findings and fully address the ToR, further work was undertaken across 6 MCCs from 3 December 2012 to 15 January 2013. This report outlines the methodology used, the findings, an analysis of the findings, and our recommendations. The sequence of presentation of the findings will largely be in accordance with the ToR; however, in some instances the findings may concurrently address several items in the ToR.

2. METHODOLOGY

As reported previously, we conducted a desk study, and dairy farmer, MCCs and other dairy value chain stakeholder surveys, public and private sector key informant interviews, focus group discussions with farmers and leaders in six MCCs. In this section, we describe the final study sites for the surveys, the questionnaires administered, and the key informant interviews (KIIs) and focus group discussions (FGDs) conducted.

2.1 Study Sites for Surveys and Interviews

Guruve, Mushagashe (Hamaruomba), Nharira, Rusitu (Mayfield), Tsonzo, and Umzingwane were the final selected MCCs. We selected these MCCs in consultation with DDP and the SNV Advisor responsible for implementation of this consultancy to represent the best, medium, and least (non-operational) performing MCCs. The basis for placing MCCs in these categories was milk volume, number of participating farmers, and herd size and quality. Rusitu and Tsonzo (Manicaland Province) were selected from among the best MCCs, Nharira (Mashonaland East Province), and Mushagashe (Masvingo Province) were selected from the middle performance tier, while Umzingwane (Matebeleland South Province) and Guruve (Mashonaland Central Province) were regarded as least-performing MCCs. All the participating MCCs at one time were on a Heifer International heifer pass-on scheme, and all are currently participating in the National Association of Dairy Farmers (NADF) and Land O'Lakes livestock improvement scheme.

2.2 Site Visits and Activities

During the visits a pre-tested questionnaire (Appendix 1) was distributed at each MCC to a total of 121 farmers (men, women & youth) across the 6 MCCs (Table 1). An enumerator from Harare travelled with our team to all the sites (Appendix 2). Targeted respondents were invited to a central place and the questionnaire was administered in a group interview. The enumerator assisted the consultant in administering the questionnaire, and also doubled-up as a data capture clerk. We proportionately sampled a representative number of respondents from individual farming system (communal, resettlement, and small-scale, where relevant) members of an MCC. In addition, we administered the questionnaire to 3 to 5 farmers who are no longer supplying milk to MCCs and 3 to 5 women and youth farmers. In addition, at each MCC, individual interviews were held, where available, with field extension worker representatives of the Department of Agricultural Technical and Extension Services (AGRITEX) and the Department of Livestock Production, and MCC officials (Table 2).

Table 1: Number of respondents in age and sex categories across milk collection centre (MCC) sites

Site (MCC)	Number of Respondents			
	Female	Male	Youth	Total
Guruve	5	5	1	10
Mushagashe – Hamaruomba	4	9	5	13
Nharira	12	23	9	35
Rusitu – Mayfield	11	21	5	32
Tsonzo	5	5	2	10
Umzingwane	7	14	2	21
Overall (6 MCCs)	44	77	24	121

Table 2: Number of respondents from interviewed organizations and affiliations

Site (MCC)	Number of Respondents		
	Public Organizations (depts.)	Milk Collection Centre	Private Organization (affiliation)
Guruve	2	2	-
Mushagashe	1	1	1
Nharira	4	3	-
Rusitu Mayfield	3	1	-
Tsonzo	-	1	1
Umzingwane	-	3	-
Overall	**10**	**11**	**2**

2.2.1 Focus group discussions

In addition to the questionnaire survey, we conducted one FGD with farmers at each MCC using a check list of questions and issues (Appendix 3). Farmers for FGDs were randomly selected from those in attendance. The group size ranged from 10 to 35. At Nharira, Mayfield-Rusitu, and Umzingwane MCCs, participants were further subdivided into smaller groups of 10 to facilitate discussions. Due to time limitations, it was not possible to hold one FGD with female members of the MCC, and another with male members of the MCC as proposed in the inception report. Local female facilitators were recruited to assist with the FGDs. The approach taken was participatory; for example, participants were asked to identify the true sign(s) of heat in a cow. We used a flip chart that had a list of options that each participant had to select by placing drawing pin on the listed option. The number of pins on individual options was counted and expressed as percentage of the total number of pins placed.

2.2.2 Key informant interviews

We interviewed key informants from the following organizations: the National Association of Dairy Farmers (NADF), Land O'Lakes (LOL), Zimbabwe Dairy Services Association, DDP, AGRITEX, Departments of Livestock Production and Veterinary Services, Dairibord Zimbabwe Ltd, the University of Zimbabwe, Livestock Identification Trust, and Milk Zim Ltd (Appendix 4).

2.3 Data Analysis

Descriptive statistics for most of the variables were computed using the Descriptive and Cross Tabulation procedures of the Statistical Package for the Social Sciences (SPSS). The data across MCCs was combined to get a general picture; however, in order to identify reasons for differences in MCC breeding programmes, specific analyses for the individual MCC performance clusters were conducted (Appendices 5-11).

3. FINDINGS

As previously mentioned, the findings are, where possible, presented according to the ToR sequence.

3.1 Status of Dairy Sector

The status of the dairy sector considered was that of the smallholder dairy sector as per focus of the consultancy activities. This was reported in relation to MCC membership and production, farmer characteristics, market access, and cattle herd characteristics.

3.1.1 MCC membership and production

As presented in our inception report, according to key informants interviewed, particularly the DDP staff, depending on site and season, MCC producer membership ranges from 3 to 250. For example, Rusitu currently has 107 active producers, against a total membership of 215 members, while at Rusitu United Dairy Cooperative (not in the sampled MCCs but visited during inception) only 37 of the 76 members are milk producers. According to the DDP, only 20 out of the initial 35 smallholder dairy schemes are still functional. Of these 20, 17 are receiving and processing an average 65,000 liters of milk per month. While the remaining three can be classified as functional, they are no longer collecting milk. Most of the milk is delivered to three MCCs: Marirangwe, Rusitu Valley, and Gokwe. Further, only 3 of the 17 functional MCCs deliver milk to large processors. These three are Rusitu Mayfield, and Rusitu United Dairy Cooperative (Chimanimani) which deliver milk to Dairibord Zimbabwe Limited (DZL), and Marirangwe, which delivers milk to Kefalos.

Depending on the MCC, members were drawn from small-scale commercial farming areas (SSC), resettlement (RS), and/or communal areas (CA). The distribution of respondents according to farm type were: Tsonzo (5 CA & 5 RS), Umzingwane (6 CA & 15RS), Nharira (28 CA & 7 SSC), Rusitu Mayfield (32 RS), Hamaruomba (1CA & 12 SSC), and Guruve (1CA, 8 RS, & 1 SSC). While the Mutoko MCC mentioned in our inception report that perennially has between 3 and 10 producers supplying milk could be an extreme case, in general, MCCs have low membership. Even in the surveyed MCCs a decline in membership and low active membership (34/MCC) is evident (Table 3).

Table 3: Current number of registered and active members and at peak performance across the study sites

Milk Collection Centre	When Established*	No. of Members				
		At Peak Performance	Current			
			Registered	% of Peak	Active	% of Registered
Guruve	2002	322	200	62.1	30	15
Hamaruomba	1997	86	36	41.9	20	55.6
Nharira	1985	258	90	34.9	52	57.8
Mayfield	1984	315	215	68.3	90	41.9
Tsonzo	1986	65	65	100	13	20
Umzingwane	2001	60	54	90	0	0
Total/Mean		**1106**	**660**	**59.7**	**205**	**31.1**

*still need further verification

Specifically, this study confirms a decline in membership relative to the peak performance membership (184 members/MCC) that was obtained largely prior to the economic meltdown. In addition, across the six MCCs, membership is low. On average, individual MCCs have 110 members of which only 31% are active. The number of current registered and active members is 60% and 18.5% of the peak erstwhile membership, respectively.

FGD participants discussed and ranked issues/challenges preventing farmers from fully participating in the MCC business (Appendix 12). Key challenges include lack of dairy herd and business management skills and knowledge; lack of feed, water, and dairy breed cows that produce more milk in response to feeding; competition with attractive alternative commodities (e.g., tobacco); embezzlement of MCC funds (e.g., USD 21,000 at Tsonzo MCC), poor MCC governance, and low milk prices; non-central, and hence unsuitable MCC location; and high cost of transporting small milk volumes (e.g., 85 litres transported 35 km from Tsonzo MCC to Mutare).

3.1.2 Farmer characteristics

Farmer characteristics included household demographics such as age, literacy levels, availability of labour, and other factors.

Age of the respondents

The average age of farmers was 50.4 (± 16.5) years (range 16-89 years), indicating that, in general, the farming community across the MCCs is comprised of old people (Appendix 13).

Literacy levels

One hundred and four (86% of the respondents) completed the section on ability of farmers to read or write at least 1 official language (English, Shona or Ndebele) (Appendix 14). Of these, 96% were literate; therefore, most farmers under study attained the minimal formal education (primary level), and are able to comprehend breeding extension materials written in English, Shona or Ndebele. However, most would be comfortable with materials written in Shona or Ndebele.

Labour availability

The household surveys indicated that, overall, 52% of the respondents employ unskilled workers. However, FGDs and KIIs confirmed that, apart from performing dairy duties, these workers also undertake other duties including tending other cattle, ploughing the fields, and assisting with household chores. Guruve and Mushagashe were the only 2 MCCs where the majority of farmers interviewed indicated they employ farm workers, while in Rusitu-Mayfield, Tsonzo, and Nharira only a minority of the farmers employ workers (Appendix 15).

3.1.3 Market access

The percentage of MCC registered farmers delivering milk to the MCCs varied with 100, 90, 87 and 53% delivering to Mushagashe, Tsonzo, Nharira, and Rusitu, respectively. Farmers are not delivering milk to Guruve and Umzingwane MCCs. Most of the farmers in the Guruve MCC scheme are located far from the MCC (about 30 km away), and hence it is uneconomic to transport small milk volumes to the MCC. The Umzingwane MCC closed down because it failed to settle a big electricity bill. As a result of low milk volumes received in the face of cooling overhead costs, the MCC could not settle the electricity bill.

In general, other reasons advanced for not delivering milk to the MCCs include non-lactating cows, collapsed dairy coops, loss of cows through death, lack of transport, delayed payments, all milk consumed at home, possession of immature heifers, and selling milk to alternative higher paying market (Table 4). About 80% of the respondents use bicycles to transport milk to MCCs, 12% use donkey or ox-drawn scotch carts, while 5% uses motorcycles or vehicles.

Table 4: Percentage of farmers that gave listed reason as a cause for non-delivery of milk to MCCs

Reasons for failure to deliver milk to MCC	Guruve (n = 12)	Mayfield (n = 9)	Nharira (n = 8)	Tsonzo (n = 1)	Umzingwane (n = 39)	Mean (n = 69)
Cows not lactating	25	44	38	100	21	45.6
Dairy coop collapsed	8	1	13	0	36	11.6
Cows died	9	44	13	0	8	14.8
Lack of transport	33	11	0	0	10	10.8
Delayed payments	17	0	10	0	8	7
Consume all the milk at home	0	0	0	0	13	2.6
Immature heifers	8	0	13	0	1	4.4
Selling milk elsewhere at better price	0	0	13	0	3	3.2
Sold all cows	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**

Milk price issues emerged from farmer and key informant interviews, particularly the large price differences between an identified large processor (USD 0.4/liter) and local milk sales at MCCs (USD 1.0/liter) in the same area.

Mean milk delivery to the MCCs ranged from 8.1 to 14.5 litres per farmer/day with Tsonzo farmers delivering the least and Rusitu the highest (Table 5). Mean milk quantity delivered per farmer/day during the rain season was almost double that delivered during the dry season. On average, farmers delivered milk for about 9 months in a year with the least duration of about 7 months for Umzingwane farmers and the longest of 10.5 months for Tsonzo farmers. Milk consumed at home during the rain season was about 60% higher than that consumed during the dry season. On average, Rusitu farmers consumed the least milk at home while Guruve farmers consumed the largest amount, particularly during the dry season when they consumed even more milk than during the wet season.

Table 5: Milk quantity (± SE) delivered to MCCs during the rain and dry seasons and mean duration of delivery/year (± SE)

MCC	MCC Milk Deliveries/Farmer			Milk Consumed at Home	
	Rain season (litres)	Dry season (litres)	Delivery duration (months)	Rain season (litres)	Dry season (litres)
*Guruve	9.0 ± 1.9	5.6 ± 1.7	9.3 ± 1.1	2.8 ± 0.6	3.6 ± 1.7
Mushagashe	12.0 ± 1.3	7.4 ± 0.9	9.6 ± 0.9	2.8 ± 0.5	1.4 ± 0.3
Nharira	11.5 ± 1.6	7.1 ± 1.5	9.3 ± 0.7	2.4 ± 0.3	1.5 ± 0.3
Rusitu	14.5 ± 2.4	7.1 ± 1.2	8.4 ± 0.7	2.3 ± 0.7	1.2 ± 0.3
Tsonzo	8.1 ± 1.6	7.1 ± 2.5	10.5 ± 0.6	2.9 ± 0.8	1.9 ± 0.5
*Umzingwane	9.9 ± 1.9	4.8 ± 1.0	7.1 ± 0.8	2.8 ± 0.7	1.7 ± 0.4
Mean	**11.4 ± 0.8**	**6.6 ± 0.6**	**8.9 ± 0.3**	**2.6 ± 0.2**	**1.7 ± 0.2**

*When operating

3.1.4 Herd characteristics

Number of milking cows

The number of milking cows per household varied with MCCs (Table 6) but the mean was 4 ± 3 and the range was 1 to 20. The number of milking cows per household also varied with season being low during the dry season (2 ± 2, range 0-8) compared to the rain season (3 ± 2, range 0-12). The decline in number of milking cows/household during the dry season was largely attributed to feed shortages caused by, among other factors, limited farmer strategies for dry season feeding such as fodder conservation, and failure to plan breeding and calving periods that coincide with periods of feed abundance. Local breed cows stopped lactating early during the dry season while crossbred and purebred dairy cows continued lactating but produced well below potential.

Table 6: Mean number of milking cows (± SE) , milk production per cow/day, and length of lactation across the studied MCCs

Item	Guruve	Mushagashe	Rusitu-Mayfield	Nharira	Tsonzo	Umzingwane	Mean (all MCCs)
No. of milking cows/yr	5.2 ± 1.7	3.8 ± 0.3	2.9 ± 0.4	3.7 ± 0.4	2.2 ± 0.3	3.5 ± 0.7	3.5 ± 0.3
No. of lactating cows-rain season	3.9 ± 0.9	3.6 ± 0.3	2.5 ± 0.5	2.9 ± 0.4	2.2 ± 0.4	3.1 ± 0.5	3.0 ± 0.2
No. of lactating cows-dry season	2.7 ± 0.8	1.9 ± 0.3	2.1 ± 0.4	1.7 ± 0.3	2.0 ± 0.3	1.9 ± 0.3	2.0 ±0.2
Milk production cow/day (litres):							
Local breed cows	4.4 ± 0.7	3.6 ± 0.3	2.3 ± 0.3	3.4 ± 0.3	3.5 ± 0.5	3.6 ±0.5	3.6 ± 0.2
Crossbred cows	6.9 ± 0.8	8.9 ± 0.8	8.4 ± 1.0	7.3 ± 0.8	7.3 ± 1.6	5.2 ± 0.5	7.4 ± 0.4
Purebred cows	-	10 ± 0.0	10 ± 2.5	12.5 ± 2.1	3.5 ± 1.5	8.9 ± 1.0	9.8 ± 0.9
Lactation length (months):							
Local breed cows	4.6 ± 0.7	5.6 ± 0.7	4.7 ± 1.3	4.5 ± 0.4	-	6.7 ± 0.2	5.3 ± 0.3
Crossbred cows	8.4 ± 1.3	8.3 ±1.4	8.3 ± 0.6	6.5 ± 0.5	9.8 ± 0.7	7.1 ± 0.2	7.9 ± 0.3
Purebred cows	-	9-0 ± 3.0	10.3 ± 0.9	8.4 ± 0.5	8-0 ± 2.0	7.3 ± 0.3	8.1 ± 0.3

Cow milk production

Individual cow milk production varied with breed and MCC. On average, local breed, crossbred and purebred cows produce 3.6 ± 1.5, 7.4 ± 3.7 and 9.8 ± 4.9 liters per cow/day, respectively (Table 6). The least producing local cows were recorded at Rusitu (2.3 ± 0.5 liters/cow/day), whereas the lowest yielding crossbred cows were recorded at Umzingwane (5.2 ± 2.1 liters/cow/day), while purebreds were worst affected at Tsonzo (3.5 ± 2.1 liters/cow/day). Various factors contribute to variations in milk yield across the MCCs. These include feeding systems, breed, calving season, parity number, and effects of location (natural farming system).

Lactation length

Mean lactation length varied with breed, being least in local breed of cows (5.3 ± 2.0 months), followed by crossbred cows (7.9 ± 2.9 months), and was highest in purebred cows (8.1 ±1.9 months) (Table 6). Some cows in this study had lactation lengths of up to 24 months. This observation was supported during FGDs and KIIs where farmers reported that they continue milking a cow as long as she produces milk and is not pregnant or due for calving.

3.2 Existing and Past Breeding Models

There are no clear current breeding models. Farmers are largely using bulls and little AI. Even the use of bulls is not organized and most farmers rely on bulls of neighbours. Although interventions aimed at reviving the smallholder dairy schemes have been on-going since 2009, most of these have been piecemeal and fragmented.

3.2.1 Dairy cattle restocking programmes

Apart from upgrading of indigenous breeds through bull schemes and AI, the NADF has collaborated in breeding cattle restocking programmes with some NGOs and schemes including LOL, Heifer International (HI), Stabex, and Cattle Bank. These programmes largely focused on assisting farmers to obtain improved cows.

One of these major programmes is the HI 'pass-on the gift' initiative in which individual farmer groups receive dairy cows. Group members choose the first cow recipients. In preparation to receive the donated cows, these recipients are trained on cattle management, and have to establish fodder plots, and build cow sheds. On receiving cows, the first recipients sign a contract to pass-on the donated cow progeny, usually heifers, to selected group members.

Stabex was an EU funded project implemented by NADF between 2009 and March, 2010. The project started with 7 dairy schemes. It had breeding, feeding, and herd health components. The feeding and herd health components were supported by a revolving fund. The LPD identified suitable commercial farmers to produce crossbred dairy cattle close to individual MCCs. The commercial farmers were then paid the full cost of raising those heifers by the project/NADF. According to DDP, some key challenges faced were that NADF did not have technical field officers to supervise implementation; no contract was signed between NADF/EU and the commercial farmers; and progress monitoring was inadequate. Some of the 'contracted' farmers failed to deliver the heifers as expected. Also, there were no specifications on the quality and type of heifers to be supplied; as a result, when challenged to meet the 'contract' some suppliers delivered what they had including old cows.

The USAID funded Cattle Bank, implemented by LOL in 2010, considered some of the lessons learned from the Stabex project, but it was still dogged by old and new challenges. Land O'Lakes employed two dairy specialists, one each for Manicaland and another for Mashonaland. It also had a number of technical field officers to facilitate extension and capacity building. The project covered 10 MCCs, and, this time, binding contracts between smallholder farmers and heifer suppliers were signed. As in the Stabex project, the LOL project paid selected commercial farmers to produce heifers (about 300 per year). However, it has been observed that at times these suppliers fail to deliver the desired heifer quality. According to the DDP, recommendations on suitable heifers for purchase have at times not been respected; perhaps this is a consequence of pressure to supply the specified number of heifers in the contract when they are not available.

The dairy cattle re-stocking programmes have met mixed reactions from beneficiaries including allegations that milk production from some of the purebred and crossbred cows supplied is below expectations. In order to enable adaptability and farmer learning, and obtain better cow milk yields, most field staff across the MCCs suggested starting with crossbred dairy cows and gradually upgrading to purebred. In addition, they were concerned that the restocking programmes were supplying breeds that fail to match farmer needs and constraints.

Interestingly, FGDs with farmers at Umzingwane revealed an overwhelming preference for the Red Dane breed because of its low feed requirement, adaptability to the local environment, and high milk butterfat content. In other FGDs, respondents had concerns on the supplied heifers/cows including obscure breed identity, non-pregnancy despite claims that the cows were sold pregnant, lack of pedigree records or history, cows sold were too old, some of the sold cows failed to re-conceive, shortage of feed for purchased cows, inadequate disease control and recipient dairy cattle management skills, low milk production, and inadequate management of the dairy cattle supply programmes.

Apart from the preceding, other concerns were that the re-stocking programmes specifically focused on breeding and improvement of herd quality, but they ignored marketing, feeding, and animal health; consequently, they failed to achieve the expected breeding goals. In addition, farmers were concerned by absence of breeding records, in particular pedigree records, when they buy heifers or cows from most sources including current sources (e.g., NADF/Land O'Lakes Programme). They further alleged that in the existing heifer acquisition programmes, farmers, as buyers, do not choose the distributed heifers. As a consequence, at times they receive old cows instead of in-calf heifers. Overall, farmers (46%) interviewed considered the cattle supplied by the schemes as of poor quality. However, 75% of cattle supplied through the Cattle Bank programme were rated as fair to very good in quality.

On general management of the schemes, the majority (64%) alleged that the schemes were poorly managed. However, the majority (67%) rated the Cattle Bank scheme management as fair to excellent (Table 7), while all farmers interviewed rated the Heifer International scheme as poorly managed. Among others, some of the major issues with the cattle re-stocking projects, as briefly stated above, have been failure to produce records of the animals at handover to the farmers. Overall, for the three schemes 97% of the farmers did not receive any cow records. The few cow records received were only in the Stabex scheme. This has been a critical challenge since record keeping is critical to dairy herd breeding. In general, the majority of farmers (81%) reported that the cattle distributed were young (Table 12). However, of those interviewed on the Stabex scheme, 33% claimed that the cattle distributed were very old.

Table 7: Percentage of farmers in each scheme management evaluation category

Management	*HI (n = 3)	Stabex (n = 10)	Cattle Bank (n = 12)	Overall
Poor	100	20	33.3	64.4
Fair	0	20	25.0	15.0
Good	0	0	33.3	11.1
Very Good	0	20	0	6.7
Excellent	0	0	8.3	2.8
Total	**100**	**100**	**100**	**100**

*HI – Heifer International

3.2.2 Mating system currently in use

Our results show that most (90%) smallholder dairy farmers currently use natural service. Only some Mushagashe farmers practiced AI. Out of those farmers using natural service, the majority (61%) did not own or keep bulls within their herds, except in Mushagashe and Nharira where 77 % and 58 % of respondents, respectively, kept their own bulls (Figure 1). However, the percentage of farmers keeping their own bulls was less than 29% in Umzingwane, Rusitu, Guruve and Tsonzo MCCs. In fact, only 10% of farmers under the Guruve and Tsonzo MCCs had their own bulls. Ninety-five percent of the bulls were of the local rather than exotic crossbreed or purebred dairy cows.

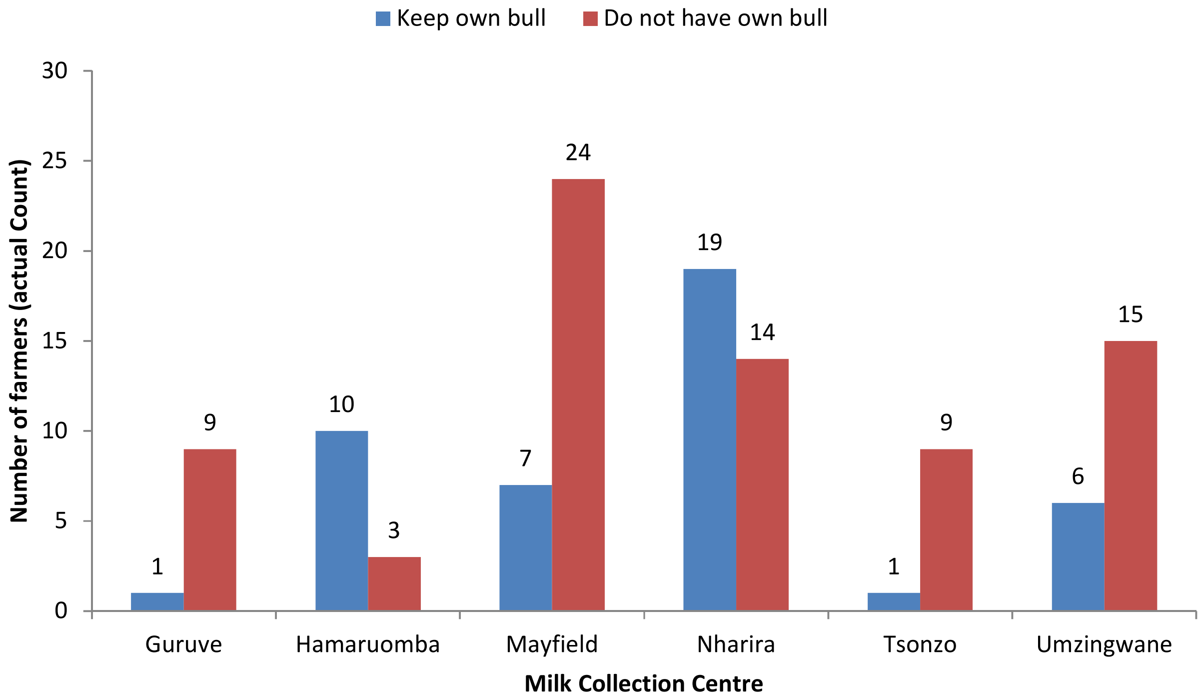

Figure 1: Number of farmers keeping or not keeping their own herd bulls across milk collection centres

3.3 Cattle Breed Distribution and Supply

3.3.1 MCC herd size

Dairy cattle herd size varies considerably across MCCs. About 10% of interviewed farmers, indicated they currently did not own any cattle, but participate in MCC meetings and workshops because they are interested in dairy. In general, the majority of farmers keep 12 ± 9 cows with herd size ranging from 1 to more than 51 cows (Figure 2). Mean herd sizes for individual farmers under each MCC varied from 8 ± 4 in Tsonzo to 17 ± 5 in Mushagashe (Table 8). In general, the cattle herd sizes for the sampled MCCs in Manicaland were smaller than in the other MCCs in other provinces.

3.3.2 MCC cattle breeds and herd quality

Purebreed Mashona, and Brahman and Mashona crosses account for 52% of cattle across the MCCs (Table 9). On average, purebreed dairy cattle account for 3% or less at individual MCCs. There is an array of breeds across MCCs including Holstein-Friesian, Jersey and Red Dane crosses which individually make up 7 to 11% of the surveyed herds. There are also some non-descript crossbreds. In the small scale commercial sector, the only *Bos indicus* breed used for dairy was the Brahman. However, the proportions of the cattle breeds varies with MCC.

Tsonzo MCC has the highest number of Holstein-Friesian crosses that accounted for 30% of the MCC herd followed by Rusitu Mayfield (15%), Nharira (9%), and Umzingwane (9%). Rusitu has the highest number of Jersey crosses (37% of MCC herd) followed by Umzingwane (14%) and Guruve (8%), Mushagashe has a high proportion of Red Dane cattle (21%) followed by Guruve. This distribution of the breeds is a result of availability from a nearby source.

Of note is the high percentage (63%) of purebreed Mashona and Mashona crosses in Guruve MCC, Mushagashe – Hamaruomba (49%), and Nharira (40%). Umzingwane had the largest array of breeds with the highest percentage of cattle being Brahman (26%).

3.3.3 MCC herd composition

Overall, the herd composition comprised of 21% milking cows and a potential breeding female herd of 52% but a low percentage of female calves (4%) (Table10). Mature bulls constituted 3% of the total herd but 6% of the breeding herd (milking cows + dry cows + nulliparous heifers). However, in some MCCs the percentage of bulls was low. In this regard, Guruve, Tsonzo and Umzingwane MCC cattle herds had 1, 1, and 2% mature bulls, respectively. Based on the herd composition figures, bulling ratios were highest in Mushagashe and lowest in Guruve and Tsonzo MCCs. These bulling ratios were calculated taking the MCC cattle as a single herd; however, it is evident that many households keep their herds in isolation and do not own bulls. Key informant interviews and FGDs revealed that most farmers share or hire bulls. In an effort to alleviate the bull shortage and enhance dairy quality, some previous dairy breeding schemes distributed dairy breed bulls to communities in Rusitu, and Umzingwane. However, a consequence of this has been contested ownership and management of these collectively-owned bulls. This practice has been implicated in disease spreading.

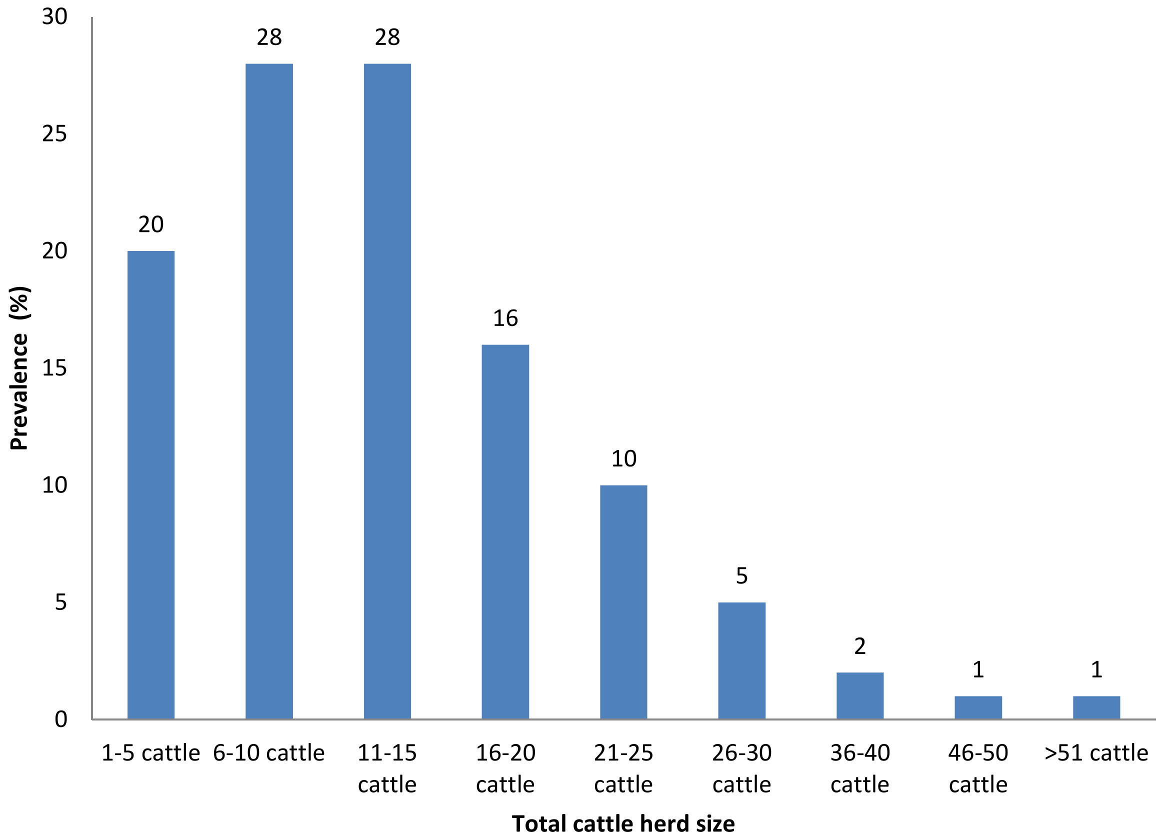

Figure 2: Percentage of farmers in individual herd ownership categories

Table 8: Mean and range of cattle numbers per individual farmer across the MCCs

MCC	No. of cows/farmer	
	Mean	**Range**
Guruve	19.7 ± 8.2	4-91
Mushagashe – Hamaruomba	16.8 ± 1.3	10-24
Nharira	16.0 ± 1.5	1-38
Rusitu – Mayfield	7.6 ± 1.2	1-26
Tsonzo	8.1 ± 1.1	4-15
Umzingwane	10.1 ± 2.2	1-46
Mean	**12.5 ± 1.0**	**1-91**

Table 9: Percentage breed composition across MCCs

Breed	Guruve	Mushagashe	Mayfield	Nharira	Tsonzo	Umzingwane	Total
Brahman cross	3	14	4	26	39	26	20
Mashona Pure	43	23	9	23	9	0	17
Mashona cross	20	26	11	17	13	6	15
Holstein - Friesian cross	1	6	15	9	30	9	11
Jersey cross	8	4	37	0	0	14	10
Red Dane cross	20	21	2	1	4	7	7
Holstein-Friesian pure	0	0	9	4	1	3	3
Tuli cross	0	0	0	3	0	9	2
Red Dane pure	3	5	0	3	0	3	2
Brahman pure	0	2	1	4	1	3	2
Simmental	1	0	1	3	0	8	2
Ayrshire cross	0	0	10	0	3	0	2
Jersey pure	0	0	1	0	0	4	1
Afrikaner cross	0	0	0	0	0	4	1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 10: Percentage cattle in individual herd composition categories and bulling ratios across surveyed MCCs

Cattle Category	Guruve	Mushagashe	Mayfield	Nharira	Tsonzo	Umzingwane	Overall
Milking cows	19	19	18	18	24	19	21
Steers	11	28	19	17	25	13	20
Dry cows	15	16	12	14	7	21	16
Bulling heifers	7	11	18	15	13	12	15
Growing heifers	14	6	11	9	7	14	11
Growing bulls	4	5	1	4	12	6	5
Female calves	16	6	10	11	4	7	4
Male calves	14	5	7	9	6	6	4
Mature bulls	1	5	4	3	1	2	3
Bulling ratio	1:41	1:9	1:12	1:16	1:44	1:26	1:17
Overall	**100**	**100**	**100**	**100**	**100**	**100**	**100**

3.3.4 MCC herd dynamics

Although the figures could not be ascertained, some farmers reported loss of dairy cows from starvation during preceding droughts. Across the surveyed MCCs, only 28% of the respondent farmers acquired improved dairy cattle over the last 12 months. The prices of dairy heifers varied, depending on breed, from $200 (non-descript crosses or local cows) to $1,700 (Red Dane or other crosses) (Figure 3). In fact, the prices were skewed upwards by the modal price range (USD 1,501-1,700) that was a result of the NADF/LOL Cattle Bank loan for a Red Dane breed heifer purchase at USD 1,560.

The reason for cow/heifer purchase by these farmers was to increase milk production (71%), replace a lost or dead cow (6%), get more manure (6%), replace an old cow (3%), elevate social status (3%), and to obtain more draught power (3%). In general, farmers identified their sources of purchased cattle, including improved dairy cattle, in descending order of importance as their village, ward, district and province. Clearly, geographical proximity of a source of cattle is a key consideration taken by farmers when sourcing cattle.

Conversely, the major reasons for selling animals cited included need for cash income (56%), old age (13%), and poor performance (13%). The modal selling price ranged from USD200 to 500 (Figure 4) which is a reflection of the low quality of the cattle sold.

Some of the farmers under study, in particular, from Mayfield, Nharira, and Tsonzo reported that they previously had crossbred and purebred cattle but they had died. Most of the farmers under these MCCs (50%) identified feed shortage during the economic meltdown period as the cause of the cow death, whereas some farmers (33%) were forced to sell their cows for the same reason. A few farmers (8%) sold their cows as a consequence of water shortage. Although the macroeconomic environment has improved, the farmers' herds have not reached repletion. This has been aggravated by unaffordable prices and unavailability of dairy cows.

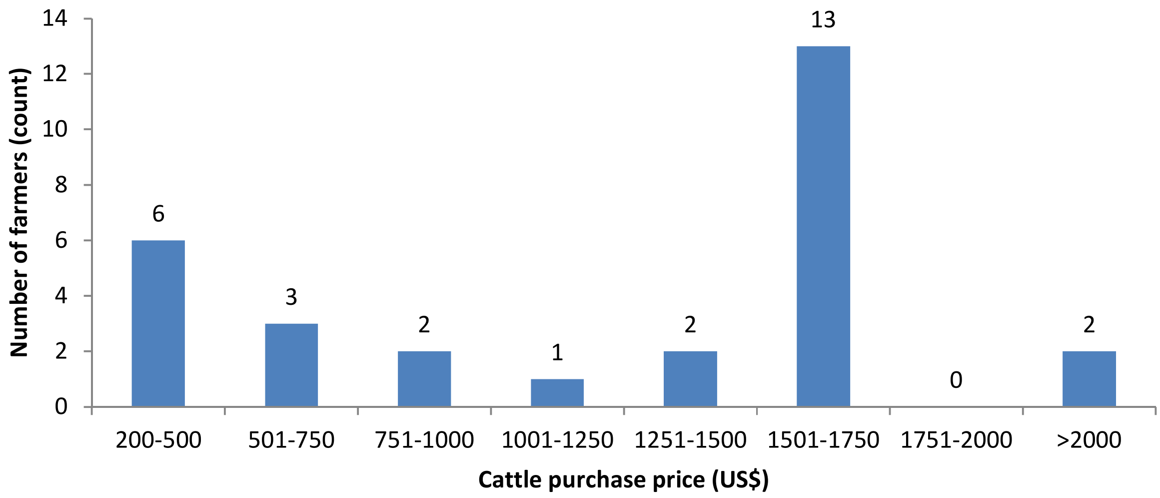

Figure 3: Number of respondent farmers that purchased cows in individual cattle purchase price bands.

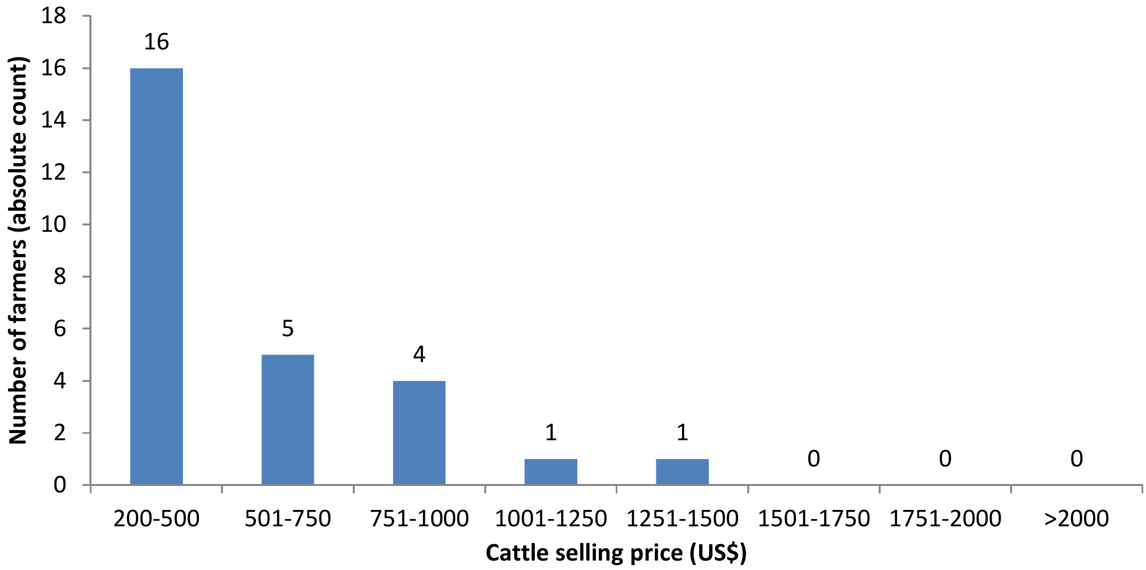

Figure 4: Cattle selling price ranges across the studied MCCs

3.3.5 Selection of best dairy animals

Farmers across the MCCs claimed that they select their cows based on some dairy characteristics. To this end, farmers were asked to indicate the characteristics they look for when choosing a bull or heifer. In this regard, farmers mainly considered disease resistance, high milk yield (15-20 liters/day), good temperament, large body size, and high fertility (Figure 5). Although farmers know what they want, unavailability of animals with the desired characteristics precluded them from implementing cattle selection for herd growth and expansion. Seventy-eight percent of the farmers interviewed reported that the heifers/cows or bulls with desired characteristics are not available, except at Rusitu where 67% reported that the cows that they desire were available at a nearby commercial dairy farm. Apparently, the farmers' choices were based on experience.

Some MCCs also identified sources of dairy cattle in their neighbourhoods (Appendices 6-11, & 16). Respondents recommended purchase of cattle from farms where cattle are reared extensively to suit the smallholder farm environment. Respondents from Tsonzo claimed that 70% of cows sourced from a nearby intensively managed farm died primarily because they could not replicate to good rearing conditions at the source farm. Mayfield respondents claimed that some unscrupulous cattle supply farmers hike prices and sell the worst cows in their herds, particularly when they supply donor-funded projects.

3.4 Breeding and AI Constraints

The ToR requires us to establish constraints to breeding including those affecting AI provision and success such as heat detection and reproductive management;

Breeding and AI constraints include, as reported above, limited availability of suitable dairy cattle; poor development of dairy extension and AI services; limited dairy herd management skills and knowledge, for example, inadequate reproductive management, heat detection and cow feeding knowledge.

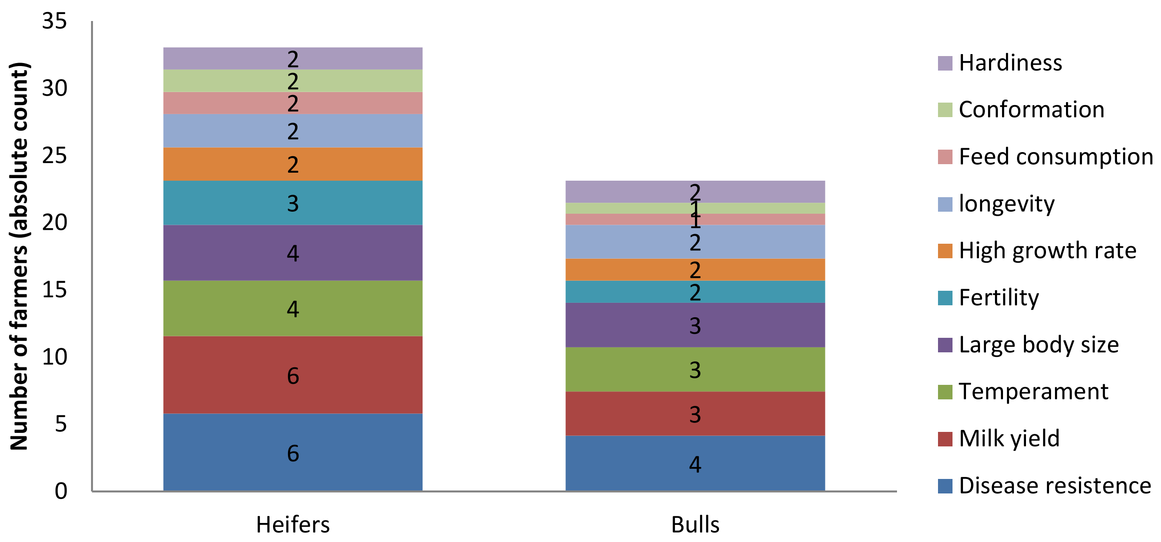

Figure 5: Number of farmers that chose individual characteristics as a basis for selecting a heifer or bull.

3.4.1 Artificial insemination

Our results show that AI has not been widely adopted by many smallholder farmers across MCCs. Where it was in use, it was heavily state subsided, and hence was affordable. Withdrawal of government subsidies, as a consequence of the economic malaise during the last decade, led to limited coverage and unreliable provision of AI service to farmers.

However, some farmers in Mushagashe, Rusitu, and Umzingwane MCCs are currently using AI. None of the farmers in Guruve, Nharira, and Tsonzo MCCs are using AI. Only 23 farmers (19% of total interviewed) indicated that they currently or have previously used AI. The majority of these farmers are in Rusitu (12), followed by Nharira (7), Umzingwane (3), and Tsonzo (1). Of these, 6 used AI in 2012, 2 in 2011, 1 in 2010, and 14 prior to 2010. At Umzingwane (Appendix 8), AI was last used at the end of 2010 and in 2011. Land O'Lakes dissuaded farmers from using it in the 2012 dry season due to natural pasture shortage caused by drought.

Currently, there are few government agents offering AI services, which are now largely provided by private service providers. Respondents identified Land O'Lakes as the only NGO that is reviving AI in smallholder dairy schemes. In general, private AI services are underdeveloped. Probably, as a consequence of this, farmers consider the costs of AI services as high leading to frequent use of bulls of unknown breeding value.

The main AI service concerns from these respondents were: too many repeat breedings (FGDs and KIIs revealed that AI is repeated 2 to 3 times/pregnancy), long distance to an inseminator, limited choice of breeds, and poor quality semen, AI technician incompetence, AI conducted without use of sire directories and ancillary records, inability to control breeding under communal grazing systems, and low heat expression and conception rates, particularly during the dry season (Table 11).

Table 11: Percentage of farmers, across four MCCs, in each AI services concern category

AI Concerns	Mushagashe	Rusitu	Nharira	Umzingwane	Overall
Too many repeat breedings	33	78	75	50	47
Long distance to inseminator	33	11	25	0	14
Limited choice of breeds	0	0	0	50	10
Poor quality semen	33	0	0	0	7
Other	0	11	0	0	22
Total	**100**	**100**	**100**	**100**	**100**

3.4.2 Bull schemes

In order to address limited availability of dairy breeding cattle and AI services, some government and non-governmental programmes such as the DDP, HI, Land O'Lakes, and some adjacent commercial dairy farmers have offered bulls to smallholder dairy farmers. Often, groups of farmers get a bull but one farmer in individual groups keeps the bull. The majority of respondents in this survey revealed that they use bulls; however, none of the bulls examined during belt transects were proven bulls. While owning a dairy bull is desirable, most farmers conceded that the initial purchase and maintenance costs are high and cannot be recouped from renting the bull for a fee to neighbours. Farmers further acknowledged that renting out a bull can bring in reproductive diseases. Cognizant of the reproductive disease spread, some farmers are now reluctant to use group bulls unless access to these bulls is limited to a few farmers.

Guruve, Rusitu, and Umzingwane MCCs had bull schemes but they faced several challenges including high maintenance costs, low frequency of bull use, and uneconomic bull service charges. As a consequence, farmers that maintained the bulls, on behalf of their group members, had to bear the bull maintenance costs. Given the high maintenance costs, most of the farmers could not afford to keep the bulls, and hence disposed them. The farmers interviewed also reported that most of the purebred dairy bulls died from diseases; for example, a bull donated to Guruve MCC by a commercial farmer died after contracting dermatophilosis (senkobo), a preventable and curable disease. Also, a bull donated to Umzingwane MCC by a commercial farmer in Nyamandlovu was allegedly neglected and died from tick-borne diseases. In the same area, a Red Dane bull donated by DDP had to be sold because none of the farmers in the area offered to take care of the bull.

3.5 Farmer Breeding Skills and Knowledge

3.5.1 Preferred breeding method

Although most farmers are using natural service, the majority (64%) of the respondents in this study preferred AI to natural service. However, 90% and 67% of the respondents in Guruve and Nharira, respectively, preferred natural service to AI and cited easy accessibility and affordability of natural service, and few or no repeats for bull service than AI. Respondents in Mushagashe, Rusitu-Mayfield, Tsonzo, and Umzingwane MCCs cited breed variety and better genetics as the main reasons for preferring AI to bull service (Table 12). In general, while AI is preferred, farmers in some areas and MCCs lack knowledge about it and the requisite infrastructure. In this study, farmer heat detection knowledge is one key requirement for a successful AI programme that was tested.

Table 12: Percentage of farmers across MCCs indicating listed AI preference reason.

Reasons	Guruve	Mushagashe	Rusitu-Mayfield	Nharira	Tsonzo	Umzingwane	Total
Get breed variety	15	33	31	21	11	29	25
Its more affordable	31	11	13	42	21	15	22
Get best genetics	0	22	31	5	26	32	20
Few or no repeats	27	11	13	21	5	12	15
Its easily accessible	27	22	9	11	11	12	15
Others	0	0	2	0	26	0	3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

3.5.2 Heat detection knowledge

When asked to rank the true sign of oestrus, on average across MCCs, respondents cited mounting other cows (55%) as the most important sign of estrus, followed by standing when mounted (20%) (Table13). The highest percentage of respondents who identified the true sign of oestrus, standing when mounted, were from Mushagashe and Tsonzo and the least percentage was from Umzingwane MCC. Interestingly, standing when mounted was identified as the second sign of oestrus by 45, 41 and 38% of farmers in Rusitu, Umzingwane, and Tsonzo, respectively. These results show that farmers are generally aware of most of the secondary signs of oestrus, but are not aware of the primary (true) sign of oestrus which is used in timing artificial insemination.

Table 13: Percentage of respondents ranking the listed individual signs of oestrus as the true (first) oestrus sign

True Oestrus Sign	Mushagashe (n = 13)	Mayfield (n = 29)	Tsonzo (n =10)	Umzingwane (n =18)	Total (n =71)
Mounting other cows	46	62	10	78	55
Standing when mounted	31	17	30	6	20
Mucus discharge	8	7	20	11	10
Decreased feed consumption	0	10	10	6	7
Vulva reddening/swelling	15	0	20	0	6
Being followed by bulls	0	3	10	0	3
Total	**100**	**100**	**100**	**100**	**100**

3.5.3 Reproductive performance indices

In order to manage an AI programme, dairy farmers should monitor standard reproductive performance indices. Based on the household surveys, FGDs and KIIs, we estimated reproductive performance indices across the MCCs (Table 14). Interval to first postpartum oestrus, days open, age at first breeding and calving interval were longer than expected. This is despite the use of bulls that often results in lower services per conception. This shows that reproductive performance across MCCs is influenced by many factors that may not necessarily be caused by breeding/mating inefficiencies. Respondents were not even aware of important reproductive performance indices including conception rate at first service, and overall herd conception rate. Services per conception to AI are higher than expected.

Table 14: Average values for standard key reproductive performance indices and those given by respondents across the MCCs

Reproductive Performance Index	Estimate	Goal
Interval from calving to 1st observed heat (days)	80	40
No. of days to first service	120	70
No. days open	248	100
Calving interval (months)	21.5	12.5
No. Services/conception (bull)	1.3	1.3
No. of services/conception (AI)	2.5	1.5
Conception rate at 1st service (%)	-	55
Overall conception rate (%)	-	85
% of herd culled for reproductive reasons	-	5
Age at first breeding (months)	28	15

3.5.4 Farmer training needs

The FGDs revealed that participants needed training in, among others, AI theory and practice, and feeding and ration formulation as illustrated by results from the Nharira MCC FGD (Table 15).

Table 15: Farmer training needs at Nharira MCC

Topic	Tallies	Rank
Artificial insemination (Theory or Practice)	9	1
Heat detection	2	2
Feeding and ration formulation	2	2
Herd health management	2	2
Dehorning	1	3
Calf rearing/weaning	1	3
General herd management	1	3
Record keeping	1	3
Pregnancy diagnosis	1	3

3.6 Breeding Infrastructure, Inputs and Services Distribution

Based on our observations and farmer accounts, breeding infrastructure and delivery of AI services remains rudimentary. The major sources of semen identified are: Red Dane Farm that supplies almost exclusively Red Dane semen; Livestock Identification Trust (LIT), which supplies dairy and beef breeds semen; and ABS TCM Zimbabwe Ltd (ABS), which also supplies dairy and beef breeds semen. None of the interviewed farmers have accessed semen from either LIT or ABS. As reported above, most MCCs have not prioritized AI use, and hence created the necessary economies of scale to support it. Clearly, the whole AI delivery network including semen and liquid nitrogen supply, relevant geographical distribution of services, and presence of proficient, accessible inseminators is not developed. In addition, AI services are not regarded as a business proposition but a public service to farmers. Consistent with this approach, public extension officers are largely expected to deliver AI services.

Interestingly, some MCCs have some AI equipment that is moribund; for example, Tsonzo MCC has a 35-litre liquid nitrogen tank that is not in use. The MCC respondent said that the MCC could not maintain the service because it is uneconomic to bring in an inseminator to serve a farmer when the need for cow insemination arose.

The majority of farmers across the MCCs have access to a crush, except some farmers in Nharira and Umzingwane MCCs. Farmers acknowledged that a cattle crush is necessary to execute AI, and administer vaccines, anthelmintics, and curative treatments. In the event they are not available, farmers are willing to construct such crushes.

Unlike prior to the land reform programme when a recognized, well resourced inseminator training institute and supplier of both local and imported semen existed, no leader in provision of these services has emerged. Several groups have irregularly offered AI training courses. Recent efforts to train inseminators have been organized in collaboration with the NADF. There appears to be no set regulatory curriculum and requirements for training of inseminators and for training of farmers in reproductive management to buttress AI initiatives.

While the use of AI and establishment of the requisite infrastructure have not been a priority to MCCs, farmers were asked about their knowledge on, and experience with, breeding technologies that have been used in similar smallholder dairy farms elsewhere.

3.7 Use of Breeding Technologies and Breeding Strategies

Few of the respondent farmers in this study (< 10%) were aware of breeding technologies including embryo transfer, heat synchronized AI, genomic bull semen, and sexed semen (Table 16). At Nharira MCC, all FGD participants had used AI before. In FGDs, respondents revealed that the Swedish Centre for Co-operation (SCC) had conducted synchronized AI for all farmers with cows/heifers. Regrettably, the success rate was low, only 3 cows out of 150 conceived (2%). As a consequence of this failure, farmers have little confidence in AI, particularly synchronized AI. However, some respondents, particularly the young, are willing to try it again.

Discussion on the low success rate identified the following reasons that could have contributed to the failure:

- Reproductive fitness of cows presented was not verified;
- Cow bodyweight and body condition scores at breeding were not considered;
- Farmers ignored a call to bring cows to a central point (e.g. at MCC) to facilitate monitoring by technicians;
- Semen was donated and the quality was not ascertained;
- Since semen was donated, farmers could not choose what to use; and
- Semen source was not known and no records were available.

The same synchronized AI initiative was reportedly more successful at the Sadza MCC where farmers brought their cows to a central place and 31 conceived. However, a different team of technicians operated in Sadza.

In general, respondents said that semen supply is irregular and often unavailable when needed. Semen is largely donated, and hence it is usually of doubtful quality. However, farmers have little choice but to accept whatever is available. Often, semen source is not known and no sire summaries are available to check on predicted progeny performance. Although respondents acknowledged that breeding is easier using synchronized AI, they cannot afford to pay the costs on their own.

It was reported that currently Land O'Lakes is the only NGO that is re-introducing AI. At Nharira MCC, AI technicians were trained in November 2012, and Land O'Lakes was to deliver AI kits and semen by December 2012/January 2013. The MCC does not have AI equipment. The initial batch of semen will be for free. However, participants were not sure of the breed of the promised semen.

Few farmers had breeding goals or strategies (Table 17). The most common breed improvement strategies used over the past five years have been hiring bulls, importation of heifers/cows, selecting bulls from individual farmers own herds, and AI (12%). In general, most farmers across the MCCs rely on bull use for breeding, and buying-in heifers and cows to build their herds or replace old cows.

Table 16: Percentage of respondents across the MCCs that have used the listed individual breeding technologies

Technology	Guruve	Hamaruomba	Mayfield	Nharira	Tsonzo	Umzingwane	Overall (%)
Genomic semen	0	0	12	0	0	14	4
Embryo transfer	0	0	12	0	0	14	4
Sexed semen	0	0	16	0	0	14	5
Heat synchronized AI	0	0	22	5	10	14	9
AI	10	8	37	15	20	29	20

Table 17: Percentage of respondents across MCCs that have used the listed breeding strategies over the last 5 years

Breeding Strategy	Guruve	Hamaruomba	Mayfield	Nharira	Tsonzo	Umzingwane	Mean (%)
Bought a bull	30	0	25	15	0	29	16
Selected best bulls	20	85	28	20	20	43	36
Hired a bull	20	8	44	55	90	76	49
Bought heifers	60	23	13	55	50	57	43

3.8 Dairy Extension and Animal Health Services for Breeding Support

Dairy extension is currently offered by the Departments of Livestock Production and Veterinary Services, AGRITEX, and the DDP. The NADF also contributes to dairy extension through linkages with many organizations. However, except for the DDP initiatives, there is hardly any extension programme that is focused on breeding. There are even no specific dairy curriculums across the agricultural colleges and universities. In general, dairy extension is not strong because of limited specialized expertise and limited resources to finance the public extension service. While the DDP is focused on smallholder dairy development, it lacks the capacity to offer sustained extension services. Public extension departments are expected to take over this role when MCCs are weaned from the DDP.

Dairy health delivery services have been adversely affected by public sector budgetary constraints and inadequate qualified manpower. This has precluded support of breeding programmes to limit disease spread through routine practices including bull breeding soundness examination, vaccination programmes, limited testing for zoonoses of dairy concern including brucellosis and tuberculosis, and mastitis control.

3.8.1 Common diseases of dairy cattle encountered

The three most prevalent diseases affecting cattle across the MCCs were tick-borne diseases (91% of the respondents), followed by mastitis (31%), and reproductive diseases (35%). However case fatality rates (number of cattle that died out of those that were affected) were low, being 8%, 9%, and 13% for tick-borne diseases, mastitis, and reproductive diseases, respectively. Recorded cattle mortality by class of stock was less than 5% for each category, indicating that disease prevalence may not be a big threat to dairy herds (Figure 6). Household survey findings were confirmed during FGDs and KIIs, where it emerged that diseases were not a big challenge at most MCCs, except Guruve where the skin diseases, dermatophilosis and parafilariosis, are prevalent. The latter is a consequence of irregular dipping of cattle against ectoparasites. The low mortality is partly attributed to the hardiness of the indigenous breeds or their crosses, but as farmers increase the percentage of foreign blood in their cattle, this resistance to diseases is lost; hence, farmers expressed a need for training in disease control. In addition, respondents claimed that they follow some routine herd health maintenance practices.

While participants confidently executed routine practices including tick-control, they were uncertain on practices such as vaccinations, particularly for the control of reproductive diseases (e.g., brucellosis). In general, most farmers were unaware of dangers of uncontrolled veterinary drug use; for example, acaricide resistance in ticks, and drug residues in milk and meat products. From discussions, it emerged that lack of acaricides or water during the dry season disrupts the government's mandatory fortnightly dipping programme. On occasions when this service is unavailable for prolonged periods of time, farmers are compelled to buy acaricides or apply tick grease themselves.

3.8.2 Routine herd health practices by farmers

Ninety-eight percent of the respondents across the MCCs said that they routinely give anthelmintics to cattle to control internal parasites (Plate 1), and more than 76% also carry out routine herd vaccinations. However, at Mushagashe, all respondents did not vaccinate their cattle. According to the household survey, the costs of providing routine herd health services were farmer dependent and wide ranging (Table 18). The cost range illustrates the wide range in farmer herd health compliance from virtually no input to substantial input.

In general, farmers requested for assistance in provision of veterinary services including tick control. Unlike the historical ectoparasite control that was a state responsibility, the majority of the respondents (65%) control ticks on their own and government contribution is now low (Figure 7). A depletion in government service provision compelled farmers, out of desperation, to self-provide animal health services. Of interest is the emergence of community animal health workers (CAHW) in providing animal health services. However, farmers do not verify the qualifications and legitimacy of those providing these clinical services. Fortunately, farmers recognize the downside of unprofessional veterinary services provision that could lead to build-up of disease-causing organisms' resistance to therapeutic treatments.

Plate 1: Internal parasites can cause weight loss and wasting

Table 18: Farmer reported costs of animal health remedies and services per household/year across the MCCs

Remedy/Service	Estimated Cost (USD)
Antihelmintics (de-worming)	182
Acaricides (tick control)	2-100
Curative treatments	2-80
Vaccines	1-150

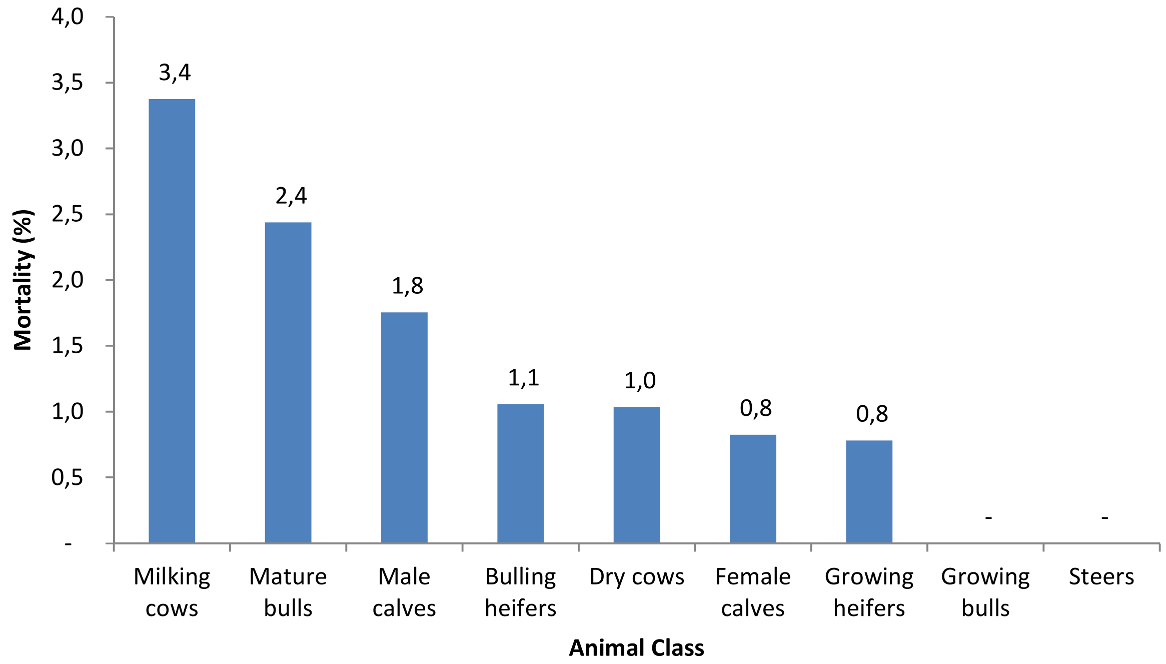

Figure 6: Case mortalities/year for individual cattle classes across the studied MCCs.

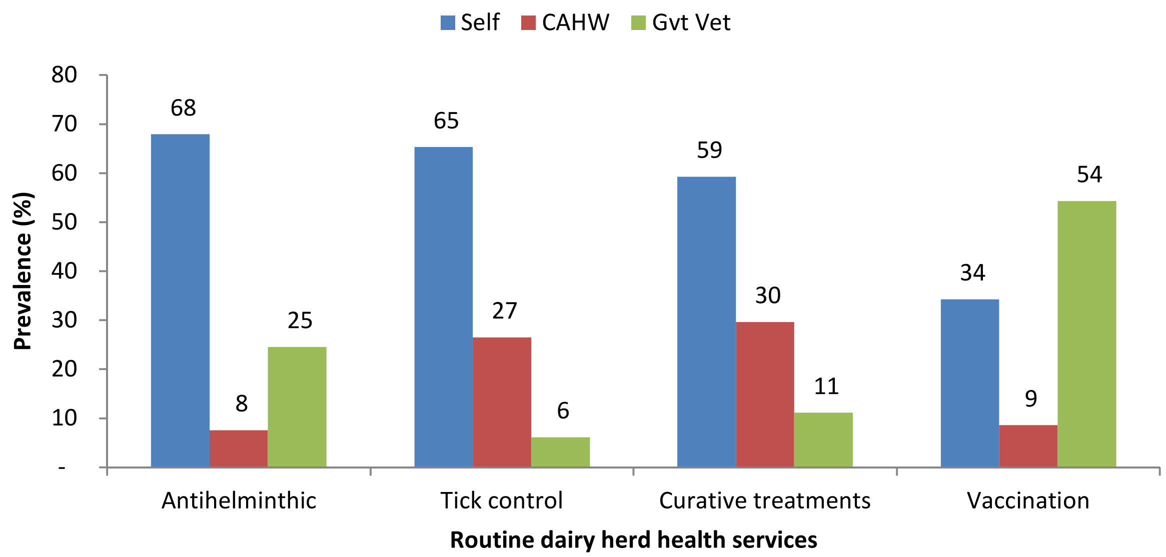

Figure 7: Number of respondents that identified the listed providers of routine herd health services across the MCCs studied.

3.9 Cattle Breeding Research

Smallholder dairy cattle breeding research has not received much attention. Past research at Henderson Research Station evaluated pasture-based milk production systems for crossbred dairy cattle. Unfortunately, the crossbreds used were not well-defined. Such research, and, in general, dairy research is virtually dead, a consequence of the economic decline and skilled manpower loss experienced over the last decade. While the rudimentary infrastructure for dairy research and, specifically, dairy breeding research still exists, reviving research to support the smallholder dairy sector will require substantial resource input including researcher training in smallholder dairy.

While the definition of research can be wide including formal and informal, 53% of the respondents across MCCs claimed that they have not benefited from research in dairy breeding. However, some respondents attested to research on breeding having been conducted, for example in Guruve, Rusitu (Mayfield), and Umzingwane (Figure 8). The major dairy breeding researchers have been from NGOs followed by Government, and MCCs and Banks, in particular AgriBank (Figure 9). Prior to 2002 the University of Zimbabwe Department of Animal Science and Veterinary Faculty were heavily involved in dairy research activities that included breeding in Nharira, Mayfield, Umzingwane and Hamaruomba MCCs. As shown in Figure 10, the research providers are no longer available at most sites except at Rusitu (Mayfield). Most of these research activities were funded by international organizations including DANIDA (Danish AID) and European Union. As noted above, there is currently limited research activity, except at Mayfield and at Umzingwane and Guruve (Figure 10). There are no research activities at Nharira MCC.

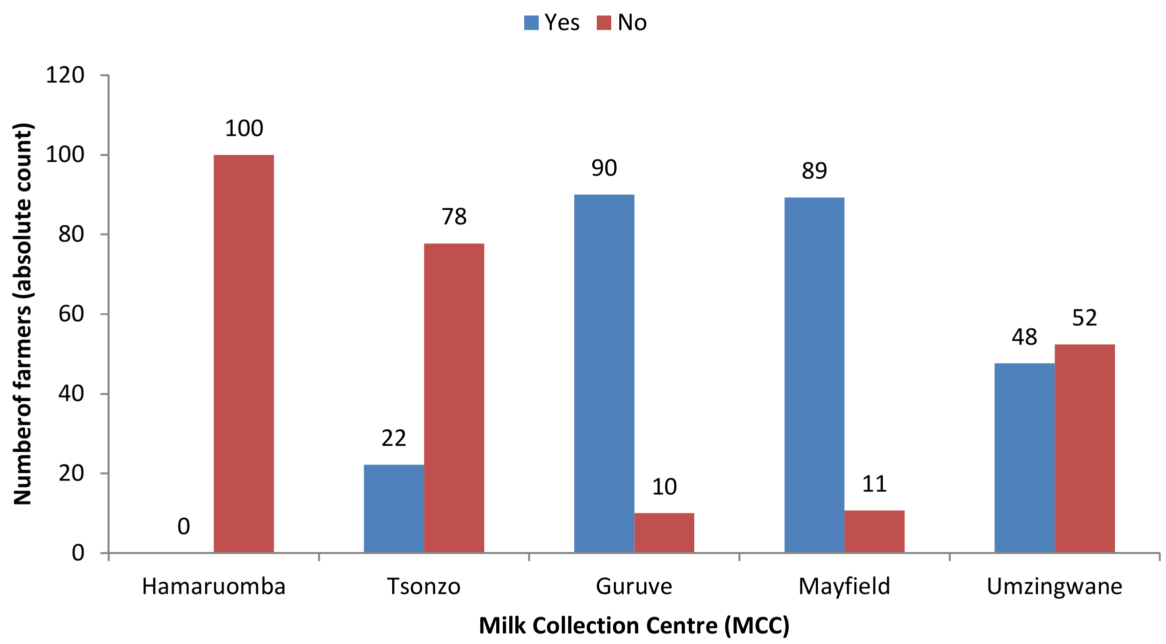

Figure 8: Farmers benefiting from research in dairy breeding

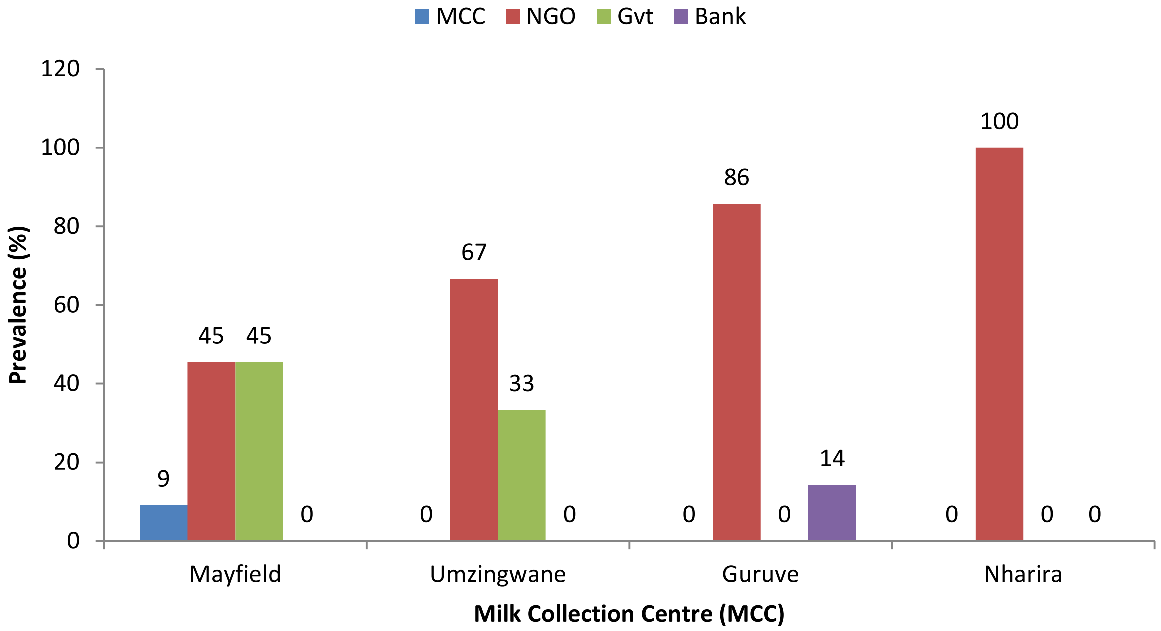

Figure 9: Main providers of dairy breeding research at selected MCCs

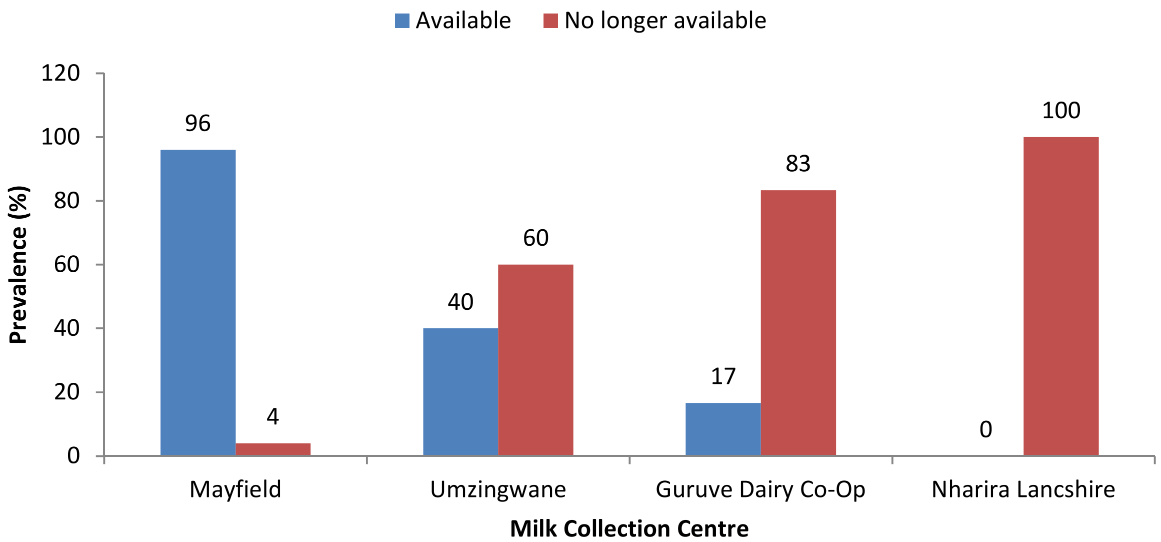

Figure 10: Number of respondents attesting to research status at the listed MCCs

3.10 Breeding Extension Service Provision

Overall, nearly all respondents at Guruve, Mushagashe (Hamaruomba), Mayfield, and Tsonzo said they benefited from extension support services. However, 80% and 60% of the respondents at Nharira and Umzingwane, respectively, claimed that they have not benefited from extension services. The main extension service providers identified were Government, NGOs, and MCCs (Table 19). These providers are still available at most MCCs except at Umzingwane where about 80% of the respondents said extension providers are no longer available.

Table 19: The major extension service providers across study sites (MCC - milk collection centre, NGO – non-governmental organization, & Gvt – government)

Provider	Guruve	Hamaruomba	Mayfield	Nharira	Tsonzo	Umzingwane	Total
MCC	0	0	15	0	0	0	6
NGO	0	100	7	33	100	38	40
Gvt	100	0	78	67	0	63	54
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

It was evident that there is a shortage of veterinarians in the rural areas, and hence farmers have to rely on CAHWs. However, these are para-veterinarians that are limited in scope, veterinary knowledge and skills.

3.11 Cattle Identification and Milk Recording Programmes

The objective of this section was to identify the cattle identification systems, and the existing cattle breed societies in place, and to determine the Zimbabwe Herd Book status and potential for strengthening its role.

3.11.1 Cattle identification

Farmers use both ear tagging, naming, and tattooing to identify cows. Most of the respondents identified their cattle using names (34%), followed by tag numbers (28%), branding/notching, ear tattooing (17%), and colour (14%). There is scant pedigree information on bulls used and purchased female cattle. However, most farmers recognize the need to keep records. Overall, 65% of the farmers interviewed kept records, while 35% did not. Poor record keeping was largely observed in Nharira MCC where 67% did not keep any records followed by Rusitu where 39% of farmers did not keep records. The most common records kept, in descending order of importance, were on production, breeding, veterinary issues, feeding, cattle deaths and births, sales, purchases, and visits (Figure 11). Among those respondents who kept records, 51% did not identify the records they kept.

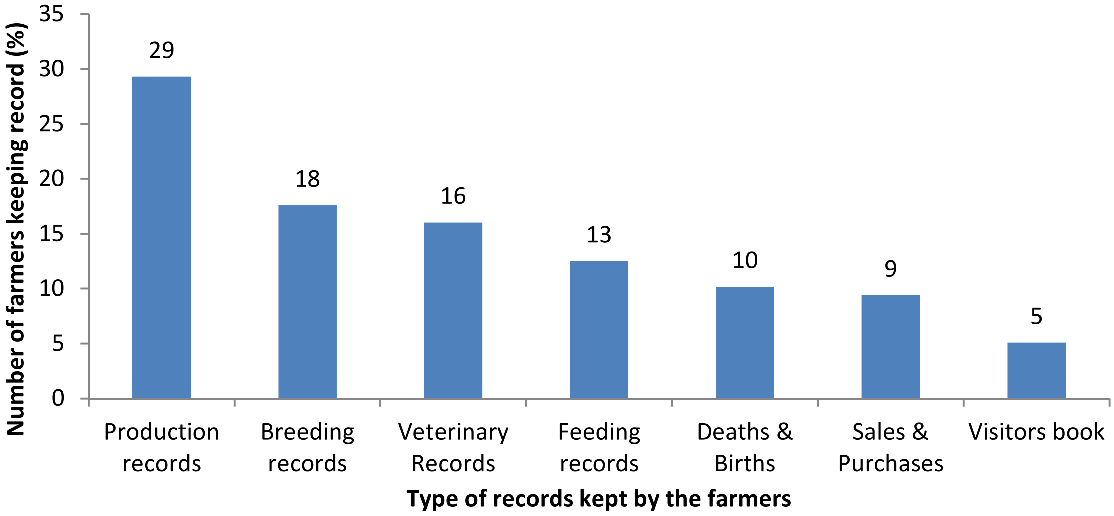

Figure 11: Percentage of farmers keeping different types of records

3.11.2 Participation in breed societies and the Zimbabwe Herd Book

None of the respondents (119) belonged to a cattle breeding society, but only 4 farmers in Tsonzo had heard of the Zimbabwe Herd Book. However, none of the respondents have ever registered cattle with the Zimbabwe Herd Book. Given the absence of cattle registered with the Zimbabwe Herd Book, none of the smallholder dairy cattle can be regarded as pedigree. Clearly, smallholder dairy farms cannot be a recognized source of tracable improved heifers, cows or bulls.

3.12 Milk Recording and Testing Services

There is currently no smallholder dairy scheme that is participating in the national milk recording scheme. Key informants reported that the national milk recording scheme started as far back as 1929 but at its most popular period only 25% of the commercial dairy herds participated in the scheme. In 1993, the scheme was taken over by the Zimbabwe Dairy Services Association. Apart from milk recording in commercial dairy herds, the ZDSA also milk recorded in 10 smallholder dairy schemes.

The work of the milk recording scheme and the Zimbabwe Herd Book was supported by breed societies including the Jersey, Holstein, Guernsey and Ayrshire breed societies. Smallholder farmers do not belong to any breed society because most of the cattle they possess are not purebreds.

3.13 Dairy Policies and Breeding Support Programmes

Apparently, there are no Government of Zimbabwe (GoZ) policies that directly address smallholder dairy cattle breeding. However, the National Dairy Strategy aims to 'continue the expansion of the national dairy production base to the small-scale, communal and resettlement farming sectors, so as to increase milk supply and develop the communities.'

Apart from basic infrastructure installation such as roads and electricity for MCCs, key informants and farmers suggest that the GoZ should enact policies to support setting up of AI services, improve animal health services including ectoparasite control to within reach of smallholder dairy farmers, facilitate financial support, revise legislation on clean milk production to allow use of less expensive structures, and multiply foundation breeding cattle using state and parastatal farms.

3.14 Cattle Breeding Investments and Financial Products

Apart from the programmes supporting purchase of female breeding cattle that were funded by HI, Cattle Bank and Stabex, there are no specific programmes or investments in smallholder cattle breeding programmes. Most investments have been private and smallholder dairy farmers have also privately purchased dairy cattle from these sources.

Securing financing for acquisition of cattle in the smallholder dairy sub-sector has been difficult because of inadequate collateral, high risk of losing secured cattle through, among others, disease and theft. In addition, there is limited supply of good dairy cattle that leads to high cattle prices on the market.

3.15 Constraints to dairy production in smallholder farming areas

Lack of finance to buy dairy cattle was listed as the most important dairy production constraint (Table 20). Combined with lack of finance to purchase feed, 30% of the respondents regarded lack of finance as a major dairy production impediment. The Government (21.8%) and NGOs (59.4%) have largely been supporting MCCs to rebuild dairy cattle herds (e.g. Stabex, & Cattle Bank Schemes). Financial institutions offering loan schemes to dairy farmers are few. This is probably a consequence of poor MCC creditworthiness and low producer collateral security. High interest rates (15-25 %) also deter farmers from borrowing. Sixty percent of the respondents did not access loans to buy dairy cattle. Among those who received project assistance to purchase cows, 10 farmers accessed the loans between 2010 and 2012. The cost of purchasing a grade heifer (USD 1,560) is high and such heifers are not readily available.

Apart from limited finance, major constraints to dairy production included inadequate feed, low milk yield/cow, low milk price and inadequate water. However, apart from lack of finance, inadequate feed and low milk yield per cow, some of the constraints are MCC specific; for example, Hamaruomba and Nharira have labour shortages while Mayfield and Umzingwane face water shortages.

Table 20: Percentage of respondents across MCCs that listed constraint as important

Constraint	Hamaruomba	Mayfield	Nharira	Tsonzo	Umzingwane	Average
No. of respondents	39	9	86	25	47	206
No cattle purchase finance	18	11	20	20	21	18
Inadequate feed	15	22	12	32	19	20
Low milk yield/cow	18	11	15	16	15	15
Lack of finance to buy feed	13	11	14	4	11	11
Low milk price	15	11	13	-	4	9
Inadequate water	3	22	7	4	19	11
Expensive feed	5	11	9	-	4	6
No labour	13	-	7	-	-	4
Poor cattle health	-	-	2	16	6	5
No milk market	-	-	1	-	-	0
Other	-	1	-	8	1	2
Total	100	100	100	100	100	100

On being asked why they did not get loans for their dairy activities, 24% of the respondents reported that they need loans but they have not been able to get them (Figure 12). An equal percentage did not know of available loan facilities, while others lacked the requisite collateral, feared the consequences of loan default, and attested to unavailability of loans.

While Tsonzo, Nharira and Umzingwane listed animal health as a constraint, the respondents identified the most important dairy cattle diseases as tick borne diseases (55%); reproductive disorders, mainly abortion and brucellosis (24%); and notifiable diseases (12%). About 32% of the respondents had lost cattle this year (2012) and 18% of the respondents said the cattle loss was caused by diseases. Although about 76% of respondents reported that their cattle survived after being affected by various diseases, often, there was no post-disease repletion of milk production.

3.16 Feeding Programmes for Breeding Support

As reported above, previous breeding cattle purchase programmes were criticized for not taking into consideration supporting pillars including feeding plans for breeding cattle. In this regard, respondents were requested to provide information on feed and grazing resource availability and management and how feed is allocated to breeding cattle.

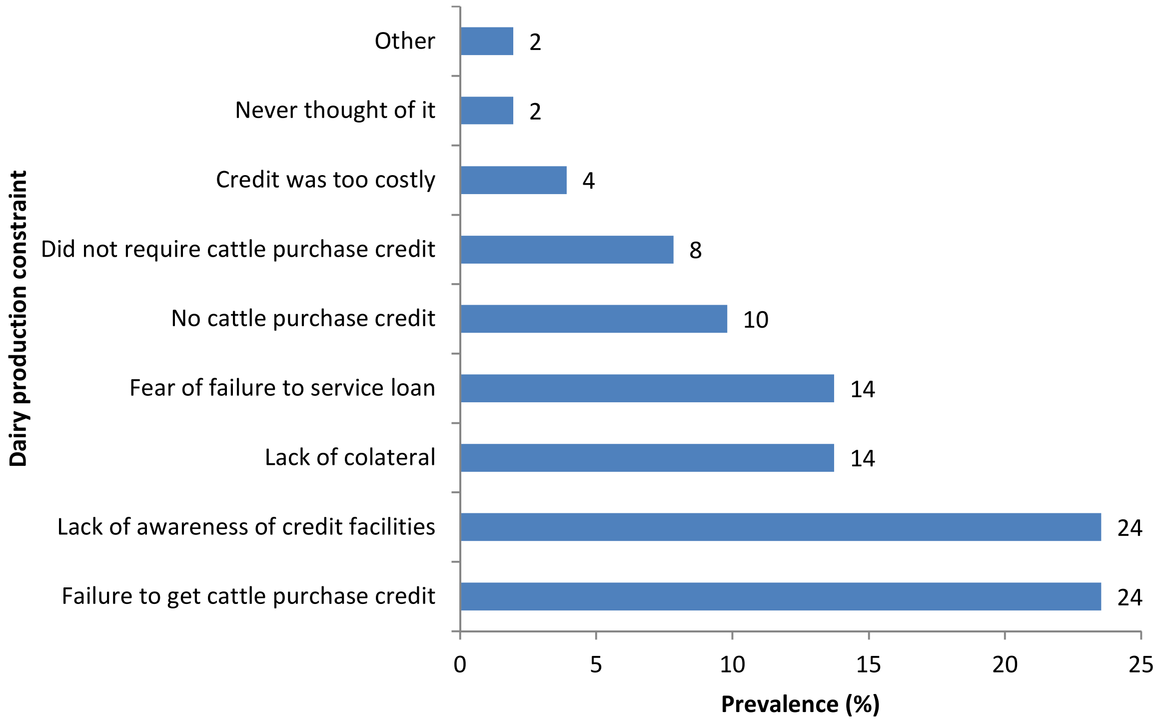

Figure 12: Percentage of respondents that listed dairy production constraint as important

3.16.1 Feed supply or flow

Currently, milk production is seasonal because it is determined by seasonal feed availability. Peak milk volumes are recorded during the rain season from December to February when pasture grass is abundant. As a result of a decline in quantity and quality of natural pasture grass and feed, milk volume begins to decline in March. Based on our farmer interviews, feed shortage during the dry season is a major milk production constraint. In general, most farmers do not have cash to purchase commercial feeds. Further, the few producers who have cash to buy feeds do not easily and consistently access feeds from commercial feed companies (e.g., National Foods, Agrifoods, & ICE Feeds) largely because of lack of demand economies of scale. The farmers allege that the commercial feed companies are more interested and loyal to large scale commercial dairy farms that buy large quantities. Indeed, many farmers are often faced with feed insufficiency, particularly in the dry season. This necessitates development and dissemination of feed technologies and interventions in order to increase feed availability at farm level.

3.16.2 Grazing management and feeding systems

Sixty-three percent of the 117 respondents in this study rely on communal or public grazing as a source of feed for dairy cattle (Table 21), while the remainder (37%) relies on private grazing. Communal grazing is predominant in MCCs that are supplied by respondents from communal areas, particularly Nharira, Umzingwane, Guruve and Tsonzo. Private grazing was dominant in Hamaruomba MCC because it is supplied by producers from a small scale commercial farming area. However, apart from Hamaruomba, all the MCCs receive milk from both communal and small scale commercial areas. The small-scale commercial farms have fenced-off grazing areas whereas grazing areas in communal areas are not fenced-off.

Table 21: Number and percentage of respondent farmers that use communal or non-communal grazing for dairy cattle

Milk Collection Centre	Grazing System				Total
	Communal	%	Private	%	
Guruve	6	60	4	40	10
Hamaruomba	0	0	13	100	13
Mayfield	20	65	11	35	31
Nharira	25	76	8	34	33
Tsonzo	6	60	4	40	10
Umzingwane	17	85	3	15	20
Total/Mean %	**74**	**63**	**43**	**26**	**117**

3.16.3 Feeding systems

On average, 76% and 27% of respondents reared local breed cows, and crossbred and purebred cows, respectively, solely on grazing or natural pasture (Appendices 17 & 18) during the rain season. However, during the dry season the percentage of respondents with cows reared solely on grazing natural pasture decreased to 56% and 8% for local breed dairy cows, and crossbred purebred dairy cows, respectively. Clearly, a combination of grazing and stall feeding is the most important feeding system for crossbred and purebred cows but the second most important feeding system after grazing only for feeding local breed cows. In Hamaruomba, stall feeding is the major feeding system for all cow breeds across seasons.

Seventy-seven percent of the respondents claimed that they grow fodder crops for dairy cattle (Figure 13). In schemes such as Rusitu, beneficiaries are mandated to grow 2.6 ha of fodder out of the 4.8 ha land allocated to individual beneficiaries. However, the fodder plots are rain fed and can be affected by mid-rain season droughts. All the respondents from Hamaruomba and Tsonzo claimed that they grow fodder crops for dairy cows. Milk collection centres that are partly supplied by communal areas farmers had respondents who do not grow fodder. Apart from natural grazing, the main sources of feed for the respondents were cultivated fodder crops including *Pennisetum purpureum* (Napier grass), lablab legume, lucerne, and maize, and crop by-products. In addition to growing fodder crops, 90% of the respondents conserve fodder for dry season feeding. The main fodder production constraints encountered by the respondents included unavailability of fodder seed (23%), high cost of fodder seed (21%), lack of technical information on how to grow and manage fodder (19%), and inadequate land. The respondents use common feeds and forages including maize stovers, dried poultry waste, hay (e.g., lucerne, grass, and lucerne/grass mixture), maize silage (a few farmers), and home-mixed concentrate derived from locally available grains and other ingredients.

3.16.4 Concentrate feeding

Seventy-eight percent of the respondents feed concentrates to dairy cows (Table 22). However, key informant interviews and focus group discussions revealed that most smallholder dairy farmers feed concentrates below recommended levels. The majority of these farmers feed a fixed concentrates quantity (2-3 kg/cow/day) at milking time to calm-down the cow, and hence improve milk let-down. All respondents from Hamaruomba MCC feed concentrate while Guruve had the least number of respondents that fed concentrates. In general, concentrate feeding was practiced more in MCCs that had members from small scale commercial farming areas.

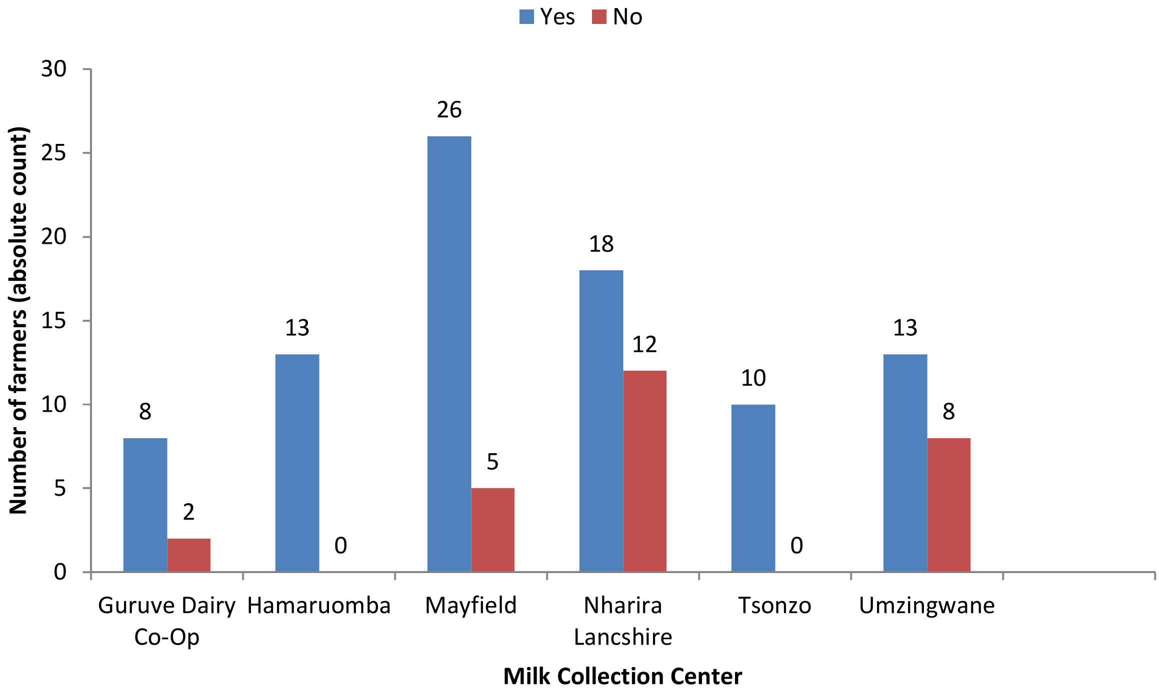

Figure 13: Number of farmers growing fodder for dairy cows in the study area

Table 22: Percentage of respondent farmers across the MCCs that feed concentrates to dairy cows

Milk Collection Centre	**Feed Concentrate**		**Total**
	Yes	**No**	
Guruve	20	80	100
Hamaruomba	100	0	100
Mayfield	72	28	100
Nharira	93	7	100
Tsonzo	80	20	100
Umzingwane	76	24	100
Mean	**78**	**22**	**100**

3.17 Dairy Leadership Development

Based on farmer interviews at Marirangwe MCC, in our inception report we reported that women constitute 5% or less of dairy participants, and that most participate on instruction from their husbands, except for female household heads. On the contrary, at all the MCCs visited during this study women participation (36% of participants) in the meetings including household surveys and FGDs was higher than stated in the inception report (Table 23). Eighty four percent of the respondents said that women owned cattle across the MCCs. In subsequent KIIs and FGDs it was estimated that women owned at least 30% of dairy cattle. The majority of male respondents reported that their spouses own dairy cattle and that they share dairy revenue. The majority of the respondents (82%) said that revenue from milk sales was put in a common pool, while 11% said they shared the revenue equally with their wives and the remaining 7% said they share revenue with their children.

Table 23: Percentage of household survey respondents by sex and percentages of women and youth respondents owning dairy cattle across the MCCs

Milk Collection centre	No. of Respondents	Respondent Sex		Total	Cattle Ownership	
		Male (%)	Female (%)	(%)	Women	Youth
Guruve	10	60	40	100	100	100
Hamaruomba	13	69	31	100	91	8
Mayfield	32	66	34	100	84	88
Nharira	35	66	34	100	72	22
Tsonzo	10	50	50	100	90	44
Umzingwane	21	65	35	100	84	39
Total/Mean	**121**	**64**	**36**	**100**	**84**	**51**

Plate 2: A women member of Nharira herds her cattle.

As mentioned in the inception report, there were no defined roles of youth and women in dairy breeding programmes. However, there is evidence of past programmes targeting women and youth participation in dairy programmes.

At Guruve MCC, FGDs debated on the contribution and inclusion of women and youth in the milk business. The discussion revealed that when the MCC started women and the youth were catered for. The DDP had the Women and Youth in Dairy groups that were well-represented and active in MCC business at the local level. Extension agents including those from AGRITEX and LPD supported the two groups. In addition, the Guruve MCC allowed women to manage their milk production, distribution and market parallel to the MCC but with its full support. However, the two groups are no longer active because the MCC is yet to recover from the consequences of the economic meltdown. FGDs identified some key issues/challenges and opportunities for women and children participation in dairy business:

- The USD 50 MCC joining fee was considered too high and a deterrent for youths to join the MCC. However, payment can be staggered or paid through a milk deliveries based check-off system.
- The traditional reliance on donors had conditioned people to expect handouts thereby precluding even little investments.
- As a way to encourage youth participation, and hence increase membership and ensure succession when parents retire, parents should not only encourage or teach their children that dairying is a viable commercial enterprise, but benefits accruing from dairy activities should be advertised.
- As a youth mobilization strategy to encourage their participation, the MCC should include youths in cow acquisition cows programs; however, it was noted that most youths are not interested in dairy to warrant considering them for cow acquisition. It was suggested that the youth have to show interest first before they can be considered for such benefits.
- At Umzingwane, some participants noted inadequate women representation in management, where one woman occupies the lowly position of secretary. However, the participants claimed that, even when given a chance, women are unwilling to take-up leadership positions.

3.18 Dairy Objectives for the Next Five Years

When asked to state the two most important objectives the respondents wanted to achieve in the next five years, most respondents listed, among others, increasing herd size, milk production, improving herd quality, and having enough feed (Table 25).

Table 24: Percentage of household respondents that listed the dairy objective as one of the two most important

Dairy objective	Guruve (n=16)	Hamaruomba (n=25)	Mayfield (n=47)	Nharira (n=6)	Tsonzo (n=18)	Umzingwane (n=34)	Total (n=146)
Increase herd size	38	52	28	50	22	24	32
Increase milk production	25	16	34	33	11	21	24
Improve Herd Quality	19	20	6	0	28	21	16
Have Enough Feed	13	0	17	17	22	21	15
To Start Dairy Herd	6	12	0	0	6	12	6
Pregnancy Diagnosis	0	0	13	0	6	0	5
Improve Cattle Management	0	0	0	0	6	3	1
MCC Processing Of Milk	0	0	2	0	0	0	1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

When asked how the respondents intended to increase milk production, the largest percentage (26%) hoped to produce more feed, followed by improving the cow dairy grade, increasing herd size, and improving disease control (Figure 14). Forty-five percent of the respondents wanted to increase herd size and increase dairy grade cows which are all components of breeding.

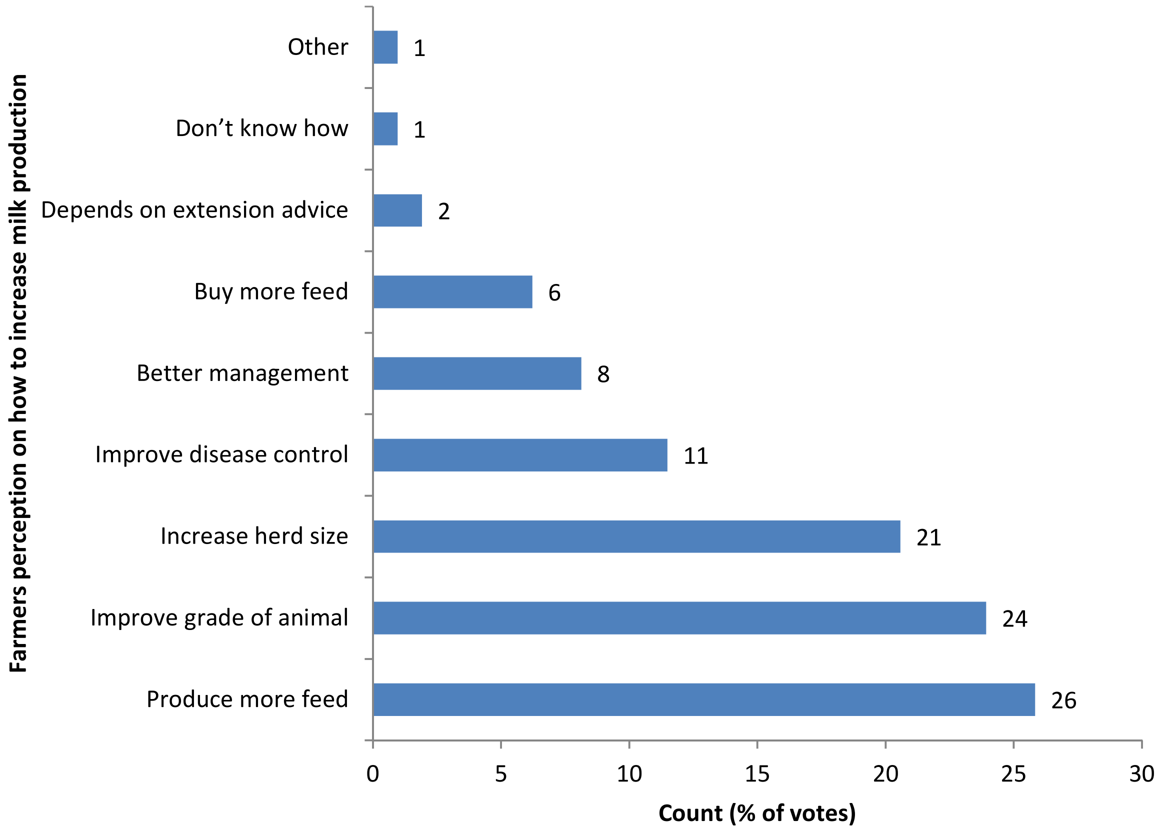

Figure 14: Percentage of respondents that selected each of the methods as a way of increasing milk production

4. ANALYSIS OF FINDINGS

4.1 Analytical Framework

Our analytical framework is the smallholder dairy breeding pillars that were described in previous reports (Appendix 19). Simply, we posit that breeding programme success is anchored on requisite breeding pillar standards that ultimately determine success of a MCC. However, realistically, a successful breeding programme is driven by the success of the entire dairy value chain in which push and pull factors play a central role. An undersupplied market can offer incentives that 'pull' increases in milk production and promote delivery of quality and support activities that increase supply.

Specifically, success of any breeding programme will be determined by economies of scale in herd size, the population of good quality breeding cattle, and number of active MCC members; observation of the dictates of the breeding equation (i.e., the obligatory combined optimum cow fertility, semen or bull quality, heat detection efficiency, & inseminator efficiency); efficient disease control and optimum breeding cattle health management; efficient MCC governance, management and leadership; adequate feed supply; availability of markets for milk; robustness of tracking of genetics in use; availability of finance and financial services; full participation of females and youth; and environmental sustainability.

The breeding programmes at MCCs and suggested breeding interventions will be evaluated based on how far they satisfy the breeding pillars.

4.2 4.2 Status of Dairy Sector

In general, at an average registered membership of 110 per MCC, such low membership does not provide adequate critical mass for self-sustaining breeding programmes when members have such small cow herd sizes (3-4 cows/member). The average number of milking cows across breeds gives a potential total MCC cow herd size of about 440. For a viable breeding programme that is AI based, a cow herd of at least 1000 will be required for economies of scale to engage AI service providers. There is no doubt that MCCs have to promote the growth of the herds of members to create economies of scale for delivery of breeding services. Calving intervals are still too long resulting in about 50% of the cows calving each year.

One way to revive smallholder dairy is to mobilize farmers for participation in the MCC business. From our experience in East Africa, MCCs should collect at least 2,000 litres of milk per day, and optimally 10,000 or more litres per day to meet costs and provide economies of scale for service provision to farmers. Specifically, large MCC membership enables exploitation of economies of scale, collective bargaining, reduction of overheads costs, and bulk procurement of production inputs including semen and breeding services, feeds, and veterinary drugs.

The MCCs should campaign for more members through incentives provision and assist these members to increase their herd sizes through increased productivity of their cows. In this regard, heifers should grow at optimum rate to be bred early (15 months for pure and 18 for crossbreeds). In addition, cows should conceive regularly and attain a calving interval of 12 to 13 months.

These interventions should be supported by a good breeding programme that leads to fast heifer growth (0.6-0.8 kg/day, depending on breed) and high milk production. The reasons for farmers' unwillingness to join MCCs are clear. Essentially, farmers do not perceive benefits from MCCs. The MCCs should, therefore, deliver benefits to farmers. Specific to breeding, acquisition of cattle should be well organized partly through improved MCC governance and execution of such cattle purchase schemes. Building herds is a cornerstone of growth of dairy operations and should therefore be given full attention. Such cattle acquisition schemes, if well organized, can be pivotal in attracting farmers to join the MCCs.

From our vast East African experience, growth of the bulk chilling enterprise at the MCC can be achieved by, among other interventions, improving farm level productivity through adoption of production–enhancement technologies (breeding, feeding, & herd health), improving market access by farmers through establishing an effective milk collection system, and mobilizing farmers to join the business centered around the MCC as a hub in what is termed the Hub Model (Appendix 20). As state above, benefits attract farmers to join an MCC.

Access to affordable, good quality dairy breeding services including AI is an example of a key benefit that is embedded in MCC functions. Access to this service and inputs can be facilitated by a milk check-off payment system that allows the farmer to access the service when needed and pay later. Breeding services are not always directly offered by the MCC but through strategic alliances with inseminators, agro-input suppliers, agrovet shops, and other service providers. Vestiges of these services exist in some MCCs in Zimbabwe, but are fragmented, and hence should be further developed and strengthened. Ultimately, the milk business should be strong, usually through binding contracts.

4.2.1 Age of the respondents

The average age of farmers of 50 ± 16) years indicates that the farming community is generally comprised of old people. The age of the farmer has implications on adoption of new/modern dairy farming practices and or technologies, and it also impacts on the continuity of dairy farming, assuming the present generation passes on. Elsewhere, it has been reported that older generation of farmers are generally not keen to change their breeding strategies, for example, from natural mating to AI. Youth participation, as will be discussed elsewhere in this report, should be promoted through provision of incentives. Strategically, breeding programme development should consider age as an important characteristic for targeting not only from the point of view of youth but of other age categories. Like many other low-input, low output systems, dairy production usually has a low status because of the low level of technology it employs and low income-earning capacity; as a result, the young usually migrate to urban areas in search of greener pastures. Breeding programmes should aim at increasing both the level of technology used and income-earning capacity.

4.2.2 Literacy levels

The high literacy level among the farmers is positive for dairy breeding extension as it enables institutions providing dairy breeding extension services to make effective use of print material (pamphlets, fliers, notes, etc.) to reach out to farmers. However, most farmers in this study attained the minimum formal education (primary level), and hence might be unable to read breeding extension materials written in English; consequently, dairy breeding extension material should be translated into the vernacular languages, particularly Ndebele and Shona.

4.2.3 Labour availability

Labour is one of the key inputs in dairy breeding programmes. Some components of modern dairy breeding practices such as heat detection are labour intensive. Given the current shortage of farm labour in some MCCs, where the economics permit synchronized AI can be considered to preclude heat detection.

4.3 Milk Production and Market Access

The main constraint to viability of the smallholder dairy projects is cited as low milk production per cow and low milk supply to MCCs. Mean milk delivery to the MCCs that ranged from 8.1 to 14.5 litres per farmer/day is low. This sales volume is too low for farmers to build-up sufficient funds for investment. Seasonal differences in milk delivered in which double the dry season quantity is delivered during the rain season illustrate the need to increase dry season production. Feed and water shortage during the dry season reduce milk production. Apart from feed and water shortage, factors that that contribute to low milk yield and variations across seasons and the MCCs include breed productivity, calving season, parity number, body condition score at calving, herd size, disease prevalence, availability of milk markets, breeding efficiency, and cost of inputs (Epaphras 2004; Msangi et al., 2005; Bee et al., 2006). Low milk production in natural pasture grazed cows is partly caused by cows walking long distances, and hence they spend energy on walking instead of using it for milk production.

Despite breeding costs constituting less than 5% of costs of production in most dairy production systems, low milk deliveries cannot raise sufficient revenue to meet these breeding costs. The estimated cost of AI per insemination is around USD 20. For an average herd size of 4, and at 2,5 inseminations per conception, as reported in this study, the total AI cost would be USD 200 per year. This would be equivalent to sale of 400 litres of milk at USD 0.5/litre of milk. Given that milk deliveries can be for up to 8 months, farmers can potentially sell 11.3 litres per day, and hence USD 1356 per year. The cost of AI elsewhere and even in East Africa is always below 5% of the costs of production while feeds make up at least 60% of the total costs of production. This shows that in well organized dairy operations the cost of AI-based breeding is not major despite the advantages it brings. However, to derive maximum benefits from the high milk production potential brought in by AI, cows must be managed and fed adequately to exploit this potential.

4.3.1 Herd size and number of milking cows

The large variation in herd sizes reflects the range of farmers supplying milk to MCCs. In general, farmers from communal areas have smaller herd sizes than those from small-scale commercial farms. Despite these differences, overall, the herd sizes at individual MCCs are not large enough to provide economies of a scale for a milk business.

The dominance of purebred Mashona and Brahman, and Mashona crosses that account for 52% of cattle across the MCCs illustrates that smallholder dairy is still largely reliant on local cattle breeds. Considering that only 3% of the smallholder dairy herd is purebred, smallholder dairy is still far from achieving the desired levels of dairy genetics. In the interim, growth of the smallholder dairy cattle has to use the non-dairy cattle base for milk production increase and crossbreeding programmes. The wide array of breeds across MCCs including Holstein-Friesian, Jersey and Red Dane crosses which individually make up 7 to 11% of the surveyed herd suggests a fragmented approach in introducing the dairy genetics.

While a farmer has free choice in selecting a cow or bull breed to purchase, technical guidance should be provided through a national breeding policy and goals. Interestingly, distribution of dairy crossbreds across the MCCs was largely influenced by availability of the breeds at adjacent farms. Clearly, smallholder dairy farmers do not have capacity to source cattle from distant places, and hence they are compelled to acquire whatever is available. Based on this observation, smallholder cattle acquisition programmes should identify local sources of cattle or those within reach of farmers.

Milk supply to MCC is largely determined by herd size (number of milking cows per household), herd quality (breed type), milk production per cow, and lactation length. Despite herd size influencing the economics of milk production, it also determines the flexibility and selection intensity of breeding programmes.

Despite the longer lactations of crossbred and purebred dairy cows than those of local breed cows, the crossbred and purebred cows in the studied MCCs produce well below their expected average potential. Interviewed farmers reported that improved cows produce less than 10 liters per day instead of at least 15 liters per day. It is obvious that any breeding programme is only justified if cow genetic potential for milk production is exploited.

In our view, prudent calf and heifer rearing, and programmes to support development of producer feed bases are key to increased milk production and full exploitation of dairy cow genetic potential. Until farmers adopt recommended feeding practices and management, benefits from improved genetics will not be fully realized. We, therefore, emphasize pursuit of breeding goals as a component of a MCC and dairy herd management improvement programme.

4.3.2 Market access

As illustrated in the smallholder dairy breeding pillars, dairy farmers should access markets in order to drive the dairy business and increase demand for a breeding programme. It is apparent that demand for milk in Zimbabwe is strong and unsatisfied. However, lack of transport in some areas and uncompetitive milk prices are impediments to milk marketing. Transport limitations can be addressed through creating sufficient economies of scale that can justify establishment of milk aggregation points close to clusters of farms. Transport can be organized to take the bulked milk from the aggregation points to MCCs. Increase in herd size, for example through improved breeding practices in a location, can help create the necessary economies of scale.

Milk price issues emerged from farmer and key informant interviews, particularly the large price differences between an identified large processor (USD 0.4/liter) and local milk sales at MCCs (USD 1.0/liter) in the same area. It would not be sustainable to prescribe prices; however, dairy producers should be equipped with negotiation and advocacy skills to enable them to secure favorable deals. Given the recently introduced 25% tariffs on imported dairy products, local prices of dairy products are likely to increase. Strategies to add value such as sour milk and yoghurt production at MCC level and selling the milk back to the communities could yield higher returns for the farmers. Again even with the low price of milk offered by processors, increase in returns would be realized from increased volumes of milk from efficient management of cow breeding and an increase in herd size.

4.3.3 Lactation length

The estimated lactation lengths for herds across MCCs that ranged from 5.3 ± 2 months for local breeds to 8.1 ± 1.9 months for purebred dairy cows are less than the standard lactation length of 10 months. Such short lactation lengths cannot be the foundation of a dairy business. In fact, milk volume is the fulcrum of revenue flows and viability of a dairy business.

The revelation that some farmers milk cows for up to 24 months in lactation suggests absence of breeding, culling and dairy herd management policies and programmes. It is likely that, while MCC member farmers may have embraced commercial dairy, pastoral practices are still strong with little regard to adoption of dairying as a business. This suggests the need for a farmer paradigm shift to embracing modern dairy management practices that are consistent with the needs of a commercial dairy. There is little evidence of a managed programme in which farmers are conscious of the reproductive cycle of nulliparous heifers, and postpartum cows and heifers. Any breeding interventions should be implemented in conjunction with business management training. Farmers should realize that organized breeding is a business that should be well executed for financial gain.

4.4 Existing and Past Breeding Models

As stated previously, apart from those we have identified by inference, there are literally no tangible current, prescribed breeding models. The prevalent rampant use of hired bulls illustrates absence of breeding policies and goals at micro (farm), meso (MCC), and macro (national) levels. It is clear that smallholder dairy cattle breeding lacks organization at all levels, probably this is partly a consequence of the economic meltdown experienced over the last decade. The tendency for farmers to use bulls for breeding instead of AI in smallholder farming areas has been observed in Kenya (Megersa et al., 2011); however, AI adoption in the smallholder dairy sector in Kenya is at least double that found in this study. The relatively high adoption of AI in Kenya is positive spin-off from the massive state subsidized AI that started in the mid 1960s. This increased AI access and affordability to smallholder dairy farmers.

Breeding models anchored on AI require public-private support. The public sector could engage in, for example, drafting supportive policies and regulations, enforcing regulations, and training inseminators whereas the private sector would supply semen and AI equipment and consumable supplies. Clearly, in some East Africa countries (e.g., Kenya & Rwanda) government subsidies and support initially used AI as a tool to build the critical mass of dairy cattle for the dairy industry. The benefits of such an AI programme are beginning to be realized in Rwanda where AI has been subsidized by the government for the last decade. The Government of Rwanda acquired semen and AI equipment and supplies centrally. We do not envisage a similar approach from the Government of Zimbabwe with the fiscal challenges it is facing, but this could be done through the DDP and support from development partners. The advent of AI in Zimbabwe was through private sector led provision of AI services to commercial dairy farmers. The farmers had the wherewithal and sufficiently large herd sizes for economies of scale to run AI programmes.

Both, the shortage of bulls and poor adoption of AI in Zimbabwe have negatively impacted on the growth and quality of the smallholder dairy herd. The reasons for farmer reluctance to adopt AI include low conception rates and repeat breeding. These are largely technical in that those trying to promote AI and the farmers do not fully comprehend the AI success cornerstone, the reproduction (breeding) equation, a component of our breeding pillar.

This equation depicts that the success of any insemination is jointly dependent on an inter-play of four factors that all have to be optimal for a cow to conceive. To illustrate this, let us suppose that cow fertility = 95%, semen quality = 100%; inseminator efficiency = 100%, and heat detection efficiency = 40%.

According to the equation, ***Cow conception percentage (rate) = 0.95 (cow fertility) x 1.00 (semen quality) x 1.00 (inseminator efficiency) x 0.4 (heat detection efficiency) x 100% = 38%***

The result of 38% conception illustrates a key concept that conception rate is always lower than that of the value of the lowest factor, in this case heat detection efficency. It is clear that all those involved in supporting AI should work as a team to ensure success because any weak link will adversely determine the success rate.

While the few programmes that have tried to help revive the smallholder dairy sector since 2009 have aimed to increase the supply of breeding cows and heifers, success has been mixed. The sources and suitability of breeding stock are limited. Most sources of dairy cattle are the commercial dairy farms where the management standards and feed resources are largely optimum. Transferring cattle from these optimum rearing environments to deficient ones always poses challenges that threaten the survival of the introduced cattle.

The losses to preventable diseases including tick borne diseases and ectoparasite including dermatophilosis indicate that any breeding programme should be supported, as depicted in our breeding pillars, by a strong disease prevention and control programme. The rampant use of hired bulls brings to light several risks including the spread of venereal diseases, potential inbreeding, missed heats that extend calving intervals, and bull upkeep costs.

As stated above, there are no discernible existing breeding models. However, a few historical and emerging models can be derived.

4.4.1 Bull schemes

Collapse of bull schemes reported at Mayfield, Umzingwane, and Guruve is not surprising because the revenue derived from renting out bulls was not sufficient to cover maintenance costs. Realistically, the high cost of rearing a bull precludes most farmers from owning breeding bulls. Besides the initial acquisition cost, limited land resources for production of fodder relegates rearing of breeding bulls on the farm. It is likely that a well structured AI programme would create fewer headaches and provide advantages including better quality of breeding stock and venereal disease control.

4.4.2 Breed choice

On the cow side, initially, largely through DDP facilitation, farmers acquired purebred and crossbred cows in an effort to increase milk production. There were endless debates on the ideal breeds for crossbreeding and the percentage genetic composition of each cross in relation to breed make up. Of concern was the insistence by farmers to acquire high yielding Holstein-Friesian cows contrary to advice that favoured the Jersey breed. It was argued that the small-framed Jersey is ideal for the limited smallholder farm feed resources and dairy herd management skills and knowledge. However, most farmers did not like the small frame of the Jersey, the slow growth rate, the low milk production relative to the Holstein-Friesian, and the inferior meat quality.

While this debate was raging, the Red Dane breed emerged as an option. The breed was largely promoted by Red Dane Farm as an option that would provide a dual purpose animal to the farmer. Other breeds including Sahiwal were also introduced and tried. The strategy was to bring in dual purpose cattle that would be hardier than the standard dairy breeds but produce high milk yields and have good meat quality.

Ultimately, these programmes largely focused on assisting farmers to obtain improved cows. There were concerns that these projects specifically focused on breeding and improvement of herd quality, but they ignored marketing, feeding, and animal health, and hence they failed to achieve the breeding goals.

4.5 Emerging Breeding Models

Milk Zim Ltd recently introduced a variant of a group cattle management scheme. In this model, farmers surrender their cows to a central cattle rearing farm where they are group-fed and milked. All the routine disease prevention and control practices are conducted at the central unit and costs deducted through a milk payment check-off system. The farmer is paid based on production from his cow. Breeding services including AI are offered at the central location and the costs of the service deducted through the check-off system.

While this system has merits, it is still to withstand the test of time. Challenges with this approach include attaining the critical mass for viable commercial operation, guarding against loss of a farmer’s cow, winning farmer confidence on fairness of business transactions, and putting in place mechanisms for farmer scheme ownership.

A successful dairy breeding programme should be anchored on AI. If growth in milk supply and quality is to be realized, substantial benefits are likely to come from AI. It is apparent that previous breeding models have neither emphasized the need for AI nor exploited breeding technologies including embryo transfer and synchronized AI.

The mixed reactions from dairy restocking programmes beneficiaries including allegations that milk production from some of the purebred and crossbred cows supplied is below capacity could either be a consequence of farmers lacking capacity to exploit the genetic potential of supplied cows, or supplied cows are of inferior quality. The supplied cows may also have limited adaptability to local conditions in harsh smallholder farm environments leading to under-performance. Indeed, most field staff we talked to in all the MCCs suggested that farmers start with crossbred dairy cows and gradually upgrade them to pure dairy locally. Additionally, a limited range of cattle breeds has been supplied to farmers. The overwhelming preference for Red Dane breed expressed by Umzingwane MCC farmers suggests that farmers in the relatively dry regions such as Umzingwane prefer the dual purpose breeds which survive better in this environment than pure dairy breeds such as the Holstein-Friesian.

4.6 MCC Herd Composition

Despite the potential breeding female herd composition of 52%, the low milking cow composition (21%), instead of at least 40% for standard dairy herds, indicates that most of the herds are not dairy focused. The low percentage of female calves (4%) illustrates a low annual calving percentage and an inadequate breeding cow replacement source. While the bull numbers appear normal, the variations in bull population and skewed distribution suggests potential shortage of bulls on some farms and MCCs. Although the bulling ratio is better or approaches the normal 1:25 in most of the study sites, these calculations were made taking the MCC as a single herd, and can be misleading because most individual households do not own bulls and keep their herds separately.

4.7 Selection of Best Dairy Cattle

It is encouraging to note that some cow selection has been practiced on some smallholder dairy farms.

4.8 Existing Breeding Strategies

4.8.1 Desired dairy characteristics/trait

The cow characteristics that were identified by respondents as important including of disease resistance, high milk yield (15-20 liters/day), good temperament, large body size, and fertility are relevant to the smallholder rearing environment. Clearly, breed selection for crossbreeding, or to keep as a purebred, should take these factors into account. The emphasis on disease resistance placed by farmers was probably reinforced during the economic meltdown when animal health supplies and services were deficient. Although farmers know what they want, the desired characteristics are not present in the breeds on the market, which have always been dominated by the Holstein-Friesian. Unfortunately, the latter breed is fragile, and hence requires a well resource-endowed environment. Arguably, as a result of availability, farmers may have to depend on crossbreeds of Holstein-Friesians and local breeds including the Mashona. In fact, 78% of the respondents confirmed that the heifers/cows or bulls with desired characteristics are not available. The farmer breed needs could be met halfway through use of AI or embryos to capture breed diversity. The farmers choices are based on experience, and it is imperative that they are given due consideration when designing a breeding programme based on either AI, or importation of live animals.

4.8.2 Artificial insemination

If the smallholder dairy sector is to develop, the low AI adoption should be addressed. There is no doubt that in most places where smallholder and commercial dairying have developedt AI has been central to herd improvement. A case in point is the Zimbabwe commercial dairy sector that attributed at least 40% of the gain in individual cow milk yields over time to AI. Reasons for limited adoption of AI in the smallholder dairy sub-sector are largely a consequence of limited AI technical and logistical skills. The causes of the low AI adoption that include low conception, long distance to inseminators, and limited choice of breeds are examples of technical and logistical issues that could be easily resolved.

The problem of too many repeats leading to low conception rates are not peculiar to Zimbabwe but have been reported in Tanga, Tanzania (Msangi et al., 2005) and Ethiopia (Lemma and Kebede, 2011). One solution to this challenge is capacity building of both the producers, and AI service providers in theoretical and technical aspects of AI. In this regard, above, we described the importance of comprehending the equation of reproduction as an imperative in the success of AI. In addition, from our experience in East Africa, AI can be decentralized to the MCC level. In this approach, artificial insemination service providers are selected from local farmers or those with interests and live in the area. Provision of transport, motorcycles or bicycles, is imperative, and adequate incentives are required for a successful AI programme. However, AI programmes have to be supported by favourable public policies that promote acquisition of semen and liquid nitrogen, and infrastructure (roads and electricity). Responding to calls by farmers to inseminate cows should be driven by incentives. In this regard, the inseminator should be paid a fee for individual cow inseminations. This naturally provides the necessary incentive for the inseminator to reach more cows provided there is a large enough herd size for economies of scale.

We speculated that limited choice of breeds mentioned as one of the erstwhile AI impediments is a reflection of limited information on semen distributors. For example, ABS has been operating in the country for more than 2 years now, but very few of the farmers identified it as a semen distributor. Substantial advertisements and promotion of these semen products across smallholder MCCs will be relevant.

Overall, currently there are few government agents offering AI services, which are now largely provided by private service providers. However, private AI services are underdeveloped. Probably, as a consequence of this, farmers consider the costs of AI services as high leading to frequent use of bulls of unknown breeding value. Despite the obvious benefits in expanding the breeding herd quicker than when the normal semen is used, sexed semen has not been used in AI in Zimbabwe. Using this technique, farmers can be about 90% certain of the sex of their calves. From a dairy perspective, apart from other benefits, the technology presents substantial opportunity for increasing the population of heifers.

4.9 Heat Detection Knowledge

The failure by most respondents (80%) to correctly identify the true oestrus sign, standing to be mounted, is evidence of the capacity building need on AI and the ancillary knowledge, logistics and benefits. This is also anecdotal evidence of the reason for low AI success across the MCCs. There is no doubt that efficient reproduction can lead to attainment of the optimum calving interval of 12 to 13 months. In order to accomplish this, efficient and accurate detection of oestrus, a key breeding pillar, must be achieved. Calving interval is the most important overall measure of herd reproductive performance. Delayed first breeding has a direct effect on lengthening calving interval. Missed heats or failure to detect heat signs is regarded as the number one reason for long calving intervals. Recent studies indicate that 85-90% of the variation in days open is caused by differences in heat detection and only 10-15% is due to differences in conception rate. Fifty to 60% of heats may be missed in problem herds.

4.10 Reproductive Performance Indices

The interval to first postpartum oestrus, days open, age at first breeding and calving interval across the MCCs were longer than expected. This is despite the use of bulls that often result in fewer services per conception than for AI. This shows that reproductive performance across MCCs is influenced by many factors that may not necessarily be caused by breeding/mating inefficiencies. Respondents were not even aware of important reproductive performance indices including conception rate at first service, and overall herd conception rate. In the few cases where AI was practiced, services per conception to AI at 2.5 are higher than the optimum expected (1.5 services/conception).

4.11 Routine Herd Health Practices by Farmers

While respondents claimed that they practice routine animal health practices, the wide range in costs incurred indicates that not all farmers apply adequate routine herd health practices to all the cattle in the herd. For practices such as tick control, vaccinations, and anthelmintic treatments, it is bad practice to apply the remedies to selected individual cattle within a herd. This practice protects only the individual cow leaving the rest exposed, and can also promote resistance to remedies.

Clearly, routine herd health practices are critical for the success of any breeding programme and should be a precondition for any breeding interventions.

4.12 Breeding Infrastructure, Inputs and Services Distribution

Based on our observations and farmer accounts, breeding infrastructure and delivery of AI services remains rudimentary. While AI infrastructure is, in general, inadequate, the existence of cattle handling facilities such as a crush can facilitate initiation of AI and routine operations on cattle.

4.13 Use of Breeding Technologies

The lack of exposure of smallholder dairy farmers to breeding technologies illustrates that the sub-sector has not been competitive. Often, commercial need drives farmers to seek beneficial innovations. The smallholder dairy sub-sector has been retrogressing. The current dairy cattle shortage demands the exploitation of technologies, particularly synchronized AI, use of sexed semen, and, to some extent, embryo transfer. Rwanda is an example of an African country that has benefited from a public sector supported synchronized AI programme. The programme has instituted annual synchronized AI campaigns in which farmers bring their cows to a central location for synchronization using a progesterone and pregnant mare serum gonadotropin based synchronization protocol. Around 100,000 cows have been inseminated following this protocol. This programme has led to a rapid growth of the dairy sector, and in less than a decade milk production has risen from deficit to surplus.

We have executed such synchronized AI programmes in Rwanda that gave 93% conception rate after 1.5 services/conceived cows. Such a programme is highly technical, and hence should be led and developed by experienced and technically strong persons. We are not surprised that when synchronized AI was tried in some of the studied MCCs the results were not satisfactory. Team work is absolutely essential and farmers must be trained to comprehend the equation of reproduction, as stated before, a key breeding pillar. The cost of synchronization and the accompanying AI can cost USD 35 to 50 per cow. This appears high but when weighed against lost milk caused by conception failure, the benefits far outweigh the costs. While the benefits from such breeding is often perceived as the calf born, if female, but when synchronization results in a higher conception rate the benefit is also in milk from the additional lactating cows. If synchronized AI is combined with use of sexed semen then more heifers can be produced; however, the cost would increase to about USD 60 per breeding.

Traditional breeding technologies such as embryo transfer are still touted as useful technologies, especially with the advent of frozen embryos. Use of embryos in MOET schemes has been advocated. Public institution farms have often been proposed as centres where such schemes and breed multiplication schemes could be undertaken. However, such publicly run schemes often lack the incentives that drive the programmes to meet market demand.

4.14 Cattle Identification and Milk Recording Programmes

There is no doubt that cattle identification and recording systems are the cornerstone of tracking genetic progress in a herd. This is a key component of the breeding pillars as they create the basis for monitoring and evaluation of any genetic improvement. The milk recording programmes are important in validating cow performance, which can be the basis for planning national breeding programmes and policies.

4.14.1 Cattle recording and identification

While most farmers (65%) claimed that they keep records and use ear tagging, naming, and tattooing to identify their cows, cattle recording and identification are inadequate. Genetic improvement in any herd is based on keeping records of all breeding transactions on the farm including those of bought-in breeding stock. The lack of purchased dairy heifer records (e.g., pedigree records) from some of the cattle suppliers is of concern to sustainability of breeding programmes. In addition, while farmers are keeping records, they are not comprehensive. It is apparent that the farmers do not comprehend the usefulness of the records. The reason for most farmers' interest in keeping production records could be to track milk available for sale. There is, therefore, room to improve on record keeping.

For successful breeding, farmers should observe cows closely and regularly for, among others, signs of disease and heat. We recommend use of cow record cards that captures records including diseases diagnosed and treated, when heat signs were detected, and when the cow was served, the bull used, and pregnancy diagnosis results. Well kept records will also enable the farmer to predict the next time heat signs are due, and will help avoid inbreeding since identity of the sires used for specific cows will be on record.

The dairy reproductive management calendar is a management tool which we often recommended for tracking reproductive events in a dairy including expected heat periods, insemination dates, and pregnancy diagnosis and expected calving dates of the animals (Appendix 21). The calendar helps the farmer to make reproductive records of individual cows in the herd. Each cow's record includes the dates of calving, first and second heat, insemination, pregnancy diagnosis, and expected calving and drying off. In this way, the farmer can see the reproductive management tasks for the day.

4.14.2 Participation in breed societies and the Zimbabwe Herd Book

The absence of smallholder dairy farmers in breed societies and the Zimbabwe Herd Book is not surprising. This is a result of lack of organized breeding among smallholder farms. For cows to be registered with breed societies and the ZHB, accurate cattle records are necessary. Smallholder farmers should be informed of the existence of such breed societies and the ZHB. Even if they may not qualify to join the societies and ZHB, they can get valuable information on herds where they source breeding stock. Ultimately, smallholder farmers should aim to be members of breed societies and the ZHB to enhance the genetic quality of their herds.

4.14.3 Milk recording programmes

The milk recording scheme that was initiated by ZDSA should be resuscitated because tracking the impact of genetic improvement programmes is necessary. If smallholder farmers continue acquiring dairy cattle without tracking impact, then breeding objectives and goals will likely remain undefined. In general, it has been noted that cows enrolled on performance testing programmes produce on average 25% more milk than those not enrolled on the programme. In addition, information obtained from recording schemes has led to rapid improvement in productivity of registered cattle.

4.15 Feeding Programmes for Breeding Support

Feed provision is a key breeding pillar that should be taken into consideration when planning a breeding programme. There are countless cases where cattle were imported into an area but they died from feed shortages. The cases reported in this study including the cattle loss in Tsonzo are poignant. The previous breeding cattle purchase programmes that were criticized for not taking into consideration breeding pillars including feed supply are yet another example.

While our TOR have little focus on cattle feeding, feed supply is central to cattle survival and success of a breeding programme. Feed availability determines growth rate of replacement cattle, particularly heifers, it also determines cow body condition that in turn influences reproductive performance. The below normal growth rate of heifers observed in smallholder dairy herds insidiously robs the genetic gains from cattle breeding improvement programmes. Unknown to most farmers, a heifer daily growth rate below optimum (0.6-0.8 kg/day depending on breed) not only delays first breeding but compromises udder growth and development leading to less milk production than expected when the heifer begins lactating. Considering that most dairy heifers in the smallholder farming areas do not grow at the optimum rates, it is apparent that most would not achieve the expected production levels.

As revealed by this study, the feeding challenges in the smallholder dairy sector are two pronged. The two prongs are feed availability or potential availability, and feed use systems. Apparently, farmers from communal areas face shortage of land for cultivation and natural pastures expansion, and also have limited grain for supplementary feeding. These resources are more abundant in the small scale commercial farming areas. Even if farmers across MCCs expressed a need for commercial concentrate, and as confirmed by key informants, most are unlikely to afford the cost of these concentrates. Prudently, most farmers feed their cows fixed quantities of concentrates (2-3 kg/day) as a cow pacifier during milking and to stimulate milk let-down.

The principle in feeding dairy cattle is, maximize low-cost forages use and accurately plan and store the required feed for your cattle, particularly for dry season feeding. There was no evidence that the farmers have any such feed flow plans or budgets. As a result, milk production and cow body condition are almost completely at the mercy of seasonal changes in feed availability.

While most farmers across the MCCs and the farming systems rely on natural pastures for feeding dairy cattle, in our experience, to succeed in dairy, farmers have to maximize forage conservation and use before considering using grain-based diets. This approach stems from difficulties often encountered in improving natural pastures for dairy production. The communal grazing set up in communal farming areas precludes improvement of natural pastures; elsewhere, attempts to improve such pastures using the collective grazing scheme approach were fraught with socio-economic, governance and logistical difficulties. Perhaps grazing schemes anchored around socially cohesive MCCs could be an option for improving dairy communal grazing systems.

However, natural pasture improvement in the small scale commercial farming areas is a viable option because of individual ownership and land availability. Rotational grazing in natural or planted pastures fortified with legumes are possible options that can improve biomass yield and quality.

A source of feed that is often neglected and yet it can supply energy and dry matter needs of dairy cattle is crop residues. Most smallholder dairy farmers across the MCCs grow crops including maize and groundnuts whose residues can be used for cattle feeding, particularly during the dry season. Maize, sorghum and millet can be treated using urea to improve palatability and nitrogen content. The treated feed can be laced with molasses to increase palatability and energy content. Such simple technologies have been used in Rwanda with success in smallholder dairy systems.

One legume that has been promoted in East Africa is the drought tolerant legume, *Mucuna pruriens* (Mucuna). It requires annual rainfall as low as 400 mm. It can produce 5 to 17 tonnes of forage dry matter per hectare with a protein content of 11 to 23%. The bean can be fed to cattle and has 20 to 35% protein. As a benefit from its nitrogen fixing ability that exceeds that of soyabean, it can be rotationally grown with maize and has been reported to double the yield of the maize crop that follows it. This crop could be planted even in communal areas for feeding dairy cattle because of its dual benefits.

Traditionally, smallholder dairy farmers have been encouraged to grow Napier grass (*Pennisetum purpureum*) largely because of its high biomass yield. This is an option in Zimbabwe that can be combined with silage making from the Napier forage or maize. Another grass of interest in hay making is Rhodes grass (*Chloris gayana*), which is usually grown in rotation with tobacco. This can be a good conserved feed for dry season feeding.

When there is an adequate forage base, home-derived grain feeds are the next option to enhance milk production and reproductive performance before considering bought-in concentrates. Use of grain or bought-in concentrate has to depend on a favourable milk price to grain ratio; for example, a ratio of 1.3:1 (price/litre of milk to 1 kg concentrate) could be the cut-off point. This means that as long as the ratio is higher than 1.3:1 then it would be worthwhile or profitable to buy-in feed.

4.16 Dairy Leadership Development

Consistent with our breeding pillar analytical framework, MCC leadership quality is a key determinant of a successful breeding programme.

4.16.1 MCC leadership as a driver of breeding programmes

A visionary leadership that has the trust and confidence of members and is capable of lobbying for appropriate services and policies is critical. Unfortunately, most MCCs did not demonstrate this capacity. We note that there are issues that can be addressed through policy changes. As stated above, in East Africa, breeding services for the smallholder sector, particularly AI, were initially developed through massive support from the public sector and lobbying. Perhaps, Zimbabwe had the luxury of a well-organized dairy sector that supplied more than 95% of commercial milk needs. The change in the dairy farmer populations warrants an approach with greater focus on smallholder dairy development and the requisite strong leadership. The existing linkage with the NADF should be exploited to strengthen lobbying and standardization of MCC governance, supervision, and accountability of MCC leaders.

4.16.2 Gender, youth and environmental sustainability

The observed participation of women in dairy activities is encouraging. We recommend that MCCs aim for gender equality in activities and governance of MCCs. The observation in Umzingwane about women's reluctance to take up leadership positions is a gender issue that needs further analysis. It is likely that there are local attitudes that prevail and could be solved through gender approaches that involve men and women. It is also positive that women own cattle and share dairy revenue with their husbands. Special efforts to involve women in the trainings and project activities provide significant benefits. Our experience in EADD Rwanda and other USAID projects is that involving husbands and wives in training helped increase participation. Times for meetings should allow maximum participation of women and youth.

Information on breeding programmes should be distributed to women and youth and dairy development projects should specifically target women and youth. The programmes on women and youth in dairy that had been initiated by the DDP should be resuscitated. Breeding is a subject that has many exciting technologies that have been developed which could be topical to youth. This is consistent with recommendations from respondents in this study in which aggressive marketing of dairying and including youth in cattle acquisition programmes is recommended. For example, youth can be trained in AI, feed processing, and in simple routine practices that they can conduct for a fee.

In all breeding activities environmental implications should always be considered. For example, any herd size increases should be matched by increased feed conservation to reduce pressure on grazing land. Environmental issues and mitigatory measures should be brought to the fore in all programmes of engagement at the MCC. In fact, the MCC leadership and employees should be educated on environmental issues and mitigatory measures. The implication of cattle breed choices on the local cattle should be discussed with particular attention on potential hazards to local cattle genotypes.

4.17 Dairy Policies and Breeding Support Programmes

Policies are a key component of the breeding pillars. Absence of supportive policies is unlikely to drive development of a sector. While there are no GoZ policies that directly address smallholder dairy cattle breeding, there is room to develop appropriate policies in support of breeding programmes for the smallholder dairy sub-sector. Consistent with the aim of the National Dairy Strategy to 'continue the expansion of the national dairy production base to the small-scale, communal and resettlement farming sectors, so as to increase milk supply and develop the communities,' appropriate breeds of cattle should be available to smallholder dairy farmers. The starting point is supporting acquisition of breeding cattle and breeding services, particularly AI.

The Government of Rwanda supports dairy cattle importation through a subsidy for transport costs to enable farmers to import cattle. Other programmes that have been initiated include the group kraal programme in which cows of different farmers are kept at a central place where plots of land are set aside for farmers to grow fodder and crops for the cows. Milking is done by individual farmers but there are economies of scale for service provision including AI and veterinary services. There are variants, of this basic model including the Milk Zim model, that are worth considering depending on the circumstances or context. Previously, some collective ownership models were tried in Zimbabwe without success. Unlike in these models, the proposed model is predicated on individual ownership of the cows and key resources and payment for services rendered to an individual.

Apart from basic infrastructure installation such as roads and electricity for MCCs, the GoZ can learn from the approach taken by Kenya and Rwanda in developing their AI programmes. Kenya started promoting AI more than 40 years ago through a subsidized AI system that even reached smallholder cattle. Today, the Kenyan smallholder dairy farmers are knowledgeable on AI issues and demand services. If smallholder dairy has to grow, it has to be recognized that the initial stage is largely a development rather than a business or commercial agenda. This initial development agenda has to be supported by favourable policies.

In addition to policies on AI and breeding, policies to improve animal health services including ectoparasite control to within reach of smallholder dairy farmers are necessary to support breeding programmes. Use of the GoZ research stations and parastatal farms facilities as foundation breeding stock multiplication has often been suggested. While this would add to the pool of breeding cattle, the programme is unlikely to be driven by incentives than would be the case when it is under the private sector. In addition, in the recent history of Zimbabwe accountability of those given this responsibility has come to question.

4.18 Cattle Breeding Investments and Financial Products

The likelihood of smallholder dairy farmers getting funding from commercial sources is low. There is no evidence of a sub-sector on a growth trajectory that is attracting investment. As stated above, the sub-sector is in a development stage needing propping up before it is considered for commercial funding. Given the expansion of risks of disease spread, lack of economies of scale and policy prioritization the financial sector is unlikely to be attracted to the sub-sector to support breeding programmes. In the absence of sufficient collateral security, funding of smallholder farmers has to be supported by guarantee funds.

4.19 Constraints to Dairy Production in Smallholder Farming Areas

The identification of lack of finance for smallholder dairy as the most important dairy production constraint is not surprising. However, farmers could earn more revenue through increasing the productivity of existing cows; for example, by improving feeding and management. Commercial money lenders will only be interested when they see potential for growth and borrower commitment to the dairy core business. Often, farmers get loans to buy cattle or finance dairy but end up paying the loan from non-core business sources. The lack of finance is partly attributed to poor MCC creditworthiness. If the MCCs were creditworthy they could guarantee group loans for cattle acquisition and breeding programme development.

Apart from limited finance, the major constraints to dairy production cited including inadequate feed, low milk yield/cow, low milk price and inadequate water could be addressed through improved dairy herd management, lobbying for favourable policies, and creating market linkages.

5. DAIRY BREEDING FRAMEWORK AND PROGRAMME DESIGN

In formulating a dairy breeding framework and programme design, it is imperative to take into account farmers' production environment, characteristics, aspirations, needs, and capabilities. The breeding framework and programme that we have designed has the goal of increasing income of smallholder dairy farmers through increased cow productivity and has 5 components (Table 26). Cow productivity is determined by the genetic potential of the animal and the environment. Breeding programmes aim to provide an animal with the expected genetic potential that is able to survive in the prevalent environment. The five components address the genetic potential and environmental components that are captured in our breeding pillars.

Component 1: Developing breeding programme clusters for efficient delivery of breeding services is an important first steps in creating awareness across the dairy value chain on the pivotal role breeding plays in milk supply. Stakeholder mobilization and capacity building are critical to buy-in and projecting the breeding issues and programme to the forefront. This step is often ignored on the assumption that all stakeholders are aware of the existence of other players in the value chain, in our experience, this is always a misconception.

Component 2: Setting up breeding infrastructure and cattle supply structures is necessary because herd breeding improvement will depend on appropriate infrastructure for application of husbandry practices. For example, facilities to restrain cattle are imperative for routine animal health practices and conducting AI. In addition, AI introduction has to be supported by provision of the requisite equipment. Unknown to most farmers, the equipment is not expensive, particularly when purchased by a group such as an MCC.

Component 3: Implementing reproductive performance improvement of existing smallholder farmer herds programme is important in generating more dairy breeding stock and enabling more cows to annually produce milk. In fact, milk production could be doubled through increasing the annual calving rate from about 45% to 85%. This is possible through improvements in reproductive management and feeding of breeding cows. Breeding cows and heifers can be selectively fed to improve body condition, and hence fertility. When the cows and heifers are in good body condition, breeding technologies, particularly heat synchronized AI, can be employed to circumvent heat detection. In hot environments and rustic cattle breeds, heat expression is not as overt as in dairy breeds.

Component 4: Establishing cattle breeding and multiplication farms to enhance dairy cattle supply is necessary in rebuilding the national dairy herd and supplying purebred dairy cattle. Dairy heifers and cows are currently being sourced from South Africa indicating that local sources are still limited. While sustainable sources of cattle are private farms, the government and parastatal farms (stations) can be used for breeding and multiplication of desired breeds. This has happened before, where government stations could sell cattle by auction to a prescribed beneficiary group, for example smallholder dairy farmers. Government stations now have revolving funds that are derived from activities on the farm and are used for the benefit of the station. This can provide incentives for stations to engage in income generating activities such as breeding dairy heifers for sale. Alternatively, state farms or vacant land can be leased for rearing breeding stock. Entrepreneurs can recover female cattle from abattoirs and use them in breeding programmes.

Component 5: Building or strengthening institutions and developing policies for breeding programme support is important to provide the institutional and policy support for sustainability. While we propose to highlight this component for breeding, it is likely to be implemented together with other dairy production issues. However, what is more important is to lobby for policy and financial support, even subsidies, to initiate the revival of smallholder dairy schemes and ensure the requisite infrastructure is in place.

5.1 Proposed and Promising Dairy Breeding Models

Our views on the promising dairy breeding models are subsumed in the programme framework and design presented above. Clearly, any breeding model recommended is contextual. There is no one size fits all because the smallholder farmer clusters differ in terms of land, livestock, and financial resources, geographical location and climate. Given these disparities, smallholder dairy farmers can be divided into 4 groups that would require individual breeding models. However, depending on farmer circumstances and resources, the suggested models can be cross-applied.

5.2 Breeding Programme (Breed Choices)

If dairy cattle of different dairy breeds are available, because of its small frame, and hence low body maintenance requirements, the Jersey breed has often been recommended for adoption in relatively harsh environments. This breed would be suitable for crossbreeding or adoption for smallholder dairy farmers in dry areas and where feed supply is limited. The demerits of the Jersey and farmer perceptions were discussed above. In Zimbabwe, the Red Dane appears to be a favoured breed for crossbreeding or keeping as a purebred. It is highly regarded for its ability to withstand harsh conditions and can thus be a breed for adoption and crossbreeding. It is also attractive because of the presence of an active breeder who has experience in heifer distribution. Depending on availability, the dual purpose breeds including the Simmmental and Sahiwal would be suitable for adoption and crossbreeding in smallholder dairy farms. The Brown Swiss has been successfully adopted in Rwanda and Kenya and is prevalent in cheese processing areas. Because of high solids content, as is common with dual purpose breed milk, Brown Swiss cow milk is desirable for cheese making.

In order to maintain heterosis, one concern in crossbreeding programmes has always been the breed composition structure. For example, would it be desirable to maintain a 50% Holstein and 50% Mashona crossbreed or the proportion of the individual parent breeds can vary?

Table 25: Dairy cattle breeding framework for the smallholder dairy sub-sector

Goal		Primary Support Services	Objectively Verifiable Indicators	Means of Verification	Risks and Assumptions
Increase income of smallholder dairy farmers through cow productivity improvement			Changes in incomes of smallholder farmers in dairy farming	Government reports, economic reports, & FAO reports	
Component 1: Developing breeding programme clusters for efficient delivery of breeding services	Objective 1: Improve dairy value chain players support of breeding programmes & delivery of breeding services.	Extension departments, DDP, local government offices, service providers & MCC administrators	At least 20 clusters (1/MCC) formed by year 2.	Annual government reports (includes DDP), MCC surveys, & NADF reports	Government departments produce annual reports & DDP continues regular MCC monitoring
Component 2: Setting up breeding infrastructure & cattle supply structures	Objective 2: Develop or improve existing cattle supply structure & breeding infrastructure to enable AI & breeding technologies application	Extension departments, local government, MCCs, farmer organizations, breeding service providers, processors & other buyers, & development agents	Individual clusters to have basic infrastructure for cattle handling and AI by year 2.	MCCs records, economic reports, DDP, extension departments & NADF reports	Willingness to adopt breeding technologies
Component 3: Implementing reproductive performance improvement of existing smallholder farmer herds programme	Objective 3: Improve reproductive performance & calf crop of smallholder farmer (village	Extension departments, DDP, MCCs, breeding service providers, & development	Calving interval of MCC herds reduced from 22 months to 12-15 months, & 90% of calf crop survives by year 4	MCCs records or surveys, extension & DDP reports, service providers, NADF & development agent's reports.	Critical mass of farmers willing to participate in programme

	herds)	agents			
Component 4: Establishing cattle breeding & multiplication farms to enhance dairy cattle supply	Objective 4: Produce breeding heifers for distribution to smallholder dairy farms	DDP, MCCs, government stations, banks, MFIs, local government, extension departments, milk processors/buyers & development agents	At least 80% of smallholder farmer dairy heifer needs are met by year 4.	MCCs records or surveys, extension, DDP, & local government. NADF & development agent's reports.	
Component 5: Building or strengthening institutions and developing policies for breeding programme support	Objective 5: Build or strengthen institutions and lobby for appropriate policies & self-regulation to support breeding programmes	Ministries of government including agriculture, local government & commerce; NADF; extension departments, DDP, MCC representatives & development agents	At least policies on dairy cattle acquisition, AI development, & financing breeding development programmes established; and an industry self-regulation framework created by year 3	Ministry, extension departments, DDP, NADF, MCC and development agents reports	Government will respond positively & value the sub-sector

In most smallholder dairy systems across East Africa the breeding goal is to get a milking cow as close to the pure dairy breed as possible. This implies that the sire breed will always be a dairy purebred. Also, it is argued that by the time the farmer gets a cow with a high percentage of exotic (purebreed) blood, she has sufficient experience to look after such a cow.

Adopting crossbreeding programmes that dilutes the purity of local breeds has been criticized as a threat to genetic diversity. Expanding crossbreeding programmes to enhance dairy production in smallholder farming areas will create some concerns; however, there is evidence that a large population of the cattle in the smallholder sector are already mixed because of the prevalent indiscriminate breeding.

Given that the surmised breeding goal is to produce a milking cow irrespective of breed composition, we suggest breeding models for the different smallholder dairy farmer contexts.

5.3 Proposed Breeding Models

We propose three basic breeding models that are based on the dairy farming system that determines availability of resources described above including land, cattle population, and infrastructure (Table 27). For breeding to be organized, a key requirement is controlled movement of cattle and existence of supporting services and structure as depicted in our breeding pillars.

Model 1 is for a typical communal area set-up where there is communal grazing and little control over the movement and mixing of cattle. In general, heat detection is challenging, except during the rain season when cattle are herded, because cows are not observed during the day. Tracing cows that are bred and identifying the sire is not always possible. In this system, using ordinary AI is difficult because of the heat detection challenge, small household herd sizes, spaced-out homesteads, and inadequate cattle handling facilities. Synchronized AI using hormones is feasible. Cows can be brought to a central place such as a dip tank, heat synchronized and inseminated. Pregnancy diagnosis (PD) by rectal palpation can be conducted at least two months after the last insemination. Cows that are non-pregnant are re-heat synchronized and bred by AI, and PD done as before. For most communal area farmers, such a programme that would cost about USD 70 per cow including a repeat breeding and PD may be high; however, farmers should weigh the cost benefit in terms of milk produced by the cow and a dairy crossbred heifer or bull. Such a programme may need the assistance of development partners to kick-start it. With good organization through the MCC, proceeds from milk sales could finance further synchronization activities. Besides continuation of the synchronized AI, the dairy crossbred bull calves can be grown into breeding bulls for the area, and hence help increase the bull to cow ratio that is low in most household herds.

Synchronized AI has not been successful in smallholder herds in Zimbabwe and even in some commercial farms. However, as described above, we have had a pleasant experience with synchronized AI in herds that we have worked in, and as a result, Rwanda nationally has routinely used the technique for the last eight years. The key to success is expertise in administering the programme, understanding the equation of reproduction described in our breeding pillars, and follow-up to check on success and re-synchronizing.$ Key breeding technologies including AI, synchronized AI, sexed semen use, and embryo transfer have not been adequately exploited. In most progressive dairy programmes in developing countries, AI has been the engine for improvement of cow productivity while synchronized AI has been a tool for massive introduction of new genetics in cattle in communal grazing systems. Sexed semen can also offer cost-effective opportunities to grow the female cattle herd instead of solely relying on imports. When these technologies are supported through appropriate policies and financing, even government subsidies, they can be employed on a large scale and create economies of scale for a sustainable smallholder dairy sector.

Table 26: Proposed breeding models for the smallholder dairy farming sub-sector

Item	Site		
	Communal Area: Uncontrolled Grazing – Model 1	**Communal Area: Group Rearing – Model 2**	**Small Scale Commercial: Controlled Grazing – Model 3**
Purpose	Increase dairy genotype & her size	Increase dairy genotype & herd size	Increase dairy genotype & herd size
Cow breed	Local/crosses	Local/crosses/pure	Local/crosses/ pure
Sire breed	Dual purpose or Jersey	Dual purpose, Jersey or Holstein-Friesian	Dual purpose, Jersey or Holstein-Friesian
Breeding method	Bulls – bull schemes/individual, & Synchronized AI	Ordinary AI, synchronized AI, & sweeper bull	Ordinary AI, synchronized AI, & sweeper bull
Use of progeny	Use crossbred bulls for breeding, beef production & draught, & replacement of cows	Replacement of cows, & males for beef	Replacement of cows, & males for beef
Advantages of model	Breeds existing cattle, does not require heat detection, & self-sustaining through use of bull progeny	Grouping of cattle from several farmers builds economies of scale & reduces costs, possible to control breeding & improve heat detection. Feed production can be centralized.	Possible to control breeding & cattle movement, & hence facilitate heat detection. Feed production can be matched to breeding herd needs.
Disadvantages of model	Risk of indiscriminate breeding, & inability to access feed, & services provision difficult due to farm scatter	Requires good coordination, and observance of operational rules	Individual; hence, difficult to organize for community benefit & economies of scale.

Model 2 is for communal or small scale commercial farmers that are willing to keep cows at a central location. However, as described above individual ownership, feeding, veterinary care and other activities are maintained. Keeping the cows together allows for controlled movement of cows within a prescribed area, and creates economies of scale for extension and AI service provision. Milking can also be done communally using a milking machine. This model is not well-developed in Zimbabwe but it is being promoted in East Africa where there is even the shared cow concept. In the latter approach, vulnerable households can have shared responsibility for a cow kept and bred at a central location. The milk and revenue from milk sales is shared between the households. This model or variants of it can be considered for some areas in Zimbabwe to create economies of scale for business development and service provision. The cross-section of breeding services and methods can be applied in this model.

Model 3 is for small scale commercial farms where controlled breeding can be practiced. In this model, just as in Model 2, all breeding services and methods can be applied. However, the herd numbers for this farming sector are small, and hence they are unlikely to have the requisite economies of scale for business development and service provision.

6. CONCLUSION

Milk collection centres have low membership that does not provide adequate critical mass for self sustaining breeding programmes. The average number of milking cows across breeds is not adequate for a viable breeding programme that is AI based, a cow herd of at least 1000 will be required for economies of scale to engage AI service providers. There is no doubt that MCCs can recruit more members and facilitate growth of the herds of members to create economies of scale for delivery of breeding services. Calving intervals are still too long resulting in about 50% of the cows calving each year.

There are virtually no existing or previous well defined breeding models for smallholder dairy farms but it is clear that they were largely anchored on bull schemes. Sire cow breeds acquired by smallholder farmers were not chosen but depended on availability and what was provided by funding agents. While some cattle acquisition projects partly succeeded, most were criticized for reasons including failure to prescribe the quality of animals distributed, lack of supplied-animal records, failure to provide ancillary support services to increase cow survival chances. Future cattle acquisition programmes should take into account farmer choices and have feasible repayment conditions.

Key breeding technologies including AI, synchronized AI, sexed semen use, and embryo transfer have not been adequately exploited. In most progressive dairy programmes in developing countries, AI has been the engine for improvement of cow productivity while synchronized AI has been a tool for massive introduction of new genetics in cattle in communal grazing systems. Sexed semen can also offer cost-effective opportunities to grow the female cattle herd instead of solely relying on imports. When these technologies are supported through appropriate policies and financing, even government subsidies, they can be employed on a large scale and create economies of scale for a sustainable smallholder dairy sector.

7. RECOMMENDATIONS

1. In order to create economies of scale for vibrant breeding programmes, MCCs should recruit more members and grow their milking herds, and hence milk volumes.

2. Attempts to increase the dairy herd size should not solely rely on buying-in heifers, the current herd could contribute to increasing milk volumes through improvements in calving percentage and calving interval, which could be achieved through capacity building of service providers and farmers.

3. As presented in the programme framework, dairy value chain players should be mobilized to support breeding activities that determine the volume of milk reaching the market.

4. The breeding programmes on farms across the MCCs should develop an AI service, which is the back bone of breeding programmes in most global dairy schemes.

5. Breeding technologies, particularly heat synchronized AI, can be a valuable tool to increase the cows that are bred without the need to detect heat, which is usually a major AI use limitation. This can be an important tool to increase dairy crossbred cows in communal areas where there is communal grazing and uncontrolled breeding. However, such a programme would initially require financial and technical support from the public sector and development agents.

6. MCCs should develop breeding programme clusters for efficient delivery of breeding services.

7. Breeding infrastructure and cattle supply structures should be set up for MCCs through collaboration with the government, private sector and development partners.

8. Cattle breeding and multiplication farms to enhance dairy cattle supply are necessary in rebuilding the national dairy herd and supplying purebred dairy cattle. These should be largely private but government stations and parastatal farms should be engaged or leased for such programmes.

9. Breeding stock should be increased through abattoir recovery of heifers and cows and purchase from smallholder farms. These can be base herds for crossbreeding with dairy semen and bulls on breeding farms.

10. Institutions supporting breeding including those involved in taking and maintaining records should be supported through policies and financial support from the public sector and beneficiaries of the service.

11. Policies that support the initiation of massive cattle breeding programmes should be enacted and given budgetary support, even from the national fiscus.

12. Suitable financial packages including loan guarantees should be developed for the smallholder dairy sector to reach economies of scale that can sustain the sector.

13. A national smallholder dairy breeding strategy should be developed to create the framework for improvement of the smallholder dairy breeding programme.

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