MOUNT KENYA MILK
"The Cool Mountain Freshness"

Meru Dairy Co-operative Union Ltd
Proposed Breeding Strategy

"The art of breeding is to breed the cow most suitable for your farm"

(Roodbont Agricultural Publishers, The Netherlands)

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List of Abbreviations

ACZ	: Agricultural Climatic Zone
ADC	: Agricultural Development Company
AI	: Artificial Insemination
BCS	: Body Condition Score
CAN	: Canada
CEO	: Chief Executive Officer
CI CRV	: Cooperatieve Rundvee Verbetering (Cooperative Cattle Improvement)
CIG	: Common Interest Groups
DVS	: Director Veterinary Services
E	: Environment
EAAP	: European Association for Animal Production
G	: Genotype
GDP	: Gross Domestic Product
GER	: Germany
GoK	: Government of Kenya
HF	: Holstein Friesian
IAT	: International Centre for Tropical Agriculture
ICAR	: International Centre Animal Recording
IDF	: International Dairy Foundation
JCSK	: Jersey Cattle Society of Kenya
KAGRC	: Kenya Animal Genetic Resource Centre
KDB	: Kenya Dairy Board
KES	: Kenya Shilling
KHFCS	: Kenya Holstein Friesian Cattle Society
KLBO	: Kenya Livestock Breeders Organization
KMDP	: Kenya Market-led Dairy Program
KVB	: Kenya Veterinary Board
LGSEA	: Livestock Genetic Society of East Africa
LRC	: Livestock Recording Centre
MAHW	: Meru Animal Health Workers
NKCC	: New Kenya Cooperative Creamery
NL	: Netherlands
PD	: Pregnancy Diagnosis
PTA	: Predicted Transmitting Ability.
PTAT	: Predicted Transmitting Ability for Type
RH	: Relative Humidity
SAP	: Structural Adjustment Program
SDC	: Standard Deviation Curve
SNV	: SNV Netherlands Development Organisation
SP	: Service Provider(s)
STA	: Standard Transmitting Ability
THI	: Temperature Humidity Index
UHT	: Ultra High Temperature
Union	: Meru Dairy Co-operative Union Ltd
US	: United States of America
VSPS	: Veterinary Surgeons and para-Professionals Service

Executive Summary

In July 2017 the management of Meru Dairy Co-operative Union Ltd requested the SNV Kenya Market-led Dairy Programme (KMDP) to give recommendations on a breeding strategy for its cooperative members.

This was initiated through a common understanding that the Union and its farmers require a clear set of criteria for selection and promotion of breeds and bulls for their farmers. A breeding strategy that values cow traits in relation to the local context, focusing on agro-ecological conditions, availability and quality of feed/fodder, cow health and prevalence of critical diseases, current production levels in relation to management skills of farmers, and quality of service provision in the area.

Chapter 1 presents a short profile of Meru Union, which is an umbrella dairy society that is solely owned by farmers in Meru County and its environs. The Union operates under the brand name Mount Kenya Milk and has been in operation for the last 30 years since its inception.

Chapter 2 gives a brief description of Meru County. For the purpose of the breeding strategy we divided the County in 2 agro-ecological zones that are suitable for dairy farming, comprising of highland and intermediate zones. The lowland area in Meru North that is part of the vast Northern Grazing Area in northern parts of Imenti North, Tigania and Igembe Divisions, is a semi-arid area where extensive livestock keeping is the pre-dominant agricultural activity. Meru Union also collects milk from Tharaka Nithi County especially from its highland zone. Tharaka forms the lowland zone in this County that formerly together with Meru County formed the Greater Meru District.

The highland and intermediate zones in both Counties are conducive for dairy farming in terms of suitable temperature, rainfall patterns and soil types. These zones – especially the highland zone - can support a wide variety of fodder crops while heat stress can be managed to acceptable levels through well-designed zero grazing systems/units (shade, ventilation).

The vast majority of dairy farmers in the two Counties is however located in the highland zone (1,400 meters and above) where tea, coffee, horticultural crops, bananas and other fruits are the main cash crops and a wide variety of food and fodder crops can be grown including maize. In Timau the highland zone is known for wheat, barley and potato production.

Chapter 3 discusses the dairy breeding policy environment at national and County level. These (draft) policies are in principle supportive to the breeding strategy here formulated and recommend for Meru. On a national level the dairy breeding policy is currently being implemented through the National Dairy Cattle Breeding Program. The aim of this program is to improve the dairy breeds for enhanced productivity. This chapter also discusses other key factors that determine the breeding environment for Meru. One of them is the quality of AI services. It is noted that the infrastructure and service level for artificial insemination are not adequate. However, there is a growing demand for better breeding services through Artificial Insemination

(AI) and better dairy genetics, which is mainly driven by the demand for more milk in the market. The main challenges in AI-service provision among others are low skills level of the inseminators, high distances to the farmer, whilst availability of good quality semen and liquid nitrogen are not always guaranteed.

Another factor is the market. Prognosis indicates that are that for the next 15 years' demand for milk and dairy products will outstrip supply, however there are significant seasonal fluctuations (and also growing inputs from Uganda) which makes the market volatile. The milk market is volume-based with most of the milk being marketed through the informal market as raw milk. However, the share of processed milk marketed through the formal channel is steadily increasing. In recent years a couple of initiatives were launched to investigate and pilot paying farmers bonuses based on the quality of their milk in terms of bacterial count and antibiotics residues, but this is still in an infancy stage. Only one small processor in Nairobi pays a bonus for butterfat and protein content.

Farm size, availability of (quality) fodder and farm management or production levels, are other key factors that impact on the dairy sector in Meru. Over the years farm sizes in the highlands and intermediate zones of the County have reduced, resulting in farmers keeping less cows but giving preference to "grade" cows. These grade cows have a high genetic potential for milk production which supports farm output to be maintained at the same level as before (with more cows). While these grade cows are known to have a high genetic potential for milk production, they are also heavier and bigger in size, thereby requiring higher maintenance by provision of more and better-quality fodder and feed to be able to express their genetic potential. In Meru however, quantity and quality of fodder are problematic and feed rations are often nutritionally insufficient for the cows/breeds kept. As a result cows easily get into a negative energy balance.

Next to maximum day temperature the Temperature Humidity Index is a good indicator if the cows experience heat stress. Heat stress has a negative impact on feed intake and nutrition, milk production and milk quality, fertility and health. The risk of heat stress is highest in the lowland zone, but it occurs in all the 3 zones - even the highland zone although for shorter periods - if cows are kept in free or semi-zero grazing systems.

There are about 180,000 head of dairy cattle in Meru County. The breed of preference is Holstein Friesian and although this is a breed with a high genetic potential for milk production, most farmers (> 80%) still have a milk production level of around 7 kg milk per cow per day only. This is largely due to low management skills and sub-optimal feeding practices.

Chapter 4 discusses the results from a mini survey during which various stakeholders were interviewed at national and County level. While discussing the breeding strategy with the stakeholders in Meru County, it was striking that most responses given were about the cost, efficiency and reliability of the AI service provision and rarely about the economic performance of the farmers and their cows. Yet the breeding study is not per se about the quality of AI services; as this will be addressed by a separate assessment to take place later in 2017.

The focus of *this* study was to find out how the farmers should use breeding as a tool to get a cow free of many complications on their farms and yet economically viable. Though it is recognized that AI is the means to achieve this goal, it is merely a technology among others used to deliver preferred genes to the cows situated in the farms in Meru County.
The County government recognizes that average production levels of the dairy cows are very low. It is interested in a breeding program that would address these issues of low animal performance through the introduction of more resilient breeds, ultimately aiming at a better income for the farmer and higher milk supply to Meru Union. Meru County has a high percentage of improved cattle but the average milk production per cow per day has hardly improved. The main challenge for the farmers is the ability to provide sufficient and good quality fodder and feeds to their cattle, which is partly a result of small farm sizes and limited land available to grow forages, and partly lack of knowledge and skills to well manage and preserve forages. Meru Union suggested the desire or need to promote a breed that is efficient and economically viable for the situation of dairy farmers in Meru. The Union has been providing AI services to her farmers since 1993 which is one of the reasons for the high percentage of exotic breeds in the County. During the period before 1993 it was mainly the government that was driving this process. The Union though, has its challenges to deal with the AI service infrastructure that is not adequate. Most important is that among the cooperatives there is readiness to adopt more efficient and economically viable breeds. A breed audit as suggested by one of the cooperatives chairman (as a zero setting) could be a good starting point. The Union may partner with KLBO to carry out this audit.
Expert breeders in Kenya and local Cattle Societies were consulted and their main recommendations were smaller breeds/cows, as they have proven to have longer productive life with less management complications than the heavier breeds (which burn out quickly). The heavier the breed the higher the demand for feeds, maintenance and management. Expert breeders also noted that the low production levels of most cows (< 3,000 kg/cow/lactation) in the Meru survey implies that any bull that qualifies in the bull catalogue is good for increased milk production.

Chapter 5 presents a case on breed suitability. When looking at the suitability of the breed, the most important factor is an evaluation on genetic interaction with the environment that the cow must perform in. The breed(s) of preference by most farmers and many who advise them, are mainly exotic breeds which originate from the temperate climate(s) in the world and were bred to perform under these conditions. When semen (genetics) are exported to the humid tropics, mostly no attention is paid to the adaptability of the offspring towards heat stress, feed conversion, disease resistance, body-size and milk production. To get a cow that is more resilient to this environment, breed characteristics are tools that can be used to select the right breed, the right breeds for crossbreeding or a crossbreeding program. An added advantage of crossbreeding would be the additional heterosis effect.

Chapter 6 presents the breeding goals, as well as a recommended strategy for Meru Union to operationalize their breeding goals, which can be formulated as "to promote and adopt suitable breeds and bulls that generate future animals that will produce more milk and offspring efficiently, and which are adapted to local production systems". The consultants acknowledge however that Meru farmers' current breed choices have multiple objectives, including the need for more milk, the provision of manure and financial role of cattle (sales of heifers and insurance and saving bank). In the choice of breed and bulls, these objectives are considered for the breeding strategy to be more easily accepted and implemented. In this light the consultants recognize the need to match - or find a balance between - breed preference of the farmer versus advice from researchers based purely on environmental and technical considerations.

In the Meru situation this would mean a breeding strategy that acknowledges preference for Holstein Friesians and Guernseys in the highlands and intermediate zones, but with a bull selection that targets a smaller animal with more efficient feed conversion, improved adaptability to heat stress, and higher resistance to diseases. Within the different breeds there are bulls available that meet these targets and with less emphasis on high milk production. For example HF bulls used in New Zealand with a smaller frame and bulls with already some cross breeding in their parentage.

Farmers in the lower areas (lower parts of zone 2 and zone 1) would be best served with Bos Indicus x Bos Taurus crosses like Boran-Holstein Friesian crossbreed or Sahiwal-Holstein Friesian crossbreed. This will give them the advantages that the offspring has the traits of both breeds: higher in milk production and at the same time hardier, more resistant to tropical diseases, lower feed and water requirements and more heat tolerant. This F1 Cross can be served with HF or another suitable breed to give a F2 cow that is well adapted to farmers practices and environment. Another possibility is to cross the Bos Taurus type of cow with a composite breed like the Girlando or upcoming Kenyan composite bulls.

In addition to taking into account agro-ecological zones, the breeding strategy also suggests a stratification as regards to elite farmers on one hand, and the mass of farmers (> 80%) that produce less than 10 liters of milk per cow per day, on the other hand.
Elite farmers in Meru County (estimated at 5% of the dairy farmers) have shown that under good management practices, i.e. zero grazing with a high nutritious feeding regime, it is very well possible to achieve high production levels of > 6,000 kg per 305-day lactation. This "elite group" of farmers is on average well conversed with breeding, bull selection, heat detection and insemination issues, and they have already a quite well-informed breeding strategy. They can be advised if need be on a breeding strategy, but they will make their own decision and are capable and knowledgeable to do so.

For most farmers who do not meet these standards (production levels averaging 5-10 liters/cow/day), the recommendation is for Meru Union to choose a breeding strategy, which aims for a smaller cow with more efficient feed conversion, improved adaptability to heat stress and higher resistance to diseases. Such a cow is better adapted to the local environment and can be expected to produce more milk in its life cycle, more calves and is easier and less costly to manage, as compared to high producing cows when not well managed. Cross breeding will be the best option for farmers to breed this type of cow.

Finally, Chapter 7 gives a summary of considerations and recommendations of the breeding strategy. The recommendations are consolidated in the table below which is derived from Chapter 7 and forms the tool for breed and bull selection for Meru Union. The table gives an overview of the different agro-ecological zones and within these the consultants' recommended *overall or generalized* breed or crossbreed preferences are given, and the targeted production level that can be achieved with targeted breeding to create a next generation off-spring more adapted to the local production systems in place.

Within these agro-ecological zones there is still stratification of farmers as regards production levels and management skills. The overall breed preferences per zone need therefore to be fine-tuned against this, meaning that breed and bull choices will be further tailored to the prevalent farm management or production level of individual farmers or categories of farmers as explained above.

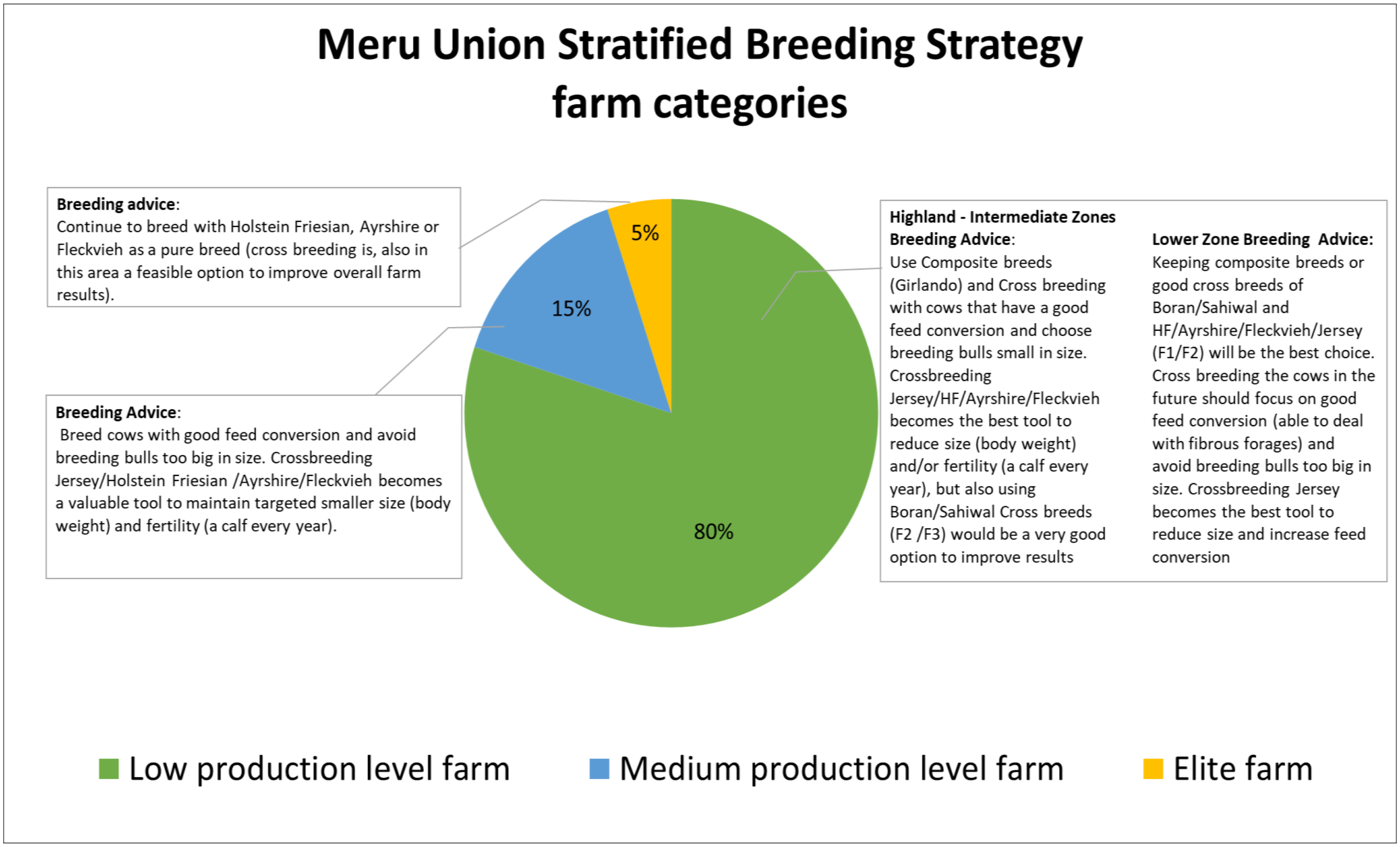
Table: Meru Union Recommended Breeding Strategy

Elite Farmers: High input in terms of nutritious feed, zero grazing units, knowledge, skills, investment --> milk output high (15-20 kg milk)

Medium Level Farmer: Lower input than Elite Farmers --> milk output is lower than elite farmers (10-15 kg milk)

Low Level Farmer: Lower input than Medium Level Farmers --> milk output is lower than medium level farmers (< 10 kg milk)

Breeding Policy	Government policies and regulatory framework		
Step 1: Breeding Goal	Formulating the Breeding Goal (Chapter 6.1)		
Step 2: Breeding Strategy	Defining the Breeding Strategy to achieve the Breeding Goal (Chapter 6.1)		
Step 3: Bull Selection	Bring the Breeding Strategy into practice, select bulls to inherit the right traits to fulfill breeding goal (Chapter 6.4 and 6.5)		
Step 4: Mating Choice	Which bull should be used for which cow (or group of cows) in Meru Union (Chapter 6.5)		
Step 5: Mating Program	Execution of the above under the farmers' cows of Meru Union		
Agro-Ecological Zones/Strategy	**Breed Preference**	**Target Production**	**Rationale**
Zones 3 & 2 (highland/intermediate) ***Elite Farmers*** Continuous breeding and improving of existing dairy cattle with appropriate exotic breeds to produce efficient, high quality, long life replacement stock.	Holstein Friesian/ Holstein Ayrshire and crossbreeds	Average 15-20 ltrs (4,500-6,000 kgs/ 305 days lactation)	Holstein Friesian and Ayrshire are known to produce more milk in right conditions while cross breeding positively impacts fertility and health
Zone 3 & 2 (highland/intermediate) ***Medium/Low Level Farmers*** Upgrading, switching to economical breeds, cross breeding; targeting less intensive management and high tolerance breeds suited to the farming system(s) and farming practices used	Ayrshire, Jersey and small type European Holstein Friesian or their crosses and crosses of exotic breeds and Bos Indicus.	Average 10-15 ltrs (3,000–4,500 kgs/ 305 days lactation)	Ayrshire, Jersey and small-type European Holstein Friesians are good grazers and tolerant. Low nutrition levels inconveniences fertility, complications with husbandry practices.
Zone 1 (lowland zone) ***Lower Level Farmers*** Grading up of local (Bos Indicus) cattle using exotic (Bos Taurus) breeds of cattle to attain F1 (50%) and F2 (75%). Which are more suited to the farming-system and farming practices used.	Jersey & Brown Swiss and Crosses of Holstein Friesian & Ayrshire with Bos Indicus	Average 5-10 ltrs (1,500-3,000 kgs/ 305 days lactation)	As a single breed smaller breeds like Jerseys and Guernseys and Brown Swiss are known to be tolerant to tropical conditions better than Holstein Friesian and Ayrshire. They are more Heat tolerant and better feed converters. Crosses of Boran/Sahiwal and HF/Ayrshire


Meru Union Stratified Breeding Strategy
farm categories
Breeding advice: Continue to breed with Holstein Friesian, Ayrshire or Fleckvieh as a pure breed (cross breeding is, also in this area a feasible option to improve overall farm results).
Breeding Advice: Breed cows with good feed conversion and avoid breeding bulls too big in size. Crossbreeding Jersey/Holstein Friesian /Ayrshire/Fleckvieh becomes a valuable tool to maintain targeted smaller size (body weight) and fertility (a calf every year).
5%
15%
80%
Highland - Intermediate Zones Breeding Advice: Use Composite breeds (Girlando) and Cross breeding with cows that have a good feed conversion and choose breeding bulls small in size. Crossbreeding Jersey/HF/Ayrshire/Fleckvieh becomes the best tool to reduce size (body weight) and/or fertility (a calf every year), but also using Boran/Sahiwal Cross breeds (F2 /F3) would be a very good option to improve results
Lower Zone Breeding Advice: Keeping composite breeds or good cross breeds of Boran/Sahiwal and HF/Ayrshire/Fleckvieh/Jersey (F1/F2) will be the best choice. Cross breeding the cows in the future should focus on good feed conversion (able to deal with fibrous forages) and avoid breeding bulls too big in size. Crossbreeding Jersey becomes the best tool to reduce size and increase feed conversion
Low production level farm
Medium production level farm
Elite farm

INTRODUCTION

This report presents recommendations for a breeding strategy for Meru Dairy Co-operative Union Ltd (Meru Union), as requested by the Union's Management to SNV Kenya Market-led Dairy Programme (KMDP) in July 2017.

SNV KMDP and Meru Union have a Memorandum of Understanding that arranges for a number of activities to support the dairy sector in Meru, and for Meru Union and its affiliated dairy cooperative societies and members (dairy farmers) in particular. SNV KMDP has worked with Meru Union since 2013 mainly on farmer training and extension through a lead farmer approach with focus on fodder production and preservation, calf rearing and general cow management. KMDP also supported improved management and governance of dairy cooperatives and trained those involved in milk collection on hygienic milk handling and testing. In KMDP-I the project worked with 7 dairy cooperatives in Meru County (of which one in Tharaka Nithi County), 5 being affiliated members of Meru Union. In KMDP-II the project supports 15 affiliated member cooperatives.

The breeding study or strategy was initiated through a common understanding that the Union and its farmers require a clear policy and set of criteria for selection and promotion of breeds and bulls for their farmers. A breeding strategy that values cow traits in relation to the local context in terms of amongst others agro-ecological conditions, cow health issues and prevalence of critical diseases and parasites (e.g. ticks), availability and quality of feed and fodder, current production levels and management skills of farmers, and quality of service provision in the area. Or as the CEO of Meru Union stated during his interview for the study, the breeding study should result in a breeding strategy that "identifies the best, most efficient and economically viable breed that suits the dairy farmer in Meru Union".

This study does not per see looks into – and gives recommendations to improve - the quality and organization of AI services in Meru, farm management skills and knowledge and extension services, or interventions to enhance quality and availability of feeds and fodders. As much as these need to be improved to raise milk production, cow productivity, competitiveness and profitability of dairy farming in Kenya, this is not the focus of this study. They need to be addressed through separate programs and interventions.

This environment does however has an impact on - and sets the pace for – a breeding strategy that is contextualized and adjusted to current production levels and agro-ecological conditions. The approach taken in this study is therefore to focus on the current status of dairy farming in Meru, and to adopt a stratified breeding strategy that takes "local context" as the starting point. Thereby acknowledging that within Meru there are different agro ecological zones and – within these zones - there is segmentation of farmers according to production levels and dairy management skills. The breeding strategy is not static, as "context" is dynamic, and therefore it needs to be reviewed periodically, say every 5 years, and adjusted if and as required.

To facilitate this study a Terms of Reference (ToR) was prepared, which is summarized in the box below. A Kenyan expert Dr Chrisanthus Silali Wafula was contracted by SNV to implement the study and prepare the report, with input from Mr Jos Creemers of ProDairy EA Ltd who contributed to most chapters.

The methodology of this study consisted of a combination of qualitative research and desk study, as follows:

- Literature review;
- Field visits and interviews with farmers, Meru dairy cooperatives, Meru Union, County Government officials and government livestock staff in Meru;
- Interviews with breeding experts from central Government and from Kenyan breeders associations/societies;
- Interviews and farm visits amongst some top breeders in Kenya.

During the study Dr C.S. Wafula and Mr Jos Creemers of ProDairy were supported by Mr Jelle Zijlstra of Wageningen UR Livestock Research, Mr Frans Ettema and Mr Tseard van der Kooi of PUM who – as reviewers - provided valuable feedback and advice on the content of the report.

The report was presented in December 2017 to the Management and the Board of Meru Union for feedback. Thereafter a presentation took place in March 2018 in Meru in a workshop with Meru Union, CRV/Coopers, PUM and SNV. Both presentations resulted in valuable feedback that is incorporated in this 2nd revised version of the Breeding Strategy report.

Terms of Reference Meru Union Breeding Strategy
• *Give recommendations for appropriate matching of the genotype of the dairy cows (to be) used by the farmers of Meru Union with the local context. This means recommendations as regards the genomic characteristics (traits) such as milk production and content, conformation, longevity, fertility, health, feed conversion of the dairy cow vis-à-vis local context in terms of:* *- agro-ecological characteristics and zoning (rainfall, temperatures, soils)* *- prevailing farming systems and farm sizes (mainly zero grazing in mixed farming systems)* *- availability and quality of feeds/fodder* *- different production levels and farm management levels* • *Benchmark the recommended breeding strategy against prevailing government policy/strategy at national and County level.* • *Share, validate and test the level of acceptance of the recommended breeding strategy with relevant stakeholders (national/County government, Meru Union Board/ Management, dairy cooperative societies/farmers, AI service providers and suppliers of semen (local and imported).* • *Give recommendations as regards the required framework and systems to be in place for Meru Union (and beyond) for successful implementation of the proposed breeding strategy (through interviews and multi stakeholder workshop).*

1. Meru Union

Meru Dairy Co-operative Union Ltd (before Meru Central Dairy Farmers Co-operative Union Ltd) is an umbrella dairy society solely owned by farmers in Meru County and its environs. The Union operates under the brand name Mount Kenya Milk and has been in operation for the last 30 years since its inception. Most of Meru Union's affiliated cooperatives were initially in the central part of Meru (Imenti), but during the past 5 years with increased processing capacity and desire and need to grow daily milk intake, Meru Unions catchment widened to other divisions or sub-counties of Meru County, and also to Tharaka Nithi County. Before the introduction of the County system, the 2 Counties were one administrative District (viz. the former larger Meru District).

Meru Union has milk collection centers spread out in Meru County and to a lesser extent in Tharaka Nithi County collecting milk from 42 affiliated cooperative societies and a number of farmer groups. It has 4 satellite coolers, viz. Kanyakine (30,000 litres), Kiirua (20,000 litres), Kabeche (10,000 litres) and Katharaka (10,000 litres). Kabeche and Katharaka are in Tharaka Nithi County. Meru Union carries out five important functions: (a) procurement, (b) processing and (c) marketing of milk and milk products, and (d) provision of technical support coupled with institutional strengthening of affiliate dairy cooperatives, and (e) planning training & extension activities. The Union owns and operates a dairy plant with a processing capacity of 300,000 litres per day. Currently milk intake stands at about 160,000 litres per day which is largely processed and marketed as long-life milk (30-90 days shelf life).

The society has a department that focuses on Extension and Service Provision comprising of 8 trained Artificial Insemination (AI) service providers, 14 extension personnel and 2 veterinary personnel who offer their services to the society membership through affiliate cooperatives on request. The Union owns a well-established breeding structure which was established in 1993. The Breeding Section owns a semen bank and liquid nitrogen storage refrigerators. The Union also distributes bull semen from the national bull stud (KAGRC).
Cooperatives under the Union receive supplies of liquid nitrogen and semen doses from the Union. Occasionally the Union offers guarantee for input supplies to members. Currently the Union distributes over 3,000 doses of semen and serves about 1,000 farmers per month. The Union ensures adoption of better and improved farming technologies through organized awareness and training programs, with the help of its extension team, including exposure visits for their members to enhance on-farm productivity.

Meru Union's Mission

"To improve the quality of life of our dairy farmers, customers and staff, by processing and marketing high quality and affordable dairy products".

Meru Union's Vision

"To be the most reputable processor of high quality dairy products" (Meru Union , 2017).

2. MERU COUNTY

2.1 GENERAL INFORMATION

- Total area 6,936.2 sq. km out of which 1,776.1 sq.km are under forest.
- Meru County has 9 sub-Counties/Districts (Administrative): Tigania East, Tigania West, Igembe North, Igembe South, Central Imenti, North Imenti, South Imenti, Buuri and Igembe Central.
- Human population is projected to be 1.6 million in 2017.
- Geographically Meru (and Tharaka Nithi) County has 3 or 4 levels in elevation going from its eastern part (300 m) all the way to Mount Kenya i.e. lower midlands, upper midlands, lower and upper highlands. In Meru County the lower midlands are largely covered by Meru National Park where no agricultural activity takes place, and the Northern Grazing Area (Imenti North and the northern parts of Tigania and Igembe and bordering Isiolo County). In Tharaka Nithi County almost 80% of the land space is lower midland covering the entire former Tharaka District.
- Meru County (except for the lower parts) has two peaks of rainfall annually in Mid-March to May (short rains) and Mid-October to December (long rains). The rains vary between 500-2,500 mm per annum going from lower midlands to upper highlands.
- Ambient temperatures range from 8°C to 32°C (max and minimum day temperatures) with average annual temperatures ranging from 23-27°C in the lowlands, 17-23°C in the intermediate zone and 15-17°C in the upper highlands. This is largely determined by the steep increase in altitude and rainfall from the eastern boundary towards Mt Kenya.
- Meru County has green vegetation throughout the year, except in the lower parts of Meru County (the lower midlands or dry zone) for two to three months only.

2.2 GEOGRAPHICAL AGRO-ECOLOGICAL ZONES IN MERU COUNTY

In Eastern Africa, smallholder dairying systems are mainly found in the sub-humid to semi humid agro-climatic zones (ACZ) II and III (Braun, 1980; Pratt and Gwynne, 1977), and to a lesser extent in the humid zone (ACZ I) and the transitional zone (ACZ IV). See Table 1 below These areas are of high agricultural potential.

The humid, sub humid and semi humid zones are mapped and visualised in Figure 1. This figure shows how they are spread over Meru County (Orodho Apollo Bwonya, 2006).

Table 1. Natural vegetation and land use in livestock–crop production systems in East Africa

Climatic zone Moisture available[1] Altitude	NATURAL VEGETATION AND LAND USE
ACZ I – Afro-Alpine > 80 mm 2500–3000 masl	Afro-alpine moorland and grassland, or barren land at high altitude, most above forest line. Of limited land use and potential except as water catchment. Apart from Kikuyu grass, which may grow at this high altitude, most sown grasses are exotic temperate genera, including *Avena, Lolium, Dactylis* and *Festuca*.
ACZ II – Sub-Humid 65–80 mm 1250–2500 masl	Forest land and derived grasslands and bush, with or without natural glades. The potential is for forestry. Intensive agriculture includes pyrethrum, coffee, tea and maize. Natural indicator grasses include Kikuyu grass at the highest altitude (1750–2500 m), star grass (*Cynodon* spp.) at mid-altitude (1500–1750 m), and Napier grass at lower altitudes (1250–1500 m). Some other common grass species are *Exotheca*, *Andropogon, Pennisetum, Eleusine, Setaria, Panicum, Rhynchelytrum, Digitaria, Imperata, Panicum* and *Brachiaria*.
ACZ III – Semi-Humid 50- 65 mm 0–1000+ masl	Land not of forest potential, carrying a variable vegetation cover (moist woodland, bush and savannah). The trees are characteristically broad-leaved (e.g. *Brachystegia* or *Combretum*) and the larger shrubs mostly evergreen. The agricultural potential is high, soil and topography permitting, with emphasis on ley farming. Maize is a major food crop, and common grass species include *Hyparrhenia, Hyperthelia, Themeda, Chloris, Loudetia, Panicum, Rhynchelytrum, Paspalum, Digitaria, Heteropogon* and *Cynodon.*
ACZ IV – Semi-Arid 40–50 mm Mostly <1000 masl	Land of marginal agricultural potential, carrying as natural vegetation dry forms of woodland and savannah (often *Acacia–Themeda* association), but including *Brachystegia* woodland and equivalent deciduous or semi-evergreen bush. This is potentially productive rangeland. Cotton, sorghum and cassava are common agricultural crops. Grass species include *Themeda, Pennisetum, Bothriochloa* and *Panicum.*

NOTES: (1) Moisture available = difference between Rainfall and Eo, where E_O = Mean annual potential evaporation. Source: (Orodho Apollo Bwonya, 2006).

In this study we will differentiate three different agro ecological zone for Meru County and Tharaka Nithi County, the two Counties in which Meru-Union is active though its member cooperatives and milk collection. It should be noted that Meru County is largely covered by two zones only, viz. intermediate plane and highlands, with the lowlands mainly situated in Meru North that is part of the vast Northern Grazing area. See Table 2 below.

As for the highlands one could break down this zone 3 into 3.a Tea Zone, 3.b Coffee Zone and 3.c Wheat/Potato Zone (towards Timau and the rain shadow of Mt Kenya).

Table 1: Agro-Ecological Zones Climatic Conditions

Zone	**Rainfall**	**Temperature °C**	**Farming Systems**	**Population**
3. Highlands >1400 m (approx. ACZ I & ACZ II)	1200- >1750mm	Min-Max 8-30 Mean: 15-17	Tea, coffee, wheat, potato commercial dairy subsystem. Average land holding 0.5-1.5 acres per household	>-300pp/km2
2. Intermediate plane 1,000-1400 m (approx. ACZ III)	800-1200mm	Min-Max: 11-30 Mean: 17-23	Mixed rain fed-arid maize, pulses, tobacco, miraa. Average land holding 3-4 acres per household	> 150-300pp/km2
1. Lowlands 300-1000 m (approx. ACZ IV)	500-800mm	Min-Max: 13-32 Mean: 23-27	Rangelands-arid, sorghum, millet, beef pastoral farming sub-system. Average land holding 5-7 acres per household (no title deeds)	25-150pp/km2

The influence on dairy farming potential through agro ecological zones is mainly a function of temperature, rainfall and soils, determining occurrence of heat stress (Temperature Humidity Index), affecting types of fodder crops that can do well in specific zones, total rainfall annual and seasonality determining number of planting/harvesting seasons, access to drinking water for cows (roof catchment, surface water).

In Meru and across Kenya agro-ecology also much determines population density, size of farms, farming systems (largely mixed farming) and hence land available for growing fodder crops. Population density in Meru are highest in the highlands (zone 3), especially the lower highlands (1,400-1,800) meters which is often referred to in Meru as the coffee/banana zone or the “homestead zone” (Bernhard, 1972).

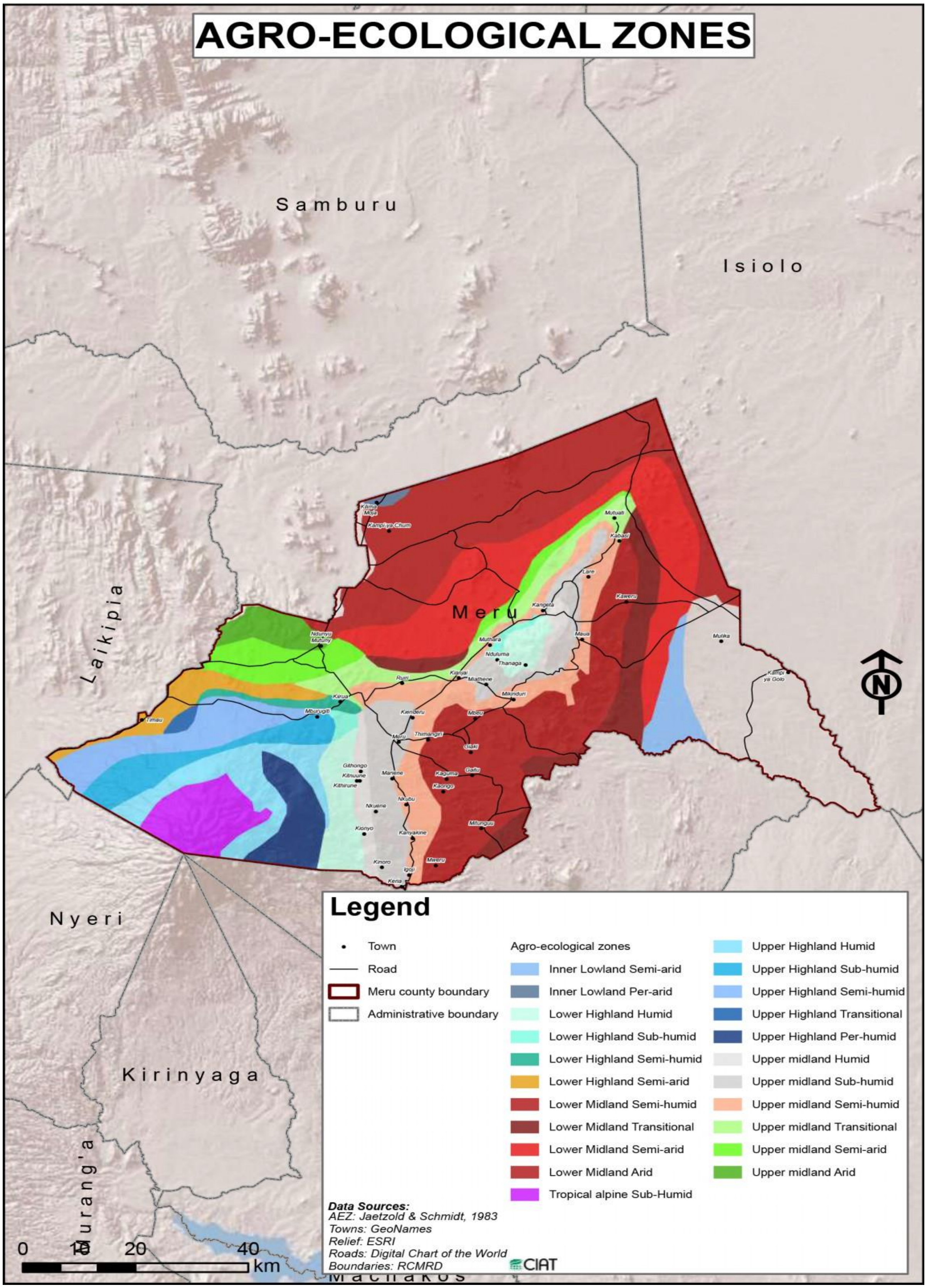


Figure 1: Meru County Agro-Ecological Zones (CIAT)

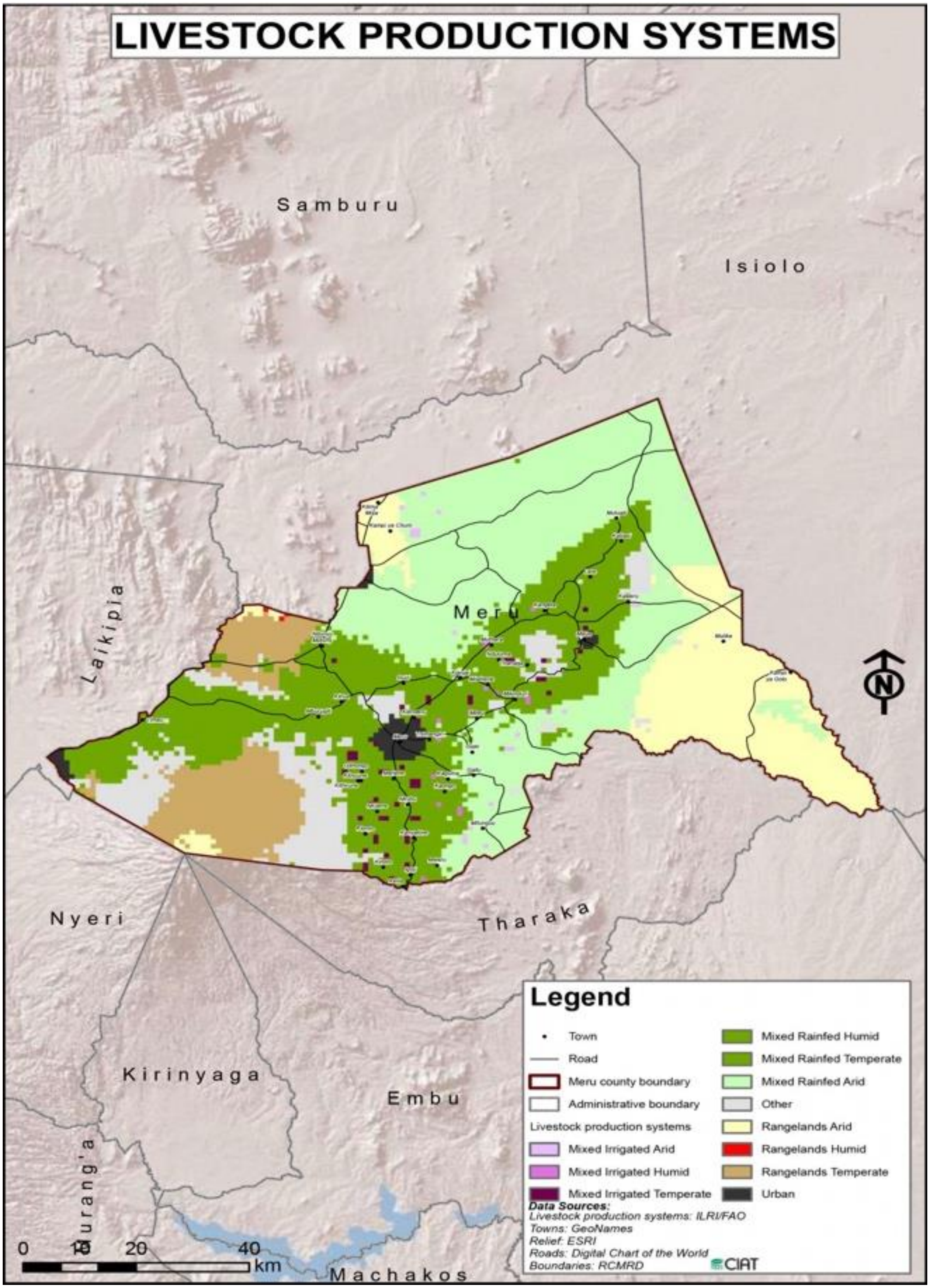


Figure 2: Meru County Livestock Production Systems (CIAT)

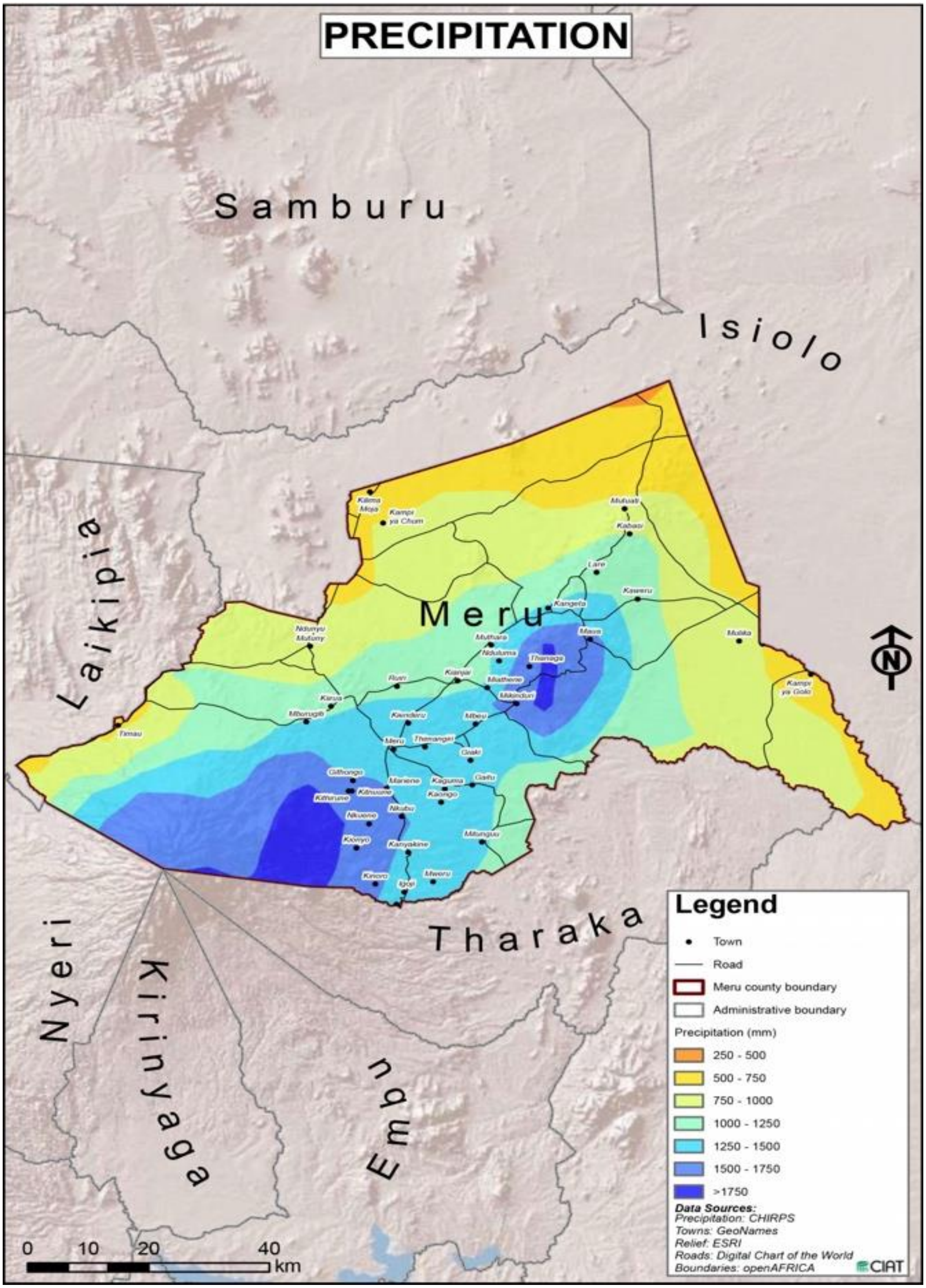


Figure 3: Meru County Precipitation (CIAT)

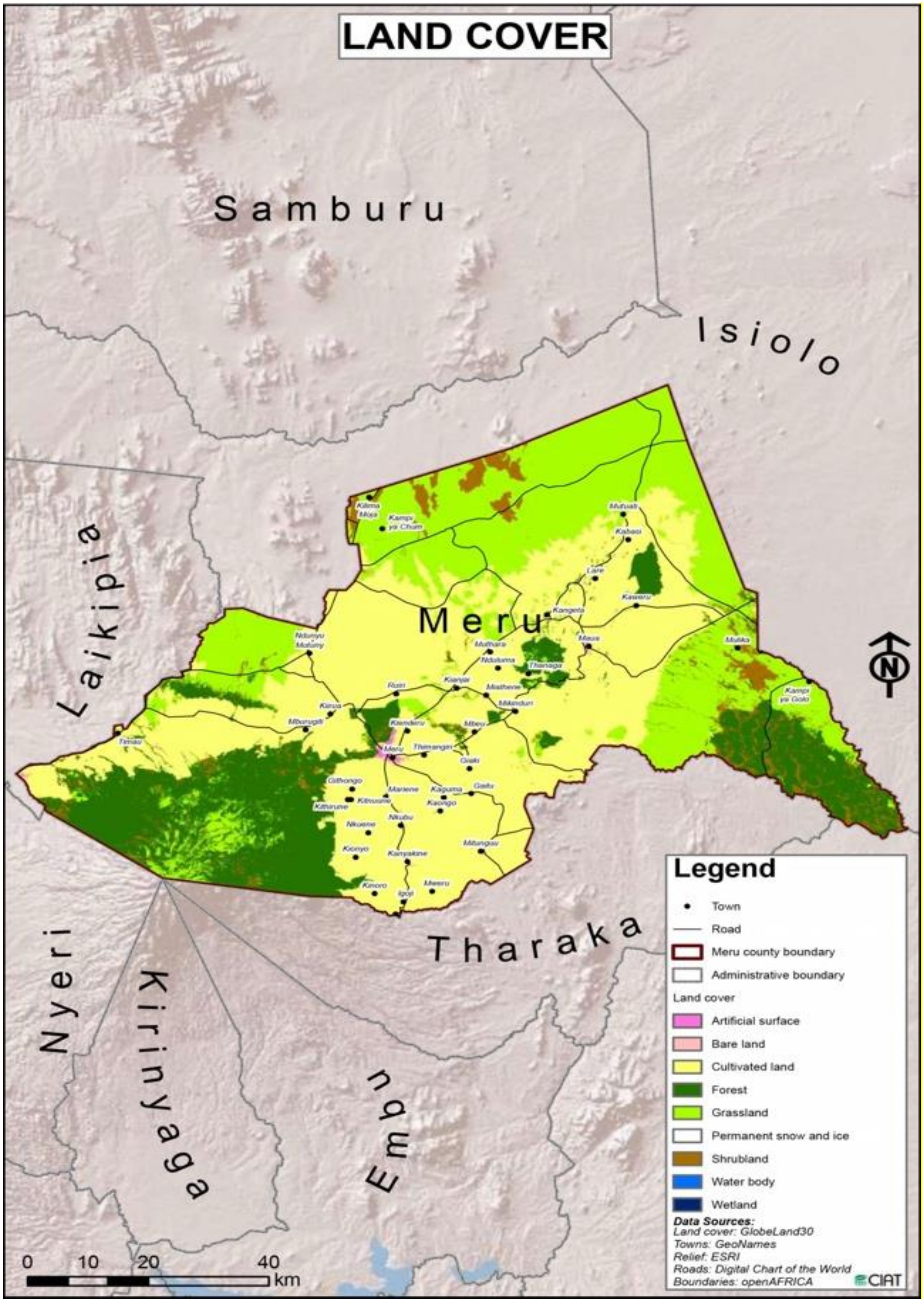


Figure 4: Meru County Land Cover (CIAT)

3. Dairy Cattle Breeding Environment

3.1 Policy Environment

The national dairy breeding policy is being implemented through the National Dairy Cattle Breeding Program. This program is the only major livestock improvement programme that has been under implementation in the country. The aim of this program is to improve the dairy breeds for enhanced productivity. The program involves progeny testing programmes, contract mating scheme, dairy recording services for milk and the artificial insemination (AI) services. The key institutions involved in this programme are Kenya Livestock Breeders Organization (KLBO), Livestock Recording Centre (LRC) and Kenya Animal Genetics Resource Centre (KAGRC) (GoK, 2016). The national breeding policy remains in draft form and has undergone several modifications and stakeholder meetings since its commencement in the year 2000.
The national breeding policy's "Specific Objectives" (GoK, 2016) are:

i. Promote & inventorise, characterization and monitoring of the population trends and associated risks in animal genetic resources;
ii. Promote the improvement and sustainable use of animal genetic resources;
iii. Promote production and multiplication of animal genetic resources;
iv. Enhance the conservation of animal genetic resources;
v. Promote research and development in animal genetic resources.
vi. Provide for development of appropriate institutions, legal framework and enhance resource capacity in animal genetic resources;
vii. Promote Public-Private-Partnerships in animal genetic resource development.

The animal breeding and regulatory frame work is anchored in the "DRAFT ANIMAL BREEDING AND IMPROVEMENT BILL, 2016" which when passed will guide and regulate breeding services and their operations. The draft bill focuses on:

i. The improvement and breeding of animals;
ii. Identification, evaluation, breeding, utilization, conservation of animal genetic material;
iii. Registration and licensing of breeders, service providers and stakeholders and assignment of roles to them;
iv. Recognition and preservation of indigenous animal genetic resources and breeding knowledge and protection of rights of indigenous breeders;
v. Regulation of import and export of animal genetic materials and live animals;
vi. Establishment of animal gene banks, recording of ancestry and performance thereof;
vii. Harnessing and harmonization of the various scientific and technological expertise for sustainable animal breeding and improvement;
viii. Establishment of a national animal breeding and improvement centre for coordination of breeding activities, breeders and other industry players;
ix. Establishment of a tribunal for resolution of disputes arising under this Act and for matters related or ancillary thereto.

Dairy breeds standards have been under development from 2014. A final draft is ready and is due for a stakeholder validation before enforcement. After the repeal of Cap 363 breeding activities do not have clear guiding principles as the policy, bill and standards all exist in draft form (GoK, 2016).

3.2 Availability and Market Structure For Artificial Insemination

Kenya has by far the largest herd of improved dairy cattle on the continent with an estimated 4.2 million heads. There is a growing demand for better breeding services nationally through Artificial Insemination (AI), which is driven by the desire for better dairy genetics. The demand for better genetics is in turn driven by the demand for more milk and dairy products to feed a growing and urbanizing population.

Despite increasing AI adoption rates, farmers as consumers remain underserved and register a lot of challenges in regard to heat detection, access to information on appropriate breed choice, bull selection and quality and reliability of AI services. The key cost drivers for an AI service are bull semen, arm service and transport. The cost of semen ranges from KES 300 to KES 1,500 for local semen and from 1,000 to 7,000 for imported semen (conventional and sexed semen). The national bull stud KAGRC dominates bull semen business. Last year KAGRC produced over 1.1 million doses of semen and distributed it through its 60 agents spread in 40 Counties. In 2016 KAGRC's total sales stood at 718,000 doses of semen. Private suppliers, mainly dealing with imported genetics, distribute either through the KAGRC appointed distributors or independently and at times directly to AI service providers SPs, farmers and Agrovet shops that act as their agents. The annual estimated imported semen that is recorded stands at 483,000 straws (2015).

Table 3: International semen sources and local distributors (Makoni, 2015)

Local Company	**ORIGIN: Genetic Company**
ABS TCM	ABS Global Inc. Genus USA
AI Total	AI Total, The Netherlands
Bimeda/Assia	Alta Genetics, Netherlands and Semen from Israel
Coopers Kenya Limited	CRV (The Netherlands former Holland Genetics)
DETF	Cogent Semen, Company, UK
Fleckvieh Genetics EA.	Fleckvieh-Germany
Highchem	Cooperative Resources International, USA
Indicus	Evolution, Serbia
Pokea	Osnabrouk, Germany
Taurus	Taurus, South Africa
Twiga Chemicals	Semex, Canada
World Wide Sires (East Africa)	World Wide Sires (Select Sires Genex),USA
Gogar Farm (Hamish Grant)	Viking, Denmark

3.3 Artificial Insemination Services

Artificial insemination (AI) as a method of breeding and breed improvement was introduced in Kenya in early 1940's by the colonial government and has played a significant role in improving dairy production in the country. The initial stages of AI service provision were entirely government driven. In 1992 the government through economic reforms (World Bank Structural Adjustment Programme-SAP) privatized AI services, among other livestock related services like extension and animal health. Many studies have noted that the inadequate structures to facilitate the transition of government services to private services hampered the advancement, development and improvement of breeding service provision up to date.

The spread and the speed of acceptance of AI since, is less than anticipated (AI 28% of which 2% is sexed semen) both by the National and local Government. This is caused by various problems along the chain of semen delivery. Many studies have noted that the inadequate structures to facilitate the transition of government services to private services hampered the advancement, development and improvement of breeding service provision to date. Many farmers still lack access to Artificial insemination services, as key inputs (semen and liquid nitrogen) are not always readily available. There are few trained technicians who tend to be concentrated in areas of highest dairy livestock density and operate from town or market centers. Moreover, although farmers recognize the importance of AI, many remain unwilling to pay the relatively high service fees. In many cases farmers' lack the appropriate skills to accurately detect heat while geographical distances between the farm and the AI service provider makes timely insemination difficult and lowers conception rates. Farmers require continuous training and acquisition of knowledge and skill set for proper dairy cattle management. See also: "Livestock Genetics Society of East Africa Strategic Plan 2012-15" and "AI Service Provision in Meru Union and the larger Meru County", A quick Scan (Mary Nganga/ SNV, May 2017). Reasons for this slow acceptance of AI are listed below.

Breeding potential in Meru is estimated at 15,000 services per month. While Meru Union distributes an average of 3,000 doses of semen per month, the Union's services are scarce to some areas and the number of Meru Union inseminators are few. There is opportunity for collaborative synergies between Meru Union and Meru Animal Health Workers (MAHW) network in Nkubu, so as to ensure enhanced outreach. Meru Union controls only about 20% of services in the region. Farmers, AI service providers and extension personnel require (continuous) training on breeding, catalogue interpretation, bull selection, breed suitability, breed matching husbandry, setting breeding goals, fertility and importance of pregnancy diagnosis.

Devolution has also played a role to address gaps in breeding and resulted in differences in AI models and cost elements with most Counties resorting to AI subsidies, particularly for semen purchases and services. In some Counties these subsidies resulted in increased uptake of AI technology (Nathaniel Makoni, 2015). However in the long run subsidy schemes tend to discourage private sector to invest because of unfair competition.

3.4 Market Structure For Milk in Kenya.

Kenya is the leading milk producer in East Africa. With approximately 5 billion litres of milk produced in 2011 (Source: Kenya Dairy Board), milk is daily food for Kenyans. The average milk consumption per capita is estimated at 115 kg per year. High population growth and urbanization, in combination with a fast growing middle class, present increased demand for safe and good quality milk and milk products (SNV/The Friesian 2014).

The Kenya dairy sector contributes 4.5% to Kenyan National GDP and 14% to agricultural GDP. It is an important source of income and employment for a large part of the rural population. The dairy sector is characterized by a smallholder dominated supply chain, which caters for approximately 80% of total milk production. The remaining 20% is produced by medium and large scale dairy farms. An estimated 50% of all milk produced is marketed – mainly to urban centres - and out of this roughly 70-80% is sold as raw milk. Kenya Dairy Board statistics indicate that in 2016 about 600 million litres of milk were processed and marketed as pasteurized fresh milk, UHT or value added products like cheese, yoghurt, butter and ghee.

The share of processed milk in total milk marketed is increasing annually. Kenya has close to 30 registered milk processors. The six largest processors (Brookside, NKCC, Githunguri, Meru Union, Daima Sameer and Kinangop Dairies in that order) have a market share of 90%. Their turnover is largely from sales of loose milk (pasteurized and UHT) and yoghurts. (SNV Annual Progress Report, 2017).

Meru Central, like all the 6 largest processors, pay their farmers and the cooperatives they source milk from according to the volume of milk delivered to their collection centres. The price paid to farmers (through the cooperative societies) averaged to KES 35-37 per kg in the period 2014-17, plus KES 2.0 end-of-year bonus to encourage loyalty.

The prognosis is that for the next 10-15 years demand for milk will continue to surpass supply which means there will be a high demand from the market (consumers and processors) for farmers to produce more milk. At any given time, it is possible that Meru-Union and other processors introduce a bonus (quality-based payment) for components. However, we do not fore see this in the nearby future. Bonus payment for butterfat and protein content has not yet been introduced in Kenya, except for Bio Foods Ltd a small processor in Nairobi.

Milk quality is a major concern of the dairy industry. This concern is increasingly shared by processors, consumers and government, including the Kenya Dairy Board which has the mandate to regulate the sector and set standards for quality of raw and processed milk. This concern is focused on micro biological quality, presence of antibiotics in milk and adulteration with preservatives and other substances, by those who handle milk from farmer to consumer. Of late attention for mycotoxins in milk has been on the increase.

There is however no harmonized and systematically applied government strategy – or code of conduct by processors - to enhance milk quality and adopt dairy industry standards, although recently new Draft Dairy Regulations (2017) were launched by KDB which points in a good direction. However, legislation of standards on milk quality, milk handling practices of dairy value chain operators, and to curb the raw milk market are often not enforced. The latter would be a prerequisite for minimizing the possibilities of side-selling by farmers and dairy cooperative societies that fail to comply with minimum quality standards (SNV/The Friesian 2014).

3.5 Farm Management, Farm Size and Nutrition

Management is one of the most important external factors influencing cow milk production. Increasing milk production starts with good management, including feeding, herd fertility management and calf rearing, and healthy cows. Without this, the genetic potential of high grade exotic breeds will not be unlocked. Cow or farm management levels in Meru are relatively low with production levels for most farmers (80%) at or around 5-10 litres of milk per day (1,500-3,000 litres per year, based on 300 days production and a calf every year).

Feed costs constitute the major day-to-day expense. In Kenya, this cost has been increased by the gradual shift from an extensive to an intensive system of dairy in both the high and the medium-to-low potential areas, as a result of shrinking land sizes and a lucrative milk market. In Meru land holdings are small especially in the high potential dairy zones (average size is 0.5-1.5 acres), whereas most farmers have a mixed farming system with crops – both food and cash crops like tea and coffee – competing over available farm land. This puts a cap on or limits the availability of land for fodder, although this is partly compensated by 2 rainy/harvesting seasons and small-scale sprinkler irrigation that is quite common in the highlands. In addition some dairy farmers lease land in the lower parts (intermediate zone) to grow fodder.

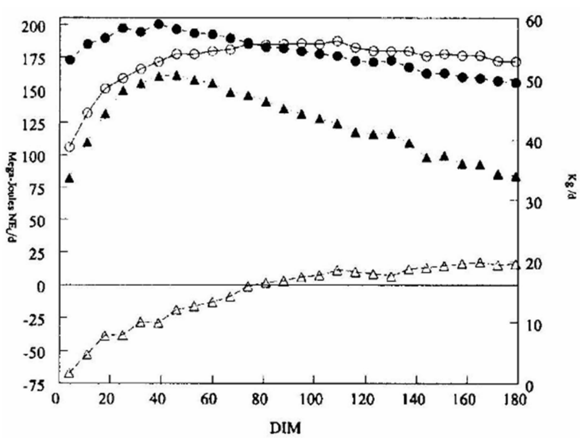
Quality of both feeds and fodders are generally low with dairy meals usually low on protein and high on crude ash, and fodders - even those high in energy and protein and produced and preserved under good farm practices - with lower digestibility as compared to fodders in temperate climates in North Western Europe and North America. This is due to a higher percentage on non-digestible fibers in tropical fodders and non-availability of high yielding (hybrid) fodder seeds. In Meru most farmers feed low quality by-products like maize stovers, rice/wheat straws, banana leaves and hay to their cows, complemented with Napier grass. Of late an increasing number of farmers (especially so-called elite or lead farmers) have adopted maize silage as a reliable and good fodder source in combination with protein rich fodders. However this is still a minority amongst the total number of farmers supplying milk to Meru Union.

The nutrient requirements of the cow will largely depend body maintenance and the amount of milk produced, which in turn depends on the stage of lactation—the period from calving. Other factors affecting nutrient requirement are gestation period, growth and level of activity. The amount of feeds required for maintenance is largely affected by the cow’s weight. Experienced farmers and breeders have noted that smaller breeds have a higher feed conversion efficiency as computed by total milk production (Kgs) over body weight (Kgs). As thus Jersey breed tops the list of feed conversion efficiency.

For Meru, considering the low milk production levels, small landholdings and generally low availability and low quality of fodder, the current preference for high producing Holstein Friesians can be questioned, as more than often the cow’s nutrient requirements according to expected adult size and level of production, cannot be met. This leads to a negative energy balance for the cow and a severe reduction in milk production, the cow will eventually become very emaciated and this will shorten the productive life of the cow. This principle is visualized and further explained in Box 1 below).

Genetics is all too often given too much emphasis in the development of smallholder dairy herd-management and improvement programs. Nutrition is by far the greatest constraint to farm milk production and profits. For breeding to have much impact on the genetic improvement in most tropical countries, governments, dairy cooperatives, inseminators and farmers require considerably more awareness and understanding of the relation between "feed and breed", and the need for breed and bull selection on traits that fit the environment of the future cow. They also need to enhance their knowledge and skills in reproductive management as regards the actual cow insemination, record keeping, heat detection, fertility management and so on and so forth. Ideally, each dairy farmer should have a strategic plan for his breeding management. For smallholder farmers, breeding strategies or plans are likely to be very similar, with the major decision being the particular breed of good milk production and with minimal fertility complications. Some farmers may like a particular bull type, whose progeny are more likely to have some specific body conformation, long life or certain milk compositional characteristics. It is notable however that smallholder farmers rarely get to have much choice in the semen they can source.

Box 1. Negative Energy Balance



▲ Milk production
● Energy required
○ Energy intake
∆ Energy Balance

De Vries en Veerkamp, 1999

The graph above shows what happens when the cow gets into a negative energy balance. The black dotted line in the top of the graph shows the energy requirements for body maintenance and production of milk. Actual milk production is shown in the graph with black triangle. At peak production the cow nearly produces 50 kg of milk/day. The open dotted line shows the actual energy intake by the cow. In the bottom line (open triangle) is the calculated difference between the calculated energy requirement according to weight and actual milk production and the actual (measured) energy intake of the feed ration (composed of different fodders and feeds). The bottom line (energy balance) shows that the cow is not able to take in enough energy until days 80-90 to compensate the "output" being the energy she loses through the milk (body heat and excrements) she produces. During these 3 month she will compensate the energy shortage by using her body reserves being initially fat (if the cow is in a good body condition (BCS score between 3-3,5) at the moment of calving, but after this, if energy shortages are severe and fat reserves have been used, also muscle tissue will be used to compensate.

If the actual energy intake will be below the required energy for a longer time (for example if the feed ration does not contain enough energy) the cow will be extremely emaciated and has no possibility to regain body weight and recover to regain the right body condition before she has to give birth to her next calf. This will cause a downwards spiral with yearly reducing milk production and it shortens the productive life of the cow considerably.

3.6 TEMPERATURE HUMIDITY INDEX (AGRO ECOLOGICAL ZONES)

Cows generate heat internally (metabolic heat) as a result of eating and digesting feed. Like most mammals, the dairy cow needs to maintain its core body temperature within a narrow range around 39°C – between 38.6°C and 39.3°C to be precise! The core temperature fluctuates slightly throughout the day, reaching a peak in the early evening and a low early morning. Cows also take on heat from the environment around them. The cycle of gaining and losing heat absorbed from the environment is on-going and always operates in the context of the metabolic heat a cow is carrying at any given time. Factors that determine the level of environmental heat a cow gains or losses over time are:

- air temperature and relative humidity;
- amount of solar radiation;
- degree of night cooling the occurs;
- ventilation and air flow; and
- length of the hot conditions.

Cows have evolved a range of physiological strategies to off-load heat to cope in hot environmental conditions, but problems occur if temperatures and humidity are high (and remain high) and cows do not have opportunities to get rid of/offload heat.

Temperature Humidity Index (THI) is a measure that has been used since the early 1990s. It accounts for the combined effects of environmental temperature and relative humidity, and is a useful and easy way to assess the risk of heat stress. The mean relative humidity in Meru is shown in the table below. The relative humidity will be higher in the morning and lower towards the evening. Temperature follows the opposite pattern.

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
%	70.4	67.4	67.2	68.1	74.9	73.1	72.1	74.3	71.8	64.1	65.2	74.3	71.7

In Meru County (and Tharaka Nithi County) the Temperature Humidity Index (THI) will regularly be between 72 and 82. The intensity and duration (hours per day and number of days per year) will increase from highlands to lowlands (from zone 3 to 1). This means that high milk yielding breeds are regularly experiencing heat stress (especially in the intermediate and lowland zones (zones 2 and 1).

This can be reduced if there is shade for the cows and good natural ventilation/airflow is provided. Proper cow house design of zero grazing units can reduce occurrence of heat stress considerably: open structure, with high roof top/ pitch and angle (respectively 3 meters and 18 degrees) preferably with an opening in the pitch for hot air to be released. See also the Handbook for Modular Cow House Design for Smallholder Dairy Entrepreneurs (SNV KMDP, Fieten Ltd, February 2016).

The occurrence and effect of heat stress (based on THI values) on the cow is as follows:

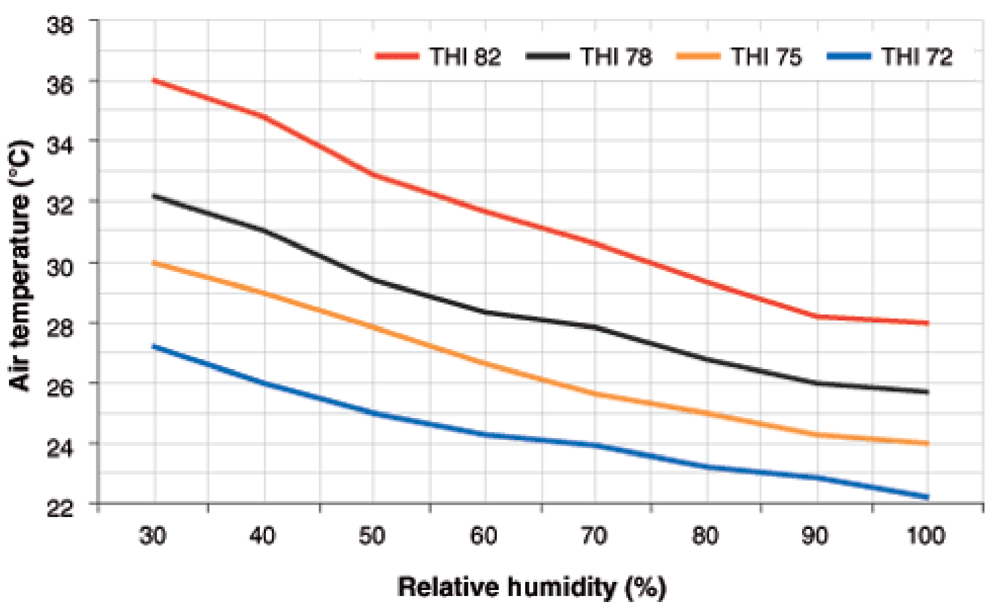
- When the THI exceeds 72, cows are likely to begin experiencing heat stress and their in-calf rates will be affected.
- When the THI exceeds 78, the cow's milk production is seriously affected.
- When the THI rises above 82, very significant losses in milk production are likely, cows show signs of severe stress and may ultimately die.

A number of important points should be made about the THI:

- A THI of 72 may underestimate heat load in high-yielding Holstein-Friesian cows – increasing milk yield increases cows' sensitivity to heat stress.
- Increasing milk production from 35 to 45 litres/day reduces the threshold temperature for heat stress by 5°C.
- THI does not account for solar radiation or air movement – those two factors, along with air temperature and relative humidity, determine the heat gained and lost between the cow and the environment.

THI does not enable us to measure the accumulation of heat load over time, e.g. after several days. Despite these limitations, THI is still a useful and easy way to assess and predict the risk of heat stress.

Figure 5. Temperature Humidity Index: Relation between Temperature and Humidity (Source: http://www.coolcows.com.au/go-on-alert/thi.htm)



You can see in this chart that a THI of 78 occurs at:

- 31°C and 40% relative humidity, or
- 27°C and 80% relative humidity

4. Fact Finding Survey

4.1 Mini-Survey and Methodology

The development of this study report commenced with a mini-survey which focused on collecting qualitative information taking into accounts vision, planning, projected changes, opinions, wishes and preferences of Meru Union & its farmers. The approach and methodology used in the study drew relevant information and data from existing work already done in the industry in Kenya through a desk research with in-depth focus on breeding practices, breeding policy, breeding regulatory environment & related studies on dairy industry and Meru County ecology. This was followed by primary research and gap analysis. Key approaches used are:

Secondary Research-Review of Relevant Documentation

Data from secondary sources mainly the Draft National Breeding Policy, Draft Animal Breeding and Improvement Bill, 2016, Kenya County Climate Risk Profile-Meru County (World Bank and CIAT document), among other reports as cited were used as a guide to this report. The relevant information in the mini survey was drawn from the Department of Veterinary Services, Director of Veterinary Services, Livestock Genetic Society of East Africa (LGSEA), County Veterinary Offices as well as global sources. The approach included literature review, drawing from best practices globally with special focus on small to medium scale farmers which has similar characteristic with Kenya.

Primary Research

- An interview/discussion with Meru Union management was carried out targeting the Procurement, Extension and Vet & Breeding Services departments. Discussions focused on breeding protocols, breeding material sourcing, marketing and outreach services, adoption rates, and personnel skill sets among others.
- 11 focus group discussions with 11 cooperatives were conducted. The discussions focused on land size, farming systems, breed preference and what informs breed choices, cultural biases, among others. The target informants composed of cooperative leadership, representative farmers and AI service providers.
- Key informant interviews were also carried out targeting the Director of Veterinary Services, Livestock Genetic Society of East Africa (LGSEA), County Veterinary Officers, KAGRC, Lead Breeders, Kenya Livestock Breeders Organization and a sample of semen importers and distributors.

In-depth Analysis

All information on breeding policy, regulation, breed selection and preference, cultural biases and ecological zones were analyzed and presented in context along possible drawbacks, and bottlenecks in enhancing better breeding technologies and improvement of management protocols, to maximize available genetic potential and to recommend criteria for breed and bull choices that take into account local context and current production and management levels.

4.2 Survey Findings

4.2.1 Livestock and Production Numbers in Meru County

- Cattle population are estimated to 180,000 dairy cattle vs. 250,000 beef cattle.
- Dairy breed preference and populations and their crosses; >80% Holstein Friesian, 15% Ayrshire, 5% others (Jersey and Guernsey).
- Highlands and intermediate zones prefer Holstein Friesian, low lands have traces of Holstein Friesian, Ayrshires and their crosses. The County government introduced Gir in lower zones through AI.
- Average milk production is roughly estimated at 60-70% of farmers produce an average of 5 liters/day/cow and below, 20-30% produce an average of 5-10 litres while 10-20% (mainly comprising of elite commercial farmers) produce averages above 10 -18 litres.
- Current milk intake at Meru Union is 160,000 liters while its installed capacity stands at 300,000 litres per day.

4.2.2 Summary Transcripts of Stakeholder Interviews

a. National level-DVS and KAGRC

- Breeding policy 2016 and Bill 2014 are in draft form.
- The DVS has developed and finalized breeding standards that are to be validated early October 2017. The standards will replace the repealed Cap 363 which provided a frame-work for breeding activities.
- Proposed breeding objectives are yet to be adopted.
- There is a noted increase in imported semen due to price penetration models by importers.
- KAGRC (Kenya Agricultural Genetics Resource Centre), producer of local conventional semen 4 different dairy breeds, Holstein Friesian, Ayrshire, Jersey and Guernsey. The organization still controls the market with an estimated 60-70% of market share.
- Semen imports have increased to 0.5 million doses annually by close of 2016.
- If 0.5 million doses imported semen straws represent 35% of the market. The total market can be estimated at 1,2 -1,4 million doses for the dairy breeds
- Complaint of low quality semen importation lowering breeding standards, specifically low milk production averages, unclear bull catalog interpretation and weaker calves. This semen has always been cheaply priced to ensure market penetration.
- Importer breed preference is demand driven: 80% Holstein Friesian, 15% Ayrshires and 5% others. The demand is particularly due to farmers seeking for high production and larger sized breeds that also fetch higher prices when culled or sold for family capital. Though this demand can also be urged to have had a lot of influence from service providers and semen distributor extension personnel. In addition processors look for increased milk volume and this may also have been a driver for this preference for high producing exotic breeds.
- Some programs like “Send a Cow” have introduced Jersey as a breed of preference in western Kenya. The choice of Jersey was particularly to exploit the breed’s resilience to harsh conditions and easier management protocols for its small sizes.

- KAGRC now incorporated genomics in their breed selection and development. Though the program is yet to be fully rolled out and as thus the Centre does not have specific breeding values apart from parent averages previously used.
- KAGRC through an agency distribution model (60 agents in 40 Counties) has ensured access to genetic material within 20 kms radius to most farmers; the same agencies are open to other distributors to provide a variety of genetic material.
- Liquid nitrogen plants installed in Kirinyaga, Eldoret and Bomet are operational and addressing liquid nitrogen scarcity and improving access to AI services.
- KAGRC annual production stands at over 1 million doses (1.1million in 2016) while absorption is over was 718,000 doses in 2016. Annual semen absorption stands at approximately 1.2 million doses of semen (718,000 local+500,000 imported=1.2 million).
- Apart from KAGRC there two other upcoming bull studs which are owned by government to be located in Nyeri and ADC-Kitale.
- There is a growing niche market for Jersey breeds (this could possibly also be linked to some smaller processors paying a bonus for butterfat content).
- Fleckvieh is an upcoming breed.

b. <u>Meru County Government</u>

- Dairy zones concentrated around Mt Kenya (highland zone).
- County estimates average milk production per cow at 7 liters (NB: this would be equivalent to 7*305days = 2,135 kg per lactation, assuming the cow would deliver a calf every year.
- Major challenges are nutrition and management.
- In Meru County there are over 120 AI service providers.
- Service providers regulation is tied to KVB regulations under the VSPS act.
- The County has 3 main genetic distribution centers: Nkubu, Kinoro and Maua
- County runs a breeding program. The program is not on paper but still under drafting and in custody of the Department Director.
- The County's main objective/goal regarding the draft breeding program is to address:
  a. Price (affordability).
  b. Outreach (targeting marginal areas).
  c. Quality (control and regulation) (NB: there is need to define quality, e.g. quality of semen: how it is kept, how many sperms per straw), quality of breeding values, quality of service).
  d. Introduce new resilient breeds. (NB: this is assumed to point at preference for breeds that are well adapted to the climatic conditions, housing conditions, management levels and fodder and feeds provided to the cows).
- The County subsidized AI-service to KES 600 per service for local semen; 1,300 for imported semen; 3,000 for sexed semen. It also imported semen from Brazil-Gir (CRV donation). The Gir breed was introduced to marginal regions-mainly for crossing with the local breed. The County is currently monitoring offspring. Gir services are at KES 1,300.
- The County employed 18 service providers ~ 2 per sub County.

- Total services to date stand at 10,000 valued at over 10 million in revenue. (NB: average of 550 services per service provider, equivalents to 1.5 inseminations per day) at the earlier mentioned rate of 1,200-1,500 KES per service (= arm service and transport) the service provider would earn 1,800 – 2,250 KES per day).
- The County resuscitated Kinoro livestock resource center which it uses to run the breeding program. The Centre is well equipped with liquid nitrogen tanks, liquid nitrogen and a semen bank-serving 9 satellites in all sub Counties.
- The County also introduced Sahiwal bulls for marginal beef farming areas (NB: Providing or introducing Sahiwal x HF or Boran x HF crosses could easily be combined with this program).

NOTES:

- County officials are discussing the roll-over of the program to Meru Union.
- County has good rapport with Meru Union and carry out collaborative work mainly: extension, vaccination and pooling resources for shows and exhibitions.

c. Meru Union

- The Union started AI service provision in 1993.
- Main goal to date is to improve genetic potential to increase milk production.
- The region has good genetics due to continued breed development, with over 70% of improved dairy cattle. Nutrition and management remain the key main challenges.
- The Union sources genetics from: KAGRC 80%; 20% shares among (Semex, Worldwide Sires, and AI total).
- Breed spread in semen distribution is 70% H.Friesian, 20% Ayrshire and minimal numbers of Jersey and Guernsey. Milk volume payment system is pushing farmers to choose Holstein Friesians as high yielders; no consideration of environment and management.
- Most farmers not well informed on breed choice as a good number of service providers lack the same skill.
- Semen price is a key factor at farm level on bull/ service selection. Service providers peddle services as either local or imported or sexed.
- Breeding by Meru Union easily diluted by private service providers (SPs) and County efforts - Service providers (spread 8:18:120 Union: County: Private respectively).
- Proposed for increment of service providers to attain one per cooperative society.
- Average estimated acreage per farmer stands at 0.5 – 1.5 in the highlands.
- Meru Union estimated better breeding services adoption to be about 70% especially in highlands, low adoption rates in marginal areas of Tigania, Igembe and Tharaka.
- Meru Union request that extension personnel be trained on breeding husbandry best practice for downward dissemination to farmers.
- Extension services started in 2014 - uptake is very good, 14 extension personnel supported by SNV staff.
- Average daily production per cow is estimated to be between 7-10 litres, depending on the sub-region. Top tier farmers doing up to averages of 20 litres per cow per day. Mainly due to better management of these fully commercial dairy farms.

d. Meru Union CEO

- Identify the best and economically viable breed that suits the dairy farmers in Meru region.
- Farmers are not breeders and need not get into complex breeding science.
- The Union through the County wishes to support the strategy by way of subsidies.
- 80% of farmers don't know what they want.
- The Union wants a simple and easy to implement strategy.
- The breeding strategy will be presented to the Governor for buy-in and support.

e. Dairy Cooperatives (Sample: Nkuene, Kithirune, Kanyakine, Nyaki, Ngwataniro, Buuri, Igoki, Antu a'Buri)

- Large majority of farmers lack knowledge and skills on breed traits and suitability, bull selection; a few have catalogues, elite farmers have been trained. Bull and breed selection is left to service providers.
- Elite farmers (producing >15 kg/day/lactating cow) interviewed were quite knowledge-able on bull selection, they keep proper farm records, straws and have their own" preferred service providers, often private. This is only a small minority of farmers.
- Holstein Friesian is the predominant breed with about 70-80% share (due to high production and weight after culling), Ayrshire range from 10-15% depending on the region, Jersey is rare and a few farmers on lower zones have crosses of Holstein Friesian, Ayrshire and indigenous breeds. Apart from expected high milk production, the preference for Holstein Friesians is also related to status/proudness and higher sales price in the market for claves and mature cows.
- Some farmers claim to have encountered problems with Ayrshires: mastitis, pneumonia, skin diseases, abscesses, short milking periods, prone to disease.
- SPs lack and don't provide catalogue information to farmers.
- Main breeding goal for all farmers is increased production; average production range from 4-18 litres per cow per day for low input low output and elite farmers respectively.
- Overall milk increments due to continued training by both the Union and SNV. Some elite farmers have over 5 animals with production averages of about 20-27 litres (registered their own CIG).
- Most Cooperatives don't have resident AI service providers and rely on the 8 Union SPs. Among the sample only Nkuene, Kithurine, Kanyakine have own semen bank, SP, select own bulls. Reliance on Union service mainly due to:
  a. Credit services
  b. Fair pricing and traceability
  c. Great variety of genetic material
  d. Meru works for the best interest of farmers, trust factor
  e. Other have complains of repeats.
- There is generally low usage of Union breeding services estimated at about 20% (Buuri 20-25 services, Nyaki ~10, Ngwataniro~ 25, highest in Kithurine~80% (40).
- Most Cooperative active memberships at any time stands between 30-40% of all regis-tered members.

- 8 AI-SPs not sufficient for service delivery to all cooperatives; those close to Meru town have sufficient access to SPs in excess of 3 at any given time.
- Of those cooperatives in the sample, private service provision predominant in most coops except Kithirune. Main reasons are easily available, offer credit, quick service, offer discounts.
- Farmers and SPs rarely perform PD on served animals.
- To a farmer price = quality; high prices for sexed semen.
- Land sizes range from 0.5–1.5 acres per household in the highlands and 3-4 acres in the intermediate zone, elite farmers hire land to grow maize for silage, many farmers struggling to feed their animals due to multiple land use.
- Holding capacity averages about 2-3 animals per farm, elite farmers have between 6-10 head.
- Farmers complain of fertility, Union information estimate fertility related issues to about 40% of the herd; infertility and repeats push farmers to use the bull (Buuri), Fertility blamed on: timing, silent heat, semen fertility (Union service has higher repeats than private service).
- About 20% of farmers sell off animals or their off springs to cater for household expenses; school fees mainly; as such these farmers are only keen on pregnancy rather than the genetic value the calf.
- Farmers only keeping a straw as breeding records mainly to avoid inbreeding
- Record keeping on other farm activities almost nil; very few farmers keep records; many farmers use memory for production, breeding and management purposes, few tag their animals for identification; others use names,
- Kenya stud book registration is almost non-existent (except Kanyakine - annual registration); trial done in 2012 but no certificates were issued; farmers don't understand the value of registration.

f. <u>Cooperatives and Meru Union proposed way forward</u>

- Farmers ready to adopt a more efficient and economically viable breed.
- Bull selection committee to involve cooperative representatives.
- Carry out a breed audit (as a starting point) within the catchment/cooperatives in-line with herd improvement program (number, features, type).
- One AI Service Provider per Cooperative.
- Semen bank/storage per cooperative and coops be allowed to run own breeding program.
- Farmers, AI Service providers and extension personnel require sufficient training on breeding: catalogue interpretation, bull selection, breed suitability; matching husbandry, breeding goals Fertility and Pregnancy Diagnosis.
- Pricing based on value not penetration.
- Farmers wish to increase the herd and replacement stock.

g. KLBO/Breed Societies

- KLBO is a secretariat for Dairy Recording Society of Kenya and The Kenya Stud Book).
- KLBO's mandate is to register and record livestock and maintain a pedigree stock.
- KLBO is the main source of information to Livestock Recording Centre (government parastatal).
- KLBO records about 12,000 animals annually.
- KLBO records indicate that Holstein Friesian is the predominant breed with over 80% of registered animals being Holstein Friesian.
- Trained a total 250 breed inspectors for the past 10 years; about 80 are active mainly covering central Kenya and central Rift valley. Meru had about 15 trained with 7 active.
- Breed inspectors are mandated to train farmers on recording, breeding and identification.
- Main cattle classification for recording are Foundation: no records, Intermediate: partial records, Pedigree: full set of records and parentage.
- Breed societies under KLBO are: Holstein Friesian, Ayrshire, Jersey, Boran, Sahiwal, and dairy goats.
- Value proposition from KLBO are: registration of animals ensures traceability; proof of ownership for loans, insurance, and making claims; easy export
- Main challenges; capital constraints, personnel, small holder farmers not keeping records, breed societies are challenged financially.
- KLBO specifies that proper breeding should be undertaken together with proper record keeping on breeding, production, and health for purposes of avoiding inbreeding, allocating proper value to the herd and easy trading.

h. Breeders and Breeder Associations/Societies

- Key considerations for goals in order of priority; a) udder conformation, b) feet, c) topline and d) production.
- Lighter animals, fertility and longevity key selection points in Kenya.
- Farmer in lower production zones should exploit hybrid vigor as a tool to improve their productivity: viable crosses are Gir x Holstein Friesian, Sahiwal X Holstein Friesian, Boran X Holstein Friesian. This crosses have proved to produce averages of over 5,000 litres of milk per lactation under good management
- Cow selection - Lean back-leg is a good indicator for a good breeding cow.
- Feed conversion efficiency calculated at production divided by kg body weight.
- Ayrshire can cope under low input management regimes.
- Smaller breeds prove to have a longer productive life with less management complications than the heavier breeds (burn out quickly).
- The heavier the breed the higher the demand for feeds, maintenance and management.
- Noted that anything that qualifies in the bull catalogue is good for increased production.
- Breeder Associations (Kenya Holstein Friesian Cattle Society and The Jersey Cattle Society of Kenya): anyone can join whether farming or intending to farm; annual subscription; main value proposition-field shows, training and participation in exhibitions. Large scale farmers not making money on milk. Turning farms into breeding studs.

- The interviewed Breeders Societies describe suitable breeds for smallholders in the tropics to be those small in size, heat tolerant, higher feed conversion efficiency and those that require moderate management practices. This is tied to the specific constraints in high ambient temperatures, inadequate fodder and feed, and low input management practices among most smallholder farmers.

4.3 Key Observations from the Mini Survey

The following are key observations that can be summarized from the mini survey findings:

- On a national level Artificial Insemination as a means to speed up genetic improvement has been taken up and accepted as a new technology, but the spread and the speed of acceptance is less than anticipated (AI 28% with 2% sexed semen). This also applies to Meru Union's catchment area and it is mainly related to the low level quality of service.
- Farmers' lack of knowledge on heat detection and interpretation of bull records and breeding values. Service providers also have low knowledge level of breeding, being often unable to advice the customer (farmer) in an independent but knowledgeable way on suitable breeds and bull traits. Their insemination skills are often sub-standard and this combined with lack of equipment results in high number of repeats. Supervision or systems that track and trace performance of inseminators are largely absent. Another complaint was the ethics of service providers, who are often only interested to sell semen with the highest profit margin, whether suitable or not for the client famer.
- Farmers, AI service providers and extension personnel require (continuous) training on breeding, catalogue interpretation and bull-selection, breed suitability, breed matching husbandry, setting breeding goals, fertility and importance of pregnancy diagnosis.
- In Meru, breeding potential is estimated at 15,000 services per month. While Meru Union distributes an average of 3,000 doses of semen per month (20%), Union services are scarce to some areas and the number of Meru Union inseminators are few. There is opportunity for collaborative synergies between Meru Union and Meru Animal Health Workers (MAHW) network in Nkubu, so as to ensure enhanced outreach.
- Meru Union and Meru County both expressed need and desire for breeds for enhanced milk production that are efficient and economically viable to the farmers.
- The National Government and County Government bodies are cooperative and do not have obstacles in place in the form of laws and regulations to develop and define a breeding strategy for Meru Union.
- All the stakeholders mentioned so far, national and local government, semen suppliers, and milk processors encourage the farmer to use genetics, which should help the farmer to produce more milk, but often, regardless of the local environment conditions under which this next generation dairy cow has to produce.
- In Meru, Holstein Friesian is the breed of preference, followed by Ayrshire. Jersey, Brown Swiss and Guernsey are almost non-existent in Meru. One could conclude that the marketing of the Holstein Friesian breed has been excellent over the years. As the breed has achieved a dominant market share. However, literature as well as our findings show that the majority of the Holstein Friesian cattle are underperforming with annual

production levels of 80% of farmers not higher than 2-3,000 liters (305 days lactation and assuming one lactation per year).

- The question that arises is if this is the right cow for the majority of farmers under the given circumstances considering the prevailing agro-ecology, farmers' management skills, average size of landholdings and thus availability and quality of fodder. As for the latter: fodder security on farm level remains very important at any production level to keep cows in a good body condition, healthy and reproductive.
- Top breeders in Kenya mentioned in order of priority the following key considerations of a breeding for Kenya: a) udder conformation, b) feet, c) topline and d) production. They recommend smaller breeds as they prove to have a longer productive life with less management complications than the heavier breeds (burn out quickly). The heavier the breed the higher the demand for feeds, maintenance and management. They also noted that anything that qualifies to be in the bull catalogue is good for increased production.
- Breeders Societies describes suitable breeds for smallholders in the tropics to be those small in size, heat tolerant, higher feed conversion efficiency and those that require moderate management practices
- The market offers a strong pull factor for enhanced milk production with relatively high prices paid to farmers for their milk. The long term prognosis is that for the next 10-15 years demand for milk will continue to surpass supply. Price in the Kenyan market is based on the volume of milk the farmer delivers to the factory; this is also the case with Meru Central. Incentives to increase the farmers' income from milk are not based on quality milk in terms of components (butterfat, protein) or food safety related parameters such as bacterial load and antibiotics residues.

5. Dairy Breeding Guidelines and Best Practice

5.1 Breed Physical and Production Characteristics

A breeding policy or strategy – and selection of breeds and bulls - is usually based on the traits of the various breeds. The table below presents the traits for the various breeds that are available in Kenya.

Table 2: Breed physical and production characteristics

Breed	**Traits**
Holstein Friesian/Holstein	Black and white or red and white, 682kg, 58inches, 11300 liters' average in the US. Can breed at 12-15months of age at 364kg body weight. Origin: Netherlands. Largest genetic pool-low chances of inbreeding and offers faster genetic gain. High production/milk volumes. Higher carcass weight. Lower heat tolerant. Lower milk components. More susceptible to diseases. Higher reproductive inconveniences.
Brown Swiss	Very light colored grey to dirty grey/cream and bigger breed than jersey. Origin: Switzerland. Dual-purpose possibility. High components. Heat tolerant. Lower production. Stubborn calves. Slow maturity. Small teat length.
Jersey	Short horned, fawn to cream with dark areas, small (average wt. of 400kg), better converter of forage to milk than other breeds. Adapts quickly and efficiently. Origin: Jersey Island Great Britain. Great components. Faster maturity. Better feed conversion. Better reproductive efficiency. Heat tolerant. Lower production. High incidence of milk fever. Small size.
Ayrshire	Red and white, but red color is brownish to mahogany with varying shades from very light to dark. Origin: Scotland. Hearty grazers. Low somatic cell counts. Small genetic base hindering progress. Better components. Lower production. Fairly hardy and adaptable.
Guernsey	Tan and white color. Produce more milk per unit body weight more than any other breed. Known to have better/excellent immunity than most exotic breeds. Origin: Guernsey island Britain. Small genetic base hindering progress. High beta-carotene in milk. High components. Reproductive issues. Lower production.

5.2 *Breed Suitability*

5.2.1 *Adaptability*

Adaptation can be described as the ability to conform to certain changes in environment mainly for survival purposes. It is a known fact that different environments have varied climatic conditions, and climate can be described as combination of temperature, humidity, rainfall, air movement ~ wind, radiation, and pressure (J.W.West, 2003). Climatic zones differ around the world and are dependent on latitude, prevailing winds, evaporative conditions, availability of water and water bodies, elevation from sea level, and proximity to mountains.

In dairy production the main challenge to increased production is the cattle comfort in relation to prevailing environmental changes. Cows are known to be affected by drastic weather changes and more so temperature fluctuation. The term heat stress is used widely referring to the climatic effects on the cow, or productive or physiologic responses by the cow.

For example, Holstein Friesian cattle may maintain still a stable body temperature at 20°C to 25°C, but above this, practices should be instituted to minimize the rise in body temperature to ensure optimal production (e.g. a well-designed open cow house offering shade, ventilation and other cow comfort). Unregulated ambient temperature will stress the cow and undermine optimal production. Different breeds will be affected at different rates and as thus proper breed choice is essential to minimize heat stress and unnecessary on-farm costs in temperature regulation and creation of a micro-environment. Also within the breed cows can be affected at different rates, for example black cattle may not do well in areas of high solar radiation this may limit grazing time during hot parts of the day. While some animals are particularly sensitive to photosensitisation of the white skin.

In adaptation to tropical diseases, particularly tick borne diseases or trypanosomiasis, from exotic breeds little can be expected. Cows and heifers from exotic breeds, directly imported from areas were these diseases do not occur, may be more vulnerable than the offspring of exotic breeds born in Kenya. However, in general the exotic breeds are more vulnerable than the indigenous breeds and the only way to make the offspring more adaptable will be trough crossbreeding indigenous breeds (Bos Indicus) with exotic breeds (Bos Taurus). The Boran for example has a useful degree of host resistance to ticks and it is reported that the breed is 'completely resistant to buffalo fly'. Borans are generally less affected by foot and mouth disease than exotics and recover faster. Also the morbidity and mortality rates of East Cost Fever are lower in Boran than in exotic breeds; the Boran being naturally more resistant.

Of the Jersey breed it can be said that its hard-black feet are much less prone to lameness which could be an advantage in farming systems were cows have to walk far between feeding and milking area.

Also when it comes to utilization of low quality fodder, fodder with low nutrient content due to the fact that crude fibre content is very high, e.g. as a result of harvesting the fodder when it is over-matured, crossbreeding may be the best way to make the offspring more adaptable to the local conditions and practices of the farmers in the Meru region (see also Annex 6 pictures

2 and 6). It has to be mentioned that Jersey and to a lesser extend Guernsey perform well under a wide range of systems and are well-known for their high feed conversion efficiency. While at the same time feed requirements in terms of quantity is relatively low, due to lower body weight.

5.2.2 Production and Genetic Potential – Efficient Milk Production

While every farmer in dairy business seeks to harvest as much milk as possible from each cow, the breed of choice influences both possible volumes and milk components (fat, protein) to be produced on the farm. The breed/bull choice also determines *efficient* milk production (extra net margin), where optimum milk production does not equal maximum (potential) production. Dairy breeds have different genetic potentials. In similar conditions each breed will exhibit its own production potential per lactation and per life cycle.

Potential production does not equal actual production as cow management and feeding play a crucial role to unlock the genetic potential of a cow (Annex 6 picture 2). Peak production during part of the lactation is not a good measure for milk production as total milk production is a function of total milk production during the entire lactation and productive life of the cow. A lower milk production per lactation period can easily be offset by reduced calving intervals, longer productive life, which implies more lactation periods and calves in the life cycle of the cow. In addition, milk production is not the only determinant of net margin or income as costs need to be deducted and may rise faster than income from more milk. This e.g. is in the Kenyan situation usually the trend when the feed ration of the cow is largely composed of dairy meal due to non-availability of quality fodder.

Holstein Friesian tops the list as the highest producers while Jerseys are lowest. On the other hand, Jerseys are known to have highest milk contents (fat and protein), while Holstein Friesian are generally known as having the lowest. Holstein Friesians are also more susceptible to heat stress and have lower feed conversion efficiency.
Holstein Friesian and Ayrshire were the most preferred breeds for high milk yield (if managed well!), which explains their predominance in the smallholder systems. However, Ayrshire was more favored over Holstein Friesian for disease resistance and feeding behavior, but not for market value and body weight (Bebe, 2004). Both breeds provide economic value depending on the target market. In Kenya milk is marketed based on volume, therefore farmers are driven to have a preference for higher producers to maximize on their profits and thus a preference for Holstein Friesian.

Milk production increases with the cow's age from the first to the third lactation, depending on breed, productive type, and proper management. There is also a positive correlation between cow milk production and size/weight: each breed has an optimum body weight that favors cow milk production. The larger breeds with high production indices have also proven to have a quicker burn-out if not properly fed and managed and under heat stress, and thus affecting negatively the breed longevity on the farm and life time milk production.

5.3 Strategic Choice of Breeds along Meru's Agro-Ecological Zones

5.3.1 Farmers

In giving recommendations for breed selection and suitability to agro-ecological zones, the consultant considered all important factors of production both biotic and abiotic. The proposed strategy exploits factors about economic viability, suitability to climatic conditions, management skills, costs, feed availability and farming systems. However, the proposed will not limit farmers to explore other breeds outside the proposed list considering input versus outputs of the alternative breeds. All three agro-ecological zones harbor farmers that are operating at different input levels from commercial to basic subsistence and mixed beef-dairy enterprises, as such these proposals will not limit or fix farmers' choices or change current enterprises unless it is catalyzed by economics and efficiency.

In summary – and based on the inventory and analysis made in the previous chapters - it is recommended to select breeds for the desired traits:

- Heat tolerance (incl. coat colour)
- Feed conversion efficiency
- Disease resistance/health
- Body size and weight
- Milk production and components
- Fertility
- Efficiency (growth and reproduction)
- Availability

5.3.2 Economics and Environment behind Genetic Performance

Genotype by environment interaction (G × E)-G=30, E=70, is a major challenge that the dairy farming industry undergoes as a result of the use of artificial insemination with genetically superior bulls sourced from around the globe to improve herd performance. This includes distribution of genetic material to multiple environments within countries and between countries. The major concern is that genetic potential – and ability to unlock it - may vary or change across the environments as thus the best animals in one environment may not be the best in another environment (Annex 6 picture 2).

Genotype x Environment interactions must be well understood if they are to be exploited to improve and enhance production. Particularly in farming systems that have wide environmental variations such as temperature, changes in quantity and quality of feed/nutrition, as well as internal & external challenges of parasites.

G x E (30g x 70e) interactions attempts to explain the effect of environment on different breeds and describes how breeds will vary in performance from one another depending the prevailing environmental conditions. G x E interaction is an integral measure for farmers to use in choosing suitable breeds that are most productive in their environment using the most efficient and cost effective methods of management where productivity can be improved. (A.R. Cromie, 1990).

From the information of the breed characteristics and our desktop study Holstein Friesian cattle in Meru, if not kept indoors (zero grazing units, medium scale or large scale cow barns), have

a hard time dealing with heat stress. Though the long term mean temperature is well below the ambient temperature at which the cows start to experience heat stress, the maximum temperatures experienced during the day will often cause heat stress in exotic cows. With high level production of 35 kg/day and above, the ambient temperature at which the cows start to experience heat stress will even be lowered with 5°C.
When we look at the temperature humidity – index (THI) it is also clear that during many days of the year (or part of the day) the cows will be in the zone that the climate (temperature and humidity) will affect the cow's milk production and reproduction, if no provisions (provide shade, milking early morning, feeding before 9.00 am etc.) are made within the farming system to reduce the effects of heat stress. Among the breeds in Table 4 Jersey will be the most heat tolerant, but even for Jersey to get good results within the breed limitations on milk production and reproduction, it would still be advisable to provide plenty shade and ventilation. Further to this it can be noted that the milk of Jersey's is high in components (mainly fat). This quality milk, in the current milk market is not awarded with a bonus being a higher price for a litre of Jersey milk. To produce milk high in components the cow needs to have enough nutrients of course.

Holstein Friesian and all other exotic breeds will have low resistance to tropical diseases and increasing their resistance can only be done through crossbreeding with indigenous cows. The choice of exotic breeds implies that a system of zero grazing or keeping cows indoors is practiced, without buying fodder from unknown sources. If this is not the case, the exotic breeds need to get preventive treatments regularly against tick and worm infestation of the herd. With the increased technological possibility to measure very small residues of pesticides in farm milk, and in combination with growing consumer awareness as regards food safety, the practice of having to treat lactating cows with these pesticides may become problematic if milk factories would refuse milk with a certain level of pesticide residues.

Out of all exotic breeds the Holstein Friesian needs high level management, feed requirements are very high and the cows need adequate clean water (>60 liters per cow per day). If these high feed requirements (in terms of quantity and quality) are not met (Annex 6 picture 2), the cows of the Holstein Friesian breed with their high genetic potential for milk production will easily get in a negative energy balance soon after calving. These undernourished cows will not show heat easily, conceive more difficult and have more health related problems. Under these conditions the performance of Holstein Friesian cows will be low with low milk production levels, low conception rates and therefore high calving intervals. Jersey - out of the exotic breeds – is a breed that requires less feed in terms of quantity due to its smaller body size, and also has a high feed conversion efficiency. It can cope with lower quality more fibrous fodder. The Jersey breed is quit hardy and adaptable to varied agro-ecological zones. The breed has under good manage-ment conditions little or no calving problems, greater fertility, a shorter calving interval, and earlier maturity as compared to Holstein Friesians.
Requirements of the other breeds will vary between these two breeds.

The breed characteristics matrix and research carried out on suitability of different breeds under low level management in tropical climate, in combination with advice from expert breeders in

Kenya, point in a different direction than the choices smallholder farmers make in the Kenyan Highlands. For instance, a frequent recommendation found in literature for smallholder systems in Kenya is the use of small mature sized dairy breeds (Guernsey and Jersey). The use of larger breeds (Holstein Friesian and Ayrshire) and/or upgrading to high exotic grades is generally discouraged because of their higher nutritional demand, lower adaptability and production efficiency, and hence lower actual milk yields under (typical) smallholder conditions (e.g Rege, 1998; Kahi et al., 2000; Wakhungu, 2000, Bebe et al., 2004). However, smallholders in developing countries have often not followed the recommended breeding practices: they have preferred to keep the large mature size dairy breeds as a key component of their intensification strategies (Tulachan et al., 2000; Devendra, 2001, Bebe et al., 2002). The choice of breed from an expert perspective would be to choose a smaller sized which is more suitable and can adapt better too and perform better under the local farm management conditions (cow management skills, fodder availability and quality, climatic conditions and susceptibility to tick borne diseases). Alternatively a strategy of crossbreeding can be used to make use of the heterosis effect. This could be beneficial to both milk production and health in the offspring. When choosing the breeds to be crossed it is important that they complement each other and bring increased milk production, heat tolerance and disease resistance to the offspring. Crossbreeding advantages of Boran x Holstein Friesian gives maximum hybrid vigour due to crossing a Bos Indicus with a Bos Taurus breed. F-1 females are great maternal cows, the cross enhances milk production for use in crossbred milk cows, brings heat tolerance to the crosses (Annex 6 pictures 5 and 6).

Heterosis

When two lines are crossed, then any undesired traits present in one line but not in the other, are masked (hidden) and there is typically a boost in the fitness of the offspring. This effect is known as heterosis or hybrid vigour, and is the opposite of inbreeding. This effect even extends to crosses between breeds of cattle, which is why crossbreeding programs are popular (for instance for producing cattle for beef operations). Essentially, one can get many of the benefits of two breeds of cattle in the first generation of a cross by using unrelated parent stock

5.3.3 Breeding Methodologies

Depending on one's goals for breeding animals, different breeding techniques can be used. The following is a brief but incomplete overview or illustration of some breeding methodologies. Some are not practical for most people, but for the dedicated animal breeder combinations can be used depending on the breeding strategy.

- Crisscrossing: A continuous program of crossbreeding with an alternate use of males belonging to two breeds. Using two breeds designated as P1 and P2, a crisscrossing program, beginning with the two-breed cross animal (P1 x P2), would begin by backcrossing to one of the parental breeds [(P1 x P2) x P1]. Females resulting from these matings would be bred to a P2 male, [(P1 x P2) x P1] x P2, and so on. Grading: mating of purebred males of a given breed to non-purebred females and the resultant female offspring in successive generations.

- Inbreeding: Mating of animals more closely related to each other than the average relationship within the breed or population concerned.
- Linebreeding: Generally mild form of inbreeding in which animals mated are related to some supposedly outstanding individual.
- Outbreeding: Mating of animals less closely related to each other than the average relationship within the breed or population concerned
- Species cross: Mating of animals belonging to different species (for example mating of European breed cattle, Bos Taurus, to Brahman cattle, Bos Indicus).
- Three-breed rotational cross: A continuous program of crossbreeding in which males of three breeds are used on a rotational basis. Using three breeds designated as P1, P2 and P3, the first generation would involve production of two-breed cross animals, P1 x P2. In the second generation, two-breed cross females would be mated to males of the third breed, (P1 x P2) x P3; three-breed cross females would be mated to males of one of the breeds used to produce the two-breed cross animals, [(P1 x P2) x P3] x P1, and so on.

Box 2. Advantages and Disadvantages of Crossbreeding

Advantages (+)
- Better fit to available feed and other circumstances
- Healthier Cows
- Improved fertility
- Higher components
- Calving ease
- Smaller type cow.
- Vital calves
- Longer productive life
- More calves
- Less Mortality
- Less mastitis / lower Somatic Cell

Disadvantages (-)
- Lower production level then pure bred
- Shape of udder
- Small population
- More variation in conformation
- Milking Speed
- Sucking behaviour of calves

Kahi et al. (2000b) presented evidence in crossbreeding studies from large-scale farms, which showed that introducing (Holstein) Friesian breed improves milk yields in the herd. In their study, crosses with 50% (Holstein) Friesian genes out-performed other crosses from Ayrshire, Brown Swiss, or Sahiwal in lactation milk yield, annual milk yield and lactation length. However, studies on smallholder systems (Wakhungu et al., 2000) showed that (Holstein) Friesian was out-performed by small breeds (Guernsey and Jersey) in milk yield per lactation, fitness traits and production efficiency. On large-scale farms, management was superior in terms of feeding and health, implying that (Holstein) Friesian will maintain her superiority with improved management (Bebe et all., 2000).

5.3.4 Practical Situation in Meru

The practical situation (according to our mini survey) in Meru County is that the majority of the farmers (>70%) gave preference to the Holstein Friesian breed to increase their milk production on their farms. This is in line with findings of the study by (Bebe 2004). Breeding practices tended to favor the use of dairy breed of larger body size, particularly Holstein Friesian, which is inconsistent with technical recommendations that favor the use of the smaller dairy breeds.
These findings suggest that acknowledging and "marrying" multiple objectives, including the need for more milk, adaptability to local feed conditions and diseases, and the provision of non-market production such as manure, insurance (cow sales) and other financial role of cattle ("saving bank"), is likely the way to go for a more adequate breeding strategy to be more easily accepted and implemented (Bebe, 2004).

If these are the underlying objectives of the smallholder farmers in the Kenyan highlands, including Meru, then the breeding strategy for Meru Union should be based on selecting bulls within the Holstein Friesian and Ayrshire population, which come closest or meet the expert advice for a smaller hardier type of dairy cow. Which has a higher feed conversion efficiency within the breed, but also meets the farmer's wish to have an animal that can be sold or culled if need be as a source of financing or insurance. A smaller sized Holstein Friesian cow or alternatively Fries Hollands breed with a lower genetic potential for milk production but with the characteristics that "it takes care of its own body condition before producing too much milk", could be a cow that is smaller but due to its higher ability to maintain good body condition and health in sub-optimal conditions, produces in its life cycle more milk and calves, and – in addition - because of its breed (black and white) and weight sells better in the market.

With this strategy in mind, in the highlands (zone 3) milk yields will be significantly higher in the cooler parts of the year than the hot ones. Risk of heat stress will be less in this zone, but is not absent during those months where temperatures go really high.
Environmental and physiological adaptability of Holstein Friesians needs considerable attention in the intermediate (zone 2), whereas it can be stated safely that in zone 1 (the lowlands) crossbreeds (Bos Indicus x HF/Ayrshire) should be recommended. In the near future global warming is assumed to impact severely on dairy animals in tropical climates and therefore selection for genetic merit of both production and adaptability should be of concern.

Farmer production and management levels stratification

a. Although technical recommendations regarding adaptability to heat stress, resistance to diseases and feed conversion favor smaller breeds, elite farmers in Meru County have shown that under good management practices, zero grazing with a high nutritious feeding regime, it is very well possible to achieve production levels of > 6,000 kg per 305 day lactation.
This "elite group" of farmers, which is estimated to represent only 5% of all dairy farmers in Meru County, is on average well conversed with breeding, bull selection, heat detection and insemination issues, and have already a quite well informed breeding strategy.

In their situation recommending bulls within the Holstein Friesian and Ayrshire breeds that are hardier and smaller, with lower potential milk production may not be required but remains a valid possibility. They can be given the choice and make their own decision (Annex 5 picture 4).
The "elite group" of farmers is mainly found in zone 3, the high-altitude areas (i.e. tea, coffee, wheat, potato zones). Due to abundant and reliable rainfall, in this highland zone it is possible to grow fodder crops with high nutritious value although land space can be a limiting factor. The highland zone is also more populated with an advanced infrastructure (roads, electricity, water), which favors marketing and demand for milk thus higher milk prices.
The intermediate zone (zone 2) can be considered as the new frontier for agricultural development, including dairy and milk sourcing. In this zone in recent years new cooperatives and farmer groups are being formed who deliver milk to Meru Union (or other milk processors). The number of "elite farmers" are fewer, but there are farmers with promising results, because they have invested in zero grazing (to prevent/reduce heat stress) and are using fodder crops with high nutritious value. There are still often two rainy seasons (short and long) but less reliable leading to frequent (seasonal) crop failure. Maize can do well provided short season varieties are used. In general the area is more challenging to grow forage crops year round. Brachiaria grass could be a promising crop for this intermediate zone.

b. For farmers who do not meet the standards of the "elite" farmers (5%), and have production levels from 5-10 litres of milk per lactating cow/day (1,500-3,000 per lactation), the recommendation for breed selection and bull selection in the previous sections, preferring a small sized cow within the breeds and/or the use of cross breeds, stands. Especially also when they must resort to buying fodder – usually of low quality - from unknown sources during periods of scarcity, and/or when they apply semi-zero grazing or free grazing which makes them more prone to heat stress and the risk of getting problems with tick borne fever and worm infections. These are referred to in Table 5 as "medium and low level farmers". They form the majority of all dairy farmers in Meru County (estimated at respectively 15% and 80% of milk producers). This means that they also form the majority of farmers in the highland zone and the intermediate zones. A combination of climatic conditions, knowledge, skills and financial limitations can be the reason behind the lower production and management levels for this segment of farmers. For this group smaller breeds and/or crossbreeding as formulated in this breeding strategy is advisable.

c. The subsistence farmers in the lower dryland areas (zone 1), mainly low level farmers as referred to in Table 5, would be best served with a Boran-Holstein Friesian crossbreed or Sahiwal-Holstein Friesian crossbreed. This will give them the advantages that the offspring has the traits of both breeds being higher in milk production (10-15 kg/cow/day or 3,000 to 5,000 kg per lactation) and at the same time hardier, more resistant to tropical diseases, lower feed and water requirements and more heat tolerant. This lowland zone (northern parts of North Imenti, Tigania and Igembe and Tharaka) will not be a focus area for the milk processors to source raw milk. However the breeding strategy is more inclusive with recommendations for the farmers in these low potential areas of Meru and Tharaka Nithi Counties. It will help farmers there to improve husbandry practices and self-reliance from a livelihood perspective.

To achieve good results with any recommended (stratified) breeding strategy, including the one suggested here, good farm management practices related to cow housing, feeding and disease control will always play a key role in the success of the smallholder farms.

Economic calculation model (illustration)

A breeding goal or strategy can best be pegged on an economic analysis/prognosis of the net economic benefits at farm level as a result of the choice of breeds and within breeds of bulls.
Farmers are mainly interested in net profit or income that is derived from keeping milking cows. Usually this is related to milk volume, especially in Kenya, hence a preference for cows with a high genetic potential for milk production. However the majority of the Meru farmers keep exotic cows (Holstein Friesian) and the economic value of more milk is usually related to the market dynamics in the country of origin, as well as the level of farm management and quality of support services in those dairy economies.
It has been argued in the previous pages that net profit – and in fact also total milk production – could be maximized very well in the Meru context, by attaching more value to traits like cow disease resistance, feed conversion efficiency, heat tolerance, cow health and fertility, rather than milk production per se. What matters is to achieve a stable milk production during the lactation (no negative energy balance), more lactations (longer life span and reduced calving intervals), and thus more calves and more milk.
In a short follow up study to this report, a comparison of a low input versus a high input level farm and the effect of breeding strategy (choice) on the economic performance of those farms.

6. Breeding Strategy

6.1 Breeding Goal and Strategy

The breeding goal is to improve the dairy producing herd in a given environment for the economic and social benefit of the farmer through proper breed and bull selection. The recommended strategy for Meru to operationalize the breeding goal, can be formulated as "to promote and adopt suitable breeds and bulls that generate future animals that will produce more milk and offspring efficiently, and which are adapted to local production systems and production practices". This is in line with an important statement of Meru Union's CEO during his interview with the author of this report as regards his expectations of the study, which were "to identify the best and economically viable breed that suits the dairy farmer in Meru Union" whilst he referred to "the farmers desire to have efficient and economically viable breeds". Hence the focus of this report is on the formulation of a breeding goal and defining of a breeding a breeding strategy that is informed by economics of key cow traits or characteristics (that go with the breed or bull selection) in the specific context of the Meru dairy farmers, both environmental and as regards management and production levels.

6.2 International Dairy Breeding Goals

Breeding goals are developed and instituted by the farmer or breeder group to attain particular ambition on the farm/herd. In developing breeding goals many factors come into play among them the purpose of breeding, herd size, target market, efficiency and profitability. Below are the most sought out breeding goals across the world:

i. Production: increased milk volume, fat and protein content.
ii. Conformation udder related traits, feet & legs related traits, frame dairy strength
iii. Longevity
iv. Functional traits, calving ease, fertility, udder health, temperament
v. Resilience to disease: easy adapting especially crossing, dual purpose breeds.
vi. Feed conversion
vii. Adaptability
viii. Diversity – maintain a wide variety of gene pools.

6.3 Key Considerations for Meru Union's Breeding Strategy

Already for quite an number of years, but more dominant in recent years, there is debate among breeding experts and farmers as regards the pros and cons of upgrading local breeds and crossbreeds to higher exotic grades (Annex 6 picture 3.) and/or use of the Holstein Friesian breed in smallholder low-external input and output systems. This debate is pegged on the low adaptability of these exotic breeds – in particular Holstein Friesian - to tropical stress factors of poor nutrition, disease challenges and heat tolerance (Cunningham/Syrstad, 1987; Bebe, 2004). The arguments are based on the results of reproduction and production evaluations, but the knowledge and preferences of the people who own and use these genotypes have - to a larger or smaller extent - been ignored. A review of published results for various dairy genotypes in the tropics (Rege, 1998) showed that at the same level of indigenous genes, crosses of different exotic breeds differed in their performance indicating that no one breed, crossbreed or crossbreeding strategy will have superior aggregate performance in all production environments (Bebe, 2004). Though genetics provide great opportunities to improve production the challenge will be to match the breed composition with the local production system and production practices (Annex 6).

Farmer's knowledge and preferences about the genotypes should therefore be an integral part of breeding improvement efforts because farmers adopt and adapt genotypes to their needs and circumstances. For example, farmers might tend to upgrade to higher exotic grades and/or Holstein Friesian based crossbreeds on the expectation of higher milk yields even though the overall productivity, on the account of reproduction and production, may be low. In addition, large dairy breeds are associated with high milk yields and are likely to be more popular than smaller breeds in production systems such as found in Kenya where milk is sold on volume basis. (Bebe 2004).
Yet there must be room to merge farmers' preferences that may not always present the best choice for their circumstances but are more led by ambitions, with experts' deeper knowledge on breeding, to come to practical recommendations and strategies that come closest to the goal of efficient milk production and suitability of the future cow to the local context and farmers production and management levels. With the development of this breeding strategy the following recommendation of one of the expert-reviewers was taken into serious consideration:

"If dairy cows with a high genetic potential for milk production are kept under low input management faming conditions they will not be able to express their genetic potential. Low input farming conditions can be caused by amongst others: low feed and/or water intake, low energy and protein content of feed, housing lacking cow comfort, high temperature in the stable, lack of adequate care in times of disease, etc. Cows kept under these conditions will perform below their genetic potential, which also means that they perform below their economic potential not paying back the money the farmer has invested in the animal by breeding and raising it. These conditions do not only lead to low milk production but will also result in physiological problems of the cow, viz. a negative energy balance since the strong drive towards milk production will make the cow to use body reserves to produce milk. Subsequently this will strongly increase the risk of disease and infertility. Many cows kept under these conditions will become skinny and will have a relative short productive life ((Jelle Zijlstra, 2017 and Annex 6 picture 2).

The basic principle of Meru Union is for its farmers of which the large majority have cows that give less than 10 litres of milk per day in lactation, to produce (and eventually improve) a cow that is well adapted to the tropical stress factors such as low-quality nutrition, disease challenges and heat tolerance, and still produce more milk than currently is the case with the existing herd.

Not overlooking or excluding the current preference for Holstein Friesians and to a lesser extent Ayrshires by the Meru farmer, the fact finding and analysis in the previous chapters revealed that this cow ideally would be medium sized, with a high feed conversion efficiency, good heat tolerance, (hardy in the low zone) and high level of resistance to diseases, has milk production level above the average production level of the Meru-farmers and components within the normal (natural) range of the breed. The idea behind this is to improve feed conversion efficiency, health and fertility of Meru's dairy cattle in each generation while increasing production as well (see: Annex 6 pictures 5 and 6). The higher importance given to feed conversion efficiency, health and fertility traits is due to its increasing importance for profitability of the smallholder farmer, or in other words: "Keeping the cost down per kg milk produced, ensured by good feed conversion, healthy and fertile cows". These traits are just as important for profitability as focusing only on improving the production capacity.
This strategy does not negate the importance of increasing the management capacity and availability of quality feeds and fodder, on the contrary this is a basic requirement for each breed whether local, exotic, pure or crossbreed to perform and stay healthy. The point made here is that focusing on exotic breeds with the highest potential milk production in the USA or Western Europe, in the Meru context means for the majority of farmers "jumping from the basement to the roof" with results contrary to the expectations. As was stated in the previous chapter this may or does not immediately apply to the elite farmers with a production of 20 litres and above. They have usually formulated their own breeding goal and defined their own breeding strategy and are able to manage "exotic high producing cows". Having said this, it is still valid that crossbreeding among the cow population of this group of elite farmers, can have a positive effect on feed conversion, fertility and adaption to local climatic and health conditions.

6.4 The Breeding Strategy Operationalized in Cow and Bull Characteristics

Meru farmers keep dairy cows to create income through milk production and through selling of its offspring. In addition, in many cases the dairy cow also serves as an insurance and bank in times that cows need to be sold due to financial stress of the household. The strategy for breed or bull selection needs to take this into account - within the wider context of agro ecological conditions and production & management levels. The proposed cow description for most of Meru Union's farmers (with average milk production of 7 kg/cow/day or 2,100 kg milk/305 day lactation) is therefore given below as follows.

Cow description:

- A smaller sized animal with a better feed conversion (body weight vs kg milk produced)
- A cow with a relative high body weight but smaller sized, and therefore a higher market value on voluntary culling/sales.
- The cow has a high heat tolerance level which means that higher ambient temperatures will not immediately result in drop in milk production and/or low conception rates. Cows with a high production (>35 kg milk/day) have a lower heat tolerance (5 °C)

- Fertility is important as preferably the cow should produce a calf every year. This will benefit replacement stock as well as lifetime milk production of the cow.
- Ease of calving as majority of farmers don't have easy access to veterinary services.
- Cows are healthy have strong legs and feet, and good udder placement. Therefore they are easy to manage. They preferably have some resistance to tropical diseases.
- Fast maturing.
- Long lifespan (longevity).

Key assumptions for this cow description are:

- Genetic potential of most dairy cattle is under-exploited due to low level management and insufficient feeding and nutrition protocols. Feeding and feed availability is key to improved productivity. Reflects in above description through improving feed conversion efficiency.
- Small type animals have, under the local circumstances less management demands and are more resilient. They have a better feed conversion efficiency)
- Heat affects animal comfort and has negative effects on production, especially high ambient temperatures due to factors related to heat stress and water availability. Hence a recommendation for breed selection on basis of heat tolerance.
- The level of farm management and production influences choice of breeds and bulls:
    a. *Elite farms* (15-20 liters milk/cow/day) – Seek to uphold high production, maintain fitness and longevity (will more likely persist on pure breeding. Take in to consideration though heat tolerance esp. with very high yielders and feed conversion efficiency. These farmers keep animals in full zero grazing /indoors, so disease resistance is less of a problem.
    b. Medium level farms (10-15 litres milk/cow/day) - Seek adaptable breeds, introduce long life/fitness traits genetics while increasing production. This can be achieved through crossbreeding of exotic breeds or through selection of appropriate bulls within the breed. These farmers may apply may apply the same feeding system (semi-) zero grazing and/or(free grazing at times in forests)or buy fodder from outside to supplement their fodder or due to seasonal lack of enough fodder. The feeding practices of the medium level farms are different using mainly crops residues or forages of low nutritional value. Feed conversion efficiency, disease resistance and heat tolerance are still very essential before improving milk production.
    c. *Low level farms* (<10 litres milk/per day/cow) – Seek for a resilient local (Bos Indicus) breed and endeavor to increase milk production. This reflects in crossbreeding (with Bos Taurus) where the offspring benefits through better heat tolerance, disease resistance, adaptation to feed practices and higher milk production form the HF sire.

Different weighing factors for different breeds

Holstein Friesian, Ayrshire, Guernsey and Jersey breeds are different from each other as the breed characteristics and farmers' preferred choices show. Therefore the weight distribution in the breeding goals for Holstein Friesian, Ayrshire, Guernsey and Jersey should be different.

What is important for Meru Union is that all the breeds develop towards the optimal desired balanced breeding outcome, while taking into consideration genetic differences and the natural breed-specific tendencies for certain traits.
For example: Ayrshires and Jerseys are naturally healthier breeds (and farmers in Bebe's et all., 2000 study also indicated this to be so) than Holstein Friesian, so therefore the weighing of improving health & fertility is lower for Jersey (44%), Ayrshire (48%) than for Holstein Friesian (53%). Jerseys are better in reproduction traits, like daughter fertility and calving. Therefore, the focus can be moved to improving production instead when choosing this breed.
Holstein Friesians are very high in production by their breed characteristics and abilities, therefore, the weight (30%) for improving their production capability is lower than for Ayrshire (33%) which is again lower then Guernsey and Jersey (37%).
Thus the breeding strategy developed and formulated for Meru Union aims for a balanced breeding outcome, it is for example more important to focus on developing the feed conversion efficiency, health and fertility traits for Holstein Friesian breed than milk production capacity that is developing well already for the breed.

Next step is the choice of bulls

Bringing a breeding strategy into practice means that one has to select bulls that inherit the right traits to fulfill your breeding goal. To select bulls, the farmer – Meru Union- need to know the strong and weak points of their cows (herd). If available, milk production results (total volume and components fat and protein), linear scoring of the conformation and functional traits, can be used to determine the strong and weak points of the cow. With this information at hand the right bull can be selected. More often however this information is lacking and proxy-indicators such as current production levels and agro-ecology need to be used.

And lastly the mating choice

When the mating bulls are selected, it needs to be figured out which bull should be used on which cow (or cow groups). As we can conclude from our mini survey and literature review it is very important to create a good match between bull and cow. Milk production, linear scoring, breeding values and pedigrees are very important to determine the most ideal breeding.

6.5 Breed and Bull Selection

In this breeding strategy breed and bull selection is guided or determined largely by farmers' production and management levels and by agro-ecological conditions, as found in Meru.
Table 5.a below presents a simplified but useful classification of farmers in Meru County according to milk production levels, which have a strong relation to farm management skills or practices and access to quality forages. In Table 5.b the agro ecological zones are depicted. There is some correlation between farmer categories and agro-ecological zones, but in principle different categories of farmers can be found in different zones. However it is safe to say that elite farmers are predominant in zone 3, whilst the medium and low level dairy farmers are found across all zones, with the remark that zone 1 is not a suitable zone for commercial milk production. Livestock keeping in this zone is more focused on goats and sheep and cattle with a dual-purpose.

Table 5.a Meru farmer classification according to production level

Farmer level of production and management
1. Elite farmers (>20 litres/cow/day) ***ca. 5% total farmers*** • Zero grazing • Practice better feeding regime (conserved silage, hay, dairy meal and mineral supplements) • Clear fodder/feed plan: set aside/hired land for maize silage, plants protein rich fodders • Keep records (breeding, production and health). • Breeding method: strictly on AI – bull selection skills. • Heat detection, calf rearing good
2. Medium level farmers (10-15 litres/cow) ***ca. 15% total farmers*** • (Semi-) zero grazing • Improved feeding (growing adoption of maize silage, hay, dairy meal but not year round) • Improved feed/fodder planning and fodder planning /planting, but seasonal shortages • Minimal record keeping (mainly milk, AI bull straw). • Breeding method: partly AI/bull services; service provider choses bulls for the farm. Limited skill on bull selection. • Heat detection, calf rearing moderate
3. Low level farmers (< 10 litres/cow/day) ***ca. 80% total farmers*** • Semi-zero and free grazing • Scavenging animals (main fodder/feed is maize and wheat stovers, banana stems, Napier grass) • No feed/fodder planning. • No records (rely on memory) • Mostly bull services, partially on AI

Table 5.b Meru County agro-ecological zones

Most Elite Farmers are in zone 3 the highland zone. Medium and Low level farmers are found across zones 1-3 (highland, intermediate and lowland zones)

Agro-ecological zones potential
3. Highland Zone 3 • Cool – suitable ambient temperatures. • Sufficient rainfall-supports fodder farming (two cropping seasons). • High population density, small farms • Land pressure, competing crops
2. Intermediate Zone 2 • Moderately high temperatures in dry seasons • Moderate to high population density- land pressure, competing crops. • Usually 2 rainy seasons, but shorter and usually one unreliable or failing
1. Lowland Zone 1 • High ambient temperatures. • Low rainfall/semi-arid conditions, high chances of crop failure, not really suitable for commercial dairy farming • Moderate population/land pressure

Based on this *classification of farmers* and *agro-ecological zoning*, a simple stratified breeding strategy is proposed that is schematically depicted in the pages and Tables 6-9 below.

Table 6. Breed Traits and Suitability per Agro Ecological Zone

Agro-Ecological Zone	**Key Characteristics**	**Breed Traits and Suitability**
Highland Zone	Small land sizes average 0.5-1.5 acres. Competing crops: fodder crops, fruits, tea, coffee. Feed and fodder availability (silage) Ambient average temperature 20°C with short periods of max. day temp. 28-30°C Sufficient rainfall (2 seasons).	Pure-bred animals. High milk producers. All breeds and cross breeds can attain high production potential. Mostly intensive commercial. production system.
Intermediate Zone	Moderate land sizes average of 3-4 acres. Competing crops: fodder crops, tobacco, miraa. Relatively high incidences of fodder shortages at farm level, yet land leased for fodder production to dairy farmers from highland zone. Max. ambient day temperatures of 28-30°C degrees for a large part of the year Unreliable 2nd rainy season.	Breeds with high feed conversion efficiency. Breeds with better heat stress tolerance. Breeds that attain high production. potential with minimal management. Medium milk producers. Small sized breeds.
Lowland Zone	Northern Grazing Area and Tharaka (in Tharaka Nithi County) Relatively large land sizes averages of about 4-7 acres (no title deeds) Semi-arid, very low rainfall. Maximum ambient temperatures up to 32°C for the largest part of the year. Livestock systems small ruminants and beef cattle (Zebu type).	Hardy breeds and tolerant to exposure to parasites, disease challenges and extensive management system. Breeds with high heat stress tolerance. Breeds that are good grazers. Crosses or synthetic breeds are preferred. Small sized breeds preferred.

According to the description in Table 6 above of the *agro ecological zones* and breed traits and suitability a more precise overview is given in Table 7 of the breeding characteristics most relevant to our choice of breed and/or bull traits.

Table 7. The rating of different breed characteristics for different breeds

Breed	**Heat Tolerance**	**Feed conversion**	**Body weight maintenance cost**	**Fertility**	**Age at puberty**
Friesian	**Low**	**Low**	**High**	**Low**	**15**
Ayrshire	**Moderate**	**Moderate**	**Low -Moderate**	**Moderate**	**15**
Guernsey	**Moderate**	**High - Moderate**	**Low**	**Moderate**	**14**
Jersey	**High**	**Very High**	**Low**	**High**	**12**
Brown Swiss	**High**	**Moderate**	**Low**	**Moderate**	**16**

To make suitable choices for cross breeding strategies Table 8 can be used to find the best match for different agro-ecological zones and farm milk production levels.

Table 8. Breed selection criteria between the different breeds: (+) means the breed has a positive impact on its offspring for this trait/criteria.

Breed suitability / Humid Tropics	**Holstein Friesian**	**Ayrshire**	**Brown Swiss**	**Guernsey**	**Jersey**	**Boran**	**Sahiwal**
Breed selection criteria							
Feed conversion efficiency (Adaptability to poor fodder)	– –	–	–	+	+	+ +	+ +
Adaptation to heat	– –	–	–	+	+	+ +	+ +
Milk Production	++	+	+	+/-	–	– –	–
Adaptability to diseases (ticks)	– –	– –	– –	– –	–	+ +	+
Size/Weight at Culling	++	+	+	–	– –	–	+

Note: Annex 5 shows the breed characteristics of Girolande breed which could also be suitable for Meru zones 1 and 2

Table 9. Importance/weight of the different cow traits in relation to farm management milk production levels of smallholder farmers

Farm Management milkproduction levels	**Elite level farmer**	**Medium level farmer**	**Low level farmer**
Bull selection adopted Trait scores for different farm management levels			
Production (mainly components-Fat, Protein).	Maintain	Increase gradually	Increase gradually
Health and Fertility (Calving ease, Udder health-udder traits)	Very Important	Very Important	Very Important
Conformation (Mobility-legs, Body size)	Moderate Important	Important	Hardy
Body Size / Weight	Maintain Size >600 kg)	Reduced Size (500 k)	Smaller Cow (400-500kg)

Based on Table 9 the rated selection criteria can be used when choosing the appropriate breed/ bull depending on the management skills (fodder and feeds available, adequate cow housing in place) and milk production levels for the different categories of farmers in Meru County.

7. Synthesis and Breeding Strategy for Meru Union

7.1 Genotype and Environment

High performing genotypes require excellent farm management to help them achieve their genetic potential. Under the more traditional low-input farm management systems that exist in many tropical smallholder systems, the performance of such animals will be less than the local stock (see: Annex 6 picture 4). This is primarily because of their susceptibility to favorably utilize their body reserves to produce milk during early lactation. Without sufficient nutrient intake, they will lose weight and upset the hormonal balances that compromise them to regain their normal estrus cycle for many months following calving. Reduced reproductive performance of high grade cows is an all too common feature of low input level feeding and herd management on smallholder farms in the humid tropics. In fact, the inability to get back in calf within several months due to lactation anestrus, can represent up to 20 or 30% of improved dairy stock losing productivity. There is continuous debate over the 'ideal' genotype for smallholder dairy farmers in the humid tropics (see: Annex 6 picture 2). One rational approach is to consider is the genotype by environment interaction (that is G × E). Briefly, the relative performance of two genotypes depends on the environment under which they are managed.

Improved genetics is just one of the tools for increasing farm production, but it is only effective if used in combination with other better farm management practices. This is described by animal geneticists as follows: *Phenotype = genotype + environment*

The performance of milking cows (phenotype) then results from a combination of:

- Genetic make-up (genotype), derived from the genes supplied by both dame and sire.
- Management in the milking herd (environment): how well are the cows housed, fed and protected from climatic stress, disease and other stresses of dairy farming.

No single tropical dairy type can be defined as the 'best'. The 'best' type will vary from local genotypes all the way through to high grade cows. Unless heat stress is controlled, high-yielding temperate breeds will always be less efficient than locally evolved ones.
Locally evolved animals would be developed through crossbreeding local (Bos Indicus) and exotic (Bos Taurus) breeds, then selecting within these populations for high milk yields, adaptability and feed conversion. Boran and Sahiwal crosses (see: Annex 6 picture 3) are known to be able to produce over 6,000 kgs of milk in 300 days under good management. Similarly, it is unlikely that purebred local breeds will be the most profitable in low level input farming systems, where feed is inadequate, parasites and diseases are uncontrolled, and levels of production barely fulfil household needs.

The genotype and its management must then be matched to the:

- Climatic conditions that exist
- Available nutrition, whether home-grown or supplemented with purchased feeds

- Degree of challenge from parasites and diseases
- Level of management skills
- Availability and costs of labor to feed, milk and market the product, and its priority with other household demands
- Availability and access to profitable markets.

The relative importance of the genotype (breed and bulls) and environment differs between agro-ecological zones, farming systems, farming practices and farmer skills, and it is not easy to apportion relative values to either one. This is a major dilemma for dairy industry policymakers in deciding whether the long-term outcome of (breeding) schemes, especially on importation of high merit dairy genetic material for national herd improvement and multiplication. Unfortunately, in too many cases, the genetic benefits of such schemes have been minimal due to lacking proper matching of the genotype to environment and management. Many tropical countries have been importing semen from progeny tested sires from temperate countries, and as thus have continued the program of genetic upgrading of local to temperate dairy stock. These programs however seem to have registered little improvements mainly due to the following:

- Importance of adaptability is underestimated
- Ages at first calving of 30+ months,
- Milk yields of 2,500–5,000 kg/lactation and
- Calving intervals of far more than 430 days in the new location.

All these performance indicators are below optimum and will not support profitable dairy enterprises. Modern day Holstein Friesians for example, are genetically capable of producing their first calf at 2 years of age, and a calf every 12-14 months, yielding over 8,000 kgs of milk over 305 days and milking for four lactations or more. The main reasons for underperformance are:

- Lack of sufficient high-quality feed
- Low adaptability of imported stock to local conditions
- Housing and management not to the right standard, and
- Too much attention on milk sourcing by cooperatives, with insufficient attention and investment in farmer training & extension on cow management, fodder and feed rations.

7.2 Proposed Breeding Strategy for Meru Union

The recommended breeding strategy for Meru Union will focus on the largest group of farmers (80%) with a production level less than 3,000 kgs of milk per 305-day lactation. The vast majority of bulls available in Kenya (imported and local semen) has a genetic potential higher than this production level. When prioritizing the breeding traits focus needs to be on breeds and bulls that improve the feed conversion of the offspring to avoid the cows, once they start lactating, ending up in a negative energy balance. Avoiding this physiological state of the cow will have a positive effect on the milk production in the current lactation, increased chances of conception and also on the milk production in the following lactation(s).

This strategy can be achieved by choosing bulls which give ***smaller off-spring*** than currently is the case. Further ***feed conversion, adaptability to heat stress and resistance to diseases*** are the most important traits to improve smallholder farmers' milk production levels in the future. Farmers' economic performance needs to be the main driver for the choices made in the breeding strategy more so than upgrading to purebred Holstein Friesian or Ayrshire cows.

The consultants however recognize the need to match - or find a balance between - breed preference of the farmer versus advice from researchers based purely on environmental and technical considerations. In the Meru situation this would mean a breeding strategy that acknowledges preference for Holstein Friesians and Ayrshire in the highlands and intermediate zones, but with a bull selection that targets a smaller animal with more efficient feed conversion, improved adaptability to heat stress, and higher resistance to diseases this can also be realized by cross breeding or the use of composite breeds.
Farmers in the lower areas (lower parts of zone 2 and zone 1) would be best served with Bos Indicus x Bos Taurus crosses like Boran-Holstein Friesian crossbreed or Sahiwal-Holstein Friesian crossbreed. This will give them the advantages that the offspring benefits from the traits of both breeds: higher in milk production and at the same time hardier, more resistant to tropical diseases, lower feed and water requirements and more heat tolerant. (For example a successful crossbreed from Brazil which has potential in Meru is shown in Annex 5 the breed characteristics of the Girolando a crossbreed between Holstein Friesian 5/8 and the Brazilian Gir 3/8. The breed could be well suited for milk production in the intermediate and lowland zones with generally low input level farm management systems).

In addition to taking into account agro ecological zones, the breeding strategy also suggests a stratification as regards to elite farmers on one hand, and the mass of farmers (> 80%) that produce less than 10 litres of milk per cow per day, on the other hand.
Elite farmers in Meru County (5% of total dairy farmers) have shown that under good management practices, i.e. zero grazing with a high nutritious feeding regime, it is very well possible to achieve high production levels of > 6,000 kg per 305-day lactation. This "elite group" of farmers is on average well conversed with breeding, bull selection, heat detection and insemination issues, and they have already a quite well-informed breeding strategy. They can be advised if need be on a breeding strategy, but they will make their own decision and are capable and knowledgeable to do so. For the majority of farmers (80%) who do not meet these standards (production levels of 5-10 liters/day), the recommendation is to choose a breeding strategy, which aims for a smaller cow with more efficient food conversion, improved adaptability to heat stress and higher resistance to diseases. Such a cow is better adapted to the local environment and can be expected to produce more milk in its life cycle, more calves and is easier and less costly to manage, as compared to high producing cows when not well managed.

In Table 10 the recommended stratified breeding strategy is summarized. The table gives an overview of the different agro-ecological zones and within these the consultants' recommended *overall or generalized* breed or crossbreed preferences are given, and the production level that can be achieved with targeted breeding to create a next generation off-spring more adapted to the local production systems in place. Within each of these agro-ecological zones there is still stratification of farmers as regards production levels and management skills (see also Table 5). The overall breed preferences per zone need therefore to be fine-tuned against this, meaning that breed and bull choices will be further tailored to the prevalent farm management or production level of the individual farmer or category of farmers as per the 3 production levels described in Chapter 6 (Elite, Medium and Low).

Table 10: Meru Union Recommended Breeding Strategy

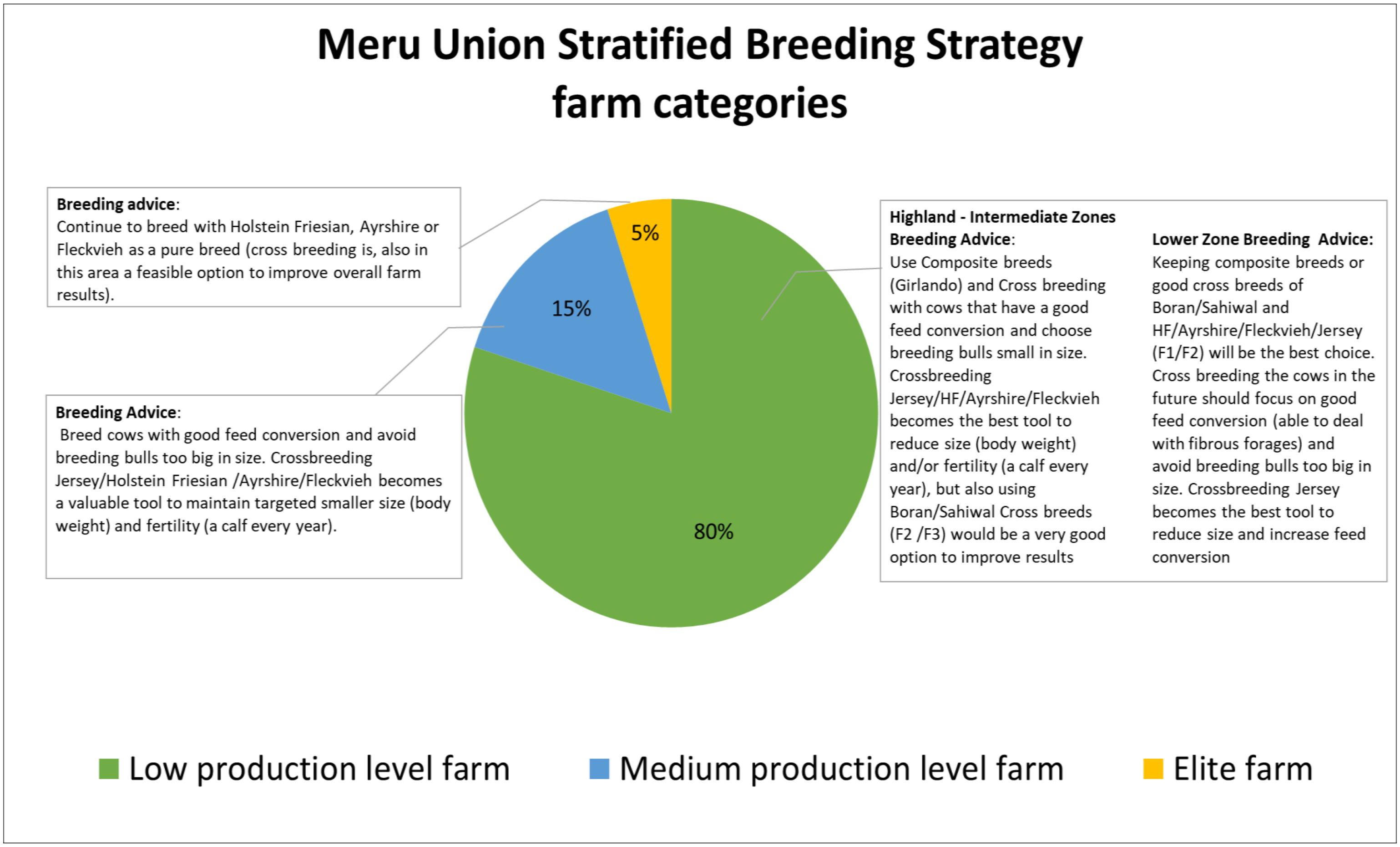
Elite Farmers: High input in terms of nutritious feed, zero grazing units, knowledge, skills, investment --> milk output high (15-20 kg milk)

Medium Level Farmer: Lower input than Elite Farmers --> milk output is lower than elite farmers (10-15 kg milk)

Low Level Farmer: Lower input than Medium Level Farmers --> milk output is lower than medium level farmers (< 10 kg milk)

Breeding Policy	Government policies and regulatory framework
Step 1: Breeding Goal	Formulating the Breeding Goal (Chapter 6.1)
Step 2: Breeding Strategy	Defining the Breeding Strategy to achieve the Breeding Goal (Chapter 6.1)
Step 3: Bull Selection	Bring the Breeding Strategy into practice, select bulls to inherit the right traits to fulfill breeding goal (Chapter 6.4 and 6.5)
Step 4: Mating Choice	Which bull should be used for which cow (or group of cows) in Meru Union (Chapter 6.5)
Step 5: Mating Program	Execution of the above under the farmers' cows of Meru Union

Agro-Ecological Zones/Strategy	**Breed Preference**	**Target Production**	**Rationale**
Zones 3 & 2 (highland/intermediate) ***Elite Farmers*** Continuous breeding and improving of existing dairy cattle with appropriate exotic breeds to produce efficient, high quality, long life replacement stock.	Holstein Friesian/ Holstein Ayrshire and crossbreeds	Average 15-20 ltrs (4,500-6,000 kgs/ 305 days lactation)	Holstein Friesian and Ayrshire are known to produce more milk in right conditions while cross breeding positively impacts fertility and health
Zone 3 & 2 (highland/intermediate) ***Medium/Low Level Farmers*** Upgrading, switching to economical breeds, cross breeding; targeting less intensive management and high tolerance breeds suited to the farming system(s) and farming practices used	Ayrshire, Jersey and small type European Holstein Friesian or their crosses and crosses of exotic breeds and Bos Indicus.	Average 10-15 ltrs (3,000–4,500 kgs/ 305 days lactation)	Ayrshire, Jersey and small-type European Holstein Friesians are good grazers and tolerant. Low nutrition levels inconveniences fertility, complications with husbandry practices.
Zone 1 (lowland zone) ***Lower Level Farmers*** Grading up of local (Bos Indicus) cattle using exotic (Bos Taurus) breeds of cattle to attain F1 (50%) and F2 (75%). Which are more suited to the farming-system and farming practices used.	Jersey & Brown Swiss and Crosses of Holstein Friesian & Ayrshire with Bos Indicus	Average 5-10 ltrs (1,500-3,000 kgs/ 305 days lactation)	As a single breed smaller breeds like Jerseys and Guernseys and Brown Swiss are known to be tolerant to tropical conditions better than Holstein Friesian and Ayrshire. They are more Heat tolerant and better feed converters. Crosses of Boran/Sahiwal and HF/Ayrshire


Meru Union Stratified Breeding Strategy farm categories
Breeding advice: Continue to breed with Holstein Friesian, Ayrshire or Fleckvieh as a pure breed (cross breeding is, also in this area a feasible option to improve overall farm results).
Breeding Advice: Breed cows with good feed conversion and avoid breeding bulls too big in size. Crossbreeding Jersey/Holstein Friesian /Ayrshire/Fleckvieh becomes a valuable tool to maintain targeted smaller size (body weight) and fertility (a calf every year).
5%
15%
80%
Highland - Intermediate Zones Breeding Advice: Use Composite breeds (Girlando) and Cross breeding with cows that have a good feed conversion and choose breeding bulls small in size. Crossbreeding Jersey/HF/Ayrshire/Fleckvieh becomes the best tool to reduce size (body weight) and/or fertility (a calf every year), but also using Boran/Sahiwal Cross breeds (F2 /F3) would be a very good option to improve results
Lower Zone Breeding Advice: Keeping composite breeds or good cross breeds of Boran/Sahiwal and HF/Ayrshire/Fleckvieh/Jersey (F1/F2) will be the best choice. Cross breeding the cows in the future should focus on good feed conversion (able to deal with fibrous forages) and avoid breeding bulls too big in size. Crossbreeding Jersey becomes the best tool to reduce size and increase feed conversion
Low production level farm
Medium production level farm
Elite farm

Annex 1. Interbull: Comparing Bulls from Different Countries

To calculate breeding values it is extremely important the national authority in charge of animal records has access to reliable data on milk production, on conformation traits, as well as on functional traits.

To compare breeding values of bulls from different countries it is necessary to convert the breeding values. "Interbull", based in Sweden was started for this purpose by ICAR (International Centre Animal Recording), EAAP (European Association for Animal Production) and IDF (International Dairy Foundation).

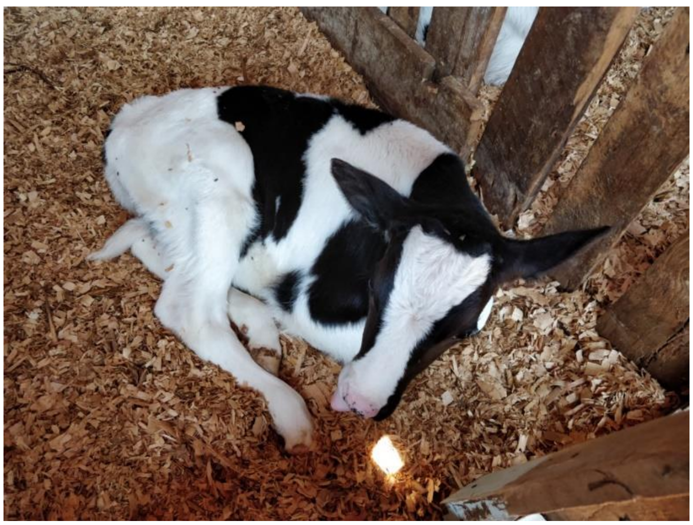
Interbull collects all relevant data and information from as many as possible countries all over the world to convert the breeding values from different countries. Interbull takes into consideration the differences between countries. For example it registers if cows from the same (and from different breeds) in one country produce more milk, or give milk with a higher fat or protein content than the same breeds in other countries.

Also differences in production environment or country specific rating systems of conformation traits, are taken into consideration and corrected for comparison sake, through conversion of the breeding values. In this way Interbull calculates the best estimate how a breeding bull within the same breed in a particular country will perform.

Annex 2. Photo Impressions of Farms visited in Meru County during the Mini Survey

Farmer interviews and random pictures of cows kept in Meru County in different farming environments and management levels





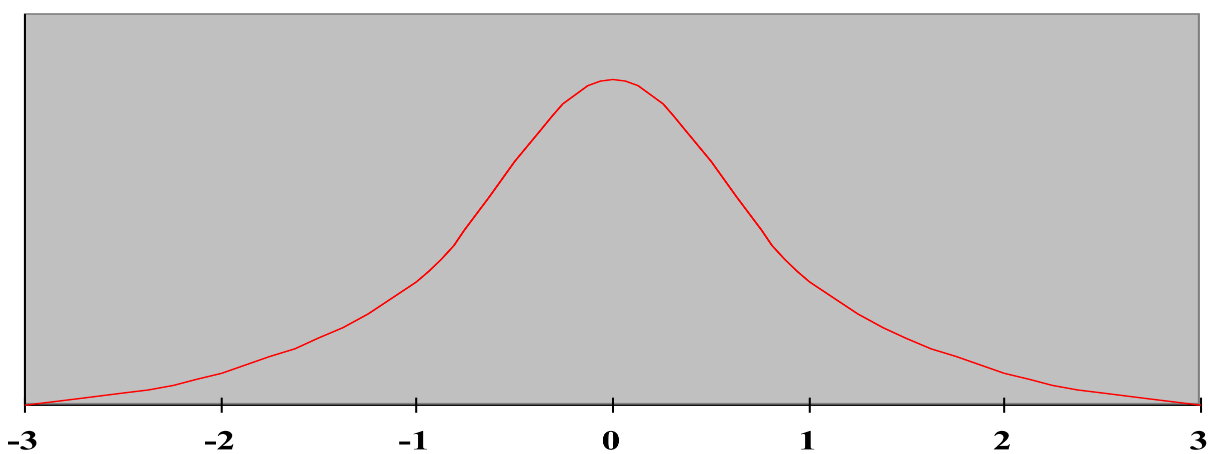

Annex 3. Linear Traits

Linear Traits

The linear traits of a cow are always determined by a certain breeding standard. The linear traits consist of 18 traits, which describe the cow in numbers. The linear traits do not pass any judgement on the cow, they only describe the cow in numbers. All traits are scored between 1 and 9 in the Netherlands while in the USA a point system is used as per the pages below. Except for stature, which is measured in centimeters.

Distribution of indices using a Standard Deviation Curve

- Genetic evaluations for the type traits are expressed on a standard deviation curve.
- Standardized values for linear traits are used because each trait has a different average PTA, and the PTA ranges vary within traits.
- All linear traits have an average score of 0.
- Standard deviation curve values generally range from –3 to +3.
- Extreme values are near –3 or +3.
- The greatest number of bulls are at the average (SDC=0).
- 68% of bulls are within 1 STA in each direction of the average.



US:-3	**-2**	**-1**	**0**	**1**	**2**	**3**
NL: 88	**92**	**96**	**100**	**104**	**108**	**112**
CAN:-15	**-10**	**-5**	**0**	**5**	**10**	**15**
GER: 64	**76**	**88**	**100**	**112**	**124**	**136**

Understanding the proofs of different countries is not as difficult as it may seem. The values of the different countries (in the graph US, and below NL = Netherlands, CAN = Canada, GER = Germany) may look different but are easy to understand. The graph above shows the ranges of the proofs in 4 different countries.

For example, a bull with a breeding value of 108 on the NL scale is comparable with a US bull at +2.00 PTAT or a Canadian bull at +10 conformation.

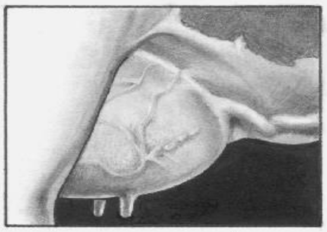
As you can see from the distribution of indices, 95% of the bulls have breeding values between -2 and +2. This means that bulls with a proof above 2 represent 2.5%of the breed.

LINEAR SCORING

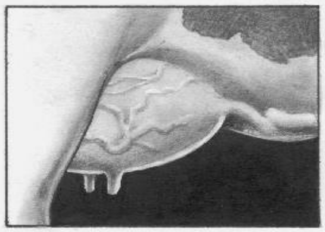
I. Udder Traits

Fore-udder attachment

Preferred when the udder fuses into the abdomen.
Firmly attached with moderate length and ample capacity



1-5 pts
Extremely loose



25 pts
Intermediate strength

45-50 pts
Extremely snug & strong

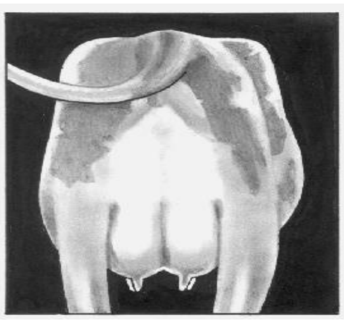
Udder depth

Moderate depth relative to the hock with adequate capacity and clearance. Consideration is given to lactation number and age. The closer to the vulva the better for better depth while maintaining a shallow depth.

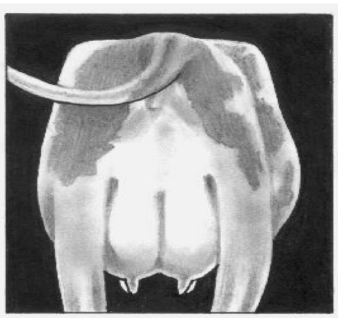
Very deep udder floor

Udder floor above hocks

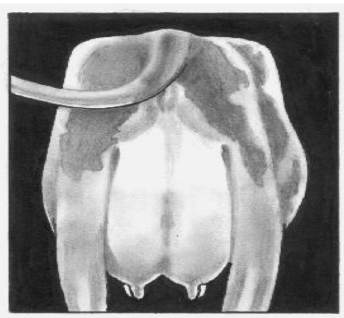
Extreme height of udder



Extremely low



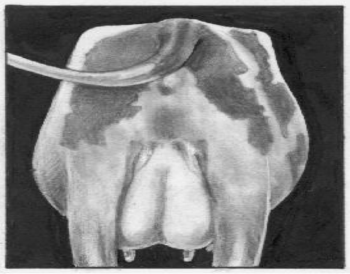
Intermediate height



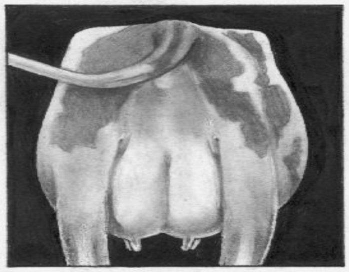
Extremely high

Rear-udder width

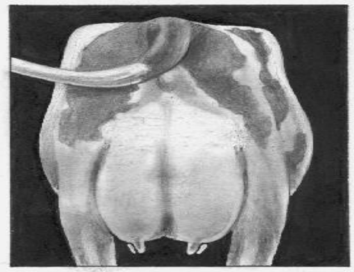
Wide and high, firmly attached with uniform width from top to bottom and slightly rounded to udder floor. The wider the better for more capacity. 5 inches or 12.7cms is ideal.



Narrow rear udder



Intermediate width



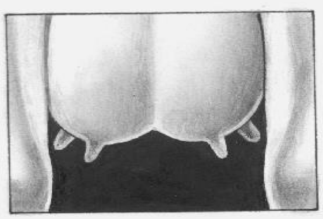
Extremely wide rear udder

Fore-teat placement

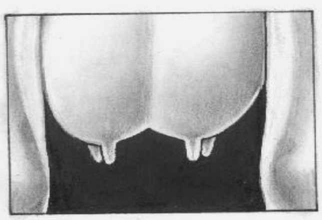
Teat Placement: Squarely placed under each quarter, plumb and properly spaced. Rear teat placement Moderately placed preferred

Fore teat placement

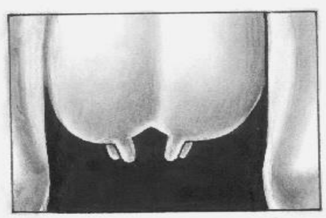
Cylindrical shape; uniform size with medium length and diameter; neither short nor long is desirable. Udder floor level as viewed from the side. Quarters evenly balanced; soft, pliable, and well collapsed after milking



1-5 pts
Extremely wide placement



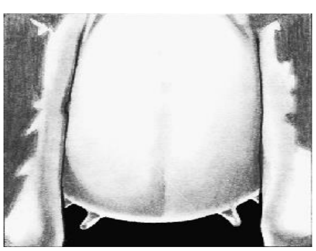
25 pts
Centrally placed



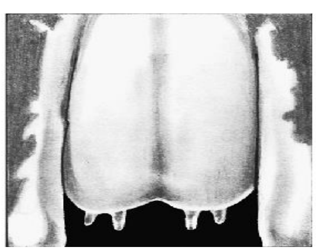
45-50 pts
Base of teats on extreme

Udder cleft

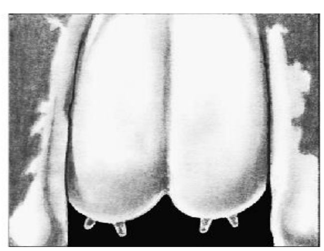
Evidence of a strong suspensory ligament indicated by clearly defined halving.



1-5 pts Weak cleft



25 pts Intermediate

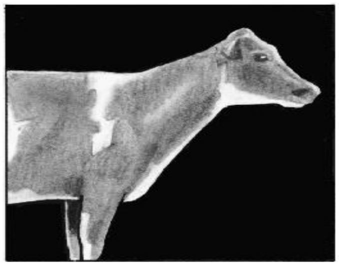


45-50 pts Extremely strong cleft

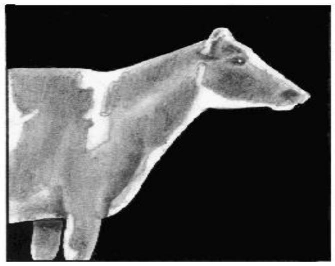
II. Fitness Traits

Strength

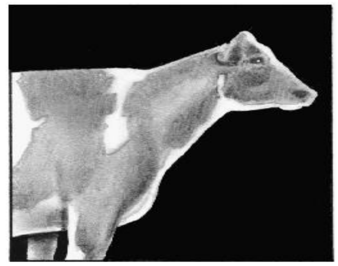
Adequate constitution with front legs straight, wide apart, and squarely placed. Shoulder blades and elbows set firmly against the chest wall.



Extremely narrow & frail



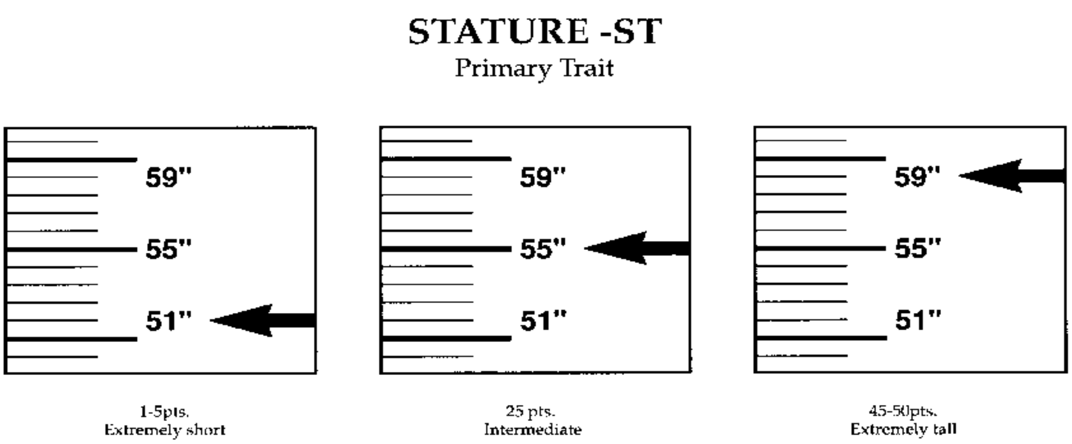
Intermediate



Extremely strong

Stature

Height including length in the leg bones with a long bone pattern throughout the body structure.
Height at withers and hips should be relatively proportionate.



Rear leg side view

Moderate set (angle) to the hock. Moderate about 45 degrees preferred.

1-5 pts
Posty and straight

25 pts
Intermediate set in hock

45-50 pts
Extremely sickled

Rear leg rear view

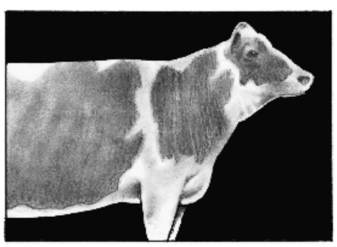
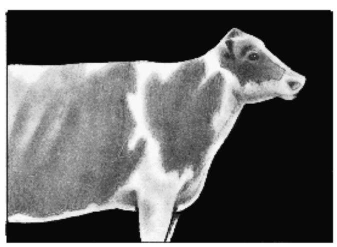
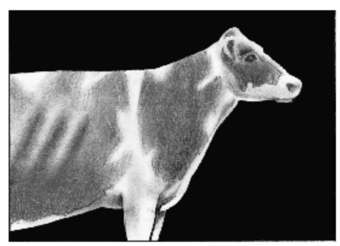
Straight, wide apart with feet squarely placed.
Avoid knock knee
Foot angle
Pasterns: Short and strong with some flexibility, having a moderate, upright angle.
Moderate –avoid lameness.



1-5 pts	25 pts	45-50 pts
Extreme low angle	Intermediate angle	Extremely steep angle

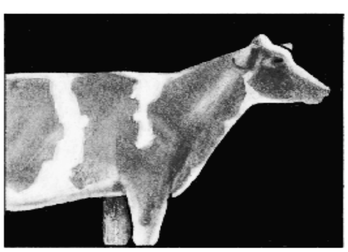
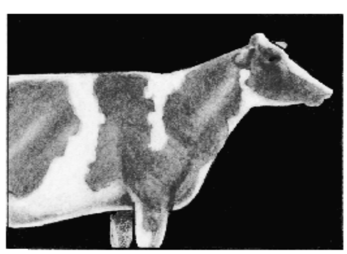
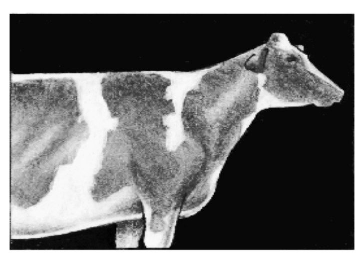
Dairy form-angularity

A combination of dairy-ness and strength that supports sustained production and longevity. Major consideration is given to general openness and angularity while maintaining strength, width of chest, spring of fore rib, and substance of bone without coarseness.
Ribs: Wide apart. Rib bones wide, flat, deep, and slanted towards the rear. Well sprung, expressing fullness and extending outside the point of elbows.

1-5 pts	25 pts	45-50 pts
Extremely tight	Intermediate	Extremely open

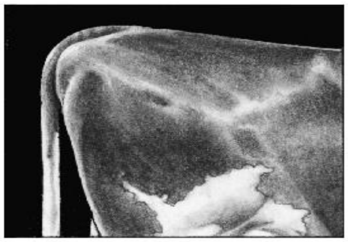
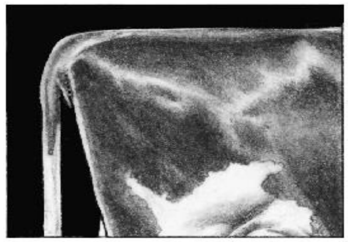
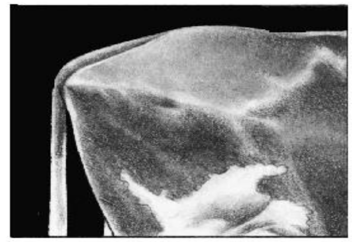
Chest: Deep and wide floor showing capacity for vital organs, with well sprung fore ribs.
Thighs: Lean, incurving to flat and wide apart from the rear.
Neck: Long, lean, and blending smoothly into shoulders, clean-cut throat, dewlap, and brisket.

1-5 pts	25 pts	45-50 pts
Extremely shallow body	Intermediate	Extremely deep body

Rump angle

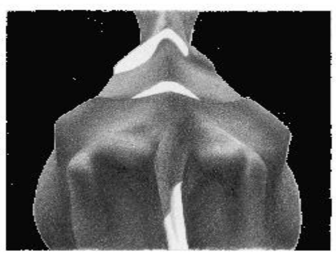
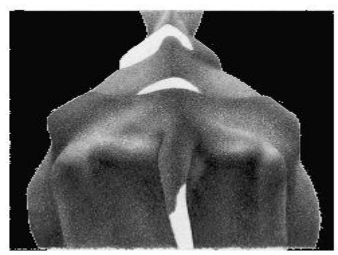
Rump: Should be long and wide throughout. Pin bones should be slightly lower than hipbones with adequate width between the pins.

1-5 pts	25 pts	45-50 pts
Pins higher than hooks	Light slope from hooks to pins	Extremely sloped from hooks to pins

Rump width

Hooks should be wide apart. Tail head should set slightly above and neatly between pin bones with freedom from coarseness.

1points = 2”	25 points = 4 ½”	50 points = 7”
Extremely Narrow	Intermediate Width	Extremely Open

Annex 4. Costs of Hot Cows *(How much does heat stress cost the farmer)*

Most farmers notice falls in milk production when cows get hot. This results in substantial losses in milk income, but reduced in-calf rates, low milk protein and fat tests, live weight loss, higher somatic cell count, more clinical mastitis cases and other cow health problems can often double these losses. With an effective heat stress management program there are substantial benefits to be gained. These include:

- Higher summer milk production;
- Increased 6-week/100-day in-calf rates;
- Reduced loss of embroyos, and
- Increased calf birth weights.

The impact on cow fertility, health and welfare last well beyond the hot months.

Impact on feed intake & nutrition

↑ 20-30% more maintenance energy needed to compensate for the effort of keeping cool

↓ Dry matter intake drops 10-20% (short or long term depending on length + duration of heat stress)

↓ Rumination and cud chewing decreases

↓ Cow's ability to digest and absorb nutrients in feed decreased

Impact on fertility

↓ 6-week/100 day in-calf rates decreased

↑ Not-in-calf rates increased

↓ Length and intensity of heats decreased

↓ Conception rates decreased

↑ Risk of embryo death increased

↓ Calf birth weight and viability reduced

Impact on milk production

↓ Milk production drop by 10-25% or more in high heat stress and by 40% in extreme circumstances

↓ Milk composition is affected with high to severe heat stress:

- Milk protein percentage decreased by 0.2-0.4%
- Milk fat % is more variable day to day, and may be severely depressed if ruminal acidosis occurs

Impact on milk quality

↑ Sediment may increase if cows' teats are allowed to be contaminated with mud and dung

↑ Risk of udder infection increased, which, if occurs, results in increased somatic cell counts

Impact on cow health

↓ Rumen buffering capacity decreased

↓ Decrease in rumen pH

↑ Risk of ruminal acidosis and ketosis increased

↑ Risk of laminitis increased

↓ Immune function suppressed

↑ Risk of mastitis increased

Annex 5. Breed Characteristics of the Girolando

History

The origins of the first Girolando date from the 1940's, compared to other breeds it is a relatively young breed. Around the 1940's Brazilian farmers began to cross the Gir intensively with the Dutch Friesian, looking for two breeds which complemented each other to serve as an improved breed for the Brazilian market requirements at that time. Production and popularity of this breed has been sped up due to its high productivity in terms of fertility and efficiency plus, the efforts of the governmental project for improvement called 'Program Girolando'. In 1989 the Ministry of Agriculture together with the representing associations, drafted the standards for the breeding of Girolando to be 5/8 Holstein Friesian and 3/8 Gir. Today the Girolando is responsible for 80% of milk produced in Brazil.

Characteristics

The Girolando takes its looks from the Holstein Friesian and the Gir, it can be black and white in color but it can vary depending on the percentage of each in the cross. Their ears are large like Gir. Female Girolando have physiological and morphological characteristics perfect for the production in the tropics (udder capacity and support, size of teats, factors intrinsic to the milk, pigmentation, thermo-regulatory capacity, strong hooves and legs, forage conversion, reproductive efficiency). Girolandos start producing calves at around 30 months, the peak of milk production is at 10 years and they can keep on producing till about 15 years. The interval between births is around 410 days. The average production of milk per lactation is 3,600 kg (two milking’s/day) in 305 days, with 4% fat, accumulating a lifetime production over 20,000 kg of milk. Males have adaptability (efficient foraging, resistance to diseases and pests, speed of weight gain), can perform comparable to any specific industrial crossing for meat, when placed in similar situations in breeding. In tests it has shown that average weight gain per day is 1kg, plus it has length and thickness with an even distribution of fat to produce a good carcass.

Criteria

- Hybrid vigor
- Quiet disposition
- Good milk production even in hotter climates
- Forage Conversion
- Adaptability to heat
- Longevity
- Fertility and calving ease
- Meat yield

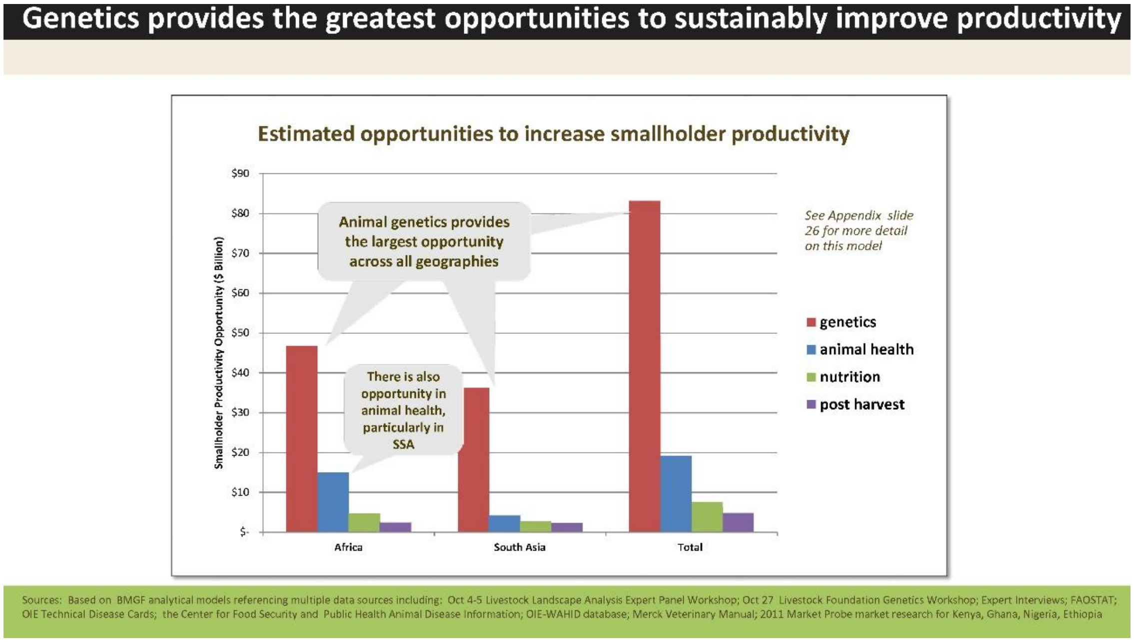
Discussion suitability for Meru County

The breed, being suitable and performing well under tropical climatic conditions, having good criteria for adaptability for heat stress, forage conversion, fertility and body size and weight (carcass) would make the Girolando a suitable breed for the Intermediate and Lowland zones in our breeding study for Meru Dairy Cooperative Union.

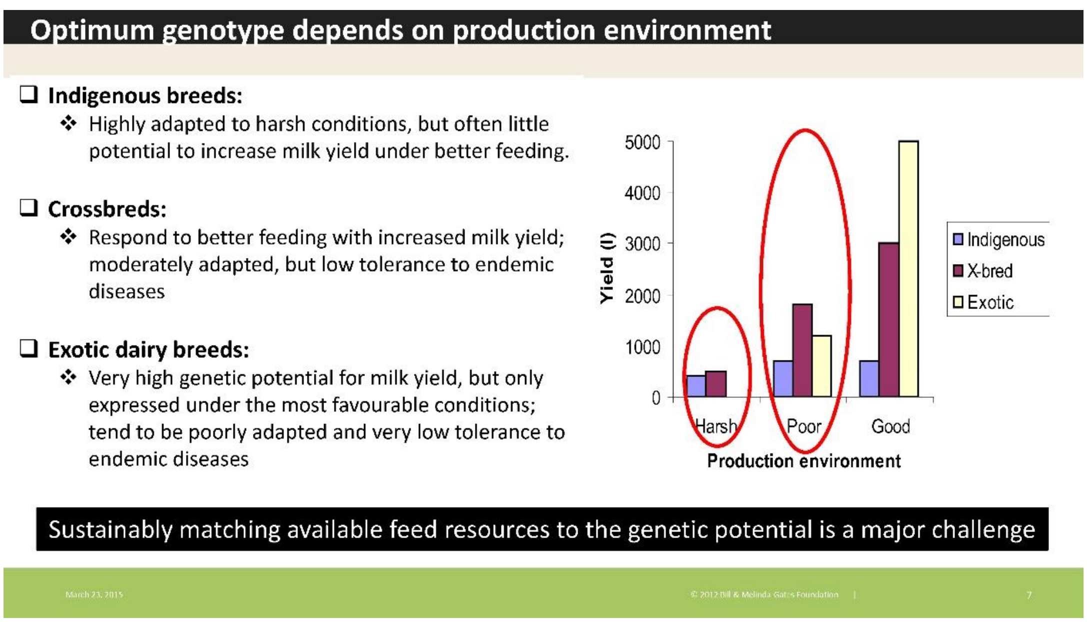
ANNEX 6. MATCHING OF GENOTYPE AND ENVIRONMENT IN DAIRY PRODUCTION SYSTEM

Derived from a power point presentation by the Bill & Melinda Gates Foundation (Dairy Genetics for Sustainable Productivity, Dairy Asia – Towards Sustainability – March 2015, Donald Nkrumah)

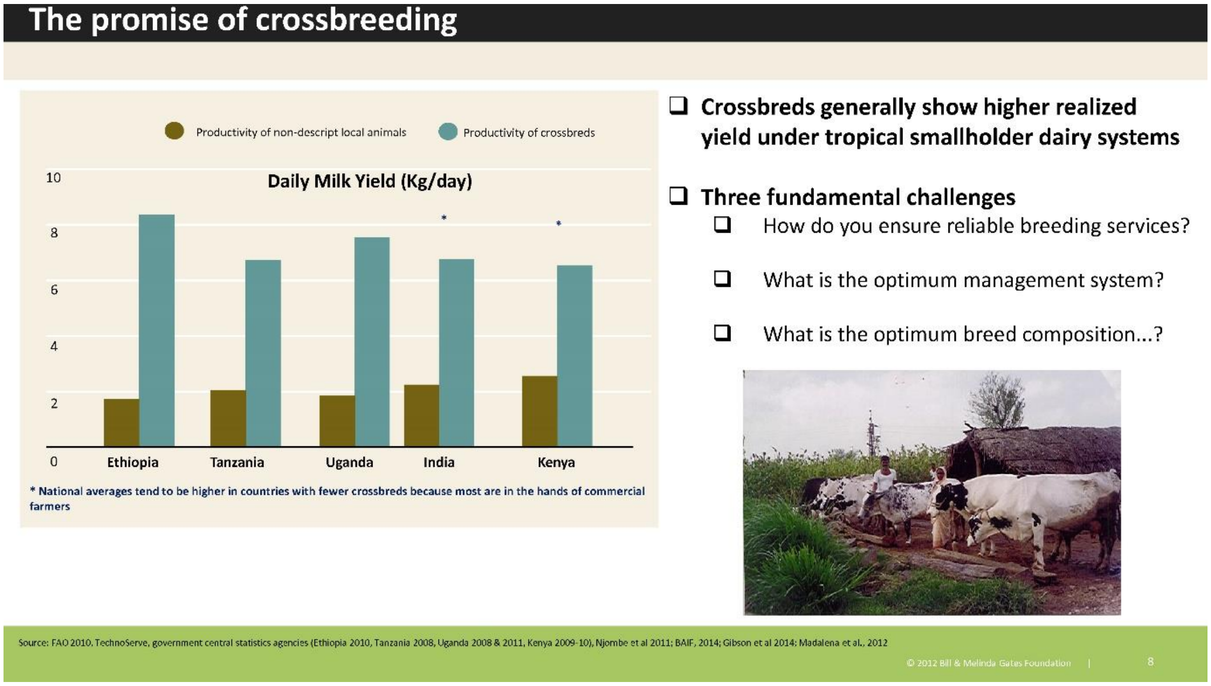
Picture 1. Genetics provides the greatest opportunities to sustainably improve productivity



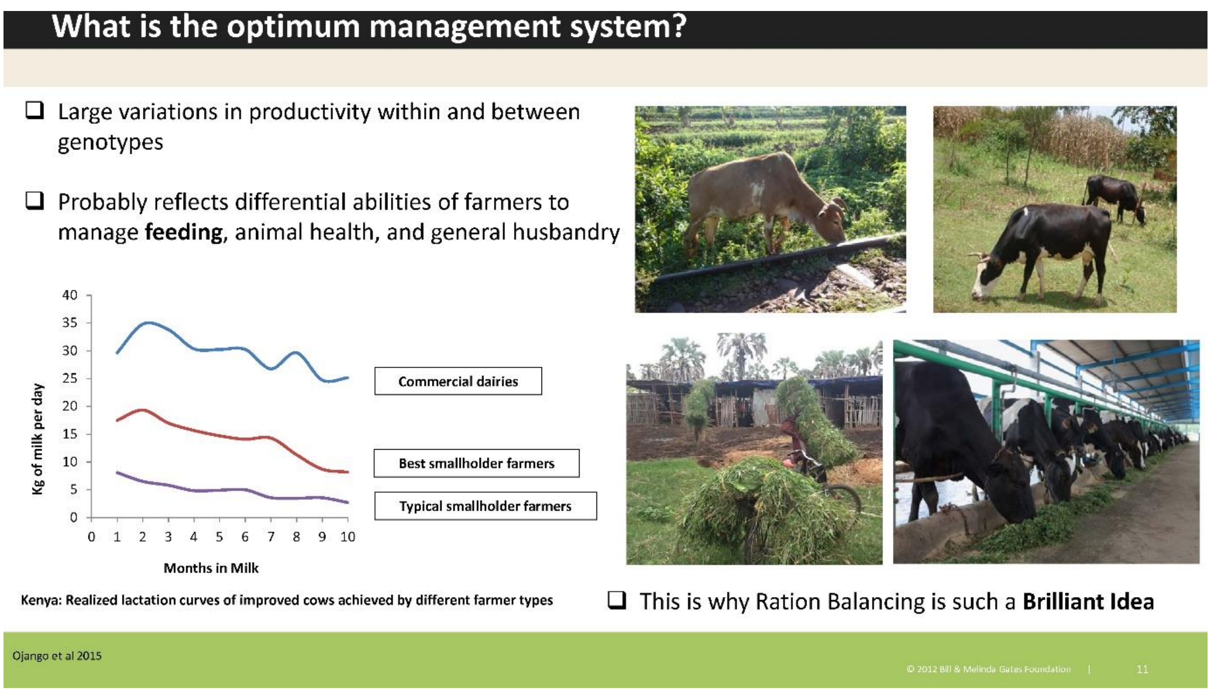
Picture 2. Optimum genotype depends on production environment.



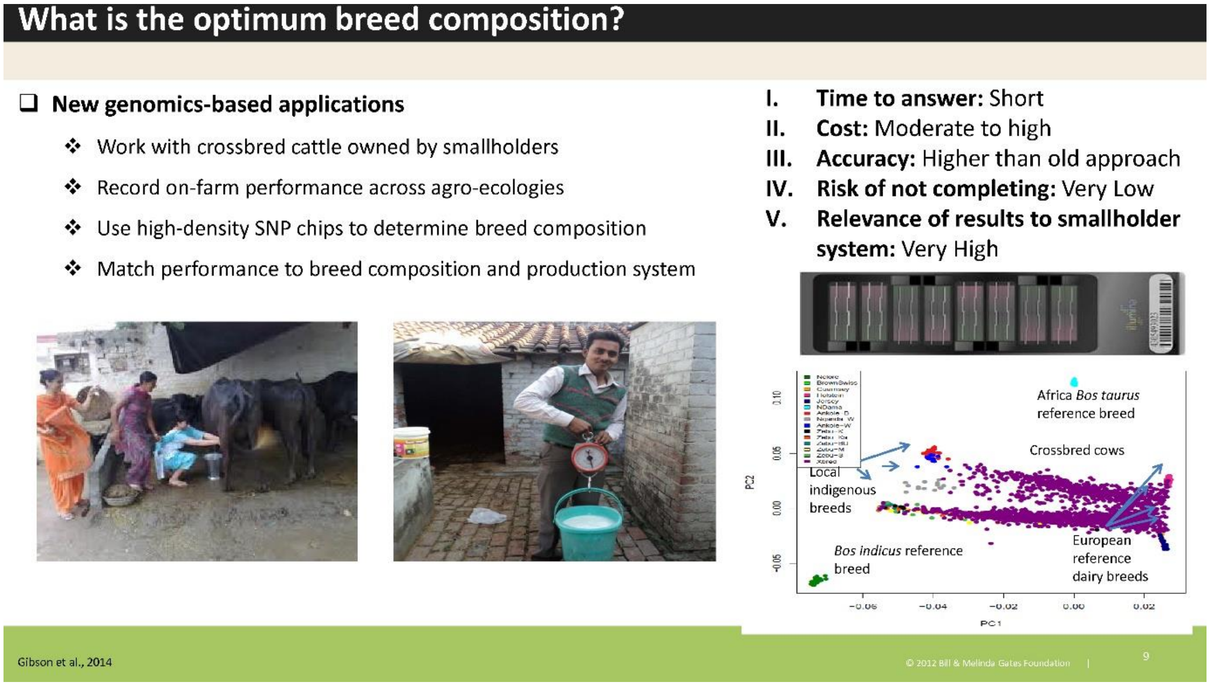
Picture 3. The promise of crossbreeding



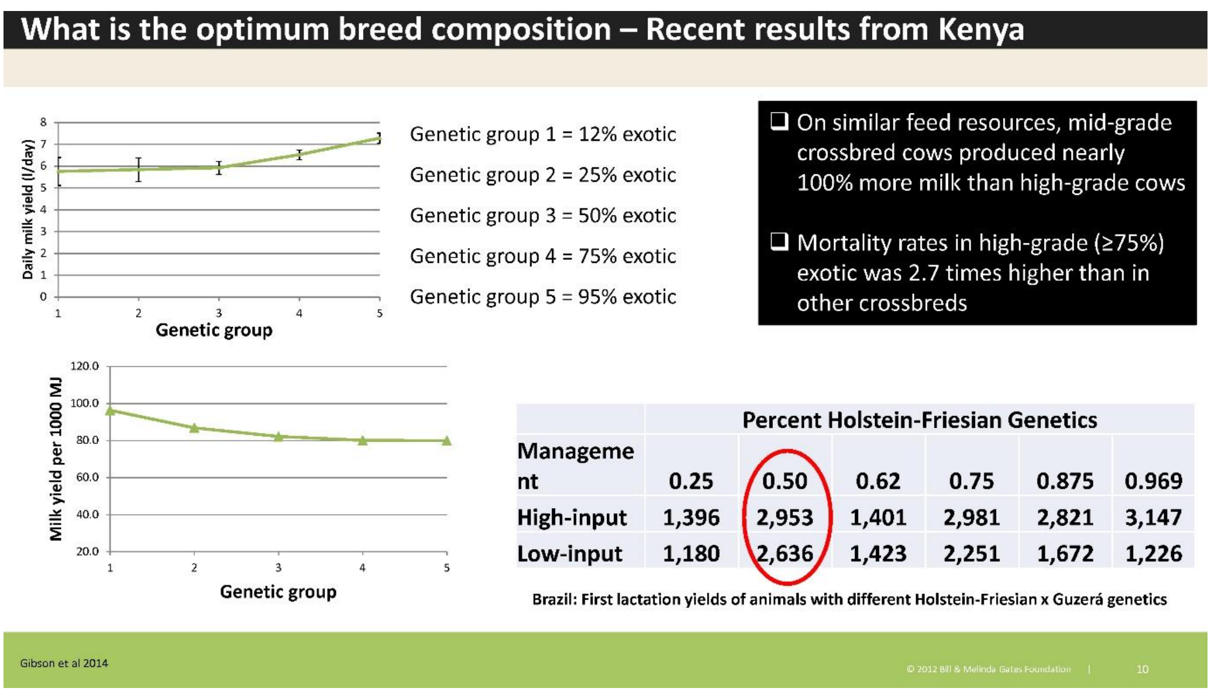
Picture 4. What is the optimum management system?



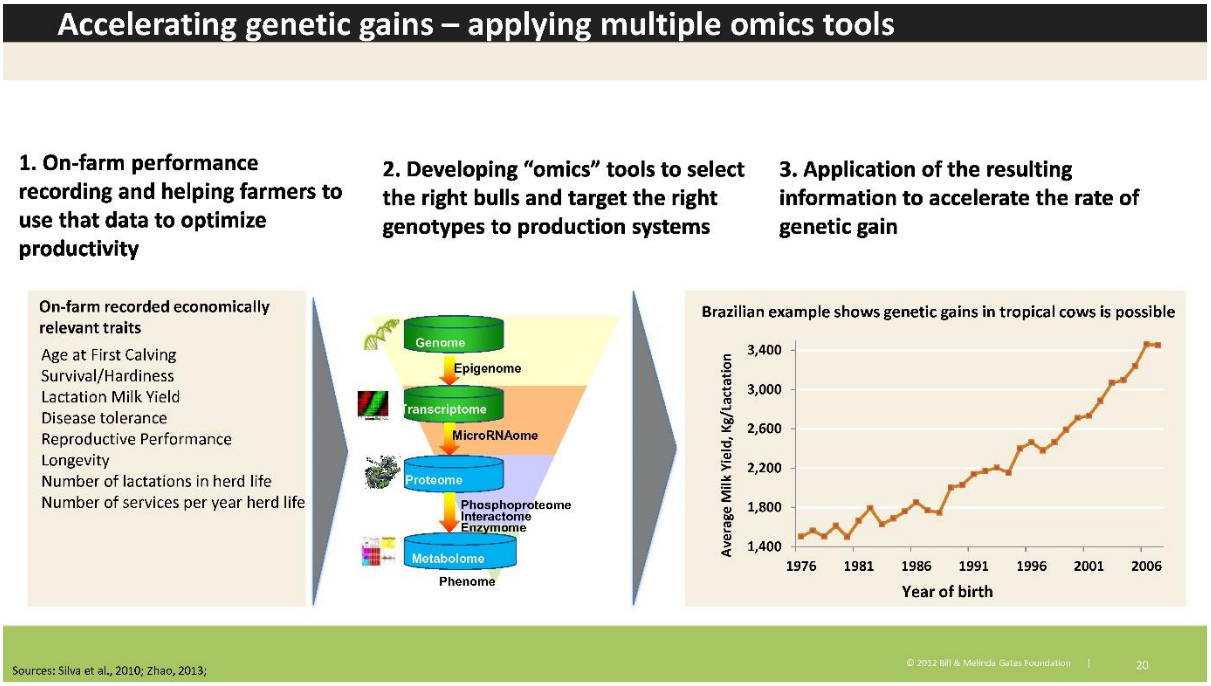
Picture 5. What is the optimum breed composition ?



Picture 6. What is the optimum breed composition? – Recent results from Kenya



Picture 7. Accelerating genetic gains – applying multiple genomics tools (new technologies)



Annex 7. Crossbreeding and the creation of composite breeds

(added during the 3rd revision)

Crossbreeding occurs when males and females of different breeds (or even species) are mated and the resulting offspring are then called crossbreds or “hybrids”.

The hybrid offspring display varying amounts of both breed complementation and “hybrid vigour” or heterosis which is measured as the performance advantage of crossbreds over the production average of both their parents. Occasionally, crossbreds will perform even better than either parent; however, heterosis should be measured against the average of the parental breeds. Heterosis can impact many traits but is especially useful in improving performance in lowly heritable traits, such as productivity, fertility, adaptability, vitality and longevity.

The greater the genetic difference between the parental breeds the larger and more dramatic the expression of heterosis will be. Maximum heterosis is therefore found in crosses between Bos Indicus (Zebu) cattle and Bos Taurus (European origin) cattle because they do not share any recent common ancestors. Additional breeds can be added to increase heterosis, but there is a realistic limit to the number of breeds that usually are included since the management complications multiply as the number of breeds increase.

Another drawback will be the substantial swing in breed composition that occurs between generations and also between years which results in a great variation in herd appearance as colour, size and body shape.

Whereas crossbreeding with the goal to produce hybrids has revolutionized production systems from crop farming to commercial livestock keeping as in poultry (meat and eggs), pig keeping and even some beef production systems, science has shown, due to complications and limitations described above, that long-term crossbreeding of dairy cattle for the sake of utilizing heterosis is very difficult unless the intent is to synthesize a new breed.

Many breeds that are considered purebreds are actually composites if you go back far enough in time. The understanding of genetics involved in crossing breeds of cattle has progressed enormously in the last 15 years. We now better understand the results of producing synthetic lines of cattle, which can be maintained on an ongoing basis when interbred, hence stabilizing new composite breeds. So, composite cattle are a range of new breeds or new lines of cattle bred specifically to improve hybrid vigor. A planned mating scheme is designed to combine the desirable traits of two or more breeds into one “package” (or composite).

While hybrids and composites are both crossbreds, hybrids are generally considered to be F1 or first crosses of purebred parents and composites are a stable inter-mating population originating from crossbred parents. Composites usually incorporate a combination of breeds, each of which contribute a characteristic desirable for good performance or environmental adaptability and designed to retain heterosis in future generations without crossbreeding and then being maintained as a purebred. Zebu breeds have contributed to several composites because of their adaptability to hot climates.

Although composite breeds do not sustain as high a level of heterosis as F1 hybrids do, they still offer some heterosis, with the amount depending on the original breed composition. As more breeds contribute to the composite, retained individual and maternal heterosis increases.

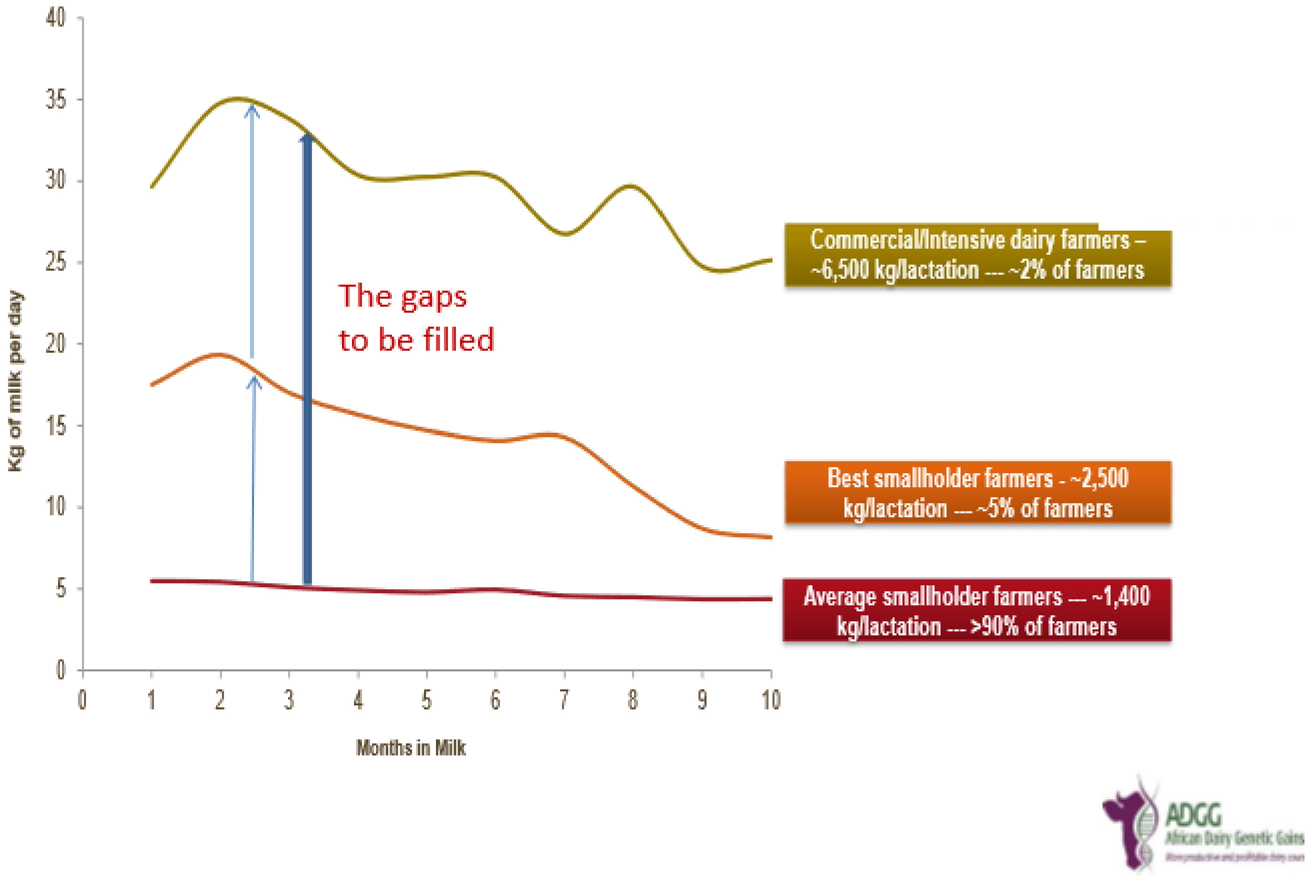
Composite breeds offer the opportunity to use genetic differences among breeds to achieve and maintain the performance level (for such traits as climatic adaptability, growth rate and mature size, carcass composition, milk production and fertility) that is optimum for a wide range of production environments and market scenarios. Further, composite breeds may provide herds of any size an opportunity to use heterosis and breed differences simultaneously.

A composite breed must be carefully formed with even greater attention to breed choices and sire selection than is used in purebred breeding programs. The better the selected sires, the better the final outcome will be. The commercial user of a composite breed has to worry about few of the constraints that the composite nucleus herd breeder encounters, as they can be as easily managed as a purebred herd. Some amazing facts about cross- and composite breeding:

- "KIAN" who was leading the Dutch Holstein charts is actually a 75% Holstein * 25% MRI crossbred
- "VR Fimbe" is one of the chart leading bulls of Viking Genetics. This Danish Red bull's genetics are combined out of 8 dairy and dual purpose breeds including Brown Swiss, Montbeliard, Holstein, Ayrshire and many more!
- Some of New Zealand's top index sires over the years have been crossbreds, having better breeding values than either purebred Holsteins or Jerseys. Semen of crossbred sires is marketed there just as intensively as that of purebred sires
- The very same imported Norwegian Red sire (Norwegian Red is not even considered a true breed yet…) was adopted and used by an Ayrshire breeders society as "purebred" Ayrshire and also extensively used by Dairy Shorthorn breeders in their pedigree breeding program
- Composite dairy breeds are primarily found in hot tropical countries or where cheap pasture based production is mandatory for the farmer's survival as for example "Jamaica Hope" in the Caribbean, "Australian Friesian Sahiwal" and "Australian Milking Zebu" in tropical Australia and…
- "Girolando" in Brazil who where developed through combined effort of farmers and an initiative of the Brazilian Government and who now produce 80% of the country's milk
- "Girolando" can produce in excess of 22,000 litres of milk per 365 days lactation!

ANNEX 8. FARMER CATEGORIES ACCORDING TO ADGG - PROGRAM

(added during the 3rd revision)



Annex 9. List of Persons Interviewed

1. Department of Veterinary Services, Assistant Deputy Director of Veterinary Services Department Breeding - Dr. Muchemi Kariuki
2. Livestock Genetics Society of East Africa – CEO Dr. Maurice Cherogony
3. Kenya Animal Genetic Resource Centre – Head of Extension Department, Dr. Roselyne Wambugu
4. World Wide Sires Kenya– National Sales Manager Dr. Denis Wachira Nyingi
5. ABS TCM Ltd – Sales Executive Wycliffe Mbogo
6. Meru County –County Director of Veterinary Services, Dr. Lawrence Mwongela
7. Meru Union – CEO Mr. Kenneth Gitonga M'Ndegwa
8. Meru Union Extension Department; Dr. John Mutua, Mrs. Dorcus Makena
9. Meru Cooperatives (Boards): Buuri, Antu a'Buri, Mujwa, Ngwataniro, Kithurine, Nkuene, Igoki, Kanyekine, Nyaki
10. Three farmers in each cooperative (names not documented)
11. SNV KMDP - Meru Coordinator Training & Extension Mr Paul Mambo
12. Kenya Holstein Friesian Cattle Society – Chairman Mr Teuri van Helden
13. Gogar Farm – MD Mr Hamish Grant (breeder in Rongai, Kenya)
14. Kenana Farm – MD Mr Bruce Nightingale (breeder in Njoro, Kenya)
15. Kenya Livestock Breeders Organisation (KLBO) – MD Mr Leonard Mukhebi

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