Engaging Opportunities for Camel Production

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Engaging Opportunities for Camel Production

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ESoRPARI

Vision

To become center of excellence in pastoral and agro-pastoral research in Eastern Africa with respect to the generation of pastoral and agro-pastoral technologies, knowledge and information usable to ensure food self-sufficiency; food-security; and economic development in the ESRS, in particular, and pastoral and agro-pastoral communities elsewhere in Africa.

Mission

Deliver and popularize agricultural technologies, knowledge, and information in a participatory and integrated way for all the pastoral and agro-pastoral communities in the ESRS, in particular, and similar communities in other regions of Ethiopia with similar agro-ecologies, in general.

Engaging Opportunities for Camel Production

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Preface

In the pastoral system, camel is becoming a leading animal because of the multipurpose role it has on the provision of milk, meat, social and cultural importance besides unpaid transport service to pastoral community. Camel is suitable in adapting to the changing climate and thriving under shortage of feeds and water and also means of utilizing rangeland feed resources that are not used by other species of livestock. Camels have the most important physiological features that make them, a unique animal. Because of these and other reasons the demand for camel and camel products is increasing and will continue to increase at a rate of much higher than that of other livestock species products and this is a good opportunity for pastoralists and agro pastoralists.

It is envisaged that camel research approach would make immense contribution to bring effective impacts on pastoralists and agro-pastoralists livelihood. However, the research information available so far, indicates that camel has not yet received attention. In this regard, with the main aim of experience sharing from scientists and researchers around the world ESoRPARI in close collaboration with other partners was organized an International Camel Conference. In this conference senior researchers, academicians, development workers, policy makers, pastoralists, international scientists and development partners came together to review the status of camel production and pastoralists livelihood from national, regional and global perspectives.

I recognize that the available information in this book is the outcome of the conference. Therefore, this book entitled ***"Engaging Opportunities for Camel Production"*** will prove helpful to the researchers, lecturers, students and policy makers. It has paramount importance in sharing the key findings and experiences of past research and development activities of camel for the best possible use of the future action plan.

Information drawn from international camel research experience, it also provides scientific updates and current state of knowledge pertaining to camel production. I would like to take this opportunity to express my deepest appreciation to authors who involved in the preparation of this important book for their contribution to address issue of camel development sub-sector.

Guulled Ali Kahin
ESoRPARI, DG

Background

The natural ability of the camel to produce milk, meat, fiber, hide and energy and its contribution to pastoralist livelihood can be improved from perspectives of productivity enhancement, value addition, market access, and institutional support.

The global scientific research in camel deals with basic science, technology development, and transfer. Besides the above significances, research effort on camel in Africa particularly in Ethiopia has also lagged behind other species and an urgent course of action is needed to benefit pastoralists and agro-pastoralists. Under Ethiopian context, camel is among the least studied livestock species and many aspects of camel remain to be investigated (Eyassu,2007).

A sound approach in speeding up camel research requires a thorough understanding of what has been done so far, identification of major gaps and intervention areas. The first attempt of comprehensive document in camel research dates back to the work of Mugerawa (1981), which was limited to the dromedary camel and African situation. The current document covers comprehensive information on the

dromedary camel (*Camelus dromedaries)* and Bactrain (*Camelus bactrainus)* supported with information generated in Africa, the Middle East, and Asia during the last three decades.

The information provided in this document is; therefore, meant to contribute towards better understanding of basic science of camel, technology/information and intervention areas to benefit pastoralists and agro-pastoralists.

Origin and Evolution of Camels

Camel belongs to the class of mammalian, sub-order of ruminant under the group of Tylopodia in the family of *Camelidae*. The family *Camelidae* consists of two genera i.e Camelus and Lama, 2 species of domestic camel (*Camelus dromedaries* and *Camelus bactrianus*) and 4 species of Lama. The third and often missed species under *Camelidae* is the wild species, which is, recently recognized by specific name of *Camelus ferus.*

The origin of camels is usually traced to the North American continent during the Eocene period and disappeared from the mother continent as part of the extinction of North American Pleistocene mammals. During this period, some Camelidae have migrated to Asia while others migrated to South America (Novoa, 1970; Williamson and Payne, 1978; Yagil, 1982). While both camels and lamas evolved from common North American ancestors over one million years ago, no significant differences exist between the various species except for sex differences (Fernandez-Baca, 1978). Taylor et al 1968 showed that the species of Camelidae have 74 chromosomes similar to the number found in llama suggesting the evolutionary changes that occurred were due to single gene or minor chromosome rearrangements.

The modern one-humped camel or dromedary (the name derived from Greek dromados, meaning “running”) is generally thought to have evolved from the two humped Bactrian species (Mugerwa, 1981). The first camels, which probably reached North Africa, were more closely related to the two-humped camel (*Camelus bactrianus*) although the stock became extinct and subsequent re-introduction of the camel to Africa involved the dromedary.

The one humped camel sometimes referred as Arabian camel is thought to have been domesticated and extensively employed in Southern Arabia around 3000 B.C. while the Border of Iran and the USSR were the first homeland of Bactrian around 2500 B.C. (Bulliet,1975). The substitution of Bactrian by dromedary in some places has occurred because the pastoralists of Syria and Arabia valued the one humped camel both as an animal and as an count of its products while the Bactrian was raised by Asian people who had alternative sources for milk, meat and wool (Bulliet, 1975).

Entry of camel into Africa involved issues on mode of entry as wild form and the route of entry. The archeological evidence suggests that two routs of entry i.e., the north route and the south route (Saber, 2012). Wild camels appear to have survived in North Africa into the Neolithic period. However, their complete absence from the early Saharan

rock drawings and from writings and tomb and temple paintings of dynastic Egypt indicates that by historical times wild camels had died out in North Africa. The domesticated camels enter Egypt after that time. This may lead us to support the north route of domesticated camel entry via Sinai i.e. the north route of entry.

The second hypothesis of the south route entry of camels into Africa is based on archeological findings in many stops along this route of Egypt, Sudan, Ethiopia, Somalia, Yemen, Arabia, Oman, and Gulf area. The dromedary appears first to have been domesticated in the southern Arabian Peninsula between 3000 and 2500 BC and it is suggested that coastal peoples there switched from hunting camels to herding them for their milk. The camel subsequently spread to Somalia between 2500 and 1500 BC, and then northward and across to Egypt in the first millennium BC. This expansion may have been connected with the growth of the incense trade.

Camels existed in Africa during pre-Roman times (Bulliet, 1975). They first entered Africa through southern Arabia and the Horn of Africa. Bulliet (1975) supports his contention with a number of facts based on similarity between Somalia and Southern Arabia in terms of focus on milk production and management type. From climatic point of view, he argues it is unlikely that camel husbandry could have spread into Somalia from the north, i.e., via the Sudan, since differences in climatic regime would have interfered with the

camel's reproduction (Farah et al, 2004). By contrast, the climate in Somalia including northeastern Kenya and southern Arabia is very similar, especially concerning the monsoonal rainfall scheme, which is a determining factor in the camel's breeding season.

Additionally, there are technological parallels between camel saddles in Somalia and the island of Socotra, which Bulliet (1975) presumes to be a staging point in the spread of the camel from Arabia to Somalia. This last presumption is supported by Socotran rock drawings of camels that are tentatively dated to the 10th century BC (Köhler-Rollefson, 1993). Ancient Somalis domesticated the camel somewhere between the third millennium and second millennium B.C. from where it spread to Ancient Egypt and North Africa.

The presence of a "colony" of domesticated dromedaries of southern Arabian origin in the Horn of Africa during the 1st and possibly as early as the 2nd millennium B.C. could also account for occasional pre-Ptolemaic incursions into areas further north, such as Sudan (Saber,2012). It is possible that a population of domesticated dromedaries existed in a circumscribed area in the Horn of Africa much earlier than 1st century BC, and that occasionally camels or at least knowledge of and familiarity with them, filtered into the African countries further to the north (Zeuner, 1963). From the presence of camel paintings with Ethiopian-Arabian style and fossils in different rock shelters in Ethiopia, it is possible

to presume and predict that camel keeping might have taken place in the Horn before 3000 years ago. (Yosef et. al. 2015)

Prominence of Camel

In pastoral and agro-pastoral mode of production, livestock production is integral component of the farming system and camel is the basis of livelihood of several millions of households in Africa, the Middle East, and Asia. In Ethiopia, such a mode of production is the basis of livelihood of about 10 million people (PADS, 2004). Ecologically, arid and semiarid environment accounts for 60% of the total land mass, 20 percent of total livestock, and 11 percent of human population in Ethiopia (PADS, 2004). Because of its harsh nature, such environment can only be utilized effectively by species such as camel. At time of drought, camels are known to suffer the least loss as opposed to cattle and sheep. Based on data taken in Niger by FAO, camels suffered 20 % loss while the estimated loss in cattle and sheep were 100 and 50 percent respectively in response to the drought of 1973 which was the worst drought over fifty years (Yagil,1982).

Camel production offers extra ordinary opportunity to combat malnutrition in arid and semiarid environments. One of the most advantageous attributes of the camel in drought areas is its ability to utilize plants that grow well under arid conditions and are unacceptable to other grazing herbivore. Camel is also noted to have unique physiological advantages

over other ruminant species that enables it to survive in harsh environment. The unique advantage of camel lies in its slower water turn over (Macfariane, 1977) and efficient nitrogen metabolism (Farid et al, 1979). Owing to its reduced nitrogen excretion in feces and urine, camel has more efficient nitrogen conservation mechanism than other ruminants leading to a steady protein synthesis even on a low-protein diet (Farid et al, 1979).

Biologically, camel is a unique animal adapting well to arid and semi-arid environments and its products and services offers special advantage over the product and services provided by other livestock species. Besides dietary value, camel milk is also known for its medicinal value related to autoimmune. Camel milk is currently in use for treating immune problems such as diabetics, allergies, autism syndrome, Crohn's disease syndrome, and hepatitis (hepatitis B, hepatitis C). Camel meat also offers unique features of advantage to human nutrition (Yagil, 1982).

In terms of socio-cultural dimensions of pastoralists and agro-pastoralists, camel is the most respected and prestigious animal species. In economic value, camel fetches the highest price in livestock marketing and its value is equated to 44 heads of shoats (Tezera et al, 2012). Based on revenue generated in 2010/11, its contribution to foreign currency earnings under Ethiopia context was estimated to be 37 million USD per year accounting for 13% of the number of

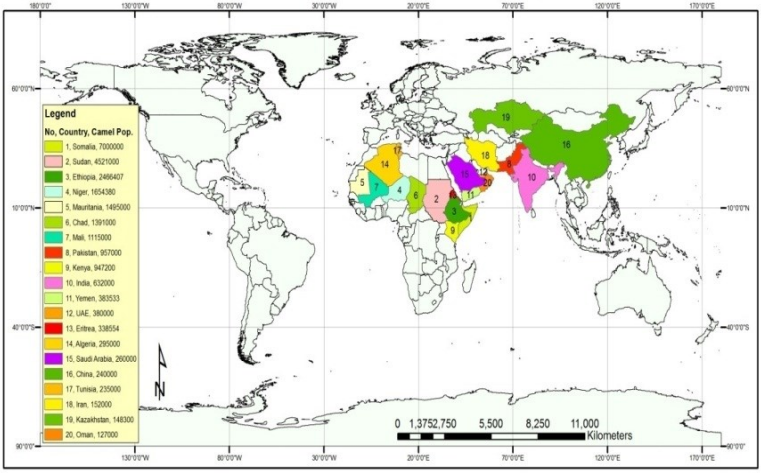
exported live animals and 25% of the total revenue generated by livestock export (NBIIA. 2011). The economic value of the service offered by camel in terms of transport and draft power is also quite significant since a single camel can replace a pair of oxen in terms of draft power capacity.

Dispersion of Camels

Information on statistics of camel population is usually based on estimates to represent a country, region, or the globe. The estimates, can serve as basis to understand the resource and opportunities accrue to the resource base in each region and country. Based on the estimates of FAOSTAT, 2011, there were 25,385,468 camels in the world in 2009. The majority of the camels in the world are one-humped Arabian or dromedary camels (*Camelus dromedaries*) with about 85% of them in Africa. Besides dromedaries, two-humped camels (*Camelus bactrianus*) are also found in Asian countries.

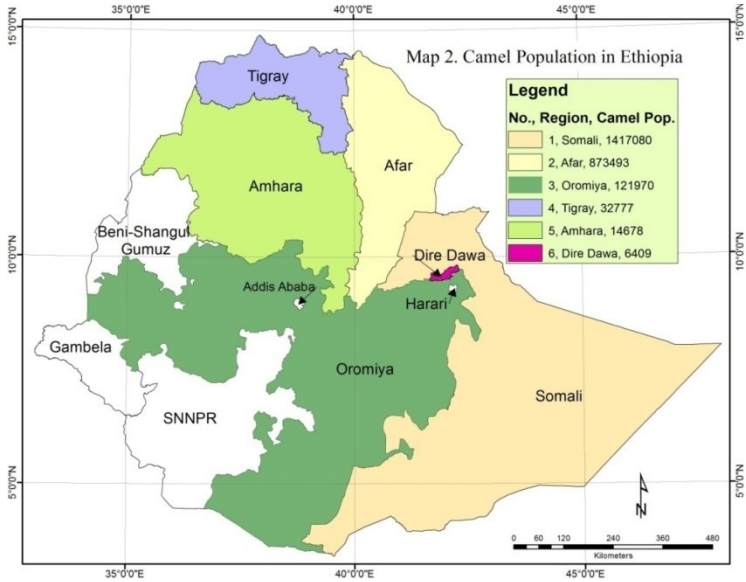
Sudan, Somalia, Ethiopia, and Kenya accounts for about 60% of the global Camelid (FAOSTAT, 2011) and these countries are not only endowed with the resource base but they also enjoy a favorable strategic geographical position because of their proximity to the Arabian Gulf states especially Saudi Arabia which offers significant markets for live camels. Based on FAOSTAT, 2011 global distribution of camel population is given in map1. The ten top countries with the highest camel population (with a herd size 0.5 million and above include) Somalia, Sudan, Ethiopia, Niger, Mauritania, Chad, Mali, Kenya, Pakistan and India (Map 1)

Map 1. World Camel Population



Currently, camel population in Ethiopia is estimated to be 4.5 million (LMP, 2014) and the one-humped camel dromedary (*Camelus dromedarius*) are found in the pastoral and agro pastoral areas (Map2).

Among the pastoral regions, Ethiopian Somali Regional State accounts for about 58% of the Ethiopian camel population and the rest five regions account for 42% of the national camel herd.



Globally different trends have been noted in terms of camel population over the years (Table 1). Comparing global camel population in base year of 1978 to the data of 2009, total population of camel has grown by about 9 million, which is a growth of about 66 percent in almost thirty years. The major increase in population was from Africa and herd growth in Asia was almost constant. African countries, which have substantially contributed to the growth, include Ethiopia, Chad, Kenya, Mali, Mauritania, Niger, Somalia, and Sudan. Earlier observation by Williamson and Payne 1978 also substantiated the trend that world camel population is not increasing very rapidly mainly because of the decrease in numbers in non-tropical areas.

Table 1 Trends in Camel population (000 heads)

Country/region	1978	2009

World	17000	25,894
Africa	12000	21,854
Asia	4.9	4,033
Algeria	147	295
Chad	26	1391
Ethiopia	960	2400
Kenya	574	947
Mali	198	1150
Mauritania	718	1495
Niger	350	1654
Somalia	5400	7000
Sudan	2904	4521
Tunisia	205	235

Source: FAO, 1978 and FAO, 2011

In Ethiopia, there are clear trends that camel production has even moved to the mid altitude areas and definitely there is an increasing trend in camel population although it is not supported by accurate statistics. The increasing ownership of camels by Borena herders (Solomon and Coppock, 2004) and the Issa-Somali in Shinile zone (Ameha et al., 2008), associated with the drought-resistance qualities of camels, changing vegetation, and other factors is an indication of such a trend.

In India, during the last one decade camel population in the arid zone showed a decreasing trend of about 25 percent which is a matter of great concern and the trend was mainly attributed to continued shrinkage in grazing resources, increase in command area both under canal and tube well irrigation and fast urbanization pressure (Patil and Gupta,2012).

Classification of Camels

Various Classification based on natural breeding areas (hill camels, plains camels and intermediate) was provided by Lees (1927) while Cole 1975 distinguished three types beast of burden, the riding and the milking camel. Within the broad classification, there are numerous breeds and types of dromedary. The names of the dromedary breeds and types found in Africa often reflect the locality or country where animals are raised, the people who breed them or simply the animals color rather any division into work, riding or milking breeds. Although application of modern tools in classification of dromedary in some countries is currently on progress much remains to be done towards comprehensive and systematic classification of camel breeds in Africa especially in the horn of Africa that accounts for the major share of the global dromedary.

Ethiopian Perspective

Camels are of great interest for Ethiopian pastoralists and agro pastoralists, they are uniquely adapted to the lowlands, and contribute significantly to the food security of pastoral and agro-pastoral households. The animal is very well adapted to hot, dry environments due to its physiology. Camels inhabit almost all peripheral drier lowlands that generally fall below 1,500 meters above sea level.

Nevertheless, to date, production or productivity levels of camels are far below the potential. Productivity per individual animal has often been reported to be very low. The major causes attributed to such low productivity has been largely because camels were not given due attention in research and development. However, from perspectives of the increasing climate change/variability, recurrent drought, and feed shortage in pastoral and agro-pastoral areas camel production is a high priority area demanding research for development intervention. Although camel is the most adapted domestic species to harsh conditions, important changes are currently occurring in the Camelid farming systems around the world and these changes have significant impacts on the animal itself and on the dimensions of the scientific questions raised

(Faye, 2013, 2015). Significant and rapid changes are undergoing in pastoral environments and the question of sustainable development for Camelid farming systems needs more support of scientific community for proactive decision-making and innovation that minimizes negative impact and maintains balance between social, environmental and economic growth. Optimization of the natural resource through appropriate livestock production systems, and particularly that of camels, is required. Research results based on pastoralists' needs and natural resources will play a significant role in nutritional security, which is a big challenge in the dry land areas of the country.

Strong bound of the national economy to research and the specific social and economic role of camels in the lives of the pastoralists have warranted the formulation of the national camel research strategy. Increased attention to camel research is clearly necessary in the context of the need for food, greater equity, and environmental considerations. There are enormous gaps between existing research findings and desired research outputs. Only little work has been carried out in camel breeding and genetics, feed and nutrition, camel health, camel production, husbandry and reproduction, camel socio economics and extension and post-harvest. In order to bridge the gap, new research strategy should be developed to address the gaps.

Regarding the economic importance camel covers in wide arid and semiarid areas of the country, which are not suitable for crop production. The one humped camel is kept by pastoralists and plays an essential role in their subsistence economy and social organization of the pastoral and agro pastoral society. Camel are an important species of livestock in the pastoral economy because of its extraordinary ability to perform in arid and semiarid environments where surface water is lacking and where there is scant vegetation that is not accessible to other livestock. Camels are also able to produce milk with long lactation period and maintain milk production throughout drought period when milk from other animals is scarce. Camel is almost the major source of food, power, cash, and means of storing wealth for pastoralists

In general, the role of socioeconomic research emphasize on camel husbandry as a priority strategy to recurrent drought particularly in arid and semi-arid areas. The trade of live camels to North Africa and the Middle East is also vibrant and prices are higher than at any time in the last 15 years, a great financial benefit for families with surplus camels to sell. In addition to all the above benefits of dromedary camels, in Ethiopia live camel trade value in 2010 was close to 61 million USD which is greater than the annual export values of other animals combined together (Aklilu and Catley, 2011).

On the socio-cultural perspectives, pastoralists use camels for travel and/or commercial operations. Domestic uses of camel include carrying grain, commodities from market, and large quantities of drinking water from wells both for people and for calves in dry season and as draft power. Members of different communities exchange male camels for transport and female camels for milk. The number of camels owned measures wealth and social status of individuals and households in the pastoral areas. Camel is highly linked with pastoral lifestyle and economy. As an ensemble of all economic and social values, camel is part of poetry and adulation between pastoral and agro-pastoral. Camels are also used as bride price and as payment to blood compensation among the pastoralists and agro pastoralist. Camels are slaughtered for *Moulid* (Birthday of the Prophet Mohammed), wedding, funeral and when payment to blood compensation is effected in contractual agreement (*ibid*) (Schwartz, 1992; Farah *et al*., 2004).

Camels are sold only during times of crisis and when there is a need to balance the sex ratio of the herd. The preference is to have more of females than males in order to ensure good supply of milk and reproductive potential. A gift of camel is a sign of high honor and is used to cement relationships between mutually dependent groups and individuals. Pastoralists see camels as a banking system or security against drought, disease, and other natural calamities that affect smaller stock more seriously. Their lineage members

commonly provide households that lose their livestock due to drought with camels. Camels also act as a linking factor between different lineage groups and promote group solidarity. Even though a man inherits camels at birth from his father and camels are individually owned, they are at the same time the collective property of a particular party lineage (Farah *et al*., 2004).

Production Systems

Based on the levels of management and targets of production, the dominant and distinct production systems are extensive, semi-extensive, and intensive system of camel production

Extensive Management

This practice is very common among camel breeders who rear small, medium to large camel herds. Under this system, camels graze on available rangeland. Everyday camels cover a distance of around 15 to 20 km along the activity of browsing and grazing. Camels in herd are collected in the spring season for hair shearing, treatment against mange, branding etc. The animals are released free grazing again after above operations. It is usual practice to collect camel herds during the 3 months of the rainy season of July to September to prevent any type of damage in crops. Most, but not all herders also like to supervise their camels during the breeding season around November and March in order to prevent fights between competing males.

Semi-extensive Management

This system is practiced around town and villages in the marginal area. Camels are partly offered with traditional local fodders like as per the availability and prevailing market rates and are partly allowed for grazing and browsing in nearby common grazing land. The ecological setting and the degree of competition from other land use strategies determine which particular herding system is adhered to it. Many of the migratory camel herds return at regular intervals to the villages for water, but they can also range several hundred kilometers from their owner's home.

Intensive Management

This system is mainly followed in cities/big towns where camels are used as a source of livelihood by transporting various materials such as food grains, building materials, fodder etc. Under this system, camels are stall fed exclusively on purchased feed form market. Some of these camel owners also are engaged in agriculture farming during rainy season of July to October.

Regarding the evolution in camel production system substantial lesson can be taken from Saudi Arabia. Abbas, et al (2000) surveyed 38 camel herds in Al-Qasim region of Saudi Arabia, and identified four distinct herding strategies for the husbandry of camels in the area, namely commercial dairy herds, family prestige herds, pastoralist and agro-pastoralist herds, and peri-urban feedlots herds. The largest

number of camels was found in the dairy herds, where two herds had 2100, and 420 animals with the average herd size of 92. Only two herds were operating on a large commercial scale while the others were not.

Profound changes in pastoral livestock production have also taken place in Saudi Arabia over the past half-century, as documented by Ahmad (1998); Al-Eisa (1998); and Abdulla et al. (1998). Traditional Nomadism as a production system no longer exists in Saudi Arabia. There is noticeable decrease in the number of pastoralists in the country (Al-Humaidi, 1994). Furthermore, there is a tendency towards settlement of pastoralists. About 40% of camels in the country are kept by pastoralists who constitute less than 10% of the total population (Al Humaidi, 1994). Dependency on range forage as a basic feed resource has declined from 100% to less than 20%. Nomadic movements have been mechanized and operations commercialized. A major shift has taken place from traditional camel rearing to commercialize sheep rearing. Herd sizes have increased manifold to suit the new economic conditions. Expansion in the sizes of production operations, in addition to other social changes, has resulted in a growing demand for foreign labor.

Recent reports (Shuiep et al, 2012) on camel production systems in Sudan also substantiate the trend that the traditional subsistence production system is evolving into commercial dairying via semi-intensive camel farming as

currently noted in Khartoum State and other big towns. The emerging production trend was noted to have features of limited herd size but focusing on high milk yielders, limited number of male to reduce cost and selling young male camels as means of extra income and feeding management based on supplementation with concentrates, use of good quality basal diet and continuous water supply.

Under Ethiopian situation, majority of camel herders inherit this mode of production from their ancestors of subsistence economy. Though they are well versed with camel, raising yet their indigenous camel production systems need up grading based on modern animal husbandry practices, keeping in view a shift from subsistence level to commercial camel production. The settlement program and introduction of irrigation schemes in pastoral and agro-pastoral setting shall push the production system along the path of intensification and market orientation. Earlier assessment report (Koness, 1976) of the potential of irrigated pasture and its contribution to camel production substantiates the possibility of supporting intensive system of production. Recent reports of Yakob and Andey (2011) on the commercialization of camels in the mid altitude areas of Ethiopia and beyond is also indicative of the evolving mode of production. The trend currently noted in Sudan is also being experienced in Gode town of Somali regional state (Sora, 2010). In response to the evolving system of production and degree of market orientation, herd structure

and goal of production, input uses and productivity and demands in service delivery of research and extension are expected to take a different shape eventually. Thus reconfiguration of thought is needed how to respond to the evolving system of production.

Current State of Knowledge

This section provides insight on the current state of camel science, knowledge and technology for one humped camel (*Camelus dromedaries*) and two humped camel (*Camelus bactrianus)* based on results of global and national (Ethiopian) studies in various disciplines to provide broader understanding. The respective disciplines whose state of knowledge is presented including aspects of productivity (genetics and breeding, reproduction, health, nutrition), product and quality (milk production and meat production), services(transport, power, and recreation) and socio-economic and marketing aspects. Additionally major findings, lessons, and gaps are highlighted to provide broader overview of what is available and what is lacking to facilitate better understanding of camel science as basis for commodity development along the value chain.

Genetics and Breeding

Among grazing herbivores camels are the least studied in terms of genetics. Genetic characterization using biochemical and DNA markers targeting camels have been attempted in few countries and genetic improvement programs in camel are so limited.

The extent of phenotypic variation is valuable to select and utilize different camel populations based on their specific characteristics and body conformation in breeding program. The presence of different camel populations in morphology, productive and adaptive characters may provide a basis for selection and improvement (Yosef *et al.,* 2015).

In most countries, identification of the camel breeds has been confined to phenotypic characterization and genetic characterization is not yet supported by molecular studies to identify distinct breeds. Attempts made towards better understanding of genetics of camel and associated improvement programs in various parts of the world are comprehensively described in the following sections.
In Ethiopia, two types (Somali and Afar) of camel based on their locality are traditionally known. Within each type, there could be different breeds as recent study on phenotypic characterization of Somali camel pointed out (Hassen et al.

2012) and (Berhanu et al. 2015). The current information on the morph metric characteristics of these indigenous camel breed types could be complemented with genetic characterization using biochemical and DNA markers to obtain phenotypic- ally of pure local genetic resources for future selection and breed improvement strategies to guide management and conservation of the breeds.

In India, eight distinct camel breeds of dromedary camel are known to exist besides several other strains developed and named after local breeding initiatives. An elite herd of four indigenous breeds namely, Bikaneri, Jaisalmeri, Kachchhi, and Mewari has been developed and characterization completed based on phenotypic appearance, biometry, and quantitative and molecular aspects. The molecular studies have also shown enough genetic variation between and within dromedary breeds. Reproducible polymorphic bands with varying frequencies among the three breeds of camel were obtained with these random primers. Based on the results of Indian studies, the lactation in dromedary can continue up to 24 months. The average daily milk production in dromedary from two teats for the initial 16 months was 3600 ml and for rest of the months until 24 month is 2100 ml. The peak yield was observed in the third month of lactation. In summary major research, findings/lessons on camel genetics and breeding in India are the following

- An elite herd of indigenous breeds can be developed and characterized based on phenotypic appearance, biometry,

and quantitative and molecular aspects;

- The PCR-RAPD technique can be adopted to show enough genetic variation between and within dromedary breeds and reproducible polymorphic bands with varying frequencies among distinct breeds of camel can be obtained with the primers; and
- Breed descriptors of indigenous camel breed could be developed.

Although information on camel breeding and genetics is very rare, the result of a recent study in the Kingdom of Saudi Arabia (KSA) has offered information on direct heritability estimates for body weight, milk yield, and annual genetic progress for milk yield. In a recent study,

Al-Mutairi, et al (2010) have reported direct heritability estimates of 0.37, 0.50, 0.60, and 0.85 for body weights at birth, 3, 6, and 12 months of age, respectively, and 0.25, 0.37, 0.49, and 0.29 for average daily gain (ADG) 0–3, 3–6, 6–12, and 0–12 months, respectively. Heritability and repeatability estimates for milk yield at 305 days were 0.24 and 0.28, respectively. The corresponding estimates for test day yield were 0.22 and 0.66, respectively. The authors reported an annual genetic progress of 0.05 kg for milk yield at 305 days and 0.0003 kg for test day yield. The corresponding values for body weight at birth, 3, 6, and 12 months of age were 0.050, −0.185, 0.079, and 0.33 kg, respectively.

Information on genetic analysis using 39 successfully amplified microsatellite markers in seven breeds of Arabia camel identified two loci named LGU79 and LGU83 to be monomorphic.

The expected heterozygosity value in this study ranged between 0.52-058 whereas the observed heterozygosity values were in the ranges of 0.48-0.56 with Oman population on the lowest side and Moroccan population on the highest extreme. The average Polymorphic Information Content (PIC) value for the 39 loci for each breed ranged between 0.458-0.518.

Results of studies on genetic diversity and relationships of indigenous Saudi Arabia Camel (*Camelus dromedaries*) populations revealed three genetically separated groups (Alawadi, Alhadana and Alshahlia) of dromedary in Saudi Arabia (Almathen et al, 2012). The authors farther argue that most of the genetic diversity of dromedary camels occurs within the Saudi Arabian population supporting the hypothesis that Saudi Arabia is a likely center of origin for the domestic dromedary camel.

The last wild representatives of old world camel in the cold deserts of Mongolia and China have been discussed very controversially to be either feral or truly wild although the International Commission for Nomenclature fixed the first available specific name based on wild population as”

Camelus ferus" for the wild camel discovered by Prezewalski in 1878 (Gentry et al, 2004). Studies of Burger et al (2012) on mitochondrial and nuclear DNA have given evidence for high genetic differentiation of wild camels and identified them as a separate species. Thus, the results of their study could serve as basis for *in-situ* conservation of the endangered wild camels.

As described above the global camel science in terms of genetics is progressing with different pace in different countries. Scientific progress in UAE, Saudi Arabia, and India is advancing while others are still struggling with the conventional approach and at a lower profile. Because of the large herd size and presumably large gene pool in the horn of Africa including Ethiopia, special attention should be given to genetics and genetic improvement of camel. To speed up the progress, genetic characterization and improvement programs should be supported by application of biotechnological tools in genetics and reproduction. Additionally recent suggestions of Ishag et al (2012) for genetic improvement of camels in Sudan can be reviewed and used to fit into Ethiopian perspectives. Possible interventions towards better understanding of camel genetics and genetic improvement programs under Ethiopian perspectives are comprehensively described in chapter 7 of this book.

Reproduction

It is often stated that the slow reproduction and uncertainty in reproductive rate are the major challenges in launching systematic breeding program in camel. Thus, understanding the physiology of camel reproduction would help to develop interventions to improve overall productivity and eventually pastoralist livelihood.

Both female and male camels are seasonal breeders, mating during the rainy or cold season and calves are born in the months most suitable to guarantee their survival (Yagil, 1982). The breeding season of male camel corresponds with that of the female. Estimates on the ideal ratio of males to females in dromedary during the breeding season vary from as low as 1 male per 5 to 7 females through medium levels of 1:10-30 (Asad,1970, Gauthier-Pliters,1979) to as high as 1:50-80 (Williamson and Payne,1978, Singh,1963 and 1966: Leupold, 1968). Based on histological observations and morphmetric data, female camels are considered as seasonal breeders, and breeding season or the season of highest ovarian activity was noted to be in autumn. Age of puberty for female camels is usually at 4-5 years and the male camels attain full reproductive vigor at 6-7 years. The length of estrus cycle is normally 2-3 weeks although in the Bactrian camel, the period can extend to 30-40 days (Yagil, 1982). The actual heat lasts for 3-4 days although 21 days was considered as being the period of heat.

Based on histological observations and morphmetric data, female camels are considered as seasonal breeders, and breeding season or the season of highest ovarian activity is in autumn. Various ranges of gestation length have been reported for dromedary camel in various countries. In Sudan, gestation length of 373-393 days was reported by Evans and Powys (1979) while in Pakistan, gestation length of 365-395 days was reported by Yasin and Wahid (1957). Results of studies on reproductive pattern of Bactrian camel suggested gestation length of 402 days (Chen and Yan, 1979).

Studies undertaken on prenatal growth of dromedary calves in various countries have led to variable results. In Indian study which involved 134 records over three years, the respective average birth weights for males and females were 38.19 kg and 37.19 with a pooled average weight of 37.23 kg (Bhargava et al (1965) while Field (1979) reported an average weight of 30.9 kg for Randille and Gabbra calves in Kenya. Studies on factors influencing birth weight of animals suggested the largest component of variation (36%) is accounted by a combined genotype of the dam (20%) and fetus (16%) followed by intra-uterine foetal environment (30%), maternal environment (18%), parity (7%), nutrition (6%), sex (2%) and maternal age (1%) although the exact role of these factors in dromedary is not yet investigated.

Studies on calf mortality also led to variable results in various countries. Cosin, 1971 studied mortality in three clans that

rear camels around Jigjiga area and recorded mortality rates of 31, 49 and 59% attributing the latter two high rates due to environment dominated by fly and predator infestation. Similar studies in Kenya also indicated high rates (30-50%) of calf mortality and the author attributed the loss to poor nutrition, diseases and predators (Bremaud, 1969).

Fertility rates in the camel especially under traditional systems are low and it is one of the major constraints in camel production. Dahl and Hjort (1976) noted that even under improved management the fertility rate of camels is very unlikely to be much higher than 50% in pastoral herds. Keikn 1976 also reported an average caving rate of 40% for Bactrian camel in a large camel ranch (4300 heads) of Soviet Union.

In Kenya, the respective fertility rates of Gabbra and Somali camels were 34% and 52.25% (Bremaud, 1969). Causes of low fertility are usually late age at first calving, limited rutting potential, prolonged calving interval, inadequate nutrition, management practices and prenatal calf losses, disease and other factors (Mugerawa,1981).

Scientific progress on camel reproduction using advanced techniques is also progressing well in various countries and significant progress has been made especially in UAE. Studies on application of embryo transfer in accelerating genetic improvement in lactating dromedary camels in the

UAE indicated success (9-10 camels) in super ovulation, significant variation in recovery rate between camels (12 to76%) and pregnancy rate of 34.8% at 60 days (Nagy and Juhasz,2012). The authors argued the problem of significant decreases in milk production in dromedary camels during pregnancy could be successfully intervened by using high producing animal as donor and low producing animal as recipients in embryo transfer program.

The world's first cloned camel named *injaz* was born in the UAE on April 8, 2009 as result of breakthroughs in optimization of ooctye maturation (Wani and Nowashri,2005, Wani and Wernery,2010), ultrasound guided trans vaginal ovum pick-up (Wani and Skidmore,2010), chemical activation of mature oocytes and i*n-vitro* embryo culture (Wani,2008;2009). *Injaz* has been produced from the embryo reconstructed with cumulus cell obtained from a slaughtered animal. In 2010, the second cloned camel named *Bin-Soughan* was born from the embryo reconstructed with skin fibroblast of an elite live bull (Nagy and Juhasz, 2012). Although the potential applications of somatic cell nuclear transfer (SCNT) are currently constrained by low pregnancy rate (0-10%) i.e. 0-10 live births after transfer of 100 cloned embryos from the transferred reconstructed embryos, optimization of the nuclear transfer procedure is in progress (Nagy and Juhasz,2012) to come up with breakthroughs.

In India so far, biological for inducing ovulation was identified; the technique of artificial insemination in camel perfected; the use of progesterone kit for assay of progesterone verified and Ultrasonographic technique was also noted to be helpful in ascertaining the presence of ovulating size follicle during different physiological stages (Patil and Gupta, 2012)[3]. In summary major research, findings/lessons on camel reproduction are the following:

- The technique of artificial insemination in camel can be adopted and its use can be perfected to improve reproduction of camel;
- Single insemination with semen extended with Tris egg yolk citrate extender at 27-28 hour of the injection of ovulating agent can lead to successful pregnancies; and
- The progesterone kit can be adopted for assay of progesterone and ultrasonographic technique can be applied in ascertaining the presence of ovulating size follicle during different physiological stages.

Studies in Ethiopia in the area of camel reproduction so far include comparative efficacy of milk and serum progesterone levels in early pregnancy diagnosis of camels, evaluation of semen characteristics and survey of the reproductive features of male camels, characterization of reproductive performances, lactation, and calf in Afar camels (Mohamed, 2012). Information on reproductive performance of Ethiopian camel around Shinile area indicated 4 years of age at puberty, 5 years of age at first calving, calving interval of 2 years and

calving rate of 50%, (Melaku and Fiseha,2001). Interventions supported by improved breeding, disease control, improved feeding is thus helpful not only in improving milk production but in improving reproductive efficiency by reducing the time at first calving and inter-calving intervals. Possible research and development interventions in improving reproductive performance of camel under Ethiopian perspectives are comprehensively described in chapter 7 of this book.

Health

Camels seem to suffer from fewer diseases than other domestic animals and epidemics are considered rare. However, camels are affected by many other diseases, some of which are unknown to date. Infectious and parasitic diseases appear to be the major constraints that are hampering the potential performance of camels. Trypanosomiasis, camel pox, contagious skin necrosis, pneumonia, mange mite infections, and internal parasites are among the major health problems reported to affect camels. To respond to the challenges various research projects related to camel health were carried out in different parts of the world and their area of focus is highlighted in the following sections.

So far, in Ethiopia, camel health research such as respiratory diseases, tuberculosis, udder health, mastitis, trypanosomiasis, disease control strategies, common causes of calf mortality, and assessment of poisonous plants were

undertaken (Abera et al, 2012, Bekele, 2009, 2010, Mohamed, 2012, Gelagay et al 2012[3], Muhumed, 2012, Tezera *et al* 2012[3], Melaku 2012[3], Solomon, 2009, Seifu et al 2006). Related research to camel health with respect to medicinal plants include ethno-botanical and ethno-pharmaceuticals studies of Seifu et al 2006 in the Chifra District, Afar Region and Odo-Bulu and Demaro areas in Bale Zone of Ethiopia (Bussmann, et al 2011). Herbal medicines in ethno-veterinary are usually used to treat diarrhea, parasites, wound, and skin infections.

Studies on camel health in Ethiopia have led to the following results:

- No causative agents are fully determined yet for camel emerging disease and the isolated virus should be further characterized;
- Investigation on etiology of respiratory disease showed the involvement of *Respiratory syncytial virus* and *Adenovirus* as a causative agent for camel respiratory disease;
- Udder health problem was noted to be a very common and major problem of camel health as 42.1% of the investigated camels in the study area had no sound teats for milk production;
- Optimal methods of clinical examination and the sources of common errors that require special consideration in the camel defined and a diagnostic decision support system generated to facilitate rapid diagnosis in the field
- The results of survey on the major camel production constraints in the four eastern districts of the Ethiopian

Somali Regional State formation has led to insight about camel diseases and possible measures to improve camel productivity in the study area

- The result of epidemiological study of major camel diseases in Borena lowland around Yabello town identified five species of internal parasites *(Strongyle, Monezia, Coccidia, Trichuris* and *Strnogyloids* with the highest prevalence recorded for *strongyle spp* during dry season
- Among external parasites affecting camels, ticks of various species have been identified and the most important external parasite (mange) affecting young camels was noted to be caused by *Sarcoptes scabiei var. cameli brucellosis*
- Infectious diseases of camel in Borena were identified as *Brucellosis, Tuberculosis, Trypanosomosis, Contagious Bovine Pleuropneumonia* and *Peste des Petite Ruminant* (PPR) with respective prevalence rate of 2.0, 12.2, 10.5, 4.0 and 2.0 %
- Camel tryps was noted to be caused by *T.evansi* mainly in zone 3 and 5 of Afar Region
- Applications of different herbs by Afar pastoralists were noted to treat gastrointestinal ailments
- The occurrence and severity of camel diseases showed variation with seasons and, animal groups;
- Parasitic diseases (*helminthiasis and sarcoptic mange infections*) were severe during the dry season, while trypanosomiasis had a higher occurrence during the wet season
- Other infectious diseases like respiratory infections, pox and clinical mastitis were more frequent during the wet season

- Young and breeding females were the most affected animal groups
- Results of on medicinal plants of Chifra district, Afar region (pastoral region) of Ethiopia identified a total of 70 plant species for their medicinal use in the district. The most frequently recorded medicinal plants of the Afar people were *Aloe sp*. used for the treatment of TB and pasteurllosis and *Acalypha sp*. for snakebite, blackleg and anthrax
- Results of efforts on Ethno-botany study conducted at Odo-Bulu and Demaro area in Bale zone of Ethiopia, indicated among 294 plant species documented in the area, 13 species were used for veterinary purposes.

In India, camel health research includes a wide variety of activities. The major lessons from Indian research in camel health include the following:

- Research results on parasite control indicate that, broad spectrum antihelmintic can effectively reduce egg count and lead to better haemato-biochemical parameters in camel
- Among tick species, *Hyalomma dromedary* and *H. anatolicum* were noted to be the common tick infestations in India
- Comparative study on various techniques for diagnosis of surra infection in camel revealed Polymerase Chain Reaction (PCR) to be gold standard in detection of cameline surra;

- C ultural examination and somatic cell count revealed infection of udder with *Staphylococcus, Streptococcus, Corynebacterium,* and *Bacillus*;
- N ine medicinal herbs revealed broad-spectrum antibacterial activity with crude and methanol extract of anar (*Punica granatum*) and pardesi kiker (*Prosopis juliflora*) leaves. Datura, (*Datura metel*) leaves, ashawagandha (*Withania somnifera*) leaves, and garlic (*Allium sativum*) bulb were also found to possess good antibacterial activity, whereas crude juice of peepal-exhibited 100 % activity against *E.coli* isolates tested. These plants may possess some values for the treatment of certain infectious diseases, after evaluation of cytotoxicity, storage, stability and excretion;
- S tudy on epidemiology of sarcoptic mange in camel and is control using indigenous herbal preparations comprising of extract of garlic, onion, and lemon in combination of camphor and linseed oil in different proportion and combinations led to encouraging results. Some of the formulations were found encouraging in terms of both clinico-parasitological recovery and economics of the particular formulation as compared to conventional allopathic preparations;
- T he results of repeated trials on role of raw camel milk as nutritional adjuvant in human tuberculosis and management of type-1 diabetes supported the positive role of raw camel milk against these diseases; and
- I n terms of sequencing haemagglutinin gene of camel pox

virus, complete nucleotide sequence of the envelope gene and topoisomerase gene of PCPV, the IL-2, IL-4,IL-6,IFN-Gamma and TNF-Alpha genes of dromedarian camels were sequenced at global level.

Indian research on camel emphasizes on calf mortality, epidemiology, diagnosis, prevention, and treatment, development of vaccines, development of immuno-diagnostic kits, control of skin diseases, abortions and mastitis (Patil and Gupta, 2012).

In Sudan, the research focus include drug resistance of trypanosomiasis, prevalence of mastitis, incidence rate of abscesses, anatomy and physiology, morphology, and histo-chemistry of the fetal membranes and placenta of the dromedary camel (Abdelgadi and Adil Salim 2012).]'3

In the United Arab Emirates, various aspects of camel health research have also been carried out. Recent progress on molecular diagnosis of camel disease led to the development of 16 PCR assays (Table 1) for routine detection of protozoan, bacterial, and viral diseases (Hakimuddin et al, 2012).

Table 2 Polymerase Chain Reaction (PCR) assays developed for pathogen detection in camels

Test	Pathogen
Chlamydophila	Bacteria
West Nile Virus	RNA virus
Trypanosoma evansi	Parasite
Mycobacterium spps	Bacteria

Mcycoplsama spps	Bacteria
Bukholderia mallei	Bacteria
Taylorella equigenitalis	Bacteria
Foot and mouth disease	RNA virus
Equine Herpes Virus	DNA virus
Coxiella burnettii	Bateria
Brucella spps	Bacteria
Camelpox	DNA virus
Piroplasmosis	Parasite
Adenovirus	DNA virus
Clostridium perfringens	Bacteria
African horese sickness	RNA virus

Source: Hakimuddin et al, 2012

In Oman, research activity on camel health so far has focused on surveillance of important diseases and parasites, brucellosis and **s**urveys of internal (theirleriasis, trypanosomiasis and hydatids) and external parasites (Mahgoub and Kadim,2012)**.** In Kenya research on camel health encompassed areas such as trypanosomiasis, brucellosis, and Q-fever, epidemiology of hemorrhagic septicemia, prevalence of mastitis, prevalence and antibiotic resistance of common pathogens in camel milk, sudden death emergency investigation in camel, traditional veterinary medicine and mastitis.

The global camel health research including Ethiopian effort varies considerably in scope, coverage, and depth. Application of molecular techniques in disease resistance can also help to develop intervention in camel health and complement the on-going effort in veterinary medicine.

Considering the challenge at the field level concerted effort in camel health research is mandatory to develop interventions in disease diagnostics, prevention, and control of major diseases in camel. Partnership and collaboration at country, region, and global levels may help in better understanding of camel health and development of intervention at a much faster rate than the current scenario. Possible interventions in camel health research and extension services under Ethiopian perspectives are comprehensively described in chapter 7 of this document.

Nutrition

Although camels ruminate, they are not "true" ruminants and some basic differences exist between ruminants and camels in terms of anatomy/ physiology of the digestive tract and feeding habits. Thus, camels are usually known as "pseudo" ruminants. In terms of anatomy of digestive tract, camels have only three compartments the missing one being the omasum and the anatomical differences could account for the much slower water turn over in the camel (Macfariane, 1977). Compared to other ruminants, the nitrogen metabolism of the camel is superior and even more apparent during water restriction owing to reduced nitrogen excretion in both feces and urine (Farid et al, 1979). Camels have more efficient nitrogen conservation mechanism than other ruminants. Even on a low-protein diet, nitrogen fixation in the rumen and constant recycling of urea contributes significantly to a steady protein synthesis. Another important difference with

other ruminants is that camels have significantly higher blood glucose level (Emmanuel, 1979; Yagil and Berlyne, 1977). Although differences in some aspects of anatomy and digestive physiology of camels have been noted, the physiology of dromedary camel especially activity during periods of drought is not known very well and much remains to be done.

Grazing camels has low feed requirement of 8-12 kg dry matter a day and the amount most frequently eaten is 6-7 kg DM a day (Gauthier-Pilters, 1979). In terms feeding habits, camel covers large areas while browsing and grazing, and it is continually on the move, even if food is plentiful. In terms of mobility, 50-70 kilometers a day can be covered by camel.

The main source of forage for camels in the Horn of Africa is obtained from trees and shrubs. When camels graze the field, their natural habit of wandering while eating opened up paths for the sheep to follow and benefit from the abundant food indicating possibility of communal grazing. The results of recent studies (Schwartz et al, 2012) on feeding preferences of camel on semiarid thorn bush savanna in Kenya indicated a distinct absolute preference for bushes, trees and dwarf shrubs with 37.9%, 29.2% and 27.6% respectively while grasses forbs and others together accounted for only 5.3% of the total feeding time observed.
The results of study on feed intake, digestibility, and milk production in mid lactation of Tunisian Maghrebi camels fed

alfalfa based diet indicated mean dry matter intake of 13.5 kg, average digestibility of 69.3% and average milk production of 7.72 kg/day (Hammadi et al, 2012). The intake values reported by Hammadi et al (2012) was 136 g/ kg of weight expressed in metabolic body size that is higher than the value reported as 56.6 gram in camels fed wheat straw and concentrate (Al-Moutairy, 1991). The results of Egyptian studies on energy needs of pregnant female camel's indicated providing energy level of 100 kcal ME per metabolic body size was sufficient to cover the energy requirement of the pregnant dromedary female in late pregnancy.

Applied and basic studies on the mineral metabolism of the dromedary camel were carried out during the last three decades by several research teams, in Sudan, Ethiopia, Morocco, Djibouti, India, and Arab Emirates or in France (Faye et al, 2012)[3]. The results suggest that mineral deficiencies and sometimes-mineral toxicity occur in camel both for major or minor elements and thus, imbalances in mineral nutrition of camel widely exist.

In India, research on camel nutrition covers areas such as nutritional analysis, nutrient requirements; complete feed blocks, supplementation of urea molasses mineral blocks, complete ration formulations, deficiency of Cu and Zn, levels of nitrogen, phosphorus, copper, and zinc in soils, and levels of Cu and Zn, Fe Ca, P, Mg, Co and Mn in the feed (Patil and Gupta, 2012).The major findings/lesson in camel nutrition are as follows:

- In some countries nutritional analysis of locally available camel feeds and fodders were done and nutrient requirements for various physiological functions were worked out;
- Under Indian condition camel calves fed on complete feed blocks were noted to attain maturity at 3 years of age;
- Supplementation of urea molasses mineral blocks enhanced growth (269 g/d) of camel calves of 2.5 years of age and it replaced 30% of concentrate mixture;
- Complete ration formulations developed using local feeds;
- Cu and Zn have been found deficient in blood samples of camel; and
- Stall-feeding plus 6 to 7 hours of grazing supplement was noted to be beneficial and appropriate system of camel management in India.

The major feed resources for camels in Ethiopia are the rangelands dominated by grass, shrubs, and woody species. In the hot and dry northeastern and eastern arid rangelands, the sparse vegetation constitutes ephemerals, annual grasses, and dwarf shrubs suiting browsing camels and goats. The vegetation composition in the slightly better moisture regimes of the semi-arid areas of Oromia (southern and eastern), parts of SNNPR (Southern), and parts of Somali (southern and western sections) regions, is dominated by *Acacia*

commiphora bush lands with understory perennial grass cover. The grass species are of good grazing value and includes *Cenchrus, Chloris, Chrysopogon* and *Themeda* spp. This environment is also rich in palatable forbs and browses, which include *Blepharis, Tribulus, Acacia, Balanites, Olea, Erythrina, Boswellia, Combrethem, Commiphora* and many other species (Adugna et al, 2012). Forage from the rangeland is the principal source of feed for domestic and wild herbivores and availability of range forage shows considerable temporal and spatial variability. Thus, sustainable camel production under this ecology requires primarily improvement in rangeland ecology and utilization. In Ethiopia, camel nutrition research so far has encompassed research activities such as feeding behavior and quality of camel's diets, supplementary dry season feed, assessment of some critical mineral elements in diet/serum and non-conventional mineral supplements, isolation and characterization of bacteria from rumen fluid of camels and feeding strategy of camel.

The most important browse plants used by camels in different seasons in the Southern rangelands were indentified to be *Acacia brevispica, Commiphora africana, Rhus natalensis, Grewia spp., Balanites spp., Boscia minimifolia, Cadaba glandulosa, Euphorbia spp.,* and *Solanum tembensis* (Desalegn, 1984). Results of studies on critical macro and micro minerals concentration in important browse species in

JigJiga area indicated that the camels in the study area could get adequate amount of the mineral elements: Ca, Mg, K, Fe, Mn, Zn, and Cu from browses except for P and Na suggesting the need for P and Na supplementation (Temsegen and Mohamed, 2012). Results of studies on critical macro and micro minerals concentration in the blood serum of camel (*Camelus dromedarius*) in Jigjiga district, Eastern Ethiopia also substantiated P deficiency both during wet and dry season suggesting the need for P supplementation to the camels in the study district (Temesgen et al 2012).

Research results of supplementary feeding in Erer valley of Ethiopia were quite encouraging in terms of camel milk production and economic benefits. Supplementation using groundnut cake increased milk yield by 5.3 lt/day (6.9 Vs 12.2) during dry season and by 5.4 lt/day (8.2 Vs 13.6) during wet season (Moges and Uden, 2005) as compared to controls. In the same trial intervention using ground maize as energy supplement led to increment of 1.7 liter /day (6.9 Vs 8.6) during dry season and increment of 1.3 Lt/day (8.2 Vs 9.5) during wet season. The results farther suggest protein was the major limiting nutrient in both seasons and interventions could be developed using different sources of protein. Reponses to groundnut cake could be due to its better digestion kinetics as significantly higher ($P<0.01$) potential digestibility of organic matter , nitrogen and neutral detergent fiber was noted compared to Noug cake, flax cake, mustard cake, cotton seed cake or sun flower cake (Seyoum, 1995).

Additionally responses from true ruminant species suggest higher responses (milk, growth, meat) could be obtained if sources of soluble or escape nitrogen are utilized as strategic supplement (Seyoum et al, 2008; Mesfin et al 2009a; Mesfin et al, 2009b). Much remains to be done in quantifying responses of camel to dietary manipulation and characterizing their diet using new principles and approaches that could be borrowed from ruminant nutrition. Improved calf growth and survival, reproductive performance, growth, meat production and milk production of camel requires nutritional manipulation and interventions.

Success stories in nutritional intervention could be borrowed with precaution from ruminant livestock and quickly test for their application in improving camel production in the arid and semiarid environments of Ethiopia (Dereje et al 2010a and 2010b, Mesfin et al 2009a, Mesfin et al 2009b, Seyoum et al, 2008, Seyoum and Fekede, 2008, Seyoum, 2011).

The strategic direction and short cut approach in alleviating nutritional constraints of camel under Ethiopian perspective may take the following path:

Understanding the nutritional attributes of feeds

Database on composition and nutritional quality of Ethiopian feeds (Seyoum et al 2008) can serve as generic guide to understand the overall nutritional attributes of common feeds

in pastoral and agro-pastoral production system. However, better understanding on specific characteristics and attributes for common feeds in these environments is an advantage to work on nutritional interventions. Mandatory updates in this regard are areas such as mineral profile, anti-quality factors, digestion kinetics, and animal responses of common feeds in the environment under discussion. The nylon bag technique can be applied to generate information on digestion kinetics (Seyoum, 1995) and the gas production techniques can also be used a promising method for diagnosing the presence of anti-quality factors (Elbashir et al, 2012).

Identifying and selecting supplementary feeds

Nutritional manipulation is a reflection of nutritional attributes in the basal diet and supplements. Thus, with complete updates of the existing data base, major feed resources in pastoral and agro-pastoral production system can be clustered into different groups based on attributes reflecting animal responses. Animal response trials on selected feeds from representatives of each cluster can serve as a short cut approach in identifying and selecting potential supplementary feed.

Strategic approach in supplementation

Some authors advocate for a strategy to offer a surplus basal diet (such as straw) to exploit selective ability of the animal such in small ruminants. With limitations to offer surplus basal feed in pastoral and agro-pastoral production system

there must be an assessment if such approach is applicable to camel in this environment. The supplement should however, provide enough nitrogen, sulphur or any essential nutrients deficient in the basal diet.

Nutrient requirements

Development of ideal rations and nutritional interventions in camel is often constrained by lack of data on nutrient requirement of camel. With the limited data available in the world at large, information generated by Indians can be used until local data is generated. Possible interventions of camel nutrition under Ethiopian perspectives are comprehensively described in chapter 7 of this document.

Milk Production and Quality

In Kenya, Ethiopia, Sudan and Somalia milking of camel is not only an act of work, but has become an integral part of the local culture and heritage. Only boys, unmarried women, or ritually clean men are allowed to milk the animals. The milk is either consumed fresh or when just soured. Although the exact amount is difficult to assess, camel is generally known for its capacity to produce large quantities of milk as evidenced by milking frequency of up to 5-8 times a day. Milk production and productivity of camel varies across production systems and levels of management.

In Ethiopia, under traditional management of pastoralists, lactation yield of camel ranges from 1090 to 2165 liters with productivity levels of 3.5 to 5 liters per day per head and 7.5 liters at peak lactation with lactation length of 282 days and longevity ranging from 20 to 25 years (Seyoum and Kidane, 2009). Milk trials in the Awash valley of Ethiopia for camel herd kept on irrigated pasture suggested an average daily milk yield of 7 liters in two milking and under rain fed conditions, 13 kg per day can be milked.

Reported lactation lengths for Ethiopian camels vary widely. Tezera (1998) reported 13 months for camels in Shinile area and 15 months in Jigjiga area. Alemayehu (2001) reported lactation length of 6 months for Afar camels and 8 months for Kereyu camels and Yohannes et al 2007 reported estimated mean daily milk yield during early stages of lactation as 5.01 and 6.41 liters for Kebribeyah and Babile, respectively with lactation length of 12 months. The major source of variation in milk yield and lactation length of Ethiopian camels could be breed and agro-ecological differences.

Experiences in camel dairy farming in Israel indicate productivity of 7-15 liters milk daily for periods of 9-18 months (Yagil, 1982). In Egypt with good feeding a daily milk production of 10-15 kg was obtained giving approximately 3000-4000 kg per lactation and daily yields of 22 kg have been recorded (Shalash,1979). In Somalia, the

average daily milk was recorded as 5 kg with a total yield of 1950 kg (Marex, 1954).

In Algeria, the lactating camel produces 4-5 kg/day on good pasture for the first three months and a good milker can even provide up to 10 kg a day. In Pakistan, length of lactation varies from 270-540 days and daily milk yield of 15-40 l and total milk yield in the ranges of 1350-3600 kg were recorded (Knoess, 1977). Farther more, Koness et al, 1986 reported a healthy camel on good feed could produce 2,000 liters of milk per lactation period.

The unique feature of camel milk is not only the amount produced under harsh environment but the composition and its nutritional value. Data concerning the composition of milk vary widely depending on diet, genetics of the animal, and stage of lactation, age, and number of calving. Of all the factors, the quality of camel milk produced is significantly affected by the feed and water quantity and quality. Most camel milk is drunk fresh and sometimes taken in its slightly sour or strongly soured form. At times camel milk is considered as having a pleasant taste and such a change is attributed to the type of fodder and the availability of drinking water.

Compared to other species, great differences in milk composition with its medicinal properties are known to exist in camel milk. The most important factor in camel milk is

water content required for young camels and humans in drought areas in terms of maintaining homeostasis and thermo neutrality. In terms of composition, dromedary milk is characterized by low fat (2%) which is mainly polyunsaturated fatty acids (PUFAs), known as Omegas, lactose content of 4.8%, which is similar to that in mothers' milk, and protein content of 3.5% with no allergies (Yagil,1982). Compared to cow milk, camel milk has high concentrations of volatile fatty acids especially linoleic acid and the polyunsaturated acids that are essential for human nutrition. Camel milk also contains insulin that is not destroyed in the stomach and it has high concentration of Vitamin C. Camel milk is also used for treating immune problems such as allergies, autism syndrome, Crohn's disease syndrome and hepatitis B or hepatitis C (Yagil, 1982).

Meat Production and Quality

Camel is a good source of meat in arid and semiarid environments where the climate adversely affects other animals. In the camel herd, sources of meat include young/old males and unproductive females. The male dromedary carcass usually weighs 400 kg or more while the male Bactrian can weigh up to 650 kg (Knoess, 1977). The carcass of female camel weighs between 250 and 350 kg. The dressing percentage of camel carcass varies between 52 percent and 77 percent (Shalash, 1979; Kutznekov and Tretyakov, 1972). The meat yield of camel and its taste is

determined by the age, sex, feeding condition and general health of the animal.

Reported mature weight of camel in Ethiopia varies widely depending on breed or environment. The mean weight of male and female camels is 435 and 378 kg respectively at Babile (Yohannes et al 2007) and 407 and 401.70 kg for male and female at Kebribeyah. Tezera (1998) reported the mean calculated live weight for adult male and female camels as 486 and 427 kg for Jigjiga and, 384 kg and 326 for male and female, respectively for camels in Shinile area of Ethiopia. Meat production potential of camel in Babile area of Ethiopia was estimated to range between 230 and 240 kg for male and 187.74 and 195 kg for female while at Kebribeyah meat production potential of camel was noted to be 214-225 kg for male and 200-207 kg for males (Mohammed, 2004). In Ethiopia, live weight of camel (male) on the average is 400 kg with carcass weight of 211 kg. The average dressing percentage camels found in Eastern Ethiopia was noted to be 54.03 for male camels and 50.65 for female camels (Mitiku, 2012).Camel meat is claimed by the Somali people to have a remedial effect for at least 13 different kinds of diseases, including hyperacidity, hypertension, pneumonia and respiratory diseases and to be an aphrodisiac (Mohammed, 2004)

Information on Ethiopian camel meat composition does not exist so far. However, some general truth on camel meat

composition can be inferred from global findings to approximate the composition of camel meat under Ethiopian situation. In general, camel meat is healthier as the carcass contains less fat as well as less levels of cholesterol in fat than other meat animals. Compared to beef, camel meat is also relatively high in polyunsaturated fatty acid giving opportunity for reducing the risk of cardiovascular disease, which is related to saturated fat consumption. Camel meat is also used for remedial purposes for diseases such as hyperacidity, hypertension, pneumonia, and respiratory disease (Yagil, 1982). Quality of meat from young camels is known to be comparable to beef (Mahgoub and Kadim, 2012).

The fat and ash content of camel meat is lower than that of beef. In proximate composition, camel meat is generally similar to beef. The meat protein tended to have a higher percentage of the amino acid profile than literature values for other red meats, and lower values for tryptophan, aspartic acid, and tyrosine (Yagil, 1982). In camel, the skeletal muscles and organs vary in terms of nutrient content. Organs have higher percentages of ash, sodium, and iron than skeletal muscles. Among organs, kidneys contain higher quantities of moisture, calcium, and sodium but lower values of protein, magnesium, and potassium than liver and heart meats.

In summary, major research findings (Mahgoub and Kadim, 2012) on camel meat include the following

- Studies at Sultan Qaboos University (SQU) indicated that the optimum age for slaughter camels is below 3 years. At this age, camel meat quality is comparable to that of beef;
- Meat pH was determined over the ageing period as well as an ultimate pH it is an important aspect for meat quality determination as it affects meat color, tenderness, as well as cooking loss. Young animals will produce tender meat but their meat will have high pH due to the low glycogen in the muscles. Consequently, meat may be less attractive due to dark color;
- One of the experimental approaches adopted at SQU was ageing of camel meat. Several studies on ageing of camel meat indicate that ageing of camel meat for 7 days at 3-4°C improved camel meat characteristics. This simple approach is affordable by camel meat producers and does not require a lot of technical knowhow. It is recommended that this approach be adopted on a wide scale in the camel meat industry;
- Electrical stimulation is a technique that has been employed in improving meat quality of beef and mutton and at lower scale in goat. Low voltage stimulation significantly improved meat quality characteristics in camel meat. The technology is simple and commercial gear is available from New Zealand and Australia. It is recommended to be adopted in camel slaughterhouses to improve camel meat quality;
- Effect of cooking on camel meat was studied including using different methods and different cooking temperature in comparison with other meat types. Cooking

significantly affected mineral content but not protein or lipids in camel meat;

- Intramuscular fat content was lower in camel carcasses than beef and mutton. Levels of polyunsaturated fatty acids were relatively higher in camel muscle than beef. These characteristics are important from a human nutrition point of view. It should be used for propagation of camel meat as a healthy product;
- Studies on histological structure of camel muscle and the different fiber types indicate that camel muscle types were similar to those of beef; and
- Regarding individual muscles, variation in meat quality and histo-chemical properties were studied between six individual muscles. Significant differences were found. This aspect should be taken into consideration in marketing camel meat.

Transport, Power Source, and Recreation

Results of studies on draft capacity of camels in Ethiopia showed that an adult working camel could be exposed to a draft force level of 1.77-KN without reduction of its draft force output suggesting a single camel can replace a pair of oxen in terms of draft power capacity. A survey results using key informants, both around Babile and Kebribeyah area of Ethiopia suggested, a camel could plough 0.5 hectare of land per day (Yohannes et al 2007). In the northern part of Ethiopia, pastoralists who engaged on salt collection used camel to carry out salt from the vast area of Afar Depression. During the last many decades salt transporting were owned

by wealthy traders and pastoralists/farmers. While in the Eastern part the country, illegal traders used camels for contraband business to transport large amount of electronics, food items and second-hand clothes from Djibouti, Somaliland and Somalia.

Yacob and Andy (2011) reported that, Afar and Issa camels are capable of meeting the physical endurance necessary to transport salt block from Berahle to the uplands. Camel laden with heavy salt blocks had to function in altitude and temperatures of extreme variations and the number of camels working on this route assumed that roughly 200,000 camels per year transporting salt between the mines and the upland. However, currently the number of camels working on this route is on the decrease, due to the new directive that requires transporting salt by trucks from the mine place to the highlands area.

The draft force generated by camel ranges from 17 to 22 percent of body weight (Patil and Gupta, 2012). The result of study on synergetic effect of nutrition on work performance Indian camels indicated *ad libitum* feeding of Guar straw (*Cympsis tetragonaloha*) with concentrate mixture resulted in improved nutrient intake (DCP and TDN) and work performance (Chaudhary, 2012).

Recreation is among the services provided by riding camels in some countries especially Arab countries. In a study

undertaken to assess factors influencing performance of racing camels in UAE, Shorepy and Yousef, 2012 reported age of the animal has significant effect on speed of race camels with the highest race speed attained by 3 years old camel and the lowest racing speed by the 6 year old camel. The results of studies on genetic characterization of local and crossbred racing camels in the UAE using polymerase chain reaction and restriction fragment length polymorphism (PCR-RFLP) have revealed diversity between different groups indicating possibility of assigning certain molecular markers to specific group.

Camel racing has become deeply appreciated and valued tradition and is one of the opportunities to increase the pastoralist's economy. Camel racing is not well known. However, there are different camel parade shows during pastoralist's festival in Afar, Oromia, and Somali Regions. Pastoralists should to conduct a selection program to improve racing performance of camels in order to contribute the racing competition. Moreover, they should continue to breed, raise, and train camels for racing purpose.

Under Ethiopian context, awareness on relevance of camel for recreation is good, as the world tourism day of 2102 has been celebrated at Dire Dawa by racing camels.

Socio-Economics and Marketing

Camel has unique position in its biological and socio-economic significance in pastoral and agro-pastoral production system. Especially in the horn of Africa, its socio-cultural and political value has reached a level where countries or regions dominated by camel production; for example, Regional State of Somali put camel on their flag. In the pursuit of recognition of the socio-cultural value of camel, it is often argued that the importance of camel is higher than its actual or potential contribution to the national economy. Its importance has increased in the region from the perspectives of food security in line with climate change and its overall economic significance.

Study on market information on camel and camel milk marketing in Jigjiga Zone indicated although camel milk is traditionally used for home consumption, there are recent developments where camel milk marketing networks have emerged to serve urban demands. Camel milk has increasingly become a marketable good in the zone and in other areas pastoral regions in the country (Yohannes et al 2009). In the same study, camel milk trade was also noted to show high degrees of complexity, flexibility, and effectiveness. Market access was also noted to influence the time of selling milk. Under situations where better access to market is ensured, pastoralists were noted to sell camel milk in both the morning and evening whereas only morning milk is sold in places with poor access to market. In addition to improving market access, interventions to improve milk

quality, safety and storability is an integral component of the overall intervention in improving the marketing system and livelihood of pastoralists.

Ethiopia earned USD 211.1 million during Ethiopian fiscal year (July 2010-June 2011) by exporting 16,877 tons of meat and 472,041 head of live animals, recording a 69 % increment from last year's export revenue (NBIIA. 2011). According to the data available with Ethiopian Revenue and Customs Authority, live animal export contributed 70% of the earnings while the balance (30%) was obtained from meat export. Of the number of exported live animals, camel accounted for 13% and contributed 25% to the revenue generated. United Arab Emirates is the largest importer of meat buying 50% of the total meat exported, while Kingdom of Saudi Arabia followed as the second destination, accounting for 30% of the export. Sudan and Somalia stood first and second importers of live animals (primarily for re-export to MENA countries) with each buying 107, 656, and 100, 278 head of animals. Therefore, there are huge market opportunities for camel export and through improved camel production and marketing the country can fetch more foreign currency (NBIIA. 2011).

Essentials of Networking in Camel Research and Development

The net working in camel research and development is supported by different forms of organization i.e. forums or society. In Ethiopia, there is Camel Forum Ethiopia (CFE) where various public and non-public institutions are represented to support research and development on camel while in Morocco, Pakistan, Sudan and Kenya there is camel association catering for research and development on camel. The objectives and functions of CFE as described in its by-law focuses on the following four major areas.

- Networking and collaborations;
- Training, research and development;
- Information, documentation and communication; and
- Advocacy, sensitization and policy support

In terms of membership qualification, the camel forum Ethiopia is open to all individuals and institutions that have a principal interest in promoting camel health, management, production, and marketing.

At international level, the first general assembly of the International Society on Camelid Research Development (ISOCARD) was hold at the conference organized in United Arab Emirates in 2006, marking the first ISOCARD conference. The objectives of ISOCARD are the following:

- Give international scientific status for camel sciences;
- Promote the camel science and practice;
- Promote the contributions of camel scientists to the development of camel farming;
- Promote scientific publications in camel fields;
- Set high standards in camel education and training;
- Promote standards of health and welfare in camel;
- Organize International camel conference every 3 years;
- Encourage the exchange of information on camel interest between the members and different networks and involved organizations; and
- Establish and maintain relations with other organizations whose interests are related to the objectives of the society

In the pursuit of its objectives, ISOCARD thus far has organized three international conferences on camel and produced scientific publications.

Implications of Development Strategies on Camel Production

The overall strategic direction of Ethiopian Agriculture and Rural Development focuses on increasing the capacity and extensive use of labor, proper utilization of agricultural land, taking into account of different agro-ecological zones, linking specialization with diversification, integrating agricultural and rural development, strengthening the agricultural marketing system and effective implementation of the scaling up of best practices in the sector. In the pursuit of implementation of this strategic direction and attainment of overall economic and social transformation, the Ethiopia government has prepared midterm strategic plan. In this strategic plan conventionally known as growth and transformation plan (GTP), agriculture including livestock sector will continue to be an engine of economic growth. The strategic direction in pastoral development in the GTP encompasses pastoral land irrigation development, resettlement of pastoralists on voluntary basis, improving marketing system, and strengthening agricultural research and extension system integrated with the pastoralist livelihood.

Like elsewhere in the other parts of the world, pastoral economy and livelihood under Ethiopian context is dependent on rainfall pattern. Observation and experiences in recurrent drought in Horn of Africa including Ethiopia has led to a rationale move for sustainable strategy to transform the pastoral setting of Ethiopia. The on-going strategy under implementation is to use underground water and big rivers for irrigation, which would serve as basis to transform pastoralists to agro pastoralists.

This would be realized in the re-settlement program of pastoralists/farmers based on voluntary basis. With the target to re-settle a total of 121000 households from the four regions (Afar, Somali, Oromia, Gambella and Benishangul-Gumuz Regions) in year I (2010/11), a total of 60000 households have been settled until May,2012 and the target shall be achieved by end of June 2012 (MoFA,2012). In addition to this, during high level federal government officials visit in the Somali Region, reported that since 2010 a 122,807 household pastoralists have been settled by their own willing along Wabi-Shebelle River basin (Addis Zemen, 2012).

The initiative on water development for both drinking (human and livestock) and irrigation schemes encompasses development of pasture for livestock resources and the overall approach has been tested and proven successful in Fentale area. Efforts to expand this initiative to Somali, Afar,

and SNNP Regional States are underway and the approach will be widely expanded in the five-year plan. Pastoral development during the plan period integrates use of improved local breeds, pasture, animal health services by expanding mobile veterinary service, access to market and marketing system and strengthening the capacity of institutions.

Based on this strategy and accompanied mode of implementation the traditional mode of camel production is expected to evolve primarily to semi-extensive and later to intensive mode of camel production. Agro-pastoralists will have access to irrigation to grow highly productive forage and pasture crops to support camel production. It is very likely that acquisition of the technology and knowledge required for the evolving mode of production would be of paramount importance to keep the production system moving to the desired direction as the settlement program has just started.

In the course of implementation of the program, various forum of public dialogue for various sections of society and government organs have been organized to ensure understanding and participation. Feedbacks so far suggest that the program has improved social interactions and a settled way of living is being adopted. Additionally beneficiaries are also gaining access to infrastructures such as roads, clean water, irrigation schemes, schools, and clinics.

Thus, “Perceptions are now changing after successes in productivity of beneficiaries of the program in Somali and Gambella Regions,” have been noted (MoFA, 2012).

Selected Interventions from Global Knowledge

Camel production is the main source of livelihood for several millions of pastoralists and agro-pastoralists in Ethiopian. Undoubtedly, issues of food security and human welfare in vulnerable households of the dry areas where camel is dominant species can be tackled by exploiting its comparative advantage and unique attributes. The products and services camel of camel can be improved with expected substantial contribution to pastoralist livelihood. Attainment of this goal requires comprehensive and long-term engagement on productivity enhancement, value addition, market access, institutional/organizational support, and capacity building. Priority areas of intervention and issues of attention are comprehensively described in the following sections.

Resource base, planning, and commodity development

All actors involved in the value chain of camel need to support their engagements by accurate and reliable statistics. Information on resource base of camel has been an area of debate largely because of the limited coverage of pastoral areas in most of the surveys. This problem is not unique to Ethiopia and some authors referred camel suffering from the lack of attention and serous underestimation in development planning. Peace and political stability in Ethiopian pastoral setting is in good shape and updated information can be generated by including all pastoral environments. Additionally perspective planning (plan for 20 to 30 years) must be thought and put in place to guide commodity development along the value chain considering milk, meat, power/ transport/racing and hide.

Improving Productivity

Productivity of camel is primarily constrained by biological factors related to genetics and reproduction, nutrition, health and overall herd management. In each of these disciplines, concerted efforts have been made globally to come up with intervention and applications of such interventions at the field level would help to increase productivity. The existing situation must be improved and this can be achieved in a number of ways each adding to successful production in times of drought.

Camel Health

Major measures/interventions include the following

- P reventative measures could be taken to reduce effects of bacterial, viral, and parasitic diseases of camel;
- S ystematic treatment against trypanosomiasis, parasites, and effective vaccination against some diseases such as pyogenic diseases, camel pox, and anthrax would help to reduce the challenges in camel health. Under the situations where the new or advanced techniques have not been used yet, the approach shall be adopting the application of the techniques. The modern tools and techniques can potentially be used in disease investigation and production of vaccine to develop appropriate health interventions. An alternative option can be importing selected vaccines from other countries and launching independent immunization programs against specific diseases; and
- A veterinary services in research and extension need to be strengthened to respond to the enormous health challenges pastoralists are currently facing. Coordination at various levels would help in ensuring effective utilization resources (human, physical and financial) and develop breakthroughs.

Breeding

Improvement in breeding, genetics, and reproduction can be realized in various ways among which the following are the major ones.

- Systematic census of camel population by breed type need to be undertaken for accurate planning;
- An elite herd of indigenous breeds can be developed and Characterized based on phenotypic appearance, biometry, and quantitative and molecular aspects. The PCR-RAPD technique can be adopted to show enough genetic variation between and within dromedary breeds and reproducible polymorphic bands with varying frequencies among distinct breeds of camel obtained with the primers. Breed descriptors of indigenous camel breed can be developed. Breeding management can be improved by record keeping and pastoralists should be encouraged to use simplified recording;
- Breeding practices should be modernized and improved by using modern tools and techniques;
- The technique of artificial insemination in camel can be adopted as its use has been perfected in some countries;
- Pregnancy diagnosis can be supported by progesterone kit for assay of progesterone and ultra-sonographic technique can also be applied in ascertaining the presence of ovulating size follicle during different physiological stages; and
- Beyond application of modern tools and techniques reproductive efficiency in camel can substantially be improved by proper disease control, appropriate feeding to reduce age at puberty, age at first calving and calving interval.

Nutrition

Based on the lessons drawn from various countries including Ethiopia, major measures/interventions in camel nutrition include the following

- Introduction of hardy shrubs or grasses to improve feed availability;
- Improving availability of water in the range lands for camel;
- Undertaking nutritional analysis of locally available camel feeds and enhancing utilization of locally available feed resources;
- Development of complete feed blocks for camels was successful in some countries like India as camels fed on complete feed block attained maturity at 3 years of age;
- Supplementation of urea molasses mineral blocks can enhance growth (269 g/d) of camel calves of 2.5 years of age and it can replace 30% of concentrate mixture;
- Complete ration can be formulated using local feeds; and
- Stall feeding plus 6 to 7 hours of grazing supplement was noted to be beneficial and appropriate system of camel management in India.

Improving Products and Services

Global experience suggests camel products and services are currently underutilized due to lack of awareness and their uses can be promoted and optimized in various ways.

Meat Quality

Among determinants of camel meat quality, the optimum age of camel at slaughter is a very important issue. Usually camels are slaughtered at old age after they finish their productive life. This led to an impression that camel meat is tough and less acceptable than other red meats. Studies in Oman indicated that the optimum age for slaughter camels is below 3 years (Mahgoub and Kadim, 2012). At this age, camel meat quality is comparable to that of beef. Under Ethiopian situation, optimal age of camel at slaughter should be assessed and determined.

Milk Quality

When camel milk is not consumed fresh, it must be processed as soon as possible, because its keeping quality seems to be poor and as it is farther affected by the climate, it soon goes bad if not treated. Post-harvest losses in camel milk can be reduced in various ways and its quality should be maintained to meet the standards. Fermented products in the form of yoghurt, butter, and buttermilk products can be prepared from camel milk. Cognizant of its quality, additional measures are needed in promoting camel milk for various uses.

Draft Capacity, Transport, and Sport

Improved practices should be thought towards better utilization and promotion of camel as means of power, transport, and recreation.

Improving Market Access

An efficient system of marketing of milk, meat, and hides should be established to make best use of camel in drought areas.

Strengthening Education, Research, and Extension Services

To respond to development challenges in the pastoral setting, education, research and extension in camel production need to be strengthened. The curriculum of universities in pastoral/agro pastoral setting must accommodate enough courses on camel, the students should be encouraged to undertake demand driven, and client oriented activities in their practical work and thesis research. Among domestic animals, research on camel is a recent initiative and there are major gaps of knowledge and technology to improve overall productivity and pastoralist livelihood. These gaps can be bridged by strengthening research in pastoral setting to use modern tools and techniques and apply cutting age science to develop interventions. In light of the economic policy Ethiopia is currently following, livestock services can also be strengthened by redistributing the roles of public and private sector through time. In liberalized market economy, some public service responsibilities can be contracted to the private sector and some activities can be delineated as purely private sector responsibilities. The public sector should retain core activities such as policy, planning, quarantine, food

inspection, and quality control while activities such as clinical animal health care, animal breeding, and credit are pure private sector responsibilities. Services such as compulsory vaccination, breeding, and some aspects of research can be contracted to private sector with closer the supervision of the public sector. The involvements of private sector in animal health delivery in Morocco and extension services in Chile were quite successful (Haan, 1995). Under Ethiopian situation because of lack of experience and strength in private sector, engagements in the above activities are taking the nature of public good. Thus, strengthening the private sector and gradual handing over of some of the tasks to the private sector may enable the public sector to focus on core engagements that can be delivered by public sector and increase its effectiveness and efficiency.

Strengthening Networking in Research and Development

Camel Forum of Ethiopia need to be strengthened to serve the primary purpose it is set for. Participation at the regional or global level need to be enhanced by members of the forum and representation in various appropriate forums shall contribute towards attaining the objectives of the forum. Beyond sharing the global camel science and technology, strong linkage and interaction with ISOCARD helps to trigger global or regional collaboration in camel research and development. Among various areas of camel research, aspects of genetic characterization of camel using

standardized approach and modern tools could be handled better through collaboration with ISOCARD and other international agencies.

Camel Research Strategic Themes, Issues and Interventions

Themes

A 15-year (2016-2030) camel research strategy has been formulated to guide research undertakings in camel across the country (EIAR 2017). The strategy has identified key issues and major interventions in this regard. The summaries are presented as follows

Considering the complex nature of the issues to be addressed by the camel research team, most of the research topics are multi-institutional, multi-thematic, multidisciplinary, participatory, and need to be implemented in collaboration with pastoralists and agro pastoralists, extension worker, traders, middle men, agro-processer and other partners to be involved in camel sub-sector. Aligned to the goal and priorities of EIAR and guided by the current national agricultural growth and transformation framework, the research strategy is believed to benefit pastoralists and agro pastoralists, agro-processors, traders and others involved in the camel value chains and the nation at large.

General Perspectives

Climate change, recurrent droughts, shortage of feed and disease are currently affecting camel production and productivity and export market requirement. Thus, camel research is supposed to focus on commodity development through vibrant multi stakeholder platform. Special effort shall be made to put in place the enabling environment (human, physical, technological and organizational set up) to bring camel research to the desired standard. Furthermore, stakeholders involved in the camel value chain need to have a strong, functional, influential and sustainable camel forum that will shape up the future of the camel research, camel export, camel production and product processing, and consumption..

Feed and Nutrition

Research on nutritional composition of feeds and animal requirement should focus on improving the existing feed and feeding system characterization and evaluation of available feed through in-vitro and in-vivo procedure. Improvement of the nutritional value of forage and other feeds using biotechnological tools and optimization of the existing feed resources shall be carried out particularly in area where the natural grazing area is degraded and availability of water is scarce, Potential application of modern tools and techniques such as, tissue culture for forage, biotechnological tools in manipulation of rumen microbes are the major areas of intervention

Production, Husbandry and Reproduction

One of effective way to increase production and reproduction performance is study on the production systems and identification of problem related to fertility, herd dynamics. Potential application of assisted reproductive biotechnology tools such MOET, *in vitro* fertilization etc shall receive due attention to enhance reproductive efficiency of camel.

Health

Animal disease has numerous impacts on production, reproductive and growth performance. The presence of animal disease apart from affecting efficiency of production hampers both domestic and export market because of

frequent export market ban. To this end, the camel research focuses on generating technologies (vaccines and drugs) to control measure important camel diseases.

Socio-economic and Research Extension

Socioeconomics and extension is one of the core members of camel research and this is an important group to bring in stakeholders together to formulate relevant research agenda as the same time taking out promising research results after demonstration processes. Addressing issues related to socio-economic and research extension in the strategy is the key to attain the successes that the research team envisages.

Post-harvest

The major gaps in camel value chain for post-harvest loss are meat, milk and hide processing and packaging and value addition. Therefore, the research is expected to address the gaps with appropriate technologies.

Gender

The role of women in camel production and productivity is critical as women contribute 50% of the farm labor (camel management). However, women have limited accesses to resource, services, land, credit, and technologies. Hence, women are more vulnerable to effect of poverty. If this gender gap is eliminated the output from camel commodity would increase. Therefore, this strategy will integrate gender concern in to research agenda.

Climate Change

Climate change and variability is already having impact in the livelihood of different communities particularly pastoral and agro pastoral society. Therefore, the camel research strategies will generate resilient/ adaptation means that would help camel producers and value chain actors to responds to climate change.

Interventions

Breeding and Genetics

In relation with camel breeding and genetics, the following strategic issues are identified:

- Breed improvement herd/facilities;
- Breed/population diversity; and

- Genetic information (camel breed improvement, and genetic parameter for important traits);

The expected outputs in breeding and genetics include the following:

Genetic improvement herd and required facilities established and linked with community herd;

- Genetic diversity of Ethiopian camels will be known at both morphological and molecular levels;
- Markers treat identified for major economic treats and use for selection; and
- Genetic parameters/information for major economic important treats estimated

Feed and Nutrition

Research strategic issues associated with camel feed and nutrition research identified include the following:

- Rangeland management;
- Forage grass and shrubs; and
- Feed composition, feeding management, strategic supplementation and nutrition requirements of camel

Expected out puts from feeds and nutrition include: :

- Technologies that would improve rangeland productivity:
- Information on, characteristics of indigenous forages and development of best bet varieties of forage
- Information on nutrition requirements of camel by physiological age and production stage.

- Intervention for strategic supplementation of various categories animals

Production, Husbandry, and Reproduction

- Milk yield, and lactation length;
- Reproductive performance; and
- Husbandry, herding, and mating.

The following research outputs are expected from thematic area of production, husbandry, and reproduction of camel:

- Information on camel production and reproduction performance under on station and on farm condition;
- Information on exiting camel husbandry and management; and
- Information on evaluation and demonstration of improved calf management techniques

Health

Strategic issues identified for camel health research for development include the following:

- Animal health facilities;
- Animal health specialists;
- Veterinary technicians;
- Diseases, distribution and effects;
- Vaccines; and
- Drugs

The research strategy on camel health is expected to deliver the following out puts:

- Establish camel health facilities;
- Train and build the capacity of camel health specialist and technicians;
- Information on major camel diseases, their ecological and seasonal distribution, mortality, morbidity rate, economic impacts on production and productivity of camel and camel products; and
- Production protocols or procedures on the effectiveness of imported and locally produced vaccines and drugs for treatment and control of camel diseases

Socioeconomics

The following are socioeconomic strategic issues identified for camel research:

- Demand and supply of camel milk and meat;
- Marketing systems (domestic and export market);
- Technology adoption

Expectation output from socioeconomics research on camel include the following:

- Updated information on marketing of camel and camel products;

- Information on socio-cultural and economic factor that limit marketing of camel and camel products;
- Information on demand and supply of camel and camel products both at domestic and export market/niche market; and
- Information on adoption status and impact of camel technologies on pastoralist and agro-pastoralist livelihood

Post-harvest

The post-harvest strategic issues identified include the following:

- Milk collection, transportation and storage and value addition (cheese chocolate, butter);
- Meat processing storage and transportation /value addition such as sausages and canned meat;
- Documentation on nutritional value and chemical composition of milk; and
- Meat production potential, dressing percentage and nutritional value

The expected output from post-harvest research on camel products are the following:

- Information on status of camel milk and milk product collection, transportation, processing/value addition;
- Recommendation on improved camel milk and meat and their products transportation, storage and value addition technologies;
- Information on nutritional value and chemical composition of camel milk and meat including their products; and

- Information on camel milk and mat quality and food safety to meat expected standard

Gender

Strategic issues related to the role of gender in camel production include the following:

- Role and responsibility of gender on camel production; and
- Benefit sharing and control over resources of women and youth

Climate Change

The strategic issues in climate change pertaining to related to camel research included the following:

- Green house gas emission and mitigation options

As crosscutting issues, expectations from gender and climate change research on camel include the following:

- Information on the role, responsibility benefit sharing, control over resources of women and youth;
- Information on green house gas emission from camel and future mitigation options; and
- Information on vulnerability and susceptibility of camel species to climate change and variability including adaptation options

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