



## Camels Through Time: History, Domestication, Challenges, Opportunities, and Sustainable Development

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### Abstract

*Camels, the ship of the desert*, have a unique old relationship with Arabian people. The Arabian proverb describes

camels as (If they carry then they can beat the weight, if they walk then they can go far away, and if they are slaughtered, they can be fed all, and if they are milked then all can drink). Since ancient times, camels were exploited as the beast of burden, for riding, milk, meat, and wool/hair. Their role in human civilization is greatly appreciated, as they facilitate trading and cultural dialog between people throughout continents. Although their role in caravan and transportation is dramatically decreased and limited, their role as the sustainable animal for future and food security saver is raising. Elucidation of their domestication, history, socioeconomic impact, and their expected role under the extreme circumstance of drought and desertification will enlighten the path for the future.

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### Introduction

The term camel is believed to be derived from Latin ‘Camelus from Greek word ‘kamēlos; or ‘kremal’ from a Sanskrit word ‘Kreluk’ which means ‘throw away legs’ and this is logic, as camel throw away its legs during walking (Khan *et al.*, 2003). Hebrew or Phoenician called gāmāl, which means to bear or carry, and this related to the Arabic word Jamal. The Camelidae family is divided into the new-world camel (Laminin) and the old-world camel (Camelina). Within the Camelina, there are two domesticated species, the single-humped dromedary camel (*Camelus dromedarius*) and the two-humped Bactrian camel (*Camelus bactrianus*) (Wilson, 1998), in addition to the



critically endangered camel *Camelus ferus*, which is considered as two-humped wild Bactrian and found in northern China and southern Mongolia (Wilson, 1998). ‘The ‘Laminin Camel’ consist of four South American camelids: the llama and alpaca which are known as "New World camels", and the guanaco and vicuña which are known as "South American camels".

Bactrian and Dromedary camels are two distinctive and recognizable livestock species. While Dromedary occupies the northern part of Africa, the Middle East, part of Asia, and the Indian subcontinent, the Bactrian camel occupy central and east Asia: China, Mongolia, Kazakhstan, Kirghizstan, Turkmenistan, and Afghanistan, northern areas of Iran, India, Pakistan and up to eastern Turkey (Khan *et al.*, 2003).

According to (Potts, 2005) in the translation of Lehmann's words in 1891 (p. 141) ‘(Without the camel neither the icy steppes of Western Siberia nor the inner Asian plains were inhabitable; they would have remained until today an insurmountable obstacle to communication and would have made a nomadic existence impossible)’ Daniel Potts said that “Silk Road is the bridge between Eastern and Western cultures, and camels specifically the Bactrian camel are the principal means of locomotion across that bridge” (Potts, 2005). Thus, old-world camels connected the Indian Ocean with the Atlantic Ocean and linked the Mediterranean Sea with Asia, Africa, and Europe (Almathen, 2014). This connection led to the merging and development of different cultures from different countries that without camels will not exist. On the other hand, camels are multipurpose animals providing milk, meat, and wool. Nowadays with modern fast transport technology, these beasts of burden seem to be out of date. However, growing demand for sustainable milk and meat production, especially in countries affected by climate change, drought, and desertification, return the camel to occupy the first line and grasp attention to be animal of the future. It is worthful mentioning that during the 1970s and 1980s while droughts hit Africa, the interest has awakened in this beast of burden, provider of milk, meat, and hides. They have shown to be better adapted to extreme conditions of harsh environments in arid and semiarid Africa and Asia than other domesticated animals (Bornstein & Younan, 2013).

In the current review, we try to summarize the literature for the existing information on domestication. We start by addressing the evolution, history of the domestication of camels, genetic evidence for domestication, and the socio-economic impact of the camels. We also hit the challenges for the research and future directions for this thematic.

## **Evolution and Domestication History of the camel**

Human civilization is largely attributed to the domestication and cultivation of wild plants and animals, providing a constant resource of food and other human needs. Accordingly, facilitate the shifting of human from hunter to farmer or producers. Humans struggled to domesticate wild animals through three pathways: commensal, prey, and direct pathways (Zeder, 2012). Dogs, cats, or chickens were domesticated by establishing a commensal relationship with a human, while cattle were domesticated in prey pathway as it was hunted for their meat. the human was started to domesticate horses, donkeys, and camelids by a direct pathway through restriction of their movements, nutrition, and reproduction (Zeder, 2012). However, animal domestication led to human civilization (Ahmad *et al.*, 2020), domestication of the wild ancestor is not an easy process, rather it is a slow, continuous, and intensive multistage process, where



is a significant change in physiology, morphology, and even genetically characters take place (Ahmad *et al.*, 2020, Rodgers *et al.*, 2020). Moreover, domestication led to a change of the biosphere and alteration of earth demography (Ahmad *et al.*, 2020).

Thus, understanding the origins and the domestication process of any species must be carefully elaborated, and answering the questions of what; where; when; why, and how domestication happened (Zedar 2015, Ahmad *et al.*, 2020). Domestication is usually accompanied by genomic and phenotypic alterations. forces of gene flow; adaptive environment, and human selection led the overall game (Ahmad *et al.*, 2020).

Camels had been domesticated through the direct pathway in the Eocene era which is known as the dawn of modern life. The earliest ancestor (Protylopus) found from the Upper Eocene period was not bigger than a hare or wild rabbit (Yagil, 1985). There is no archaeological evidence about the exact time of camel's domestication as nomads with their camels were in permanent movement and migration throughout the desert. However, there is evidence for the domestication of southern American camels in the Andes of Southern Peru and western Bolivia (Khan *et al.*, 2003). The evolutionary history of the camel traces back to the middle Eocene (around 40 million years ago) (Burger 2016). The ancestor of the camel was lived in the North American continent and spread to Eurasia around 11 or 16 million years ago through the Beringia bridge (Ming *et al.*, 2020), and then split into dromedary and Bactrian camels around 4 or 5 million years ago (Ming *et al.*, 2020).

The wild two-humped camels, discovered by Nikolaj Przewalski in 1878, might have been distributed throughout Central Asia, but the lack of remains of bone and rock art from archaeological sites, made the mission very difficult to draw a logical scenario (Peters & Driesch, 1997). Although the available genetic data for the two domesticated species (Dromedary and Bactrian camel) was established, the available data for the wild two-humped (*Camelus ferus*) was recognized as a separate species with separate lineage. The data shows independent development of the old-world camels (Burger, 2016), and the wild two-humped (*Camelus ferus*). it was not the direct progenitor of the domesticated camel (Ji R *et al.*, 2009, Wu, H. *et al.* 2014) although the morphological similarities with its domestic counterpart (Peters & Driesch, 1997). Several studies confirmed that the wild two-humped camel is an original wild form and separate species (Ji *et al.* 2009; Silbermayr *et al.* 2010; Wang *et al.* 2012; Mohandesan *et al.* 2017; Yi *et al.* 2017).

The first domestication of Bactrian may have occurred in the cold desert (Ji *et al.*, 2009), domestication seems most likely to occur in multi-regions of the east, then spread west towards Central Asia (Han *et al.*, 2002). It seems that the wild camels present may have originated from those escapees of their domesticated counterparts (Ji *et al.*, 2009). The logical frame of the scenario builds up by (Ming *et al.*, 2020) seems to fill the gaps in the puzzle of camel domestication and answer any questions. This scenario suggested that after the ancestor of camels moved from North America and split into dromedaries and Bactrian camels, the wild Bactrian camels spread from East to Central Asia, then domestication occurred in Central Asia. The domesticated Bactrian camel was then migrated back to East Asia. The domesticated Bactrian camels in Central Asia were further hybridized with dromedaries out of Arabia, thus the gene flow occurs. Apparently, 'The direct wild progenitor of domestic Bactrian camels was not found in central Asia now and may no longer exist'. (Ming *et al.*, 2020).

It was believed that because of the extinction of the wild dromedary, the wild Bactrian camel (*Camelus ferus*) was the only representative of the wild tribe Camelini (Ming *et*



*al.*, 2020). Historically, the wild Bactrian camel was widely distributed throughout Asia, extending from the great bend of the Yellow River in the west to central Kazakhstan. Now, it is only found in the Mongolian (Great Gobi Strictly Protected Area ‘A’) and Chinese (Taklimakan desert, Gashun Gobi Desert, Arjin Mountains in the Lop Nur Lake region) (Burger *et al.*, 2019). These regions are considered refuges and conservative for the remaining wild camels. Their estimated numbers range from 1000 to 1600 (Lei *et al.*, 2012) and they are critically endangered. According to the sequence data available on the *cytb* gene, the wild camels surviving in China and Mongolia belong to the same lineage (Ji *et al.*, 2009). Based on this and besides the presence of the Camelid faunal remains at Neolithic sites near Mongolia, it could be suggested the dispersed of the camel from Mongolia to the west.

Camel was prominently depicted on Assyrian and Achaemenid Persian carved reliefs and figured in Biblical texts as indicators of wealth at the first millennium BCE. Among the most famous depictions are those in the ruins of Persepolis, where both main camel species--the one-humped dromedary of western Asia and the two-humped Bactrian of eastern Asia are represented in the processions of those bearing tribute to the Persian king (Daniel C. Waugh, (n.d.)). In China, the value of the camel was increased by the interactions between the Han and the Xiongnu toward the end of the first millennium BCE when camels were listed among the animal’s taken captive on military campaigns or sent as diplomatic gifts or objects of trade in exchange for Chinese silk (Daniel C. Waugh, N.D.)

In contrast to Bactrian camel domestication, Dromedary domestication is limited to one geographical region. The most likely is around present-day Oman about 4000 years before BP (Before Present) (Uerpmann & Uerpmann, 2002; Khan *et al.*, 2003). Worldwide sequencing of modern and ancient mitochondrial DNA (mtDNA) suggested that the region of dromedary domestication is most likely the southeast Arabian Peninsula. As camels are known to be used for long journeys, the intensive back and forth movements are a unique feature compared to other livestock. Accordingly, the low initial number of domesticated dromedaries, and once domesticated, a relative absence of gene flow between wild and domestic populations.

Pamela Burger from the Research Institute of Wildlife Ecology at (Vetmeduni Vienna) said that “We have managed to turn the wild dromedary into a domesticated, but we don't know how and where domestication began and what effect it has had on today's animals”. Burger and her team analyzed up to 7,000-year-old DNA from bones of wild and early domesticated dromedaries’ camels and compared the samples with the genetic profiles of modern dromedary camels’ populations from around the world. For the first time, it was possible to identify the Southeast Arabian Peninsula as the region of the first domestication. According to Burger, the early domesticated dromedaries’ camels are breeding many times with the wild dromedaries (that used to live above the hills of Hadhramaut around thousand to five thousand years ago) and thus, limited the range of the wild ancestor dromedaries and went extinct about 2,000 years after the first domestication. Since that, the dromedary camel has been rightfully known as the Arabian camel and the ship of the desert. The Arabian camel has become an integral part of the nomadic culture that has crossed the door of history and spread across continents. Moreover, a hybridization through multiple long trade routes between Bactrian camels (*C. bactrianus*) and dromedaries (*C. dromedarius*) occurred in the early centuries of domestication. This was for sake of producing animals with the robustness of the Bactrian camel, endurance, and ability to tolerate the abrupt contrasting



temperature of the dromedary. The archeozoological study revealed hybridization in a Roman archaeological site in Serbia, Viminacium, in the late third to fourth centuries CE ( VukoVić & Blažić, 2014).

After domestication, during 1st millennium BC up to the late second millennium BC (according to arkeological osteological and pictorial evidence as well as cultural context studies) (Uerpmann & Uerpmann 2002; Von den Driesch & Obermaier 2007; Grigson, 2012; Magee 2015), small numbers of dromedaries arrived northeastern Africa via the Sinai and continues as small numbers. Larger camel herds in northern Africa only start during the fourth to seventh centuries CE (Late Antiquity/Early Middle Ages), and their contribution to the local economy has been slow (Bulliet, 1975). Another possible route for dromedary introduction into Africa could involve a transfer from the south of the Arabian Peninsula via the Gulf of Aden to Eastern Africa Islands of Socotra (in the east part of Africa) or further north across the Red Sea to Egypt. The islands of Socotra play a crucial role to connect Arabian Peninsula with Africa through the trade pathway “sea-borne incense trading” (Epstein, 1971). Parallel to incense trading and in the controversial direction, Aden port connects Africa to the Arabian Peninsula trading luxury goods, ivory, wool, and skins (Al-Ghabban *et al.*, 2010).

Clearly, via ancient trading routes, the domesticated dromedary camels in the southeast Arabian Peninsula spread into the northern part of the Arabian Peninsula and Africa. As dromedary camels are well adapted to the harsh desert environment they were used as a means of people and goods transport through trade routes such as the trans route” incense road”. The incense road connects southern parts to northern parts of the Arabian Peninsula and is used to transport valuable spices and perfumes.

Parallel to the arkeological studies, the microsatellite detection supports the introduction of the dromedary camels into Africa through entry routs: Egypt entry point; East of Africa entry point; and by crossing the Red Sea all along its coast (Almathen, 2014)

In the 7th century and as trade dramatically increase between Arabian Peninsula and Africa, dromedary camels were widespread throughout the African Sahara (Gauthier-Pilters *et al.*, 2010). The spread of Islam to Africa is also playing a vital role in the spreading of dromedary camels to Africa, as they were used for transportation during the annual pilgrimage “hajj” to Makkah (Wilson, 1998).

Even though dromedary camels were domesticated in the Arab Peninsula at the beginning, about 80% of the dromedary are found in Africa. According to (Ali *et al.*, 2019) Sudan accommodates around 4.8 million heads which represent about 22 % of animal biomass, accordingly, Sudan is the first among the Arab countries and second in Africa concerning animal population. Sudan is considered the second country in the world in camel population (Eisa & Mustafa, 2011). The history of the dromedary camel in Sudan can be traced to 15–25 years BC following human migrations from Egypt (Wathig *et al.*, 2007; Eisa & Mustafa, 2011; Hashim *et al.*, 2015).

The most updated migration route started in the 1860s and was attributed to link the Indian Subcontinent to Australia, thus several thousand camels were imported to Australia till the 1920s to develop the Australian outback (Faye *et al.*, 2004; Rangan & Kull, 2010).

### **Estimated Camels’ Population Figures**

The estimated camel populations were generally delicate to be known exactly and varied from source to source. This is attributed to numerous reasons similar as the nature of camel life, utmost herdsmen are nomadic and pastoralists who are in dynamic



movement, lack of targeted camel population census, absence of veterinary vaccination coverage obligation, and sub estimation of the precise contribution of camel products into market and economy (Njiru, 1993). In keeping with FAO (FAO 2014), the whole number of camels within the world was around 27 million heads, but this number is presumably undervalued, as it is readjusted after the applicable census. As the case in Chad where the camel population was readjusted from 800,000 to quite 1.3 million heads after an applicable census by the Ministry of Animal Resources. Therefore, by considering both the wild Australian camel population and the different national estimations, the camel world population is presumably around 30 million heads (Gee,1996). Indeed, however, this population represents lower than 1% of the entire herbivorous domestic population within the world, far -off behind cattle (1.5 billion) sheep and goat (further than one billion each), and indeed behind the horse (70 million) and buffalo (200 million).

Per the FAO, out of roughly 35 million camel heads worldwide (FAO, 2019), the bulk (95%) is of the dromedary type (Hashim *et al.*, 2015). The Bactrian camels are distributed throughout central and eastern Asia and the dromedary camels substantially colonize the desert and semi-desert areas across Africa, the Arabian Peninsula, and southwest of Asia (Wilson, 1998). Accordingly, quite 80% of this estimated population board Africa with 60 % within the Horn of Africa. Per the Indian Research center (NRCC) 19.31 million camels were reported, divided into 15.13 million camels in Africa and 4.17 million in Asia, ranking as follow: Somalia with 6.2 million camels, Sudan with 3.2 million, Mauritania with 1.2 million, Ethiopia with 1.07 million and India with 1.03 million (NRCC, 2007). In another exploration, it was recorded that 18.58 million camels were planted worldwide, from that population, 13.62 million were present in Africa, while only 4.76 million in Asia and 0.2 million camels were present in Australia (Afzal, 2006).

According to the info from FAO in 2020, the overall number of camels recorded within the world was quite further than 35 million (35,525,270) (FAOSTAT 2020). Database from FAO 2018 (FAOSTAT 2018) has refocused out that among the 46 national entities declaring a camel population, only 50% are the official data provided by the national ministries, and therefore the remainder is grounded on the predicted FAO's estimates (Faye, 2020). Among the 46 countries, 25 are in Asia, 20 in Africa, and only one country in Europe is proscribed to Ukraine. The dromedary camels are found in African countries, Near, Middle Eastern, and Southern Asian countries. while the Bactrian camels are found only in Central Asia. The two species (dromedary and Bactrian ) are cohabiting in a very few countries substantially in Kazakhstan. In step with FAO statistical data, a drop in camel population in numerous countries similar as Afghanistan, China, India, Israel, Jordan, Mongolia, and Soviet-Union republics was reported. while other reports declare that Turkey had been the Camel population is dramatically decline from 65,390 heads in 1961 to 1703 head in 2018, with a chance of 98% (Caliskan 2016). This dramatic decline may be attributed to the negotiation of the machine in different agricultural work and transportation, indeed though camel wrestling which is a notorious artistic cultural sport in Turkey and is believed to be the explanation behind keeping camels from the risk of endangered (Yilmaz & Ertugrul,2014; Faye,2020). On the opposite hand, an unforeseen rise has passed lately in some countries like Chad during which the camel population was increased fourfold, from 1,550,000 heads in 2014 to 6,413,000 in 2015. also in Kenya, the camel population was duplicated in 2012 (3,065,400 heads) compared to 2011 (1,350,000 heads), In Nigeria, the camel



population was 285,000 in 2013 compared to 20,500 in 2012. likewise, a pointy sharp increase in some Arabian Peninsula countries was also observed, Saudi Arabia in 2015, Qatar in 2011, and Oman in 2013. The pattern of this increase may indicate an increased interest and demand for camel products, further contributing to different economic sectors (Faye,2020).

The camel population in 2010 was slightly quite further than double in 1961 (it was multiplied by 2.04), corresponding to annual growth of 2.4% (Faye, 2015), still comparing this annual growth to other species at the global level, the camel population was growing faster than cattle (1.46), sheep (1.08), horse (0.95) and lama (1.48) and was near buffalo increment population growth (2.12), but not up to goat (2.52) (Faye & Bonnet, 2012).

### **Camels in Religions**

The camels were mentioned in holy books. The Bible that mentioned that the Queen of Sheba, who came to Solomon, peace be upon him, in an exceedingly very great procession, with camels loaded with spices, gold, and precious stones. It's also mentioned within the Bible that the Bedouins normally carry their wealth on the shoulders of donkeys, and the humps of camels as their treasures. moreover, it came within the Gospel of Matthew: "It is easier for a camel to pass through the eye of a needle than for a rich man to enter the kingdom of God."

For Jewish, they're prohibited and banned from consuming camel meat and their products as mentioned in Al Torah in 2 places: ("The LORD said to Moses and Aaron, 'Say to the Israelites: "Of all the animals that live on land, these are the ones you may eat: You may eat any animal that has a split hoof completely divided and that chews the cud. Some only chew the cud or only have a split hoof, but you mustn't eat them. The camel, though it chews the cud, doesn't have a split hoof; it's ceremonially unclean for you.'"") Leviticus 11:1-4)

("Do not eat any despicable thing. These are the animals you'll eat: the ox, the sheep, the goat, the deer, the gazelle, the deer, the goat, the ibex, the antelope, and therefore the sheep. You'll eat any animal that has a split hoof divided in two which chews the cud. However, of these that chew the cud or that have a split hoof completely divided, you may not eat the camel, the rabbit, or the coney. Although they chew the cud, they do not have a split hoof; they're ceremonially unclean for you." Deuteronomy 14:3-7)

The prohibition materialized after the Exodus of the Hebrews from Egypt and not before that supported this text. 'Then he loaded ten of Abraham's camels with all types of costly gifts from his master, and he traveled to distant Aram-naharaim.'Genesis 24:10)

Then Rebekah arose along with her maids, and they mounted the camels and followed the person. So, the servant took Rebekah and departed. Genesis 24:61 "Then they sat right down to eat a meal. And as they raised their eyes and looked, behold, a caravan of Ishmaelites was coming from Gilead, with their camels bearing aromatic gum and balm and myrrh, on their thanks to bringing them down Egypt.'Genesis 37:25.

Reportedly, the rule before Prophet Ya'qub plays peace be unto Him (Jacob aka Israel) had made a vow with God. Which was to forever stop eating camel meat if his prayer was fulfilled. He's reported to own loved camel meat. So, when it came to pass, Jacob dutifully stopped eating camel meat which was made the rule for his people. This was the Jewish tradition. The Ishmaelites followed the pre-Jacobean permission to eat as was



practiced by Abraham and Ishmael and Isaac and have done so ever since. (Vayikra - Leviticus - Chapter 11, 2015)

### **Camels in Arab heritage and Holy Quran**

There is a unique, special, continuous, appreciative, faithful, and respectful relationship between the camel and the Arabian people. This might be attributed to a special life that's necessitated by the character of the environment within which both get adapted. Since that camel is thought to be a ship of the desert and known as Arabian Camel. Till now Camels occupied a prominent place of Arab interest and Arabian people still have great interest keep and raising camels, especially the pure and expensive breeds.

Moreover, this special position for the camel is getting higher after Islam. Holy Quran mentioned camel either directly or by special characteristic. Allah Almighty reminds people about the creation of camel (AL-GHASHIYAH 17 (Then do they are doing not have a look at the camels - how they're created? and at the sky, how it had been raised, and at the mountains, how they were raised?). This verse calls us for contemplating the various aspects of the marvelous creation of the camel. other verses within the Quran also mentioned camels by name of their special characteristics that distinguish them from other animals, like human, wa -farsh, wa -badan, wa-rukaab, wa-hudaa(Alrarimedia news, 2013; The Society for the Protection of Animals Abroad (SPANNA), Animal Encyclopedia, Camel Atlas (n.d.)). on the opposite hand, the prophet Mohammed (bless him and his family) mentioned camels about 109 times in his honest Hadith such as (Camels provides a Glory to their owner) (AL Sanae, 1983).

Arab culture is bounded by lots of Islamic values and literature associated with camels, including books, stories, and poems. The placement of the first masjid alnabwi (AL medina) was resolute in keeping with the sitting place of the camel of Prophet Mohammed (Alshahrour Abedalgader, 2019). Camels are used in sacrifices in Hajj, Eid al-Adha, and other related worship that require slaughtering animals. Camel racing and throwing, besides getting used to war within the desert, also are popular in Arab Culture. History has preserved several famous camels, including she-camel to Thamud, The camel of al-Basous (as she was the rationale for the eruption of war between the two tribes of Bakr and Taghlib for forty years), The she-camel of Prophet Mohammed (prayers and peace be upon him) al-Qaswa (on which Prophet Mohammed migrated from Makka to Almadineh, and when al-Qaswa lay down she chooses the place of the first mosque in Islam ), The red she-camel of Omar Ibn Al-Khattab( she carried him to Bait Al-Maqdis).

Famous Arab tribes have their original breeds of the camels, they play a task within the preservation of heritage and traditions. The Arab man relied on the info of nature, and camels came all together in all their details existence. Camels have represented a source of pride for their shepherds throughout the historical eras within the Arabian Peninsula. 'The owners of the camels are proud and distinguish themselves from the owners of sheep herds in line with the social custom within the desert communities'. There's a famous Arab proverb regarding the camels (milking sitting down and drinking standing up), which mean that folks wish that the camel owners will lose their camels and become sheep owner if they hurt them, and this may be a touch ashamed. Archaeological sites in several historical sites indicate that camels were formed a pillar for commercial caravans within the past in the transport of goods and fetching water, additionally to



the multiple uses of their skin and wells, including the manufacture of ropes and near water.

### **Food security**

Food security is the most horrible issue everywhere on the globe. The explosion of the human population, increase poverty, global climate change, desertification, and limited water resources grasp the eye toward the wants of a brand new food resource that may be sustained and survive. Priorities of food security as a global issue for the world's population are outlined within the FAO & WHO in 2018 report. This priority is reflected within the Sustainable Development Goals (SDGs) and heading the thanks to decreasing the climatic impacts. The Sustainable Development Goals (SDGs) aim to play a vital role in poverty eradication (SDG 1), eliminate all kinds of malnutrition within the world by 2030 (SDG 2), improve nutrition and health status (SDG 3), quality education (SDG 4), gender equality (SDG 5), promoting economic growth process (SDG 8) and reducing inequalities (SDG 10). Thus, achieving the world's sustainable development goals and getting a more stable and prosperous society nutrition may be a critical driven force. Currently, an emerging interest in camels is coming around because the camel is understood for its resilience to dryland conditions and drought in pastoral communities in many countries. Accordingly, the camel plays a vital role within the financial system and food security for a few countries within the world, and it's been nourishing the Bedouins, nomads, and pastoral people since ancient. Supported that, the camel may be the most effective candidate to satisfy several SDG goals and be an element of the answer. Scientists assume that the camel can mitigate and face many threats, it's sort of a superhero.

### **Sustainability and challenges of sustainable development of the camel**

Sustainability was defined by the United Nations (UN) as 'the development that meets the wants of this without compromising the ability of future generations to satisfy their own needs (Adams, 2006). The three pillars of sustainability are constructed on the combination, integration, and reconciliation of environmental, social equity, and economic demands. However, for a few environmentalists, the idiom of sustainable development is nonsense, as development entails environmental degradation (Redclift, 2005). Sustainability implies responsible and proactive decision-making to limit the negative impact and maintain the balance between the social, environmental, and economic processes. Thus, ensure a desirable planet for all species now and within the future.

During this context, the camel, the foremost important animal domesticated by humans within the desert ecosystem and occupies a hotspot livestock/environment interaction area (Steinfeld et al., 1999) is facing a vital challenge regarding sustainability. Camel stakeholders face many challenges like changes in camel demography and also the reflecting effect on the environment, preservation of the camel diversity, conversion of feeding management of camel into intensive systems, preservation of water resources, integration of camel rearing within the global economy, and promotion of high-value products to the growing market, social dimension of the camel within the desert societies and control of the health constraints for a highly mobile camel population. All the above-mentioned challenges must be under attention and control.



‘ Since 1900, the Sahara has extended by 250 km to the south and along a 6000-km front in total’ (Leroux,2004). The camel is the least stricken by this desertification and recurrent drought-affected Sahelian countries, in contrast, the observable impact of this condition is the expansion of the geographical distribution of the camel. Accordingly, the camel is being well adapted to the arid environment. Camels have a decent friendship with the environment because the camel farming system has low environmental pressure activity (Raziq et al., 2008).

Yet, the changes within the camel farming systems from traditional into semi-intensive or intensive farming systems, consequently, modify the well-known relationships between the camel and the environment (Faye & Konuspayeva, 2012). Despite the importance of the camel, the intensification within the camel production system seems to make pressure on emerging disease status and increase the chance of emerging diseases like the MERS-Coronavirus outbreak (Sirohi & Michaelowa, 2007; Faye & Konuspayeva, 2012; Megersa et al., 2012, Gossner et al., 2016).

Water resources availability is the most upcoming challenge for livestock raising (Faye, 2013) even for the camel that’s believed to be a cost-effective animal in water consumption. As an example, in Saudi Arabia where camel farming moved toward an intensive system, water consumption increased from 3000 to 35,000 m<sup>3</sup> /ha, and in step with biomass productivity, water consumption for the feeding of 1 camel was multiplied by 3.2 contributing to higher pressures on water resources (Faye,2013). At the national level, comparing the case in 1961, water consumption in Saudi Arabia has increased approximately from 180,000 to 280,000 m<sup>3</sup> within the traditional system, whereas it’s risen from 7000 to 860, 000 m<sup>3</sup> in intensive systems during the last 50 years (Abdallah & Faye, 2012; Faye 2013). Thus, the intensification of camel farms may have a powerful effect on water demand, which consider as a constraint for sustainable development.

Camels browse and graze a wide variety of plants (including halophyte grasses, bushes, and trees), thus, exerting a minimum pressure on the floristic biodiversity of the arid lands and low destructive behavior on pasture else than other herbivorous ruminants (Laudadio et al., 2009). The digestive physiology of camels (nitrogen recycling, slow transit, rumen flora,) allows them to create better use of low-quality forages resulting in more feeding efficiency than other ruminant species. The consequences of the intensification rearing system of the camel haven’t been well studied still thanks to the effect on the rumen flora, feeding conversion, metabolic disorders, and other aspects. The impact of the changes in feeding practices on the milk composition and medicinal activities of intensively farmed camels has not been investigated, and neither has the nutritive value and chemical composition of their meat (Kurtu, 004). The modernization of management (as milking machines) use, and effect must be also evaluated (Atigui et al., 2015).

The globalization of the global economic forces the camel farming owners to be more integrated into the market because the contribution of the camel products within the global economy is restricted, apart from camel meat, which is integrated into the regional market between the Horn of Africa and Arabian Peninsula, or for alpaca wool, which integrated into the international textile market (Faye, 2016). Increasing integration of camel and camel products into the economy could also be led to significant changes within the added value chains of camel products (especially milk and milk products). A dairy plant must be established near the camel intensive farm, new milk products like pasteurized milk, cheese, yogurt, frozen dessert or ice cream must be lunched and new methods for marketing must be adapted (Faye *et al.*, 2014)



In the light of the predictions of increased global warming, the camel probably would be the foremost favored animal for rearing with the apparent contribution within the social and economic sector. However, the effect induced by intensification farming on water resources, environment interaction, and emerging disease risks can't be ignored.

### **The Socio-Economic Profitable Value of Camels**

In the line with the Economic Survey 2020-2021, agriculture's share within the gross domestic product (GDP) is sort 20 % you look after the primary time within the last 17 years, making it the only bright spot in GDP performance during 2020-21. Globally, livestock contributes about 40% to 47% of agricultural gross domestic product (GDP) or a fellow of 12% of the National GDP (FAO 2008) and provides livelihoods and inflows for at least 1.3 billion people. (International Livestock Research Institute (ilri.org)).

The camel encompasses a reputation among domesticated creatures as a multi-purpose, and beast peace and wartime, well acclimated to extremely harsh surroundings of the desert (Farah & Fisher 2004; Faraz et al., 2019). Camel husbandry has a strong attachment for the herders and Bedouins, and it's interwoven with their socio-profitable life. Still, the streamlined specialized chops for camel welfare and general health status are lacking for these local communities, and the camels' productive possibilities may be overlooked. Probably, the inadequate understanding of relationships between the nature, profitable economy, and social factors of each pastoral and rangeland system end up with problems in both government and communities(Faraz et al., 2019).

Camels will be used also for wool(hair), transportation, racing, tourism, agricultural work, medicine, and beauty care products. camel in some countries similar as India is considered as an animal of industry, where it is an inexpensive source of power and fuel for drawing water from wells, furrowing, leveling of land, working mini mills for oil extraction (from oilseeds), grinding wheat and corn, crushing grains and engaged in the transport of salt, fuelwood, agricultural products commodities in addition to people (Simenew et al., 2013), where the opposite mechanical vehicles don't seem to be possible to maneuver thanks to agriculture roads, desert, and mountainous areas. The camel can carry loads up to 300 Kg at a rate of 30 Km/day (Ahmad, 2010). It can do a massive help for the herdsman to enhance their livelihoods. Camel tourism is being concentrated in numerous countries (Jordan, Egypt, India, Pakistan). Camels may be used for riding on the beaches, stacks, or round the pyramids in Egypt, for the festival, fantasia, and other spectacles just like the dancing camel at Pushkar fear (India). In Saudi Arabia, a very important event occurs for assessing the beauty of the camel with high-value awards for the winner (Faye, 2015), also, the camel race is a vital cultural event within the Arabian Peninsula and becomes popular also in Africa. Camel power is additionally utilized in war further as peace. During wartime, the camel utilized by the military, camel military companies is implemented in Sub-Sahara countries.

This beast plays a serious role in socio-profitable life and supports countless people for their survival and income within the dry arid zone of Africa and Asia. It's the most effective source of nourishment for the people of pastoral areas throughout the times. This beast proved that it's a fit domestic beast indeed in drought and harsh periods. This beast not only survives in severe condition but also keep a continuity process of production and reproduction(Wardeh, 1989).



Globally, Camel products are regularly increased but this increase is substantially not attributed to the enhancement of camel productivity. Rather, it's attributed to the rise in camel population and increase of both of slaughtering rate and proportion of lactating animals (Faye & Bonnet 2012). Indeed, neither the typical average carcass weight (183 to 205 kg/carcass, nor the dairy yield (331 to 337 l/100Kg LW/year) have changed significantly between 1961 and 2009 (Faye & Bonnet, 2012).

Current trends in camel-derived product demands and consumption are anticipated to change throughout time ( Samara et al., 2012), for illustration, meat demands are added particularly for Muslim people on the religious occasion of Eid-ul-Adah (Faraz et al., 2021). In Pakistan, annually plenty of 50000 tons camel meat is produced which is valued at Rs. 250 million (Khaskheli, 2020) and in Kenya produces 10000 tons (Faye, 2007), this is often a profitable economic resource. The marketing channels for camel meat aren't well developed within the world except in Sudan, but profitable export opportunities are available in Egypt, Saudi Arabia, Libya, and Gulf States (Farah et al., 2007).

Novlaity of camel milk making it as white gold of the desert (Wernery, 2006). Camel milk is believed to retain an optimum quantum of fat, minerals, protein, and vitamins (substantially Vitamin C). The superiority feature of camel milk over that of other domesticated animals is the quantity of phosphorus (Raziq, 2009, Khaskheli, 2020). No doubt, people of urban areas have gotten apprehensive of the therapeutic value of camel milk, while in other places not yet (Kalla et al., 2017).

The camel milk production can be estimated at 6 million tons with the assembly rate unequally. In some countries as northern Africa, the camel milk yield dropped between 1961 and 2009, while in Sub-Saharan countries (Niger, Mali, Sudan) and Saudi Arabia the milk productivity is bettered. In Asia, the very best growth is observed in Uzbekistan. Kenyan camels are estimated to produce plenty of 340 to 350 million liters of milk (Faye, 2007). With an analogous enhancement everywhere in the globe, camel milk production could reach further than double the present world production.

Controversial these data, lack of information of additional value for the camel milk, attractive market, and value chain services opaque the real value of camel milk. Camel milk production is substantially in arid faraway places, where it's delicate to supply the urban markets. The pasteurized milk of camel may be vended in some foreign countries i.e., UAE, Kazakhstan, Saudi Arabia, and Mauritania (Khaskheli, 2020).

The hair and hides of the camel also play a crucial role in socio-profitable life, the standard of camel hair/wool is extensively variable, better in countries having cold downtime, Bactrian wool is more qualified, some Mongolia breeds are used for wool production as their fiber resembles cashmere. average about 1-3kg hair is often produced by one mature camel each year (Ahmad et al.,2010; Khaskheli et al., 2020).

Since the mid-'70s, there has been a steady drop within the nomadic population and transhumant herds. Therefore, nomadic people must produce a replacement opportunity for work (Aujla et al.,1998), local social organizations and associations must help them to suppose outside of the box. Women play a significant role, not only in raising animals, but also in creating new opportunities and opening as converting their products into useful marketable handmade particulars similar as bags, mats, ropes, carpets, and blankets.

Another new opportunity of the wok, Camels were introduced in zoo or circus, or for conditioning of tourism, walking in far off and beaches. Some camel farms in Western Europe or North America were established, but marginally significant (Faye et al.,1995).



The preface of camel in Australia was significantly succeeded especially feral camel, still, the preface of dromedary to the South-African desert (Kalahari) was inadequately developed (Faye et al.,2002). consequently, the wild camel in Australia, which is estimated to be approximately 1 million, is considered a pivotal environmental problem rather than an implicit source of meat (Saalfeld & Edward, 2010).

As we are convinced that camels are sustainable food security animals, they will be squeezed to optimal effectiveness of the camel value chain and quality of breeders, but constraints face this sector limit success. The main constraint facing camel husbandry is the use of old traditional styles of husbandry practices, additionally to lack of data on nutritional requirements and reproduction, inadequate of both veterinary services and extension. The constraint extended to after production services similar as lack of a well-established market, long-distance market facility, and presence of middlemen or mediators (Gebremichael et al.,2019, Faraz et al.,2021)

To overcome constraints facing the camel industry, government authorities and researchers must push the enhancement of camel husbandry, improvement of nutrition, and commercializing the profit of camel products. Also, held training, mindfulness, and awareness programs for the camel herdsmen, refine and upgrade their knowledge to enhance their skills in management, housing, feeding, and breeding program for better camel production, additionally, to perfecting their marketing skills. taken into consideration, education of the females to produce a broad spectrum of camel milk products and utilizing other products properly, especially, the handmade ones. Marketing facilities should be established within the areas where the population of the camel is abundant. Improvement of veterinary services and establishment of a mobile clinic that offers treatment of the camels in remote areas, in addition, to offering small loans for pastoralists can each together overcome the constraints faced by this industry.

## **Camel and Research**

No further than 10000 official publications are available within the camel sciences field from 1779 to 2010, which is the total number of publications for cattle within three years. Nonetheless, The International Scientific community's interest and trend within the camel sciences is growing up each time. In keeping with the number of publications on the website (<https://www.sciencedirect.com/>) using the keyword (the camel) within the interval between 1991 to 2021, the number is increased from 276 to 1637 and prognosticated to be 1746 papers in 2027. still, the camel studies are not satisfactory nor sufficient compared to other ruminant species. Scientists, Veterinary faculties, and funding agencies escape the interest within the camel as there's an occasional camel population compared to other livestock animals, limited and remote geographical distribution, and low estimation of camel productivity (Faye & Brey, 2005). In the contrast, the camel-funded research projects were increased in sub-Saharan African countries only for a political issue, and this is often coming after the rebellion of nomads in Mali, Niger, Chad, Morocco (Faye, 2015). On the brilliant side, other countries increase their interest in camels milk production and therefore drove the rise in camel research interest. others fascinated by camel as a biological model for studying adaptation to extremes conditions (Faye, 2015), or for studying Lactoferrin or lysozymes in milk, medicinal properties of camel milk (Konuspayeva et al.,2006), and immunoglobulins properties (Hamers-Casterman et al.,1993).



For the above-mentioned interest and trends, besides the looks of emerging diseases, and adaptation of camels to climatic changes scientists heading toward the establishment of specialized centers for camels' studies.

The government of India established a Project Directorate on Camel at Bikaner (India) on 5th July 1984 within the Indian Council of Agricultural Research (ICAR), then upgraded to National Research Center on Camel (NRCC) on September 20, 1995. The target of this center is to hold out basic and applied research of camel production and health as influenced by different farming practices, enhancing productivity by nutritional intervention and milk production eventuality in camels, management of camel diseases through surveillance, monitoring, and control measures of complaint, a baseline survey of camel genetic resources in India, and everyone other fields regarding camel research. The National Research Centre on Camel Bikaner \ Rajasthan (the Camel Breeding Farm) was established in 1984 for studying various breeds of camels. Additionally, adding a museum that facilities camel riding and Safari and visitors can enjoy beverages and ice-creams made from camel milk.

From India toward Sudan, the staff members of the school of the Veterinary Medicine\ University of Khartoum establish a research focus group within the faculty in 1939. throughout the seventies and eighties, the researcher enriched the globe camel field by numerous outstanding research which end with the establishment of a camel research unit in 1982, with help of the Germans (University of Hanover). In 1989 a camel research station was established at Alshuwak (Gadarif State) to support the conditioning of the camel research unit in Khartoum. The Camel Research Unit was promoted to a Camel Research Centre (CRC) in 1995. Collaboration with national and international agencies, organizations, and/or societies of camel to conduct research in camel genetics, fertility productivity, disease control, and vaccine production, and enhancing productivity by nutritional intervention are the most objectives of this center. In Pakistan also an association was established under the name of Camel Association of Pakistan (CAP) in 2012 to support Camel research and researcher and convey Camel's population to a precious place everywhere on the planet. To Iraq, a global Colloquium a held continuously under the supervision of veterinary faculty in ALMuthanna University under numerous slogans to conserve this national wealth and improve this sector.

On the opposite side, The International Society of Camelid Research and Development (ISOCARD) was created in 2006 at Al-Ain (United Arab Emirates) with the article of giving international scientific status to camelid sciences by promoting research and practice, organizing regular international conferences, and inspiring the exchange of data between the members of the Society and various networks and involved organizations. ISOCARD hopes to administer a degree of camelology and recognition to camelologist. many international conferences or symposiums of ISOCARD are held every three years like that held in Almaty (Kazakhstan) in June 2015, or the Symposium held in Muscat, Sultanate of Oman in 2020, where all researchers participate in a very scientific paper or bridging overworld trend in camel research.

The International Camel Consortium for Genetic Improvement and Conservation funded under the umbrella of the International Society of Camelid Research and Development, or EU projects like 'Towards a CAMEL tRAnsnational VAlue chaiN (CA.RA: VA.N)' and 'CAMEL MILK', still like a new International Committee for Animal Recording initiative (ICAR), aim to ascertain animal identification and performance recording of camels.



### **The Effect of the Syrian crisis on the camel in Jordan**

The Jordanian Bedouins board the Badia (semi-arid desert covering nearly 80 percent of the country) raising camels was confined to Bedouins in Jordan as frequently be a part of culture and tradition (Abu tarbush et al.,2019). Camels interweave the life aspects of the Bedouins, they used them substantially for transport and as a source of meat and milk. Currently, some camels are being raised in herds and farms closer to urban cities and wish to supply meat and milk, moreover, also, used for tourism and racing.

Camel population in Jordan is relatively low compared to other countries, it had been estimated to be 10872 camels distributed through 10 governorates. Near 75% of herds graze on ranges when available during springtime and the rest of the time on alfalfa, hay, barley, and bran (Abutarbush, et al.,2019). Camel herds are principally supplied with water through tanks vehicles and pipelines provided by the government (Abutarbush et al.,2019). The Northern Badia of Jordan as well as the whole country is full of seasonal environmental conditions, downfall, and climatic changes particularly increase in temperatures, affecting water's availability and quality (Sada et al.,2015, Al-Khaza'leh et al.,2020). Thus, affecting forage quality and production and consequently, having a non-neglectable influence on livestock growth, productivity, and health (Al-Khaza'leh et al.,2020). Moreover, the influx of Syrian refugees squeezes the resources, especially water, and shifts utmost of the water resources into drinkable.

Quite 490,000 Syrian refugees are estimated to live either in remote areas or into the urban landscape and face inadequate life expenses. The non-governmental organization (NGOs) and Jordanian governmental sectors face enormous challenges and redundant loads. There's a requirement to scale back poverty and improve livelihood among refugees within the Zaatari camp and areas along the Syrian border. Also, to revive and improve the livelihoods of smallholder farming families on border communities hosting refugees that are seriously suffering the Syria crisis (United Nations High Commissioner for Refugees (UNHCR), 2018)

Traditional livestock herds movements across the closest region are common, particularly across the Badia rangelands of southern Syria, north-west Iraq, and north-east Jordan. The Badia rangelands are very fragile, semi-desert steppes covered by sparse vegetation. Continues instability in Syria led to disintegrated grazing because the cross-border movement of Bedouin herdsman from downtime grazing in Syria to summer grazing in Iraq and Jordan has been stopped, so as that they lose Syrian ranges and stay each time around on the rangelands of northwestern Iraq and northeastern Jordan. The results of this could not affect livestock only, but also the invasion of unpalatable species (weeds and scrub) within the Syrian ranges. on the contrary hand, overgrazing, and land degradation will end up with the implicit desertification of the Badia rangelands of both Iraq and Jordan. Over the past 20 years, Jordanian farmers are flushing parts of the Badia rangelands using underground water sources to grow fruit and vegetables (especially tomato, watermelon, and potato), wheat, fruit trees, and animal fodder. The Jordanian government is now veritably concerned that recent boreholes sunk for water supplies at the Zaatari camp will deplete along with the local aquifer employed by rural communities. The government is further concerned that the inadequate waste disposal systems found at the Zaatari Camp will also lead to pollution of local water supplies. The ("Integrated Investment Framework for Sustainable Land



Management” report by the Ministry of Environment in Jordan 2014-UNDP) (UNDP in Jordan, 2016)

A study by the Arab Centre for the Study of Arid Zones (ACSAD) and therefore the Syrian Ministry of Agriculture found that there are 50,202 camels within the country in 2010, with an annual growth rate of 12.7 %. the shocking fact is that this percent is dropped to 2,561 in 2018 and 1,935 in 2020. Across Syria, thousands of camels are being sold on the black market and smuggled into Jordan, Turkey, and Iraq than to the other neighboring countries and Arabian Gulf countries. It was rare to figure out Syrian Camels within the Turkish province and villages near the Syrian border (Amberin Zaman, November 2021).

In 2011 Swiss and Syrian archaeologists found the remains of an enormous camel in Palmyra thought to retain lived 100,000 years ago and formerly stood “as big as a giraffe or an elephant.”, unfortunately, this may be coming with the horrible drop and loss of the precious wealth of camels. both drought and conflict are accelerating Syrian camels’ demise inside Syria, side by side with overgrazing and disturbance of ecosystem in neighbors’ countries.

supported data and situation, rearing camels by the refugee, especially those in Al-Mafrq governorate and Zaatari camp may help all partners (Jordanian government, Jordanian people, and refugees), and keep water resources, rangelands, livestock, and animal health status, consequently, lead to food security.

### **conclusion**

camels are drought-resistant animals, be able to handle dramatic change that global climate change creates, are friendly to the environment, walk with people since old centuries to enlighten human civilization, and be able to play a significant role in food security and improvement of livelihoods and household income. But more studies and spotlight must be conducted continuously to take advantage of camels and pitfalls or risks which may be created together with an intensification husbandry system.

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