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Goat System Productions: Advantages and Disadvantages to the Animal, Environment and Farmer

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Abstract

Goats have always been considered very useful animals. Goats success is related to its excellent adaptability to the difficult mountain conditions, extreme weather and low value feed acceptance, versatile habits and high production considering their size. These are some reasons because goats are among the first animals to be domesticated. In terms of evolution, goats could be separated by their dispersion area in three large groups: the European, the Asian, and the African. Global goat populations, mainly in Africa and in Asia, have increased for centuries but very strongly in the past decades, well above the world population growth. They are also used for forest grazing, an integrated and alternative production system, very useful to control weed growth reducing fire risk. Despite some exceptions, no large-scale effort to professionalize this industry has been made so far. There are consumers for goat dairy products and there is enough global production, but misses a professional network between both. Regarding goat meat, the world leadership also stays in Africa and Asia, namely in China, and there is a new phenomenon, the spreading of goat meat tradition through Europe due to migrants from Africa and other places with strong goat meat consumption.

Keywords: goats, production systems, milk, meat

1. Introduction

Goats were among the first farm animals to be domesticated. According to Ref. [1], goats have been linked to humans for at least 10,000 years. Due to their great adaptability to difficult environment conditions and to different diets, they have always been considered very useful animals for their good productivity and easy to handle and they do not compete with man for food and eat cheap feeds.

In the last 50 years, global goat populations have increased by about 240%, while other livestock species have maintained or decreased their populations. Currently, there are about 1 billion goats around the world. More than 90% are located in Asia and Africa and only 1.8% in Europe. While in the countries, where goat production is massive, high adaptability to the environment is one of the main breed characters, in the developed countries, most of the goats are of genetically selected breeds for high production [2].

In rural areas of developing countries, the contribution of goats is highly valued and has an important role in feeding the populations, an item that is often not adequately recognized when comparing goats with sheep and cattle. In fact, goats are extremely intelligent animals, very agile, and independent, with a high level of resistance to diseases, much better than other ruminant species.

Despite the fact that in recent decades there has been a great progress in research aimed at increasing the goat productivity, there is still a great work to be done, namely in the applicability of the different races to the different environmental realities of the underdeveloped and developing countries. In these areas, the current and potential importance of goat production combined with the use of breeds that have not yet been fully selected and exploited will certainly be a reality in the near future. At both local and macroeconomic levels, goats will certainly be an animal production that will enhance the livelihoods and sustainable development of the world's poorest populations [3].

2. Material and methods

To prepare this theme, a documentary research was carried out to analyze world goat products and its production systems. The main sources of information were scientific papers, books, and statistical data from FAO.

This chapter covers the broader framework for goat's production systems, milk and meat production, and major advantages and disadvantages to the animal, environment, and farmer.

3. The origin

The origin of the current goat breeds is not clearly known. It is believed to have been originated from wild goats found in Asia Minor. The origin of the domestic goat is attributed to the wild species of the Quaternary: *Capra aegagrus* (**Figure 1**), *Capra falconeri* (**Figure 2**), and *Capra prisca*, being disseminated by all the continents and all originating from different regions of Asia [4, 5]. The main morphological elements of differentiation were related to the insertion, section, and configuration of the horns. The elements of comparative morphology and the interspecific crossbreeding experiments suggest that the bezoar (*Capra hircus aegagrus*) from Southwest Asia is probably its most significant ancestor. Scimitar horns are common and probably due to the influence of this species. It is believed that another species already extinct,



Figure 1. *Capra aegagrus* [6].



Figure 2. *Capra falconeri* [7].

like the *C. falconeri*, would have given rise to the majority of the breeds of India and Central Asia, giving them characteristics such as the long and coarse coat and the predominance of the black color over the others [4].

According to the majority of the authors, the enormous variety of breeds (although much smaller than that of the ovine species) is grouped by their area of dispersion in three large groups or trunks: the European, *Ovis capra europaea*; the Asian, *Ovis capra asian*; and the African, *Ovis capra africana*. The European trunk belonged to *C. aegagrus*, the Asian trunk to *C. falconeri* and *C. prisca*, and the African trunk to *Capra nubiana*, another ancestral species. Some authors consider *C. aegagrus*, the only ascendant of domestic goats or the main progenitor. This one has long horns and is still found in the mountains of southwestern Asia [5].

The identification of the geographic origins and ancestral forms of the current goats has been subjective, since the scarcity of data requires extensive speculative exercises of considerable controversy. Theories that have broader consensus suggest that the origin of goats lies in a set of primitive goat populations that have evolved in the arid and mountainous regions of Central Asia and Southeast Asia. Unlike the sheep, goat migrations allowed their spread to the Southern Europe and to the Northern Africa without having populated the American continent [8].

Goats do not have as many breeds as sheep, and unlike them, they easily adapt to the harsh environments if they have the opportunity. Like the sheep, goats were probably among the first animals to be domesticated by man. These animals are also considered to be one of the first helpers of man, for in addition to providing manure, skins, hair for cloths and shelters, he gave to the primitive man meat and milk for food [9].

The goat must have been domesticated at the same time as the sheep in the East during the Neolithic period about 7000 BC, and traces of this species are found in the lacustrine cities of Western Europe, as well as in archaeological evidence and in excavations of the neolithic places.

4. Goat production in the world

Figure 3 shows the global distribution of goat production between 1994 and 2014 [10]. In the last two decades, we can see that the geographic areas with the largest goat production are located in the global African continent, in a range from Southeastern Europe (Greece and Turkey) to South Asia (India and China), passing through the Arabian Peninsula and, in the American Continent, where the highlight goes to Mexico, Brazil, and Argentina.

The production of small ruminants is largely rooted in some world regions, for both historical and religious reasons. This is the case in all Muslim countries where pork is not a food option, as also in the case in India where beef is also out of the food tradition, in both cases due to religion.

Soil and climatic matters greatly condition the animal species produced, benefiting goat production in poorer areas in terms of forage capacity and enhancing this species in areas with steep slopes and mountainous rocky areas. Sometimes goat production is the only possible, due to the excellent adaptability of these animals to the difficult mountain conditions. On the

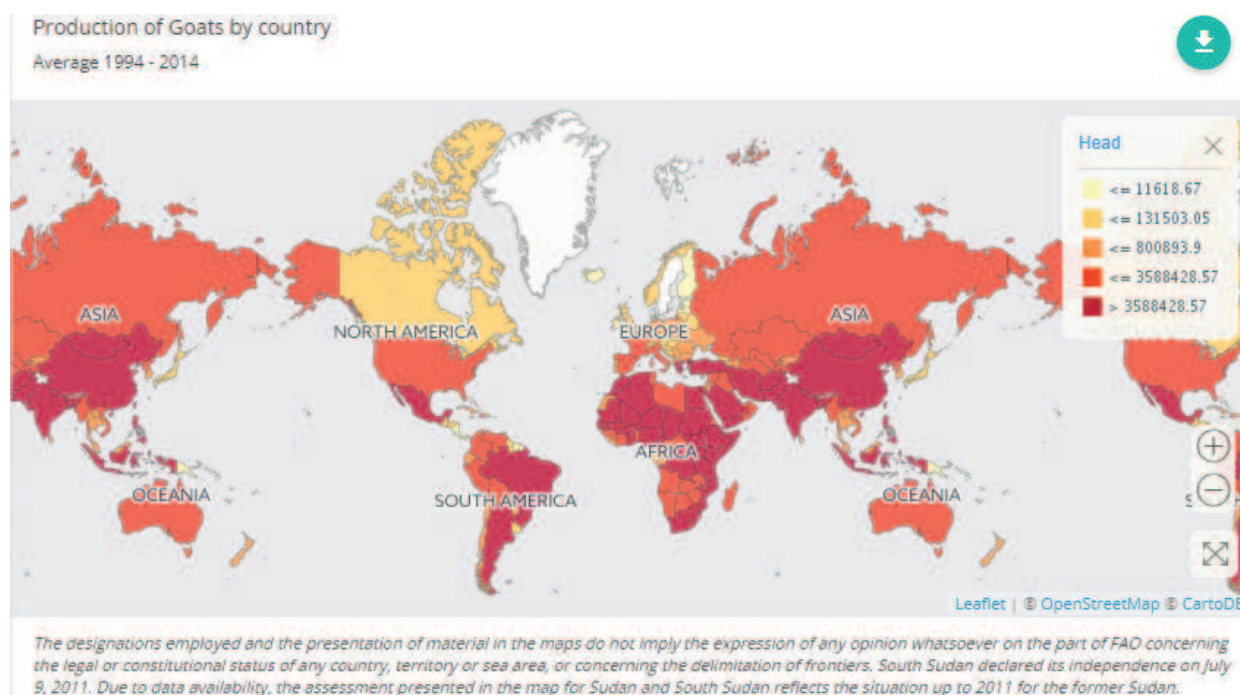


Figure 3. Global distribution of goats by country in number of heads [11].

other hand, forest grazing is an excellent productive alternative, associating in an integrated way the forest and animal productions. It helps to control unwanted weed growth with a consequent strong reduction of fire risk and, on the other hand, is often a valuable complement to the farmer or forest producer income, while it also helps to fertilize forest soils with their waste. To confirm this evidence, we can also verify in **Figure 4** that goat production reaches high levels in the most important forest and mountain areas.

In **Figure 5**, we can see similar results to those in **Figure 4**, but here we can see the distribution by animal density, in number of heads per km^2 . Here we find the highest values in Mexico, northeastern Brazil, sub-Saharan tropical strip, India, and Eastern China.

Figure 5 shows that, only in the referred 20 years, the world goat population (from which there is a register) go from slightly over 600 million head in 1994 to over 1 billion in 2014, 67% rise in just two decades, much higher than the world population growth in the same period, which was about 28.5% [12].

The Asian continent clearly leads the world goat production between 1994 and 2014, a percentage well above the sum of the non-Asian world goat production (**Figure 6**). Then, we can find the African continent with about a third of the total, and finally, with very low percentage values, we have America, Europe, and Oceania, in this order, which make up, in total, about 7% of global goat production.

These figures complement and confirm those reported in **Figure 4**, where sub-Saharan Africa, China, and India showed their worldwide leadership in the production of this species.

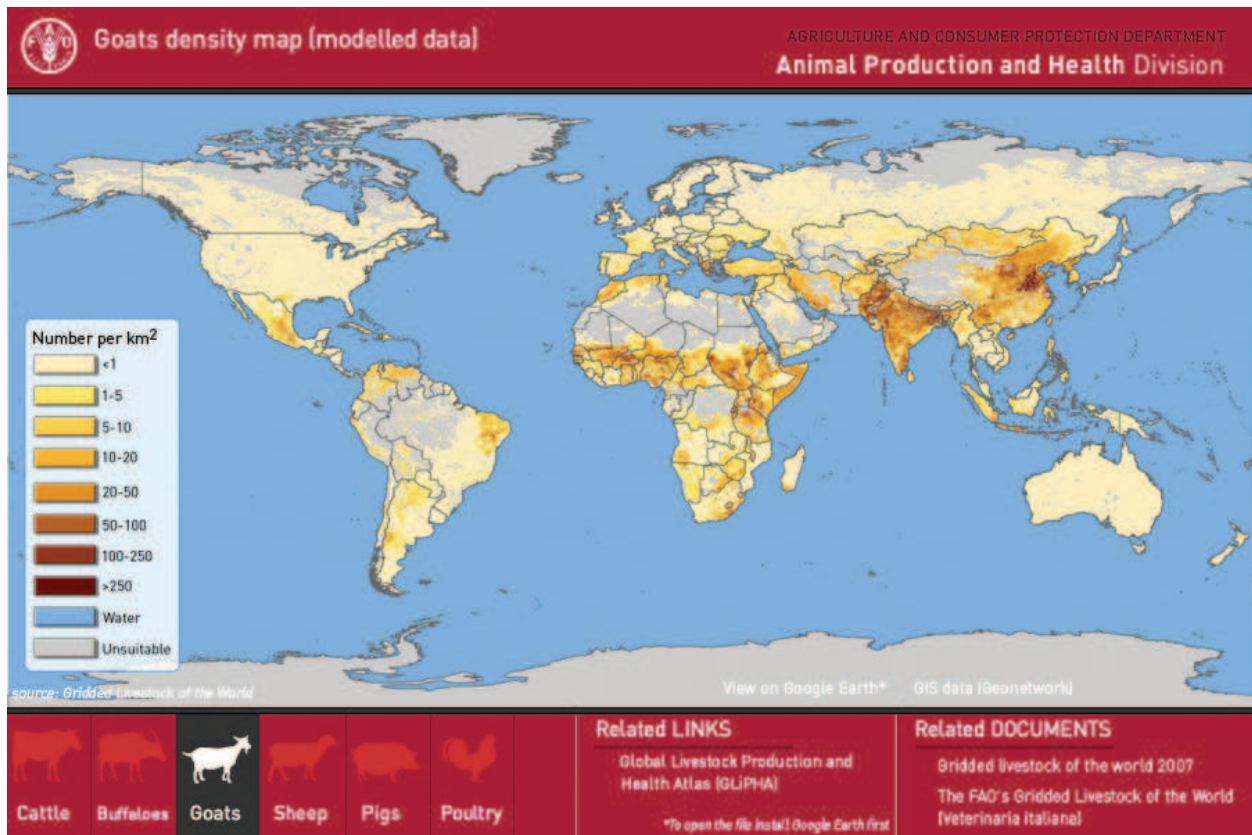


Figure 4. Worldwide distribution of caprine by country, in animal density [10].

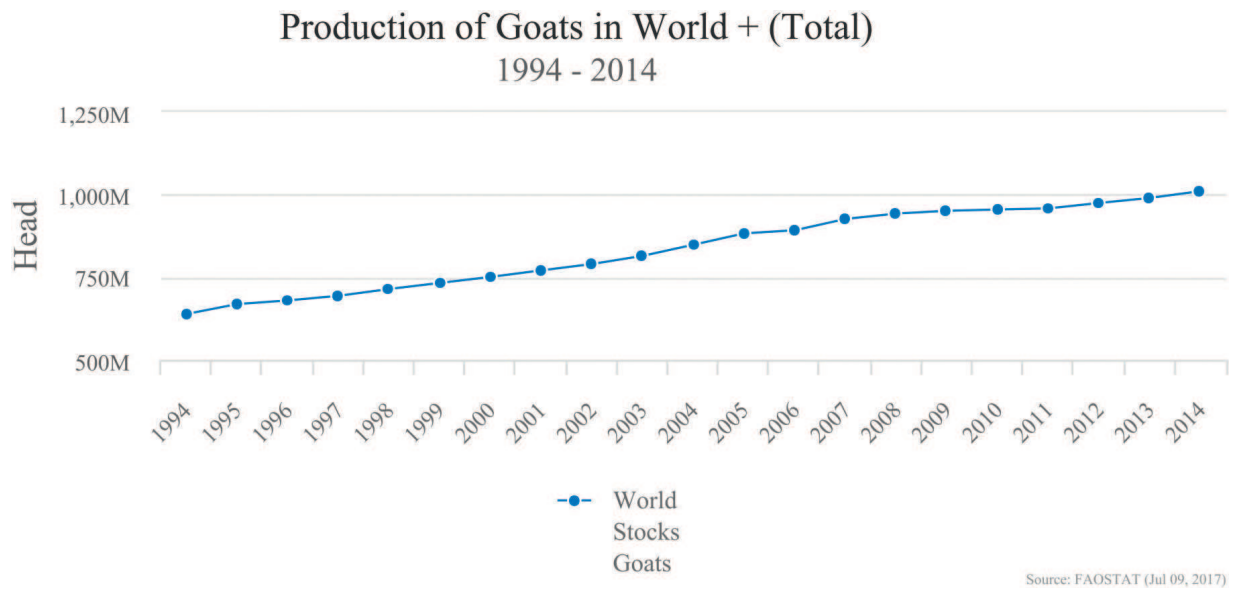


Figure 5. Evolution of world production of goats between 1994 and 2014 [10].

Goats are mainly grown to produce milk, meat, or fiber. Usually, the primary production is meat and milk, and there is little global information on fiber production.

The potential of goats for the sustainable supply of milk and meat for human consumption is unquestionable, and their contribution to improve the nutrition of rural populations is likely

Production share of Goats by region Average 1994 - 2014

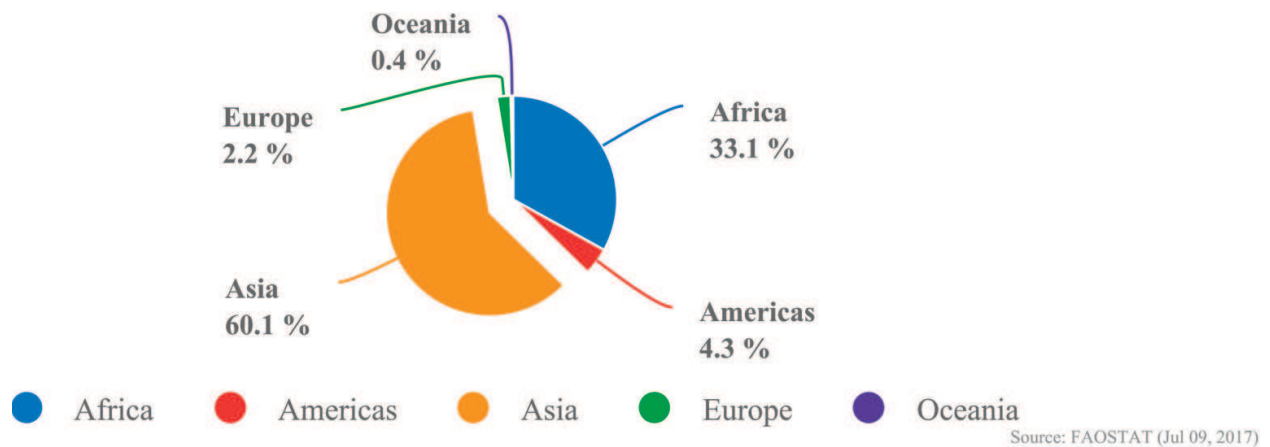


Figure 6. Evolution of world goat production between 1994 and 2014 [10].

to increase. At the same time, consumption of goat cheese should also increase in developed countries. This is attributed to the image of goat cheese as a product obtained under natural conditions when compared to cow's milk and its products, obtained from more industrialized farms.

Government programs to support goat rearing should focus on research and training on genetic improvement, farm management, infectious disease control, product collection and marketing markets [3].

4.1. Milk production

Unfortunately and unfairly, the dairy goat is still considered in some regions as the cow of the poor. In proportional terms to its size and feed intake, the milk yield of the goat is often remarkable. The goat has a reduced food intake, its feeding is cheap, it is a small animal and easy to keep, and each goat produces enough milk to feed an average family. Comparatively, and due to its size, the cow has very high maintenance costs and is more difficult to maintain at home.

Dairy goats produce about 15.2 million tonnes of milk, representing about 2% of the world's total milk produced by livestock species [13]. Developing countries, particularly in Asia and Africa, account for about 83% of the total value produced. In Europe, dairy goat farming is the main reason for goat production, where only 3% of the world goat population produces about 15% of the global goat milk, mostly for cheese production [14]. Spain, France, and Greece are the main European producers of goat's milk. In France, the development of research and development in the dairy goat sector has been intensified with programs organized for the selection, processing, and commercialization of goat's milk, mainly produced from the Saanen and Alpine breeds. In France, it is where the highest production figures per animal are achieved, whereas Iran has the lowest values.

China has the largest number of goats in the world, but they are bred mainly for meat production. Milk production by milk breed occupies the third place, behind France and Spain. According to China's official statistics, there are between 1.4 and 5.8 million dairy goats producing about 0.3 million tons of milk [13, 15]. The statistics on these goats can be questioned because they are not based on actual censuses, and knowledge of the number of dairy goats is even more difficult [15].

At the global level, interest in dairy goats has steadily increased, and in less than two decades, milk production has grown from around 10 million tons in 1990 to about 15.2 million tons in 2008. In developing countries, goat milk production has continued to grow partly due to a trend toward self-sufficiency of rural populations, where goat milk is the nutrition basis of millions of people. In these regions, milk is largely consumed raw but can also be processed into a wide variety of products for better preservation and commercialization. We can say that the global marketing of goat's milk is still at a very early stage, and so far, there has been no large-scale effort to professionalize this industry, exception for some developed countries. According to Refs. [15, 16], the marketing rate of goat's milk at the global level does not exceed 5%.

There are still many obstacles to achieve the professional level of production and sale of goat's milk. Access to productive data to enable the development of breeding programs is very scarce, and on the other hand, reproductive and productive seasonality, which is very marked in some breeds, prevents a constant supply of milk demanded by markets [17]. In sum, there are consumers for goat dairy products and there is enough production to meet this demand, but there is a lack of bridges between both sides in order to enhance this market in terms of an efficient marketing of the product toward profitable industry [3].

4.2. Meat production

Goat meat is widely consumed in developing countries. Of the approximately 280 million total tonnes of meat consumed per year, goat meat accounts for only 2% of this total, about 4.9 million tonnes [13]. Developing countries produced approximately 97% of this amount, reflecting the great importance of goat meat to feed these populations. China leads the world production of goat meat, representing 38% of the total. As we could see in milk production, also in goat meat production the Asian and African continents are leading. As in milk production, the increase was also notable in the same 18 years of comparative production and raised from the 2.65 million tonnes of goat meat produced in 1990 to 4.93 million in 2008. Most of this meat is not commercialized but is produced and consumed locally [3].

The goat meat business is not already become profitable on an industrial basis. It is not enough to know the proper management techniques, but nowadays it is also essential to control the market and the economic limiting factors for farming success, as well as the financial management and marketing techniques. In addition, there are an increasing number of challenges associated with meat production, including knowledge of regional preferences and consumer education for consumption. In the production and processing sector, producers have to undergo training programs, and slaughter and processing facilities have to be modernized.

Finally, there has to be made a strong commitment to organized programs of genetic improvement, market analysis, and marketing channels [18].

The increase in goat meat consumption has been occurring in some parts of the world due to the migrations of people who prefer goat meat to the developed countries. This recent fact has increased demand for goat meat in these areas [19].

5. Characteristics of goat production systems

Goat production systems, like other production systems, are not just a combination of crops and animals with the aim of achieving short-term results. They represent a set of interacting elements, managed by the farmer, according to their objectives. The farmer will define the objectives influenced by the social environment in which he is inserted, his degree of technical knowledge, and the available production factors [20, 21].

Several authors consider that the general and strategic management approaches are applicable to agricultural enterprises and those who apply them are more successful [22, 23]. The application of strategic management concepts helps to design the way the farmer will achieve the objectives, and it is convenient to know the strengths and weaknesses, the opportunities and the threats [24, 25].

A caprine production system has production subsystems, whose performance influences the overall results, for example, the forage system; if there are nutrient deficiencies in the soil, its production is lower, and then, the animals may not have adequate feed to their needs.

The increase in the meat and milk ruminant production has been much greater than the increase in the pasture area, mainly because this increase was due to the increase of mixed or landless production systems (intensive systems) than to the pastoral or extensive systems [26].

Increasing livestock production to provide food to the growing human population has increased the potential to cause environmental problems, and the balance between the environment and livestock production is now a concern. It is important to avoid an increase of grazing land and arable land for crops production to feed the animals, with the consequent reduction of areas of natural vegetation, soil and air contamination. Overgrazing also leads to several bad consequences like high amounts of animal excretions and overuse of natural pastures with low productivity and with high risk of soil degradation, especially in the arid and semiarid regions of the tropics and subtropics [26–28].

The terms equilibrium, disequilibrium, and nonequilibrium are commonly used and can be understood by equilibrium when the animal population and forage resources are under stable climatic conditions. Otherwise, climatic variations disturb the system, causing disequilibrium, which differs from nonequilibrium, represented by modifications in vegetation due to changes in the proportion in the plant species or where the dynamics of the animal population

is disassociated with key factors that determine their survival, and their survival is maintained through feeding supplementation [29–31].

Goats are the best adapted ruminants to highly antinutritifibrous low-protein forages, often in conditions of poor availability of water [32, 33]. Goats are opportunistic feeders, the time they spend on grazing species depends generally on the relative frequency of encounters, but this relationship depends on species of vegetation and habitat visited [34].

Compared to other domestic ruminants, namely bovine and sheep, raised in regions of poor agricultural resources, goats' advantage is clear. These animals combine the advantage of being able to feed on a variety of low-quality fodder and shrubs, they also manage to walk long distances, with short breeding intervals with high reproductive rates, they provide high rates of investment return and, consequently, low investment risk. Goats also have high energetic efficiency in milk production, excellent utilization of marginal lands, a very strong flocking instinct and a docile behavior, which enables herding by children and elders [35, 36].

Farmers tend to have mixed herds of sheep and goats as a strategy to maximize the use of environmental resources [37]. Small ruminants in many traditional systems in the Mediterranean basin are the main source of red meat for human consumption [38], while in Northern Europe, in addition to meat, the milk, wool, and skin were also the main products [39]. However, with development for a market agriculture, meat has become the main product in the sheep sector, while in the goat sector milk has been, and still is, the main product while meat is secondary in most cases followed by skins and hair [40]. There are, however, local variations where a particular product can be valued such as sheep's milk for the production of traditional cheeses and the production of goats in the southern Mediterranean. These products are mainly consumed regionally, constituting market niches with low international visibility.

Often, small ruminants, especially goats, are extensively produced using the poorest land, shrubland, and forest areas where other species cannot survive [41]. This helps to fix the rural population, reduces the risk of depopulation of marginal or less-favored areas [42–44], and contributes to the maintenance of good agro-environmental practices and landscape preservation.

6. Models of goat production systems

6.1. Extensive goat production systems

Extensive systems are characterized by large areas to feed the animals, with a low animal density. It uses soils of poor agricultural ability, located in mountainous areas with large rainfall or in areas of low rainfall, sometimes with extreme temperatures. There is a use of natural resources, made by autochthones goat breeds that are perfectly adapted to the environment, very rustic, but with low productivity.

The goat production in this extensive system uses family labor, often as a second source of income for families. The goat milk is obtained for family consumption or for cheese to sale.

However, the sale of the kid goat is the main reason for this production. In the Southern Mediterranean, this product is very appreciated and valued, mainly in the Easter and Christmas seasons.

Usually, the number of animals produced is low and they are usually raised under climate adversities, where probably there are no shelters, no food supplementation and also often these animals have hygienic sanitary problems, which leads to poor economic results.

It turns out that the use of natural pastures can be done in two ways, a mobile grazing system and a sedentary grazing system. The first is characterized by annual or seasonal movements of the animals with the shepherd to new places in search for feed, and while sedentary grazing, the animals are driven freely to pastures near the farm, usually keeping the animals at night in the stable.

In the mountains, they can practice transhumance, which consists of seasonal movement of animals regularly between two or more areas of seasonal pasture, through established paths (called "canadas" in Portugal and Spain), conducted by shepherds in the summer to the mountain to take advantage of the still fresh pastures and return to the valley in early autumn. This modality is currently disappearing due to sanitary issues and also because of the greater easiness to feed the animals through the purchase of commercial feeds.

Although the extensive production is not very productive, it is of great importance regarding the maintenance of the rural landscape and with the aim of the biomass management that avoids the occurrence of forest fires, and where the goats are well adapted to take advantage of these feed resources.

The use of goats in extensive systems can be valued by the quality products. In Europe, many of them have protected designation of origin (PDO) and the protected geographical indication (PGI) which are certified to attest the traditions and specific product qualities, strongly linked to a certain region. The awareness of society about the damaging effects of intensive livestock systems has changed the methods and aims of researchers and even research centers, trying to focus on improving system sustainability instead of increasing productivity [45].

6.2. Intensive goat production systems

Intensification is often associated with a decrease in grazing dependence and an increase in the use of concentrated feeds, mainly cereals, to supplement natural feeds. At the same time, improved and balanced feeding practices together with improved breeds in ruminant systems enabled more efficient feed ratio conversion to meat and milk production rather than to maintenance of the animals [28].

The intensive system implies a high density or animal concentration per area unit, under reproductive and sanitary control, and the feeding process includes advanced technologies. Sometimes, some farms seasonally require higher feed and labor resources such as through the calving season and milk production, so the supplementing of animals with concentrated feed may be needed at this point, but the remaining year is mainly grazing.

In order to meet the feed requirements of animals in an intensive system, pastures must have high dry matter yields per hectare, good growth throughout the year, in both regions with regular rainfall or holdings with irrigation systems, without extremes of heat or cold temperatures.

It is important that the breeds used in the intensive system have a high fertility and growth rates than the adaptability to the environment, that is, the rusticity. The equilibrium with the environment can easily be compromised by the insertion of exotic breeds, as well as with exotic or genetically modified plant species. The intensive use of natural resources may lead to their depletion and increase the environment pollution, having serious social consequences.

Goats are well adapted to harsh environments but can also be used in intensive systems with permanent housing, as is happen with many farms for milk production. Here too, mainly because these farms are usually in regions with weak resources, they use less labor but with higher qualifications, with the danger of triggering a process with social negative consequences, namely with soil erosion, high risks of fire and depopulation. Also industrial production can replace the artisanal production, losing ancestral traditions and biodiversity.

Intensive goat farms have higher costs for the installation and maintenance of production than extensive farms (**Table 1**), but their choice should allow for a balance between environmental, economic, and social factors, since only then will it be sustainable.

Extensive system	Intensive system
<i>Eco-agrarian conditions</i>	
Dependent on the climate (environmental) factors	Independent of the climate factors
Scarce resources	Constant forage production
Intermittent feed cycles	Continuous feed cycles
Parasitic problems	Good sanitary condition
Use of marginal land and nonagricultural resources	Use of technology
Low animal density	High animal density
<i>Animal biotypes</i>	
Autochthonous breeds	Improved breeds
Low productions	High productions
Multi-production exploration	Animals with high energy efficiency
Great ability of adaptation	Increased sensitivity to diseases
Lower fecundity and fertility	Increased fecundity and fertility
<i>Environment</i>	
Natural environment	Artificial environment
Long productive cycles	Short productive cycles
Traditional system	Industrial system
<i>Note: Adapted from Refs. [1, 4, 8].</i>	

Table 1. Main differences between intensive and extensive production systems.

7. Conclusion

Concerning difficult environmental conditions, goats are probably the most well-adapted farm animals, and due to its cheap management and good meat and milk production, goats have been considered one of the ancient animals to be domesticated all over the world.

In several regions, namely in Africa and Asia, goats are the most important source of meat and milk to feed very large populations with scarce income. But these animals also contribute to a sustainable farming, a very ecological way of living which enables to use their waist to fertilize crop fields, control and prevent fires by forest grazing.

We can also find some intensive goat production all over the world, with selected high production breeds, namely for milk and cheese production, and in a near future, we will certainly need to spread the know-how from goat production research, applied to the different environmental conditions and its regional well-adapted breeds, enabling higher productions with lower effort, in order to feed more population from the developing countries.

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