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# Diagonal dairy goat barn design offering alternative area usage for different seasons in dairy goat breeding

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ABSTRACT

Goat's milk has highly significant benefits in infant feeding due to the fact that it contains some components that are closer to breast milk. Increasing the quantity and quality of goat's milk is possible through the implementation of husbandry in barns designed in accordance with the principles of animal welfare. Taking into account animal welfare and barn area preferences, this study was conducted to design a new diagonal open-front barn in order to be used in dairy goat breeding. In this design, small resting areas having a width of 10 m were placed diagonally on both sides of the feeding area in order to eliminate negative effects of the Northern winds. In the shelter design in question, mini resting areas with group partitions and open courtyard areas were provided to prevent animals from unfavorable effects of winds in the winter and enable animals to benefit from sun and open air. For the summer conditions, on the other hand, barn areas suitable for natural goat raising conditions having open surroundings and covering trees and natural rocks were planned. The resting area, winter courtyard, summer courtyard and feeding lengths had 1.5 $m^2$animal$^{-1}$, 3.0 $m^2$animal$^{-1}$, 6.0 $m^2$animal$^{-1}$ and 0.64 manimal$^{-1}$, respectively. The newly developed diagonal dairy goat barn design met the recent increasing demand for a shelter appropriate for animal welfare in goat raising and enabled those working in this field to perform goat breeding in more modern, economic and alternative barns.

Anahtar Sözcükler:
Barn design
Dairy goat barn
Goat breding
Goat housing

## Farklı mevsimlerde alternatif barınak alan kullanımı sunan diagonal keçi ağılı tasarımı

ÖZET

Keçi sütü anne sütüne en yakın süt özelliklerine sahip olması nedeniyle bebeklerin beslenmesinde oldukça önemli bir yere sahiptir. Keçi sütünde miktar ve kalitenin arttırılması, hayvan refahına uygun olarak tasarlanmış barınaklarda yetiştiricilik yapılmasıyla mümkündür. Bu çalışma, hayvan refahı ve barınak alan tercihlerini dikkate alarak, süt keçisi yetiştiriciliğinde kullanılmak üzere sosyal gruplu diagonal açık keçi ağılı tasarlamak amacıyla gerçekleştirilmiştir. Barınak tasarımında, kuzeydoğu ve kuzeybatı yönünden gelecek rüzgarın olumsuz etkisinin ortadan kaldırması amaçlanmıştır. Mini dinlenme alanları 10m genişliğinde planlanmış yemleme ünitesinin iki tarafına diagonal olarak yerleştirilmiştir. Barınak tasarımında, hayvanlara kış mevsiminde rüzgarın olumsuz etkisinden korunmuş, güneş ve açık havadan faydalanma imkânı sağlayan grup bölmeli mini dinlenme ve açık gezinti alanları kullanım imkanı sunulmuştur. Yaz mevsiminde ise kendi doğal yetişme koşullarına uygun etrafı açık, ağaçlar ve doğal kayalıklarla donatılmış barınak alanları planlanmıştır. Çalışmada dinlenme alanı, kışlık gezinti avlusu, yazlık gezinti avlusu ve yemleme uzunluğu sırasıyla 1.5 $m^2$hayvan$^{-1}$, 3.0 $m^2$hayvan$^{-1}$, 6.0 $m^2$hayvan$^{-1}$ ve 0.64 mhayvan$^{-1}$ değerlerindedir. Geliştirilen barınak tasarımı ile keçi yetiştiriciliğinde son yıllarda artan hayvan refahına uygun barınak talebinin karşılanması sağlanarak, bu konuda çalışanlara daha modern, ekonomik ve alternatif barınaklarda yetiştiricilik yapma imkanı sağlanmaya çalışılmıştır.

Keywords:
Ağıl tasarımı
Barınak tasarımı
Keçi ağılı
Keçi yetiştiriciliği



## 1. Introduction

Goat's milk has quite a significant role in infant feeding due to its properties. These properties have led to an increase in goat husbandry in recent years. Increasing the quantity and quality of goat milk is possible through implementation of husbandry in shelters designed in accordance with principles of

animal welfare.

Three fundamental factors that are important to increase animal productivity are genetic features, care and nutrition, and environmental conditions. It is necessary to breed races that are genetically highly productive, and these races need to be raised so that productivity can be increased in animal production. Moreover, for high level of yield and continuity in animal production, animals need to be fed suitably and with appropriate ration. Environmental conditions have a significant role in animal production. Since environmental conditions are factors that regulate animal comfort in accommodation areas with regard to climatic, structural and social issues, they constitute an inseparable threesome together with genetic makeup and nutrition (Uzal and Uğurlu, 2009).

There is an inverse relationship between stress and productivity in living beings. A living being under stress spends a significant portion of its energy to eliminate the stress factor it is exposed to and this leads to a decrease in productivity. Factors causing stress in animals need to be modulated in designing animal shelters in order to ensure animal welfare. Causes of stress can be subsumed under four headings, namely climatic, structural, social and, other factors such as noise, dust etc. (Uğurlu and Uzal, 2004). Demir (1990) states that the purpose is to protect animals from inappropriate environmental conditions and provide them with healthy living and production areas with respect to planning of animal shelters. Elimination of impacts of unfavorable factors and creation of healthy living-production areas for animals could be implemented by designing shelters in accordance with animal behaviors (Uzal and Uğurlu, 2009).

Suitability for animal behaviors, optimum environmental conditions, herd management and farm economics are important issues that need to be dealt with and investigated carefully in designing shelters (Uzal, 2008).

The barn systems used in small ruminant breeding can be listed as closed system, open system, system with a courtyard and slatted floor shelters (Hirning et al., 1994, Okuroğlu and Yağanoğlu, 1993, Olgun, 2011, Yüksel and Şişman, 2003). However, animal breeding is conducted mostly in closed system shelters in the Konya region, like in many places in Turkey, and animals are taken to pastures in the summer. In the winter seasons, animals are bred in closed system barns in Konya but they are raised in pastures in the summer seasons and transitional periods (Uzal Seyfi, 2016). Barn systems that have been used in small ruminants in recent years offer many advantageous features when compared to the previous barn systems. However, they may remain inadequate in terms of climate, building, the principles of social planning and animal welfare. The most prominent lack of these systems involves the failure to protect animals from adverse effects of winds or the presence of insufficient ventilation conditions at the expense of protection from wind. Inadequate ventilation causes the quality of the air in the shelter to reach dangerous level in terms of animal and employee health. In addition, construction costs rise in shelters that have an unappropriate building plan. This situation draws attention of farm owners and they resort to alternative solutions (Aslan and Uzal Seyfi, 2015).

In this study, as a result of research and observations, a model of diagonal dairy goat barn design was developed for the purpose of meeting the need for a new shelter design in goat breeding which offers alternative area in goat raising in different seasons. Here, an effort was made to provide animal breeders engaging in this field with an alternative project that is economical, suitable for animal behaviors and preferences for different shelter needs and which can be applied to varying capacities. In this way, it is believed that the desired level of production and quality will be attained in animal husbandry.

## 2. Material and methods

The diagonal dairy goat barn design with a capacity of 300 or 400 goats was chosen as material in this study. In the herd projection for the goat barn with a capacity of 300 heads, the number of animals was planned to be 300 for dairy goats, 66 for billy, 68 for nanny, 5 for yeanling and 5 for kid (Dağ, 2015). The overall capacity was determined to be 440 heads. The farm size of 98.5 % of the farms dealing in small animal breeding in Turkey is below 300 heads (Anonymous 2014). In this study, a barn design, which could be used conveniently in both small-scale farms and large farms engaged in commercial breeding, was made. Moreover, the designed structure had the opportunity that can be adjusted to different shelter capacities.

This study emerged as a result of research and observations that have been conducted for long years concerning animal behaviors and barn area preferences of animals (Uzal Seyfi, 2016a,b, Aslan and Uzal Seyfi, 2015). The diagonal dairy goat barn design was developed for dairy goat breeding, taking into account the effects of seasonal changes, that could ensure a high level of animal welfare, be functional, allow mechanization. In the study, the initial goal was to create windless areas for animals protected from winds, in places where prevailing winds came from different directions such as north, northwest and northeast. In the barn design, mini resting areas of 10 m in width were placed diagonally on both sides of the feeding area in order to eliminate the adverse effects of winds that might come from northwest and northeast. Moreover, a summer courtyard covered with natural stones and trees was planned in the shelter which had a front open to summer winds. Dairy goats were provided with different courtyards suitable for natural conditions and could be used in winter and summer. In this way, goats would be protected from the unfavorable winds in winter and in summer, and the effect of heat would be alleviated by winds. In the study, group partitions were

formed to facilitate herd management. Animals were offered a free resting area involving simple mini structures for small social groups. The goal in the shelter design was to gain optimum protection from the wind in winter and utilization from the wind in summer. In addition, the designing of the shelter in a way that was composed of mini structural units for social groups allows the planned building to be used in different capacities and enables it to be used conveniently in sloping and terraced lands.

The presence of two different courtyards may initially seem to require more area and hence be costly. However, increasing animal welfare will be quite beneficial in terms of the quantity and quality of production. Moreover, the aesthetic beauty of the building would enhance the visual quality of the farm. To determine the barn area needs of animals and planning criteria, the studies of Uzal Seyfi (2016a, b), Olgun (2011), Yüksel and Şişman (2003), Ekmekyapar (1999), Hirning et al. (1994), Okuroğlu and Yağanoğlu (1993), Ekmekyapar (1991), Balaban and Şen (1988) were used. On the other hand, in the formation of specific planning criteria in the open system building design, the method of Uğurlu and Uzal (2007) was used in relation to other issues. The planning and organization schema used for the design is given in Figure 1.

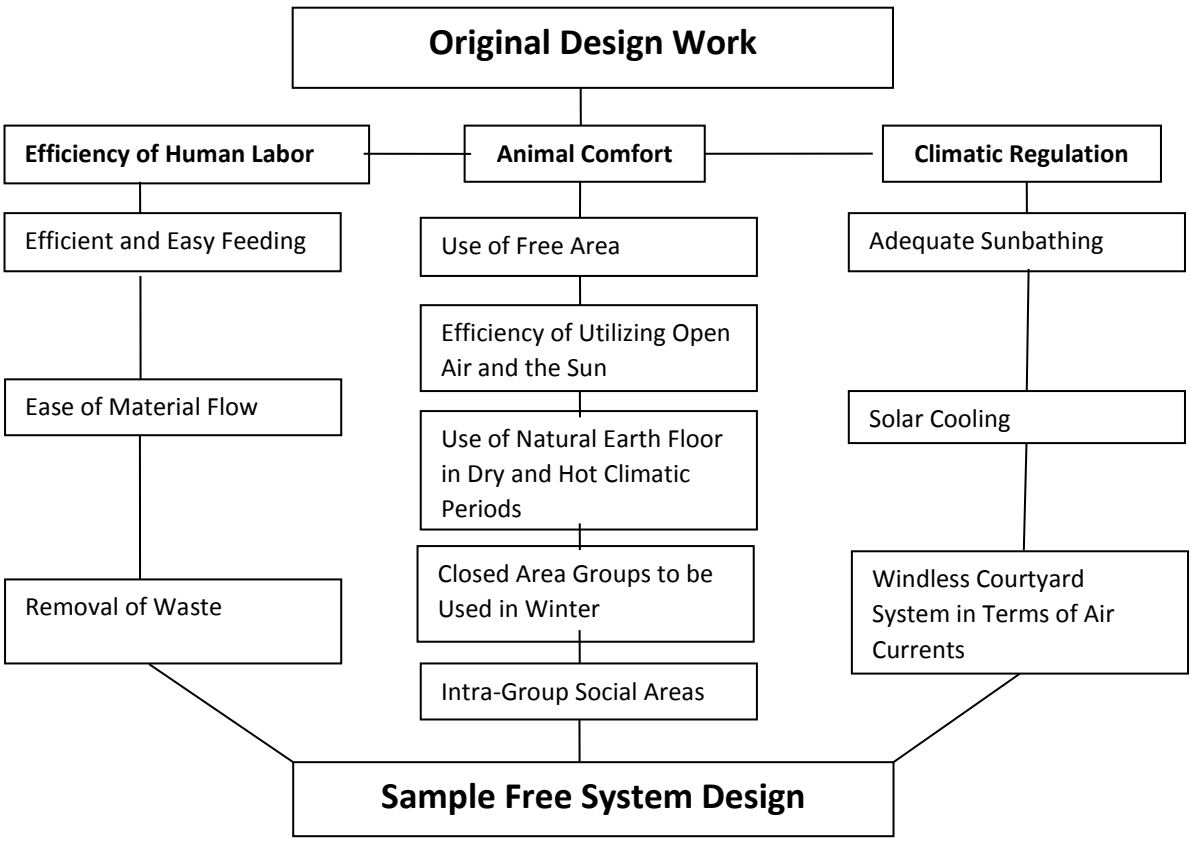


Figure 1. Planning and organization schema used in the shelter design (Uğurlu and Uzal, 2007)

The 2D drawing of the designed shelter plans was created by using Auctocad software (version 2017, Autodesk, San Rafael, Cal., USA) and also 3D geometry of the designed shelter plans was created by using Sketch up (version 2017, Google, Colorado, USA) and Lumion software (version 6.0, Warmond, The Netherlands)

## 3. Results and discussion

The perspective of the building design developed in the study for the social group diagonal dairy goat barn is given in Figure 2-3 while the plan view of the shelter is given in Figure 4-5 and the view and section drawings are given in Figure 6-9. Small ruminant production has increased as a result of the rising demand for goat and sheep milk in recent years. Farm owners, who have small animal breeding commercially, have started to build more modern shelter systems where mechanization could be performed conveniently instead of the closed system.

All these factors have made it inevitable that new shelter designs should be developed as an alternative to the existing barn planning systems. A prominent approach in the barn design today appears to be a planning method appropriate for animal behaviors that could raise the production performance to the highest level possible.

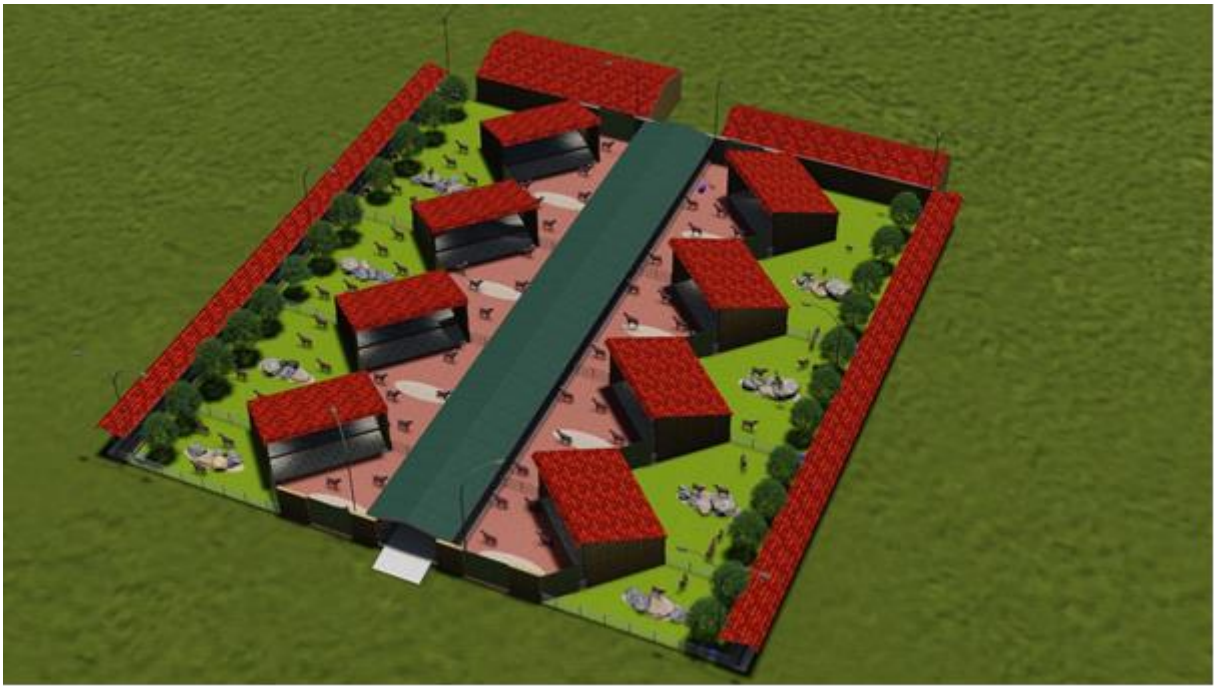

Figure 2. The perspective of the designed diagonal dairy goat barn

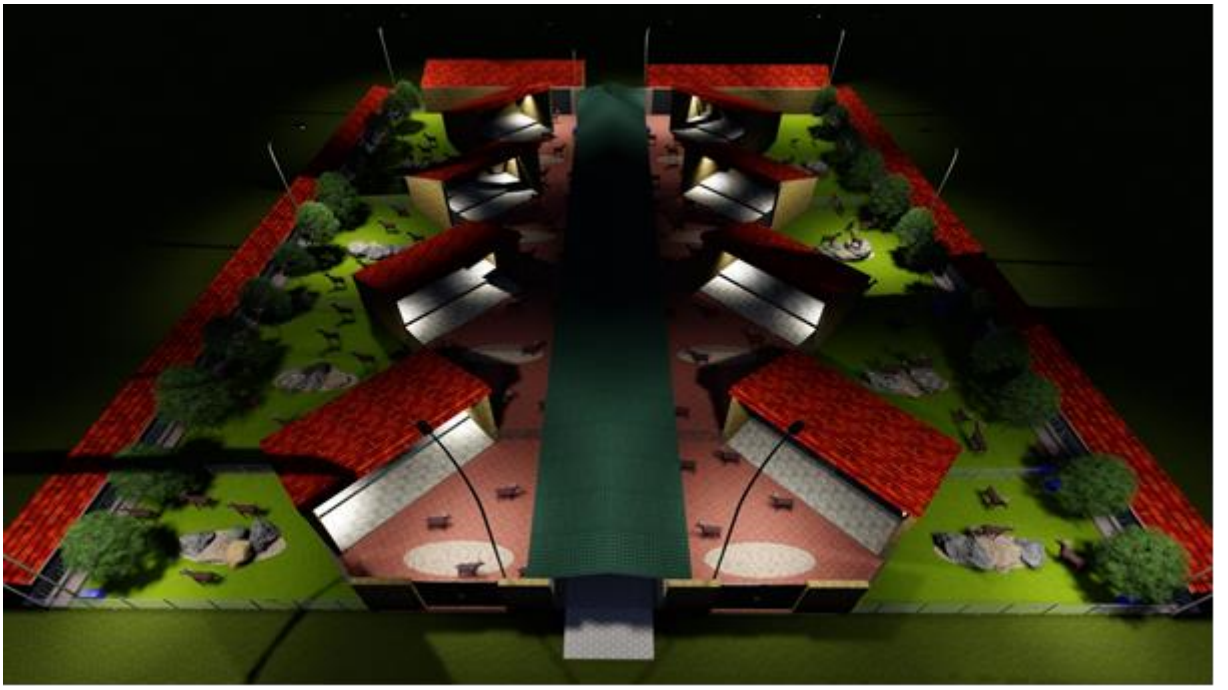

Figure 3. The another perspective of the designed diagonal dairy goat barn for night time period

Micro structural groups were formed in the diagonal dairy goat barn designed. Instead of mono-block, wide, big and costly buildings, structures that were smaller in dimensions (6.50x10.00m), simpler and lighter in terms of structural construction were preferred. In this way, the ease of construction and construction economy were ensured. The planning of the shelter in the form of micro structures, and the placing of the resting place perpendicular to the northeast and northwest, and diagonally to the feeding area were intended to protect the animals from winds that would come from the predominant wind direction. Micro structures were not only built with a view to economy but also in order to prevent formation of air currents in the semi-open resting areas and ensure dairy goat breeding in social groups. Big and wide buildings are structures whose construction costs are high and where problems can be experienced with respect to controlling of air currents. On the other hand, environmental conditions to which goats are most susceptible are wet floors and winds. For

successful breeding, resting areas should have dry floors, be protected from air currents, and be windless and comfortable. However, goats prefer to have air currents in hot seasons and range in large and shady places. To this end, summer courtyards were planned which animals could use in hot periods and enjoy winds easily but when they are disturbed by winds, they could use stationary areas between the resting areas. In this way, different spatial demands of animals in different seasons were met. Milking operations were concentrated in one place. Also, the efficiency of human labour in the farm was intended to be increased. Spatial plans belonging to the building designed are given in Table 1.

Table 1. Area dimensions in the designed shelter and unit areas per animal değerleri

| | Resting (Closed) Areas | Courtyard area (for winter) | Courtyard area (for summer) | Feeding Areas (m) | The Areas Covered with Roads | Total ($m^2$) |
|---|---|---|---|---|---|---|
| Barn areas (for spen with a capacity of 300 heads) | 520 | 1209 | 756 | 192 | 340 | 3017 |
| Areas per animal ($m^2$ $animal^{-1}$) | 1.5 | 3.0 | 4.5 | 0.6 | 1.1 | 10.8 |

*3. 1. The active areas used by animals*

The newly designed diagonal dairy goat barn system consisted of 8 micro structures. The groups that were formed were for 50, 40, 40 and 30 heads beginning from the North depending on the feeding length. Groups were formed from among the goats bred in the farm according to their ages, genetic features and social states (such as aggressive, compatible and shy animals), and different care and feeding conditions were created. In guiding and managing animals between group partitions, paths added to the group partitions could be used to ensure animal traffic. Diagonal micro structures which were placed symmetrically around the feeding area were so planned that one side of the structure was 4 m and the other side was 10 m to prevent animals from the unfavorable effects of winds in even extreme winter conditions. In this way, an effort was made to increase animal welfare by forming stationary areas. Moreover, automatic and portable walls could be added to the front of the resting areas so that in places where winters are extreme, walls could be closed to protect animals from adverse climatic conditions.

In the designed shelter system, the floor of the winter courtyard was built of soft keystone, whereas the summer courtyard was built of earth floor. Dry manure management was used in both places. The yards were constructed in a sloping fashion to prevent the floors from remaining wet too long in wet seasons and also the soil there was drained. Moreover, natural mounds were formed in the winter courtyards from stones of different granulometer to create drier resting areas in wet seasons. In the summer courtyards, on the other hand, mounds were formed of large stones to enable goats to practice rock-climbing, which is an innate habit of goats. The reason for building the resting lots in sloping fashion was to allow manure or fertilizers to be removed from the resting grounds through movements of animals and by the influence of gravity. In addition, good quality dry manure would be obtained via removal of manure from the place at certain periods (weekly or fortnightly) when the ground is dry.

One of the housing systems used in Konya for ruminant is the application of the freestall barn system (without stall), which is commonly used in dairy cow breeding. This system involves a closed area where feeding and resting areas are in a closed area and which has large doors (the doors are kept open except for cold periods) and an open courtyard. In spring and summer seasons, animals are taken to the grounds of the farm or pastures that are close to the farm in certain hours of the day. This type of structure is an old kind of system that has a high cost of construction for dairy cow breeding. As for sheep and goat breeding, this kind of shelter increases construction costs and fails to create appropriate environmental conditions for animals because the building is too wide and it has not been planned for sheep and goat. Systems that have been used for small ruminants in recent years have advantageous features over the previous barn systems but they remain inadequate in terms of climate, building, principles of social planning and animal welfare (Uzal Seyfi, 2016; Aslan and Uzal Seyfi, 2015).

In the designed diagonal dairy goat barn system, maximum animal welfare was ensured by allowing optimum benefit to be obtained from fresh air and the sun, protecting animals from winds in cold seasons and allowing winds into the structure in hot seasons. Animals were provided with the comforts of resting lots with covered floors, courtyards covered with a soft material in cold seasons, courtyards covered with earth floor in hot seasons so that animals would use different areas in different seasons. Movement between shelter areas was enabled through easy and simple lines. In this way, an accommodation opportunity commensurate with their natural conditions, thereby increasing animal welfare as well as quantity and quality of production was supplied for animals.

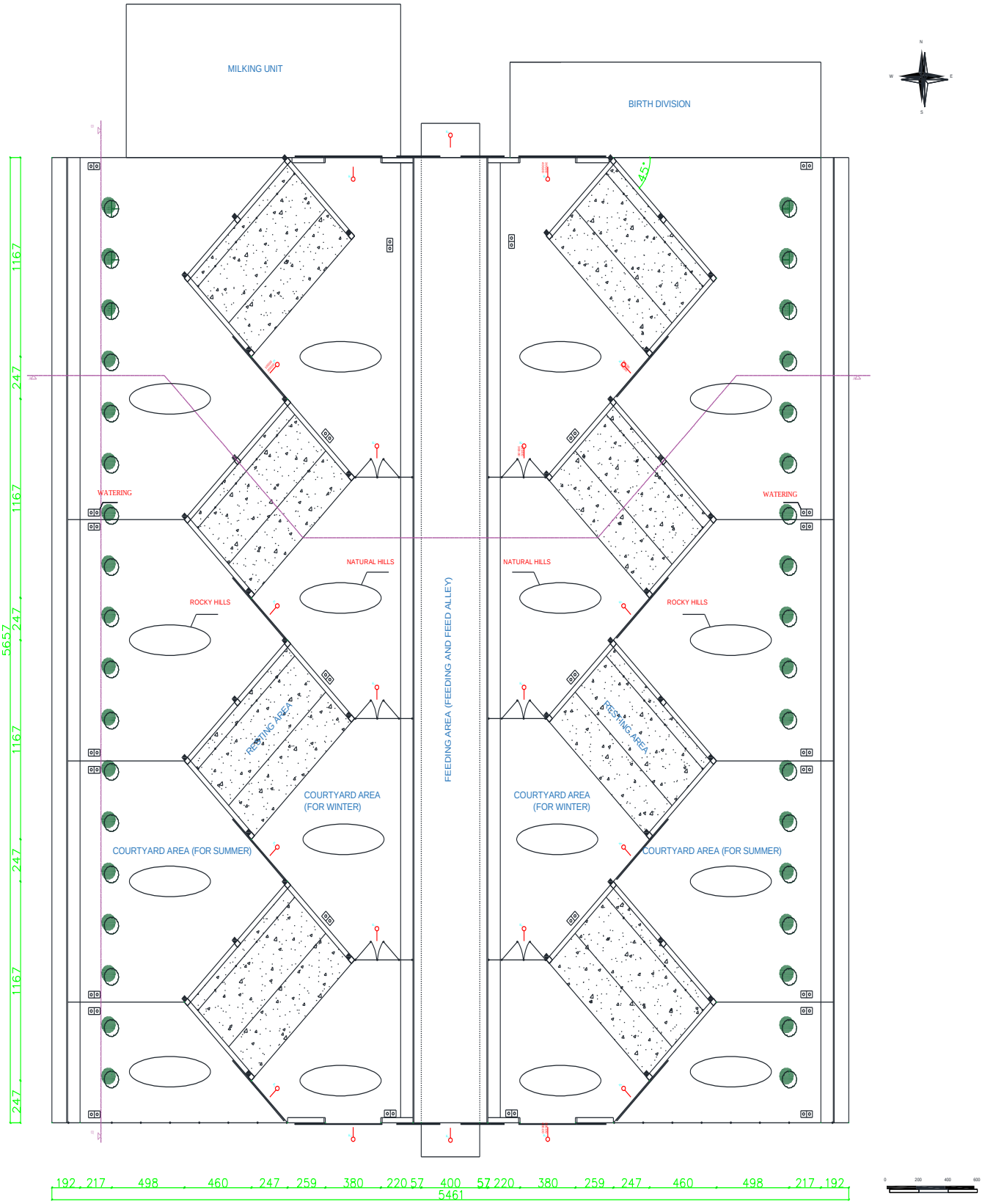


Figure 4. The plan view of the designed diagonal dairy goat barn

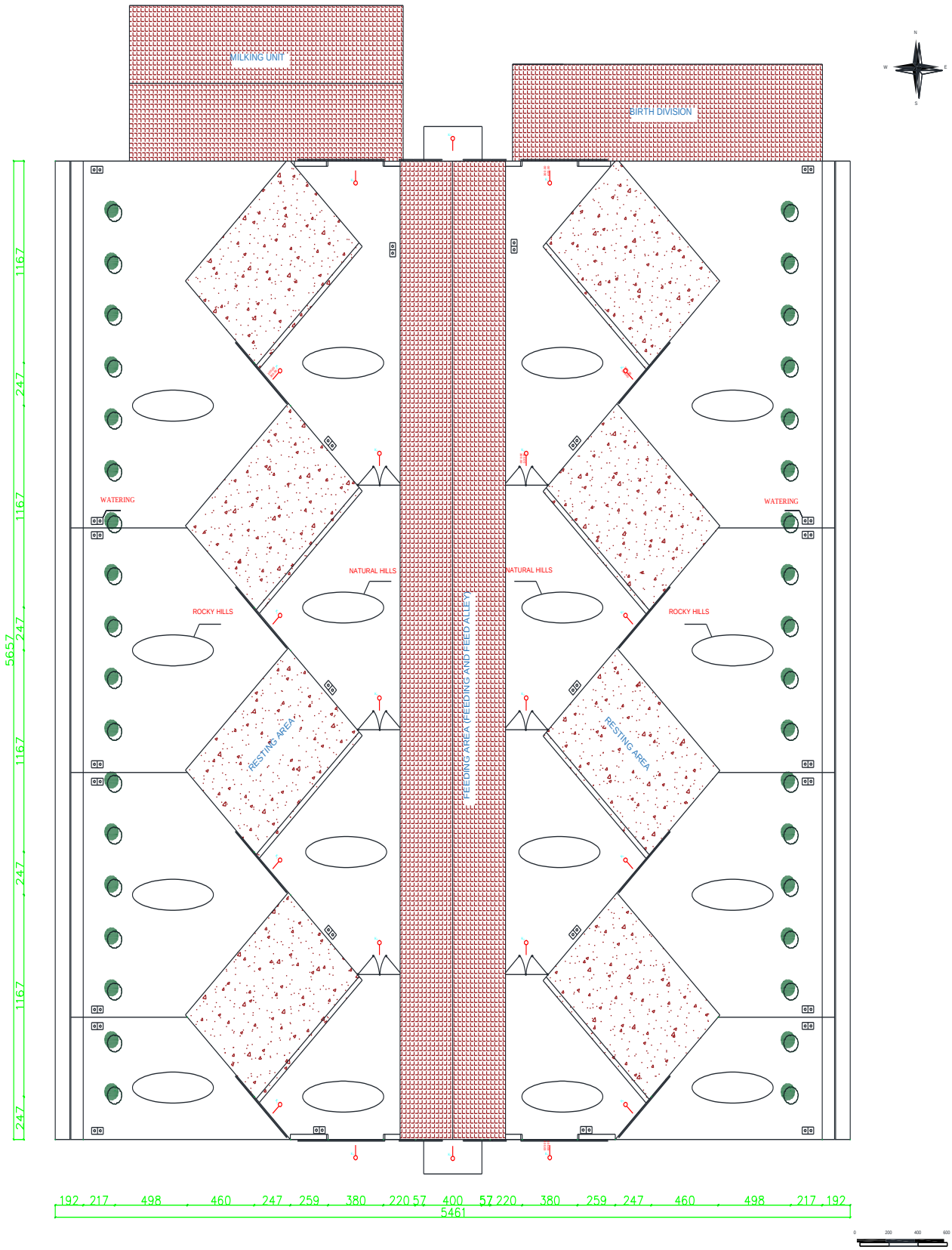


Figure 5. The another plan view of the designed diagonal dairy goat

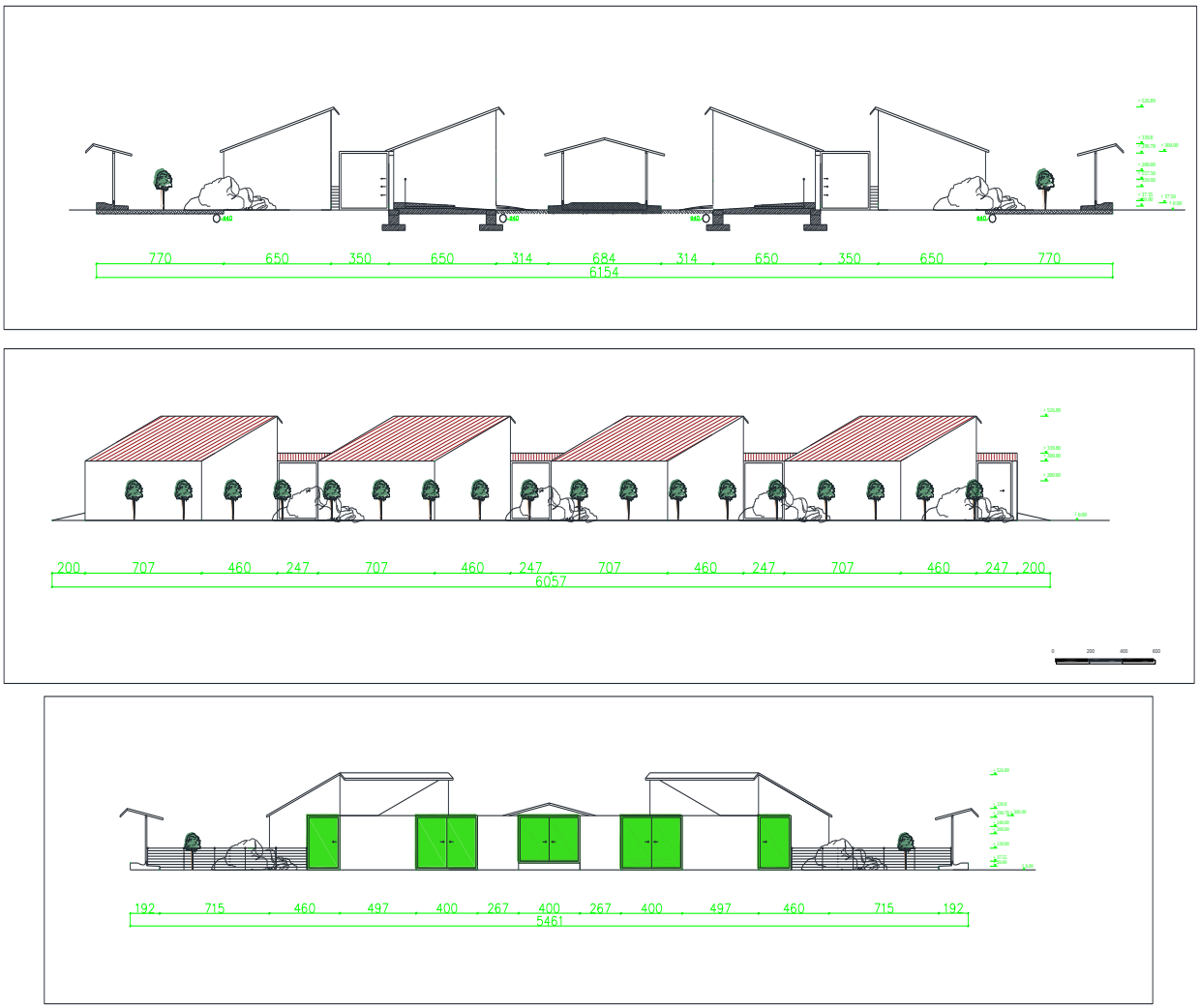


Figure 6. The cutaway view and side views of the designed diagonal dairy goat barn

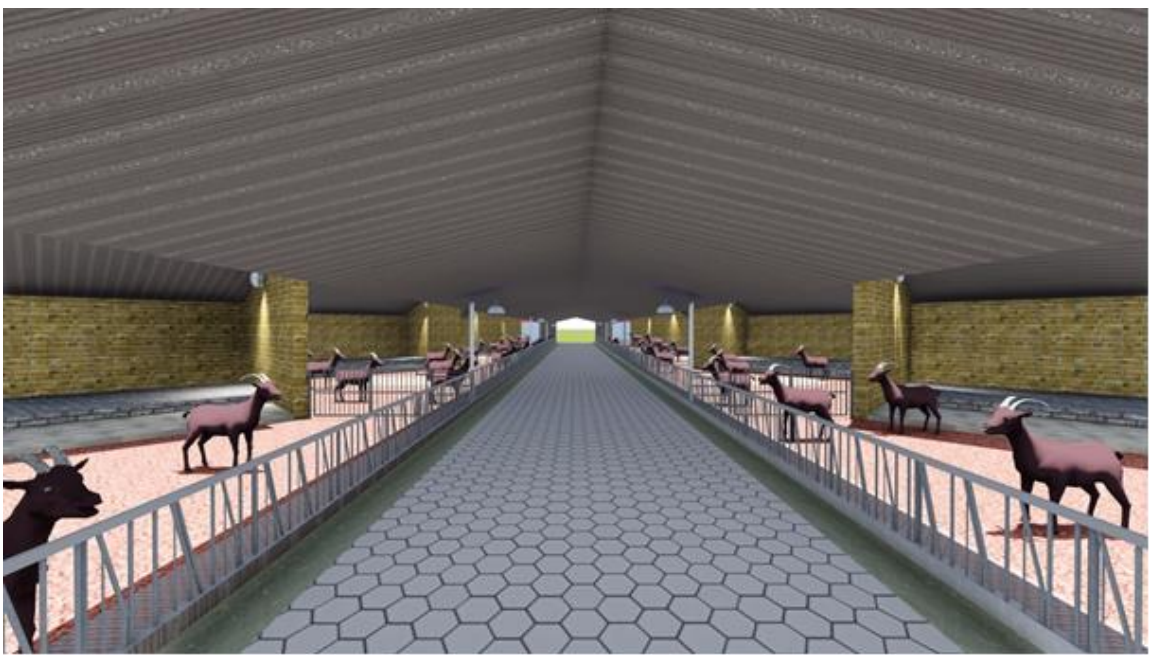

Figure 7. The view of feding area in the designed diagonal dairy goat barn

Figure 8. The view of resting and winter courtyard area in the designed diagonal dairy goat barn

Figure 9. The view of summer courtyard area in the designed diagonal dairy goat barn

## 4. Conclusion

Achieving an increase in animal productivity and quality could be possible through the shelter designs compatible with animal welfare. With the designed diagonal dairy goat barn, animals would be able to benefit from the fresh air and sun at an optimum level; they would also be protected from winds in cold periods while the areas created to allow winds in hot periods, thereby, would raise animal welfare to a maximum level. In this way, the environments appropriate for natural conditions of animals would be created to increase the quantity and quality of animal production.

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