Optimal Layout Design for Milk Goats Livestock Farms Using Genetic Algorithms

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Abstract

In this article we present a methodology for the generation of optimal layouts in milk goats' units, characteristic of the south of Spain. For this purpose we used the S.L.P. (Systematic Layout Planning) methodology developed for the planning of industrial facilities, and a computer program for layout generation based on genetic algorithms and on "slicing tree" techniques. The genetic algorithms allow us to solve combinatory optimization problems in a heuristic way, as in the case of the optimization of layouts. The procedure consists, basically, of building an initial population of solutions (layouts) by means of a recursive process of location domain cuts, so that each solution obtained can be represented by a slicing tree and the initial population of solutions sequence can be coded by the application of genetic operators that use a cross and mutation probability. The optimizing process is managed by means of an objective multicriteria function that contemplates parameters of a qualitative, quantitative and geometric character.
This methodology has been applied to two type farms that present a semi-intensive, free housing production system, characteristic of the south of Spain, with 120 and 240 milk goats, starting from hypotheses, obtaining in both cases good layouts that minimize the cost of the flow of materials through the farm, which represents a saving both in costs and in labour, and an improvement in the welfare of the animals, in short, a rational design of the farms.

Keywords

Optimal layout design, facilities layouts, genetic algorithms, farm building, milk goats, livestock farms.

1. Introduction

The goat head census in the European Community has gradually increased in the last 25 years. The country with the largest number of heads is Greece, followed by Spain, France and Italy. In Spain, most of the goat stock is located in Andalusia, mainly in the counties of Seville, Málaga and Almería. In Almería the most popular breed is the *murciano-granadina*, kept under semi-intensive conditions.

For a long time in the Spanish region of Andalusia, research projects have been carried out, geared to the genetic and health improvement of the of milk goat breeds grown on the units, such as the *murciano-granadina* or the *malagueña*, with the purpose of increasing the production of milk. However, an investigation project on the optimization of the design of the housing within these units had not been planned until now. Therefore, in this paper we present the results of a study focused on the improvement of the housing from the point of view of its functionality, optimizing the distribution in plant (layout) of the units starting from the flows of animals, people, machinery, products, raw material and by-products that occur in them due to the daily handling operations. That is to say, we intend to optimize the design of the unit starting from the productive process developed in it, applying the productive process concept used in the optimization of industrial plants, for which we will apply the methodology used in the optimization of the layout in industrial plants facilities widely developed by a great number of authors.

1.1. Solution of the layout problem

For many years the layout of facilities has been studied efficiently, since there are many factors that need to be born in mind when distributing spaces to implement an industrial process (flow of materials among activities, security reasons, noise, work in progress, form restrictions, etc..) and many are also the methods that have been developed to solve the problem. Thus, Koopmans and Beckmann (1957) were the first to formulate the layout problem as a quadratic assignment problem. After them, there have been many methods both analytic as heuristic developed in search of a solution, (along the lines of: Aldep (Seehof *et al.*, 1967), Corelap (Lee *et al.,* 1967), etc.) or based on special techniques such as "Simulated annealing" (Tam, 1992b)," Tabu Search", Theory of Graphs, "Fuzzy Sets","Genetic Algorithms" (Tam, 1992a; Santamarina *et al.,* 1994a; Santamarina *et al.*, 1994b; Wu *et al., 2002).* The majority of them have been developed starting from the methodology of layout resolution contributed by the S.L.P. (Systematic Layout Planning) method proposed by Muther (1961) which consists of a methodology or organized form of approaching the problems of layout generation. This procedure consists, basically, of fixing an operational phase chart and a series of procedures that allow us to identify value and visualize all the elements involved in the installation and the existent relationships amongst them.

The S.L.P. methodology structures the layout problem in 6 stages or phases:

I. In the first phase, the problem is defined and an analysis of the type and quantity of products that will experience flows in the layout is carried out. For this purpose the flows of the products among the different activities are studied and a qualitative relationship amongst these is planned.

II. The second phase is analytical, the relational diagram of routes and/or activities is obtained and interrelated with the space required for each activity and the available space, thus obtaining the relational diagram of spaces, which in turn is subjected to practical limitations and other influential factors.

III. The third is a phase of synthesis, where the generation of alternative layouts is carried out.

IV. The fourth is a phase of evaluation in which each alternative is studied in detail.
V. The fifth is a phase of selection, the best alternative is chosen.
VI. The sixth is a phase of implementation and pursuit where the selected installation is carried out.

The mathematical formulation of the layout problem is the following: (Figure 1):
Given a domain D, of area A and fixed, flexible or free, known or unknown geometry, locate, without overlapping, inside it, n activities of area a_i *and free, flexible or fixed geometry* $D_i(a_i)$ *among which a series of relationships exists and therefore of relational intensities* w_{ij}*, so that the relational cost of the system* $S(D,D_i)$ *is minimal.*

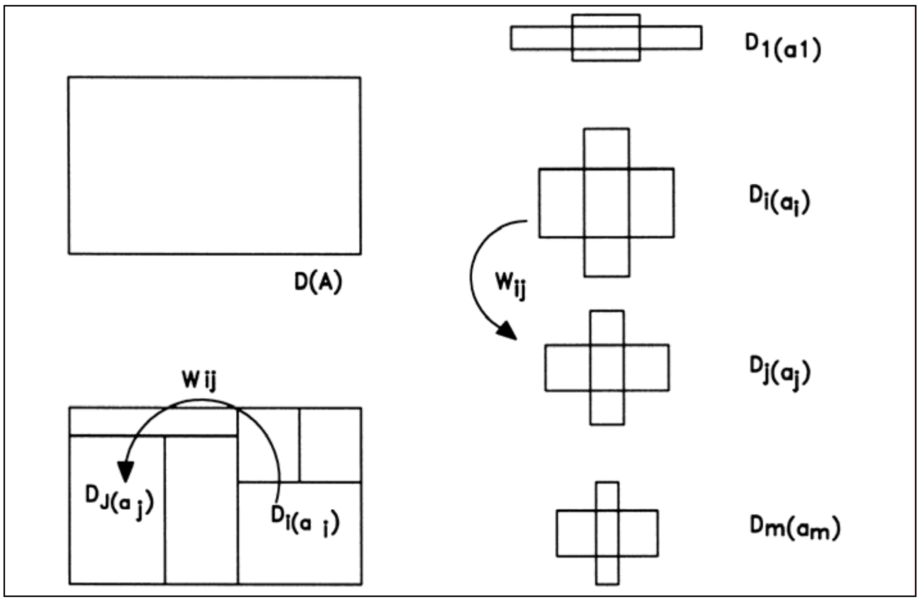

Figure 1. Mathematical formulation of the layout problem with free geometry plant and activities

1.1.1. Genetic algorithms as elements of optimization

Genetic algorithms were developed by Holland and collaborators during the sixties (Goldberg, 1989). Their development is based on the analogy that exists between the techniques that use these algorithms and the genetics and the natural selection mechanisms of the species.

Genetic algorithms are constructed to describe variations that take place in individuals as a consequence of changes in their genetic content. Randomly, a set (population) of solutions to the outlined problem is generated by this technique. By means of this technique we are trying to find the best solution, searching for relevant information for these solutions. The optimization procedure is carried out defining a group of genetic inter and intra-chromosomal operators, in a similar way to that observed in Nature (crossing, inversion, selection, mutation...). Applying these operators to the genes of different chromosomes (that represent different individuals) it is possible to obtain new genetic codes (that represent new individuals descended from the previous ones) which have inherited the best qualities of their ancestors. During this optimization process, the adaptability of each individual to its external environment is evaluated in terms of the characteristics that the individual develops in this environment (which are a consequence of its genetic code). After generating successive populations of descendants, the optimization process ends when the algorithm converges or when an individual is found with a preset adaptability level.

1.1.2. Application of genetic algorithms to the layout problem

The solution of the layout problem as an assignment quadratic problem using Genetic Algorithms has been treated by several authors, mainly in the last decade of the XX century, (Pham *et al.*, 1992), (Fujita *et al.*, 1993), (Tate *et al.*, 1995), (Conway *et al.*, 1994), (Banerjee *et al.*, 1995), (Maniezzo *et al.*, 1995), (Gen *et al.*, 2000) highlighting (Tam, 1292a), (Santamarina *et al*, 1994a y b), (Santamarina, 1995), (Santamarina *et al*, 1996), (Kado *et al.*, 1995), (Gupta *et al.*, 1996), (Suresh *et al.*, 1996), (Garcés-Pérez *et al.*, 1996), (Gero *et al.*, 1997), (Santamarina *et al*, 1997), (Norman *et al.*, 1997), (Rajsekharan *et al.*, 1998), (Castell *et al.*, 1998), (Cheng *et al.*, 1998), (Gero *et al.*, 1998), (Islier, 1998), (Kochhar *et al.*, 1998), (Mak *et al.*, 1998), (Tam *et al.*, 1998), (Tavakkoli-Moghaddain *et al.*, 1998), (Hamamoto *et al.*, 1999), (Mahdi *et al.*, 1999), (Matsuzaki *et al.*, 1999), (Al-Hakim, 2000), (Azadivar *et al.*, 2000), (Balakrishnan *et al.*, 2000), (Cantoni *et al.*, 2000), (Li *et al.*, 2000), (Lee *et al.*, 2002), (Wu, *et al.*, 2002) for their applications to the facilities layouts problem, Pérez and collaborators (2002) and Pérez (2003) for their applications to the layout in milk goats´farms.

1.2. Design of milk goats´farms

In any milk goats´unit a productive process take place, in the sense that there is a design and project of industrial facilities. Only here it is rather particular, since in free housing the goats can move among the different functional areas of the farm, according to the handling carried out by the farmer. Thus, in a free housing milk explotation, the animals pattern of movement and the farm´s layout cannot be neither separated nor tackled independently, when the housing is designed. That is because the movement of animals, people, machinery, raw materials (fodder, concentrates, ensilage,..), products (milk, kids) and by-products (manure) can be simultaneous. Bearing all this in mind, the following aspects should be integrated in the design of a modern milk goats´farms:

1. Location:
    - Selection of a plot where the unit will be built.
    - Distribution of spaces in the plot.
2. Design of the building:
    - Layout.
    - Structure.
    - Walls and partitions.
    - Floors.
3. Design of the process systems:
    - Animals handling systems.

- Staff handling systems.
- Machinery handling systems.
- Products handling systems.

4. Design of the auxiliary systems:
   - Food handling systems.
   - Water handling systems.
   - Manure handling systems.
   - Control systems.

In the design phase of the farm building it is necessary to study the relationship between the distribution in plant, the typology and the structural materials, the walls, partitions and supports, in order to make the building appropriately functional (Pérez, 2003). In this type of free stabling farms, according to, among others, (Toussaint, 1985), (Constantinou, 1987), (Caja *et al.*, 1988), (Boschetti, 1989), (Guerrero, 1989), (Fuentes, 1992), (Corcy, 1993), (Daza, 1996), (Toussaint, 1997), (Falagán, 1998), (Pérez, 2003), the layout should have the following functional areas: breeders rest area, area for suckling kids, area for replacement young goats, rest area for reproductive males, lazaretto, exercise areas, feeding corridor, warehouse, hayloft, Milking waiting room, milking room, dairy and dungheap.

2. Methodology

2.1. Method proposed for layout generation based on genetic algorithms

Any optimization technique based on genetic algorithms requires as starting point a population of individuals (solutions to the problem). These Algorithms act on the individuals' genetic information expressed through their chromosomes. Therefore, a procedure is needed that allows the coding of each solution through a finite length chain (chromosome). Thus, the algorithm that will be used in the present study, optimization of layouts in milk goat farms, is the one developed by Santamarina (Santamarina, 1995), known as LAYAGEN, which uses a slicing tree-based technique, as a method for the location of activities, in the solutions generation phase, and once the structure of the slicing tree has been determined by means of a " clustering " procedure (Figure 2), it is possible to generate different solutions (layouts) just by randomly varying the slicing operators inside the set $\theta=\{a,b,i,d\}$, being: a: up, b: below, i: left, d: right.

To obtain the slicing tree from the dendogram devised by means of the clustering procedure, one only needs to place in each node of the dendogram the slicing operator corresponding with the combined θ, as shown in an example in Figures 2 and 3 for a layout that presents 6 activities.

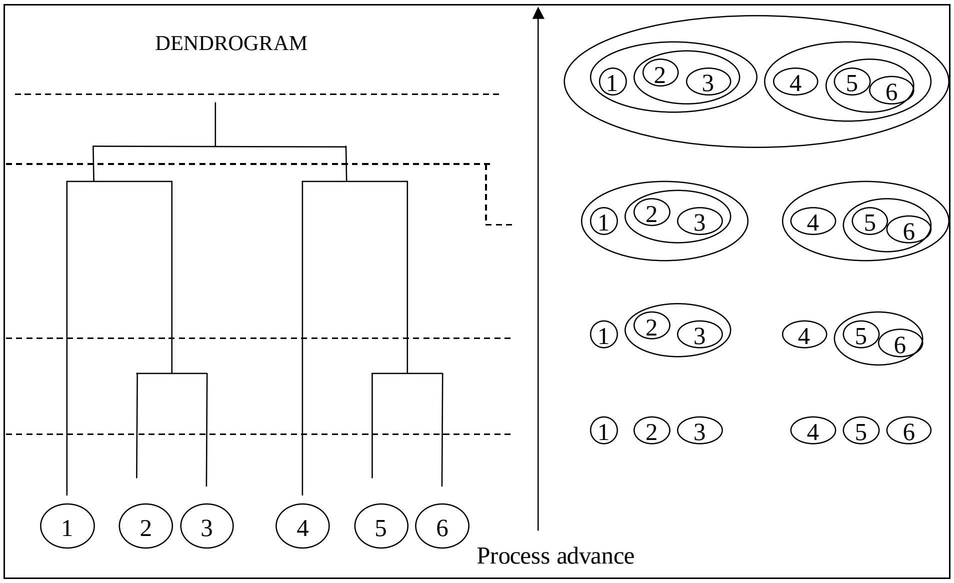

Figure 2. Construction of the dendogram by means of an agglomerative clustering technique

The coding of the solutions depends on the procedure used in their generation; since it is carried out through the set of slicing operators associated with this procedure. To code the solutions through a coarse finite length chain it suffices to carry out a pre-order search of the slicing tree, although one could also follow an in-order or post-order search.

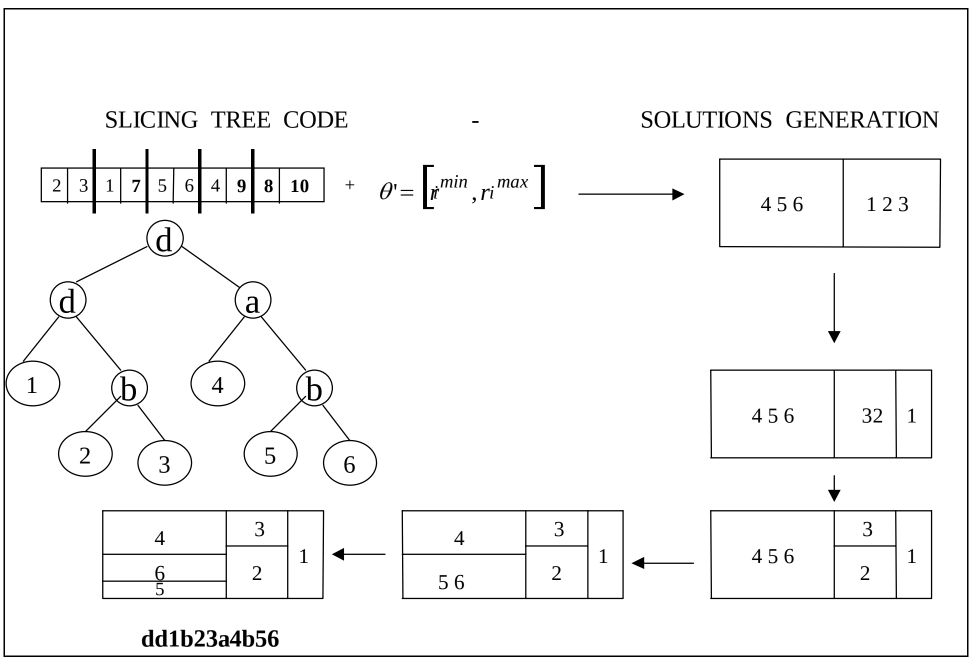

Figure 3. Solutions code (Santamarina, 1995)

The proposed procedure is the one developed by Santamarina (Santamarina, 1995) to code the solutions by means of a finite length chain with a pre-order search of the slicing tree, which is shown by an example in Figure 3, the code of the solution would be: *dd1b23a4b56*. However, if the grouping sequence of the different activities remains fixed, that is to say, the slicing tree, the solutions coding can be simplified, in this way: *dd1b23a4b56* $\rightarrow$ *ddbab*. Thus, the sequence *ddbab* is the coded solution, and represents the individual's genetic code. However, when an individual, characterized by a genetic code, faces a certain external environment (location domain) it develops a phenotype, and likewise, when an individual, characterized by a genetic code (chain), is exposed to different external environments, it develops different characteristics, and therefore, different phenotypes (which are those that show if the individual is really adapted to the environment or not). Therefore, if we take an individual with a genetic code and add to it a new gene that directs the geometric control of the location domain, of all the possible solutions that can be obtained from the chromosome provided by the slicing tree, we can obtain the one that is closest to the geometry preset by this last gene. In this study it is proposed that this new gene should adopt pairs of values from the set $\theta' = \left[r_i^{min}, r_i^{max} \right]$, where the first one indicates the minimum high/wide ratio, and the second one the maximum high/wide ratio.

Each of the solutions coded by means of the above mentioned methodology is evaluated, calculating a cost associated with them that should be the lowest for the best solution. Santamarina (1995) proposes that this cost should be determined using a mathematical multicriterion function that considers the qualitative and quantitative relationships among the activities, as well as a cost that penalizes the solution if it does not fulfill the geometric restrictions imposed a priori for each activity, which is known as Relational Cost of the System S(D,Di) and is defined as:

$$S(D, D_i) = \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} \cdot \left[\pm \alpha \sum_{u=1}^{k} f_{u,ij} \pm \beta \sum_{v=1}^{k'} t_{v,ij} \right] + \mu \sum_{i=1}^{n} f(l_i) \qquad (1)$$

Where:

$f_{u,ij}$ = value of the relational intensity existing between activities i and j, under the quantitative criterion u_avo.

$f_{v,ij}$ = value of the relational intensity existing between activities i and j, under the qualitative criterion v_avo.

α,β,μ: weight coefficients representative of the relative importance between factors of quantitative, qualitative nature and geometric criterion.

$\pm$ = the sign will be chosen " +" or " -" in terms of the meaning of the indicator used to estimate the relational intensity.

k = number of quantitative criteria contemplated.

k' = number of qualitative criteria contemplated.

d_{ij} = rectilineal distance between the gravity centers of the activities.

$f(l_i)$ = penalization for non-fulfillment of geometric restrictions, an exponential function, potential, etc. can be used.

The geometric restrictions of the spaces to which the activities are assigned are formulated by mathematical expressions, and the non-fulfillment can be considered as the difference between the value that the restriction takes in the obtained solution and the limit value that it can take.
To quantify the penalty f(li) of each activity, as a consequence of the non-fulfillment of the geometric restrictions, mathematical functions will be used (potentials, exponential, etc.) that increase the penalty as the non-fulfillment increases (li).
For the determination of the formal non-fulfillment, we must differentiate between the free orientation activities and those that should be developed in spaces with a particular orientation (horizontal or vertical).
For free orientation activities the formal nonfulfillment is calculated by the expression:

$$l_i = max\left(0, \left\{\frac{max(high_i, wide_i)}{min(high_i, wide_i)} - max\left(r_i^{max}, \frac{1}{r_i^{min}}\right)\right\}\right) \quad (2)$$

where:

r_i^{max}: is the maximum value of the high/wide ratio, allowed for activity i, in a predominantly vertical orientation.

r_i^{min}: is the minimum value of the high/wide ratio, allowed for activity i, in a predominantly vertical orientation.

$high_i$: height of activity i.
$wide_i$: width of activity i.
As can be observed, the penalty is the same one in both cases, if the activity fails to fulfill the restrictions in a vertical or in a horizontal way.
If the activities present a fixed vertical orientation the non-fulfillment would be calculated by the expressions:

$$\text{If } ri > ri^{max} \Rightarrow li = ri - ri^{max}$$

$$\text{If } ri < ri^{min} \Rightarrow li = \frac{1}{ri} - \frac{1}{ri^{min}}, \text{ if } r_i<1 \quad (3)$$

$$\Rightarrow li = ri^{min} - ri, \text{ if } r_i \geq 1$$

where:
r_i : is high/wide ratio of the activity i.

r_i^{max} is the maximum value of the high/wide ratio allowed for activity i in a predominantly vertical orientation

r_i^{min} is the minimum value of the high/wide ratio allowed for activity i in a predominantly vertical orientation.

If the activities present a fixed horizontal orientation, the non-fulfillment would be calculated as in the previous case, carrying out the following transformation:

$$\frac{1}{r_{i'}^{min}} = r_i^{max} \quad \rightarrow \quad \frac{1}{r_{i'}^{max}} = r_i^{min} \quad \rightarrow \quad \frac{1}{r_{i'}} = r_i \quad (4)$$

where:
$r_{i'}$: ratio high/wide of the activity i.
r_i^{max} : the maximum value of the high/wide ratio, allowed for the activity i, in a mainly horizontal orientation.
r_i^{min} : the minimum value of the high/wide ratio, allowed for the activity i, in a mainly horizontal orientation.
Finally, for all the cases, the following function is suggested as penalty for the non-fulfillment:

$$f(l_i) = (l_i + 1)^p ,\ p \in \left]1, \infty\right[\qquad (5)$$

2.2. Livestock reference framework: milk goats´farms

To achieve the set objectives, that is to say, the optimization of layout in milk goats´farms, we carried out a study of their characterization in the county of Almería (Spain) that allowed us to take the starting data for the implementation of optimal distributions that minimize the length of the production means routes (Pérez *et al.*, 2002; Pérez, 2003).
For the elaboration of the present study, a survey was carried out in the first place that picked up 121 variables, structured in 5 sections: general characteristics of the exploitation (18), exploitation system (17), characteristic of the housing layout (28), constructive characteristics of the housing (23), characteristics of the facilities and equipment (35). Later on, with this survey, we carried out a stratified random sampling of 60 milk goats´farms in the county of Almería during the year 1999, with a previous analysis of the data collected, and subsequently carrying out a multivariant treatment consisting of a factorial analysis that reduced the quantitative variables to 49, and later on a cluster analysis that allowed us to divide all the farms into five homogeneous groups, in terms of the number of livestock heads (Pérez *et al.*, 2003).
These five groups of farms present a semi-intensive system of exploitation on the way to becoming intensive, therefore, we will focus on the study of two type farms, one with 120 and another one with 240 goats, respectively to optimize their layout, for which purpose we will use the layouts generation method described in the previous section. For these two farm sizes we adopt an investigation hypothesis that presents the 9 activities contained in the same rectangular enclosure indicated in the Table 1.

Table 1. Activities occurring in the farms to be studied

Activities	Nomenclature
Rest Area lot 1	1
Re-rearing Rest Area	2
Males Rest Area	3
Lazaretto rest area	4
Warehouse-hayloft	5
Milking waiting room	6
Milking room	7
Dairy	8
Rest Area lot 2	9

3. 3. Results and discussion

The automatic program of layouts generation that has been used is based on the S.L.P methodology., therefore, to implement the experimental phase, it is necessary to carry out, two detailed studies of the productive process, as a starting point: the Route of Products and the Relationship among the Activities. Next, this data are detailed, as well as the established hypotheses.

Products route:

With respect to the flows described in paragraph 1.2., a special attention will be paid to those due to the flow of food materials for the animals, such as concentrates, hay and fodders, since these are the flows that account for the greatest cost. As they are heterogeneous products, the MAG Count has been used with the purpose of being able to quantify the flow of materials among activities, as well as the difficulty to transport them. This is a system of units that quantifies the flows of each material in a homogeneous way. The use of this MAG unit is preferable to volume or surface units, since there is no direct relationship between the transportability or the manageability of the products and the volume. In Table 2 the flows of daily materials are expressed among the different activities for the farm of 120 goats, this flow being double for the 240 goats one.

Table 2. Flow of materials (MAGs/day) among activities in the 120 goats farm

Activities		1	2	3	4	5	6	7	8	9
Rest Area lot 1	1									
Re-rearing Rest Area	2									
Males Rest Area	3									
Lazaretto Rest Area	4									
Warehouse hayloft	5	31,4	11,4	3,6				6		31,4
Milking waiting room	6									
Milking room	7									
Dairy	8									
Rest Area lot 2	9									

Relationship among activities:

The Relational Table of Activities shows the need for the different activities to take place close to each other; this vicinity need arises from the handling that is carried out. In the S.L.P. methodology, Muther (1961) establishes six relationship categories among activities: A: Absolutely necessary, E: Especially important, I : Important, O: Ordinary, U: Unimportant, X: Rejectable.

Following this terminology, in the Table 3 the relationships are exposed among activities of both farms.

In order to optimize the layout in the S.L.P the methodology it is important to know the surface needed for each activity. Beause of that, in Table 4 we present the surface required for each activity and farm type, as well as the long/wide ratios of each activity (Rmax) maximum and (Rmin) minimum, since each activity needs certain geometric conditions due to their functionality.

Table 3. Relational Table of Activities

Activities		1	2	3	4	5	6	7	8	9
Rest Area lot 1	1		O	X	X	A	A	O	U	A
Re-rearing Rest Area	2	O		U	X	O	U	U	U	O
Males Rest Area	3	X	U		X	O	U	U	U	X
Lazaretto Rest Area	4	X	X	X		O	E	X	U	X
Warehouse/ hayloft	5	A	O	O	O		U	E	U	A
Milking waiting room	6	A	U	U	E	U		A	E	A
Milking room	7	O	U	U	X	E	A		A	O
Dairy	8	U	U	U	U	U	E	A		U
Rest Area lot 2	9	A	O	X	X	A	A	O	U	

Table 4. Surfaces and Rmax and Rmin ratios for each activity

Activities		Surface (m^2) 120 goats	Surface (m^2) 240 goats	Rmax	Rmin
Rest Area lot 1	1	90	180	4	0,5
Re-rearing Rest Area	2	19,2	38,4	2	0,5
Males Rest Area	3	18	36	2	0,5
Lazaretto Rest Area	4	9	18	2	0,5
Warehouse/ hayloft	5	65	100	2	0,5
Milking waiting room	6	30	43	2	0,5
Milking room	7	45	56	2	0,5
Dairy	8	9	16	2	0,5
Rest Area lot 2	9	90	180	4	0,5

The LAYAGEN algorithm in its operative process also uses as starting data the long/wide maximum and minimum ratios for the total surface of the enclosure where the best layout is to be generated, having taken values 3 and 1 respectively for the 120 goats farms, and for those with 240 goats 4 and 2 respectively. Likewise, we require as starting data the initial number of individuals to generate, taken as 50, as well as the number of generations that we have adopted 1000, and all this for both the optimization of the slicing tree and the generation of the optimal layout. Finally, the algorithm needs to operate the mutation and crossing probabilities in both cases, and we have taken them respectively as 0,95 and 0,05.
The optimum solution, that is to say, the lowest cost of the flow of materials, obtained for the 120 goats farms is the one expressed in Figure 4, and the one for the 240 goats farms is shown in Figure 5.

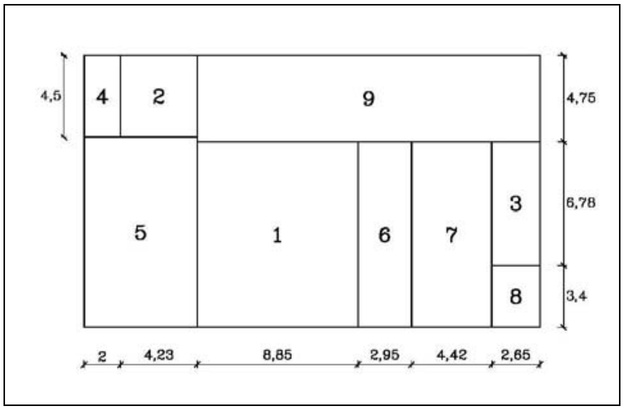

Figure 4. Optimal layout for the 120 goats farm.

As can be observed in Figure 5, in the farms with 120 goats all the rest areas are external, as it is desirable in a free livestock farm where grounds for specific external exercise exist for each rest area, so that the goats have free movement from the inside to the outside of the housing and vice versa. The exercise grounds of each functional area, have not been considered in the calculation as external to the housing, but the optimum solution is conditioned by the fact that the exercise grounds referred can be adapted to that solution. Equally, the existence of a feeding and handling corridor has not been considered in the calculation, however in the optimum solution it should be possible to include this corridor, as it actually occurs, because you can trace a corridor parallell to activities 4, 2 and 9, which connects all the functional areas with the warehouse-hayloft, which would facilitate the tasks of feeding the livestock, milking, removal of manure. Likewise, the dairy which includes the milking equipment room, is also located in a corner far away from the animals rest area, and the lazaretto. Other layouts have been obtained with a flow of materials cost which is similar to this solution, however they had high penalization for breaking the established geometric calculation ratios.

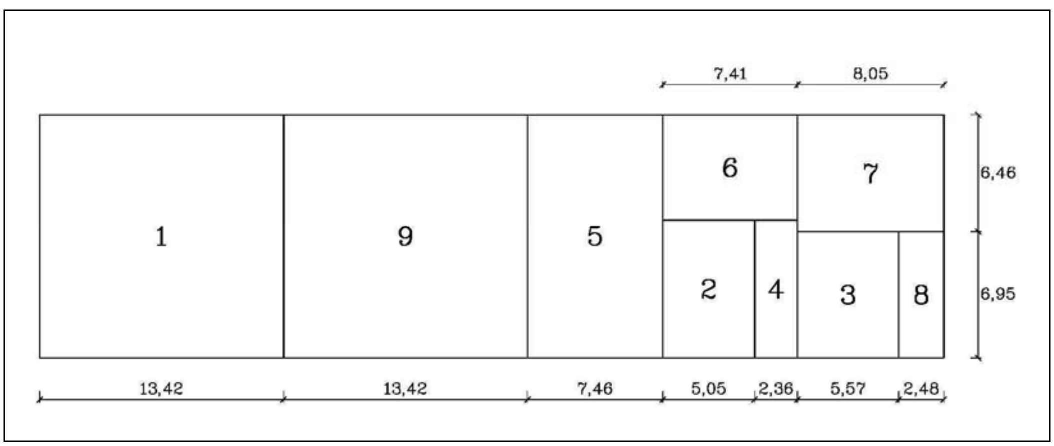

Figure 5. Optimal layout for the 240 goats farm

As can be observed in Figure 5, in the farms with 240 goats all the rest areas are external, as it is desirable in a free stabling farm, as it happened in the farms with 120 goats. Equally, the exercise grounds of each functional area, have not been considered in the external calculation of the housing, but the optimum solution is conditioned by the fact that the previously mentioned exercise grounds can be adjusted to this solution. Likewise, in the calculation the existence of a feeding and handling corridor has not been considered, however in the best solution it should be possible to build this corridor, as is actually the case. One of the reasons is that you can trace a corridor laterally in the aisle, parallel to activities 1, 9, 5, 6 and 7 which connects the warehouse with all the animals rest areas or indirectly through the milking waiting room, which would facilitate the tasks of feeding the livestock, milking and removal of manure. Likewise, in this solution, the dairy that includes the milking equipment room, is also located in a corner far away from the rest area of the animals, and the lazaretto. In the same way, with a similar flow of materials different layouts have been obtained all of them with a not very different cost. However they had high penalization for breaking the established geometric ratios for the calculation.

4. Conclusions

Of the basis of the results obtained, it is possible to conclude:

The LAYAGEN program based on genetic algorithms, in "slicing tree" techniques and on the S.L.P methodology, is adapted for the design of optimal layouts in milk goats´farms, minimizing the flows of materials costs in the farm. It could be extended to other types of farms and agricultural activities.

From the block layouts that provide the above mentioned program as a solution, we can carry out an appropriate interpretation of the operation of the different farm activities, and the latter inclusion of activities that provide a greater functionality, as in the case of the feeding or the handling corridor, and that possess a specific geometry.

In the 240 goat's farms, when the flow of materials increases, the warehouse-hayloft figures in a more central position with regard to the 120 goats farm, to minimize the flows of materials.

Layout design in the early phases of the design process of a project to house milk goats entails better handling conditions of the livestock rebounding on the animal welfare and on the economic optimization of the livestock farming.

State and autonomous administrations should foment the application of the new optimization techniques of productive processes to the livestock sector, developing investigation projects, and promoting the diffusion from the results to the livestockmen.

In the future, it will be necessary to implement the function that determines the Relational Cost of the System (1) contemplating the implications of the climatic parameters that regulate the animal well-being in the farm.

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