

Regular Article

Developing and Implementing a Software Program for Configuring Three Dairy Corral Designs

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Abstract

Eleven simulation models were developed to plan and design several dairy farm facilities. A decision tree was developed for each simulation model, and then the simulation models were integrated into the relevant decision trees. C# programming language was used to develop a software program via the simulation models and decision trees.

The objective is to develop a software program to plan and design dairy farm facilities for dairy farms in hot climates.

Keywords: Software program, Simulation models, Precision livestock farming.

Problem and Objectives

Planning and designing dairy farm facilities is a sophisticated work where a multitude of procedures should be carried out which requires time and efforts; moreover, making mistakes is also possible. [3] It is necessary to develop computer tools that have the ability to pre-process the data so as to produce value-added information, in order to accelerate analyses and improve decision-making.

This paper aims at developing a software program to plan and design dairy farm facilities, to compute the required amounts of construction materials, to implement technologies and to calculate the costs.

Methodology

Eleven simulation models were developed to plan and design several dairy farm facilities. Subsequently, an electronic spark map (decision tree) was developed for each simulation model, and then the simulation models were integrated into the relevant spark maps. Afterwards, C# language (C Sharp), which is an object-oriented programming language [2], was used to develop a software program via the simulation models and the electronic spark maps.

The developed software program is able to plan and design several dairy farm facilities (Fig. 1 and 2), e.g. housing system (corrals system), shade structure and roof material, concrete base, cooling system, milking parlour, forage storage, and manure handling system. Subsequently, it plans the farmstead layout, and it leads to implement the technologies, equipments, and machines required for performing several farm operations. Furthermore, it studies water and electricity requirements of the planned dairy farm and the available sources on site. Moreover, it calculates the capital investment and the fixed, variable, and total costs. Data of 6 dairy farms were used to carry out the software program validation and evaluation.

Fig. 1: Architecture of the software program

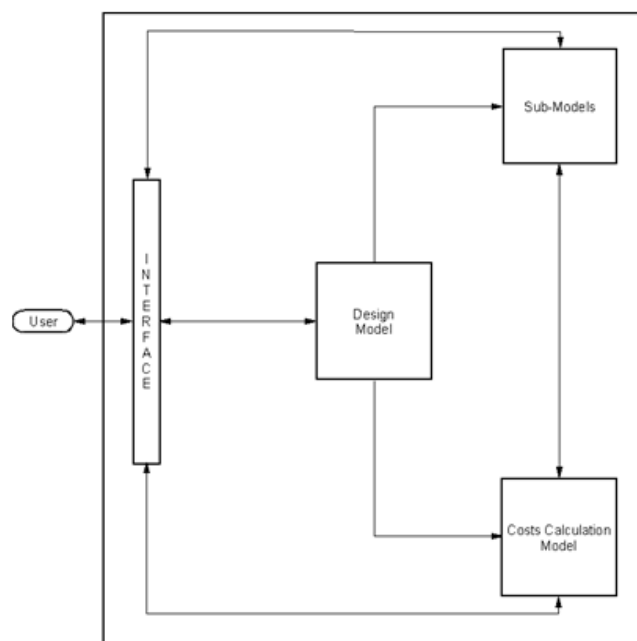
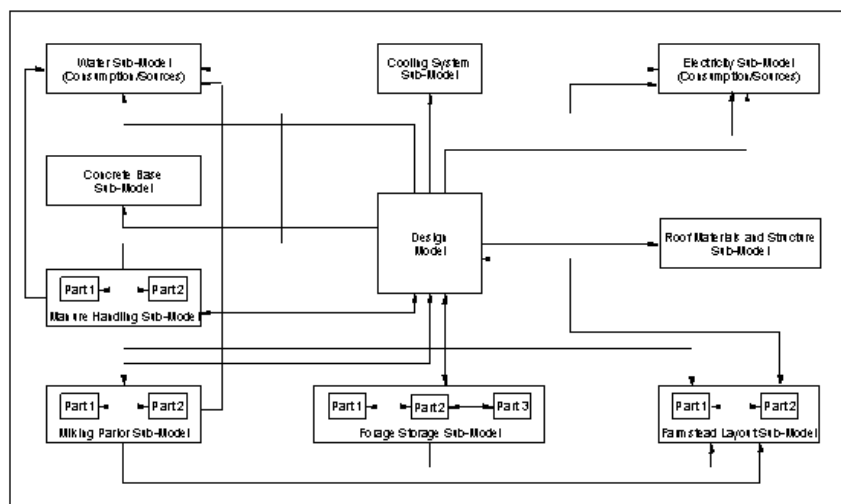


Fig. 2: Architecture of the program sub-models



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The simulation models were developed using the plans, designs, parameters, variables, and constant values of the dairy farm facilities and their concrete structures available in the references, mainly in [1] and [4]. Further knowledge was acquired by making contacts with the experts of the Cattle Information System of Egypt (CISE) in order to mimic the expertise thought.

Results

The differences between the actual and calculated values were determined and the standard deviations were calculated. The coefficients of variation range between 3% and 7%. The accuracy of the developed software is 98.6%. The software is developed in order to be used either as separated units, which means each model and each sub-model can be used as a stand-alone unit which is the case of an existing farm having several facilities but it is required to plan and design a new facility which is not existing on farm, or as a complete unit, i.e. a new farm will be planned and designed using all models and sub-models by means of follow wizard.

When using follow wizard, a multitude of the output data of one model/sub-model will be used as input data in other models/sub-models. Furthermore, several input data inserted into one model/sub-model will be transmitted automatically as input data for other models/sub-models. Figure 3 shows the main window of the software, where the menus are also shown.

Fig. 3: Main window of the software program



Fig. 4: Input data window of design model

In this paper, it is focused on the Design Model as an example of the models and sub-models, Figures 4 and 5 show the input and output data windows of the design model, respectively. Data of 6 dairy farms were used to perform the validation and evaluation of Design Model. The statistical analysis of the actual and calculated values (Table 1) elucidated that COV for the output data were between 4.12% ($\sigma = 0.03$) and 3.28%. The calculated accuracy of Design Model is 98.8%.

Fig. 5: Output data window of design model

Table 1: Data of design model

	Parameter	Corral Length (m)	Corral Width (m)	Number of Corrals in One House	Ratio of Feeding Area to Corral Area
Farm 1	Actual Value	26.15	11.52	20	0.1
	Calculated Value	26.32	11.4	20	0.1
Farm 2	Actual Value	22.37	9.1	20	0.09
	Calculated Value	22.22	9	20	0.09
Farm 3	Actual Value	21.85	20.22	1	0.06
	Calculated Value	22	20	1	0.06
Farm 4	Actual Value	23.38	17.18	1	0.09
	Calculated Value	23.53	17	1	0.09
Farm 5	Actual Value	35.52	14.33	1	0.06
	Calculated Value	35.29	14.17	1	0.06
Farm 6	Actual Value	27.96	9.7	6	0.07
	Calculated Value	28.13	9.6	6	0.07

The software program is able to make three different housing designs (corral systems), which are: Two Sides of Corrals, One Side of Corrals, and One Corral System. A short description of examples of these three designs, calculated by the software is given in Table 2. The design "Two Sides of Corrals" is best suited for large herds (>180-200 cows) where The length of the cowshed is too high. Thus, the sun intrusion will be considerably across the width but the width in this design is big (about one half of the length) because there are two sides. Consequently, sun intrusion will be dramatically decreased resulting in high shading 90%; in other words, this design can provide much more shade with higher cowshed which provides better microclimate for dairy cows. Although both sides of corrals use the same feeding alley, this design requires more steel for cowshed structure and more concrete. One argument, if a design is double sided the volume of the concrete base should be less (per corral or cow) compared with one sided because two corrals are placed on both sides using the same length of concrete alley. In fact, the aforementioned argument contradicts this case because inside each side there is a feeding area where the cows stand to feed from the feeding alley, as a result, it requires more concrete.

On the other hand, "One Side of Corrals" is suitable for medium herds (up to 100-120 cows) The width of the cowshed in this design is one half of the first design because there is here one side of corrals, and then the sun intrusion will be more than the first design. However the length of the cowshed still long, thus the most of the

sun intrusion will be across the narrower width which results in 75% shading.

The "One Corral" system is designed to house a small herd (10-20 cows) but this design can be adjusted to house more cows (up to 40 cows). According to the specification of this design, the shade structure covers one third of the total area, i.e. shading is 33%. This system is able to house more cows in one corral than the other systems but it provides lower shading which is negatively evaluated under hot climate conditions. The software has specified lower cowshed height for this system in order to avoid sun intrusion, as much as possible, into the corral which ultimately results in more span or distance between two posts carrying its steel structure, because when lower cowshed height is specified, the force of air that thrusts the cowshed will be minimized, consequently the required building resistance will decrease which results in possible and acceptable increase of the span between the posts. This reduces costs and eases the movement of cows without facing many barriers. However, selecting a roof material (reed mats, straw mats, burnt-clay bricks, polished aluminum, or isolated aluminum) depends on climatic conditions. In addition, the roof types suitable for different corral systems are: Compound (3 Parts) Roof and Open Ridge Roof which are best suited for "Two Sides of Corrals", Horizontal Roof and Mono-Slope Roof which are suitable for "One Corral", and Compound (2 Parts) Roof and Mono-Slope Roof which are appropriate for "One Side of Corrals".

Table 2: Comparison among three different corral designs

Model/Sub-Model	Variables	Two Sides of Corrals	One Corral	One Side of Corrals
Design Model	Number of Cows in One Corral	12	20	12
	Shading (%)	90	33	75
	Cowshed Height (m)	8.2	4.5	6.5
Concrete Base Sub-Model	Concrete Base Length per Corral (m)	11.5	27.5	9.6
	Volume of the Concrete Base per Corral (m ³)	28.25	24.9	16
	Roof Type	Compound (3 Parts) Roof or Open Ridge Roof	Horizontal Roof or Mono-Slope Roof	Compound (2 Parts) Roof or Mono-Slope Roof
Roof Material and Structure Sub-Model	Steel (Ton per Corral)	1.55	1.05	1.25
	Post Span (m)	5.8	8.5	4.8

When it is intend to design a farm where the farm size is between small and medium (Table 3a) or between medium and big (Table 3b), the design is ought to be prone to the smaller design.

According to Table 3a, where One Corral System has been compared to One Side of Corrals under a precondition that both house the same number of 40 cows, the required building materials (steel and concrete) are minimized when the design of One Corral is implemented in comparison to the One Side of Corrals.

Similarly, when One side of Corrals has been compared to Two sides of Corrals under a precondition that the farm house 150 cows, the required construction materials are minimized when One Side of Corrals is implemented.

Hence, the bigger designs ought to be implemented with higher number of cows. In this case, the amount of the entailed building materials will be minimized when the farm houses a big number of cows.

Table 3a: Comparison between two designs where each houses 40 cows

Model/Sub-Model	Variables	One Corral	One Side of Corrals
Design Model	Number of Corrals in One House	1	4
	Number of Cows in One Corral	40	10
	Shading (%)	35	70
	Cowshed Height (m)	4.5	6
Concrete Base Sub-Model	Concrete Base Length per Corral (m)	27.5	9
	Volume of the Concrete Base per Corral (m ³)	24.9	15
	Volume of the Concrete Base per House (m ³)	24.9	60
	Roof Type	Horizontal	Mono-Slope
Roof Material and Structure Sub-Model	Steel (Ton per Corral)	1	1.25
	Steel (Ton per House)	1	5
	Post Span (m)	8.5	4.5

Table 3b: Comparison between two designs where each houses 150 cows

Model/Sub-Model	Variables	One Side of Corrals	Two Sides of Corrals
Design Model	Number of Corrals in One House	10	10
	Number of Corrals in One Side	10	5
	Number of Cows in One Corral	15	15
	Shading (%)	76	89
	Cowshed Height (m)	6.5	7.5
Concrete Base Sub-Model	Concrete Base Length per Corral (m)	14.5	14.5
	Volume of the Concrete Base per Corral (m ³)	24	35.5
	Volume of the Concrete Base per House (m ³)	241	356
	Roof Type	Mono-Slope	Open Ridge
Roof Material and Structure Sub-Model	Steel (Ton per Corral)	1.25	1.55
	Steel (Ton per House)	12.5	15.5
	Post Span (m)	7.25	7.25

Conclusion

The developed software program is able to plan and design several dairy farm facilities, specify their different dimensions, and compute the required amounts of construction materials. Afterwards, it plans the farmstead layout, and it determines the water and electricity requirements versus the available sources on site. Furthermore, it calculates the capital investment and the fixed, variable, and total costs.

The methodology developed in this paper represents a new approach for developing software programs by using the simulation models for practical implementation. Furthermore, integrating a simulation model into a specially customized electronic spark map to form the heuristic and the back diagram code of an expert simulation system represents a new approach.

Acknowledgement

The project is supported by the Cultural Affairs & Missions Sector of the Ministry of Higher Education and the State for Scientific Research, Egyptian Government.

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Please Cite This Article As:

M. Samer. 2010. Developing and Implementing a Software Program for Configuring Three Dairy Corral Designs. J. Exp. Sci. 1(3): 19-22.