International Journal of Artificial Intelligence and Neural Networks – IJAINN
Volume 4 : Issue 1 *[ISSN 2250 – 3749]*
Publication Date : 09 January 2014

Design And Implementation Of An Advanced Web-Based Dairy Feeding Decision Support System

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***Abstract*— one of the most important issues in dairy farm is feed management which aims to manage available and required feed. There are several problems associated with managing cattle feed such as how to best satisfy feed deficits or how to utilize extra feed available. Since early 70s, feed planning decision support systems have been developed to help farmers addressed issues. However, many of those systems have failed because of several reasons such as being designed for specific geographical region, missing dairy farm's production variables (e.g. milk yield per cow) or using very complex model which is hard to understand and handle. The objective of our research is to proposed an advanced web-based decision support system to address issues of feed management on the basis of stock inputs (required feed estimated based on stock numbers) and basic pasture (available feed for cattle). The system then provides a solution for 12 months feed planning which can be reviewed and improved if required. The system will be developed using web-based decision support system to help decision making process for dairy farming using decision models. We collected data from several dairy farms in Malaysia to validate our proposed model. We contribute by estimating long term strategic solutions for feed management, providing modification of initial solution and adjustment of pasture growth rate based on type and times of the year.**

***Keywords*— decision support system, web-based decision making , Knowledge management, dairy resource management**

I. INTRODUCTION

Biggest differences in productivity and profit between dairy farms are related to the patterns of feeding and level of food supply. Generally, cost of feed for dairy cattle includes half to three quarter of total farm's costs which varies depending on farms geographical region. One of the well-known techniques to reduce feed costs is planning for cattle feed. It measures the amount of available feed from pasture repository and compares it with the amount of required feed based on statistic gathered from cattle's daily usage. This food plan is usually developed for annual cycles which illustrate change of feed consumption patterns in an average rate. With the help of feed planning farmers are able to set long term policies for the stocks to deal with shortages or surpluses of feed. It is a strategic planning tool for farmers to set up a rigid approach toward managing the farm. A well-managed dairy farm with feed planning program will also achieve healthier cattle near optimal live weight gain which increase performance of the farm at minimum casts possible [1]. Thus, management issues should be considered in different decision process when it comes to breeding and feeding cattle. Decision support system (DSS) can be a major help for farm owners to increase performance. Since early 70s many studies focused on developing biophysical models which simulate regions in the farm and a group of crops to only predict offered food for the farm. These models illustrate a group of systems from geographic region dependant systems, such as [2] and [3] which were developed for specific regions, to very specific models such as [4], a farm simulation model for integration of cow beef production and sugar cane production. These models have been developed to judge the quality of supplement and they don't consider farm's production profit variables like milk yield per cow. For this reason, many of these systems were unsuccessful in presenting their simulated results directly to farmers as a solution for crop management. In the meantime, many researchers have studied farm's management practices which led to strategic systems, such as [5] [6] [7]. These models thoroughly observed on farm decision making processes. They consider both financial profit and environmental performance of a dairy farm using different inputs. However, farmers were not eager to use these systems [8]. Reasons for this include, very complex model that are not user friendly, lack of one or more specific solution for farm's problem, lack of user requirement consideration such as visual demonstration of statistic.

This paper presents a new Advanced Decision Support System for determining food resources and management requirements of it. This allows decision makers to determine availability of feed against requirement and to provide alternative solutions to deal with surpluses and shortages. The remainder of the paper is organized as follows. The next section is dedicated to determining of a feed plan and discusses how to inspect the pasture growth rate and animals requirements. Later on we outline our proposed system and explain its design specification and data diagrams. Finally, we conclude our paper and provide summary and discuss other possible future works.

II. FEED MANAGEMENT

One of the well-known techniques to reduce feed costs is planning for cattle feed [9]. It measures the amount of available feed from pasture repository and compares it with

the amount of required feed based statistic gathered from cattle's daily usage. This food plan is usually developed for annual cycles which illustrates change of feed consumption patterns in an average rate.

A. Feed Availability

To develop an initial feed plan the first step is to develop a growth curves for available pasture types on the dairy farm. The pasture growth curves make annual calculation of available pasture. By calculating this pattern we'll be able to determine months or seasons when pasture growth rate probably limits dairy production of farm. Finding animals requirements is the second step. A dairy farm may contain various classes of stock at any particular time so requirements of each class should be calculated separately on monthly basis. Various methods are available for calculating feed requirements.

B. Feed Planning

Upon completing above steps, feed plan is able to calculate either a surplus (available feed is more than required) or a deficit (available feed is less than required) for each month of the year. We call this initial plan .

III. PASTURE ASSESSMENT

Methods of determining quantity and quality of pasture have been available for many years [10]. Usually they contain visual estimation and tools like rising plate meter which measures pasture density [11] and estimating forage mass with a capacitance meter [12]. The method of assessing pasture is needed in order to predict live stock production. This method should be easy to understand and at the same time precise. The estimation method should be determined in kilo gram dry matter (DM/ha). There are other variables that need to be measured in order to estimate feed on offer (FO) accurately like pasture type, digestibility, percentage of dry weight basis, height and pasture species composition [13]. Considering mentioned variables, total FO can be calculated from equation (1):

$$FO\left(kg\,\frac{DM}{ha}\right)=\frac{\left(F(r)-I(r)\right)}{2*(\beta)} \qquad (1)$$

Whereas FO is actual feed on offer for cattle which measures mass density of pasture. $I(r)$ and $F(r)$ are the initial and final records stored by raising plate measurement. It is a very common way among farmers to record mass density of pasture. They measure how much a standard paddock plate would rise because of the pasture's weight. β represents the rate of change in recorded data in both initial and final readings as height of raising plate in $\frac{DM}{ha}$ changes. To be more specific, β is slope of the regression line where r is the correlation coefficient between measured density of pasture (gathered from raising plate method) and recorded data from readings [14] (e.g. Ryegrass or ryegrass – white clover = 195; Oats = 185; Kikuyu = 200).

IV. ADVANCED DECISION SUPPORT SYSTEM

The proposed system is an advanced decision support system which indicates the most profitable pasture planning for daily dairy farm usage. By estimating annual usage pattern, the system makes the efficient solution of pasture usage. To do so, the system considers maximum feed usage of pasture during a season and compares it with required pasture. The system also allows the decision maker to effectively manage pasture with various nutrition. Furthermore, it store and manage pasture surplus or deficit. The core of the system consists of a robust database in which contains data on both pasture usage and consumption each month. This database consists of name, type of stock, and grass growth region type, daily usage of pasture, solution and alternatives, reports and comments. The proposed system has been validated by several experts in dairy farm industry. They suggest that the system is most beneficial when it's used by a group of farmers.

We develop a web-based application framework because it is more convenient to use and maintain, also it is more cost effective and can be run without dependency on platform. We use Microsoft ASP.net and SQL Server database to develop our web-based system because of their flexibility which allows different views to be presented for different users. For example, web page for human user and web service interface for online applications.

A. List of Inputs

The system divides the farm in different regions and determines pasture growth rate for each type of pasture based on regions. It uses available pastures from past measurements provided by the farm owners. This allows farmers to define regions based on type of pasture for any other state or region. List of common inputs for each region regardless of pasture type is presented in Table (1). After entering required inputs the system will develop 'an initial plan' , later on system provides 'final plan' which includes different alternatives including supplements.

B. Initial Plan

The initial plan includes stored pastures from current season and pastures that have been stored in the farm for more than one year (basic pasture). Basic pasture varies depending on pasture growth rate. Input required for initial plan calculation includes area of basic pasture, area of replacement pasture and month of the year. Replacement pasture is required if the farmer wants to change pasture type of an area. Feed on offer in at the ith month of the year is calculated as follow:

$$FO_i\left(kg\,\frac{DM}{d}\right)=\left(areaBP_j+areaR_j\right)\times ROG_{ij} \qquad (2)$$

Where FO is available feed for ith month of the year (e.g. March to April). $areaBP_j$ is the area of a basic pasture with type j. $areaR_j$ stands for replacement area of pasture type j. ROG_{ij} is the rate of growth for pasture type j with ith month of the year for replacement date.

After determining offered food for animals on the farm the system calculates their requirements based on both their weight and milk yield and its composition (in lactating animal)

$$FR_i = \sum_i \begin{pmatrix} mc_i \times fr_{mc} + dc_i \times fr_{dc} + h_i \times fr_h \\ + ctm_i \times fr_{ctm} + w_i \times fr_w + y_i \times fr_y \end{pmatrix} \quad (3)$$

Where we defined FRi as feed required in ith month of year . mc, dc, h, ctm, w, y are user's inputs for milk containers, Dry Cow, Heifer, Cattle to mate, Weaning, yearling in ith month of year.

C. Final Plan

Upon establishment of initial plan the system calculates surplus or deficit for every month of the year. Later the user starts a new plan known as final plan. This step requires seed sowing and supplements information. Type seed options are categorized by geographical region and temperature because different seeds have different growth rate. Later the system will scale these inputs as normal(N), satisfactory(SA) and unsatisfactory(UN) for each month and compare their effect on ROG. For example effects of irrigation in summer in comparison of winter. fr is a modifier for scaling a variable up or down in specific month. This option will create solution based on follow problem statements: what are the options for ROG equal to X considering average number calculated by all the previous data on ith month of year .generally speaking, required feed will be calculated based on comparing calculated number for available feed (gathered from all variables in a specific month) with average feed requirement recorded in this specific month. Reports should be visible and printable in every step of the process, region and pasture growth rates.

V. DESIGN AND DEVELOPMENT

Our proposed web-based feeding system, as any form of decision support system, should comply with basics and concepts of developing a decision support tool and provide supporting details for understanding functionality of the system. Such a system grants the user to interact with data, generate plans, and visualize reports and alternative solutions.

Option	*input*	*Includes all of the following*
Dataset management	Dataset name	Database Tables variables
	Created data	Solutions Alternatives
	Description	Comments Reports
	Pasture regions	Region number Pasture type Replacement pasture Rate of growth
Livestocks	Milk containers	Container size
	Dry cow	Not lactating animal
	Heifer	A young cow
	Cattle to mate	Ready to breed
	Weaning	Transition from milk to pasture
	Yearling	Between 1 and 2 years old
Feed required	Total capacity of Milk containers	
	Total number of Dry cows	
	Heifer	
	Weaning	
	Yearling	
Basic pasture	Area of regions	In hectare (ha)
	Area of replaced	
	Month of the year	
Replacement	Region temprature	
	Area of region	
Supplements	Type	Grain, hey, etc

TABLE I. LIST OF INPUTS FOR THE DECISION SUPPORT SYSTEM

A. System architecture

System architecture will provide a plan for the system development by introducing the structure of the system, representing system components and their relationship in the development prospective, and finally defining graphic user interface. First, for a specific architecture under consideration, the decision support system should be user friendly and provide a set of solutions and alternatives. This system will enable decision maker (end user) who might not have analytic expertise to identify or modify solutions and prevent decision maker from misinterpreting results. Second, appropriate variable matching is necessary for system to operate [15].

For development of the system we used client-server architecture. This architecture allows multiple tasks to be distributed over central server and the clients which are connected to it. The distributed resources are available to every client on the network while the server manages set-up and resource allocation, access rights and so forth, keeping farmers away from any of those issues. Furthermore, this architecture makes managing and maintains the system easier by storing all data and software in an easily accessible place. The system consists of two-tiered architecture n. The first tier, server which is back-end of the system includes model base management system (MBMS), knowledge base management system (KBMS) and database management system (DBMS).The model base management system grants access to model base sub-systems and their connections with other parts of the system. The model base is a set of decision models such as algebraic equations and mathematic operations for forecasting and recommendation. Model base sub-systems are model analyses which analyze "what if "questions such as feed on offer, rate of growth and required feed, structural analysis which supports model making, selecting and integrating processes. Solver, that manages models to find a solution. The knowledge base management system comprises of strategies and policy generation and analysis unit which represents process, practices and experience. It also includes system ontology. The database management system is a set of programs which allow us to store, modify and fetch information from the database. It contains list of inputs indicated in Table (1), calculated value for required feed, basic pasture, replacement pasture and finally supplements. KBMS, DBMS and MBMS incorporate inside the system kernel in process of decision making. Such a strong integration between them can make decision making process more efficient and result in a more streamlined system architecture which leads to easier system development and maintenance. The other tier is client which is front-end of the system that incorporates with the user to secure requests and deliver them to back-end side and finally presenting results and the interactive analysis of data and base models. The proposed system is hosted on a Windows Server operating system. This server is connected to farm's computer using internet connection. The system supports a two-tier architecture. The user sends hyper text mark-up Language request (user interface tier) through hypertext transfer protocol to the server (server tier). Then the server will process the request using common gateway Interface scripts. These scripts will handle processing models, storing or retrieving information on database through Structured Query Language. Dot Net is a technology which helps model and query processing and improves displaying of results through graphic representation and interactive user interface. Figure (1)

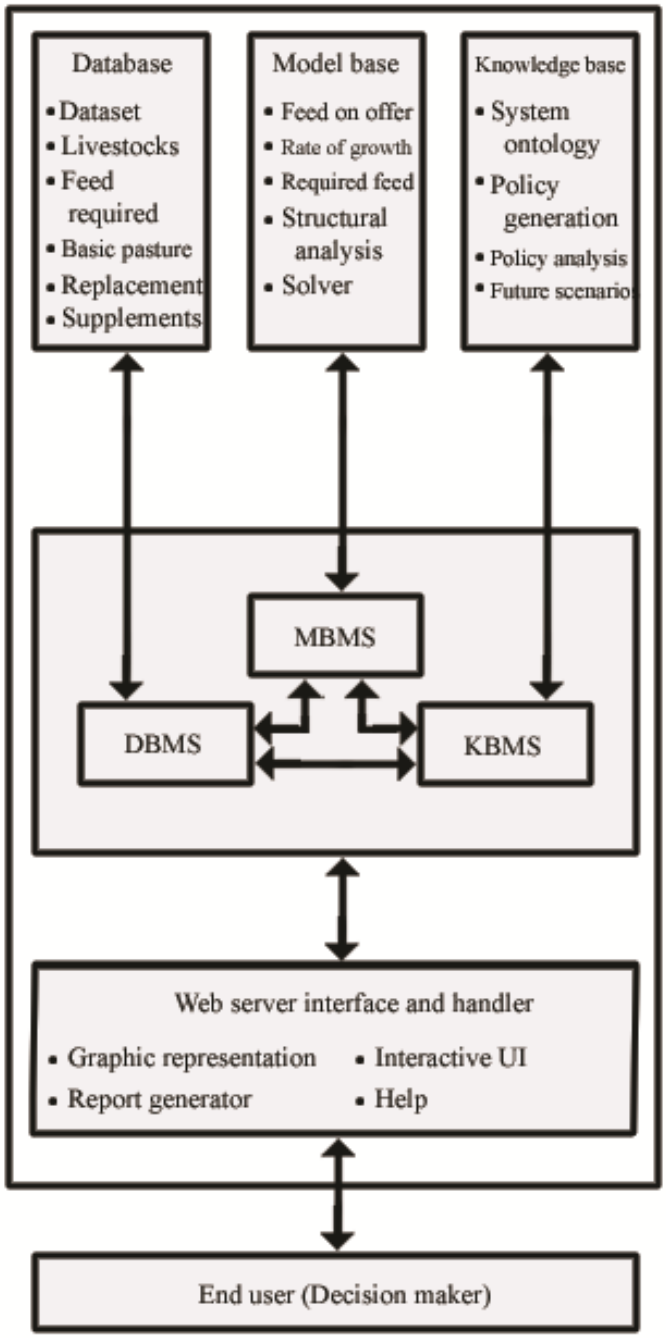

Figure 1. Conceptual diagram

VI. DISCUSSION AND CONCLUSIONS

This paper has described an advanced web-based decision support system for feed planning on dairy farms. The system estimates an initial feed plan based on decision maker's inputs of required and available feed through the interface of the system. It examines different options introduced in model base sub systems to refine management of feed shortage or surplus. To validate decision models, data was collected from several dairy farms in Malaysia. The system then calculates final plan or solution which is a long term feed planning to meet feed requirements of the dairy farm. A feature of the proposed system is the modification of initial plan by decision makers, so solutions can be improved to inspect seasonal fluctuations in pasture growth rate.

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