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MICRO-BASED DECISION SUPPORT SYSTEMS FOR STOCK FARMERS.

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ABSTRACT

Decision support systems were developed for use on stock farms. The systems were designed to run on Commodore 8032 microcomputers. They give the user quantitative results on which decisions such as feed mixes, sale of livestock, work programmes, etc can be based. In this paper these systems are described and illustrated with printouts from sample runs.

Key Words: Agriculture, Decision support system.

1. INTRODUCTION

The use of Operational Research techniques in agriculture is of course nothing new. After a long relatively quiet period, new interest has recently been shown in this kind of application. See for example the introductory remarks in Butterworth [1]. For other recent examples, see Peart, et al [2] and Audsley [3]. Of particular interest are recent publications which concentrated on the application of such techniques with the aid of microcomputers. A case in point is Wilson, et al [4]. See also the entire issue of the *Journal of the Operational Research Society* [5] which was dedicated to this subject. This article describes another application of O. R. techniques in agriculture, implemented with the aid of microcomputers.

According to the relevant literature, a decision support system (DSS) should concentrate on improving the effectiveness of a manager, without necessarily improving his efficiency. (See for example Keen, et al [6].) Effectiveness is defined as the ability to identify what the right decisions are and ensuring that the chosen criteria of what is "right" are the relevant ones, while efficiency is more or less linked to productivity in the decision making process. DSS are supposed to support a manager in the decision making process, not to replace him. Such DSS usually include clerical facilities (e.g. records of account reviews, summaries of historical activities, etc) and technical facilities (e.g. regression analysis, etc.).

In a naive view of the types of problems encountered by any manager, these problems can be classified as either "structured" or "unstructured" problems. A structured problem is one for which the solution process can be fully automated and which thereafter does not require any managerial intervention. An unstructured problem, on the other hand, is one which cannot be automated in this way, and must be solved through intuitive reasoning by managers. Between these two extremes lie semi-structured problems, i.e. problems that have parts which are structured and others which are not. DSS, and thus also those described in this article, focus on semi-structured problems.

The DSS to be discussed in this article were designed to assist stock farmers in their decision making. Examples of the kind of decisions faced by stock farmers are: How should feedstuffs be mixed, when should stock be marketed, when should an animal be innoculated, etc. Some of these decisions give rise to structured problems (e.g. the optimal feed mix problem), while others give rise to semi-structured problems (e.g. when should an animal be sold). A DSS could thus significantly enhance the effectiveness of the farmer's decisions. Such a DSS would be of no practical value if a mainframe computer were necessary for its implementation, since only a small percentage of potential users can afford to obtain access to such facilities. Therefore it was decided to develop a limited system which could run on a microcomputer. The decision maker needs no knowledge of computer programming, since the systems were designed for use by farmers with minimal numerical proficiency. A minimal amount of training is necessary before the systems can be used, since most of the input and output is self-explaining. It must be emphasized that the aim was to develop a system which could run on a reasonably-priced microcomputer. Therefore it was not meant to compete with existing systems designed to run on more powerful and thus expensive machines, e.g. the STELPLAN system [9].

2. GENERAL DESCRIPTION OF THE DSS

The two DSS under discussion (one for dairy and one for pig herds) can be used together or separately. Since some of the facilities are common to the two systems, the various options open to the decision maker will be described separately, while an indication will be given of which system each option is attached to. These options are presented to the decision maker in the form of menus appearing on the screen of the microcomputer. Examples of these menus as well as system responses will be referred to at various stages of the presentation. These examples are contained in the Appendices. The system output is presented as ordinary type, while the decision maker's response is underlined. The user can return to the previous menu at any stage by pressing the <Escape> key. This option was omitted from the presentation below for the sake of brevity.

The systems can be installed on a Commodore 8032 microcomputer with 64K byte memory and a dual 615K floppy disk drive, a video display unit and a dot matrix printer. All the necessary routines were written in BASIC. Figure 1 shows the input and output relationships that occur for the running of the systems. Note that the systems have all the ingredients of a typical DSS, i.e. user/system interface (block 1), model subsystem (blocks 2,4) and data subsystem (blocks 3,5,6).

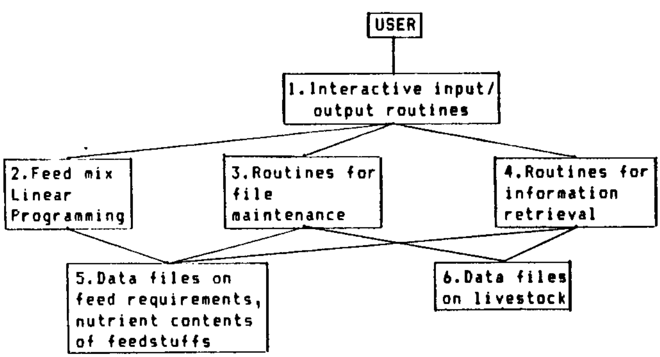

Figure 1: Input/output relationships.

Figure 2 shows the main menu presented to the decision maker upon initialisation of the system for dairy farms. The menu for the other system is similar.

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                    MILK

     The program consists of the following:

     Choose the program you want to execute [ ]

1. Program to enter data into files.
2. Program to read in batches of similar data.
3. Program to obtain information.
4. Work programme.
5. Least cost feed mix program.
```

Figure 2: Main menu

3. OPTIMAL FEED MIX

The menu obtained when the feed mix option is chosen is shown in Appendix A. Data on the composition of the various feedstuffs are contained on the relevant files. The problem is to choose the blend of feedstuffs satisfying various nutritional constraints with minimum cost. This is an example of the classical blending problem of Operations Research and can be formulated as a linear programming problem (see for example [10,p60]). The linear programming model is set up automatically by the routine and the problem is solved by the dual simplex method, since a dual feasible starting solution is available without any further calculations (such as, for example, the use of a two phase method). As can be deduced from the menu, the systems make provision for changes in various parameters and the subsequent re-run of the algorithm (so-called "what-if" questions).

Furthermore, the optimal values of the dual variables are used to supply sensitivity information to the decision maker.

A sample output is provided in Appendix A. The first three menus are self-explaining. The "RAW MATERIALS AVAILABLE" section gives a list of all possible raw materials. The user can then include (exclude) any of them in the ration by selecting Y (=Yes) (N =No) in the appropriate column. He can also specify the minimum (maximum) amount of a raw material to be included in the "Min" ("Max") column. Note that the system assumes default values of 0 minimum and 100 maximum. In the example 17 raw materials are marked "Y". The next section is used to obtain information on the desired nutritional content of the ration. Data are entered in the same way as in the previous section. Note that in the example 13 nutrients are marked "Y". The number of constraints in the resulting LP model is indicated by the "restrictions 16" response from the system.

4. THE INPUT OF DATA

As can be seen from the main menu displayed in Figure 2, there are two options that can be chosen for the input of data. The first option is chosen if a variety of data are to be read in, while the second option is chosen if large volumes of similar data are to be read in (for example if a whole group of sows had been innoculated at the same time). The details of the procedures to be followed in the two cases will not be discussed here. It is sufficient to say that the input of data is also achieved with the aid of extensive menus (in both cases with about 30 items on each menu).

Some types of data are of course read in only once, for example the nutrient contents of the different feedstuffs used in the feed mix part. These can be changed if necessary, but are usually kept in the original form. Other data files are updated more regularly, for example the production figures on the data files of the different cows. Some information could influence the data on more than one data file. For example, when a certain piglet is sold, his own file will be updated, while his slaughtered weight will be incorporated into the files of both his father and his mother in the form of certain indices, to be discussed later. It goes without saying that all this updating is done automatically when one such piece of information is fed into the system.

5. PROGRAMS TO OBTAIN INFORMATION

The main object of keeping extensive data files on the livestock is of course to be able to obtain various sets of information on which well-informed decisions can be based. If the third item on the main menu is chosen, the system displays a menu with 33 items. Instead of describing all the possible choices on this menu, representative groups of items will be described to give the reader an idea of the possibilities open to the decision maker when using these systems.

The first group of choices can be used to obtain information on individual animals. The complete file on any cow can be inspected and printed, for example. An example of such a file is given in Appendix B.

The second group of choices can be used to obtain lists of animals with common characteristics. Lists of cows with the same father is an example.

Various lists can also be drawn in which certain groups of animals are ordered according to a specific characteristic. For example, a list of heifers according to age, a list of cows according to lactation or a list of sows according to index. The indices used to rank the individual animals will be discussed at the end of this section. These lists can be used when decisions concerning the sale of stock (for example, cows at the lower end of the list according to index will be sold first), or decisions about which sows should be inseminated (the sows with the best success rate will be the best candidates). An example of a list of cows according to production is shown in Appendix C.

Lists with information concerning events in certain time intervals specified by the decision maker can also be drawn. Examples are a list of all calves which arrived in a certain time interval and a list of all cows which had mastitis in a certain time interval.

This brings us to a discussion of the indices used in the ranking of animals, as indicated above. For the sake of brevity, we shall concentrate on the index used for sows. Similar indices are used for bulls, boars and cows.

The index used for sows was developed in Belgium by J. Daelemans [7,8]. The global production index (G.P.I.) for a sow is calculated as

$$G.P.I. = \frac{365 \, . \, SPW}{SCL}$$

where

SPW = Total number of piglets produced by sow which survived weaning

SCL = Sum of cycle lengths between production by sow

6. WORK PROGRAMMES

The only remaining item on the main menu still to be discussed, is that of the work programmes. Since similar strategies were followed for the two systems, we shall concentrate on the system for dairy farms.

As in the other cases a menu is presented to the decision maker upon choosing this option on the main menu. This menu is shown in Appendix D. Since the items on this menu are largely self-explaining, we do not discuss all these items, but only show the result of the choice of item number 9 on the menu in Appendix E. Here "REM" stands for "remarks" and can be used by the farmer for any special information he may want to add to the data on the specific animal.

7. SUMMARY AND CONCLUSIONS

Two micro-based decision support systems for use on stock farms were described. These systems are used to good effect on 5 farms in the Western Cape region of South Africa. The success of these systems have attracted the attention of a commercial software firm, which have incorporated the greater part of these systems into a larger financial aid package for farmers. This larger system, however, can only be run on much more powerful and expensive microcomputers (i.e. the I B M XT) which places it outside the reach of the farmers for which the original systems were designed.

Various feed mix companies have also shown interest in the optimal feed mix part of these systems (an experience shared by other researchers in this field, e.g. Wilson, et al [4]). An extension of that part of the systems to incorporate the so-called multi-mix problem (where common stocks of feedstuffs must be used to formulate more than one feed mix) is currently under development (also for implementation on a microcomputer). This will be reported on as soon as testing of the system has been completed.

REFERENCES

[1]. K. Butterworth (1985) Practical application of linear/integer programming in agriculture. J. Opl. Res. Soc. 36, 99-107.

[2]. R. M. Peart, J. R. Ogilvie, J. R. Barrett and D. A. Bender (1985) Some examples of the use of simulation in U. S. and Canadian agriculture. J. Opl. Res. Soc. 36, 109-115.

[3]. E. Audsley (1985) The development of Operational Research at the National Institute of Agricultural Engineering. J. Opl. Res. Soc. 36, 117-123.

[4]. E. Wilson and R. Willis (1985) Microcomputers and linear programming -- Feedstock revisited. Eur. J. Opl. Res. 19, 297-304.

[5]. *Journal of the Operational Research Society* (1983) 34, no4.

[6]. P. G. W. Keen and M. S. S. Morton (1979) *Decision Support Systems: An Organizational Perspective.* Addison-Wesley, Reading, Massachusetts.

[7]. J. Daelemans (1975) Een zoötechnisch kontrolesysteem voor de Zeugenhouderij. Landbouwtijdschrift No. 1, Rijksstation voor Landbouwtechniek Merelbeke-Gent.

[8]. J. Daelemans (1977) Rationele vruchtbaarheidskontrole op het Zeugenbedrijf. Landbouwtijdschrift No.4, Rijksstation voor Landbouwtechniek Merelbeke-Gent.

[9]. STELPLAN Agricultural Consultants (1985) Minimum cost ration program. 105 Dorp Street, Stellenbosch.

[10]. B. Kolman and R. E. Beck (1980) *Elementary Linear Programming with Applications.* Academic Press, New York.

APPENDIX A

Sample run of optimal feed mix program

MINIMUM COST RATION FORMULATION

Enter the required option [3]

1. Raw materials
2. Nutrients
3. Rations

- -

RATIONS FOR DEMONSTRATION

Enter the required option [2]

1. Enquiry/Deletion of Rations
2. Formulation of Ration
3. Rounding of Ration
4. Summary of Rations
5. Detail report of Rations

LEAST-COST FEED FORMULATION

Enter your selection [5]

1. Display rations
2. Delete ration
3. List of rations
4. Reformulate existing ration
5. Formulate new ration

- -

RAW MATERIALS AVAILABLE

raw materials 17

Enter number to change [ ] nutrients 13

batch size (kg) = 100 restrictions 16

No	Code	Y/N	Min	Max	No	Code	Y/N	Min	Max
1	MAIZE	Y	0	100	14	SOY	Y	0	100
2	OATS	Y	0	100	15	SOC	Y	0	100
3	WHEAT	Y	0	100	16	BRAN	Y	0	100
4	BARLEY	Y	0	100	17	POLL	Y	0	100
5	FISH.M	Y	0	100	18	S.LIS	N	0	100
6	CAS	N	0	100	19	LIME	Y	0	100
7	CAR.M	N	0	100	20	DCP	N	0	100
8	BLOOD	Y	0	100	21	SALT	Y	0	1
9	SKIM	N	0	100	22	VITMIN	Y	.3	.3
10	WHEY	N	0	100	23	LUCERN	N	0	100
11	BONE	N	0	100	24	P.GLUT	Y	0	100
12	COTT.S	Y	0	100	25	POC	Y	0	100
13	GLUT	Y	0	100					

THE FOLLOWING NUTRIENTS CAN BE CONSIDERED

raw materials	17
nutrients	13
restrictions	16

Enter number to change [0]

No	Nutr	Y/N	Min%	Max%	No	Nutr	Y/N	Min%	Max%
1	WATER	Y	0	100	11	TRYP	Y	0	100
2	PROT	Y	18	100	12	THRED	Y	0	100
3	ME	Y	11.9	100	13	ISOL	Y	0	100
4	FIBRE	Y	0	4	14	HIST	N	0	100
5	CA	Y	.7	100	15	VAL	N	0	100
6	P	Y	.3	100	16	LEU	N	0	100
7	NaCl	Y	.35	100	17	ARG	N	0	100
8	MET	Y	.25	100	18	PHE	N	0	100
9	METCYS	Y	.5	100	19	GLY	N	0	100
10	LYS	Y	0	100					

- -

COMPOSITION OF THE RATION

To Proceed [ENTER]   COST/TON = R287.49

Ingredient	Min	Max	Actual	Effect of marginal increase
WHEAT	0	100	72.389	0
PDC	0	100	14.466	0
P.GLUT	0	100	6.486	0

POLL	0	100	3.866	0
LIME	0	100	1.61	0
SALT	0	1	.883	0
VITMIN	.3	.3	.3	14.72

- -

UNUSED RAW MATERIALS

To proceed [ENTER]

Ingredient	Min	Max	Cost	Cost at which raw material may become attractive
MAIZE	0	100	290	270.8
OATS	0	100	195	59.39
BARLEY	0	100	250	193.19
FISH.M	0	100	720	500.76
SKIM	0	100	1600	476.39
COTT.S	0	100	1000	140.15
GLUT	0	100	250	95.63
SOY	0	100	455	324.7
SOC	0	100	243	169.1
BRAN	0	100	169	48.51

- -

ANALYSIS OF THE RATION

To proceed [ENTER]

Nutrient	Min	Max	Actual	Effect of marginal increase
WATER	0	100	12.18	0
PROT	18	100	18	6.02
ME	11.9	100	11.9	28.25
FIBRE	0	4	4	21.91
CA	.7	100	.7	3.44
P	.3	100	.404	0
NaCl	.35	100	.35	3.68
MET	.25	100	.331	0
METCYS	.5	100	.688	0
LYS	0	100	.539	0
TRYP	0	100	.186	0
THREO	0	100	.549	0
ISOL	0	100	.877	0

- -

LEAST-COST FEED FORMULATION

Enter your selection [5]

1. Display present solution
2. Change constraints
3. Add ingredients/constraints
4. Change ingredient prices
5. Save formulated ration

APPENDIX B

Example of complete file on cow

FILE OF COW NO. 74 --- FATHER : FDH

BASIC DATA

date of birth	770108
mother's no	543
father's name	FDH
date of death	0
date sold	0
price fetched	0

SUMMARY OF PRODUCTION AND INTERVALS OF CALVING

calving date	production	index	interval
790511	5439	0	
800515	6565	0	369
810422	6806	0	342
820501	6863	111	374
present lactation			
830513	5008	9	377

average calving interval (days) = 365.

DATA LACTATION NO 4

calving date	820501
calf's number	30
date of pregnancy	80921
pregnant by bull	786
no of times with bull	2
production up to 300 days	6863
date dried off	830513
no of days in milk	377
relative performance	111

PRESENT LACTATION: CALVE AND INSEMINATION DATA

no of lactation	5
calving date	830513
calf's number	50
father of calf	FMJ
last date douched	0
last date inseminated	831120
name last bull	FIN
next to last insem. date	830730
name next to last bull	ROCKET
no of inseminations	2
last date examined	840117
examination pos or neg	P

PRESENT LACTATION: PRODUCTION DATA

lactation no	5
team no	1
position	11
last date milk weighed	840618
ave. production present month	6.9
next to last milk weighed	840416
productions from first month:	

8.5 22.1 14.2 22.4 19.8 16.1 17.4 14.3 13.6

accumulative production	5008

MOTHER'S PERFORMANCE

production first lactation	4620
production second lactation	4080
best of further lactations	4695

INNOCULATIONS AND TB TESTS

last Cont. Abort. innoc.	79114
last lumpy skin innoculation	810601
last anthrax innoculation	810601
last Ecoli innoculation	820330
next to last Ecoli innoc.	0
last TB test	810529
last Cont. Abort. test	0
Cont. Abort. test pos or neg	0

APPENDIX C

List of cows ordered according to production

LIST OF COWS ORDERED ACCORDING TO PRODUCTION

INTERVAL: FROM 30 TO 50 KG

DATE: 841002

NUMBER	FATHER	LACT	TEAM	PRODUCTION
309	FDA	6	1	44.0
53	HARM	6	3	39.0
321	FDH	5	3	38.3
758	FEL	3	1	35.6
230	FDA	4	3	34.0
299	FDA	6	2	32.0
288	FVH	6	1	30.0

APPENDIX D

Work programme menu

WORK PROGRAMME

Choose which section you want: Your choice [ ]

1. Calves to be weaned.
2. Remarks demanding action on files.
3. Heifers to visit bull.
4. Heifers to be innoculated for Cont. Abort.
5. Herd innoculations and tests.
6. Cows between 7 and 8 months pregnant - Ecoli innoc.
7. Cows more than 8 months pregnant - Ecoli innoc.
8. Heifers to be examined.
9. Cows to be examined.
10. Cows to be dried off.

APPENDIX E

Example of work programme no. 9.

WORK PROGRAMME

DATE : 830220 PREVIOUS DATE : 830220

COWS TO BE EXAMINED

A. COWS INSEMINATED MORE THAN 6 WEEKS AGO

NUM.	TEAM	NXT.INSEM	LST.INSEM	NO.INSEM	LST.EXAM.	REM.
225	2	821228	821228	2		....
365	1	821212	821212	3		....

NO. OF COWS = 2

B. COWS NOT INSEMINATED YET

NUM.	TEAM	CALVING DATE	LST.EXAM.	REM
227	3	830101	0	....
321	3	821229	0	....
317	2	821015	0	....
172	1	820923	0	....

NO. OF COWS = 4

C. COWS WITH 3 OR MORE UNSUCCESSFUL INSEMINATIONS

NUM.	TEAM	NO. INSEM.	LST. INSEM	LST. EXAM.	REM

NUMBER OF COWS = 0