AGRICULTURAL RESTRUCTURING

IN

SOUTHERN AFRICA

Papers presented at an
International Symposium
held at Swakopmund, Namibia

24-27 July, 1990

Edited by

Csaba Csáki
Theodor Dams
Diethelm Metzger
Johan van Zyl

International Association of Agricultural Economists
in association with
Association of Agricultural Economists in Namibia
(AGRECONA)

First published in 1992 by the Association of Agricultural Economists of Namibia
P.O. Box 21554, Windhoek, Namibia.

Printed in Namibia by Windhoek Printers & Publishers (Pty) Ltd,
P.O. Box 1707, Windhoek, Namibia.

Distributed by the Association of Agricultural Economists of Namibia,
P.O. Box 21554, Windhoek, Namibia.

ISBN 99916/30/10/4

24

A MULTI-PERIOD LINEAR PROGRAMMING FRAMEWORK FOR THE ECONOMIC ANALYSIS OF DAIRY DEVELOPMENT PROJECTS IN DEVELOPING COUNTRIES

E Kizito

BACKGROUND

This paper is largely based on a study of Uganda's experience in trying to develop a modern dairy industry in the 1960s and 1970s by importing dairy cattle. In many of the developing countries of Africa, and elsewhere in the world, the drive to import dairy cattle comes from the need to counteract the low genetic value of the indigenous cattle. Current developmental problems facing developing countries trying to develop a dairy industry based on imported dairy cattle are very similar to those which Uganda faced in the 60s and 70s. This is certainly the case in a number of countries in Southern Africa, such as Malawi, Swaziland and Lesotho. Specifically, the development and modernisation of the Malawian dairy industry based on imported dairy cattle can be traced back to the 1960s, culminating in the shipment of 240 and 222 Canadian Holsteins in 1981 and 1982 respectively to Malawi.

In Uganda, exotic cattle were first brought into the country in 1928 on an experimental basis. They were first kept at research stations but in a few months, all of them died of different diseases. In the 1950s the government introduced Acaricide (a form of insecticide) for tick control, which made it possible to introduce pure exotic cattle in the 1960s, increasing to a peak of 2 100 in 1963. A total of 8 853 exotic dairy cows were imported from Kenya. In later years Kenya began to use more and more of its available exotic cattle to develop its own dairy industry as part of the mixed farming programmes in re-settlement areas. This prompted Uganda to obtain cattle from temperate areas, as shown in Table 1.

Table 1
Number of exotic cattle imported and country of origin[1]

Year	Kenya	U.K.	Holland	Denmark	Canada	U.S.	Total
1960	100						100
1961	300						300
1962	290						290
1963	2 100					15	2 115
1964	1 800						1 800
1965	1 500						1 500
1966	1 000						1 000
1967	1 025	400					1 425
1968	738			42			780
1969					600	125	1 465
1970-71			740				
TOTAL	8 853	400	740	42	600	140	10 775

[1] **Source:** Dairy and medium-sized farm development in Uganda, study undertaken by CIDA, 1972.

PROBLEM-SETTING

Usually when a developing country suggests to a donor such as the Canadian International Development Agency (CIDA) the idea of importing cattle, the first requirement is to find out whether the climatic, feeding and management situation is adequate. The next logical step is to recognise that a good plan should not only be technically feasible but also economically plausible and acceptable, thus determining the overall economic feasibility of the development program. Hence the need for economic analysis of the sort presented here.

OBJECTIVES OF THE STUDY

In view of this need, the objective of the study was to develop a framework which could be used at the national level:

- to calculate the resources required by the national dairy industry, thus indicating critical areas in the dairy industry development process;
- to compare plausible alternatives of livestock improvements including the introduction of exotic cattle such as the Canadian Holsteins; and
- to provide a picture of the changes which are required to improve a dairy industry.

ALTERNATIVES EVALUATED IN THE MODEL

The alternatives analysed and evaluated are:

- importing dairy cattle from temperate countries
- importing dairy cattle from neighbouring countries
- importing milk
- native cattle on private farms
- upgraded cattle.

METHODOLOGY[1]

A multi-period linear programming (L.P.) model, national in scope and covering a time period of 15 years, was used in this research. The objective of the model is the maximization of negative costs and positive revenues. This resulted in minimising cost of the development programmes. Technical and cost coefficients were set at "consensus values" developed through discussions with industry experts such as farmers and extension education staff. The L.P. approach is justified because of its budget-like nature. The methodology builds on the "budgeting for resources" process which is a familiar method used in developing countries. The methodological process used in this research is further illustrated in Charts 1-3. Chart 1 describes the effective "Linear Programming" Process. Charts 2 and 3 provide a diagrammatic illustration of the linkages within the model. The imported cattle are kept on government breeding farms for acclimatization and research while progenies are distributed to farmers. In some cases, imported cattle could be put directly on commercial farms, especially those imported from neighbouring countries. Upgraded progenies produced by native cows are transferred to graded activity. Native cattle are transferred to fenced farms which represent a higher level of management and therefore require more resources in a linear programming model.

---

[1] A detailed presentation of the methodology of Linear Programming is beyond the scope of this paper. Some selected references are included in the last section of this paper.

RESULTS OF THE ANALYSIS

Table 2 illustrates the six policies/scenarios[2] which were selected, evaluated and compared in order to illustrate the possible use of the empirical model.

The output from the runs show a detailed tabulation of resources "required" to sustain each programme over a period of 15 years such as: capital, land, labour, feeding, management and disease control programmes.

Furthermore, the results indicate how alternative programmes can be ranked according to costs, as shown in Table 3. This enabled the determination of the least cost programme. Policy A was the baserun. Policy B was the least cost programme which met the "required" demand for milk. A milk demand schedule was built into the model which gave a more realistic way of evaluation, involving the consideration of the consumer's desires. The total cost calculated as being necessary to maintain this programme was about U. Shs. 520 million. The explanation for the relatively low costs estimated for this policy was that the additional milk demand was met through upgrading the indigenous cattle and by importing cattle from a neighbouring country (Kenya).

Other key economic issues analysed

Chart 4 illustrates some of the major infrastructure critical to the viability of a sustainable dairy industry such as the establishment of the milk processing plants and milk collecting centres. These establishments usually occur alongside uneconomical milk transport systems. Figure 1 illustrates the complexity and dilemma of formulating an effective milk pricing policy in developing countries.

CLEARLY STATE OBJECTIVES	LINEAR PROGRAMMING - OBJECTIVE FUNCTION
■ FROM THE DONOR'S PERSPECTIVES	■ OPTIMIZING — TRADITIONAL CATTLE KEEPER
■ FROM THE RECIPIENT'S PERSPECTIVES	- MAXIMIZE PROFIT | VERSUS - MINIMIZE COST — MODERN CATTLE KEEPER
■ ASK THE RIGHT QUESTIONS	**LINEAR PROGRAMMING RESULTS**
■ SHORT TERM DIRECTION	■ BEST OR MOST EFFICIENT USE OF RESOURCES
■ LONG TERM DIRECTION	■ PRINCIPLE OF 'OPPORTUNITY COSTS' ■ WHAT 'OUGHT TO BE DONE'
DEFINE	**IS LINEAR PROGRAMMING USEFUL?**
■ PLAUSIBLE ALTERNATIVES	■ LINEAR PROGRAMMING AS A TOOL ENCOURAGES DECISION MAKERS TO THINK CAREFULLY ABOUT ALL ASPECTS OF THE PLANNING PROCESS - AND ABOUT THE QUESTIONS TO BE ASKED AND THE POSSIBLE ANSWERS
■ RESOURCES	
■ 'LIMITS' (CONSTRAINTS)	
■ TECHNICAL COEFFICIENTS WITH SUBJECT MATTER SPECIALISTS	■ LINEAR PROGRAMMING IS A TOOL TO ASSIST DECISION MAKERS TO MAKE BETTER AND MORE INFORMED DECISIONS BY ASKING THE 'RIGHT QUESTIONS'

Chart 1: Effective 'linear programming': development process

[2] Space does not allow full discussion of these runs. Bear in mind that this series of policy runs is only a limited illustration of the kinds of experiments which may be conducted with the model. The model is capable of analysing many more policies and handling many more variables which the user may wish to test.

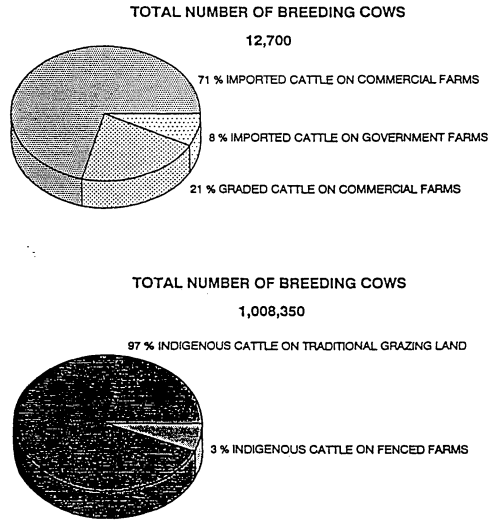

Chart 2: Dairy cattle inventory, baseline assumptions starting in year one

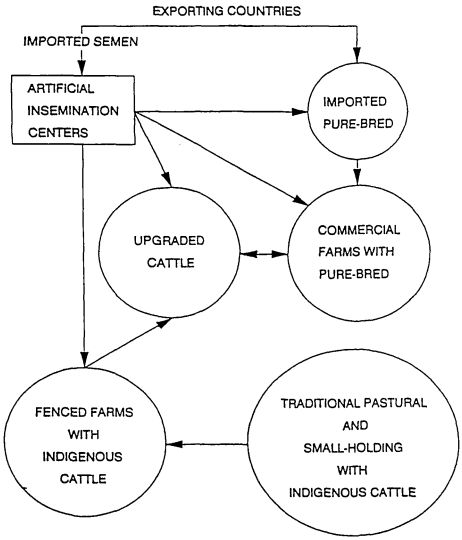

Chart 3: Cattle inventory linkages within the model

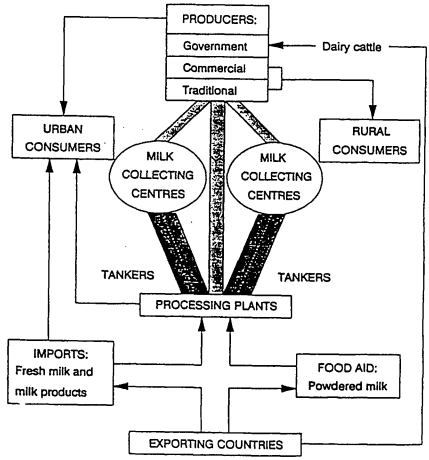

Chart 4: Critical infrastructure for a sustainable dairy industry

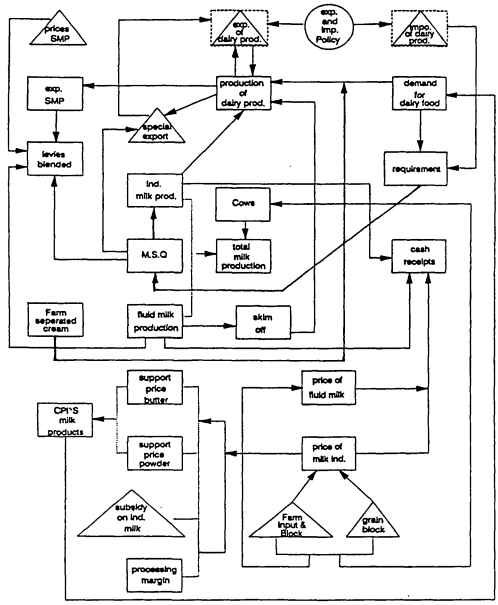

Figure 1: Canadian dairy industry dairy model structure

Table 2
Summary of policies run in order to illustrate some of the possible uses of the empirical model

Run name		Run definition	Importation of milk	Milk demand constraint
1	Policy A	"Status quo" policy, no importation of cattle no grading up of indigenous cattle	None	None
2	Policy B	Importation of bred heifers and heifer calves, upgrading of indigenous cattle	Importation of milk without limitation	Included
3	Policy C	Importation of bred heifers and heifer calves *No importation of Kenya cattle, upgrading of indigenous cattle	Importation of milk without limitation	Same as run 2
4	Policy D	Same as run 3	Imposing a quota	Same as run 2
5	Policy E	Same as run 2	None	Same as run 2
6	Policy F	Importation of temperate bred heifers and heifer calves, no importation of Kenya cattle, upgrading of indigenous cattle	None	Same as run 2

Table 3
Milk supply (mil. gal.), total costs (mil. shs.)

Policy	Year	1	5	10	15	Total costs
A	Milk production for urban use	7,1	7,8	8,7	9,8	
	Milk production for rural use	51,8	59,1	67,6	77,3	130
B	Milk production for urban use	7,8	11,4	18,4	29,6	
	Milk production for rural use	51,8	59,1	67,2	75,1	520
C	Milk production for urban use	7,1	11,4	18,4	29,6	
	Milk imports for urban use	0,71				576
	Milk production for rural use	51,8	58,7	65,8	73,4	
F	Milk production for urban use	7,8	11,4	18,4	29,6	
	Milk production for rural use	51,8	58,8	66	73,5	527

CONCLUSION

The solutions from the model using the data for Uganda indicated that the most efficient way to develop the dairy industry was through crossbreeding and importing dairy cattle from the neighbouring country. The alternative of developing the dairy industry based on imported dairy cattle from temperate areas proved to be very costly: it had the disadvantage

of being based on the most expensive activities.

The framework which has been developed, works and is generally useful. It is widely applicable to the dairy development problems in many developing countries. The methodology is especially relevant to tropical Africa because the model was empirically tested in a developing country, Uganda, in the 70s. Uganda had built a herd of about 10 000 head imported from Kenya, the UK, Holland, Denmark, US and Canada. However, the model solutions were not expected to produce the "answers". L.P. as a tool encourages decision-makers to think carefully about all aspects of the planning process by asking the "right questions" which are critical to a sustainable industry.

The methodology used in this research is timeless. The analysis is current in the sense that the key economic development issues analysed using this framework are identical to current problems faced by many developing countries trying to develop a sustainable dairy industry based on imported cattle.

ACKNOWLEDGEMENT

The author is grateful to the IAAE Canadian Council for the financial assistance offered to him in order to attend this conference. The author wishes to thank Des Doran, Shankar Narayanan, Dr Gerry Robertson and Dr Jim McKenzie for helpful suggestions.

REFERENCES

Agriculture. 1979. *Toward 2000.* Conference Twentieth Session, Rome, 10-29 November 1979.

CIDA Report. 1987. *Mid-term evaluation - Malawi/Canada Dairy Cattle.*

CIDA Report. 1987. *Sharing our Future.*

CIDA. 1988. *Country Report, Namibia.* CIDA Briefing Centre, Ottawa, Canada.

Bryant, Coralie. 1988. *Poverty, policy and food security in Southern Africa.* London: Mansell Publishing Limited.

Duloy, J.H. and R.D. Norton. 1973. *CHAC - A Programming Model of Mexican Agriculture.* In Goreux, L. and A. Manne (eds.). Multi-level Planning: Case Studies in Mexico. North Holland.

Economic Report. 1989. *Malawi Monthly Digest of Statistics.* International Development Research Centre Library, Ottawa, Canada.

FAO. 1989. *The State of Food and Agriculture: World and Regional Reviews, sustainable development and natural resource management.*

Intrilligator, M.D. 1971. *Mathematical Optimization and Economic Theory.* Prentice Hall, Inc., Chapter 2, 3, 4 and 5.

Kizito, E. 1976. *A Multi-Period Linear Programming Approach to a Macro Livestock Sector Analysis with Special Reference to Uganda.* M.Sc. Thesis, Department of Agricultural Economics, University of Guelph, Guelph, Canada.

McDowell, R.E. 1970. *Improvement of Livestock Production in Warm Climates.* San Francisco: W.H. Freemand and Company Press.

Oloya, J.J., I. Miclaus, F.A. Ishengoma and K. Aho. *Agricultural Economy of Namibia: Strategies for Structural Change.* Lusaka: United Nations Institute for Namibia.

Redekop, W.B. 1975. *Canada/Lesotho Dairy production project.* Canadian International Development Agency, Ottawa, Canada.

Redekop, W.B. 1970. *Canada-Uganda Holstein Friesian Dairy Cattle Project.* Parts I and II. Compiled for the Canadian International Development Agency, Ottawa, Canada.

Walker, N. and R. MonyPenny. Linear Programming as a tool for agriculture sector analysis. *Review of Marketing and Agricultural Economics.* 44(4): 165-178.