ASAE Publication 1-92

COMPUTERS IN AGRICULTURAL EXTENSION PROGRAMS

Proceedings of the 4th International Conference
28-31 January 1992, Orlando, Florida

Sponsored by the

Florida Cooperative Extension Service
Institute of Food and Agricultural Sciences
University of Florida, Gainesville

Edited By

Dennis G. Watson
Fedro S. Zazueta
A. B. (Del) Bottcher

Co-Sponsored and Published by

American Society of Agricultural Engineers
2950 Niles Rd., St. Joseph, Michigan 49085-9659 USA

Farm Planning for the Brazilian "Cerrado" Region: A Planning Framework for Crop Farm Development

R.F. Veloso[1], M.J. McGregor[2], J.B. Dent[3], and P.K. Thornton[4]

ABSTRACT

To be successful any planning framework for analysing investment opportunities in regions such as the "Cerrado" in the Midwest of Brazil must emphasise sustainable development. This implies a shift from the traditional single objective of agricultural expansion to a multiple objective approach incorporating economic, social and environmental factors. This paper describes a planning methodology which allows ex-ante evaluation of trade-offs between economic, social and environmental factors in determining the most appropriate development options.

INTRODUCTION

In recent years considerable effort has been directed towards economic development in the Midwest of Brazil. This development has been characterised by subsidised agricultural investment projects which have increased the area devoted to agricultural production in the "Cerrado" region by three million hectares. However, although these projects have been effective in terms of agricultural production and have improved the basic infrastructure in the region, they have been criticised for failing to improve the economic and social well-being of the majority of the local people. The major reasons for this are the;

* high levels of capital required for establishing farms on the poor "Cerrado" soils,
* low number of farmers involved,
* high risks involved in the production of staple crops such as rice and maize,
* failure to incorporate production risks into the farm management plans,
* unestimated ecological impacts of the new technological packages, and
* lack of local public and recipient participation in the planning process.

This paper is concerned with describing a suitable planning methodology which would allow the ex-ante analysis of farm development in the "Cerrado" region and provide decision makers with the means to explore trade-offs between the full range of impacts (economic, social and environmental) resulting from such development.

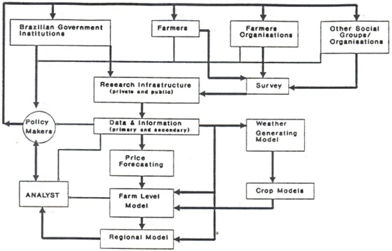
THE PLANNING FRAMEWORK

This study has been conducted from a systems research viewpoint because the systems research framework presents an opportunity for placing narrowly focused

1. Research Economist, Brazilian Agricultural Research Corporation (EMBRAPA), Brasilia, Brazil.
2. Head of Rural Systems and Management, The Scottish Agricultural College (Edinburgh), Scotland.
3. Professor of Agricultural Resource Management, University of Edinburgh, Scotland.
4. Systems Modeller, International Fertilizer Development Centre, Muscle Shoals, Alabama, USA.

research in a broader perspective. The boundaries of the system have been defined by the network of relations from the crop production process level to the socio-economic environment at the farm and regional levels. A hybrid model structure (outline shown in Figure 1) has been developed whereby crop yields and prices are predicted from individual crop and price forecasting models to provide inputs into a farm level MOTAD mixed integer, multi-period linear programming representation of a farm. Outputs from the farm level model are in turn used as input coefficients in a multiple objective goal programming model to assess regional issues. The three sets of models - simulation, linear programming and goal programming - work independently and require the analyst to provide the appropriate set-up data for each[5].

Figure 1: Outline of the proposed planning framework.



Crop Simulation Models

Four crop (wheat, rice, maize and soybean) simulation models[6] were used to generate site specific input-output coefficients for the farm level linear programming models. The crop models adopted have been designed as generic models which are able to simulate plant growth and development at any site where the crop can be grown. This was useful in this situation because there was little, or no, experience of growing these crops in the region. The models were used to provide crop yield distributions for a range of management e.g. planting date, variety, and fertiliser and irrigation programmes.

However, the application of these models for specific sites requires validation against independent local data sets. In this case only incomplete data sets were available for calibrating and validating the crop models for the Paracatu region.

5. Further details of the modelling framework can be found in Veloso (1990).
6. Further details of the crop models can be found in Harrison, et al (1990).

Further work is required by Brazilian research institutes to allow this process to be carried out reliably but in this case it was felt they were appropriate for developing the methodological approach.

The crop yield distributions provided by the individual crop models were randomly sampled to provide 10 input coefficients for the MOTAD element of the farm level models. This sampling was carried out on the unordered yield distributions to preserve the correlations observed between crops within years. The resulting information was then incorporated into the farm level model with the sampling information providing the basis for the MOTAD structure of that model.

Price Forecasting Models

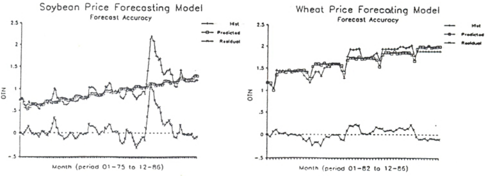
Price forecasting is a difficult task under any circumstances however, forecasting in the Brazilian economy brings with it considerable difficulties. Agricultural product prices in Brazil are effected by climatic variation, extremely high and erratic inflation, and Government intervention in the market. A large number of techniques are available for carrying out time series analysis of data but their use in many cases is inappropriate because of the costs of implementing them. In this case the adoption of more complex modelling methodologies was avoided and autoregressive models were used. The mathematical description of the product price forecasting models for maize, rice and soybean is;

$$Y_t = b_0 + b_1 t + c_1 Y_{t-1} + c_2 Y_{t-2} + e_t$$

where: $b_0 + b_1 t$ are used to denote the trend components, $Y_{t-1} + Y_{t-2}$ are used to denote the seasonal component and e_t is used to denote the random component. Plots for soybean and wheat are shown in Figure 2.

The results indicate that the approach used here has a satisfactory level of precision but the major area not accounted for is the continuous government interventions in the economy (shown for example by the period post-1985).

Figure 2: Plot of historical versus predicted values for prices and corresponding regression residuals for soybean and wheat.



Farm Level Model

The information generated by the crop simulation models and the price series forecasting models have been used as the input coefficients in a representative whole crop farm model of the "Cerrado". The basic model developed was a multi-period mixed integer linear programming model and a later version included a MOTAD formulation. The crop farm model was developed to analyse a range of crop farm systems from a range of individual farm enterprises - maize, rice, soybeans and wheat; farm resources - 3 different land types, machinery, labour, etc.; agricultural credit policies - private and public investment, reinvestment, leasing, etc.; and other management strategies - such as the use of rotations and irrigation - which maximise the discounted cash flow over 10.5 years.

The farm development is viewed from the point of view of a decision maker responsible for agricultural credit policies. The objective function used in the model is the Net Present Value of the farm business in terms of National Treasury Bills (OTN). By optimising the NPV of the farm business, the model establishes the resource requirements of a specific farming system.

Monthly time steps are used for the first four years followed by annual time steps for the next six and one half years. The adoption of a non-standard time horizon was necessary in order to ensure the synchronisation of production and financial years.

The farm level model incorporates the major biological, financial and social (family consumption, family and hired labour) aspects. However, in an integrated regional development sense, trade-offs must be made among diverging objectives (i.e. economic, social and environmental) in order to select the most appropriate farming system(s). The outputs from the farm level model were used to define the farming systems, their resource use and profitabilities for input into the regional level model.

Regional Level Model

Lexicographic goal programming (LGP) was used in this study because of it's; potential to mimic the decision making process (where goal setting and goal ranking are essential issues); successful application in a number of previous studies involving the resolution of resource use conflicts; and access to reliable software (Bartlett et al., 1976). The objective of developing the LGP model was to analyse the consequences of alternate farm plans at regional level and to develop an understanding of the trade-offs between the interests of farmers and the interests of Brazilian society associated with rural development of the "Cerrado".

Data (in the form of 9 alternative farm systems) from the farm level models was integrated with region specific data concerning wider social and environmental impacts. The matrix generated is composed of goals and resource, or non-goal constraints. The relevant goals from a Government perspective are ordered in terms of goal levels, goal priority and associated weights. The priorities, their relative weights and goal levels can all be varied. The base-line values used in the analysis are shown in Table 1.

The goals included in the model are:

Land-use/environmental - minimisation of total soil losses from cultivation and maintenance of minimum areas of natural vegetation.
Farm family - maximisation of the family discretionary consumption and minimisation of the initial start-up capital for the farm business.
Social - maximise employment and the number of farmers settled in the region.
Economic - minimisation of the capital required from the public purse, maximisation of the regional income generated and maximisation of the market capital used for developing new crop farms.

Table 1: Baseline goal variables used in the regional model.

Goal Description	Priority	Differential Weight	Goal Units	Goal Value	Type of Achievement
Public programme budget	1	4	OTN	0	Over
Farmer's initial capital	1	3	OTN	0	Over
Regional income	1	2	OTN	99999999	Under
Market capital	1	1	OTN	99999999	Under
Discretionary consumption	1	1	OTN	100	Over
Total soil losses	2	1	tonnes	0	Over
Hired labour	3	1	hours	99999999	Under
Reserve 70% LVA land	4	1	hectares	37394	Under
Reserve 70% LVE land	4	1	hectares	112182	Under
Reserve 70% LHI land	4	1	hectares	37394	Under
Number of farmers	5	1	farmers	99999999	Under

RESULTS

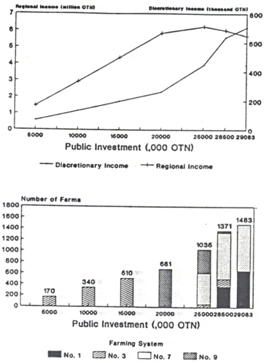
The model was run to investigate the impact that differing levels of public programme monies would have on the other goals. Such an analysis allows possible trade-off functions, like that shown in Figure 3, to be explored. For instance, the choice of farming systems involves trade-offs between such things as greater number of farmers generating lower marginal regional income but providing higher discretionary consumption possibilities for the target population; or a smaller number of farmers generating higher marginal regional income, lower discretionary consumption possibilities and lower total soil losses.

CONCLUSIONS

The framework described here is an effort to incorporate the strength of the individual modelling techniques in such a way as to give a comprehensive planning framework which could be used to support rural development policy makers. However, the potential of any modelling approach depends (amongst other things) on the modeller's abilities, data availability and the assumptions incorporated into the model to overcome the natural difficulties in mimicking real world problems.

The effectiveness of the planning framework developed here will depend on the results of its practical implementation by Brazilian planners. If this planning framework is to be effective in incorporating the goals and objectives of the wider community, it requires the backing of policy-makers in an interactive way. It is our opinion that with some minor refinements and properly validated crop models this planning framework will provide a better basis for ex-ante planning of sustainable agricultural development in the "Cerrado" region of Midwest Brazil.

Figure 3: The results of changing goal levels in the LGP model.



References

Harrison, S.R., Thornton, P.K., and Dent, J.B. 1990. The IBSNAT project and agricultural experimentation in developing countries. Journal of Experimental Agriculture, 26:369-380.

Bartlett, E.T., Bottoms, K.E., and Pope, R.P. 1976. GOAL: Multiple objective programming. Range Science Series No.27. Range Science Department, College of Forestry and Natural Resources, Colorado State University,

Veloso, R.F. 1990. Crop farm development in the Brazilian Cerrado Region: An ex-ante evaluation. Thesis, PhD (unpublished), University of Edinburgh, United Kingdom, 268.