DECISION-MAKING AND MANAGEMENT IN AGRICULTURE

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Introduction

Agriculture has been the main industry of the Caribbean over the past three hundred years. Within recent decades, however, much consideration in planning has been given to what is termed "industrial" development. This is supposed to include all industries other than agriculture (i.e. small, large manufacturing etc.) and emphasis and incentives have been given to this sector to an extent which has been unknown to agriculture.

There is also a school of thought, lacking in knowledge about agriculture, which considers the non-agricultural industries to be the only one desirous of "proper" management. Even at our institutes and centres of management and productivity in the LDC's, there seems to be little attraction to persons involved in agriculture. There may be reasons for this. One possible reason is that the present structure of agriculture does not encourage management development from within the system. Another possible reason is that we may have overemphasized the technical aspects of agriculture at the expense of management techniques, etc.

The purpose of this paper is to outline a few management techniques as they relate to agriculture. It assumes that if agriculture and tourism are to be mutually dependent sectors, then one should not strive towards efficiency, while the other remains static. They must develop and improve together. If the tourist industry is capable of attracting highly skilled management services, agriculture must be in no less a position to do likewise. In agriculture, we must think in terms of long term capital and mechanization, and the structure of the organization required to attract these inputs. We must also think of production, marketing and finance and it is in these areas that decision-making and management skills are important to the success of any agricultural venture, and indeed to the agricultural sector as a whole.

What is Management?

Management has been defined by Webster's New International Dictionary as a judicious means to accomplish an end. This was normally applied to large corporations and organizations only. Recently, however, there has been increasing acknowledgement that governments, hospitals, libraries, etc. require a management team. This extension of the management concept can be traced to a growing awareness of the fundamental similarities in the basic pattern of all administrative issues.

There are certain elements and patterns in management which can be learned and utilized independently of the specific area of application. Managing a retail shoe store has much in common with managing an oil refinery, a library or a hospital. What is implied is the ability to assess managerial efficiency on a cross-industry and cross-institutional basis. Within reason, a transferable science of management systems can be said to exist.

Decision theory in conjunction with operations research and management science are the present day culmination of business management's evolution. These areas are at present the most advanced developments available for generalizing among administrative situations. At the level of description, they are especially applicable to automobile production in the U.S.A. or vegetable production in Antigua.

The most general characteristic of management problems is that some kinds of resources are always being used as inputs to produce some kinds of outputs. It is generally found that these resources may be used in alternate ways at different costs, such that the output or benefit derived from using resources does have a value. For management to be efficient it must try to minimize the costs associated with a given benefit or maximize the benefit associated with a given use of resources.

Management as a science is concerned more with both short and long range planning, and less with production tasks and the efficiency of men and machines. It attempts to establish whatever relationship exists between an organization's objectives and its resources. It neither avoids nor overlooks the effects of behavioural problems even though such problems cannot always be solved.

Management with Ministries/Departments of Agriculture

There is need for improved management within the various ministries and departments of agriculture in the Caribbean. This is perhaps more important than the management of private agriculture operations. Briefly, we shall comment on two areas. First, there must be management within the budget and the development plan for the ministry. The plan will merely provide a frame for the decision-makers, whereas the budget allocates the financial resources within a given time period. These must be followed by the implementation process which attemtps to achieve the targets of the plan. There is thus the need for proper accounting and reporting systems for ministry management.

A second area of ministry management is related to specific projects. In order to manage effectively, the project must first be properly identified. This must be followed by pre-feasibility and feasibility analyses so that the decision to finance the project is well documented. The next step is the implementation phase when the schedules of work and activities are laid out in detail. Since the project is expected to achieve specific targets, management must be in a position to evaluate the performance of the project at all times, and may need to define performance indicators by which the plan may be evaluated and which are consistent with the plan.

Management of Private Agricultural Ventures

We now turn our attention to management as it relates to private agricultural operations and examine three vital areas for management. These are production, marketing and finance.

Production

Production is essentially a transformation process and production problems are more subject to control than in the case of marketing or

financial decisions. Yet, unlike industry or manufacturing, there are many hidden variables which may drastically affect the outcome, e.g. weather. Production in agriculture is peculiar in that many decisions are made under risk, yet at the same time a number of decisions are made under certainty. In the former case, they require probability assumptions to provide a useful basis for analysis, whereas, in the latter, no such assumptions are necessary. In the former case, we may be concerned with the chances (probability) of an insect damage to crop, whereas in the latter we know to a fair degree of accuracy, through experimentation, the level of yields to expect after the application of a given fertilizer mixture. Of course, the problem of risk is present if we consider that the effectiveness of such a fertilizer may be dependent on the weather after application. However, there is still a degree of certainty since the weather patterns tend to be seasonal and are often well known to producers. Besides decision making under risk and decision making under certainty, ther is also decision making under uncertainty and such decisions are of particular importance in production. For example, the decision to diversify or to produce a crop without a marketing contract involves uncertainty. All three types of decisions involve different costs which influence the returns to the farm.

There are other areas in which management of production is vital. One area, for example, is in the operation of capital equipment used on the farm. Take, for example, a large sugar producing company with a fleet of tractors. The question may be asked: how does management tackle the replacement problem of the tractors? Experience has shown that management would have to resort to the application of replacement theory which is concerned with situations in which efficiency tends to worsen in time, and in which it can be restored to a previous level by some kind of remedial action. The problem is to determine the times at which remedial action should be taken.

Let us assume that the company wants to determine the replacement policy of a tractor whose current replacement cost as new is $20,000. It is necessary to consider running costs and the likely resale price at the end of each year, for say, the next five years. The approach normally used is to minimize the average cost per year of the running and capital costs; and it is important that we discount, where appropriate, if we are considering costs at different times. It is, first of all, necessary to calculate the total discounted running cost each year to the present time so that a comparison of costs incurred at different times can be made. The total discounted running cost may thus be obtained at the present date for each year.

The second step would be to calculate the total discounted capital costs by discounting all of the resale prices. Then subtracting these figures from the initial purchase price of $20,000 will give the total discounted capital cost for each year. The third step is to obtain the total overall cost by adding for each year the discounted total running and capital cost. Dividing each of these figures by its year number gives the average cost per year. The lowest value indicates the end of the year at which replacement should take place. The differences between the averages should be noted, and some form of sensitivity analysis should be carried out if the differences are small. This might allow management a more flexible replacement policy.

In practice, there is a further complication in this type of replacement problem. The tax situation of a business is affected by its capital equipment replacement policies; therefore, any analysis would take the effects of tax into account.

The above example serves to illustrate a principle which is applicable to any agricultural producing organization where capital equipment is bought, and needs to be replaced from time to time. Management must not be influenced by an aggressive tractor salesman, or by the feeling that capital equipment should be replaced after some fictitious period of time. Techniques are available to assist management in making rational decisions.

Marketing

Marketing is that subject which treats all conditions under which the supplier meets the consumer. It is the testing ground where the cumulative effect of many of the decisions on production can be observed.

One of the fundamental and most complex marketing decision problems is the determination of the "best" price for a product. Many factors influence the demand for a product. A change in price can shift the market to an entirely different group of consumers rather than add or subtract consumers from the same basic group. Psychological factors also play an important part in determining the value which a consumer imputes to a particular product. These values can change quite rapidly for reasons which are often known only long after the effects of the change has been felt. A wide spectrum of consumer values are involved in every pricing decision and this is part of the reason why a genuine pricing model has not yet been evolved for agricultural products, or even commercial products.

Let us look at an agro-industry where one or more agricultural products are used as the raw materials. For agricultural products it is often that, owing primarily to the growing season and to storage problems, there is a fixed season when the product is marketed. The price of the agricultural commodity will vary throughout the selling season and it is difficult for a business to predict accurately what the price will be. The problem is therefore: what purchasing policy should the firm follow in order to minimize its total cost of buying the needed amount of the commodity?

Let us take a hypothetical example and assume that our business is to manufacture citrus juices and citrus meal and we compete with the fresh citrus market for our supplies. The harvesting and selling season for the fruit is over a four-month period of the year. Let us assume that the probability distribution of the price per unit has been determined for each of the four months from historical data and that these distributions are as follows:

Price ($) per 50 fruit	Month			
	I	II	III	IV
2.00	0.02	0.04	0.05	0.03
2.25	0.09	0.12	0.08	0.08
2.50	0.14	0.18	0.13	0.12
2.75	0.19	0.24	0.18	0.15
3.00	0.23	0.22	0.20	0.20
3.25	0.16	0.09	0.26	0.13
3.50	0.08	0.07	0.10	0.11
3.75	0.06	0.03	0	0.10
4.00	0.03	0.01	0	0.08
Arithmetic Mean	$2.95	2.81	2.90	3.06

A naive approach would be to wait for some specified price which is deemed to be "satisfactory". Of course, the difficulty is that the specified price may never occur.

Another naive approach would be to purchase one-quarter of the total requirements each month. The expected price under this policy would be simply:

$$\tfrac{1}{4}(2.95 + 2.81 + 2.90 + 3.06) = \$2.93$$

The firm may also consider a policy of "dollar averaging" where the ideal policy would be to spend a constant amount of dollars per month rather than to purchase a constant amount per month. With this policy, more will be purchased when the price is lower so that the final average price ought to be lower. We could obtain this price by calculating the harmonic means of the price distributions.

Of the three policies considered, the first one is probably the best, though not necessarily the best of *all* possible policies. So the problem still remains as to how can the optimum policy be determined. This kind of problem is sometimes cited as an example in dynamic programming, and the basic idea on which the solution depends is a key idea in dynamic programming. The difficulty in finding the optimal policy is that there are many possibilities to be considered.

Let us begin at the end of the four-month season when there is no choice at all. If the first three months had gone without any of the commodity being purchased, the firm has no alternative but to purchase in the fourth month, no matter what the price. In this case, the firm must be content with an expected price of \$3.06, the expected price of the fourth month.

Bearing this in mind, let us now consider the third month. The firm knows that it has to pay an average price of \$3.06 in the fourth month; so there is no reason why it should pay more than \$3.06 in the third month, since it would get this price by waiting an extra month. On the other hand, the firm has no reason to take a price lower than \$3.06 in the third month, since they cannot expect to do as well if they wait until the fourth month. Therefore, the optimal policy in the third month is to buy if the price is less than \$3.06 (i.e. \$3.06 or less) or wait until the fourth month. According to the probability distributions, the firm has a probability of 0.64 of buying in the third month (assuming that they have reached the third month) and a probability of 0.36 of having to wait until the fourth month. The expected price of the optimal policy for the third month is:

$$0.05(2.00) + 0.08(2.25) + 0.13(2.50) + 0.18(2.75) + 0.20(3.00) + 0.36(3.06) = 2.80$$

Therefore, if the third month is reached without any of the commodity bought, the optimal policy would be to buy in the third month if the price is \$3.00 or less, otherwise wait. The expected price of this optimal third month policy is \$2.80.

We can similarly consider the second month where the firm has a probability of 0.58 of buying (assuming the firm has reached the second month without buying) and the expected price of the optimal policy would be:

$$0.04(2.00) + 0.12(2.25) + 0.18(2.50) + 0.24(2.75) + 0.42(2.80) = \$2.64$$

Note that 0.42 is the probability of having to wait until the third month to

purchase and $2.80 is the expected price of the optimal policy for the third month. We can therefore say that the optimal policy for the second month will give an expected price of $2.64.

As regards the first month, the optimal policy would be to buy if the price is less than $2.64 (i.e. $2.50 or less) or otherwise wait. The expected price for the first month optimal policy would be:

$0.02(2.00) + 0.09(2.25) + 0.14(2.50) + 0.75(2.64) = \$2.57$

So we now know what policy to adopt in each month as follows:

Month	Policy
1	Buy if $2.50 or less, otherwise wait
2	Buy if $2.75 or less, otherwise wait
3	Buy if $3.06 or less, otherwise wait
4	Buy

It is this total policy which is optimal and which gives an expected price of $2.57. It must be appreciated that the same reasoning could be used to discover the optimum selling policy for the orange producer. The structure of the argument is a very important one, but has yet found little use in agriculture. Much of the power of dynamic programming comes from the same general idea, i.e. to find a place in the decision process where the decision maker has a choice, and to build from that position of fixed choice to a determination of optimum policy.

Finance

In considering financial applications to agriculture, it will not be possible to discuss all of the major kinds of analyses. First, some financial decision problems are so complex that it would be difficult to present them in simple terms. Secondly, some financial decision problems require mathematical methods beyond the scope of this paper. Complexities of financial decision problems often result from their involvement with multiple objectives, and many of these objectives are difficult to quantify and relevant costs are often hard to estimate. It would be useful, however, to mention three simple models which can be used in financing agricultural development. These are the capital budgeting decision, simulation and linear programming.

(i) The Capital Budgeting Decision

Capital budgeting involves a current investment (e.g. tractor) in which the benefits are expected to be received over a period of time, usually more than one year. The capital budgeting decision thus involves the generation of investment proposals, the estimation of cash flows, and the selection of projects based upon an acceptance criterion and the continual evaluation of investment projects after their acceptance. We can use some of the basic ideas of decision theory, e.g. pay-off, matrix, probability of states of nature, and expected values, and put these together in a distinctive way to make a valuable contribution to the analysis of a capital budgeting decision.

(ii) Simulation

The technique of simulation has many applications to agriculture, and

much of the work to date has been done with livestock projects. For example, we can have a livestock project consisting of cattle, sheep and pigs as the major producing elements. It is possible by simulation to project the size and composition of the various herds, develop corresponding revenue and expenditure flows, project profit and loss statements, information about loans, terms of loans, available costs, etc. The information can then be used to generate a cash flow table giving the source and uses of funds to the producer; also the return on investment, the return to the economy from the project and an approximate risk probability of the project.

Investment decisions are generally based on the application of one or another criterion to the particular project under consideration. Some of the common yard-sticks used are internal rate of return, payback period, net present value, etc. Regardless of the specific criterion used, the overall structure of the analysis is likely to be the same. Using the prescribed criterion the analyst tries to produce a specific value for the investment proposal. In agricultural projects, it is useful to simulate the investment proposal so that an explicit probability distribution of the possible returns on investment can be given to management. This kind of simulation is often referred to as risk analysis.

(iii) Linear Programming

Linear programming is useful in agriculture in determining the allocation of funds within the operation. One example of its use is in short-term financing decisions. The first step would be the preparation of a cash budget for each future period to determine a cumulative cash deficit or surplus. The manager will have available to him a number of alternatives by which the cumulative cash deficit can be financed or excess cash invested. If there is a deficit, we can assume that the following alternatives are available:

(1) Unsecured borrowings under a line of credit.
(2) Accounts receivable loan.
(3) Stretching accounts payable
(4) Term loan from a bank.

The objective function of the linear programming problem would show how to provide the funds needed by the cash budget at the minimum total cost. It will be subject to the constraints under the alternatives listed above. When the problem is solved, we will obtain the optimum financing strategy for each period of the planning horizon. The optimum amounts of each alternative will be obtained together with the cost of this optimal financing procedure. By evaluating the dual variables, the manager would obtain some insight into the opportunity cost of the various constraints. This approach thus provides the manager with a decision-making tool for solving rather complex short-term financing problems.

Concepts of Decision-Making

In the above discussions it has been intimated that risk and uncertainty are directly related to management and, therefore, management must involve decision-making. Management always wants to achieve some goal, purpose or objective and there is some state of affairs that it desires. Decision-making involves choosing an action which management believes will help him obtain his objective. This action takes the form of some kind of utilization of his own efforts or any resources that he controls. If there is only one course

of action, then there is no decision problem, as decision implies choice. Decision will consist of the specific utilization of particular resources that management controls, selected from among all the resources that are available, and we call any such resource utilization under the decision-maker's control, a strategy.

If we recognize that we do not always achieve our objective, despite our best efforts in that direction, we would appreciate that there are at least two factors outside the control of management. One such factor may be referred to as a state of nature and the most common example is the weather. A second uncontrollable factor is the competition of rational opponents. Most managerial decision problems involve both kinds of factors simultaneously. Therefore, the decision-maker wishing to achieve some objective selects a strategy from among those available to him. This strategy, together with the state of nature that exists and the competitive strategy, will determine the degree to which the objective is achieved.

There are many ways to classify decision problems, depending on the amount of information available to the decision-maker about the likelihood of occurrence of the various states of nature. Five classes of decision problems may be distinguished as follows:

(a) Decision-making under certainty occurs when we have a problem where we know with certainty which state of nature will occur. A great number of organizational decision problems fall under this category. There is no difficulty, in theory, in determining the decision criterion under certainty. All we need do is find the strategy which has the best pay off, and that is the strategy which should be selected.

(b) Decision-making under risk occurs when there are a number of states of nature but when the decision-maker knows the probability of occurrence of each state of nature. Typically,in many organizational problems, the probabilities of the various states of nature are known by virtue of determining how frequently they occurred in the past.

(c) Decision-making under uncertainty when the probabilities of occurrence of the various states of nature are not known. Such problems arise wherever there is no basis in past experience for estimating the probabilities of occurrence of the relevant states of nature. The decision problems involved in marketing a new agricultural product would include various levels of demand as states of nature. Decision problems concerning the expansion of production may have states of nature including such events as recession, inflation, import restrictions etc. At the present time, decision theory does not provide one best criterion for selecting a strategy under conditions of uncertainty. Instead, there are a number of different criteria, each of which has a perfectly good rationale to justify it. The choice among these criteria is determined by organizational policy and/or the attitude of management.

(d) Decision-making under partial information may be regarded as an intermediate between risk and uncertainty where we know something, but not everything, about each state of nature.

(e) Decision-making under conflict occurs when management becomes involved

in a competitive situation with a rational opponent. This part of decision theory is commonly known as game theory.

The above classification on decision-making, though theoretical in outline, nevertheless has considerable applications to agricultural development in the Caribbean. Decisions on production and marketing, pricing and credit all bear testimony to this. Further complications arise as individual farmers attempt to grapple with all the possible decisions at the micro level while, at the same time, the planners attempt to co-ordinate the overall agricultural sector with its many agencies and bodies. Rationalization of production and marketing at the macro level often bears no relation to how the individual farmer sees his position being improved.

The two most vulnerable areas appear to be marketing and finance. In this context, marketing begins from the time the seed is planted, hence we may consider production as a part of marketing. The decision of the planners to provide marketing facilities for the purchase of carrots may be valid for many reasons, e.g. foreign exchange, nutrition, etc. These facilities will have to be financed, organized and managed and the farmer must be assured (possibly through contract) that his carrots will be purchased, provided his produce meets the required standard and specification. The farmer's first decision is whether or not he will produce to sell to the marketing agency, and the agency must know this. This follows a period of about three months where decisions are made under risk and uncertainty and even conflict, before the produce is delivered to the agency. The product may never be delivered. Assuming, however, that it is delivered, the management of the agency must have decided what will be done with the carrots. This assumes that adequate market research would have been conducted in order to determine the form and outlets of the products. The problem is that this market research is not usually done. An excess of 10 acres of carrots and tomatoes should not be allowed to glut a local market; yet it happens very often in the Caribbean. The reason seems to be that market research is lacking, hence decision-making on the basis of such results cannot possible be made. As regards carrots, should the agency sell them whole in one-pound or two-pound bags, or should they be diced or cubed? Should the carrots be juiced? Could the juice, which is high in vitamin A, cut into the soft drink market? If so, at what price? These are but a few of the questions on which decisions should be made, and should be occupying the attention of our planners and marketing agencies. Failing this approach, gluts and scarcities will continue and the decision to produce will always be a farmer's nightmare.

As regards the administration of finance, it is well known that credit is an important element in agricultural development, especially where diversification is to be implemented. However, the decisions which lead to the conditions under which credit is provided may be in conflict with the conditions under which the farmer is prepared to accept. There are many examples of this, e.g., farmers may be unwilling to produce security, or they may resent credit supervision, etc. It is possible that many of these types of decision problems are due to the present structure of the agriculture sector. Until the structure is altered, in order to accommodate more capital and technical input, decision-making and management will be difficult.

WORKSHOP REPORTS