OPERATIONAL RESEARCH – STRATEGIC TOOL IN ENVIRONMENT–AGRIBUSINESS INTERACTION

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Abstract

Although it is a science in its own right operational research is not so well known in the field of economics and agribusiness but it possesses methods and relationships that could help ensure the natural-agribusiness environmental balance. Operational research is not a strictly mathematical science; it uses mathematical techniques but has a much wider application spectrum representing a systematized approach to solving problems that uses analytical methods in the process of finding the appropriate solution. In the environment-agribusiness interaction, operational research can represent a tool that can contribute to more effective planning, generating scientifically based solutions to current problems and therefore gaining a competitive advantage in relation to similar enterprises. By means of the specific methodology (modeling, simulation, optimization through linear programming, etc.) it can determine the optimization of production flows, establish the most efficient way of determining feed in the livestock sector and realize the optimization of transport networks (e.g. the shortest path problem). The decision-making process under conditions of risk and uncertainty is one of the essential elements in the management of a company that can provide the necessary data for a viable strategic approach, providing optimal solutions to the problems encountered. The work aims to highlight the importance of operational research as a science, to provide an image of how to use specific techniques and methods, indicating the favorability of using it as a strategic tool both in agricultural business and for environmentally friendly policy.

Key words: operational research, linear programming, agribusiness, natural environment

In the context of the growing global concern for sustainable development, the environment-agribusiness interaction is a constitutive element of ensuring the balance between nature and economic activity. Often economic development damages the natural environment and it is a difficult mission to find a compromise favorable to both sides.

As a strategic tool in this fundamental relationship for the evolution of a society, operational research can also be used to provide mathematical solutions in finding the optimal result respecting the restrictions imposed by the natural environment or the production structure.

Operational Research can be defined as the discipline of optimizing decisions with the help of mathematical modeling (Brezuleanu S., 2004) seeking to provide decision and policy makers with necessary analytic tools in order to increase efficiencies and to generate better decisions (Mishra M.K., 2020) providing scientific method and mechanisms as structured and critical approach to problem solving aiming at solving real life problems through helping people to establish optimum utilization of limited resources (Monks T., 2016; Sharma J.K., 2017).

Technology development and the improvements in computational processing contributed to the development Operational Research as science. Methods used within Operational Research in order to ensure better decision, highest profit, lowest costs or shortest time in agribusiness activity are: decision trees, scheduling models, queueing theory, location, allocation, and routing models, Markov chain models, Discrete-Event simulation (Romero-Conrado A. R. *et al*, 2017), linear programming, non-linear programming, game theory or inventory control (Lyeme H., Seleman M., 2012).

Most of the models are prescriptive or optimization models that will enable an organization to best meet its goal(s). The components of a prescriptive model include objective function(s), decision variables and constraints, seeking to find values of the decision variables that optimize (maximize or minimize) an objective function among the set of all values for

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the decision variables that satisfy the given constraints (Winston W., Goldberg J., 2004).

Given the very large number of computations, the linear programming method implies the use of computational electronics. The optimization of the crop structure by linear programming requires elaboration of the economic-mathematic model, which consists in objective function and restrictions (Viziteu Șt. *et al*, 2018). A solution for a problem using operational techniques has three stages or phases: formulation, solution, implementation *(figure 1)*.

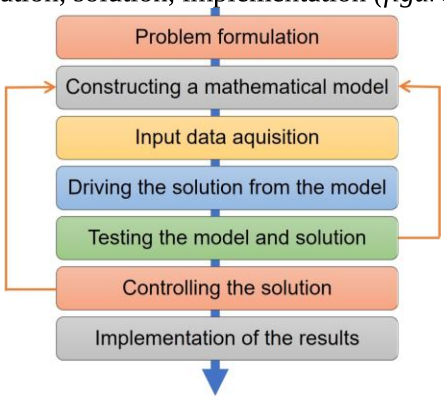

Figure 1 **Phases of Operational Research**

Operational Research is used in decision-making for researchers especially by agricultural economists in solving problems regarding transportation, manufacturing, purchasing and selling, suggesting which strategy should be adopted by the companies under a given set of situations for the best management (Singh A., Tesema M.W., 2018; Brezuleanu S., 2008).

The environmental issues like habitat protection of species, chemical fertilizers abuse or soil protection are analyzed together with the economic and social dimensions. Economic growth is often considered to be in conflict with sustainable development and environmental aspects (Mishra M. K., 2020) as limited resources and environmental pressures demand for better decisions that should be technically better grounded. Fertile land being limited and scarce, Operational Research and Management Science become more and more fundamental sciences in making decisions in the agricultural sector (Carravilla M.A., Oliveira J.F., 2013).

MATERIAL AND METHOD

In order to carry out this work, the bibliographical resources related to Operational Research, production systems and agricultural management were consulted. For the data used, the FAOSTAT, EUROSTAT and National Institute of Statistics databases were used as information resources. Along with documentation and statistical data analysis, the linear programming method was used and presented as an operational research tool in optimizing the use of production factors and ensuring the efficiency of technical and economic activities in agribusiness.

RESULTS AND DISCUSSIONS

Land is one of the most important resource for the world as it provides the base for agricultural production. Land use (*figure 2*) and land structure in ration to climate conditions and environment are important issues that Operational Research operates with.

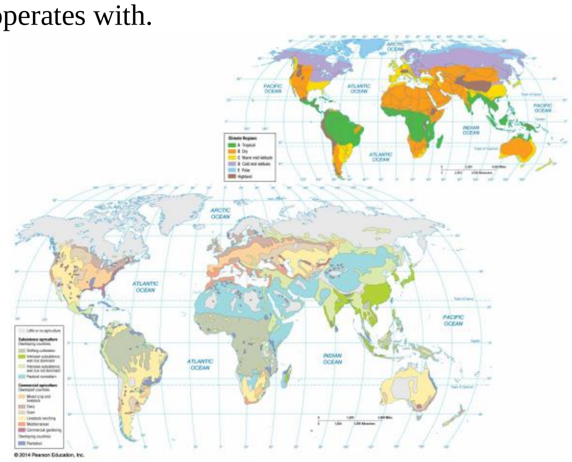

Figure 2 **Global land use related to climate regions**
Source: FAOSTAT

The strategic approach regarding sustainability and the offering of natural products requires generating an appropriate land use structure. For the EU, the average of organic farming areas is 8.5% (*figure 3)*.

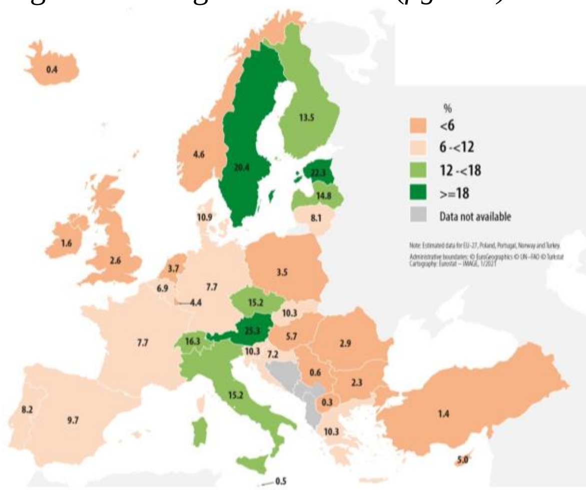

Figure 3 **Organic farming area 2020 (% of organic area in total UAA)** Source: Eurostat

Economic theory has benefited from the contribution of the interdisciplinary approach that allowed deepening the analysis of the maximum efficiency for complex systems and discovery of new concepts of the economic optimum and knowledge methods. The economic practice was enriched with a particularly useful tool for economic analysis and substantiation of decisions, especially in the economic units related to the agricultural sector. For Romania, the counties of Timiș, Bihor and Constanța stand out with the largest number of units in the field of Agriculture, forestry and fishing (*figure 4*).

Figure 4 **Number of active economic units in Agriculture, forestry and fishing, for Romania (2020)**
Source: National Institute of Statistics

Mathematical programming models and especially their subclass - linear programming models - occupy a particularly important place, both in theory and in economic practice.

The structure of the general linear programming model is constituted primarily by the set of activities $\{A_1, A_2, \ldots An\}$ that build the analyzed economic system, the set of resources used $\{R_1, R_2, \ldots R_m\}$ as well as by the technical relations - economic among them. The link between activities and resources is determined by the manufacturing technology corresponding to each activity Aj (j=1,...,n) and can be numerically characterized by the column vector a(j) of components $(a_{1j}, a_{2j}, \ldots a_{mj})$. The elements $\{a_{ij}, i = 1,\ldots,m; j = 1,\ldots,n\}$ are called technical coefficients or specific consumption coefficients and show what amount of the resource R_i is consumed for the production of one unit of the product (service) P_j (as a result of the activity A_j). All manufacturing „technologies” defined by the column vectors a(j) can be organized in a matrix A with m lines and n columns; each line refers to a resource R_i (i = 1,...,m) and each column refers to an activity A_j (j = 1,...,n).

Denoting by x_j (j = 1,...,n) the result of activity A_j in a given period and by b_i (i = 1,...,m) the quantities available from resources R_i (i = 1,...,m), the following technical-economic restrictions can be written mathematically:

$$(1)\quad \begin{array}{l} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \le b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \le b_2 \quad \text{or } A\cdot x \le b \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \le b_m \end{array}$$

where $A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}$; $x = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$

Each inequality/restriction reflects the fact that the amount consumed from a resource cannot exceed the available volume and the total consumption R_{ij} from the resource R_i as the performance of the activity A_j is proportional to its intensity (x_j), so $R_{ij}= a_{ij}\cdot x_j$.

The system of restrictions (1) makes the connection between resources and activities by means of the m linear restrictions. The model of the linear programming problem contains restrictions of type (1) as well as a „performance„ criterion that allows the evaluation of the efficiency foreach activity. Depending on the goal pursued, we can choose as an efficiency criterion an indicator that measures the effort, one that measures the result or an indicator expressed as a ratio between result and effort (or effort per result). It is obvious that maximum efficiency means minimizing effort and maximizing the result, and the concept of optimal is defined, in this case, as a program $x \in R^n$ that minimizes or maximizes an objective function and, at the same time, satisfies all technical-economic restrictions.

Assuming that each component of the line vector $c = (c_1, c_2, \ldots, c_n)$ measures the efficiency of one unit from the result of the activity Aj, then the linear function can be introduced: $f(x) = c_1\cdot x_1 + c_2\cdot x_2 + \ldots + c_n\cdot x_n$, which evaluates the performance of any program x. Summarizing, we obtain the following linear programming program:

$$\underset{x}{\text{optim}}[f(x)]$$

$$\begin{cases} \sum_{j=1}^{n} a_{ij}\cdot x_j \le b_i & i \in I_1 & (1) \\ \sum_{j=1}^{n} a_{kj}\cdot x_j \ge b_k & k \in I_2 & (2) \\ x_j \ge 0 & j = \overline{1,n} & (3) \end{cases}$$

Relations (1), (2) and (3) together constitute the general model of a linear programming problem, each having a specific role:

1. relation (1), where $f(x) = \sum_{j=1}^{n} c_j \cdot x_j$ is called the objective function of the efficiency of the problem, it evaluates the efficiency/ performance of each program variant *x*;
2. relations (2) $\sum_{j=1}^{n} a_{ij}\cdot x_j \le b_i$ represent resource constraints; and the restrictions $\sum_{j=1}^{n} a_{kj}\cdot x_j \ge b_k$ refers to technical-economic constraints of a qualitative type (as a result the

indicator b_k is the lower limit imposed on the „optimal recipe”);

3. relation (3) $x_j \geq 0$ $j = 1,...,n$, called the condition of non-negativity of the variables, ensures obtaining a feasible solution from the economic point of view.

The basic structure of an application in the economy is primarily determined by the objective pursued. Thus, in the case of the problem of establishing the optimal assortment structure of the production, the available quantities (the quantities that can be obtained during the analyzed period) of each raw material are known $\{b_i,\ i = 1,...,m\}$, technological coefficients $\{a_{ij},\ i = 1,...,m,\ j = 1,...,n\}$ (a_{ij} represents the quantity of the raw material i required to manufacture one unit of the type product j), maximum amounts$\{\overline{x}_j, j = 1,...,n\}$ and minimal $\{\underline{x}_j, j = 1,...,n\}$ what can be produced from each assortment in the analyzed period and profits unit $\{p_j, j = 1,...,n\}$ of each type of product. It is required to find those quantities x_j that must be manufactured from each type of product so as to obtain the maximum profit, without exceeding the available from each resource.

To simplify the model, it is assumed that the price of a good does not depend on the quantity produced from it or from the others, the consumption of each raw material is directly proportional to the quantity produced and, for each good, the consumption of one resource or another is not mutually conditioned. The equivalent mathematical problem is:

$$\begin{cases} \max\limits_{x_j\ j=\overline{1,n}} (p_1x_1 + p_2x_2 + ... + p_nx_n) \\ a_{i1}x_1 + a_{i2}x_2 + ... + a_{in}x_n \leq b_i & i = 1,...,m \\ \underline{x}_j \leq x_j \leq \overline{x}_j & j = 1,...,n \\ x_j \geq 0 & j = 1,...,n \end{cases}$$

In some problems, instead of profits p_j, unit revenues v_j, costs unit c_j or another efficiency criterion, is known the optimal goal of the respective efficiency indicator. The production limitation conditions may also be missing or there may be other conditions.

CONCLUSIONS

The efficient use of agricultural land, aggressive climate changes, the tendency of consumers to orient towards organic products have a high impact on economic units in the agricultural field (both primary production and processing). Agriculture is a field in which there is a strong interaction between economic activity and the natural environment, ensuring this balance having a significant impact on the development of society as a whole. Linear programming and the other methods associated with Operational Research help to obtain viable mathematical solutions and implicitly the scientific substantiation of managerial decisions.

In order to operate at the parameters required by economic evolution and in compliance with environmental conditions, it is important for companies to find solutions to maximize profits but also to minimize expenses, especially due to the new global evolution of energy prices. Operational Research can represent one of the strategic tools for implementing these objectives, ensuring the sustainability of the activity and the strategic vision in environment-agribusiness interaction.

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*** FAOSTAT database

*** EUROSTAT database

*** National Institute of Statistics