INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

**ISSN: 2454-132X**

**Impact Factor: 6.078**

**(Volume 7, Issue 5 - V7I5-1252)**

Available online at: https://www.ijariit.com

# Application of Operational Research in Optimization of Agricultural Sector

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## ABSTRACT

***The goal of this study is to see if operation research approaches are suitable and applicable to decision-making in farming. The methods and principles of operational research can be applied to agriculture and development in a variety of ways. The process and problems are investigated as to how operational research can be put into use in the manner to optimize value. The technique of integrating advanced logical theories and models to aid in better decision making and resource utilisation is termed as operations research. This research is focused on the use of operations research methodologies in the realm of agriculture. They are used in a variety of elements of agriculture, including day-to-day decisions made by farmers such as selecting the best grain, farm planning, cost reduction and profit maximisation on a single farm, and crop production and transportation. This research study uses scenarios and issues to demonstrate several Operations Research theories and models applied to agriculture.***

***Keywords-*** *Operations Research, Agriculture, Linear Programming, Queuing Theory, Game Theory, Inefficiency*

## 1. INTRODUCTION

According to India's Agricultural Census, more than 50 percent of the country's population lives in rural areas and is reliant on agriculture. Agriculture is important in several countries, including numerous European countries, Japan, and parts of the United States. Agriculture is incredibly important and critical to India's economic growth. India is the world's second-largest producer of fruits, overtaking and outnumbering vegetable production. In terms of agricultural and farm production goods, India is ranked third, with horticulture output, which includes vegetables, spices, and fruits, reaching a new high this year.

Agriculture has traditionally been thought to be a low-profit, high-risk business. Thousands of farmers commit suicide each year because of the industry's dire state. Farmers can use a variety of operations research techniques to solve their troubles. Linear Programming is an optimization technique that uses a collection of linear relationships to express a set of criteria, it can also be used in agriculture to make better decisions about resource distribution and livestock formulation. The framers can use Game Theory to determine risk and uncertainty because it is a type of decision theory in which one's choice of action is determined after considering all possible alternatives available to an opponent playing the same game, rather than just the possibilities of several outcome results. The Queuing Theory is another important theory. It is the mathematical study of how waiting lines, or queues, form, function, and congestion of waiting lines. It can be used to assess upkeep and maintenance in agriculture.

## 2. LITERATURE REVIEW

Agricultural land disposition issues are frequently discussed in the literature. The study shows how to apply an alternative decision model to help farmers make decisions in the face of ambiguity. Linear programming and hybrid linear programming are commonly used to solve these challenges. The application of linear programming for individual farmers is referred to as "programme planning" in Europe and Japan. Game-theoretic models were emphasised. These models don't have much empirical support when it comes to farmer's decision-making. Only the model for maximising expected utility, game-theoretic models, naive or econometric models, and different precautions for uncertainty provide an objective method for achieving an implicit or explicit goal among the various models for decision making under uncertainty. However, according to this study, it indicates plans that farmer in a variety of issue situations would choose to pursue. The model could be used by researchers and extension agents to generate farmer recommendations. Queuing theory, at its most basic level, concerns arrivals at a facility (e.g., a computer store, pharmacy, or bank) and the facility's service requirements (i.e., technicians, pharmacists, tellers). Because the results are frequently employed for making business choices regarding the resources needed to provide service, queueing theory, the mathematical study of waiting in lines, is a branch of operations research. Queuing theory models can be used to solve a variety of difficulties and elements in agriculture, including loading and unloading issues, upkeep and maintenance evaluation, crop production and delivery, and feed production.

To find sets of locations that best represent specific species, Church et al. (1996) devised a maximal-covering-location problem. The reserve-selection problem was solved using OR models by Cocks and Baird (1989) and Rosing and ReVelle (1986). This specification is a simplification of the genuine problem since different species require distinct habitat types described by levels of tree growth (or seral stages). Murray (1999) demonstrated that by taking a step back and including the construction of cutting units into decision models, they might improve solutions. Barret et al. (1998) used solely local search techniques to solve numerous instances of the ensuing difficult combinatorial problems.

## 3. PROBLEM STATEMENTS

- The inefficiency to resolve the challenges in appropriate distribution of resources in agriculture.
- The inefficient marketing of agricultural output and its spatial analysis.
- The challenges of weather factors, market price fluctuations, and agricultural and animal illnesses which are loaded with risk and uncertainty.
- In low profitability, high risk vocation, the sector suffers from losses due to lack of modernisation.
- Formulating Livestock Rations and Feeding Stuffs usually gives an ultimatum to the workers.

## 4. ANALYSIS

- ***Application of Linear Programming***

A linear solution is also found for the problem of selecting agricultural land / agricultural practises at the farm level to avoid soil degradation. Since its inception, linear programming has been utilised in the agricultural industry to model crop optimization as well as resource allocation (water, land, fertilisers, etc.) These techniques were utilised at the macro level to handle agricultural marketing problems and spatial analysis, in addition to their usage at the micro level, i.e., cost minimization and profit maximisation for a particular farm. In agriculture, transportation models are simpler linear programming models. The model can be used to find the best way to pick or combine agricultural projects to increase income or cut costs while staying within budget constraints. It is an alternative to the usual system of "process and errors" that farmers have been forced to utilise. There are three key reasons for employing the LP model to tackle most farm problems:

(a) Increase the profitability of small farmers' crops, allowing them to meet their production needs for food crops while also encouraging them to use the environment meaningfully.
(b) It is used to maximise profits and determine whether profits have increased or decreased after the model was implemented.
(c) In the realm of agriculture, where ambiguity and vagueness influence decision-making, several researchers used LP model types, such as relevant programming objectives, to tackle their difficulties.

Waugh (1951) used LP models to identify the least-cost combination for the feeding-stuffs industry and farm-level livestock feeds that met specified nutritional needs, which was the first successful application of mathematical programming in agriculture. Many farmers and feed mixers have depended on LP for the optimal design of livestock diets since the early 1950s. The basic analytical LP framework has been expanded in numerous ways by analysts. They employ parametric LP to investigate the impact of price changes in ingredients (objective function coefficients) on the best blend. They determine the shadow price of each model constraint (nutritional requirement) by examining the dual models. When the real composition of some constituents is unknown, incorporating chance-constraint programming boosts the realism of the model. Analysts have expanded the approach in this sector in a variety of ways, including looking into the relationship between the ration's weight and cost, and putting the technique to use in a real-world setting.

- ***Application of Game Theory***

Agricultural decisions are frequently made in a climate of uncertainty. Technical and technological advances, pricing fluctuations, and unpredictable human behaviour all contribute to uncertainty. The employment of game-theoretic approaches in farm planning could be very beneficial. In most cases, averages are utilised as input-output coefficients in linear programming or budgeting. They are susceptible to change. This fluctuation may have an impact on the farm's overall profitability. Some farmers wish to ensure that their income does not fall below a certain minimal or achievable level. As a result, a comprehensive farm plan based on average input-output coefficients is not feasible. Farmers, on the other hand, might embrace a strategy that guarantees maximum-minimum levels each year. A scheme like this may be built around the input-output coefficient generated from a game versus nature using the Wald criterion. A plan that ensures a minimal return would be suggested as a remedy to an agricultural enterprise challenge. The output coefficient can be thought of as the minimum return. The input coefficient is determined by the required combination of varieties, fertilisers, and cultural methods in crop planning. The specific crop is an activity that should be considered as part of a linear programming analysis that is used to plan the entire farm operation.

The application of game-theory rules was questioned by Anderson et al. (1977, p. 204) because the decision criteria utilised is incompatible with the axioms of rational choice. Analysts, on the other hand, are rediscovering the game-based approach and critiquing the axioms of rational choice that underpin Markowitzean techniques (e.g., Zeleny 1982, pp. 437–438). Despite the dominance of these two approaches in agriculture, analysts have proposed and implemented additional methods to cope with risk and uncertainty. Safety-first models, chance-constraint programming, and stochastic programming are some of them. The decision makers' preference for safety is lexicographically satisfied with safety first models. Then there's the possibility of profit-driven initiatives. The analyst deals with the uncertainty of available resources in chance-constraint programming by assuming that their distribution probability is known and setting a lower bound on the probability of the constraint being satisfied. Finally, some or all the constraint set's coefficients are random variables in stochastic programming.

 

Hardaker et al. (1997) examines the technical aspects of these techniques, as well as their potentials and limitations.

- ***Application of Queuing Theory***

Loading and unloading challenges, upkeep and maintenance evaluation, crop production and distribution, and feed production are all problems that queuing theory models can handle. The queuing theory can be used in industries that are related to agriculture, such as fertiliser, tractor, and so on.

From the initial application of operations research during World War I through today's sophisticated technologies across a broad array of industries. Education, health, welfare, urban affairs, and even agriculture are all areas where operational research is used. Other techniques, such as game theory, simulation, time-network analysis, queuing theory, inventory control, and others are commonly used in addition to linear programming. The bulk of these tools can be used in all parts of agricultural economic activity including production, consumption, exchange, and distribution. As a result, operation research can be utilised in agriculture to make the most use of land and grow crops that are suited to the climate of the location.

## 5. CHALLENGES

- Operations researchers while commenting on conflicts in the business, do not focus on the incentives and structures that drive these conflicts. Operations research models do not give a complete theory of decision making in the firm. In policy analysis and finance, these professions come together when there is a desire to enhance decisions based on needs and create chances for increased productivity and profit. Environmental issues are becoming increasingly complicated, posing new challenges for Operation Research models.
- As one moves from farm level to regional-sector models, an aggregation bias emerges, making it difficult to discern the true goals that farmers pursue.
- Using Linear Programming models to estimate optimal animal diets is not without challenges, despite its proven efficacy. The cost of the mix cannot be used as the sole basis for making decisions, especially when calculating cattle rations at the farm level. Farmers are looking for economically optimal rations that strike a balance between competing goals including cost, bulkiness of the mix, and nutritional imbalances.
- Another issue with the classic LP technique is the very strict dietary requirements definition.
- In agriculture, Operation Research has focused on breaking down the problem into components, then applying mathematical tools to identify the best solution for each component. Because there are complicated interacting drivers in productivity, markets, the environment, and people, this strategy has limits. It is no longer sufficient to focus solely on optimising sections of these complex systems without considering the entire system.
- A computer is necessary to perform the math required to analyse the situations. The agricultural company's operations would be harmed if technology failed or if records were lost in some way.
- In many circumstances, operations research will require people to rely on estimates. One of the results used to decide could be misleading.

## 6. CONCLUSION

In the agricultural industry, operations research is extremely important, especially when it comes to decision-making.

Agriculture, as we indicated in our literature review, plays a vital part in the economies of many countries, but it is now under threat from issues such as climate change, resource scarcity, soil composition changes, and so on. Many of the tests undertaken in various locations have yielded favourable results, and these techniques, if implemented on a wide scale, can result in huge improvements in the sector of agriculture. As a result, resources will be better utilised and waste will be reduced, enhancing process efficiency and profitability. OR is a discipline that applies advanced analytical approaches to assist people in making better decisions. It has been used in the agriculture management industry since the 1950s to solve challenges ranging from higher-level strategy planning to farm operating concerns and integrated supply chains. Although OR is already widely used in agriculture management applications, the potential for growth is enormous, especially in times when resources are becoming increasingly scarce and more must be done with less in a sustainable manner.

If we continue to deplete our resources at this rate, there will be little left for future generations. The key to a successful future is sustainable development, and Operations Research can help us get there. To boost growth, use fewer inputs, and improve the quality of the food. new inventions, better procedures, and improved facilities can be developed for use in farming.

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