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Research Paper

Making agriculture efficient with Operations Research

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I. Introduction

Indian agriculture dates back to 9000 BC as a result of the early cultivation of plants, and domestication of crops and animals. The green revolution (1960) transformed India from a food deficient country to a surplus food market. Approximately 43% of India's land is used for farming/agriculture. Agriculture plays a vital role in India's economy. 54.6% of the total workforce in the country is engaged in agricultural and allied sector activities and accounts for 16.5% of the country's Gross Value Added (GVA) for the year 2020-21 (at current prices).

Operations Research in agriculture sector assists in finding scientific, mathematical and logical solutions to a problem leading to informed decision making. The OR research techniques help in resource optimization, production planning of crops, product mix etc. resulting effective and efficient farm planning.

The focus of this research paper is to study various Operations Research techniques for implementation of effective and efficient farm management strategies. The paper exhaustively deals with the problem of Custom Feed Mixing, whereby a farmer can order a specific amount of livestock feed and specify the amount of corn, grain and minerals the feed should contain using Linear Programming Technique of Operation Research.

II. Literature Review

Research Papers related to Linear Programming:-

This research paper, written by Andres Weintraub and Carlos Romero is about 2 finding the solution to 2 problems- Agricultural Planning Problems at farm level and Agricultural planning Problems at region-sector level using Linear Programming. Using Linear programming, the professors were able to find the combination which maximises profitability with least cost.

One research paper is based in China. It is written by Zhao Qingzen, Wang Changyu and Zhang Zimhin. In Their paper, they conduct a study on Chang Qing County, where with the help of linear programming they figure out how to maximise the productivity of the land, while also meeting the social demands of the area and following the polices of the government.

Research scholar mahak Bhatia and professor of mathematics G.M.J. Bhat co published a paper called linear programming approach-application in agriculture in which they discussed how linear programming can be used by farmers to maximize their profit by efficient utilization of available resources while also considering all the uncertain variables which comes in agriculture

Ahmad Maidamisa, Rohanin Ahmad and Mohammed Ismail Abdulaziz published a paper titled operations research in agriculture in which they showed how the application of analytical hierarchy process can help farmers determine how much portion of land should be allocated to which crop to gain maximum profit

A paper named operational research tools in irrigation published by Zia ul haq, Muhammad Nasir Jamal among with three more researchers talked about how GA optimization tool can help in irrigation and agriculture sector by creating optimum technique for water delivery scheduling and make it more efficient

Moghaddam A. K. et al. (2018) in their paper titled 'Optimization of Tillage and Sowing operations using Discrete Event Simulation', have discussed about development of a simulation model for secondary tillage and sowing operations in autumn using simulation technique using Arena simulation software. The study highlights the process of evaluation of 8 machinery sets on a 50-hectare farm wherein total costs including fixed-costs, variable costs and timeliness costs were calculated for each machinery set, timeliness costs for 21-years period on daily basis.

Singh, Ajay S et al. (2018) in their paper 'Operations research in agricultural and economic research for multiple criteria decision making: a linear programming approach' have critically defined the use of OR techniques in agriculture sector. Tools such as linear programming (integer and non-integer, price variable and resource variable, perturbation techniques, etc.) and nonlinear programming (e.g., quadratic programming, concave and convex programming) and dynamic programming have been discussed at length. They have discussed the importance of an objective function which can be defined in terms of a mathematical model for obtaining the desired result through OR techniques grouped under a general heading of mathematical programming.

OR is used for solving the problems related to decision making strategies for planting crops and also using optimal minimum costs to feed the livestock. Linear Programmingis a tool which can be used to determine the minimum cost for feeding livestock. Also, it can be used to determine crop rotation patterns where we take objective function as objective function and land and labour as the constraints. Apart from that, it can also be used for obtaining the optimal food combination with all the required nutrition.

Research Papers Related to other OR tools:-

In the second research paper by Biesta Andric Gušavac, Dragan Stefanović and Zeljko Sokolov, they have chosen a large agriculture filed of company X which is situated near Belgrade. Company X is one of the leading companies in food production and production of this corporation is main base for meat and milk industry, industrial and other vegetables used in food industry. With the help of simple plant location model, they are able to identify 9 points, or 9 airfields where cost would be minimum and profit would be maximum.

Positive Mathematical Programming is a tool which can determine farmers' behaviour when profit maximization is the goal.

Simplex method is another method which can be used in place of graphical linear programming is used when there are more than 2 variables.

Data envelopment is a programming- based method which is used to determine efficiency in farming by finding optimal farm land areas.

Game theory is a tool which is used to solve the problems where agriculture is dependent on various climate uncertainties such as weather, soil and climate conditions.

III. Analysis and findings

The OR tool used, that is linear programming, has helped in solving two problems- agricultural problems in farm level and agricultural problems in sector region level. Linear programming has not only helped in maximizing profit and minimizing cost, but has helped to assessing and simulating the economic impact of some agricultural policies. Linear programming has also helped in analysing on increasing yields through the intensive use of agro- chemicals, fertilizers, and other inputs. Linear programming to some extent has also helped in identifying impact on profitability because of factors such as changing weather conditions, change in market prices etc. Linear programming, along with maximising profit also helps in other factors such as identifying which crop rotation pattern is best, which feed mixing will give the highest nutrition to crops etc.The agriculture sector is mainly concerned with the problem of how to plant crops i.e., the planning involved and the decision - making strategies and also how the livestock can be fed at the minimum optimal cost.

Linear programming can be used to determine the minimum cost required for feeding the livestock wherein, minimum cost can be obtained with the nutritional requirements being the constraints

Agriculture is a field where OR is being used since quite a long time. It is a tool which helps in good decision making in the sector. Countries such as Japan and parts of USA use linear programming to determine the optimal production.

The criteria under which it will work is that the number of farmers should be finite. Game theory tends to change the behaviour of the farmers to attain the outcome. Another tool which is used is called two-person, zero-sum games which involves 2 farmers and there is one winner and one loser.

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IV. Conclusion

Operations research, specially Linear Programming in agriculture has been used since a very long time. However, the use of Linear programming in agriculture in decision making is hardly 20 years old, but has been highly useful specially in developing and under developed countries, where there is shortage of resources like water. It has been able to provide farmers with best combination of least cost, maximum profit and maximum nutrition in spite of factors like changing environment conditions, lack of resources, social demands(as seen in the case of China) and other economic factors. There are many other Operations research tools that have been proven to be useful, like simple plant location problem which helps the decision maker to decide where to do farming among all the possible locations(as seen in the case of Serbia's air field). Another OR tool is positive mathematical planning, which analyses a farmer's behaviour when profit maximisation is the goal. This tool has been highly useful to analyse if a farmer resorts to unfair means to maximise their profit. Next tool is the simplex method, which is used when there are two or more variables. It is a part for linear programming but is used when the constraints are multiple and complex .One of the most recent OR tools used in agriculture is data envelopment, which maximising efficiency by finding optimal farm land areas. For choosing the best land or area, simple plant location model and data envelopment have been proved best. Another tool which is used in agriculture is game theory, which is useful for areas where there are many uncertainties related to weather conditions, for example in areas where the weather is highly unpredictable. However, in the long history of Operations research in Agriculture, after using, trying and testing so many tools, it has been accepted worldwide that Linear programming is the best Operations research tool when it comes to agriculture.

Limitations and recommendations

Even though Operations research has been very useful for finding out maximum profit and least cost combination over the years, there are still some limitations that are prevalent.

Here are the limitations of use of Operations research in Agriculture-

1.Magnitude of "other factors"

OR tools have been able to tackle many factors like changing weather conditions, social demands, change in market prices etc. but does take into account all the factors? That is debatable. There are endless of number of factors that can affect the agriculture industry and considering all of them is next to impossible.

2.Non quantifiable factors

Operations research is quantitative subject, and hence it can take into account only those factors which can be expressed in terms of numbers. For example, it won't take into account the mental health of a farmer due to huge debts, death of a family member etc. This is a big limitation as it can affect the overall productivity.

3.The gap of knowledge between user and analyst

It is a well known fact that farmers all over the world, especially in India are not much educated, let alone being educated in the field of Operations research. Hence, for them to understand an OR problem is very difficult. Therefore, even if an expert analyst gives a detailed and excellent report to a framer related to his/her land, it would be tough for them to Implement it.

4. The never ending problem of money

Farmers in India live a very poverty stricken life. Majority of the farmers remain in a debt trap all of their lives, paying unjustifiable amounts of interest and keeping their personal assets mortgaged. Hence, they can't afford to hire expensive OR analysts to get their lands analyse, neither can they do the analysis themselves because of their lack of knowledge regarding the subject . Therefore, majority of the farmers are not able to utilise the advantages of operations research.

V. Recommendations

Our recommendations would be that linear programming no doubt is a very good OR tool and should continue to be used in the field of Agriculture. However, it would be better if unknown or unexpected factors are also taken into consideration life coronavirus, =recession, natural calamities such as earthquakes etc.

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