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Applications of Operations Research in Agri - food Industry

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"TRUE OPTIMIZATION IS THE REVOLUTIONARY CONTRIBUTION
OF MODERN RESEARCH TO DECISION PROCESSES." - George Dantzig

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ABSTRACT
We know how we get our meals ready at homes but we rarely think how we receive those fruits, vegetables, beef etcand how readily they are available to us as our demand to answer this question we use the theories and tools of operations research to find the best optimal path so we can receive our requirements as and when required in this research paper we discuss how and when these tools are used and implemented in the different parts of world. We have taken all the practical application which have been tested around world to solve the problems optimally and feasibly around the world

Key Words: - Operations Research, Agriculture, Food Tech, Supply chain

I. INTRODUCTION

In the world of changing technology and finding efficient ways of doing things and delivering your services at a faster pace resulted in the advancement of the technological systems and implementation in the agri-food industry while the implantations are considered most of them are been used in the programming software's and in the process of delivering the desired food products optimally to the desired market. In this research paper we will touchon the following topics Planning about horticulture, Productions and Logistics of seed corn, harvesting of apple from orchids, simulating the fruit supply chain, planning optimal transport of fruits to fruit logistic centres , optimizing the sugar supply chain, Swarm Intelligence in Optimal Management of Aquaculture Farms, : An Application of TOPSIS Models, ,Optimal Delivery of Pigs to the Abattoir and Multi-objective Optimization for Improved Agricultural Water and Nitrogen Management.
Our objective of this research is:

1) Understanding the useof different Operations Research topics in different scenarios related to agriculture and supply chain.
2) Using the Operation research tools for solving the problems.
3) Understanding the constraints/limitations of the tools and technologies uses around.

Industry overview

The sector of natural resources has been utilizing OR for a time now. Mining, agriculture, and forestry have all seen significant breakthroughs. One sector where OR has performed exceptionally well is forestry. This has been greatly influenced by the fact that forest lands and enterprises are quite large in terms of both area and financial resources. Environmental constraints, sustainable development, and consumer demand for better-for-you, safer-for-you, and more secure products all provide challenges that heighten the need for wise decision-making. It is widely acknowledged that operations research has proven to be extremely valuable in these fields through the application of its problem-solving techniques and, perhaps more importantly, through the way it assists in defining the current problems and characterizing the challenges that must be overcome. The use of OR tools has become more essential as a result of growing industry specialization, more competition in a globalized world, the need to efficiently produce and transport commodities. Consequently, there is an opportunity and a reason to invest money in implementing sophisticated management systems. Although the majority of this special issue is devoted to agriculture, we can also see the effects of linked developments in that sector.

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II. LITERATURE REVIEW

After studying through many articles, we identified the following application of OR tools in agriculture industry and the problem areas which they solved.

- MCDM Approach –It helped in evaluating the sustainability of olive farms by different methods (TOPSIS and Weighted sum) and analysing the differentiation between influence of selection of indicators for each dimension of sustainability and social preferences regarding olive grove sustainability.[10]
- Transportation Problem (TP)
- It solved many issues for beef supply chain - At what locations should meat processing take place so as to minimise transportation costs subject to infrastructure choices and budget? What transportation infrastructure is crucial to keep the beef value chain operating? What are the flows to be transported and processed among facilities during the time horizon?
- Keeping in mind the planning of Seed Corn, Transportation problems help solves the most frequent issues such as demand constraints, maximum concentration restrictions, transportation resource limits, production capacity constraints, and minimum capacity usage requirements.[11]
- LPP - This method helped in allowing to feed animals with a different mix every day without increasing the storage cost.[13]
- Minimization Linear Programming - It simplifies the problem of decision-making for a manager as to which type of harvesting is more convenient for labour and harvest schedule. It is recommended to improve the crop estimation method used in orchard.[3]
- Mixed -integer linear programming (MILP)
- It helped in determining the start of delivery of pigs to abattoir and how many pigs to sell under a pig operating unit called AIAO(all-in-all-out). The problem that producers faced was the time from service which was required between the 2 batches of pig out for delivering and fattening. [12]
- In case of Cuba, we have the problem that the big sugar mills which take supplies from the surrounding farms the coordination between them is very important to avoid problems like overflow of mills capacity during the peak of harvest season.[4]
- Multi-objective Evolutionary Optimization Model (MOEO) – It solved the problem of crop production and at same time being sustainable by providing set of optimal choices where the decision maker has to trade-off between them.[12]
- Finite & Infinite Horizon Markov Decision Processes – This decision-making tool aims at finding a policy of decisions that maximizes the output, discounted rewards etc. It solved the problem of Livestock farming where it was difficult to determine the state of an animal.[14]
- SCDT (supply chain digital twin) – It helped in proposing the solution for vegetable supply chain where supply chains are complicated to evaluate due to the geographically diverse supply networks between farms, processors, and retailers.[6]
- CPLEX - the problem was the delivery fruit supply chain and how it varies from country to country. For this we had developed and tested of a model used to optimise the delivery of flowers by a cooperative. The model was written in the ILOG OPL modelling language and the CPLEX v12.2 solver was used to test it.[5]

III. ANALYSIS AND FINDINGS

The use of linear programming was used to solve the following problems:

1) Planning the Planting, Harvest and Distribution of Fresh Horticultural Products the problem of perishability of the crops (PER) was solved by the modelling approach (mixed integer linear programming) and the supply chain was changes accordingly by using Game Theory Principles, The New Vendor Problem, Non-linear Optimization.[1]
2) Use of minimization linear programming in optimising the harvest of apples from orchards.[3]
3) Here use of the mathematical model of linear programming (MILP) model dealing with all of the aspects of the operational problem of sugarcane transport for one day in case of sugar industry of Cuba.[4]
4) Use of mixed integer linear programming in solving the supply chain issues of the vegetables and fruits to find the optimal paths for harvesting.[6]
5) Optimal Delivery of Pigs to the Abattoir (MILP) was used in solving the problem. [12]
6) Multi-objective Optimization for Improved Agricultural Water and Nitrogen Management in Selected Regions of Africa by driving the memo framework.[8]

We use transportation problem to solve: -

1) Logistics Planning in Seed Corn to solve this a tool IBM MPSX (Mathematical Programming System Extended) was used which showed that a saving of $5.69 million was possible per year using the paths and conditions described by

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MPSX. It also included the Stochastic Operations Research (SOR) Model for distribution problems that may be involved.[2]

2) Use of supply chain digital twin for finding thePaths to reduce emission in the transportation.
3) On the Feasibility of Establishing a Northern-Western Australian Beef Abattoir as a Facility Location Problem.[11]

Use of Multi-criteria decision making (MCDM): -

1) In analysing Multicriteria Analysis of Olive Farms Sustainability [10]

IV. CONCLUSION

Having the knowledge of constraints and concepts can help to solve any problems in any scale it's all about observation and conclusion of the problem. And having proper resources and mindset we can come with models which are optimal and having the potential to impact lives and changing them. Having a good understanding of the constraints we can come up with solutions of constraints this applies to any field which wants constraint free framework with the understanding of the tools and topic we are now able to find the best possible framework for defining the solutions and using it optimally and feasible and we understand how some basic concepts operations research are being used to solve big problems around the globe which is actually saving resources, reducing emissions and reducing wastage it's true that " Having basic knowledge of thing help to create big difference".

V. LIMITATIONS AND RECOMMENDATIONS

1) Nonlinear optimization problems are intrinsically more difficult to solve than linear problems, and there are fewer guarantees about what kind of solution Solver can find.
2) As the number of players increases in the actual business the game theory becomes more difficult.
3) A highly complicated succession of events can be modelled using a few parameters by the stochastic reserving approach. As a result, like any model, stochastic or otherwise, it is susceptible to the charge that its presumptions are overly optimistic.
4) The occurrence of a local optimum. If your problem is nonconvex, there is no guarantee that the solver will discover the global optimum. Convex problems do not have this problem.
5) In case of harvest planning of apple orchards,the model takes into consideration the expertise of orchard managers who oversee the harvest with regard to characteristics like harvest estimation, harvest type, destination of the fruit in each field, and quality standards for fruit export.
6) The constraints that we used in the model of Cuba they vary in seasonal basis or due to fluctuation in demand and supply of the sugar.
7) The variability of the two factors the Sociocultural (Total labour, labour productivity, Soil cover, etc.) and Environmental Sustainability Indicators (no. of olive grove varieties, energy balance, etc.).
8) The non-predictable weather conditions.
9) The models were implemented in a very fine/small regions which may lead to inefficiency of model in a large scale.
10) As most of the operations depends on human resource there can be some misfunctioning which may lead to non-optimal solutions.
11) The factors considered in a region it might or might not be possible that if other region having the similar factors the model will work that optimally.
12) MVKDE is always biased.
13) As each diet problem is unique, so are the restrictions that drive the change, making it challenging to identify linear programming problems even after determining the objective function.

Considering the limitations, we can have some opportunities possible in the model

1) Having a leaner or adapting variables and tools.
2) Testing the process in demo environment can be used such in the case of SCDT (supply chain digital twin).
3) Using the models as examples and coming up with models which can have world-wide impact.
4) Using the flaws in the model to come with a flawless model.

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[5]. Chapter7 - Optimal Transport Planning for the Supply to a Fruit Logistic Centre
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