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Application of Operations Research in agriculture logistics and supply chain

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ABSTRACT

The purpose of this paper is to review already existing literature on conventional agriculture supply chain management and an analysis of the risks, opportunities and supply chain management. This research is an attempt to study both the conventional and organic agricultural supply chain through literature in order to reduce costs in all components (like production, warehousing, transportation, marketing, selling) of the agricultural supply chain throughout the process through operational research. The research also shows how the transition from conventional to organic agriculture can be the most cost-effective for farmers.

Keywords— Agriculture, India, Supply Chain, Organic, Optimization, Minimization

1. INTRODUCTION

India is at the epicenter of an organic farming revolution. According to the International Federation of Organic Agricultural Movements (IFOAM), there were 2 million farmers who stuck to organic farming methods out of which about 80 percent of the organic farmers are based in India. The Indian food and grocery market is the world's sixth-largest, with retail contributing 70 percent of the sales. The Indian food processing industry accounts for 32 percent of the country's total food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth. Organic food is a holistic approach in the Indian environment that starts at the farm and ends at the fork of the consumer. "A holistic and community-driven approach, similar to the 'Swachh Bharat' for 'Swachh Food' needs to be undertaken". Organic agriculture is important because it has the potential to maintain and increase yields while improving soil fertility, biodiversity, and other ecosystems. Indian organic food industry is growing in double-digits since 2013, hence it would not be wrong to say that this industry will perform well in 2020. The organic food industry is poised to be valued at USD 1.5 billion by the year 2020. The e-commerce sector is the facilitator for the organic food industry to reach out to potential consumers in tier II and tier III cities. Due to free/low-cost internet, people are becoming aware of the health benefits and popularity has increased the demand for organic products. Lastly, the industry landscape is becoming more competitive as more and more players are entering the market.

1.1 Overview of the Industry

Agriculture plays a critical role in contributing to a nation's economy and various other factors; some might even argue that it is the backbone of the economy of our country. India ranks second worldwide in farm outputs and first in the world with the highest net cropped area followed by US and China. Agriculture and its allied sector have been major contributors in India's economy and as per 2018; agriculture employed 50% of the Indian workforce and contributed 17-18% to the nation's GDP. Agribusiness, Supply Chain Management (SCM) suggests managing the relationships between the organizations in charge of the production and supply of items from the farm level to the consumers to meet consumers' requirements regarding quantity, quality and cost. In practice, this often incorporates the management of both horizontal and vertical alliances and the relationships and processes between firms.

Agriculture is one of the fields in which Operations Research models were first utilized and have been most broadly applied. Operations Research in agriculture and food management is already used in many different countries but its potential especially country like India, is huge along with considering shortage of resources worldwide where the yield has to be increased to cater the demands of growing population with the limited resources available. Extensive pre-planning and co-ordination are required up and down the entire chain to affect key control procedures for example forecasting, purchase planning, production, and processing programming, sales promotion, and new market and product dispatches. Following are the components of an organized Agri-supply chain:

- a) Procurement or sourcing
- b) Logistic management
 - Transportation
 - Material management
 - On the premise of supplying mostly from production, not stock
 - Warehousing
 - Logistics Network modeling
- c) Organizational management
 - I. Contracting
 - II. Strategic alliances and partnerships
 - III. Vertical integration
 - Long term storage
 - Packing and technology
 - Cold chain management
 - Energy-efficient transport
 - Quality and safety
- d) Application of Efficient Consumer Response (ECR) System
 - Electronic scanning of price and product at the point of sale
 - Streamline the entire distribution chain

1.2 Research Objectives

- Studying the organic and conventional food chain
- Identifying the limitations that are currently present in the process of production of crops
- Minimizing fertilizer costs
- Maximizing the output by the minimization of the various cost incurred during the process
- Improving the storage capacity through the correct assignment of goods and products
- Showing the scope of OR in the field of agriculture in India and how the industry as a whole can benefit through the inclusion of such analytical methods
- Showing benefits of expansion and shifting towards organic methods of farming and cultivating products instead of the traditional methods followed over the years.

2. LITERATURE REVIEW

Conventional Agriculture Supply Chain: This review of literature on agriculture supply chain management has tried to identify gaps that are to be explored in agricultural Supply Chain Management (SCM). It has attempted to review various studies concerning SCM and shed light on findings essential to supply chain policy like financial issues, mode of organizing & performance of different components of supply chain. It represents all the functions involved in the process of transforming agricultural materials from their raw stage to consumption phase.

These activities in SCM include procurement of agricultural raw materials, production mode and the process of marketing, storing and selling of final product. Important agencies involved in this process are suppliers of raw material like farmers, processors, human resources used to transport and store and consumers.

Although India is an agro-based economy with the agriculture sector being the major source of employment for most of the population but this sector only contributes 18% to the Gross Domestic Product (GDP). Inefficient Supply chain management might be a major reason for that.

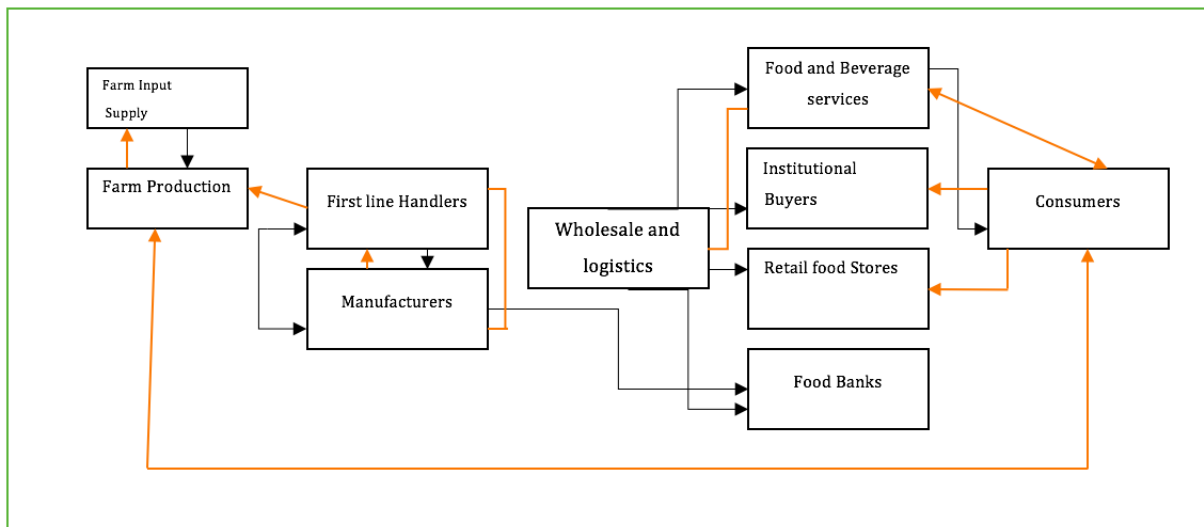
Good coordination and interrelationship between different components of the supply chain enhance chances of innovation, thereby increasing the probability of competitiveness and compete. SCM and product diversification has been necessitated in developing countries due to the following reasons:

- Food security at the forefront
- Increasing urbanization
- A rise in the standard of living
- Preference for traditional food

These developments have enhanced the income of farmers. However, these farmers are still seriously suffering on many fronts from the following problems:

- Selfish traders and middlemen who exploit them for their own gain
- Landholdings divided into small fragments

- Extremely high cultivation costs – Fertilizer costs being the major part
- Poor infrastructure for marketing in agriculture like packaging, branding, and certification
- mass wastage of produce due to lack of or ineffectiveness of storage and warehousing facilities
- Deficient price discovery system



SOURCE: [Institute of Medicine and National Research Council (2015) A framework for assessing effects of the food system Washington, DC: The National Academies Press]

Combinations of the issues lead to high costs for the farmers. A number of measures may be adopted to overcome these problems of Indian agriculture. Most important of them is minimizing the costs of fertilizers. This can be solved by application of assignment problems in Operation Research. The main focus is on minimising costs of fertilizers as it forms a major part of the cost of production.

SOURCE; [Ganeshkumar, C., Pachayappan, M. and Madanmohan G.(2017) Agrifood Supply Chain Management; Literature Review. Intelligent Information Management, 9, 68-69]

Other factors that contribute to the cost to the retailers are transport costs, marketing costs, environmental factors, wastage, climate changes, strikes and hoarding of employees. All of these costs minimize the profits for the farmers. Whereas the objective is to maximize profits and minimize costs. The problems engulfing Indian agriculture are unique, complex and tough due to presence of majority of them among bulk of Indian agriculturists. Hence, advanced techniques need to be device to address these problems which warrant rapidly changing methodologies, technologies and management practices in the supply chain mechanism.

2.1 Organic food: History

The organic food industry in India is not a new phenomenon. Back in the 1970s Chamong Tee Exports Private Limited started in the conventional food business and diversified into organic food and in 1980s they realized the preference for organic food by the consumers in developed country markets and the premium price that the organic food products earn. Organic agriculture has evolved as a movement in India over the last few years. A number of companies such as Navdanya, Sresta Natural Bioproducts Private Limited, Bio-Diverse Farming Private Limited, and Fabindia have now entered the organic business, and some of them deal only in organic products under their own brand name. While many people tend to follow the food trends which have been there for years, organic food is slowly being bought and consumed by large number of consumers worldwide. There has also been a significant expansion in the range of organic products offered in supermarkets and many market chains offer a variety of organic products, including private and own-brand organic labels. The market for these products has many customers which include-health-conscious people, families with children, soon-to-be parents and the consumers who are heavily invested in organics.

2.2 Opportunities

Organic agriculture in India is creating employment in the processing sector and supply chain and the increasing investment in food processing is enhancing the farmers' incomes. Various initiatives have been taken by the government at the state and central levels to support organic food production and exports. Overall the government of India is keen to involve the private sector in organic food business and is trying to come up with supporting regulations. Many Indian companies have entered the organic export market giving the rising demand for organic products in foreign countries. The study found out that certain products like organic tea, organic rice, and organic spices have a high demand in the export market. The export of fresh fruits and vegetables is comparatively low maybe because Indian companies are yet to explore the potential.

2.3 Risks

The major risk in this sector for companies is the lack of willingness of the farmers to get involved in organic farming is due to the risk of lower yield in the initial period of conversion from conventional to organic. Higher price compensates for the loss of yield. For continuous flow of supply, companies procure organic products from multiple farmers. To increase the income of farmers the companies suggest the farmers engage in multi-cropping and practice holistic agriculture. Organic farming is mainly practiced in hilly and tribal areas and hence there is a chance of contamination and spoilage as warehouse and transport facilities are not

efficient here. Frauds and malpractices such as mixing of organic products with the conventional product or using third party's logo to sell non-certified products occur after the cultivation stage. In India, there are no mandatory requirements for processors and retailers to be third party certified and hence, there cannot be any audits and checks to ensure there is no mixing. A huge amount of subsidy is given to farmers for chemical inputs which are banned in key export markets are allowed in India. Though organic farming requires more hard work compared to conventional farming, if done properly, the cost can be low and yield can remain high. The main obstacles to the optimization of the organic food chain include poor information management, insufficient communication with consumers, and diverging objectives and needs of the actors of the chain.

3. RESEARCH METHODOLOGY- IMPROVEMENTS

3.1 Minimizing fertilizer costs

Table 1: Previous allocations of crops to states

Uttar Pradesh	Maize	605
West Bengal	Oats	889
Maharashtra	Rice	714
Punjab	Wheat	289
TOTAL		2497

The total cost of Fertilizers for producing the above-mentioned crops in their respective states is Rs. 24, 97,000

Step 1: Balancing

Rows = Columns, therefore balanced

Table 2: Cost of Fertilizers in producing different crops in different states

	Uttar Pradesh	West Bengal	Maharashtra	Punjab
Wheat	321	443	200	289
Maize	605	902	457	363
Rice	514	109	714	272
Oats	900	889	901	555

Table 3: Step 2 – Row Minimisation

	Uttar Pradesh	West Bengal	Maharashtra	Punjab
Wheat	121	243	0	89
Maize	242	539	94	0
Rice	405	0	605	163
Oats	345	334	346	0

Table 4: Step 3 – Column Minimisation

	Uttar Pradesh	West Bengal	Maharashtra	Punjab
Wheat	0	243	0	89
Maize	121	539	94	0
Rice	284	0	605	163
Oats	224	334	346	0

$\theta = 94$

Table 5: Step 4 – Modified Solution

	Uttar Pradesh	West Bengal	Maharashtra	Punjab
Wheat	0	243	0	183
Maize	27	445	0	0
Rice	284	0	605	257
Oats	130	240	252	0

Table 6: Step 5 – Assignment

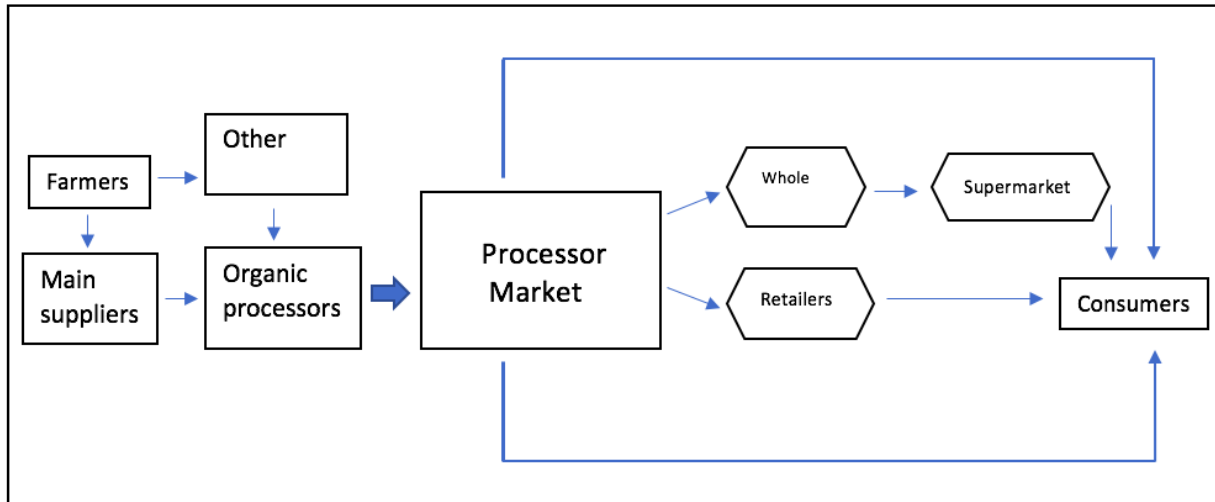
Uttar Pradesh	Wheat	321
West Bengal	Rice	109
Maharashtra	Maize	457
Punjab	Oats	555
	Total	1442

The total cost of Fertilizers for producing the above-mentioned crops in their respective states is Rs. 14, 42,000.

3.2 Optimizing the Supply Chain

The organic food supply chain is the alternative supply chain which is shorter, more locally oriented and the consumers and producers are more tightly connected to that of the conventional supply chain. The main problems of the organic supply chain are an imbalance in supply and demand, high operation costs, lack of information flow and poor supply chain reliability. To understand the demand-supply of organic food, case studies were carried out with a qualitative approach and the focus was kept on the information management as it is the key to improved performance. Closer collaboration between the actor's co-ordinates the

other flows, such as the product flow and is an essential element of the inter-organizational relationships. The following diagram gives us a brief idea about the organic demand-supply chain. This focuses on reducing the number of levels from the farmers to the consumers so that costs are minimized. A minimized supply chain is shown below:



4. FINDINGS AND ANALYSIS

4.1 Fertilizer costs

Cost minimization in agriculture is an ongoing task. It is very difficult to consider all the various factors which affect its costs. Some of them can be quantified and some can't, but now due to advanced OR techniques, cost minimization can be simplified.

The above tables show the cost of fertilizers when one particular crop is produced in different states. Table 1 shows the pre-allocated crops to the 4 states that are, Uttar Pradesh, West Bengal, Maharashtra, and Punjab. The total cost comes out to be Rs.24, 97,000. The cost of the fertilizers is a major proportion of the cost of production of the crops- Wheat, Maize, Rice, and Oats. This cost can, therefore, be minimized by allocating crops and states in a way that gives maximum optimization. As shown above, with help of Assignment problem in OR, cost has been reduced to Rs.14, 42,000. This is done by allocating Wheat to Uttar Pradesh, Rice to West Bengal, Maize to Maharashtra and Oats to Punjab.

4.2 Supply chain management

As seen in the above case, the original supply chain has many levels that waste time, resources and money. To optimize this, we have designed an organic supply chain that has fewer levels from the farmer to the consumer which makes it more efficient. It uses the concept of **Kaizen** which means continuous improvement by reducing wastage. The lesser the levels in the supply chain there are fewer chances of wastage at every level and therefore more efficient.

5. DISADVANTAGES OF OPERATIONS RESEARCH

- **Costly:** Operations research is very costly. This happens because the mathematical models have to be made to take decisions and solve problems to reach the optimum level. Companies have to invest in making models, which involves huge costs.
- **Complexity:** OR problems are complex since there are particular deviations in the solutions. It becomes difficult for frontline managers to analyze the answers. They are the ones who are the action takers who have very basic knowledge or order quantities and transport schedules. There is a gap between the specialist and the manager.
- **Qualitative v/s Quantitative factors:** OR only takes into consideration the quantitative factors such as the costs and mathematical figures. It ignores factors that are non-quantitative. Factors like strikes, holidays, and medical emergencies are all examples of the same. Factors that cannot be quantified do not hold any place in OR.
- **Dependence on electronic computers:** The optimal solutions in an OR problem are solved taking into consideration all factors. In reality taking them into consideration and expressing them as numerical values can be a difficult task. Vast calculations are used for the same which require computers.
- **Implementation:** This is the most important part. It is delicate and must take into account the complexities of humans and their behavior patterns.

6. LIMITING FACTORS OF APPLICATION OF OR IN ORGANIC FOOD SUPPLY CHAIN

- **Changes in Weather conditions:** These changes have a direct connection with the production of crops. This factor is not in control of humans and cannot be taken under consideration when OR is applied.
- **Changes in Fuel prices:** Fuel is the main aspect while deriving an optimal solution to transportation problems. Any changes in their prices will affect the optimality
- **Changes in Government policies:** If the model is set based on the Policies of the government in the current scenario and there is a change in the policies, costs might differ and the issue will have to be formulated all over again.
- **Blocked roads:** the route is very important while applying traveling salesman type problems in OR. In case of any blocked routes which was unknown while calculating the optimal costs and solution will lead to a completely different answer in reality?
- **Strikes and Riots:** Strikes and Riot scans take place suddenly. Employee behaviour cannot be quantified and considered in the OR technique. This factor, therefore, limits the producing capacity.

7. CONCLUSIONS

This research paper discusses the use of operations research in the field of agriculture and its potential in India in the years to come. It also discusses how through the use of OR in agriculture, heavy expenses like transportation costs and supply chain costs. An assignment problem was used in this paper to determine which crops are profitable and suitable for what states and what the correct assignment is in order to minimize all costs, especially the fertilizer cost which makes up the majority of the final cost incurred in the production of crops. From the problem it was concluded that, by allocating the respective crops to the suitable states correctly i.e. Rice to West Bengal, Maize to Maharashtra, and Wheat to Uttar Pradesh and Oats to Punjab, the cost was reduced by Rs. 10, 55, 000. Therefore, as a whole, it could be concluded that while OR in agriculture industry has its own risks and disadvantages, its increased use in India could be a major success and could help in increasing the produce while operating at a low cost and using resources efficiently.

8. LIMITATIONS

The limitations faced while writing this paper were

- Gathering data
- Formulating the assignment problem
- OR couldn't be used in transportation minimization as there are many factors other than the basic cost

9. REFERENCES

- [1] YuanitaHandayati (2015), Agri-food Supply chain coordination: the state-of-the-art and recent developments; <https://link.springer.com/article/10.1007/s12159-015-0125-4>
- [2] Economic Times (2015), Organic food market growing at 25-30%, awareness still low: Government; <https://economictimes.indiatimes.com/industry/cons-products/food/organic-food-market-growing-at-25-30-awareness-still-low-government/articleshow/49379802.cms>
- [3] Souvik Dutta, Arpita Mukherjee (2017), Understanding the Opportunities and Risks in Organic Food Businesses; <https://www.iimb.ac.in/sites/default/files/2018-06/Working%20Paper%20no.%20561.pdf>
- [4] Jennifer Chait (2019), Who Buys Organic Food: Different Types of Consumers; <https://www.thebalancesmb.com/who-buys-organic-food-different-types-of-consumers-2538042>
- [5] Caravella, M. A. & Oliveira, J. F., 2013. "Operations Research in Agriculture: Better Decisions for a Scarce and Uncertain World," AGRIS on-line Papers in Economics and Informatics, Czech University of Life Sciences Prague, Faculty of Economics and Management, vol. 5(2).
- [6] Anderson, J.C., Narus, J.A. (1990) A Model for Distributor Firm and Manufacturer Firm Working Partnerships. *Journal of Marketing* 54, 1 January, 42 -58
- [7] Lambert, D, M., Cooper, M, C., Pagh, J, D. (1998) Supply Chain Management: Implementation Issues and Research Opportunities. *International Journal of Logistics Management* 9, 2, 1-18.
- [8] Carter, C.R. and Rogers, D.S. 2008. A framework of sustainable supply chain management: Moving toward new theory. *International journal of physical distribution & logistics management* 38, 5: 360-387.
- [9] Marja-RiittaKottila (2010), Understanding the organic chain; The framework of the interaction between actors in organic chains in relation to the ecological modernization of food production; <https://pdfs.semanticscholar.org/173a/434fad932e50508418777c0b0efc68c12a29.pdf>
- [9] <https://www.mapsofindia.com/my-india/food/indias-organic-food-revolution>