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## Machine Learning in Food Supply Chain Management – A Review

Rohit B. Diwane<sup>1</sup>, Dr. Kavita S. Oza<sup>2</sup>, Nisha A. Nerlekar<sup>3</sup>, Annasaheb M. Chougule<sup>4</sup>

<sup>1,2,4</sup> Department of Computer Science, Shivaji University Kolhapur (Maharashtra, India)

<sup>3</sup> Department of Biochemistry, Shivaji University Kolhapur (Maharashtra, India)

<sup>1</sup> rohitdiwane111@gmail.com, <sup>2</sup> kso\_csd@unishivaji.ac.in, <sup>4</sup> annasahebchougule999@gmail.com,

<sup>3</sup> nishanbiochem@gmail.com

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### Abstract:

The purpose of this study is to investigate how Machine Learning (ML) methods are applied in the food industry. Using a systematic literature review methodology, this study examines the research work on carried out at several scientific platforms that connect ML and the food sector from one side and AI and supply chain from the other. AI and ML technologies have good prospects to improve the performance of the Food Industry (FI) which is highly promising. The application of AI and ML in FI networks offers competitive advantages for improvement because numerous researchers have developed AI and ML-related models that were validated and discovered to be successful in optimizing FI. Some scholars contend that AI and ML are now both generating value, while others think they are still underused and that the food industry may benefit much from their tools and approaches. The review shows that AI and ML have the ability to lower financial losses, support the responsiveness and efficiency of the food industry.

**Keywords:** Artificial Intelligence, Machine Learning, Supply Chain Management, Sustainable Development, Food Industry.

### 1. Introduction:

The network of manufacturers, exporters, retailers, and consumers that makes up the supply chain is essential to the world economy. The digitalization of businesses and trades has created a significant dynamic that benefits the supply chain ecosystem nowadays. and the basis of this revolution is machine learning. The supply chain needs to be digitally modernized more than ever in this new environment. For all types of organisations, the digital transformation has become a crucial concern and strategic issue. The supply chain Management (SCM), which is now more than ever one of the core aspects of any industrial or commercial activity, is entering a new era of digital change. A flexible and effective supply chain management gives businesses a significant competitive advantage

[1].

SDG 2: "Zero Hunger" is the goal that this goal is trying to accomplish. One of the United Nations' 17 Sustainable Development Goals, it was adopted in 2015. The statement "End hunger, improve food security, boost nutrition, and promote sustainable agriculture" is the official one. SDG 2 addresses the various relationships among food security, nutrition, rural development, and sustainable agriculture [2]. Over 690 million people worldwide—roughly 10% of the world's population—are considered to be food insecure, based on the United Nations. Every night, one in nine people—including the 20 million people who are currently under famine danger—go to bed hungry. The goal of reducing hunger worldwide by 2030 is not being met. In order to ensure that the nation "leaves no one behind" on the path to a future with zero hunger, there is a lot of work that needs to be done, as evidenced by the symptoms of rising hunger and food shortages [3].

The sophisticated and significant of supply chain management system used in the food industry sector. By implementing machine learning technological breakthroughs in supply chain management, it is feasible to make sure that there are open pathways for interaction and data processing across the chain, which increases profitability and efficiency [4]. Machine learning is essential in maintaining food management along the supply chain since it can use data to check on all linkages within the chain. These processes can be made better by implementing quality control and reviewing previous results.

## 2. Contemporary issues in the food Industry:

This portion of the study report lists the various issues the food business is currently facing.

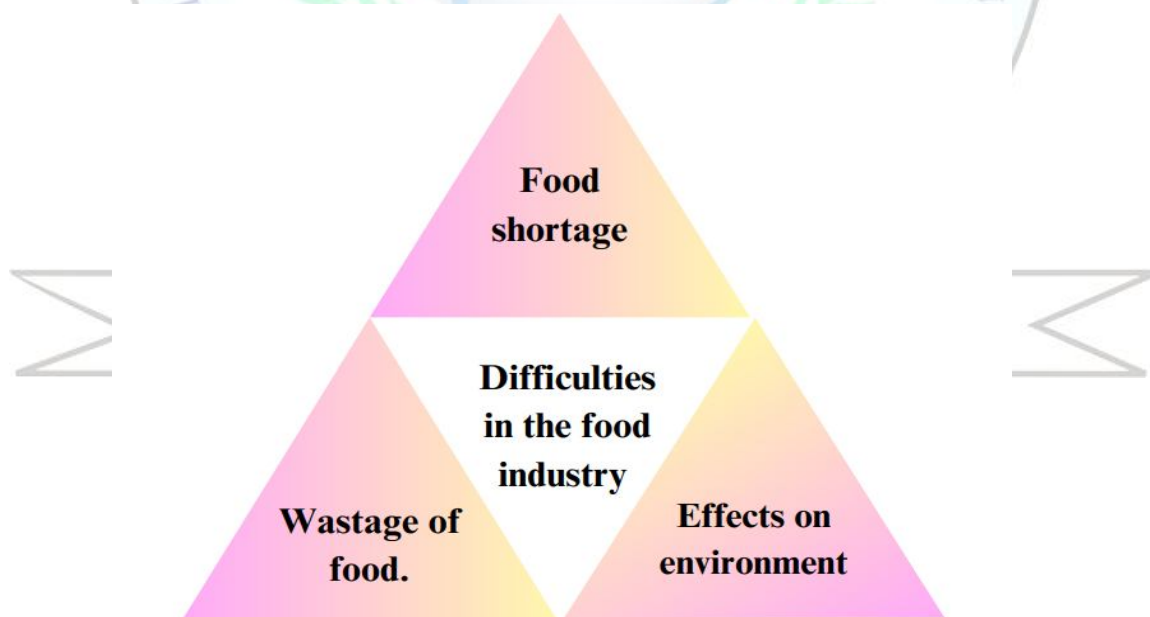


Fig. 1. Contemporary issues in FI.

## 2.1. Food shortage:

In the world, 2 billion people are expected to go hungry at the same time as food waste is a significant issue. In the food industry, there are two levels of food Shortage: severe and moderate, which are used to describe the issue of hunger. 10 % of the world's population, or 700 million people, suffer from severe malnutrition, which leads to starvation, while 18 % of the world's population, or 1.4 billion people, suffer from moderate malnutrition, which is defined as frequent access to wholesome food [5,7].

Since that food is at the root of the issue, the food industry might have to responsible for food insecurity. Food availability will not enhance at all by 2030, as per predictions, if "business as usual" evaluation and planning continue to evolve.

While it varies regionally, food insecurity is more prevalent in developing countries. Data from the Worldwide Food Policy Research Institute show that continents like Africa and Asia have higher rates of food insecurity. It is least prevalent in Europe and North America [8].

## 2.2. Wastage of food:

One-third of all food produced each year is wasted, which is one of the most critical issues facing the food industry. Food waste is defined as a reduction in the quantity and quality of food as a result of behaviors or decisions made by customers, retailers, or restaurant employees [9].

A third of all food produced is wasted, and this is an issue at every point in the supply chain, especially during transportation, harvesting, and by consumers. This shows that by collaborating on preventing food waste strategies, it may be possible to conserve food [10].

Food waste may affect every market in the food industry since it occurs along the whole supply chain, from crop production to consumer consumption. Transportation, food harvesting procedures, food that consumers discard or buy from retailers are the primary sources of waste.[11].

## 2.3. Effects on the environment:

The main food concentrate is on meat and dairy items. Because of this, the contribution of the food industry to environmental factors highlights the need to reverse harmful trends and create sustainable food alternatives for coming generations [12].

Because these are the primary elements that have an impact on the environment, the production, usage, and waste management of food, as well as their global consumption, are currently significant concerns for the food industry. Together with housing and transportation, food is responsible for 70% of all environmental effects.[13].

## 3. AI and ML in Supply Chain Management Systems:

Sustainable work has essential to addressing current issues and upcoming difficulties. AI have become more and more a part of food sector supply chain management systems. This includes supermarkets, coffee shops, and restaurants have upgraded their inventory management software.



Demand-supply chains and food delivery chains can be streamlined as our world becomes more interconnected, allowing everyone to access local resources and enabling products to arrive at their destination quickly and efficiently [14].

AI can help with food preparation, storage, and transportation. Cost-effective packing can also be achieved with the aid of smart technology like robots and drones. Also, it will aid in the distribution of high-quality goods, the transportation of food, and the completion of tasks in dangerous locations.

### **3.1. Sorting food and evaluating its quality:**

The process of sorting food has essential to ensuring that the food supply chain runs smoothly. Yet, if done manually, this procedure can be complex and time-consuming. However, this procedure should be mechanised with the use of machine learning and artificial intelligence. Not only would this quicken the sorting process, but it will also take care of any human error [15].

The use of artificial intelligence is helping to ensure that food satisfies certain standards. It can increase production effectiveness and decrease waste. AI have been utilised in the food sorting and quality control industries to identify product flaws and take them off the production line. To further enhance product quality, sensor-based sorting technology is employed. AI can help businesses save time and money by automating the process of food sorting and quality monitoring.

### **3.2. Food Safety Regulations and Resources:**

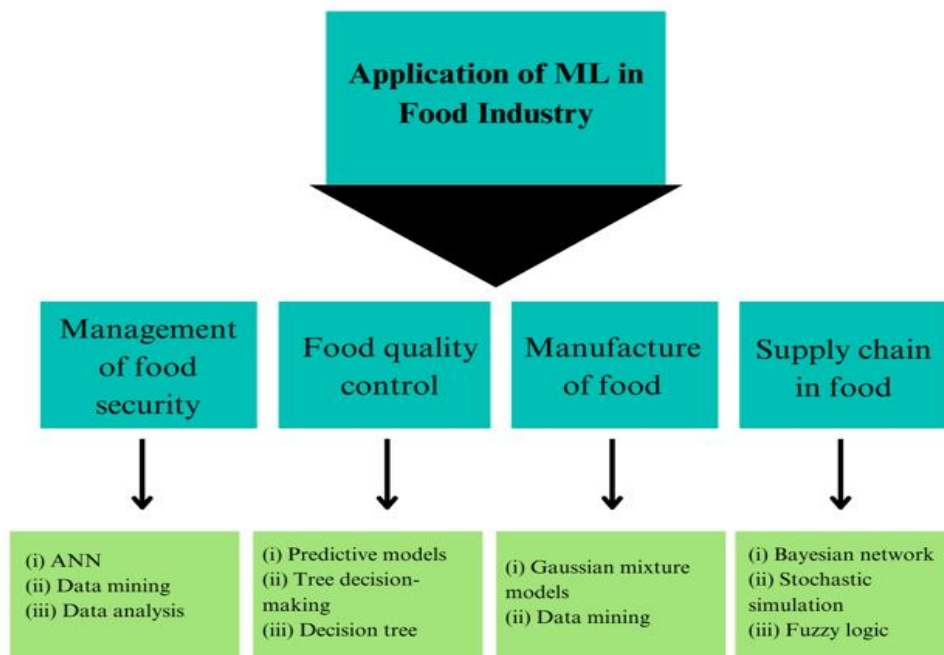
Organizations must consumers to continue as security management and food safety laws become more stringent. The food supply chain can be kept transparent and accountable with the aid of artificial intelligence. By utilising AI, retail AI enables food service businesses to cut down on waste and boost performance. However, the supply chain's overall amount of food waste may be decreased. A reduction in the risk of food contamination or other safety issues can be achieved with the use of AI [16].

### **3.3. ML based segmentation (clustering):**

The analysis of categorising items based on their relevance, such as on sales value or volume (quantity), or profit, etc., has typically done while adopting an SCM solution. A customized approach can be designed, used, and implemented using this categorisation. It would be preferable to segment using clustering (such as K-Means) and then use various techniques on each section. Segment (cluster) interpretation must be done manually, though. Also, various analysts may interpret the same portions in different ways. Perhaps in the future, a clustering problem solution that is better and easier to understand will be made possible by an AI-based algorithm [17].

## **4. Applications of ML in Food Industry:**

The uses of artificial intelligence in the food industry are very diversified. ML can be applied quietly throughout the process in the industry.



**Fig. 2. Application of ML in Food Industry.**

#### 4.1. Analysis of trend:

The application form of ML mostly in food sector is in the fast-moving consumer products sector, where it aids in the investigation of typical consumer requests and preferences. Machine learning (ML) can leverage big data analytics and machine learning models to gain useful insights about consumer demands and preferences that aid in product design. By utilising the trend research technique and machine learning algorithms, food businesses may efficiently meet customer demands and precisely target the relevant audience that is available across the market[18].

#### 4.2. Effective Speed:

One of ML main benefits is that it encourages an efficient production method in the food industry. Over the course of the year, the food industry had a number of issues and a poor output rate, as opposed to prior eras when individuals had to manually complete every task. Machine learning algorithms can now be used to quickly produce better outcomes and more products at once thanks to automation and artificial intelligence. The result is that industry benefit and revenue rise[19].

#### 4.3. Predictive Management:

While discussing the influence of ML, predictive analytics utilising these technologies in the industry cannot be ignored. Throughout the beginning of time, the food industry has experienced significant losses, mainly because certain methods were not fully understood at the time. Food shortages, food management, and power outages are just a few examples of the many ways that the food sectors may be impacted. In order to prevent such catastrophes, predictive analytics helps the

food industry use predictive indicators to foresee future consequences. [20].

## **5. Using AI and ML, a sustainable food industry development strategy:**

In this investigation, a systematic approach is employed to gather data and carry out analysis. Data collecting is place throughout the first phase. In the second stage, a prototype search is conducted to better recognize the present condition of the airs in the region. Data for the study was gathered from several sources using specified keywords, titles, and abstracts as well as a particular time frame. In order to discover links and potential growth areas for a more sustainable industry, these data will be compared. Also, we will make recommendations based on in-depth study results, rational responses, and the current state of the food industry.[21].

### **5.1. Data Collection:**

Data is the first step in machine learning. Yet a number of procedures need to be followed for this data to function. Data gathering is one of them. Simply defined, data collecting has been the practise of acquiring information pertinent to the aims and objectives of an Individual task. It eventually obtains a dataset, which is basically a collection of data ready to be put into an ML model and trained on [22].

### **5.2. Abductive reasoning:**

A style of logical thinking known as abductive reasoning starts with one or more observations and then finds the most likely explanation or conclusion for them. Deductive reasoning is extended into it. In abductive reasoning, the premises do not, however, ensure the conclusion.

### **5.3. Feature Mapping:**

The process of transforming raw input data into a collection of useful features that a machine learning algorithm may use is known as feature mapping, often referred to as feature engineering. The quality of the features can have a big impact on how well the algorithm performs, hence feature mapping is a crucial stage in machine learning. In ML, some a variety have been used, such as feature extraction, feature transformation, feature selection, feature scaling, and feature mapping [23].

## **6. Finding and Discussion:**

It is noticeable from a survey of the food industry literature that significant investment is needed in the food processing, management of food wastage and manufacturing sector. System-based AI is more equipped to identify a variety of production flaws than human-based methods. Also, it has been emphasised that researchers play a significant role in this field. The lack of automation caused by globalisation creates a number of barriers in the food processing chains, with health and safety being one of the main concerns. A processor produces output spikes when sensors are attached, offering a low-cost and Clint-friendly platform for a number of adaptive intelligence robotics applications. That might have a hugely positive impact on the food business. In quite a



while, implementing sustainable development objectives to alter the food supply chain in the environment using machine learning techniques has become increasingly important for everyone in recent years.

AI-based sensors in the agro-based sector that concentrate on agricultural output, yield forecasts, detection of diseases, and features that are available to provide innovative types for decisions and moves have been combined with machine learning and big data. Many sectors are considering using artificial intelligence and machine learning to automate processes, save money, and eliminate human error. AI and machine learning can benefit food makers as well as bars, cafes, and restaurants. These two divisions provide numerous common application cases for AI in the food sector. It has never been more important to stay one step ahead of the competition because customer and market expectations are changing quickly. In order to identify which food software platform will be most in demand in the near future, machine learning uses data collection and a significant technique.

#### **Discussion:**

The examinations and present procedures lead to the conclusion that industries are under pressure to address global challenges includes waste food and environmental destruction. On the other hand, the challenges from a micro perspective show that there are currently some significant barriers local industry from trying to respond to market growth as much as it should, both in terms of much more workable product offerings, stakeholders, and the global social, economic, and environmental challenges that the world faces today. The report has already mentioned artificial intelligence technology as offering a wide range of prospective solutions that can assist in satisfying the present need for environmentally friendly development in the local food industry. The use of AI and ML also confront other difficulties, such as a drop in employment due to a reduction in the workforce. A capable staff and financial backing are needed for its execution. The investigation and conclusions are consequently founded on the information we gathered. We only looked at a few papers for this study during a short period of time.

#### **7. Conclusion:**

This article analyzes to the reader how to go from a traditional strategy to the modern and inventive automated procedure in the food industry. Although many different approaches have been developed to address the difficulties that have arisen in the food industry, artificial intelligence and machine learning have offered practical possibilities to encounter cutting-edge technology. In AI/ML controls a variety of multidisciplinary systems to evaluate a wide range of criteria illustrating quality, appearance, texture, general customer acceptance, and so forth. In order to provide output that is accurate, trustworthy, efficient, competent, and aids the operator in anticipating changing conditions over time, this novel approach involved evaluating data patterns and modifying the process. These

methods can be seen as a benefit in terms of filling the gap left by the growing number of defects in the food industry. Over time, drone technology would represent a significant turning point in the management of the food supply chain.

The process of preparing food is utilizing sensors more and more. The food sector has in fact used AI and big data to provide better, more effective and actual results. Food safety is already being handled by AI due to the application of ML and AI in restaurant operations and food processing. By lowering human manufacturing errors and, to a lesser extent, unused items, artificial intelligence has elevated the food safety sector to new heights. More client happiness, quicker services, voice searches, and more customized orders are all provided together with decreased packing and shipping costs.

These commercial advantages can also benefit large food corporations, and they will ultimately result in a definite gain.

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