Re-IMAGINE The Journal for Hospitality, Tourism & Culinary Professionals
Volume 1 Issue 1 (July-Dec 2026) | **ISSN**: 2839-6383 | **Page No**: 27-52

Examining the Critical Role of Supply Chain Management in the Success of Farm-to-Table Systems in India

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Abstract: -

The wastage of vegetables and fruits in the Indian farm sector is believed to be one third of the total produce. Supply chain management plays a vital role in controlling such wastage. The supply chain management in India used to be weak with its own inherent contradictions. While it has taken great leaps in the past decade, it is necessary to study the areas that needs attention as India is an agriculture-based economy to a large extend and is in its path to economic consolidation globally.

This paper looks at the management of supply chain in general and the challenges it faces in the specific context of Farm to Table model of food facilities in India. The aim is to identify the challenges supply chain management faces as a whole and peruse it further to understand with respect to Farm to Table model in India, suggesting possible solutions for its restructuring. The paper looks at the evolution of Farm to Table concept and its status in Indian scenario. It reviews the multiple challenges that Supply chain faces and categorises them under four distinct headings.

For this purpose, the researcher has adopted secondary research only, perusing papers already published on the subject for information. Journal articles, case studies, industry reports and government publications were the main source selected. A general criterion of sticking to articles that are not more than 10 years old is followed to ensure that the information is latest and reflect contemporary scenario. A comparison of the information from different articles were carried out to assess the gaps.

Review of literature has thrown up some major findings. Farm to table concept as such has great potential for community development and financial empowerment of the locals. A shorter and efficient food supply chain leads to reduced carbon foot print, fresher produce and high quality of output. It reduces the middlemen and results in farmer wellbeing. On the food facility side, an efficient food supply chain would help in better menu design, addressing seasonal variability and balancing supply-demand quotient. It is found that investments in technology in food supply chains has picked up in the recent times in the country, such as cold storages

and refrigerated transport systems, leading to less wastage and better quality. Adoption of advanced quality control systems such as block chain technology and IoT has led to improvement in traceability leading to heightened food safety standards.

However, challenges of technological competence, cost considerations and regulatory frameworks are issues still persisting. In recent times supply chain automation and AI driven management systems are introduced. But there is competence gap that need to be addressed. While the supply chain remains fragmented in the country to a large extent, considerable work is done by the government for its improvement such as introduction of e-NAM. Overall, the growth trajectory is encouraging with specific areas requiring attention.

Key Words: -

Farm-to-Table, Supply Chain Management, Sustainable Supply Chain, Risk Management, Traceability, Food Safety

Introduction: -

The Farm to Table concept, otherwise referred to as farm to fork system, involves food items made from commodities that are directly sourced from the growers or the farm. In other words, it deals with locally sourced ingredients which are often organic and natural. Establishments that adopt this system are classified as Farm –to-Table establishments and there is a growing demand for such eateries in the commercial food market. While the concept is rather vague, Farm to Table denotes "*a food system in which food production, processing, distribution and consumption are integrated to enhance the environmental, economic, social and nutritional health of a particular place*" as defined by Rutgers.

The concept as such is anything but new as it existed in the early 1900's in America where the American postal department made it possible to ship farm-fresh products across the country for the discerning citizens who were very concerned with the freshness of the produce. However, by 1930's and 40's, the desire and importance of fresh produce slowly started eroding with life style of the populace changing. With the advent of technology and subsequent explosion of the processed food industry, there was a drastic shift towards packaged food. 1950's to 1960's saw increased use of processed food in restaurants, hotels and ultimately to home kitchens. Post war prosperity combined with abundance of canned food, food shows on TV and electrification of home kitchens all contributed to this phenomenon.

By around 1970's America saw the hippie movement becoming prominent. This movement was characterized by affinity to environment, local produce, a repudiation of commercialism and materialism, leading to widespread rejection of industrialized food practices. This was a counterculture to the processed fast-food culture that prevailed in American society at that time. Soon enough this culture made its entry into formal food establishments with chefs reorienting to adopt the philosophy. Opening of the legendary "Chez Panisse" in Berkley, California by the renowned chef, restaurateur, author and a champion of local, sustainable agriculture, Alice waters in 1971 was the first of many that came up (Albert, 2024). This was followed by "Organically Grown" in Orion and the subsequent travel of the concept to Europe in 1986 with the foundation of a slow food movement by Carlo Perini in Italy. From here on the movement came to centre stage backed by demand for clean, pesticide free organic produce. Establishment of non-profit organizations supporting farmer's cause, slow food movement etc. gave the fillip that the trend required. It was soon realized that farm to table concept would go a long way in creating sustainable food practices, addressing the environmental issues as it reduces food miles and enhances biodiversity (Malini & Anand).

In India, a civilization whose origin is yet to be decided, the concept of Farm-to-Table is simply a rediscovery of the age old practices that existed. Here the society was hyper-local in its production and consumption, focusing on seasonality and following highly effective organic farming practices. Each neighbourhood produced for themselves. Freshness of the food was emphasized and crop selection were as per the season with high importance to millets. The evolution is from an abstract subsistence farming to an organized eco-friendly movement where sustainability was given importance and a fair, mutually beneficial relationship was established between consumer and producer. The cuisines of India where naturally farm to table. The cooking methods employed traditionally were extremely healthy, focusing on retaining nutrients and serving fresh food as opposed to preserved and processed food (Jain & Aggarwal, 2016).

Green revolution that took place in India in 1960's, led to the introduction of industrial farming practices with the use of chemical fertilizers and pesticides to boost harvest yield. This also led to creation of middlemen in the farm produce domain. Emergence of cold storages, food processing facilities etc. led to the development of a convenience driven food chain that weakened the linkage between farmers and consumers (Eashani Chattri, 2023). This kind of

farming practice impacted the cultivation pattern making many products available year-round which had direct impact on nutritional constitution and functional utility of the produce. This system shifted the crop focus to wheat and rice, whose cultivation has direct environmental impact as it required large quantity of water (Malini & Anand).

By the end of 1990's, the negative aspects of industrial farming practices started showing up by way of increased dietary problems, nutrient deficiency and other health disorders in addition to its impact on environment. This led the general populace to revert back to traditional food system, if only partially at present. This resulted in the resurgence of farm-to-table concept in India which started really establishing itself by 2010's (Code Nast Traveller India, 2019). The movement has been gaining popularity from 2000's along with the growth of information technology sector, as people started understanding the health and life style benefits of it. Fundamental nature of the system of promoting fresh, organically grown local produce had great appeal in itself. Added to it was the fact that it reduced supply chain length, thus providing nutritious and safe food. With the return of the direct relationship between farmers and restaurants, there was a marked reduction in processed/ stored produce, thus maximizing freshness. Reduction in supply chain length had direct contribution to sustainability, as a shorter supply chain reduced carbon foot print and supported small scale farmers and local economy. The Farm to Table concept results in an increased traceability and visibility factor, resulting in increased customer confidence in quality and safety of food, as per Smith…2021.

While Farm-to-Table model has risen as a trend, enabling food facility operators to adopt it with enthusiasm, supply chain is vital to the success of the model. Although a coherent Farm to Table system demands supply chain to be short, management of it is crucial. Infrastructural shortfalls, unpredictable climate, agriculture sector disarray and logistical limitations, all have direct impact on supply chain. This in turn will have implications on sustainability of the facility. Hence it is crucial to have an understanding of the challenges that food supply chain faces in Indian context and develop viable solutions to overcome them, for the facilities to succeed.

Structural flow of this paper is as follows: the introduction looks at the evolution of farm to table movement, globally and in India. It also briefly touches on supply chain management, in relation to its importance. It is flowed by an extensive review of literature pertaining to farm to

table concept, supply chain management and the challenges it faces, both globally and in India. A brief write up on the methodology adopted follows. Findings from the review of literature is written next followed by discussion on the criticality of supply chain management to farm to table model. The paper concludes by summing up the discussion and suggesting the way forward.

Literature Review: -

Relevance of this study stems from the fact that an increased number of urban dwellers in India are gravitating towards healthy food trends. There is a growing demand for sustainable dining options among populace and the shift is spreading to semi-urban areas too. This has provided great opportunity for Farm-to-Table model (F2T) as it presents the core of this trend. But for this to happen, a thorough study of the infrastructure capability, economic feasibility and competence of the intermediaries is vital.

Supply chain management (SCM) is the management of movement and storage of raw materials and services from the point of origin to the ultimate consumer (Zutsara & Numena, 2022). SCM deals with functions such as supplier selection, competitive sourcing and risk management. An efficient SCM is needed for production planning, quantity and quality control, supplier management, quick identification of problems and management of customer relationship (Jamal & Singh, 2023). A food supply chain (FSC), on the other hand, comprise of all the stages, facilities, functions and activities that a food commodity goes through, starting from farmer through producer to ultimately consumer. The stages or blocks of a typical food supply chain include production, handling and storage, processing and packaging, distribution, retailing and consumption. The stages will vary depending on the type of sector/ facility. With the growth of FSC's in recent times, there has been a lot of fragmentation that has happened to the original supply chain. This has led to traceability issues (Addie Lewis, 2022).

There are six types of FSC which can be broadly classified into two categories of Efficiency and Responsiveness. They are Continuous Flow, Fast Chain, Efficient, Agile, Flexible and Custom Configured. Which type of supply chain to select depends on the type of business and facility. For example, in a high demand production facility a continuous supply chain is suitable where as in a short product life cycle scenario, a fast-food chain would be apt (Addie Lewis, 2022). It is important for business to choose the right type of FSC that suit their operation to achieve desired results. In essence, a systematic food supply chain management (FSCM) that

suit the business operation is very important for achieving efficiency and removing the inherent blocks.

It is pertinent to understand the operation of a typical food supply chain in India. There are various forces (partners/stakeholders) that are at play here, each of whom have definitive roles in the stability of the chain. The sum total of their effort is what leads the movement of the produce from farm to the ultimate consumer. Shown below is a typical agricultural produce chain in India, called the Mandi System (Gosh, 2013, Hedge and Madhuri, 2013). The supply chain has a push and pull dimension to it. The farmers moves the produce from farm to the market place/ whole sellers, either directly or mostly through agents, who in turn pushes it to the retailers or small merchants. This constitutes the "push". The small merchants/ retailers further pushes it to the consumer. The market pull comes into play here with demand- supply factor. Customers tend to pull the product depending on the requirement for further consumption (Kumar & Agarwal, 2023).

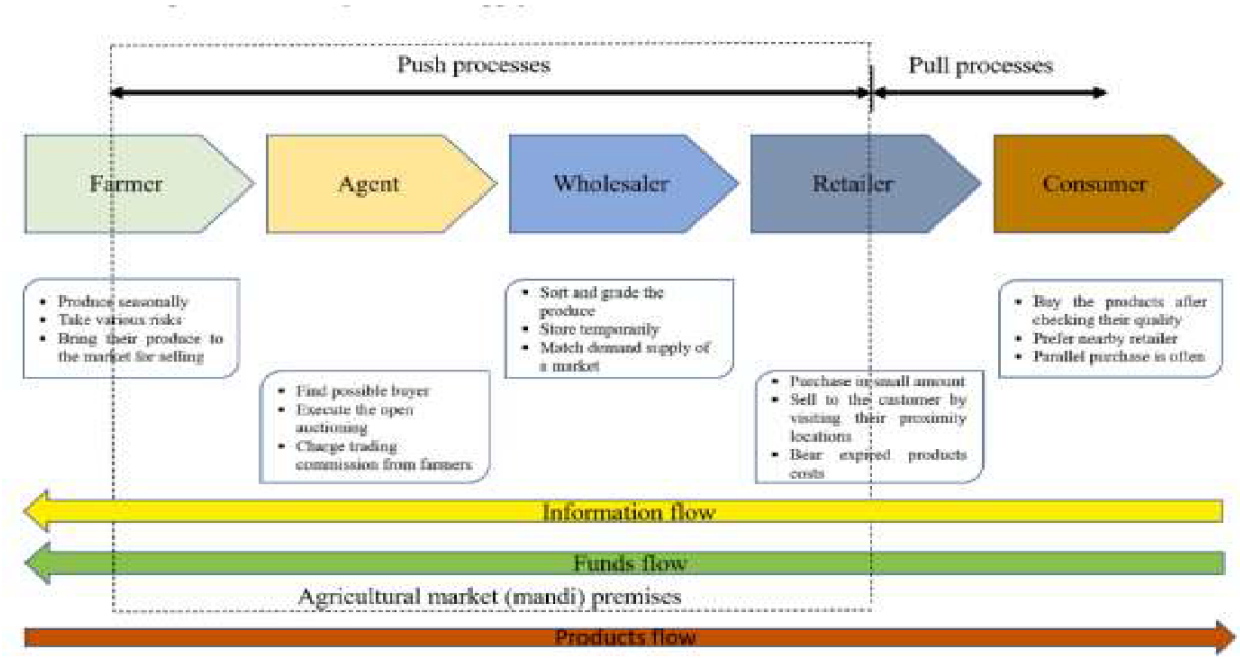

Figure 1 - Flow of Supply Chain

The cost factor including transportation/ storage/ spoilage/ damage etc. are important considerations in the operation of the chain. Efficiency at each stage is vital for the supply chain to be effective and sustainable (Kumar, Saraswat, & Kucheriya, 2020). The major challenge in the above system is the lack of cooperation and competitive climate for the

participants (Balaji and Arshinder, 2016, Sheoran, 2015). Also unorganized intermediaries use their monopolies in determining the prices, in the absence of a regulatory body. This affects the cost of goods. Their commission also gets added on to the total cost (Ramkumar, 2020).

Indian farm sector, being diverse and spread out with abundant variety, demands a well-organized supply chain to enable the F2T concept. The bulk nature of products, scattered and seasonal production, high variability in quality and quantity of produce and specific requirements on logistics services, all forces food supply chain take centre stage in operational viability assurance (Akkerman et al., Gokaran and Kuthambalayan, 2019). High perishability of the agri products, having very short life span mostly, demands the supply chain to be given special consideration and hence the unique nomenclature, AFSC, Agri-fresh food supply chain (Shukla and Jharkharia, 2013). Gupta, 2024 mentions farmers and unorganized food processers are generally located in remote locations with limited accessibility, requiring a strong supply chain for F2T concept viability. Efficient FSC helps to ensure traceability, which leads to quality guarantees, as providing customers with knowledge of the origin of the commodities used, is very important in this concept (Addie Lewis, 2022).

In recent times, food supply systems in India have adopted many technological advancements to increase efficiency, agility and accuracy. Modern technologies like block chain and IoT, have helped the supply chains to become more transparent, efficient and traceable (Kumar , saraswat, & Kucheriya, 2020). Setting up of the National Agricultural Market (e-NAM) and investments made in cold chain infrastructure by GoI has strengthened the system. It has resulted in decreasing post-harvest losses and increasing market access across a varied geographical locations for farmers. This has provided a big boost to the F2T concept. In addition, different small geographical networks of farm producers and social media platform have drastically enhanced the farmer's reach and have greatly empowered them. This has led to fair price deals and competition in market, both of which have bolstered the F2T approach (Kumar, Saraswat, & Kucheriya, 2020).

In today's world, concern for food safety is a high priority for customers. Same is the case with demand for sustainably produced food commodities. As a result, both these factors need to be integrated into the FSCM. This has led to evolving of newer fields such as Sustainable Supply Chain Management (SSCM) and Dynamic Capabilities (DCs). Seuring & Muller defined

SSCM as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements." Contemporary FSCM need to consider all these three dimensions of sustainability, in which the food is produced and offered. Cooperation of all partners in the chain and recognition of legitimate requirements of all stake holders to the activities in the chain are critical to the smooth operation of the system (Beske, Land & Seuring, 2014).

Risk management is very important in FSCM as it is required for stability of the system and sustainability. Mentoring and monitoring of individual suppliers through the institutions of internal and external auditors is a common practice found in SSCM (Beske, Land and Seuring, 2014). Design of the structure of the SCM (categorized as continuity) need to be done diligently. Processes and practices needed to build long term relationships, through development of partners, should be chosen carefully (Pagell and Wu, 20009, Gold et al, 2010). Collaboration in SCM links structural aspects of the chain to business processes (Vlajic et al, 2012), helping in the joint development of products and technologies and sharing of resources (Beske, Land and Seuring, 2014).

One of the major challenges faced by Indian FSCM is the shortage of manpower. The shortage is felt in both technical and general category, where capable hands are in short supply. This has a direct impact on efficiency and scalability. Areas such as cold chain system, technical logistics etc. are of concern. Training of man power is another area that needs attention (Mallik et al., 2023). This issue is compounded by the callous nature of recruitment and management style in this sector characterized by low pay, broadly defined job descriptions and poor developmental opportunities. In many stages of the chain, working environment is strenuous with hot, humid conditions and meagre employee facilities (Haessner, McMurtrey, 2024). Seasonal nature of the work in many segments of the chain, makes the employment unstable in nature and thus unattractive. This in turn prevents broad alliance with in the chain that has productivity outcomes.

Seasonal variability of the commodities and the associated changes in the FSCM structure is another challenge as per Graceblood. Variation is also found in production and demand. Quality control with in chain need to be prioritized in this context. FSCM disruptions due to natural calamities, political turmoil, pandemics and other natural or man-made reasons is

another area of concern as mentioned in Graceblood. Other challenges to FSCM in India include wastage, lag in technology, insufficient infrastructure and hoarding tendencies, all of which needs careful consideration (Gupta, 2024). Maintaining high service levels is found to be challenging in Indian food supply chains, where timely delivery of quality product has a scope for improvement. Stock optimization and shelf-life management are another two areas that needs attention. The demand- supply balance has to be achieved to avoid over or under stocking. In shelf-life management, fresh and perishable products needs special attention through product cycle optimization (Compass360, 2024). Climate change has its impact on agriculture productivity and associated supply chain (Malik et al, 2023).

To have a clear understanding of the bottlenecks the system faces, "Theory of Constraint" (TOC) is useful. The model can help in identifying the bottlenecks that the goods faces in its movement from farm to consumer and provide corrective steps to improve efficiency in the chain. Analysis of the issues that FSC faces in India, through the adaptation of insights gained from study of global application of the TOC has thrown up the following

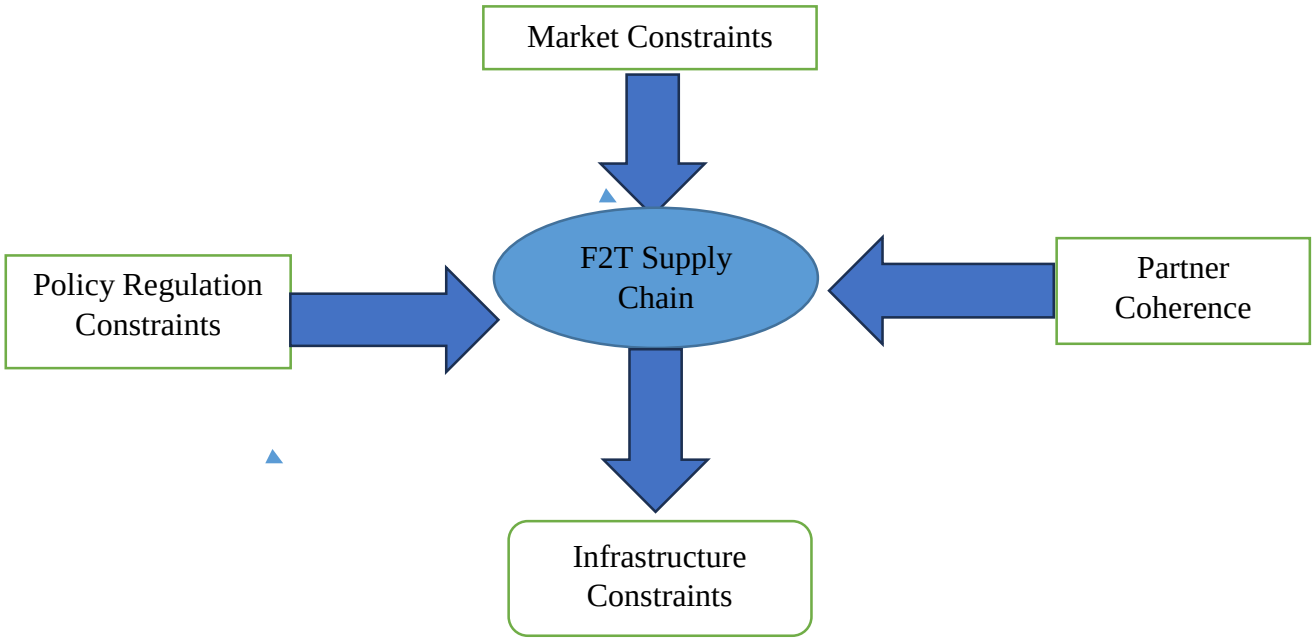

Figure 2 – Constraints to F2T Supply Chain

The constraints; policy regulations, market access, infrastructure and chain partner coordination, all have a negative impact on the functioning of the supply chain. These constraints act as roadblocks for efficiency optimization and contribute to quality deficiencies. Thus, it is pertinent that they are effectively tackled to achieve desired results.

F2T model food facilities are dynamic in nature with availability of fresh produce being very important for its sustenance. The supply has to be consistent, timely and quality conscious. This demands an effective FSC which ensures timely delivery of quality fresh produce consistently. Industrialization of processes in contemporary food industry which is characterized by mass production is a reality. Production, financing and marketing have integrated to form a global food chain (Manning et al., 2005, Trienekens et al., 2012). This results in long supply chains with its inherent bottlenecks. Such chains also presents the danger of ignoring small farmers who are critical in a F2T model. In addition, quality and safety of the commodities being supplied is very important making control of supply, integration of quality assurance tools and enhanced tracing and tracking crucial for the success of the model (Manning et al., 2006). Above factors makes establishment of a strong, viable and sustainable FSC critical for the success of F2T model of food facility.

While there are many works on FSCM such as "Challenges and opportunities for Agri-fresh Food Supply Chain Management" by Kumar, A., & Agrawal, S. (2023) & "Assessing Supply Chain Innovations for Building Resilient Food Supply Chains: An Emerging Economy" by Joshi, S., Sharma, M., Ekren, B., & Kazancoglu, Y. (2023), very little work is done specifically in the area of "Critical Role of Supply Chain Management in the Success of Farm to Table System". This subject requires in-depth analysis of the factors involved and development of solutions for the challenges identified. The research work attempts to highlight the criticality of FSCM in F2T model of food facilities and make suggestions for addressing the bottlenecks in the system in India and does not endeavour to develop frameworks or models as solutions. While this study has perused the existing literature on the supply chain management in FSC's, further study is required, specifically with respect to integration of technology into FSCM for F2T system of food facilities and also synergy of government policies and FSC.

Conceptual and Theoretical Model: -

Theory of Constraint by Eliyahu Goldrati: - This is a process improvement methodology which advances the principle that every complex system has at least one limiting factor—a bottleneck—that prevents it from reaching its highest potential. Effort should be taken to identify the constraint(s) and optimize it to improve overall system efficiency. When applied to FSCM, the model helps in identifying the bottlenecks. By targeting limiting factors such as policy regulations, market access, infrastructure and chain partner coordination, supply chain efficiency can be maximized. The five focusing steps of the model - Identify the Constraint, Exploit the Constraint, Subordinate Everything Else, Elevate the Constraint & Repeat – when implemented judiciously, is bound to elevate the chain efficiency and maximize output.

Agile Supply Chain Management by Professor Martin Christopher: - This is an operational strategy to address customer demand shifts and unexpected market fluctuations. The focus is on speed, real-time visibility and flexible logistics to prevent stock outs and wastage. When applied to FSC, it enhances **Market Sensitivity** by capturing real-time point-of-sale data and driving demand led production, achieves **Process Alignment** by fostering collaborative relationships and seamless communication across all tiers, builds **Network Flexibility** by nurturing alternate suppliers and transport modes to address bottlenecks and creates **Traceability and Visibility** by using digital tracking techniques.

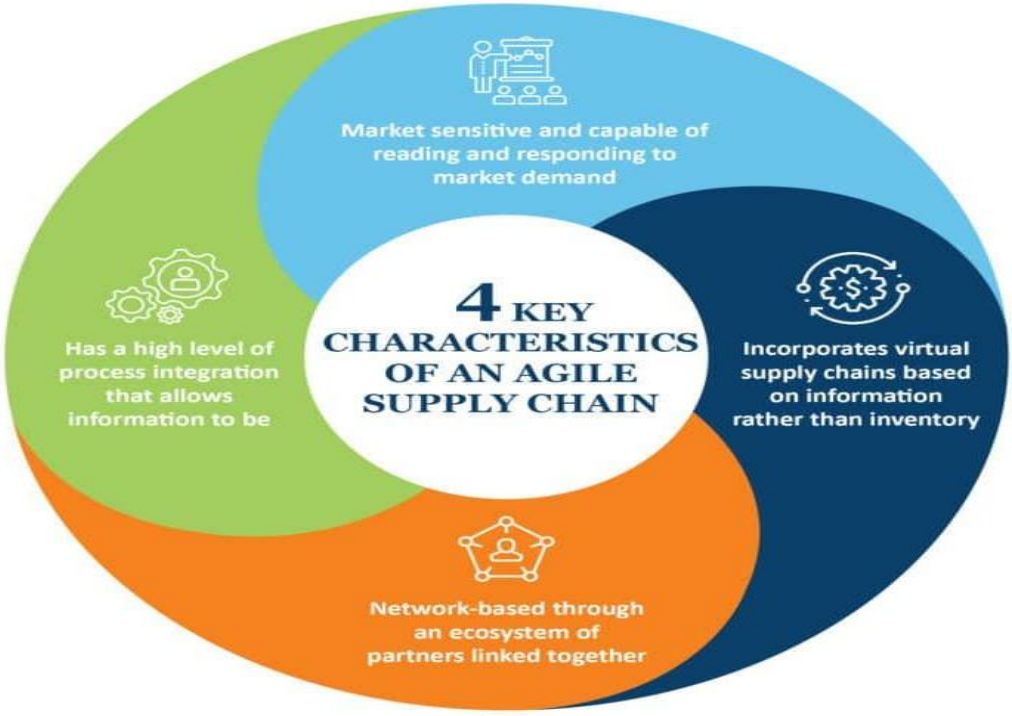

Figure 3 – Characteristics of Agile Supply Chain

The Short Food Supply Chain Model: -

Here a direct connection is established between producers (Farmers) and consumers with no or a maximum of one intermediary. The system bypasses traditional markets and enables the producers to reap maximum benefit while providing freshest produces to establishments. It ensures complete traceability and reduces carbon footprint. In this model the logistics is redefined to focus on three core types of proximities - **Geographical Proximity, Relational Proximity and Informative Proximity**. Geographical proximity reduces "food miles" by sourcing locally or regionally while relational proximity limits middlemen. Informative proximity builds customer trust and knowledge by enhancing traceability.

Methodology: -

In order to assess the criticality of supply chain management in the F2T concept in India, paper has perused the nature of the FSC including its functions, the challenges they face and opportunities they have in the country. The research has adopted qualitative technique that is entirely based on secondary data. The study has aimed to understand the operational dynamics

of F2T mode and assess the significance of FSCM in making it efficient. It also critically looks at the shortfalls of the existing FSC and makes recommendations to address them. This paper has been written based on the study of earlier works including case studies, industry reports and government publications. There is no primary research conducted and the researcher has strived to provide the entire spectrum of knowledge from secondary source.

A structured keyword search was conducted in four major electronic databases: Emerald (www.emeraldinsight.com), Springer (www.springerlink.com), Wiley (www.wiley.com), Elsevier (www.sciencedirect.com). Extensive use of the Google Scholar platform was also resorted to identify and select the articles of relevance. In addition, use of Brightspace (Access provided by Huddersfield University) to access articles was also done. The following keywords were searched to be in the title, abstract, or keywords: "food," "supply chain," "farm to table", "Supply Chain Management" and an alternation between "critical," "sustainable," and "Efficiency." Only publications with a clear link between the food supply chain management and food service establishments were considered initially. Search was conducted with time span of 2014 to 2024, covering a total of a decade of research. The period was decided because supply chain management with respect to food supply has gained relevance only in the recent years. This approach was affirmed during the research as only limited study material was available on the specific field in earlier years. As the credible published articles were limited, the scope was increase to include key words of: "Agri-supply chain", "Food markets" and "Food regulations". As the topic had limited research done in the country, no geographical focus was taken during the search for literature in the beginning, which was later restricted to India.

Research papers in peer reviewed journals containing food industry related white papers, government reports and case studies were perused to collect information. Platforms such as Google Scholar, Research Gate, Brightspace Library, News Articles, E-Magazines and Institutional Sources were used for the perusal. While the general criteria of not more than 10 years old from publication date was decided to select the source of information, exceptions were made to include critical articles of relevance that are older. Case studies have provided a deeper insight into the real time operation of F2T model facilities. Study of "Farmalore Restaurant" case have thrown light into the significance of food miles in sustainability, as the facility practices local produce procurements. In the case of farm to fork initiatives in Mumbai, it has highlighted the relationship between rural farmers and urban entrepreneurs, leading to active promotion of sustainable initiatives. Review of these case studies, not only supports the

theoretical inputs obtained from secondary data with regard to the subject, but also enables to have an understanding of the practical application of the model. It helps to gauge the solutions adapted to address problems and probable hiccups in the chain.

Evaluation of bottlenecks in the F2T supply chain in India was done by the application of Theory of Constraint (TOC). This theory captures the critical concerns that affect the FSC and suggests remedial measures. It is trusted that such corrections would create conducive environment for the efficiency in chain. The journal articles were perused with clear objectives to attain relevant information pertinent to the study. Articles such as the one by Kumar & Agarwal (Challenges and opportunities for agri-fresh food supply chain management, 2023) was used to study constituents driving supply chain management and their implication, while article by Beske, Land and Seuring **(**Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature) provided insight into sustainability in SCM and its impact on F2T model.

The literature were studied to compare different points of view and approaches on the subject. It considers the existing literature available as primary material (Jauch et al, 1980) and endures to analyse them to arrive at potential solutions/ suggestions. Through this approach, the researcher has strived to summarise relevant subject material and make comparison with the case studies perused, to ascertain validity and gauge applicability.

Research Question: -

How critical is the role of supply chain management in the success of farm-to-table systems in India?

Aim and Objective: -

The research paper aims to establish the importance of supply chain management in the success of farm to table system of food facilities in India.

The objectives that the article strives to achieve are

- Identify the challenges in supply chain management in general
- Peruse the factors that influence operational efficiency of supply chain management in India

- Assess the impact of supply chain management in the success of farm to table system of food facilities in India.

Findings: -

The potential of the F2T concept to boost, both the agricultural sector and dining business in India is tremendous. The concept supports local farming, thereby ensuring crop diversity and traditional farming practices. It also ensures protection of culture and its promotion. F2T concept leads to sustainability through shorter food chains and reduced carbon foot print. The dining landscape has the advantage of using fresh ingredients for food production that works on nutrient balancing of the diet. Traditional farming practice ensures that the food is safe and organic. A direct relationship between the customer and farmer would ensure the reliability of the food chain on all these fronts. As the restaurant operators procure the produce directly from farmers, it bolsters community support and ensures adequate compensation.

A FSCM system that supports F2T concept, removes middlemen, thereby enhancing the assurance of the system in providing quality and safety. As the travelling time of food is less in locally sourced scenario, freshness is guaranteed along with lower wastage and spoilage. This increase productivity and enhanced customer experience. For timely and accurate delivery of commodities to the user/ operator, the supply chain must have right information passing through the system. It enables coordination and right decision making, which can be further enhanced through modern information technology. It also results in transactional visibility which again impacts FSCM efficiency (Kumar & Agarwal, 2023).

Seasonal variability of produce and the supply- demand balancing are critical for a FSC servicing F2T model. Investments in technologies such as cold storage, refrigerated transportation vehicles etc. will help, to a great extent, to keep the produce fresh. Integration of forecasting tools and data analytics into FSCM will facilitate greater accuracy and efficient management of supply-demand loop. Adoption of advanced quality control systems, using block chain technology will help in enhancing traceability. This will result in improvement in food safety standards. These technologies also facilitate stringent audit of suppliers to ensure quality. Resilience of the supply chain can be augmented through supplier base diversification, adoption of risk analysis and management in FSC and implementation of business continuity plans. However, Indian scenario has challenges in adoption of block chain technology with

regard to technical competence, cost of implementation, safety & security and regulatory framework presently.

FSCM need to ensure transparency of their operation and the produce they handle. Information needs to be shared with customers on a continuous basis about the product like its origin, to achieve customer trust and support. QR codes and block chain ensures that relevant information is readily made available to the customer of the products journey from source to customer. Embedding risk management processes in the cycle helps in addressing supply chain disruptions. As FSCM systems face labour shortage and skill inadequacy, automation, especially in repetitive and labour intensive work is initiated. AI driven management systems like ware house management system are employed to increase productivity. In addition, investment in employee development and skill enhancement are also done. Competitive remuneration and flexi work timings also help in worker morale and help in retaining talent.
The coordination between partners with in FSC is an area of concern in India, with multiple streams of communication leading to confusion. Farmers, industry, facility operators and governmental organizations need to be integrated to make the FSCM effective to support the F2T model. Many of the problems faced by the Indian FSC is rooted in the above concerning factors (Gardas et el., 2019, Raut et el., 2018). The regulatory framework is complex in the country with overlap of central and state policies. The Essential Commodities Act, APMC regulations, GST policies, all work at odds many a times leading to administrative paralysis. It also hinders direct relationship between farmers and restaurant operators affecting the F2T system (Jayanth & Nair, 2020). Failure to integrate the farmer's network horizontally and inadequate farmer- wholesaler- retailer integration results in improper produce supply which has direct consequence to this model. Licencing regime is another impediment to a smooth FSCM, whether in the form of cold storage or transportation which is causing difficulties for F2T operators. Add to this the varying import-export regulations and the scenario becomes tiresome. While the government has worked on this area to some extent, there are still areas that need closer scrutiny (Ghag & Shedage, 2025).

The fragmented FSC in India, is a severe handicap for F2T system. This is compounded by food fraud, inadequate record keeping and partial compliance to rules and regulations. This character of the FSC leads to quantity, quality and time deficit in commodity supply, which has to be overcome for efficiency. Another factor that needs to be attended is the tracking of

transactions and movement of goods in FSC. Block chain technology facilitates real time tracking of transaction and has to be effectively utilized in FSCM. It provides information such as origin, farming method, storage facilities and mode of transport, making it easy for customer to gauge the antecedents of the produce/ commodity. This is an area that has further scope for improvement in India (Ellahi, Wood, & Bekhit, 2024).

Triple bottom line (TBL) frame work can be adopted to strengthen F2T network in India. TBL talks of three pillars for business performance – Economic, social and environmental sustainability (Prajapat, Zhou, Dwivedi, & Singh, 2022). The frame work addresses the failures in FSC in India, arising out of fragmented and unorganized supply chain, bureaucratic bottlenecks and logistic cost (Kumar, Wang, & Kumari, 2019). Economic dimension of the model includes promotion of fair trade, short supply chains, increased cost efficiency and streamlining of pricing systems. On the social front, the model provides framework for ethical sourcing, fair wages and transparent food systems supporting local community which is the basis of F2T model. The food safety and security paradigm of the FSC would also be addressed through TBL, by intensifying implementation of food regulations by bodies such as FSSAI, pursuing rigorous training regimes and conducting awareness campaigns (Saha, Raut, Yadav, & Majumdar, 2022). Through adoption of block chain and IOT interfaced monitoring systems, there is significant reduction in wastage in chain which has direct environmental impact and sustainability dimension. These systems help in maintaining food quality and reduce the perishability of food. In short TBL framework helps in integrating market driven innovations and sustainable practices with economic resilience, social equity, and environmental accountability in FSCM in India.

The government of India has taken many initiatives to promote F2T concept that will strengthen FSCM. Establishment of National Agricultural Market (eNAM) is one such reform. This digital platform enable farmers to have access to multiple markets in different geographical locations and connects directly with the customers. Enacting of the Model Contract Act has helped to strengthen the bond between farmers and processing/ handling/ producing firms. This provides the way for contractual agreement between restaurants and producers on commodities with specific quality guidelines and price stabilization provisions.

A study of some of the established F2T facilities in India would give clear picture of the theoretical propositions and helps in ascertaining its commercial status. Chef Vanika Choudry's journey gives a very good perspective of the challenges and benefits of sustainable eating practices in an urban food system (Oslen, 2024). With a background of the rich heritage of Jammu and Kashmir, her experience in Mumbai draws on the strength of ethnic food philosophy by sourcing locally, including seaweeds and edible flowers. Her effort in creating hyper-local food, served in a fine dining atmosphere has led to re-imagination of the F2T concept in itself. Her culinary journey has brought forward the importance of FSC, as sourcing seasonal and local produce from remote areas and reducing food miles had presented challenges (Kehoe, 2024).

Study of Farmlore restaurant also highlights the significance of having supply tie-ups with local farmers to maintain quality and freshness in the food and address price fluctuation. The practice of food facility operators creating their own vegetable and herb garden is another trend that helps in contributing to food chain. Hobby Garden is becoming popular with food facilities and helps in creating a niche food facility segment. Practices such as Terrace farming in states like Himachal Pradesh, has helped in optimum use of land and address supply chain inadequacies. A sustained integration of Hobby farming and Terrace farming into the FSC will go a long way in strengthening F2T concept in the country.

Discussion: -

A critical analysis of the information gathered has divulged the present scenario of the FSCM in India with specific reference to F2T concept. Seasonal availability of local produce and market demand need to be synchronized. With developments in agricultural sector, year round availability of commodities is a reality. So it is pertinent that facility operators are made aware of the locally produced commodities to reinforce sustainability. Technological and infrastructure developments produce mixed results. While on one hand there is efficiency and optimization of the chain, on the other there is the possibility of resource overuse and environmental hazard generation. A balanced approach need to be adopted to achieve desired results of sustainability.

F2T system have to deal with the demand and supply issue to some extent due to the perception gap between consumer and producer. A strong FSCM would help to bridge this gap through

two way flow of information, so that both parties are clear about the requirement of the other. This is same for quality demands also. When information of the seasonal availability/ shortage of produce starts flowing through the supply chain, it makes supply-demand challenge a differential impediment to F2T model that can be curtailed. Agricultural sector in India has a large chunk of small holders and marginal farmers, making the FSC decentralized. The agri-market model in many states in India prevents their direct market access due to the presence of middlemen. It also results in the fracturing of the chain at many crucial points. This leads to cost hikes, slower movement of goods, quality degradation and wastage, resulting in inefficient FSCM and inadequate F2T model (Renkema & Hilletofth, 2022). While the government has taken many initiatives to address these challenges, political differences, weak process framework and farmer union apprehensions have curtailed its effectiveness.

Advent of block chain technology has revolutionized FSCM in India. Its application ensures productivity, transparency and traceability in the chain. The decentralized form of record keeping makes it highly efficient. It produces accountability at each stage in the chain from farm-to-table. When technologies such as IoT and smart contracts are added on, stake holders can opt for transaction automation, wastage monitoring and logistic streamlining. Real time monitoring of food movement, identification of contamination source, locating despatch errors, all becomes easy. This will lead to food safety and wastage control. Monitoring of shelf life and compliance to standards employing minimum manual effort was demonstrated by IBM Food Trust through block chain. While much work has taken place in this domain, their application in Indian FSCM has much more potential. Technological complexity, excessive resource consumption etc. still remains challenges.

Production efficiency in farm sector is vital to the success of F2T model. Technological advancements co-opted to farm sector has produced impressive results in India. Precision farming is one such area where the government has been focusing to achieve sustainability and productivity. A 6000 crore project for the adoption of smart technologies like AI, drones and data analytics has been launched by Gov. of India with a view to modernize the sector. Centres of excellence is being set up in collaboration with other countries to drive innovation and productivity (Behuria, Ojha, & Nayak, 2024). While precision farming has the potential to drastically increase productivity and efficiency, high capital investment in the beginning, shortcomings in information & communication infrastructure in rural areas and smaller farm land holdings are major road blocks in achieving full adoption.

Digital twin technology is another field that need to be integrated to F2T system in India. It will make the system agile, resilient to address seasonality challenges and logistic bottlenecks, and making it transparent (Abideen, Sundram, Pyeman, & Othman, 2021). Digital twin of the F2T system i.e. Virtual model of the physical supply chain assets and processes, provides real time visibility of the complete system helping in minimizing bottlenecks and optimizing inventory. Situation simulation can be carried out by supply chain managers through effective use of IoT, sensors, AI and advance analytics which will help in predicting disruptions and conduct strategy trial runs. However, due to the cost involved and the complexity, it would be advisable to adopt this in phases. Starting with selected agriculture hubs having large distribution centres, it can be gradually applied across the chain. On full implementation, the technology would provide a great fillip to precision in forecasting, wastage reduction and operational efficiency of the complex Indian agricultural supply chains (Huang, Ghadge, & Yates, 2023).

Presence of middle men in the Indian FSC leads to reduced income for farmers as they lack direct market access. This has a morale issue which can impact productivity and quality. This gives the scope for a community supported agriculture (CSA) model, like in USA, to establish. Here the restaurant operators gets into an agreement with the farm producers to buy a share of their produce. Such a model eliminates middlemen, assures fresh produce and reduces supply shortage. The F2T operators has the advantage of procuring locally grown, farm fresh produce which fits well with their requirements (Rossi & Woods, 2024). While multi-national companies sponsor limited seasonal produce, by its guarantee to buy them at the start of the season, it is not institutionalized at the food facility level in the country. Restaurant Supported Agriculture-cum-Community Supported Agriculture Mechanisms, which are prevalent in European nations, are at a nascent stage in India. Such systems ensures cash flow to farmers, as the crop is purchased directly from growers at the season's beginning. This establishes a direct bond between the consumers and producers of food commodities. Restaurants like "The Deck at Island Gardens" provides seasonal menu to customers, through this practice, minimizing food wastage and supporting sustainable farming practices (Island Gardens, 2024).

Infrastructure in India, in the form of roads, railways, waterways, cold storages and market link-ups, has shown tremendous growth in the last decade. However, considering the geographical size of the country and the fact that most of the F2T facilities are urban or semi-urban, there are areas to address to boost competitiveness. An up-tick in the cold chain logistics

with more storage space, connectivity boost to rural areas and convenience in market accessibility would strengthen F2T model. The "Grameen Sadak Yojna" is a step in the right direction, as far as rural connectivity is concerned, but needs more focused effort (Kiran, Prasad, & Mohan, 2023). In India, the second largest producer of horticulture products, the post-harvest loss is around 35-40%, mainly due to cold storage facility shortage. The number stands at 8186 as of 2020 (Tiwari, Harischander, & Rane, 2022) (NCCD, 2021). While this number may show improvement due to the efforts in the last 5 years, there is also the issue that the facilities are focused on certain specific commodities such as potato. This require urgent attention as the revenue loss in monetary terms is about ₹1.16 trillion.

Government regulations, in India, many a times tend to become hurdles for an efficient FSCM (Barman, Mondal, Quader, & Jairu, 2024). The complex food safety regulations, bureaucratic red tape, periodic changes in policies and spiralling compliance costs, all add to the vows of the small scale farmers and restaurant operators. Compliance with the stringent food safety and hygiene rules of FSSAI is a pre-requisite for procuring operating licenses. This has a cost dimension that is too much, many a times, for small scale operators. Time and resource required for certification, periodic inspection and documentation are cumbersome for such operators. Many of them also lack the knowledge and expertise to run such systems. Add to this the cost and time that need to be invested to maintain requirements such as traceability conditions, hygiene standards etc. and many of the players choose to opt out of FSC (Kandukuri, 2023). These short comings need to be addressed to establish an efficient FSCM that supports the F2T model.

Conclusion: -

Along with the world, Covid-19 had brought out the shortcomings of the FSC in India. It has reinforced the dire need for strengthening of the chain and building in new checks and balances. This paper has identified multiple challenges that the FSCM faces through the perusal of earlier works. The study focuses on selected areas of manpower, technology, government regulations, supply chain structure, Infrastructure, seasonality, partner collaboration and demand–supply balance. Researcher endeavours to suggest solutions to address the many challenges that these domains faces that are applicable. The paper has also tried to capture the many advancements that has been achieved in the field and has looked at the role of the stakeholders in it.

With the advent of technology, it is inevitable that FSCM become more lean and mean. As food safety and security is going to become a big challenge in the future, it is pertinent to strengthen FSCM and enhance the internal collaboration. With the life style changes that the society is witnessing, the F2T concept is only going to consolidate in the coming years for which the FSCM need to be prepared. There in comes the relevance of this paper in identification of challenges and proposal of solutions. It is pertinent that further research need to be conducted in this domain with specific focus on technological advancements, supply chain collaboration and government regulations.

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