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REVIEW ARTICLE

A Comprehensive Review of Safety, Security, and Food Waste in the Food Supply Chain Logistics

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Abstract: The food supply chain logistics (FSCL) plays a vital role in ensuring food reaches consumers safely and efficiently. As the global food system becomes more complex, ensuring the safety, security, and minimizing food waste throughout the supply chain has become increasingly important. This review examines the key challenges and solutions associated with food safety, food security, and food waste in the FSCL, highlighting their interdependence and the need for integrated solutions. Food safety encompasses measures to prevent contamination, spoilage, and health hazards from farm to fork, utilizing technologies such as traceability systems. Food waste, which accounts for approximately one-third of global food production, results from inefficiencies and improper handling throughout the supply chain, with significant losses occurring in production, distribution, and consumption stages. Strategies to combat food waste include improving logistics infrastructure, better inventory management, and consumer education. This review advocates for a holistic approach to improving safety, security, and waste reduction in the FSCL, emphasizing the adoption of advanced technologies, policy interventions, and sustainable practices to create a more resilient, efficient, and sustainable food system.
Keywords: Food Supply Chain Logistics, Food Safety, Food Security, Food Waste, Supply Chain Management, Traceability, Food Loss, Sustainable Practices, Logistics Infrastructure, Consumer Education.

INTRODUCTION

A tragic reality of today's world is that despite the advances and achievements of mankind, 795 million people starve every day. This is more common in developing countries. Almost fifty percent of death occurring in children below the age of five is due to malnutrition in these countries. This problem will only further aggravate by climate change. The Goal 13 of Sustainable Development Goal highlights that a considerable portion of the flora and fauna is destroyed by fire, drought, floods and another natural disaster. "It is time to rethink how we grow, share and consume our food," urges United Nation's Sustainable Development Goal (SDG). Climate change is one of the many issues that are adding to this precarious situation of global food security. According to School of Environment, Resources and Sustainability (SERS) professor Jennifer Clapp, the way the dominant global food system is organized perpetuates unsustainable food production practices and inequalities where millions of people don't get enough to eat while others have too much. The global data available corroborates this fact. There are 2 billion people around the world who are obese. At the other end of the spectrum are 1 billion people who are suffering from malnutrition. There is considerable wastage of food amounting to 1.3 billion tons. This wastage is due to deterioration of food, bad harvesting practices and poor transportation management. The SDG 12 highlights this aspect and emphasizes on sustainable development and consumption patterns. This will reduce the impact of such wastage and the effect it has on the environment, economy and society.

"Global trade rules, patterns of agricultural aid for developing countries, and growing corporate concentration in the agri-food sector have all contributed to a system that many say is highly skewed and ecologically damaging," affirms Clapp. Clapp is a renowned expert in food politics. He is also a Canada Research Chair in Global Food Security and Sustainability. Clapp also suggests that there is a need to inspect below the surface to comprehend the supply chain. "Basically, we have a global food system that is highly concentrated. Certain corporate players dominate all along the chain, right from the inputs they sell to farmers, to the trading of agricultural commodities, through to processing and packaging and on to retail."

Clapp expresses his view about the retail environment. He feels that it is here that consumers can bring about a change. He says, "If you shop at the supermarket without thinking about how your food was produced and where it came from, you might be supporting some of those kinds of relationships that some people would say are socially unjust or ecologically unsound. Clapp has researched deeply about the politics on international stage concerning food aid. There are many issues concerning food security, the major one being that fact that some countries like the U.S. use the food they produce for aiding the developing countries. This means most of the activities of the supply chain like production, processing and packaging are done in the country that is extending the aid. This is an inefficient method of providing aid. If the food sources are closer the country that is receiving the aid, the cost can be cut down by 30 to 50 percent of what is being incurred when it is sourced from the country providing the aid. The other issues with respect to this kind of arrangement are the environmental impact. Shipping the food to the other part of the world increases the ecological footprint. Moreover, the country receiving the aid may have banned some genetically modified organisms that are present in whole grains like maize. This poses a serious ecological risk to the country receiving aid.

As per the UN data, almost 80 percent of the food consumed in the third world country can be attributed to 500 million small-scale farms. These farms should be developed further by way of aid or other methods to increase food security. Small farms can play a key role in developing sustainable food systems. These local farms produce regional food that can cater to the local consumers. A recent trend is the increasing importance of speculative financial investments in the agri-food systems. It has a serious implication on hunger and the environment that has to be investigated. There has been an increase in investment in complex financial derivative which is based on agriculture. Theoretically, these investments look financial, but they have serious implications on the real world. Many land grabs, biofuel production and forest clearing cases have been associated with these investments. Clapp points out that "Global economic forces affect the food system in myriad ways, and it's important to understand the linkages if we wish to work toward more sustainable and just food systems for all."

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FOOD SUPPLY CHAIN SAFETY AND SECURITY: A CONCERN OF GLOBAL IMPORTANCE

In the last two decades, the issues global food supply chain has been highlighted in many global platforms. This attention has increased post the 9/11 attacks in the United States. The extent of destructions and havoc the attacks caused an increased focus on the issue of supply chain security. Terrorism is one of the many concerns that have caused a significant increase in the profile of supply chain security. Supply chain security has faced challenges from various quarters. This includes theft, smuggling, adulteration, duplicate goods, and sabotage among others. The issue of supply chain security is fundamentally pertinent to the food industry as these traded products are consumed by humans, imposing significant threats to human life and our standard of living.

Food security is a major concern in the food supply chain. Food safety management concerns a variety of practices that are aimed at foodborne illness. Food safety is concerned with many issues. It is not limited to intentional acts like food adulteration and terrorism. A lapse in food security can have a devastating consequence. For example, if proper hygiene protocol or standard operating procedures is not followed, it can lead to epidemics or even death. The food supply chain is a complicated chain involving many elements. The process from farm-to-fork involves many security challenges. For instance, there is a popular grocery store chain in the United States that procures its supplies from over 30,000 suppliers and one-fifth of them are from across the border. This global food supply chain poses significant threats to the safety and security of food.

The management of food supply and assuring its safety is a daunting task. The threat that emerges from safety and security is glaring. It is also a recurrent phenomenon. This has encouraged many international bodies, industry groups, nations to address this issue. They have enacted legislation and established many standards both national and international to find a solution. An example of one such standard is the ISO 28000 introduced by International Organization for Standardization (ISO). This standard is concerned with supply chain security. The other ISO 22000 is another standard which deals with food security. In 2011 the US, the Food and Drug

Administration established the FDA Safety Modernization Act. This act was aimed at improving the safety of the food supply chain. Safety and security are of utmost importance in the food industry. However, there is not much academic research which seeks to identify those practices and strategies that enforces food security. A major challenge in this respect is that organizations are not transparent about their strategies that could have an impact on food security. They are reluctant in disclosing and cite confidentiality as the reason behind it. Even in cases where lapses are noticed while conducting empirical inquiries, organizations do not disclose sensitive data to preserve their legitimacy. Secondly, theoretical and conceptual development which can demonstrate how the organization has fared in food security is absent. In the last two decades, many nuances and variables have been presented. However, literature still lacks conceptual frameworks that can explain the phenomena.

SUPPLY CHAIN EFFICIENCY IS CRUCIAL TO ENSURE FOOD SECURITY

Almost one-third of the food that is produced is wasted or lost. Improving the efficiency of the food supply chain is one way to feed the ever-growing population. This requires simplifying and streamlining the food supply chains. "One clear avenue to increase regional food system resilience would be through the systematic reduction of food waste through the entire supply chain," wrote the authors of *The Risks of Multiple Breadbasket Failures in the 21st Century: A Science Research Agenda*, (2017) a paper co-sponsored by Thomson Reuters.

Food that is sourced from local sources can ensure shorter and less complex chains. This reduces the number of points where food could be lost or wasted. Theoretically, increasing the supply of regionally grown food seems to solve the problem. However, a large-scale shift may not be possible. All the regions of the world are not equipped to produce food in bulk. Small scale operations that have tried expanding have faced challenges in the past. Hence, it is important to work with greater efficiency and make the food supply chain seamless. The FAO wrote in one of its paper Global food losses and food waste – Extent, causes and prevention "Improving the efficiency of the food supply chain could help to bring down the cost of food to the consumer and thus increase access." It is a daunting task to improve the efficiency of supply chains.

Some measures include:

- Risk management of the supply chain can maintain the safety of food, reduce the risk of loss, minimize food waste and develop a sustainable supply chain.
- The price of food must be monitored. Managing the supplier risk helps in managing the price of the food.
- It is important to increase awareness of global markets. Their interdependency and interaction have an influence on the supply chain. Unfavorable changes in the global level can disrupt all or any stage of the supply chain including production, compliance and logistics. Thorough knowledge of global markets can improve efficiencies. It also helps the stakeholders to adapt the supply chain as per the changing conditions.
- Historical events can indicate the changes that might occur and suggest how to adapt to them. This is known as predictive analytics and enables the food industry stakeholders to adapt their practices. This will help in minimizing food wastage and meeting the consumer needs more efficiently.
- Due diligence of suppliers is a vital aspect of an efficient food supply chain. It enhances transparency which allows controlling the food quality issues. It leads to greater awareness of safe processes and operating controls which can hinder malpractices.

Streamlining and increasing the efficiency of the supply chain is crucial to ensure food security. This requires a sustained and multi-faceted approach. The task is daunting, but it can mitigate the risk of food shortage and safeguard the food supply.

IMPACT OF CLIMATE ON FOOD SUPPLY CHAINS

The short-term and long-term changes in the climate lead to serious disruption in the food supply chain. There are various factors that make the food supply chain vulnerable to climatic change. These vulnerabilities arise due to rapid urbanization, changes in food habits and changes in food systems. All the supply chain actors must be involved in minimizing the risks and reducing their vulnerabilities. Supply chains have transformed because of climate change. This change has occurred at varying speeds over different products and regions. Small farmers who rely on traditional supply chain face higher threats from cli- mate change because the process is less commercialized, and they depend on the low spending capacity of the local economy.

Modern supply chains may be facing threats from various quarters, but they are more robust to mitigate climate change. Altogether, whether the farmer who depends on traditional or modern supply chains is exposed to lower overall risk is an empirical question that will vary by place and crop.

IMPACTS ON FOOD SUPPLY CHAINS FROM SHORT-TERM CLIMATE CHANGE

Short term climate changes or climate shocks make the supply chain more vulnerable to climate. It has an impact on various stages of the supply chain. Examples of short-term climate shocks are landslides on highways, devastating rains, tidal wave or tsunami. These calamities could destroy ports, disrupt

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sources of energy, hinder transportation and destroy crops. These climate shocks can hinder or disrupt the input or output flow especially when the supply chain is long. For example, in Thailand, CP Foods, a large poultry production and processing chain relies on China, the United States and Russia. A disruption in any of the facility can hinder the production throughout the system and cause heavy losses.

An example of a domestic supply chain, is poultry production for urban consumption in Bangladesh or Nigeria. They are dependent on inputs on feed ingredient shipments from grain and cassava zones to peri-urban feed and poultry production facilities, which are vulnerable to road flood-outs and political strife. These climate shocks cause massive destruction of food. The situation is further worsened in countries which are characterized by food shortages. The prices of the food tend to inflate during these periods of climate shocks to reduce the access of food by low-income consumers. It is important to conduct a compelling evaluation of the impact of short- term shocks of the climate and the changes that are permanent on all stages of the supply chain. This includes cultivation, processing, packaging, and distribution. The farm is a major segment of the food supply chain and it accounts for fifty percent of the costs and value added. The entire supply chain is crucial to maintain food security and for job opportunities. It is a source of employment for many actors who are involved in the chain from urban and rural areas.

There are three types of supply chains which help the functions of the urban and rural area. They are rural to rural, rural to urban and urban to rural. In a dynamic context, these three supply chains must be analyzed since both supply chain and climate change is a highly dynamic phenomenon. There are various policies that are being developed so that all elements of the supply chain can adapt to climate change. However, supply chains are constantly evolving hence they should be based on future trends and not on their current structure. It is important to approach the analysis of climate shocks on supply chains with a clear view of the complexity of a given supply chain as an interdependent set of segments and sub-segments. Climate shocks at the top of the link, like a flood in the regions in the vicinity, can disrupt the elements in the entire food supply chain below. It can affect the assembly and transportation. It can hinder the sale of surplus output from the rural areas and block the supply of input to the farmers. These have a ripple effect which could delay or block the supply of food to urban areas.

The impact of climate change on the supply chain can be analyzed from the viewpoint of "hotspots" of vulnerability along the chain. The hot spots have seven determinants:

- The robustness of physical infrastructure to prevent any disruption of production in the supply zones
- The geographical area over which the supply chain is spread
- The shelf-life of the product
- The strength and durability of physical capital
- Asset specificity cum location specificity
- The concentration of elements in the supply chain
- Vulnerability to climate risk.
- These hotspots are different across products and locations and the extent of modification of supply chains. Hence the solutions to mitigate climate change have to cover various aspects and evolve as per changing conditions.

IMPACT OF LONG-TERM CLIMATE CHANGE ON FOOD SUPPLY CHAIN

The long term effect of climate change is global warming. This is causing the melting of glaciers which could cause irreparable loss to agricultural production in many parts of the world. It could alter the water availability patterns, cause floods and dislocate farm production patterns. The melting snow can later become the supply of water for irrigation. For instance, in regions close to the Himalayas rains may cause floods while there could be a shortage of water during dry seasons. While floods damage crops, the crops cannot survive when there is an acute shortage of water. The reduced supply often cannot meet the food requirement of the entire population and causes food prices to surge.

The intermediaries involved also suffer since the flooding can destroy the infrastructure facilities including cold storage and transportation. The risk of these floods may compel the relocation of processing and storage facilities. This involves additional investment which can cause the food prices to soar and make it unavailable to low-income groups. Changes in patterns of farm production and the availability of food supplies may change procurement strategies of intermediaries as well as prompt them to invest in agricultural production in regions less vulnerable to these effects. Some of the risks can be reduced by building dams and better storage facilities and irrigation systems. The mitigation of long-term climate change impact involves higher investment since the impact is experienced on a large scale. The strategies for minimizing loss require public sector support since it involves huge investment. Countries with political will and good governance systems can adapt to these changes better. Many of the changes transcend national borders which necessitate the involvement of multinational organization and international bodies.

FOOD LOSS AND WASTE IN THE FOOD SUPPLY CHAIN

It is estimated that almost one-third of the food produced for consumption worldwide is wasted or lost when in the various stages along the food supply chain. In the meantime, by 2050, the global population is expected to reach around 9.1 billion. This prediction is threatening food security. It is estimated that to feed this growing population, food availability should increase by 70 percent. A substantial proportion of this population explosion will be witnessed in developing countries. The rapidly increasing population in the urban areas is creating a complex and extensive supply chain. They involve various intermediaries which increase concerns about the safety of food. Another important consideration is the quality and nutritional value of food. Food loses have to be minimized and the waste should be tackled in an efficient, integrated and sustainable manner. This will go a long way in meeting the requirements of the growing population and at the same time result in the optimum utilization of resources both natural and financial. The private sector including the food sector can contribute significantly to minimizing food loss and tackling the waste. This can be done by making the food processing procedures more efficient, establishing an organized food supply chain and connecting the farmers to the market besides other factors. Nuts and fruits are high-value items and a great source of nutrition. However, fruits have a short shelf life. It is crucial to minimize the wastage and loss of these items since they have a significant potential for value addition.

FOOD LOSS AND FOOD WASTE

Food loss and waste results in a decline in the quality or quantity of food that was intended to be consumed. It makes the food inedible and causes shortages. Some reasons that cause wastage include using food intended for human consumption as animal feed, transforming foods into bioenergy and dumping into landfills. There exists a difference between food wastage and loss and the circumstances in which they occur. It is important to differentiate the two especially

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when identifying the cause and implementing measures to tackle this issue. Food loss occurs when there is a malfunction in any of the stages of the food supply chain, including its institutional and policy framework. This loss is often the result of technical limitations or managerial errors. Examples of these challenges are lack of proper storage facility, inadequate cold storage, poor food handling, underdeveloped infrastructure or inefficient marketing systems.

Food waste means the elimination of edible food from the food supply chain. In other words, it refers to the removal of food which can be consumed by humans. Generally, food loss happens in the early stages of the supply chain. It is more common during production, processing or packing stages while food wastage occurs during the retail sale or consumer level. Some of the reasons for food wastage include poor management of stock or negligence. It may happen by choice or after the food decays or expires.

IMPLICATIONS OF FOOD LOSS AND WASTE

Food loss and food waste have a profound adverse effect on the economy, environment, and food security. It is estimated that the value of food loss and wastage amounts to US$ 1 trillion at a global level. The wastage and loss reduce the supply of food in the market, which causes the prices to surge. This has a negative impact on low-income consumers who now have access to less food for the same amount of money. On the other hand, food spoilage also affects the producers. Sometimes the food must sell below cost or disposed of when it becomes stale. The livelihood of marginal farmers is greatly affected due to this. Food loss and waste represent not just the food. It is also wastage of all the resources consumed like land, water, energy and other natural resources that go into the production. As per statistics the number of resources lost or wasted due to wastage of food results in almost 4.4 giga tonnes of greenhouse gas emissions per annum. This makes food loss a major contributor to the greenhouse gas emissions. Climate change is a leading cause of worry globally. The nut and dry fruit industry can gain immensely from strategies employed to mitigate climate change. One effective measure is by curbing the food loss and wastage in all phases of the food supply chain.

THE STAGES OF OCCURRENCE OF LOSS IN THE FOOD SUPPLY CHAIN

The quantum of loss varies amongst the different stages of the food supply chain. It depends on many factors like the type of produce, the economic development of the region, social customs and tradition, etc. As per a study of FAO, in industrialized regions, the maximum loss of fruits and vegetables during, production, sorting, and grading stages. One of the reasons causing this could be that some food is discarded during grading if it fails to meet the quality standards that the retailers demand. Emerging economies experience high losses during harvest, sorting, and grading. In addition, they also experience high loses in the processing phase which approximately between 14-21%. In the developed countries this loss is much lower at around 2 percent. This sharp contrast further stress on the requirement to use better technologies in emerging economies to harvest short shelf-life fruits and vegetables. The food industry can play a crucial role in this phase by innovating new low cost and effective methods which can reduce the loss.

STRATEGIES AND SOLUTIONS TO REDUCE FOOD LOSS AND WASTE

It is important to recognize the interlinkages between the various phases of the food supply chain. This will enable the formulation of effective solutions to curtain the wastage and loss. In other words, the performance of each actor and the cost of activities in upstream segments of the chain could determine the quality of the product further down the food supply chain. This is a cohesive approach towards supply chain management. An important consideration here is how technical intervention affects the social context and the environment. Moreover, the cost of the solutions invented should be less than the loss that occurs due to wastage. For example, the certain cot is involved in improving the storage facilities so that post-harvest loss is minimized. However, this increased supply should have buyers so that the increase in cost can be recovered. Hence proper strategies have to the employed simultaneously to enhance market access. However, the cost of all the techniques and strategies should exceed the amount of loss that it prevented.

In developing countries solutions should be arrived at after considering the producer's position. For example, more effective solutions would include adopting better harvest techniques, increasing the farmer's awareness, improving the storage facilities and cold storage. In more advanced countries, solutions from the producer and industrial perspective would be inadequate if it is not supported by increases awareness among consumers and proper management and handling of stock at the retail level. Moreover, government investment on capacity building for agriculture and infrastructure and policy support to facilitate market access for farmers and to provide an enabling environment for private sector investment is a non-negotiable factor that cuts across most measures to reduce food loss and waste.

The food industry is dependent on technological innovations to curtail wastage and improve productivity. This is even more important for food that has a short shelf-life. Some of the solutions that have been effective in minimizing the loss include the following: The lack of proper drying facilities in case of marginal farmers is one of the leading causes of wastage. This is more pertinent when it comes to nuts. Most farmers rely on hot climate and employ conventional sun-drying techniques which are affected when there is a sudden shower or clouds. Moreover, these poor farmers do not have awareness about best practices to handle the crops and they are not equipped to measure the moisture content of the crop post drying.

Inadequate drying could cause biological contamination of the crop. As a result, mold and toxins develop during handling and storage. The value of the crop diminishes, quality deteriorates, and food safety is compromised. Therefore, training farmers and facilitating their access to basic tool kits to measure the moisture content of the crop and provision of alternative drying methods such as hot air, "oxidized bed, infrared and solar should be considered when formulating solutions to reduce losses in the nut sector. For instance, in Kenya, effective drying technique has been developed to dry mangoes and reduce wastage. Kenya faced a major challenge with respect to transporting mangoes to market. More than half of the mangoes were lost before they could make it to the market. To minimize the loss, the German Corporation for International Cooperation (GIZ) collaborated with a Nairobi-based company called Azuri Health and developed a dry mango product. This happened post the FAO's initiative to minimize food wastage and losses.

GIZ was able to provide technical and financial assistance to Azuri. Azuri was able to purchase solar driers and packaging facilities with the help of financial and technical support from GIZ and other members of Save Food. These techniques helped Azuri to develop a dried mango product that adheres to the quality and safety standards which can marketed in Kenya. In autumn 2016, Azuri started work on a new production facility near Nairobi. This step was taken with the objective of penetrating the US and Europe markets.

Similarly, the freeze-drying technique was applied to fruits to enhance their cosmetic appeal in the US. The fruits that were not accepted by retailers because they were not appealing were converted into dried fruit products. The freeze drying technique increases its shelf life without affecting the nutritional value. In an Italian nut company, an improved packing system was introduced this new system reduced the loss occurring during the packing stage of the food material to less than 1 percent. Many food products like nuts and dry fruits have a high market value. Hence minimizing wastage and loss is crucial. Besides

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introducing better techniques, simple measures like improving coordination and cooperation among the various intermediaries involved in the supply chain can minimize the losses.

In Australia, a study revealed that in the late 90s almost 37,000 tonnes of bananas were being wasted every year because the pack house was rejecting it. Apparently, they were not as fresh as the consumers demanded. The harvesters collaborated with companies engaged in packing, retailers, and state primary industry departments so that the primary factors in the supply chain behind this loss can be addressed and an effective solution can be implemented. It was identified that major losses were due to damage of fruits during transportation, handling, and storage. Moreover, even in the supermarkets the staff and consumers were handling the fruits poorly. The reason behind this was inadequate staff training and a lack of consumer awareness. The extensive collaboration and cooperation paved the way for making the supply chain more efficient. A major Australian retailer conducted extensive research and devised a cluster packing method. This led to the development of the six-per-layer carton, absorbent paper for sap control as well as the development of product specifications and systematic quality assurance to monitor fruit outturn at points along the chain and implementation of improved cold chain and processes from harvest through to retail.

SUSTAINABLE LOGISTICS AND TRANSPORT TO ENSURE FOOD SECURITY

Transportation and logistics play a crucial role in ensuring food security. Transport and logistics involved in the food chain has a considerable impact on the climate and contributes to global warming. Some of the alarming facts are:

- Almost 50 percent of the food production is lost between farm and fork
- Fifteen percent of the overall greenhouse gas emission is due to emissions from
- transport. Out of this, 60 percent of the emissions are from road transport.
- The cost of logistics is often a significant component of the costs incurred by marginal farms. It accounts for almost 23 percent of the total costs.

Thus logistics – the services, knowledge, and infrastructure that allow for the free movement of goods and people – is now recognized as a key element in achieving sustainable food security, and thus a driver of competitiveness and economic development. Agro-logistics is one such development which has a holistic approach to tackle the challenge of food security in all stages of the food supply chain from "farm to fork". The general belief is that most of the loss occurs during production, handling, and storage. However, the Food and Agricultural Organization has highlighted the fact that even during the consumption phase much loss takes place.

Advancements in technology and modernized value chains have contributed towards reducing the loss in the post-harvest harvest period from the field to storage. However, marginal producers will gain economically only when losses are minimized throughout the value chain. The supply chain of staple foods suggests that when a greater number of intermediaries are involved between production and consumption, then each intermediary has less motivation to minimize food losses. Consequently, the producer who is at the beginning of the food supply chain is in a disadvantageous position since he has little control over the losses further up in the chain. Another impact of complex value chains is that it increases the risk for broken cold storage chains or food losses due to poor storage, handling and packaging (losses up to 37% of retail value). Moreover, freight movement affects people's lives in numerous ways including noise, road safety, air pollution among others. For instance, the refrigeration units used in transport and cold storage facilities are not energy efficient. Mostly the commercial vehicle run on diesel which further increases the greenhouse gases emissions.

These issues with respect to transportation and logistics support the argument in favor of localized production. However, it is not always the case that geographical distance makes the global supply chain more complex. Ships are economic modes of transportation of cargo and they are fuel efficient as compared to other modes. Hence it is a convenient option when food products have a longer shelf life. Farmers can make higher margins if they use shipping for export of produce to foreign markets. In many cases, the bulk transport of produce results in a low ecological footprint. Hence a case-by-case basis analysis is required for maintaining the balance between economic yields, total transportation costs, and overall greenhouse gas emissions. The technological advancements and other innovations have improved the prospects to minimize food waste and reduce the adverse impact on the environment. For example, the invention of mobile refrigeration units powered by solar energy is a game changer. It caters to remote areas and removes their challenge of cold storage in these locations. The underdeveloped areas do not have an adequate supply of power or they are too expensive. The dependency on fossil fuel increases to produce the required energy.

CONCLUSION

Food security is a major issue across the world. Food safety depends not only on agricultural production but on the entire food. Only then the problem of starvation and malnutrition can be solved. All the processes involved in the chain like harvesting, grading, storing, packing, transporting and selling are a crucial function that can ensure the supply of safe food to the population. The food supply chain is the key to mitigate this global risk. Efficient management of the food supply chain and streamlining the processes will help to minimize the loss and prevent price inflation. This requires the support of all the actors involved in food supply management. The global food supply chain also poses the challenge of food safety. Hence there has been a focus on localized food. A shorter and less complex food chain can minimize the loss that takes place between farms to fork.

Food supply chain stakeholders face a multitude of issues which can be overcome by efficient management of supply chain. The food industry must act as one to overcome the challenges of food safety, security and sustainability. Collaboration and trading-partner alliances will become necessary strategic imperatives. It is important to curtail the loss and wastage of food throughout the supply chain so that the environmental impacts of agriculture can be minimized. It will also improve the earnings and standard of living of the various actors involved in the supply chain. Moreover, it will enhance the food quality and improve the nutrition of the food consumed by low-income consumers. The food supply chain has become very complex and lengthy in today's world. There is a continuous increase in the urban population, the food preferences and consumption patterns have changed. Globalization also has a profound impact on global food supply chains. Hence the traditional methods of addressing the issues of food loss and wastage in the various stages of the supply chain must be addressed in an integrated manner.

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CONFLICTS OF INTEREST

"The authors declare no conflict of interest".