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An Exploratory Study of Risks and Food Insecurity in the Agri Supply Chain

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Globally, the agricultural industry has increased the market for various farm products. The timely production and distribution of harvested crops and fruits are essential because of the increased demand across the globe. According to the Food and Agricultural Organization of the United Nations, one third of the food produced for consumption is lost or wasted worldwide, amounting to approximately 1.3 billion tons per year. The productivity of the farm's yield decreases mainly because of unstandardized processes. The employment of an optimal supply chain management scheme must be the key to the situation. This would not only promote consumer shielding; however, it will jointly help corporations sustain economic supply chains. Due to health and socio-economic consequences, the most vulnerable population groups' food security is likely to decline further (Food and Agriculture Organization, 2020). The agriculture sector's supply chain faces many challenges, such as inadequacy of information flow, lack of logistics efficiency, lack of infrastructure and storage facilities, lack of risk mitigation systems that are critical during unforeseen disruptions. The paper identifies various risks in the supply chain and their ability to disrupt the supply chain in terms of severity, food insecurity, and sustainability. A study has been done among a hundred stakeholders, and thirty experts from the field, and the exploratory research suggests possible approaches to these challenges using technology.

Keywords: Sustainable Agriculture, Food Supply Chain, Food insecurity, Technologies

Introduction

The significance of the food supply chain’s multiple levels depends on the risk and safety concerns associated with that specific level. Before the food product hits the market, the supplier must find the risk associated with it, find the critical problems, track them, and provide a continuous check on compliance. Methods for addressing and reducing the risk stress the value of working with manufacturers and suppliers with sufficient data on their food safety procedures. Improper temperature control during storage, insufficient cooking, poor personal hygiene of food production workers, dirty production equipment, and raw materials from hazardous sources or vendors are some of the problems. In ensuring food safety, several more problems continue to come day by day, and customers play a significant role.

Methodology

We have conducted research to identify fallout areas in the food supply chain, foundations of the global food crisis, threats, and the global food crisis management. To understand the risks in the food supply chain, a survey has been performed on 100 stakeholders in different areas of the supply chain. An interview with 30 experts from the food supply chain was also conducted that could demonstrate the impact of these problems. To classify the significant threats and their effects, a risk impact review has been carried out. Models have finally been proposed to reduce the risk associated with the supply of food.

Objectives

Access to nutrition is nutritional poverty, and healthy food is central to human life. Stable food access will have a broad spectrum of beneficial impacts, including improved global security and peace. And the flow & transportation of products from the suppliers to the final customers is the Agri supply chain.

Fallouts Area in Food Supply Chain

Any fallout pertaining to production, harvesting, storage and distribution can be considered as risk in food supply chain. Can be called as “From field to fork, literally”. This chain should be able to provide, without its waste, quality, nutritious, sovereignty and uncontaminated food for all.

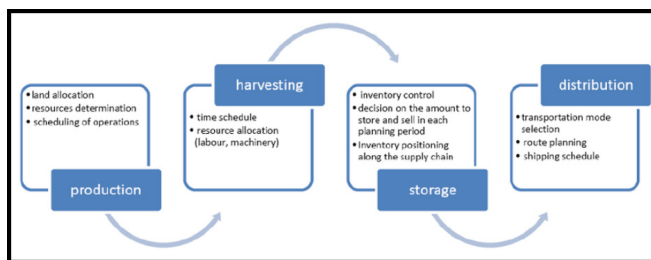


Diagram 1.1. Source: The four main functional areas in the context of the agri-food supply chain (Ahumada and Villalobos, 2009)

Link: https://www.researchgate.net/figure/The-four-main-functional-areas-in-the-context-of-the-agri-food-supply-chain-according-to_fig1_266456282

According to Food and Agriculture Organization - The figure of 113 million people represents a slight improvement over the number for 2017. The modest decline from 2017 to 2018 is primarily due to changes in climate shocks (Food and Agriculture Organization, 2020). Countries of migrants

and low incomes are the ones affected the most from the food crisis. It is found that high food prices, migration and conflicts are worsening the situation. Protection, security, autonomy, and accessibility are at extremely low levels.

Table 1

Dimension of Food Security	Pottential Oppurtunity	Potential Threat
Availability	<ul style="list-style-type: none"> • Specialization associated with efficiency gains can lead to increased production of food on a global scale • Imports can increase the domestic food supply 	<ul style="list-style-type: none"> • There is no guarantee of greater food availability in all the countries • Availability of locally produced foods may decline if countries are specialized in non-food agricultural exports
Access	<ul style="list-style-type: none"> • Increased production on a global scale may result in lowering the food prices and increase in access • Income or growth can contribute to improved food access 	<ul style="list-style-type: none"> • Unequal distribution of gains within a country due to corporate control of supply chains and unequal land holdings • Some producers may lose income and be transitioned out of agriculture with no viable alternatives
Utilization	<ul style="list-style-type: none"> • Imports have the potential to enhance dietary diversity in different ways that have nutritional benefits 	<ul style="list-style-type: none"> • Imports of processed foods or specialization of production can harm nutrition
Stability	<ul style="list-style-type: none"> • Food imports can smooth the domestic shortfalls due to variability of seasonal weather and other factors • Trade can smooth price variation within countries by stabilizing supply 	<ul style="list-style-type: none"> • Specialization can lead to environmental externalities that may result in future instability • Reliance on food imports can increase the risk of supply and access disruptions caused due to global production fluctuations and price volatility

Source: Food and Agriculture Organization, 2015

Pillars of Global Food Crisis

There are a variety of factors influencing the global availability of food. Usage, availability, adequacy, affordability, accessibility and governance are among these variables.

Availability, how much is available, refers to the food supply. The availability of food is determined by the production of food and the food trade (Food and Agriculture Organization, 2008). However, to avoid food insecurity, food supply chain is important. The availability of food addresses the issue of is there sufficient food to feed everyone? ” What’s going to be produced? ; How is development going to occur? And who will make use of the products created?

Adequacy is aimed at improving the nutritional value of food. This adequate nutrient diet helps to estimate the cost and affordability of acquiring all nutrients in the proportions required to determine the ability of the food system of each country to deliver adequate nutrients at all times and places.

Affordability is all about the ability of individuals to provide food.. The tendency has been for food availability to increase compared to modern history, but this is not a guaranteed pattern.

Accessibility refers to the ease of availability of food. Access includes economic and physical access to food.

Governance challenges are yet another factor leading to food crises. Governments are the key players in the physical, social and economic dimensions of the food security of a country, so the role of governance must also be taken into account in any effort to improve the results of agriculture and food security.

A shifting atmosphere, an increasing global population, rising food prices, and environmental stressors would have significant yet unpredictable impacts on food security over the coming decades. Adaptation plans and policy responses to global change are urgently needed, including options for water allocation management, land use trends, food trade, food production post- harvest, and food prices and protection (IFPRI, 2020).

- Feeding all sustainably, equitably, and healthily,
- Availability, affordability, accessibility,
- Ecologically sound and robust, and
- Maintaining capabilities and skills necessary for future generations are the essential elements of sustainable food systems.

Risk in Global Food Chain

An agricultural supply chain might experience multiple risks from different sources. These risks can impact the reliability, costs, and efficiency of production, and marketing activities. These risks are as follows:

Weather-Related Risks

Weather risk related to non-extreme weather events, such as too much or little rainfall or too high or low temperatures, often affects agricultural supply chains for a single growing season and the production cycle. However, such events can have an impact on decision making, productivity, and market options. These non-extreme weather risks are usually associated with a particular geographic location.

Natural Disasters

Natural disasters can also affect the agricultural supply chain in the production cycle. These risks result in significant short- term yield reductions, subsequent market price increases, and asset destruction that fluctuates the flow of goods, services, and information. These risks can always

impact logistics along the supply chain, causing the disturbance in transport, communications, and energyservices.

Biological and Environmental Risk

Biological and environmental risks exist and affect the agricultural supply chains. Some are due to production post-harvest reduction, but many times they are due to quality losses. The presence of certain plant pests or livestock diseases might have a negative effect on the international market access, not only for the farmers and firms, perhaps the entire country.

Risks Caused By Temperature Control Issues

Temperature maintenance across the entire supply chain is necessary to ensure the quality and safety of food products. Taking into account the meat cold chain, where items are frozen. Microbial growth is affected by temperature, water movement, and other factors, such as bacteria on the meatsurface

Risks Caused By Fragmented Supply Chain

An increase in the number of intermediaries leads to higher probabilities of food safety issues. This can lead to a more extended holding period of products in the supply chain that drastically affects the product quality, especially for highly perishable products in nature, especially with Agroproducts.

Phases of Risk

The Endogenous risks refer to the shocks that are generated and amplified within the system (Dannielson & Shin 2002). Endogenous risks in the agricultural supply chain are mainly five: quality risks, technical risks, ergonomic risks, logistics risks and management risks.

In addition, the exogenous risks apply to the shocks that come from outside the system and affect all supply chain participants equally. The key causes of exogenous risks in the agricultural supply chain are the natural environment, the business environment, and the political environment. The dangers of the natural environment deal with the availability of crops, soil fertility, climate effect, extreme events, and accidental disasters.

Managing Risk

It is of primary importance to handle agriculture's supply chain risks to effectively monitor eventualities such as shortages, wastages, price spurts, malnutrition and suicides of farmers. Before an incident happens, the supply chain participants should take precautionary steps for risk management, risk sharing, risk preservation, risk avoidance, or risk mitigation.

Several government schemes are being offered to boost agricultural and rural household incomes. The risk management exercise is taken up by individual supply chain players so that the risks are managed for themselves by passing certain risks to others above or below the min the chain. This does not necessarily regulate the overall risks of the entire supply chain.

Growing trends in Factors of Food Risks

As the demand for food and the variety of food is growing worldwide, food security concerns are also increasing. The four main trends in shaping food system pathways are Demographic trends, socio-economic trends, Environmental trends, Political drivers.

Demographic Trends: The world population is expected to increase from 7.7 billion in 2019 to 8.5 billion by 2030 and 9.8 billion by 2050 (Pauline, Nicolas & Thierry, 2019). Growth in the

population means a rise in the demand for food and higher pressure on natural resources such as land and water.

Population growth in rural and urban areas Induces diversification of food supply and a changing consumer food landscape and changes in food habits and in consumer concerns.

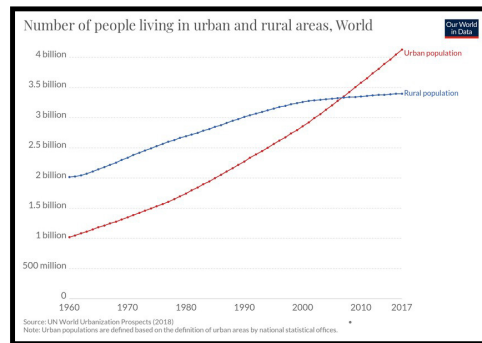


Diagram 1.2: Source: Our world in data

Link: <https://ourworldindata.org/grapher/urban-and-rural-population>

Socio-economic trends: In several parts of the world, and especially in Asia, growth in the middle class means a rise in buying power for a part of the population. With the rising intake of animal products, sugar, fat, and refined food, this translates into the diversification of diets. **Environmental trends:** Climate change is characterized as “climate change that is directly or indirectly attributed to human activity that changes the composition of the global atmosphere and is observed over comparable periods in addition to natural climate variability

Food systems are increasingly utilizing finite resources (e.g., fossil fuels, phosphate), completely renewable (e.g., solar energy), and conditionally renewable (e.g., trees, water, and fish) and changing to fertilize the soil, generate and process goods (e.g., biodiversity). The shortage of non-renewable resources, the management of stocks of renewable resources, and the over-exploitation of renewable resources on a conditional basis, the rise in the competition can lead to conflict and the effect on production potential. As they usually include other ecosystem services, not only potential food production but also ecological balances are jeopardized by resource degradation and over exploitation.

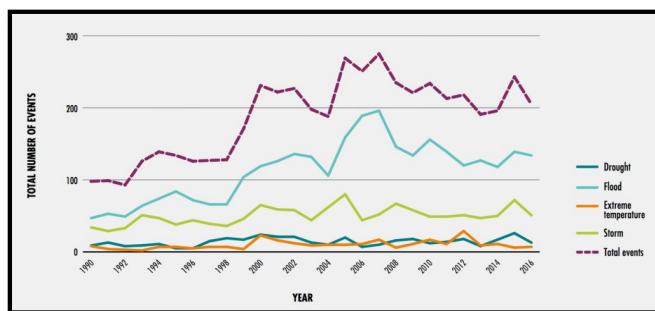


Diagram 1.3: Source: FAO elaboration based on data from Emergency Events Database (EM- DAT). 2009

Link: <https://www.emdat.be>

Risk Impact Analysis

The below table shows the risk impact analysis which was done by conducting survey in the form of questionnaire, given to 100 stakeholders and 30 experts from the supply chain.

Table 3 High risk priority factors

Category	Risk	Severity	Occurrence	Detectability	Risk priority= Severity* occurrence* detectability
SC/Logistic issue	Improper inventory management	8	6	5	240
SC/Logistic issue	Improper storage facilities	7	6	6	252
SC/Logistic issue	Packaging problems of various food grains and products	7	4	8	224
SC/Logistic issue	Lack of collaboration and coordination	6	8	5	240
Governance	Lack of education and training	6	6	6	216
SC/Logistic issue	Disposal and recycling mechanism for food categories not clear	8	5	4	160
SC/Logistic issue	Improper transportation spooling quality of perishable product	6	6	5	180
Producer	Lack of scientific farming	5	5	6	150
SC/Logistic issue	Reducing price transparency	6	5	4	120
Governance	Government policies	7	4	7	196
SC/Logistic issue	Handling issues	8	3	5	120
SC/Logistic issue	Lack of information	7	5	4	140

Infrastructure	Insufficient cold storage	6	4	4	96
Infrastructure	Fresh water scarcity	8	4	3	96
Infrastructure	Expensive agricultural production due to new technologies	7	8	3	168
Environmental	Reduced soil fertility	6	5	2	60
Producer	Improper management of bacterial growth	4	4	4	64
Infrastructure	Involvement of middlemen	4	5	3	60
Environmental	Climate shocks (draughts, floods etc.)	7	2	5	70
Infrastructure	Increase in price of energy (petroleum)	4	3	4	48
Producer	Non availability of funds	5	6	2	60
Producer	Reduced land area for cultivation	4	4	3	48
Environmental	Other weather issues	5	4	2	40
Environmental	Elevated levels of co2 due to climate change	5	2	4	40
Environmental	Reducing sea level	5	2	3	30
Infrastructure	Increased use of pesticides and fertilizers and chemicals	4	3	2	24
Consumer	More demand on horticulture and livestock	1	2	1	2

From table (2), the risk priority above 200 has high risk factor (improper inventory management, improper storage facilities, lack of collaboration and co-ordination, packaging problems of various food grains and products and lack of education and training) as shown in the table. The severity implies how severe this issue is in its effect on the food supply chain. The occurrence indicates how frequently this issue occurs to create an impact on the food supply chain. Detectability implies how easily this issue is identified in the chain and brought to the notice of stakeholders. When sorted in descending order of the impact factors, the chart shows the most important and impactful factors that affect the food supply chain.

Pareto Chart

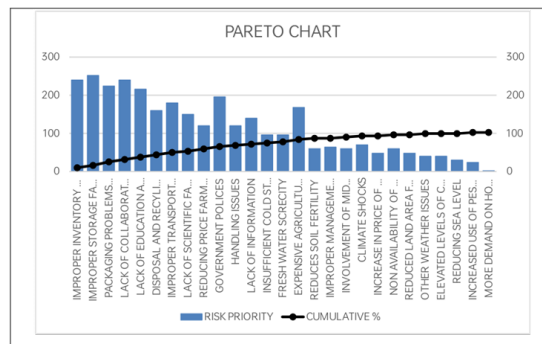


Diagram (1.4): Pareto chart of various Risk Factors

As from the Pareto chart, it is understood that 80% of the total risk is being contributed by improper inventory management, unsuitable storage facilities, packaging problems, lack of collaboration and co-ordination, lack of education and training, disposal and recycling mechanisms, lack of scientific farming, reduced pricing transparency, government policies, and handling issues. This needs to be eliminated on the first hand to reduce the risk level significantly. Priority needs to be given for reducing risk to top contributing factors like improper inventory management and unsuitable storage facilities.

Recommendations & Suggestions

One of the major problems in the agriculture sector is the inadequate flow of information between producers, wholesalers, retailers, customers, and other entities along the agricultural supply chain. (Piali & Pati, 2011). Many farmers are unaware of the market value of their produce. Many lack the training and infrastructure to access current information and communication technologies that prevent them from receiving updated information about market prices. The lack of information flow may be due to a lack of trust among different players along the supply chain. The use of modern information and technologies for communication can bring better returns to all the players along the supply chain. In most of the rural areas, there is a lack of infrastructure, limiting the use of modern information and communication technologies. Insufficient infrastructure and logistics need to be developed to reduce wastage and to improve efficiency. Allowing private entities into the agriculture sector can improve the efficiency of the supply chain. Since India is an agricultural economy, the rural population's concerns who depend on agriculture for a livelihood should be addressed before making changes to the existing laws.

Introducing block chain into the agricultural food sector will build trust, transparency, and accountability within the various stakeholders. Altering the details in any single system will make

changes all along with the network. Also, it can be easily traced; hence manipulations can be prevented effectively. IoT devices collect data relating, such as water usage, crop diseases, Climatic conditions, etc. The stack of technologies in IoT includes sensors, actuators, drones, navigation systems, cloud-based data services, and analytics. These used and decision support tools can provide valuable Intel to monitor the crops and be applied throughout the supply chain. In the agri sector, IOT technologies appear under labels such as “precision agriculture” or “smartfarming.” (I, Ashokumar, & J, 2016) Example is the use of GPS to control tractors (auto-guidance of machinery) to ensure precise coverage of a field, whether plowing, planting, or engaging in some or the other activity. These services can optimize the supply chain by enabling optimal route planning, facilitating recalls in food crisis scenarios, generally improving stock taking and ordering processes, etc. Artificial intelligence can be used in many areas of agriculture, namely production, distribution, consumption, and uncertainty management. In production, AI can provide recommendations in crop rotation planning, planting times, water and nutrient management, pest management, disease control, optimal harvesting, food marketing, product distribution, and food safety. AI can be used in disease detection in the plant using image recognition systems. All these technologies can transform the agriculture supplychain.

Many farmers are unaware of the market value of their produce. They lack the training and infrastructure to access current information and communication technologies which prevent them from obtaining updated information about market prices.

- Improper inventory management (1)
- Improper storage facility (2)
- Packaging problems (3)
- Lack of coordination (4)
- Unclear disposal and recycling mechanisms (5)
- Reducing price transparency (6)
- Handling issues (7)
- Lack of Information (8)
- Lack of education and training (9)
- Government policies (10)
- Lack of scientific planning (11)
- Improper management of bacterial growth (12)
- Non availability of funds (13)
- reduction in cultivable land (14)
- Insufficient cold storage (15)
- Fresh water scarcity (16)
- Increased cost of production due to new technologies (17)
- Involvement of middlemen (18)
- Increase in price of fuel (19)
- Increased use of pesticides and chemicals (20)
- Climate shock(droughts, floods etc) (21)
- Weather issues (22)
- increasing levels of CO₂ (23)
- Reducing sea level (24)

To solve the existing problems in the agriculture sector, innovations in technology such as Blockchain, IoT, and artificial intelligence is being used now. Introducing block chain into the agricultural food sector will build transparency, and prevent fraud within the various stakeholders. The information in a block chain is almost impossible to manipulate as the data is stored in a

network of thousands of computers. Also, any such attempts can be easily tracked. The certificates of the farm products is viewable to anyone in the network.

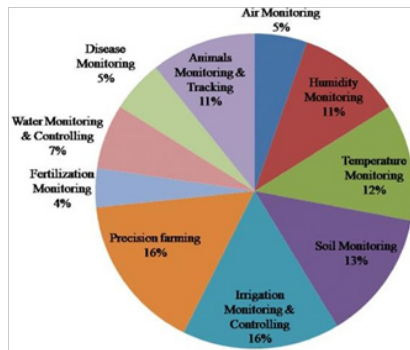


Diagram (1.5): the percentage of application of IoT in various areas

IoT devices collect data relating to various aspects of the agricultural produce such as weather patterns, soil conditions etc. Example of IoT in real life is the use of GPS to control tractors (auto-guidance of machinery) which ensures precise coverage of a field. These data generated by IoT devices can optimize the supply chain and enable optimal route planning, improving stock taking and ordering process etc.

AI can be used in automatic disease detection, planning of crop rotation, planting times, water management, pest management, food marketing, product distribution, and food safety.

Conclusion

The challenge of supplying the world's population with adequate food indicates why food security is such a concern for all countries, whether developed or developing. In short, this is a global problem because it's not only about people eating and feeding, but also about almost every part of the economy and society in general. This paper figures out the area so frisk, food crisis, and sustainability. Even analysis of risk impacts and their severity and recommendations have been suggested. The risk impact on food security and sustainability can be overcome in the present or future using modern technology. The depth of agricultural change and the maximization of its dividends are at stake for millions of small-scale food farmers, food businesses, and consumers worldwide. In reality, future studies and research could develop advanced and advanced danger and criticality identification tools that can recognize gaps in food safety in any supply chain.

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