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Introduction

Bangladesh is witnessing rapid changes in retailing with urbanization, increase in disposable income, changing lifestyles, preferences and eating habits of its population. Bangladesh with diverse agro-climatic conditions offers both opportunities and challenges in retailing of fruits and vegetables. Concentration of production with small and medium farmers in remote areas without proper infrastructure facilities and market linkages has led to large scale inefficiencies in supply chain.

There is a huge deficiency between demand and supply of vegetables in Bangladesh. One of the reasons of this deficiency is ineffective supply chain through which vegetable reaches from farmers to ultimate consumers. In the existing supply chain, there are a number of middlemen which causes a huge gap between vegetable growers and end consumers. Again, the vegetable marketing information system rarely exists in current context for which the vegetable growers do not have current vegetables' price and demand information. So, they cannot sell it at the right price to the middlemen. They often take loan from local money lenders who charge higher rate of interest for the loan.

A supply chain is effective at that time when it meets the demand of end consumers at the right place, at the right time and at right price. It creates benefits for all the parties involved in the chain. In case of vegetable supply chain, it needs to meet the vegetable demand of consumers effectively so that consumers, vegetable growers and middlemen get equal benefit from it. If it is not effective then the interest of any party may decrease which also impact on the overall supply chain negatively. So, it has become the right time for everyone involved in the vegetable supply chain to participate in a planned way to improve the overall performance of the system.

Literature Review

The vegetable supply chain in our country is not effective where growers of vegetables are always deprived of profit. Growers in this chain face three challenges: financing crop production; poor yields; and losses due to the elements which reduce their bargaining power significantly (The Daily Star, 2009).

Asian Productivity Organization (2007) on "Marketing System for Agricultural Products" indicated that the agricultural marketing system of Bangladesh is inefficient because of the different territories, scattered location of production areas, natural disasters and relatively poor condition of infrastructure. The report suggested that two approaches should be adopted. First approach is the establishment of regulated markets which are setup to regulate the conduct of market functionaries, promote grading and standardization of products, collect and disseminate of information. The second approach is the establishment of central wholesale markets which will provide facilities for assembling large volume of products which are properly stored, graded and packed to facilitate their auctioning. The author also highlighted some major aspects namely infrastructure required for efficient marketing of vegetables. One aspect, the author mentioned, was the marketing arrangement in terms of extent of coercion exercised by marketing institutions.

Objectives of the Study

The overall objective of the study is to analyze the key factors of existing vegetable supply chain operating in Bangladesh. The specific objectives of the study include –

- to analyze the current market structure and its performance;
- to analyze the number of middlemen, their roles and effectiveness;
- to identify major constraints, opportunities of production and supply;
- to analyze the impact of inefficient supply chain on vegetable growers and consumers; and
- to analyze the key factors of existing vegetable supply chain.

Methodologies

There are several methodologies that can be used to identify the key factors in a farmer's product supply chain Some of these include:

1. Supply chain mapping: This involves creating a visual representation of all the activities, actors, and relationships involved in the supply chain. This can help to identify bottlenecks, inefficiencies, and opportunities for improvement.

Supply chain mapping is a methodology used to visually represent the flow of goods, information, and resources in a supply chain. It involves creating a diagram or a flowchart that shows the various actors involved in the supply chain and their interdependencies. The purpose of supply chain mapping is to provide a comprehensive overview of the supply chain and to help identify bottlenecks, inefficiencies, and areas for improvement.

Supply chain mapping typically starts with identifying the actors in the supply chain, including suppliers, manufacturers, distributors, retailers, and customers. The flow of goods and information is then traced from the point of origin to the point of consumption, highlighting the various stages in the supply chain. This information can then be used to identify areas where the supply chain can be optimized and to develop strategies for improvement.

Supply chain mapping can be a useful tool for organizations that are looking to improve their supply chain performance, reduce costs, and enhance customer satisfaction. It can also be used to identify risks and vulnerabilities in the supply chain and to develop contingency plans in the event of disruptions.

2. Root cause analysis: This involves breaking down complex problems into smaller parts and identifying the underlying causes. This can help to identify key factors that are impacting the supply chain and find ways to address them.

Root cause analysis is a problem-solving methodology used to identify the underlying causes of an issue or problem. The goal of root cause analysis is to understand why a problem is occurring and to identify the root cause, rather than just addressing the symptoms. By

addressing the root cause of a problem, it is possible to prevent the problem from recurring and to implement permanent solutions.

Root cause analysis can be applied to various types of problems, including quality control issues, production problems, customer complaints, and supply chain disruptions. The process typically involves several steps:

- Define the problem: Clearly define the problem and gather data and information about the problem.
- Identify the causes: Generate a list of potential causes for the problem and evaluate each one to determine which is the root cause.
- Analyze the data: Use data analysis techniques, such as statistical process control or process mapping, to help identify the root cause of the problem.
- Verify the root cause: Verify the root cause by conducting tests or experiments to validate the findings.
- Develop a solution: Based on the root cause, develop a solution that will prevent the problem from occurring in the future.
- Implement the solution: Implement the solution and monitor its effectiveness over time.

By conducting root cause analysis, organizations can improve the efficiency and reliability of their processes, reduce costs, and enhance customer satisfaction. Root cause analysis can be a valuable tool for organizations that are looking to improve their operations and identify areas for improvement in their supply chains.

3. SWOT analysis: This is a tool used to identify the Strengths, Weaknesses, Opportunities, and Threats in a given situation. This can be applied to the farmer's product supply chain to identify key factors and find ways to improve it.

SWOT analysis is a strategic planning tool used to identify an organization's strengths, weaknesses, opportunities, and threats. The goal of SWOT analysis is to provide a comprehensive overview of an organization's internal and external environment, and to help organizations make informed decisions about their future.

SWOT analysis is typically conducted by evaluating the following factors:

- Strengths: Characteristics of the organization that give it an advantage over others.
- Weaknesses: Characteristics of the organization that put it at a disadvantage compared to others.
- Opportunities: External factors that the organization can take advantage of to achieve its goals.
- Threats: External factors that may have a negative impact on the organization.

The results of a SWOT analysis can be used to develop a strategic plan, to make informed decisions about investments, to identify areas for improvement, and to allocate resources more effectively.

SWOT analysis can be applied to an entire organization, a business unit, a product, a service, or a project. It is a useful tool for organizations that are looking to identify their competitive advantages and disadvantages, and to develop a strategy for growth and success. SWOT analysis can be used in various industries, including agriculture, manufacturing, retail, and healthcare.

4. Stakeholder analysis: This involves identifying and assessing the key stakeholders involved in the supply chain, such as farmers, suppliers, distributors, and customers. This can help to identify the interests, motivations, and potential impact of each stakeholder on the supply chain.

Stakeholder analysis is a process used to identify and evaluate the interests and influence of stakeholders in a project, program, or organization. The goal of stakeholder analysis is to understand who the stakeholders are, what their interests are, and how they may impact or be impacted by a particular initiative.

Stakeholder analysis typically involves several steps:

- Identify stakeholders: List all of the individuals, groups, or organizations that are directly or indirectly impacted by a particular initiative.
- Evaluate stakeholders: Assess the level of influence and interest of each stakeholder, and categorize them as high, medium, or low influence and interest.
- Analyze stakeholders: Analyze the relationships between stakeholders, including any potential conflicts or areas of cooperation.
- Develop a stakeholder management plan: Based on the results of the stakeholder analysis, develop a plan for managing stakeholders, including strategies for engaging, communicating, and collaborating with stakeholders.

Stakeholder analysis is a critical step in the planning and implementation of any initiative, as it helps organizations to anticipate and manage potential conflicts, build supportive relationships, and ensure that the initiative is aligned with the interests and needs of all stakeholders. Stakeholder analysis can be applied in various contexts, including business, government, non-profit organizations, and community initiatives.

5. Data analysis: This involves collecting and analyzing data related to the supply chain, such as production and sales data, shipping data, and market data. This can help to identify trends, patterns, and areas for improvement in the supply chain.

Data analysis is the process of examining and interpreting data to uncover patterns, relationships, and insights. The goal of data analysis is to convert raw data into meaningful information that can inform decision-making and support effective problem solving.

Data analysis involves several steps, including:

- Data collection: Collect relevant data from various sources, such as surveys, experiments, or databases.

- Data preparation: Clean, organize, and prepare the data for analysis, removing any errors or inconsistencies.
- Data exploration: Examine the data to get a general understanding of its distribution, patterns, and relationships.
- Data modeling: Develop mathematical or statistical models to describe the relationships between variables in the data.
- Data visualization: Represent the data in a graphical form, such as charts, graphs, or maps, to make it easier to understand and communicate.
- Data interpretation: Interpret the results of the analysis, draw conclusions, and make recommendations based on the insights derived from the data.

Data analysis can be applied to a wide range of fields, including business, economic, social sciences, health sciences, and environmental sciences. It is an essential tool for organizations that want to make data-driven decisions and gain a competitive advantage. The methods used in data analysis can vary depending on the type and complexity of the data, as well as the research question being addressed.

6. Lean methodology: This is a process improvement approach that focuses on minimizing waste and maximizing efficiency in all areas of the supply chain.

Lean methodologies are a set of principles and practices aimed at reducing waste and improving efficiency in the production of goods and services. The goal of lean methodologies is to deliver value to customers in the most efficient and effective manner possible, by eliminating any non-value-adding activities and processes.

The key elements of lean methodologies include:

- Value stream mapping: Identifying the flow of activities and information required to deliver a product or service to a customer.
- Elimination of waste: Identifying and eliminating any non-value-adding activities, such as overproduction, waiting, defects, excess inventory, unnecessary motion, overprocessing, unused talent, and unused space.
- Continuous improvement: Encouraging a culture of continuous improvement, where employees are empowered to identify and implement improvements in their work processes.
- Just-in-time (JIT) production: Producing goods and services only when they are needed, and in the quantities required, to minimize waste and increase efficiency.
- Total quality management (TQM): Focusing on quality at every stage of the production process, and continuously improving quality through the use of statistical process control, process improvement teams, and customer feedback.

Lean methodologies have been widely adopted in manufacturing, healthcare, and service industries, and have been shown to improve quality, reduce costs, and increase customer satisfaction. Lean methodologies can be used in a wide range of organizations, from large

corporations to small businesses, and can be customized to meet the specific needs of each organization.

These are just a few of the many methodologies that can be used to identify the key factors in a farmer's product supply chain. The best approach will depend on the situation and the goals of the analysis.

Nature of the Study

This is a Descriptive Research, because the main objective of this research is to find out the key factors of existing vegetable supply chain operating in Bangladesh and the problems which make the supply chain ineffective.

Method of Data Collection

Data were collected from every vegetable market of Gopalganj. Farmer's name, farmer's selling price, farmer's distance, wholesaler's name, distance, selling price the retailer's name, distance, selling price, trend of vegetable production, number of markets and middlemen, and other data relevant to the study were collected.

Sources of Data

Secondary Data were collected from research papers, articles, websites, journals, newspapers etc.

Current Vegetable Production in Bangladesh

In Bangladesh vegetable crop occupied only 1.8 percent of total cultivable land. The per capita supply of vegetable is one-fifth of cereal production while it is double in case of developed countries. It is because farmers find few incentives and encouragements to grow vegetables.

The distribution of cropped area for vegetables is less than some other cereals. It is much less than that of rice. However, there is very lucrative market for vegetable in national and international level. But still the production is not enough to meet the demand of all these markets and the quality of produced vegetables is not good enough to meet the requirements of those markets.

Existing Supply Chain of Vegetables

  A. Number of Markets:

  There are broadly four types of market in the existing supply chain of vegetable in Bangladesh. These are:

Rural Primary Markets:

Primary market is held once or twice in a week and it often deals with commodities which are required by the local rural people. In this market vegetables are directly sold to the local consumers. The basic producer or primary markets at village level are the haats, in which the trade is characterized by direct sales of small quantities of produce by growers to village traders or retail sales to rural consumers.

Assembly and Secondary Markets:

These are larger markets where greater quantities of produce are disposed of either by growers themselves or by village traders. These markets are usually located within larger settlements and as well as operating on a periodic basis for assembly purposes they may operate as daily retail markets, serving nearby urban populations.

Terminal Markets:

Urban wholesale, wholesale/retail and retail markets are located near to large consumption areas. For the retail markets permanent retailers predominantly handle the transactions. In the wholesale markets transactions are by wholesalers or commission agents and only larger growers and marketing cooperatives are likely to bring produce. It is the central or wholesale markets from where distribution starts.

Other Markets:

In case of horticultural marketing, channels other than through markets exist, including, direct on-farm sales and, the use of pre-harvest contractors who purchase the produce while it is still on the trees and arrange for harvesting, packaging and transport to wholesale outlets.

B. Number of Middlemen:

Figure 2: Different Categories of Middlemen.
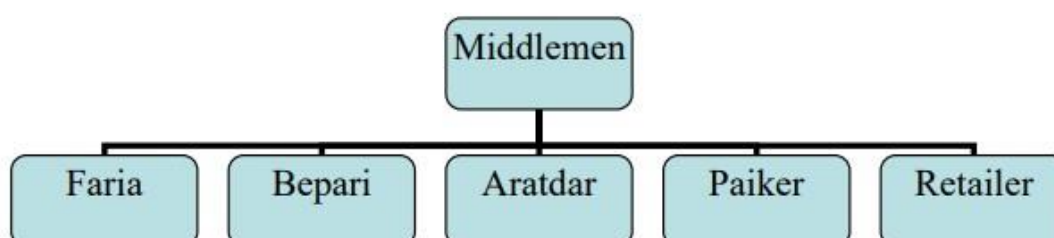
There are five categories of middlemen from farm gate to ultimate consumer. They help the vegetables reach from growers to consumers. They are faria, bepari, aratdar, paiker and retailer.

Farias:

Farias are small scale rural traders who purchase vegetables from growers either in village or from primary markets and sell them to beparies or local retailers.

Beparies: Beparies are rural assemblers who generally purchase vegetables from secondary markets or directly from the growers through farias in village and transport them to the central wholesale markets for urban consumption through retailers.

Aratdars:

Aratdars are commission agents who charge commission from both beparies and paikers. They have permanent staff and establishments in the wholesale markets and arrange sale of vegetables from bepari to paiker who further sell vegetables to the retailers.

Paikers:

Paikers are regular traders who generally purchase vegetables from the beparies through aratdars and sell vegetables to retailers or consumers.

Retailers:

Retailers generally purchase vegetables from the beparies through aratdars and sell them directly to consumer. They have permanent shop in retail market or they have markets on open air outside the markets called foot-path. However, in rural areas retailers purchase vegetables directly from the growers and sell them to rural consumers. So here, in general vegetables supply chain starts from vegetable growers. From them, beparies buy vegetables. From many beparies, aratdars buy vegetable who later sell them to paikers. Then vegetable retailers buy from paiker and sell them to ultimate consumer. In this way, vegetables reach from vegetables growers to ultimate consumers.

Problem Analysis

In order to get fair prices for the farmers of our country, the middlemen take advantage of the various helplessness of the farmers, and they make huge profits. Farmers have many problems, and they do their work on the basis of those problems. They take advantage of the financial distress of farmers by purchasing crops at low prices.

Out of the remaining 50% of the farmers, there are 25% who own some land and some others. The remaining 25% is completely owned land. These classes of farmers have their own land but do not have the money to cover the cost of crop production. Even if they do not borrow from anyone, they cannot store crops to cover the cost of crop production. 30% of the farmers sell their crops to cover the next season's crop production and household expenses, even if they

can keep 2 months of crop production at a profit less than the cost of production. Wholesalers and dealers wait for these opportunities. The remaining 15% of farmers have to sell their crops due to a lack of storage space. Excess rain and excess heat risk crop failure. They sell the crop, fearing that the production costs will not come if the crop is destroyed. Wholesalers and traders are afraid that if the crop is damaged a little, the price will be low and the market will continue. As a result, they sell the crops before these calamities.

The remaining 5% of farmers are fully self-reliant and work as traders and wholesalers themselves. They make huge profits by hoarding crops and buying other farmers' crops and selling them at higher prices during times of crisis. The price of the crop after the farmers takes it to the market reduces the price of the crop when the rain falls because the farmer has no way to bring it back home. Crops will be ruined if wet by rain. Wholesalers and traders take advantage of every weakness of farmers to buy crops at rock-bottom prices. Later, by creating an artificial crisis in the market, they sell the crops in the market at a huge profit.

Now main key factors are:

High-Cost Product

Market Structure

Power imbalance

Lack of information

Limited access to finance

Inadequate logistic

Lack of policy support

Dependence on middlemen

Climate Change

Inadequate govt support

Quality and Grading

Market power of intermediaries

High-cost product:

In the vegetable supply chain, the high cost of the product is a key factor that significantly impacts various stages of the supply chain. One of the primary contributors to this high cost is the extensive labor required for activities such as planting, cultivating, harvesting, and sorting vegetables. Labor-intensive processes drive up production costs, as skilled and manual laborers

are needed to ensure the quality and timely delivery of the products. Additionally, transportation costs play a crucial role in the overall cost of vegetables, as perishable items require careful handling and refrigeration to maintain their freshness. Furthermore, the cost of inputs like seeds, fertilizers, pesticides, and packaging materials can also contribute to the high cost of vegetables. These factors combined emphasize the need for efficient supply chain management practices to minimize costs and ensure affordable pricing for consumers.

Market Structure:

Market structure is a key factor in the vegetable supply chain as it influences the dynamics of how vegetables are produced, distributed, and consumed. The market structure refers to the organization and characteristics of the market in which vegetables are bought and sold. It includes factors such as the number and size of buyers and sellers, the degree of competition, the presence of intermediaries, and the level of market integration. A market structure with a large number of buyers and sellers and low barriers to entry fosters competition, leading to competitive prices and efficient allocation of resources. On the other hand, a market dominated by a few large buyers or sellers may result in market power and the ability to influence prices and terms of trade. The market structure also affects the distribution of power along the supply chain, with implications for pricing, quality standards, and bargaining power of different stakeholders. Therefore, understanding and analyzing the market structure is crucial for optimizing the efficiency and effectiveness of the vegetable supply chain.

Power imbalance:

Power imbalance is a critical factor within the vegetable supply chain, exerting significant influence on various stakeholders involved. The power imbalance refers to the unequal distribution of power and control among different actors within the supply chain, such as farmers, distributors, processors, and retailers. Large-scale retailers and processors often hold a dominant position, enabling them to dictate terms, set prices, and impose strict quality standards on farmers. This dynamic leaves farmers with limited bargaining power, making them vulnerable to exploitation and unfair practices. Consequently, farmers may receive low prices for their produce, face delayed payments, or experience pressure to conform to specific requirements. Addressing power imbalances in the vegetable supply chain is essential to create a fair and sustainable system that benefits all stakeholders and ensures the viability of agricultural practices.

Lack of information:

Lack of information is a key factor in the vegetable supply chain, influencing its efficiency and effectiveness. Throughout the various stages of the supply chain, including production, processing, distribution, and retail, access to accurate and timely information is crucial for decision-making and coordination. Without sufficient information, farmers may struggle to determine the appropriate planting schedules, leading to imbalances in supply and demand. Inadequate knowledge about market trends and consumer preferences can result in mismatched production volumes and varieties, leading to excessive waste or shortage. Additionally, without

proper information sharing, it becomes challenging to anticipate and address issues such as transportation delays, quality control, and food safety. Thus, the lack of information in the vegetable supply chain hampers its ability to optimize operations, respond to market demands, and ensure a reliable and sustainable flow of vegetables from farm to table.

Limited access to finance:

Limited access to finance is a critical factor in the vegetable supply chain. Small-scale farmers and producers often struggle to secure the necessary funds to invest in their operations and overcome financial challenges. Insufficient capital restricts their ability to purchase high-quality seeds, fertilizers, and modern farming equipment. It also hampers their capacity to adopt efficient irrigation systems, implement sustainable farming practices, and improve post-harvest handling and storage facilities. Limited access to finance prevents these stakeholders from expanding their operations, diversifying their crops, and accessing new markets. This results in lower productivity, reduced quality, and increased post-harvest losses, ultimately affecting the availability and affordability of vegetables for consumers. Addressing this issue requires initiatives that provide affordable credit, financial literacy training, and support for farmers and producers to improve their financial management skills, enabling them to invest in their businesses and contribute to a more resilient and sustainable vegetable supply chain.

Inadequate logistic:

Inadequate logistics is a key factor that can significantly impact the vegetable supply chain. Logistics involves the efficient movement and management of goods from the point of origin to the point of consumption. When logistics in the vegetable supply chain are inadequate, it can lead to various challenges and disruptions. For instance, inadequate transportation infrastructure and limited access to proper storage facilities can result in delays, spoilage, and loss of product quality. Inefficient inventory management and inadequate handling practices can also lead to increased wastage and higher costs. Moreover, insufficient coordination and communication among the different stakeholders involved in the supply chain, such as farmers, distributors, and retailers, can further exacerbate logistical challenges. Addressing these inadequacies is crucial to ensure the timely and efficient delivery of fresh and high-quality vegetables to consumers while minimizing waste and cost.

Lack of policy support:

Lack of policy support is a key factor contributing to challenges in the vegetable supply chain. Without proper policies and regulations in place, the smooth flow of vegetables from farm to market becomes hindered. One of the major issues is the absence of comprehensive guidelines and standards regarding quality control, storage, transportation, and distribution. Inadequate policy support leads to inconsistencies in handling practices, resulting in significant post-harvest losses and compromised product quality. Additionally, the lack of clear policies on pricing, subsidies, and market access further exacerbates the problems faced by growers, wholesalers, and retailers in the vegetable supply chain. Without a conducive policy environment, it becomes difficult to establish efficient and sustainable systems that can ensure

the availability of fresh and nutritious vegetables to consumers. Addressing these policy gaps and implementing supportive measures are essential to enhance the resilience and effectiveness of the vegetable supply chain.

Dependence on middlemen:

Dependence on middlemen is a key factor in the vegetable supply chain and can have significant implications for both producers and consumers. Middlemen, often referred to as intermediaries or wholesalers, play a crucial role in connecting farmers with retailers or consumers. However, their involvement can lead to various challenges and inefficiencies in the supply chain. One major issue is the lack of transparency, as middlemen often control the pricing and distribution of vegetables, leaving farmers with limited bargaining power. This can result in low profits for farmers and higher prices for consumers. Additionally, the presence of middlemen can lead to delays and increased transportation costs, as vegetables pass through multiple hands before reaching the end consumer. These factors highlight the need for alternative models that reduce dependence on middlemen, such as direct farmer-consumer relationships or the adoption of technology-driven solutions that streamline the supply chain and promote fairer pricing and distribution practices.

Climate Change:

Climate change is a key factor in the vegetable supply chain, significantly impacting every stage from production to consumption. Rising temperatures, changing rainfall patterns, and extreme weather events have direct implications on the growth, yield, and quality of vegetables. Shifts in climate conditions can disrupt planting schedules, affect pollination and flowering, and increase the prevalence of pests and diseases. Moreover, unpredictable weather events such as droughts, floods, and heatwaves can cause crop failures, leading to reduced supply and higher prices. Climate change also affects transportation and storage, as changing weather patterns can disrupt logistics and increase the risk of spoilage. These factors collectively highlight the urgent need for adaptation strategies, sustainable farming practices, and improved resilience in the vegetable supply chain to mitigate the adverse effects of climate change and ensure food security.

Inadequate govt support:

Inadequate government support has emerged as a key factor impacting the vegetable supply chain. The absence of effective policies and initiatives from the government has hindered the smooth functioning of the entire process. Farmers, who are at the forefront of vegetable production, often face challenges such as lack of access to quality seeds, fertilizers, and modern farming techniques. Additionally, insufficient infrastructure, including storage and transportation facilities, exacerbates post-harvest losses. The absence of supportive policies, such as fair pricing mechanisms and subsidies, further discourages farmers from engaging in vegetable cultivation. Consequently, this leads to a reduction in the overall supply of vegetables in the market and escalates prices, ultimately affecting consumers. It is crucial for governments to recognize the significance of a robust vegetable supply chain and provide the necessary

support to ensure its sustainability and meet the growing demand for fresh and nutritious produce.

Quality and Grading:

Quality and grading are key factors in the vegetable supply chain as they directly impact consumer satisfaction and market competitiveness. Quality refers to the characteristics of vegetables that meet or exceed consumer expectations, such as freshness, taste, appearance, and nutritional value. Grading, on the other hand, involves the classification of vegetables based on their size, shape, color, and overall quality. By implementing strict quality standards and grading systems, the vegetable supply chain can ensure that only the highest quality produce reaches the market. This helps build consumer trust, enhances the reputation of suppliers and retailers, and promotes fair pricing. Effective quality control and grading processes also facilitate efficient inventory management, minimize waste, and enable better traceability throughout the supply chain. Overall, quality and grading play a crucial role in maintaining product integrity, consumer satisfaction, and the overall success of the vegetable supply chain.

Market power of intermediaries:

The market power of intermediaries is a key factor in the vegetable supply chain. Intermediaries play a crucial role in connecting farmers with consumers by facilitating the movement of vegetables from farms to markets. They act as middlemen, handling activities such as transportation, storage, and distribution. The market power of intermediaries refers to their ability to influence the prices, terms, and conditions within the supply chain. When intermediaries possess substantial market power, they can exert control over pricing and negotiate favorable terms for themselves, potentially at the expense of farmers and consumers. This can result in higher prices for consumers and lower profits for farmers. Therefore, it is important to monitor and regulate the market power of intermediaries to ensure fair and efficient functioning of the vegetable supply chain, benefiting all stakeholders involved.

Implementation details:
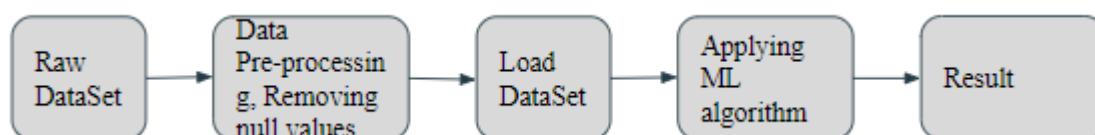
When it comes to finding key factors of a vegetable product supply chain, implementing a comprehensive analysis is essential. The process typically involves various steps, starting with data collection. Gathering relevant information about the supply chain, such as the involved parties, transportation routes, storage facilities, and market dynamics, is crucial. This data can be obtained through surveys, interviews, and industry reports. Once collected, the data needs to be analyzed to identify patterns, trends, and potential bottlenecks. Statistical techniques, data

visualization tools, and supply chain management software can aid in this process. Additionally, conducting stakeholder consultations and engaging with experts in the field can provide valuable insights. The implementation details also include mapping out the entire supply chain, from farm to consumer, and examining each stage for factors such as quality control, logistics efficiency, pricing mechanisms, and the role of intermediaries. By carefully examining and understanding these implementation details, one can gain a deeper understanding of the key factors influencing the vegetable product supply chain and develop strategies for optimization and improvement.

Raw dataset:

BANGABANDHU SHEIKH MUJIBUR RAHMAN SCIENCE & TECHNOLOGY UNIVERSITY, GOPALGANJ

Agricultural commodity data collection from Singipara Hat

Friday
Date: 16 Sept, 2022

Product name	Farmer's name	Farmer's address	Farmer's distance	Farmer's selling price	Name of wholesaler	Wholesaler's selling address	Wholesaler's distance	Wholesaler's selling price	Retailer's name	Retailer's distance	Retailer's selling price
Banana	Ananda Biswash	Sener Char	2 km	15 Tk	Masud Ali	Gopalganj		20 Tk	Siraj		25 Tk
Lemon	Jabindra chandra	Dakshin Bashuriya	1 km	15 Tk	Masud Ali	Gopalganj		20 Tk	Md Mustyne		25 Tk
Brinjal	Abdur Rashid	Singipara		50 Tk	Latif Mia	Nawla Bazar	30 km	60 Tk	Fazar Ali		70 Tk
Basil	Abdur Rashid	Singipara		20 Tk	Latif Mia	Nawla Bazar	30 km	25 Tk	Sajal Ali		30 Tk
Pumpkin	Lutfur Rahman	Dakshin Kulshi	1 km	15 Tk	Sohel Mullah	Ghonapara		18 Tk	Md Ali		20 Tk
Palwal	Lutfur Rahman	Dakshin Kulshi	1 km	35 Tk	Sohel Mullah	Ghonapara		40 TK	Md Mustyne		45 Tk
papaya	Lutfur Rahman	Dakshin Kulshi	1 km	15 Tk	Sohel Mullah	Ghonapara		18 Tk	Md Mustyne		20 Tk
Red Leafy	Jahir Sheikh	Singipara		5 Tk/Per	Latif Mia	Nawla Bazar	30 km	7 Tk/Per	Fazar Ali		10 Tk/Per
Onion	Emdadul	Dakshin Kulshi	1 km	30 Tk	Sohel Mullah	Ghonapara		36 Tk	Abdul Ahad		40 TK
Collard greens	Azizul	Dakshin Bashuriya	1 km	5 Tk/Per	Nttananda Bala	Singipara		7 Tk/Per	Md Ali		10 Tk/Per
Ghee Kanchan	Azizul	Dakshin Bashuriya	1 km	5 Tk/Per	Nttananda Bala	Singipara		7 Tk/Per	Md Mustyne		10 Tk/Per
Green Chili	Jabindra chandra	Dakshin Bashuriya	1 km	25 Tk	Masud Ali	Gopalganj		30 Tk	Islam		40 Tk
Gourd	Lutfur Rahman	Dakshin Kulshi	1 km	25 Tk	Nttananda Bala	Singipara		30 Tk	Mintu Mullah		40 Tk
Hog Plum	Ananda Biswash	Sener Char	2 km	18 Tk	Nttananda Bala	Singipara		22 Tk	Arif Sheikh		30 Tk
Potato	Arif Reza	Singipara		20 Tk	Sohel Mullah	Ghonapara		24 Tk	Abdul Ahad		30 Tk
Garlic	Jahir Sheikh	Singipara		50 Tk	Sohel Mullah	Ghonapara		60 Tk	Abdul Ahad		70 Tk
Zucchini	Jabindra chandra	Dakshin Bashuriya	1 km	15 Tk	Sohel Mullah	Ghonapara		18 Tk	Abdul Ahad		25 Tk
Bitter gourd	Ananda Biswash	Sener Char	2 km	20 TK	Latif Mia	Nawla Bazar	30 km	25 Tk	Md Rajib		50 Tk
Cucumber	Lutfur Rahman	Dakshin Kulshi	1 km	25 Tk	Latif Mia	Nawla Bazar	30 km	30 Tk	Md Rajib		50 Tk
Cabbage	Jahir Sheikh	Singipara		15 TK	Masud Ali	Gopalganj		20 Tk	Fazar Ali		40 Tk
Coconut	Billal	Singipara		200 Tk/Pair	Latif Mia	Nawla Bazar	30 km	210 Tk/Pair	Md Ali		220 Tk/Pair

Data Pre-processing:

Null value check
Data level
Data plotting

Null value check:

```
[ ] df.isnull().sum()

    Product  Name                       0
    Farmers Distance                    0
    Farmers Seling Price                0
    Wholesalers distance                0
    Wholesalers selling price           0
    Retailers distance                  0
    Retailers selling price             0
    High Cost Product                   0
    Market Structure                    0
    Power imbalance                     0
    Lack of information                 0
    Limited access to finance           0
    inadequate logistic                 0
    Lack of policy support              0
    Dependence on middlemen             0
    Climate Change                      0
    Inadequate govt support             0
    Quality and Grading                 0
    Market power of intermedianies      0
    dtype: int64
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Data level:

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[ ]  df = df.replace({"High Cost Product": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
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                       "Power imbalance": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Lack of information": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Limited access to finance": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "inadequate logistic": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Lack of policy support": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Dependence on middlemen": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Climate Change": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Inadequate govt. support": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Quality and Grading": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5},
                       "Market power of intermediaries": {'Low': 1, '2': 2, 'Medium': 3, 'High': 4, '5': 5}})
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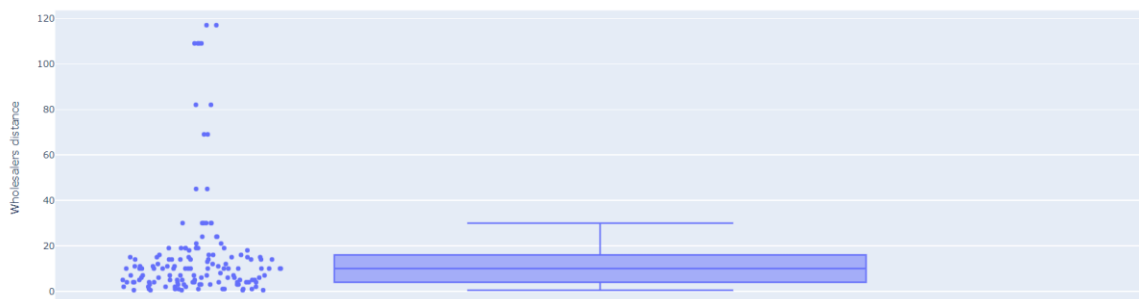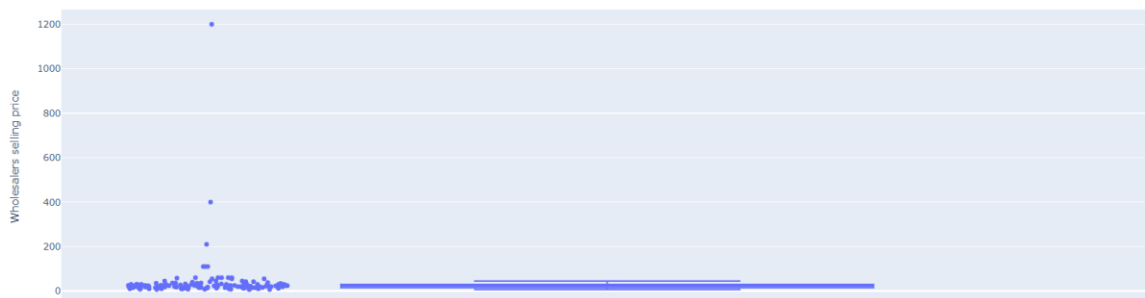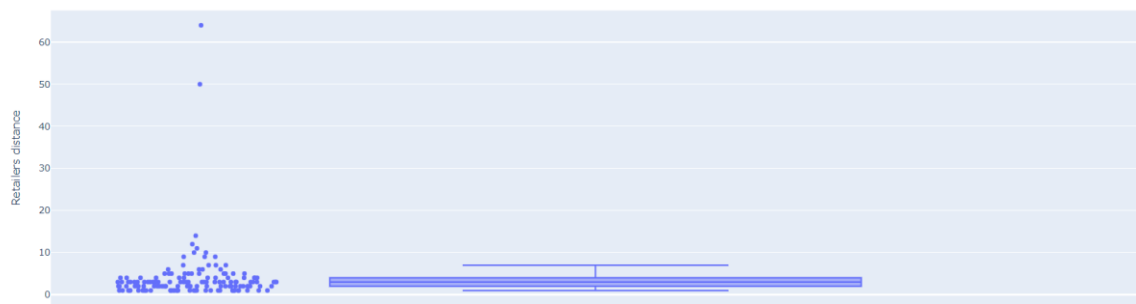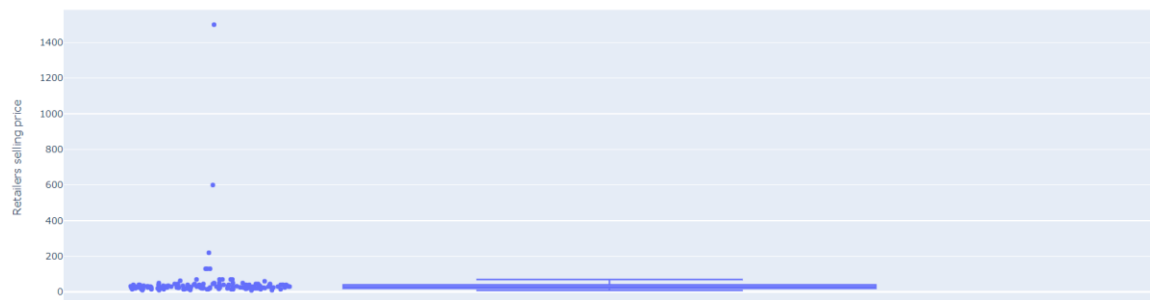
Data plotting:
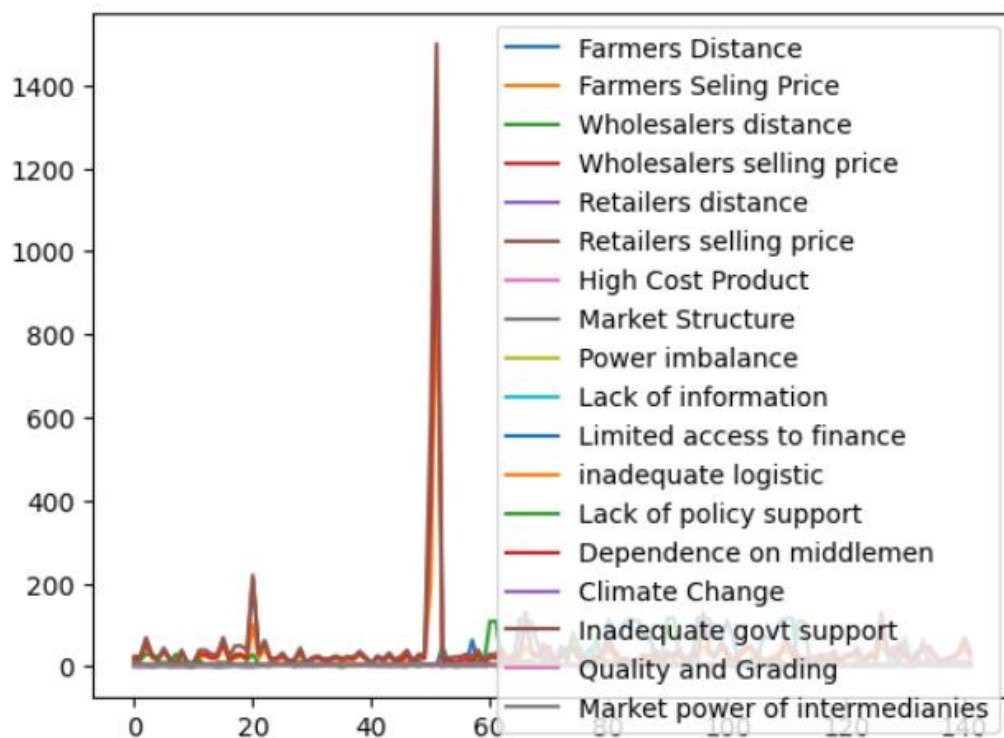
Methodology and Models:
- Logistic Regression
- Decision Tree
- Confusion Matrix
- LightGBM
- Correlation
- Plot
- Ensemble Learning(Bagging&Boosting)

Plotly Express:

For Farmers Distance
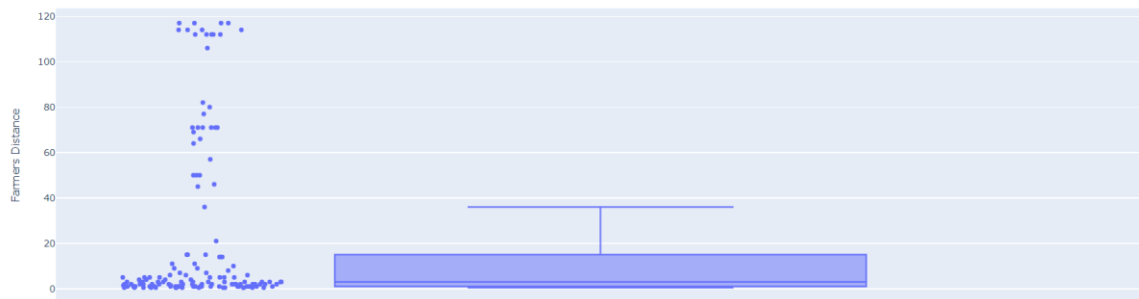
For Farmers selling price
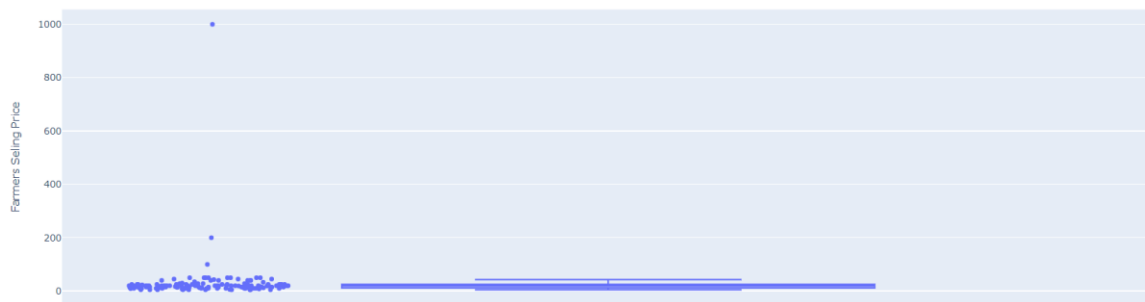
For wholesalers Distance

For wholesalers selling price
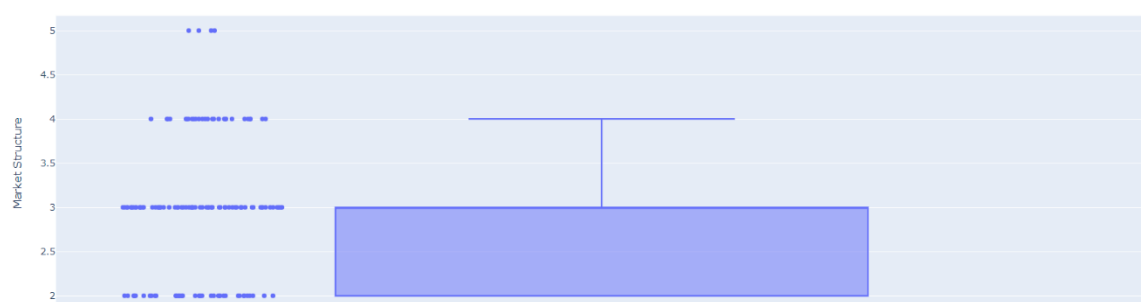
For Retailers Distance
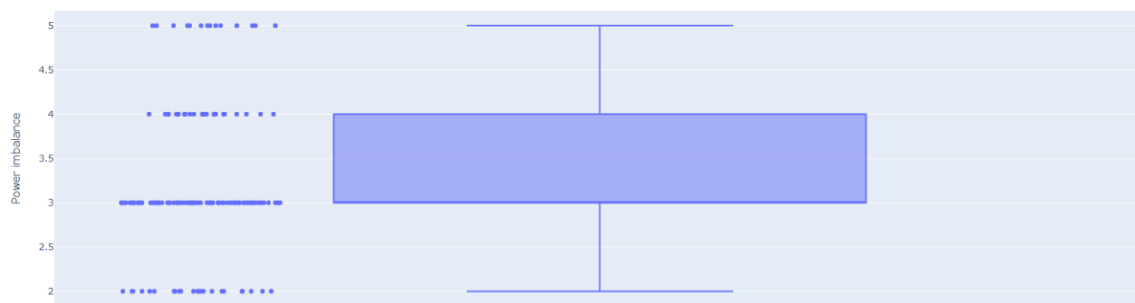

For Retailers selling price
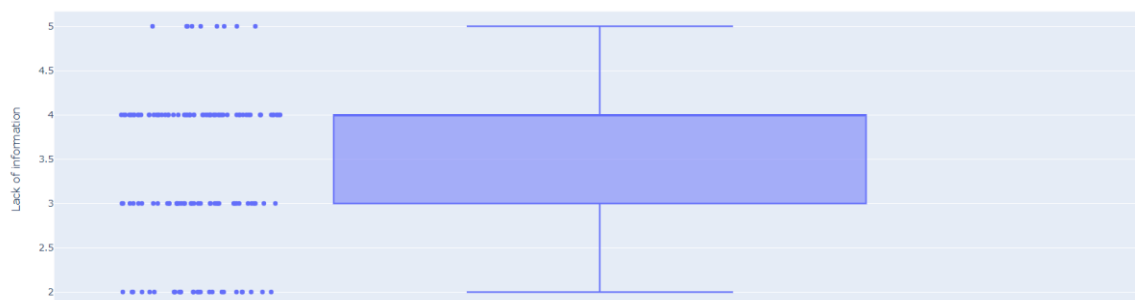

For High-cost product
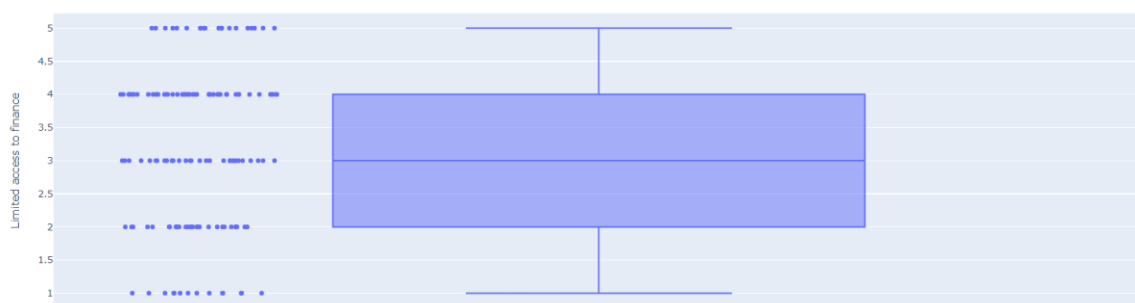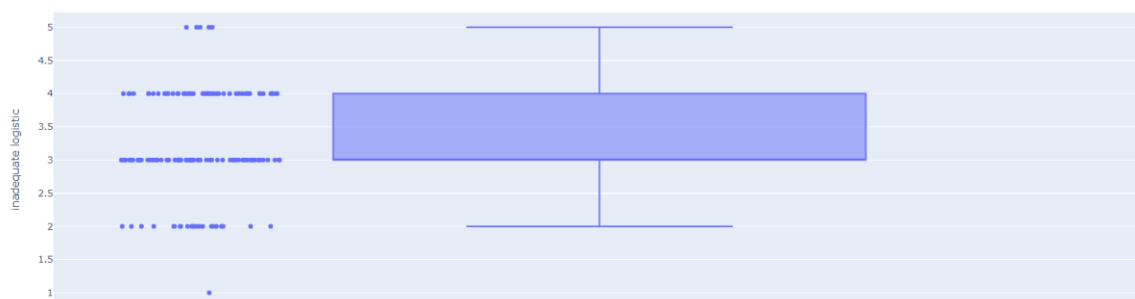

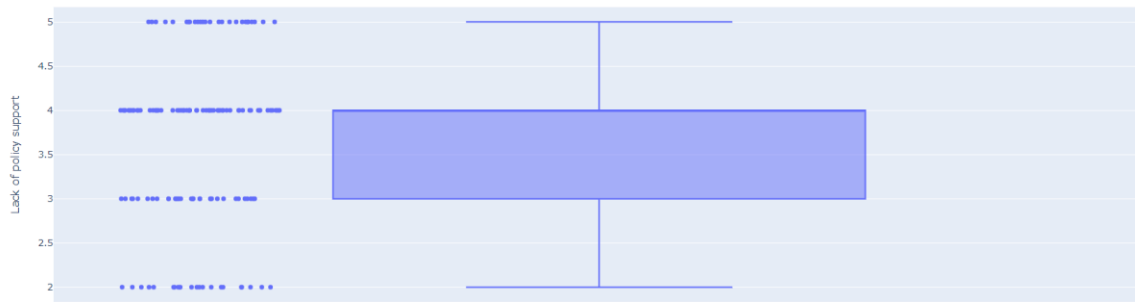## For Market Structure

For Power imbalance

For Lack of information
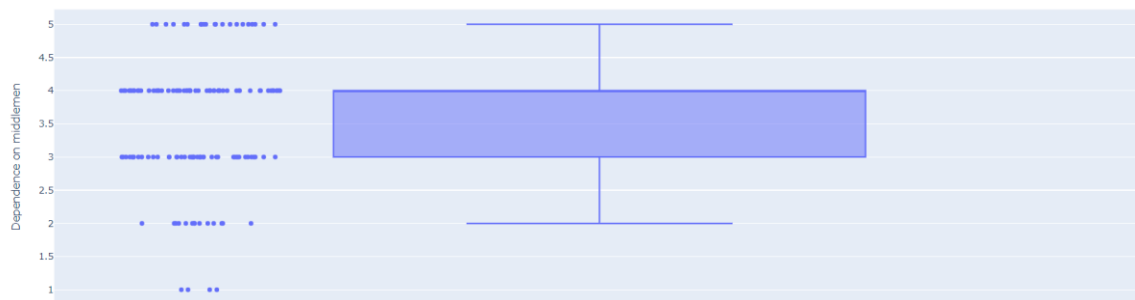

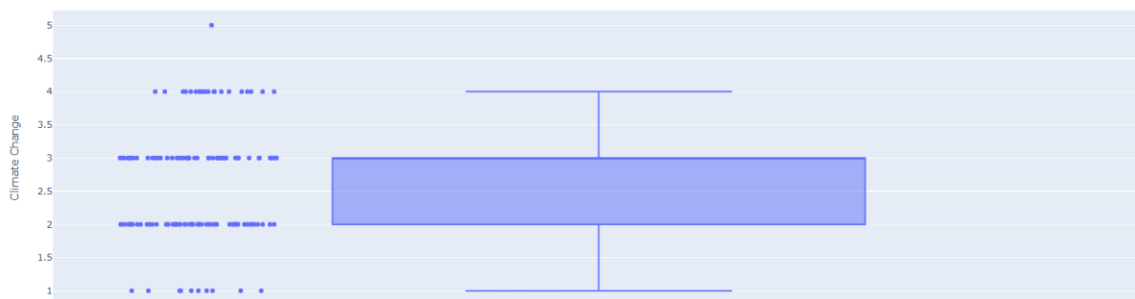For Limited access to finance
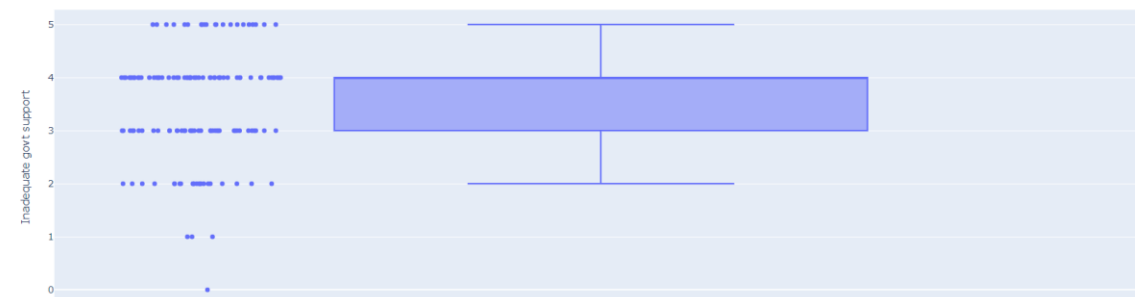

For Inadequate logistic

For Lack of policy support
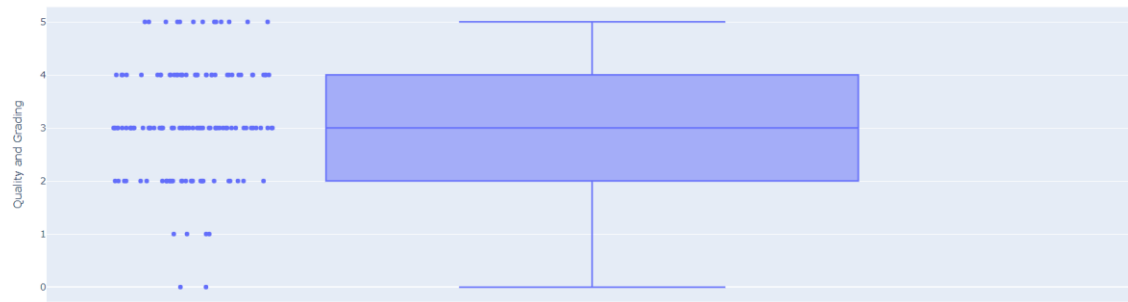

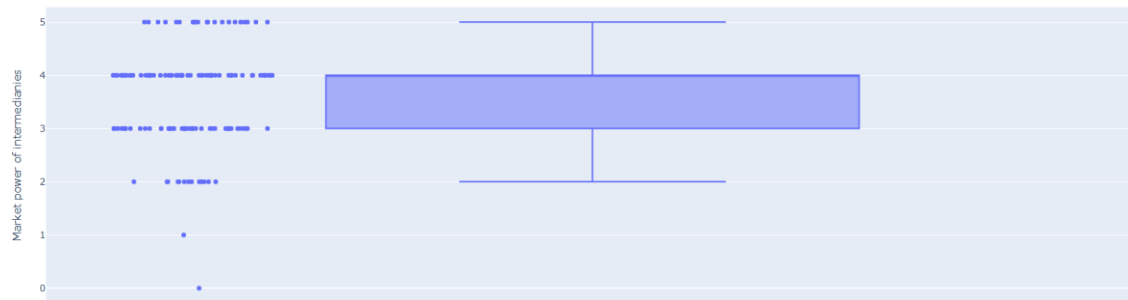## For Dependence on middlemen

For Climate Change
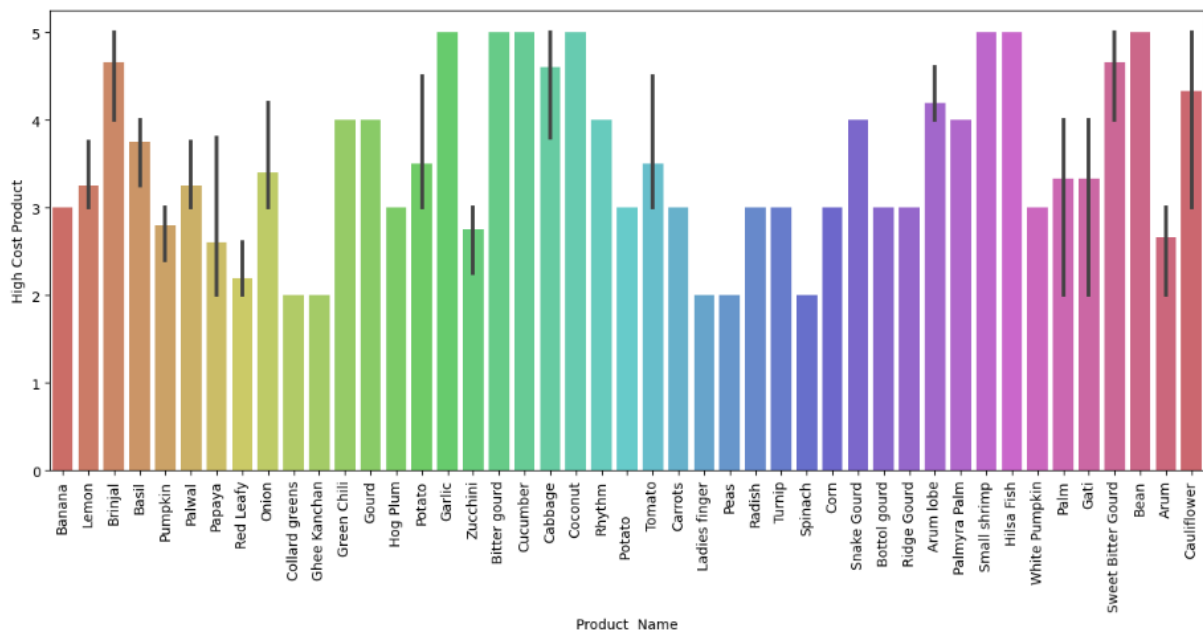

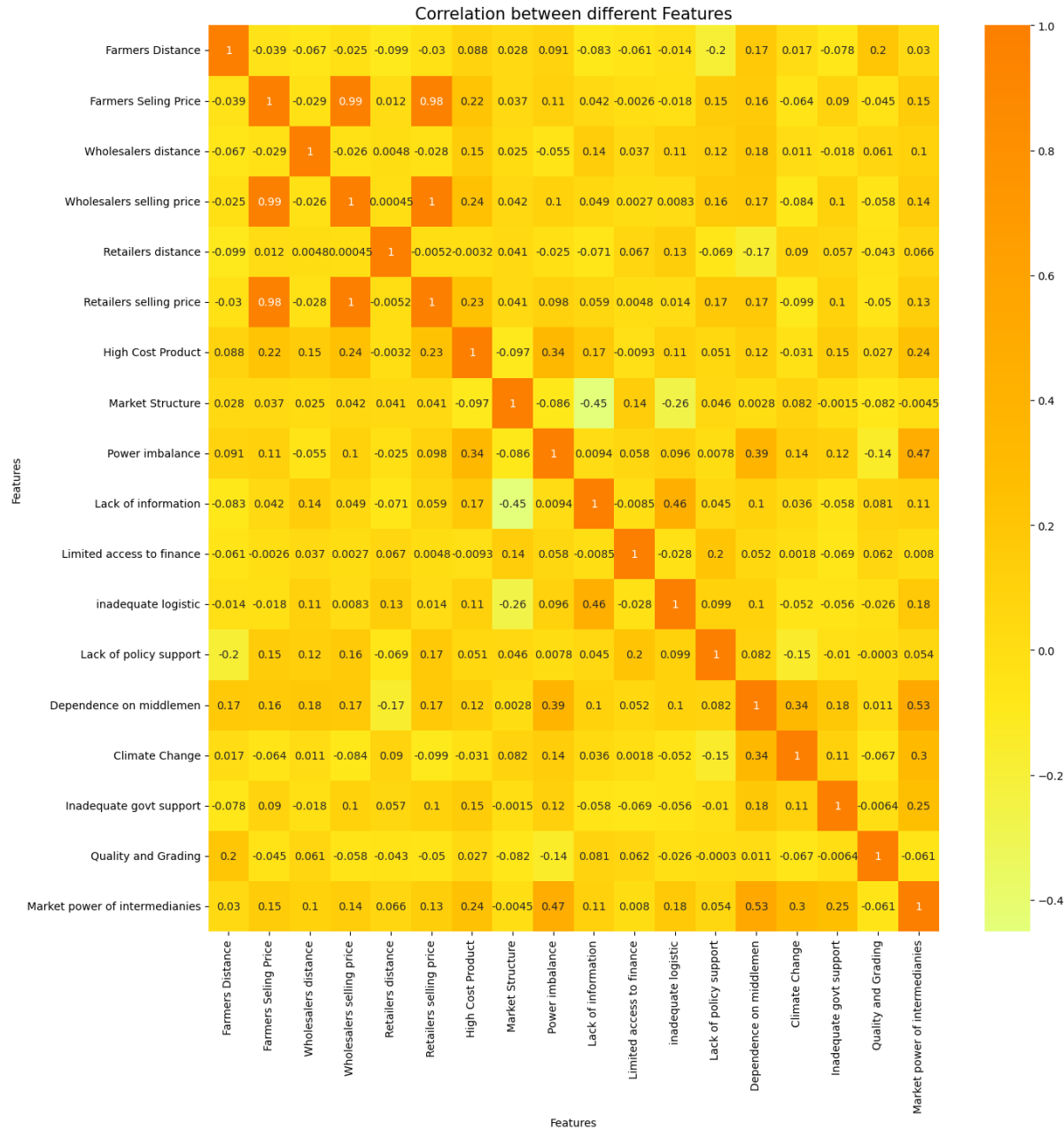## For Inadequate govt support

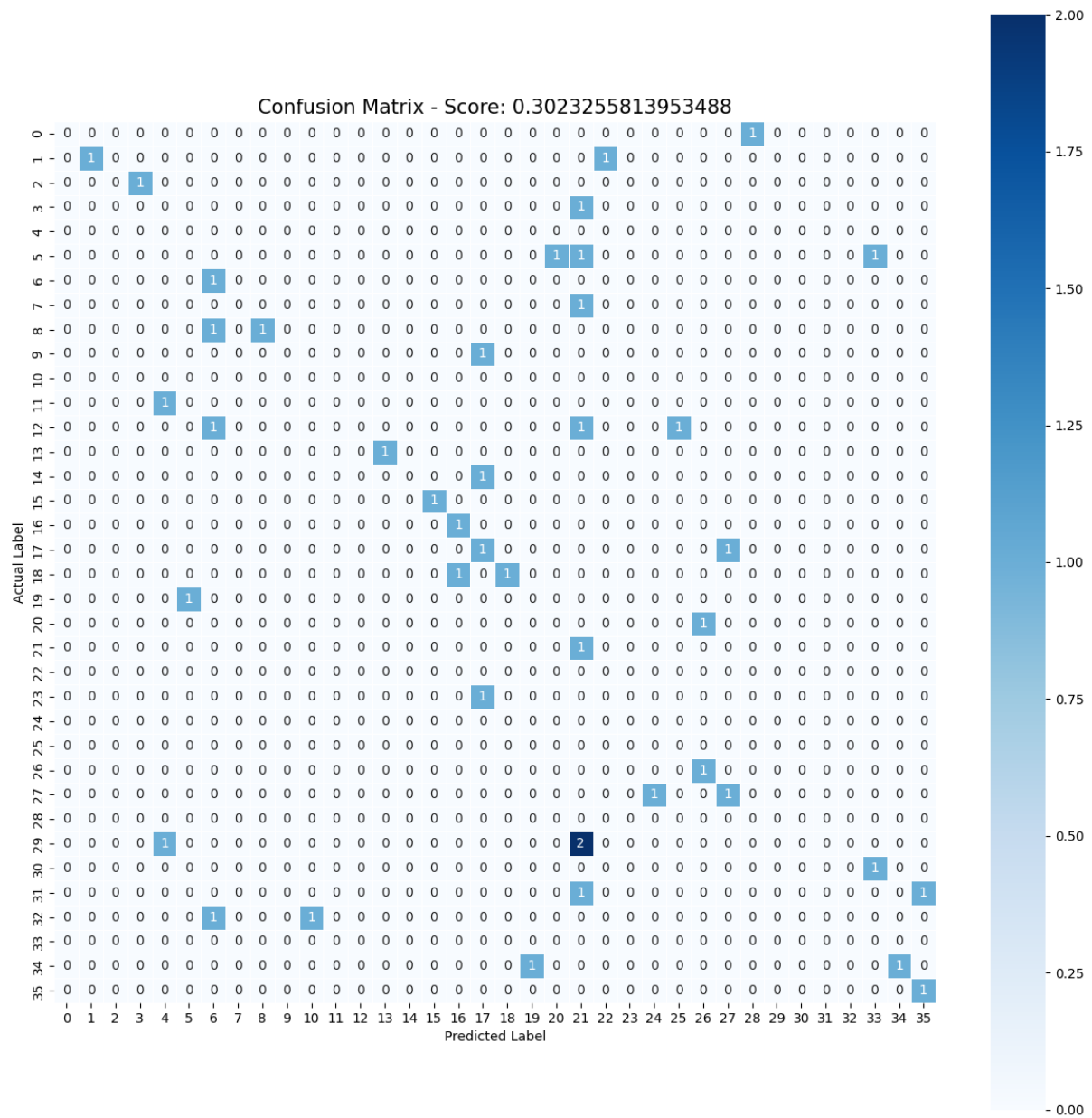For Quality and Grading

For Market power of intermediaries

Bar Plot:

Correlation Between Different Features:

Correlation between different Features

Confusion Matrix:

Confusion Matrix - Score: 0.3023255813953488

Classification Report:

	precision	recall	f1-score	support
Arum	0.00	0.00	0.00	1
Arum lobe	1.00	0.50	0.67	2
Banana	0.00	0.00	0.00	1
Basil	0.00	0.00	0.00	1
Bitter gourd	0.00	0.00	0.00	0
Bottol gourd	0.00	0.00	0.00	3
Brinjal	0.25	1.00	0.40	1
Carrots	0.00	0.00	0.00	1
Cauliflower	1.00	0.50	0.67	2
Collard greens	0.00	0.00	0.00	1
Corn	0.00	0.00	0.00	0
Cucumber	0.00	0.00	0.00	1
Garlic	0.00	0.00	0.00	3
Gati	1.00	1.00	1.00	1
Ghee Kanchan	0.00	0.00	0.00	1
Green Chili	1.00	1.00	1.00	1
Hog Plum	0.50	1.00	0.67	1
Ladies finger	0.25	0.50	0.33	2
Lemon	1.00	0.50	0.67	2
Onion	0.00	0.00	0.00	1
Palm	0.00	0.00	0.00	1
Palwal	0.12	1.00	0.22	1
Papaya	0.00	0.00	0.00	0
Peas	0.00	0.00	0.00	1
Potato	0.00	0.00	0.00	0
Potato	0.00	0.00	0.00	0
Pumpkin	0.50	1.00	0.67	1
Radish	0.50	0.50	0.50	2
Red Leafy	0.00	0.00	0.00	0
Ridge Gourd	0.00	0.00	0.00	3
Snake Gourd	0.00	0.00	0.00	1
Sweet Bitter Gourd	0.00	0.00	0.00	2
Tomato	0.00	0.00	0.00	2
Turnip	0.00	0.00	0.00	0
White Pumpkin	1.00	0.50	0.67	2
Zucchini	0.50	1.00	0.67	1
accuracy			0.30	43
macro avg	0.24	0.28	0.23	43
weighted avg	0.31	0.30	0.27	43

Result Analysis:

Feature Importances
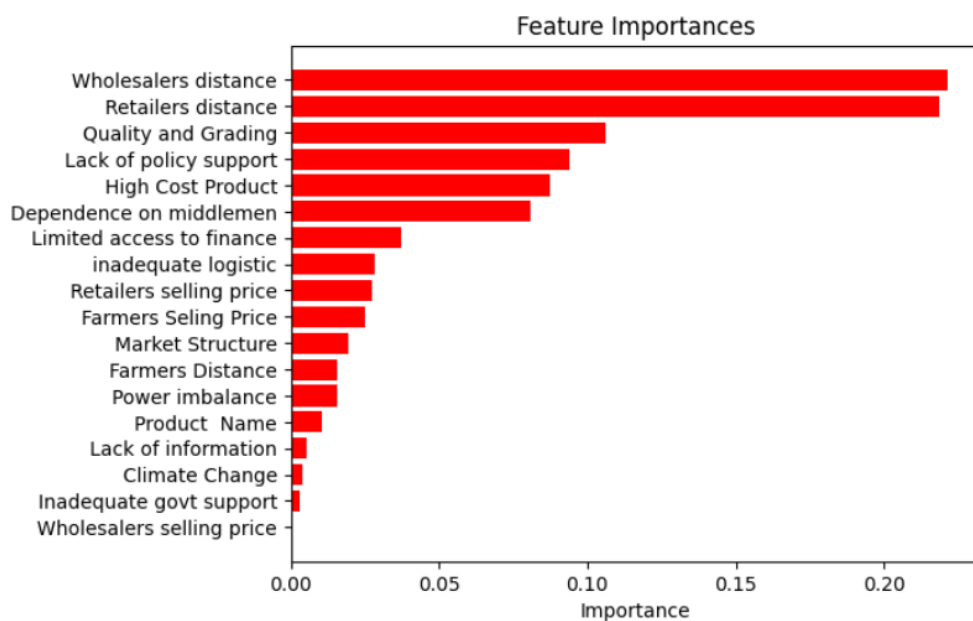
Conclusion:

In conclusion, identifying and understanding the key factors of a vegetable product supply chain is essential for optimizing its efficiency and ensuring the satisfaction of all stakeholders involved. Factors such as quality control, transportation logistics, storage facilities, market demand, and the market power of intermediaries play significant roles in shaping the success and effectiveness of the supply chain. By addressing these factors and implementing appropriate strategies, it becomes possible to streamline operations, minimize waste, enhance product quality, reduce costs, and ultimately deliver fresh and nutritious vegetables to consumers in a timely manner. It is crucial for policymakers, farmers, distributors, retailers, and consumers to collaborate and work towards improving these key factors to create a sustainable and resilient vegetable supply chain that benefits both the industry and the consumers.

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