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Systematic Approach to Reduce Carbon Emission in The Wheat Supply Chain

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Abstract - *There is a growing need for supply-chain management to incorporate the principles of sustainable development into its practice. Unfortunately, a broad framework for the supply chain of wheat production in India is not yet developed. This lack of understanding undermines the effectiveness of regulations designed to promote green supply-chain management for wheat. This paper aims to provide a comprehensive classification of the various aspects of GSCM, which is needed to help academicians, researchers, and practitioners understand it from a wider perspective. It covers various aspects of the literature on the subject. Through a process-based approach, the paper identifies the various factors that can contribute to the efficiency of the supply chain of wheat produce. The study explores how the wheat supply chain can reduce its environmental impact by replacing vehicles and tools with more energy-efficient options.*

Key Words: Green Supply Chain Management, Environmental Impact, Efficiency, Sustainable Development

1.INTRODUCTION

Despite the growing focus on designing an optimal wheat supply chain, the concept of optimal network design is rarely considered in the existing literature. The paper proposes a mixed-robust optimization model for designing a supply chain network for wheat. The model was formulated according to three possible scenarios, namely optimistic, most likely, or pessimistic. It also tried to minimize the total network cost by taking into account different factors such as transportation modes and the presence of silos. Through the study of real data of the Iran wheat supply chain network, an analysis was done on the various impacts of the proposed model on the network's cost. The results revealed that the reliability and perturbation levels played a major role in the network's cost. The performance of the different models was compared by analysing the changes in the capacity of the silos. The results revealed that the uncertainty related to the supply and demand can have a direct effect on the cost of the network. In future studies, the paper proposes a model that takes into account the various environmental and social impacts of the network. For future studies, the paper suggests taking into account the various factors that affect the transportation costs and choosing the most appropriate mode of transportation. The model can also be extended to include cross-supply of wheat, which can help lower the network's transportation costs.

Supply chain management is a broad spectrum of functions that encompass various disciplines such as transportation, logistics, marketing, and distribution. It is designed to enhance a firm's performance. Modern business management has shifted from being autonomous entities to being a supply chain. Instead of being purely focused on one brand or store, businesses are now competing against each other through the use of various supply chains. The success of a single company will largely depend on its ability to integrate its various business relationships. As a result, the concept of supply chain management has become more prevalent. The concept of supply chain management is not about having one-to-one relationships with suppliers. It's about having a network of relationships that can be seamlessly integrated. This allows companies to achieve total business process excellence.

Due to the effects of climate change and resource depletion, people and businesses around the world are calling for transformative change in how they interact with the environment. As cost pressures and environmental constraints increase in the supply chain, businesses have started to consider sustainable economic models. Due to the various factors affecting the environment, enterprises and organizations have been required to improve their environmental performance. Green supply-chain management is a concept that draws on the principles of supply-chain management and the environment. This concept involves addressing the relationships between supply-chain operations and the natural environment. Various terms have been used for Green supply-chain management, such as green purchasing and integrated green supply chains. {This paper aims to introduce the concept of Green supply-chain management and how it can be utilised in various aspects of wheat supply-chain management.} It involves integrating environmental considerations into the multiple aspects of a supply-chain operation. Green operations encompass the various activities related to producing and remanufacturing products. The goal of green manufacturing is to minimise the ecological impact of the industry. Due to the increasing interest in GSCM, various industries and academia have started to explore the integration of supply chain

and environmental concerns. This can be achieved through the use of multiple green practices such as green design, reverse logistics, green purchasing, reuse, recycling and environmental technologies.

Due to the increasing population in India, the demand for wheat has also increased. This has resulted in the need for more production and proper transportation methods. The country's wheat production has also increased due to the use of modern agricultural technologies. The transportation and storage of food grains are some of the major issues that are faced in the functioning of wheat supply chain management therefore It is necessary to improve the efficiency of these operations. The improper transportation and storage of bulk wheat in India has been identified as one of the major factors that can affect the cost of the food grain supply chain.

2. LITERATURE REVIEW

Michael Mutingi [1] conducted a research to explore the empirical green supply chain activities and develop a framework that is taxonomic in nature and can be used to create/formulate new strategies for existing supply chains to convert them into green supply chain. He developed a taxonomic framework by analysing all the existing green supply chain activities present, he further identified all the major dimensions which influenced the green supply chain management strategies. From the research he concluded that there are a set of characteristics dimensions that influence strategic green supply chain. He further developed a well organised plan for selecting green strategies to be implemented in the existing supply chain.

According to Zuraidah Sulaiman et al [2] the idea of green supply chain management is important as it directly impacts/influences the environmental impact of any organization's activities. They defined the concept of green supply chain management as a method to integrate environmental thinking into normal supply chains. The main aim of their research was to study the existing supply chain and its effects on environment and find strategic ways to modify the supply chain to make it more sustainable in nature. After analysing the data from already published articles and research papers it was found that green supply chain and sustainability performance are two important aspects/concepts of supply chain, however it is difficult to implement these concepts on the whole supply chain as it leads to huge investments and requires significant time and resources to be implemented. It was suggested that organizations must establish long-term collaborative relations with theirs vendors and customers which would make the implementation of green supply chain more feasible.

TR Rajeswari et al [3] recognized that in post-industrial era environmental impact of supply chain in businesses is a growing concern. They collected quantitative data from 12 companies concerned with corporate green supply chain practices and environmental drivers in order to identify the factors that influence the implementation of the environmental drivers. With the structural equation modeling technique, path analysis was performed to identify the significant environmental drivers. The results of the studied depicted that the factors influencing the green supply chain are regulatory pressure, customer pressure, socio-cultural pressure and competitor pressure. However they have varying level of impact in the supply chain at different stages of manufacturing process

Akinlabi et al [4] presented an overview of Green Supply Chain Management and its various components. Green Supply Chain Management is a paradigm shift that's happening in the supply chain management industry. The main objective was to brief on the various literatures on Global Sustainable Construction Management and to explore the new directions of this emerging field. In most corporate, construction firms and businesses the emphasis now is to raise environmentally responsible consumption and production with a view of promoting environmental quality, reduce poverty and bring about economic growth, with additional improvements in health, working conditions, and sustainability. Although it's widely used in the construction industry, most companies and individuals are still unaware of its concept.

Ming-Lang Tsenga et al [5] reviewed and analyzed literature on GSCM through the use of Scopus and ISI web of science databases. The study finds that there is a decline in research on drivers and barriers to green supply chain management and there is increasing popularity of implementing mathematical optimization models for improving decision making. Also there is an increase in the evaluation of green supply chain management practices and performance. The metadata analysis reveals influential authors, popular journals, publications by year, top contributing countries, institutions, and disciplines. Sarkis and Zhu were found to be the most influential authors in GSCM area considering the number of publications and citations. Journal of Cleaner

Production is the most popular journal regarding its impact and number of papers it publishes during this area. China and America dominate the discipline in terms of the number of publications as well as the impact .The business management discipline dominates the share of literature published in GSCM. According to the content analysis, articles connected to

conceptual development are continuing on the rise, indicating that writers are still developing the concept of GSCM and that more and more sub-disciplines or branches are forming. Articles connected to drivers and barriers, on the other hand, reveal that the number of papers is not rising when compared to other categories, indicating that the research of drivers and obstacles in GSCM has achieved a maturity level. Firms are encountering new hurdles as new sub-disciplines and branches emerge. The use of mathematical models is most frequently aimed at addressing these new issues. Furthermore, constant effort on the assessment of GSCP and GSCM performance has been noted throughout the time range. However, there are few studies in the literature that explore GSCM from the perspective of supply chain network parties such as suppliers, customers, logistics, and manufacturers. There is also a scarcity of big data research. There is a lack of comparative research between various nations and continents. Comparative research between industries are also limited. Only a few studies have attempted to address the theoretical foundations of GSCP and performance. Nonetheless, when it comes to assessing the relationship between drives, practises, and performance, a considerable number of notable publications in the GSCP field lack good theoretical justification. Most research focus and use data for big corporations and how these firms can adopt GSCP with little research and optimization being done on the SCP of smaller firms. Smaller businesses must be considered and cooperatively involved in environmental preservation in order for them to be motivated and contribute to a more sustainable process. and make them more effective. Future directions include the use of algorithms to predict future trends.

[6]Anass Cherrafi et al aims to investigate and explain the link between green and lean management (LM) practices and the performance of supply chain management (GSC). It also aims to identify the various effects of these practices on GSCs. The theoretical contributions and implications of various fields related to green lean, supply chain sustainability, and process innovation have been extensively reviewed. The practical implications are also applicable to operations and supply chain managers who are trying to improve their green performance. Greater knowledge about the link between green and process innovation can help in effectively implementing GSC. This study aims to provide insight into the various aspects of sustainable development and how these practices can help improve the profitability of companies. It will also help them develop effective strategies and implement them within their organizations. Although this study mainly focused on the manufacturing industry, other industrial sectors such as healthcare, logistics, and food services can also benefit from this study's findings. The implementation of a GSC can help an organization achieve its goals and provide it with the opportunity to sustain and improve its operations through continuous improvement. This study aims to encourage organizations that are not yet committed to sustainable operations to consider adopting a similar approach. Various limitations were identified in this study which prevented it from being able to provide a full analysis of the relationship between green and process innovation and the GSCs performance. This study can also provide insight into the various factors that influence the performance of GDSs. It can also reveal the various ways in which these factors can affect the performance of GSCs.

This paper aims to include theoretical dimensions of the study so that they can be included in the final product. It is also proposed that the concepts of lean, green, and process innovation be integrated into the study so that it can be conducted in the future.

[7]M. Abdel-Baset et al propose a robust technique for assessing and tracking the performance of green supply chain management (GSCM). The method is based on the neutrosophic set theory. It is used to detect and improve the efficiency of GSCM practices.

A robust ranking technique and neutrosophic set could be used to develop GSCM practices and improve their performance. They proposed that the GSCM should be developed in three phases: reverse logistics, supplier environmental collaboration, and carbon management. The study revealed that GSCM practices could help organizations reduce waste, improve resource use, and lower costs. They could also contribute to the development of sustainable business models. Support of two case studies could help validate the approach and show that it could be adopted. This could also help us improve our predictions and make them more effective. Future directions include the use of algorithms to predict future trends.

[8]R.P. Mohanty & Anand Prakash in their paper studied the practices of green supply chain management(GSCM) in the Micro, small and medium enterprises of India also known as MSMEs. In the area of GSCM the research has been growing in recent days but with the help of all the literature, it is still difficult to find a valid explanation for why green practices are needed in supply chain management with the presence of internal and external pressures. The Indian MSMEs have been involved in the green supply chain practices only as far as their participation as distributors, suppliers, and business partners. Their study consolidates that MSMEs of India have to face significant pressures from stakeholders to practice GSCM practices.

Their study empirically examined the reasons why Indian MSMEs are heavily involved in green supply chain management practices. It found that they face significant external and internal pressures to adopt these practices. This study also confirms that these MSMEs are fully influenced by their employers.

The study summarised that GSCM aims to improve efficiency. usage of all available resources regardless of how business is conducted, regardless of whether the company is in the manufacturing, service, or retail industries, Whether it's transportation, mining, or agriculture, the overall concept is the same. The goal of GSCM is to improve environmental efficiency. GSCM is a comprehensive management system strategy and looks for economic and environmental efficiency.

[9]Jamal Fortes observed that sustainable development has made significant progress in establishing a green supply chain. During the late 1980s, many companies went beyond what was required in order to achieve a more sustainable approach. The key themes that emerged from the literature were green operations, green design, waste management, and reverse logistics. The paper consists the various issues that these themes faced and why organizations would prefer a green supply chain. This paper reviews the various perspectives on Green supply chain management (GrSCM). It argues that these principles have helped minimize the ecological impacts of industry. Over the last couple of decades, the literature on green design, reverse logistics, waste management, and green manufacturing have been very useful for students of GrSCM. This paper briefly discussed some of these concepts and their various applications. The next part of the paper covered green design and green operations, which were briefly discussed. Although the Green supply chain has been comprehensively reviewed, some areas still require further study. One of these is the stakeholder's views on green supply chain. Most of the time, when the concept of green supply chain management comes up, most of the stakeholder groups would agree that it constrains the organization's generation of profits. This paper argues that in order to properly implement green supply chain management, researchers should focus on interviewing the various stakeholder groups.

[10]Md Shamimul Islam et al noted that due to the increasing number of green supply chain studies, many new authors are venturing into this field. Although the literature review has been conducted over time, a comprehensive list of these practices is not available. This study aims to provide an up-to-date review of these practices through a structured review process. The study was carried out through a structured review process, which was aimed at ensuring that the data were filtered through the highest-quality peer-reviewed journals. This paper presents a comprehensive list of various aspects and practices related to the green supply chain. Some of these include carbon management, reverse logistics, green design, and industrial symbiosis. The study focused on reviewing literature on green supply chain management. It compiled a comprehensive list of green supply chain's various aspects and practices. Although there are few studies on this topic, a comprehensive list of these has not been compiled in the past. Through a review of the literature, it has been discovered that there are various aspects of the green supply chain that were previously focused on purchasing green goods and services. This is mainly due to the increasing number of researchers in this field. This paper mainly focuses on the various aspects and practices that were identified by the scholars of the GSCM in the past two decades. It will help people in their studies in this field. Due to the limitations of the study, the findings were not presented in a comprehensive manner. Future work should explore the various facets of GSCM and identify key strategies and practices that can be utilized.

[11]Seth Kofi Nkrumah et al recognized the literature on green supply chain management has been heavily focused on the adoption of GSCM practices, the role of green capabilities has been neglected. This study aims to explore the four green capabilities that are most likely to influence GSCM adoption. The survey was conducted in 2017 to explore the capabilities of 200 manufacturing and extractive companies operating in Ghana. The results revealed that the development of green suppliers and environmental solutions had positive effects on GSCM adoption .Although green marketing capabilities have a positive impact on GSCM adoption, they did not significantly affect the adoption rate. The study also highlighted the importance of developing green capabilities in order to achieve higher levels of GSCM adoption. Despite the efforts of various authorities and other relevant parties to enforce strict environmental regulations, many firms have failed to achieve higher levels of green performance. This study suggests that firms should start developing their own green capabilities. The study only focused on Ghana, which is a sub-Saharan African country. This limitation makes it hard to generalize the findings to other regions. Also, the data collected for the study were only limited to Ghana.

[12]Dhanavanth Reddy Maditati et al's study aims to analyze the various factors that influence the green supply chain management process (GSCM). It provides a comprehensive view of the various GSCM factors' structural associations. Co-citation analysis was coupled with content analysis of the 39 most cited articles and this was further used to identify six underlying research streams, namely (a) conceptual development and sense-making, (b) GSCM impact on performance, (c) integration of green and sustainable operations in the supply chain, (d) green supplier development, (e) GSCM implementation drivers, and (f) review and future research directions. HistCite software was used to perform a bibliometric citation meta-analysis on 1523 articles on green supply chain management (GSCM). The analysis revealed six main research streams that contribute to the development of green supply chain management.

This paper proposed a comprehensive conceptual framework that draws on the various groups and factors involved in the study of GSCM. It was also supported by the findings of key papers in the field. Future research may only focus on the relationships between drivers and practice indicators in order to validate the framework.

[13]Yigit Kazancoglu et al's paper aims to create a new conceptual framework for assessing and managing GSCM performance. This framework integrates the various aspects of GSCM performance and has a three-dimensional hierarchy. As the transition to a circular economy approaches, companies should start thinking about the impact of their operations on the environment. This is because the concept of circular economy is focused on minimizing waste and environmental protection. The goal of this study is to provide a comprehensive view of GSCM's performance by analyzing the various indicators such as environmental, economic/financial, operational, logistics, organizational, and marketing performances. A framework is proposed to establish a system to assess GSCM performance. This process consists of gathering and analyzing data, establishing an assessment method, and monitoring and evaluating the gathered data. The importance of marketing criterion was added to the GSCM performance assessment to enable the companies to improve their environmental performance. This criterion aims to measure the extent to which their marketing activities contribute to the improvement of their customer satisfaction. Further research could be conducted to identify the causal relationships among the various criteria and sub-criteria of GSCM, and to develop a road map for the company

[14]Sulafa Badi, Niamh Murtagh et al's study focused on the Green SCM research conducted before the end of 2017 in the construction industry. It provided a comprehensive and rigorous analysis of the available literature on this topic. The sources cited have been described in terms of their publication outlet, date of publication, geographic setting, methods used, tools and techniques, conceptual definition and the role played by the stakeholders. Radical change is rare and most of the time it is incremental. This is because the complexity of the system , comprising of hundreds of actor-organizations and thousands of actors individuals makes it difficult to implement radical change.

Baoshan Xing et al [15] studied the effect of chemical fertilizer, manure compost and biochar-amended manure compost strategies on wheat production and its effect on the environment. It was observed that though the use of chemical fertilizers increased productivity, they had a lot of negative environmental effects. They conducted a study where the environmental impact of using four different types of fertilizers was analyzed. From the study it was found that the use of conventional chemical fertilizers impacted the environment in the most harmful manner. The use of manure compost instead of the conventional fertilizer was found to be significantly less damaging to the environment. The use of biochar fertilizers increased the productivity of wheat, while impacting the environment the least.

Mingxin Wang et al [16] conducted a life cycle assessment to examine the environmental impact of wheat production in winters. It was found that there was excessive use of nitrogen, potassium and phosphate fertilizers. Insufficient control measures and an improper application of nitrogen and phosphorus fertilizers were found to be the major factors that contribute to the excessive use of these chemicals. The study revealed that the use of these chemicals has a significant impact on the environment, such as energy depletion, aquatic eutrophication and acidification. The acidification was found to be an outcome of SO2 emissions and NH3 volatilisation from N fertilizers. Manufacturing of fertilizers was found to be a very energy intensive task thus causing energy depletion. It was concluded that by adopting energy-saving techniques and reducing the amount of SO2 and CO2 emissions, winter wheat production could improve its environmental performance.

[17]Amit Sachan et al stduied the effect of awareness programs to help in addressing the various issues faced by the farmers and government regarding the timely testing of soil. They also help in managing the storage capacity of the farmers and ensure the quality of the agri-produce. The acceptance of agri-produce depends on the storage facilities and the status of buyers in Mandi. The capacity of these facilities and the status of their payment cycle are important factors that influence the availability of seeds and fertilizer. The green revolution has greatly changed the scenario of India's agricultural produce industry. Before the revolution, the country did not face a scarcity of grain and other food crops. The factors identified as enablers of an efficient supply chain for agricultural production have been identified and modeled through an interpretive structural modelling approach. The results of the study revealed that the various factors identified as enablers of an efficient supply chain can help increase the overall surplus of an agri-produce. Some of these include crop rotation If the purchasing capacity of buyers in the market is not sufficient, then the farmers would have to sell their crop at a lower price, which would have a negative impact on their earnings. This could also discourage them from buying the necessary equipment at the right time. The inter-relationships between these nine factors and the various other factors identified as enablers of an efficient supply chain can help boost the

[18]Ankur Chauhan et al found the rise of the green revolution has significantly changed the scenario of India's agricultural produce. After this, the country has never faced a situation of scarcity of food. In the study, the various factors that play a crucial role in sustaining an efficient supply chain for agriculture were identified. The findings of the study were then

analyzed using various statistical methods, including an econometric model, to identify the most advantageous supply chain for an Agri-produce. The model revealed that two key enablers are awareness programs and forecasts for demand for the commodity.

[19]Seyyed-Mahdi Hosseini-Motlagh et al found that despite the growing focus on designing an optimal wheat supply chain, the concept of optimal network design is rarely considered in the existing literature. The paper proposes a mixed-robust optimization model for designing a supply chain network for wheat. The model was formulated according to three possible scenarios, namely optimistic, most likely, or pessimistic. It also tried to minimize the total network cost by taking into account different factors such as transportation modes and the presence of silos. Through the study of real data of the Iran wheat supply chain network, an analysis was done on the various impacts of the proposed model on the network's cost. The results revealed that the reliability and perturbation levels played a major role in the network's cost. The performance of the different models was compared by analyzing the changes in the capacity of the silos. The results revealed that the uncertainty related to the supply and demand can have a direct effect on the cost of the network. In future studies, the paper proposes a model that takes into account the various environmental and social impacts of the network. For future studies, the paper suggests taking into account the various factors that affect the transportation costs and choosing the most appropriate mode of transportation. The model can also be extended to include cross-supply of wheat, which can help lower the network's transportation costs.

[20] A. Ghalegolab Behbahani et al took 1-ton of wheat as a functional unit and conducted a life cycle assessment to study the impact of wheat and barley production on the environment under rainfed and irrigated farming systems. Soil acidification and salinization, emission of gases with adverse effects, nitrogen leaching to groundwater, and eutrophication were some of the environmental impacts found due to the excessive use of synthetic chemicals and other environmental contaminants. The overuse of these chemicals has become an irreversible antagonistic consequence for nature.

[21] D.G. Mogale et al identified the multi-period bulk transportation and storage problems that can significantly affect the cost savings of food grains. The proposed non-linear programming model was designed to minimise the cost of transporting and storing food grains. The complexity of the Indian food grain supply chain's operations was a major challenge. This issue was caused by the various constraints faced by the various entities involved in the supply chain. In order to address these constraints, they proposed a novel algorithm for the chemical reaction optimization of food grains. The proposed algorithm was able to solve the various problems faced by the users of the supply chain in different sizes. The results of the study showed that the proposed algorithm is more effective than the CRO algorithm. The paper focused on the Indian food grain supply chain's two-stage multi-period storage and transportation problems. The objective of the solution was to minimize the transportation and storage costs of the grain. The paper proposed a cyclic random number scheme (CROTS) for solving the problems related to the supply chain. The algorithm was then compared with a cyclic random number scheme (CRO) for the other problems. The results of the study revealed that the implementation of CROTS significantly improved the performance of the CRO algorithm for all the problems. The paper also focused on the single food grain transportation problem. In future, it may also be applied to the multi food grain transportation issue. The paper also noted that the algorithm could be extended to solve the multi-objective problems of the supply chain. This method would help the FCI in planning and coordinating the various activities related to the food grain supply chain.

[22] D.G. Mogale et al discussed the Public Distribution System of India's food grain supply chain problems. These issues involved the transportation of bulk food commodities from surplus states to deficit ones. A non-linear programming model was formulated to minimize the overall cost of the supply chain by taking into account various factors such as the vehicle preference constraints, seasonal procurement, and storage capacity. The complexity of India's food grain supply chain network was caused by the various interventions . This paper proposed a meta-heuristic approach to address the issue. The proposed algorithm was then validated through the use of the Max- Min Ant System (MMAS). A statistical analysis was then carried out to confirm its superiority. The issue of the public distribution system's food grain supply chain has been solved through the development of a mathematical model. This model allowed the system to minimize the holding and handling costs of the food grains while ensuring their safety. The model was formulated using a mixed integer non-linear framework. It featured a number of features such as vehicle preference constraints and multi-period shipments. The model was formulated using the IMMAS algorithm. The solutions obtained from this method are then dominated the solutions of the MMAS algorithm. The capacity and vehicle characteristics of different capacitated vehicles were analyzed through sensitivity analysis. The model can then be extended by considering a procurement process and a demand. Another modification of this work is the development of a multi-food grain scenario. This scenario allows the transportation of food grains to be handled through different modes of transportation.

[23]Gholamian et al presented a new mathematical model for the design of a wheat supply chain in Iran. It tackled the various aspects of the supply chain, including collection, production, inventory and distribution. The complexity of the

wheat supply chain network's structure can be challenging to manage due to the uncertainties related to supply, demand, related costs, and climate changing. This paper aimed to introduce a robust approach to address these uncertainties. The study revealed that the design of the robust network increases the cost of the whole supply chain, but it also saves costs in situations where uncertainty exists in several parameters such as supply and demand and prevents the system from running out of wheat in the future. The seasonal supply of wheat affects the utilization of the network and its costs. This study also revealed that the location of silos is very important in terms of reducing wastages and keeping the network running smoothly. The study also indicated that at the higher levels of perturbations, there will be more silos with higher capacities which will raise the cost of construction and the overall network. Therefore, fewer silos should be established with more capacity for each silo.

[24]Hosseini-Motlagh et al presented a multi-period objective math model to support decision-making processes. It proposed that the model can minimize silos establishment, transportation, food loss, inventory holding ,carbon emission, and risk penalty costs. The proposed model is based on the supply and demand dynamics of the food grain stock. It can be utilized to plan and manage the movement of food grain stock efficiently. The capacity of warehouses can also be utilised through the well-organised inventory storage plan to minimise post-harvest losses and also ensure speedy movement of food grains. The proposed model can also be utilised to control the excess inventory cost by encouraging the use of lean and operational procedures. Food grain loss is less in bulk transportation and storage as compared to gunny bags. Therefore, conventional activities should be shifted to bulk grain operations. One of the main factors that can contribute to the reduction of the inventory cost is the reduction of food grain loss.

[25]Mogale, D. G et al aimed to develop a robust supply chain model that will enable the procurement of food grains in India. It utilises the NK Hybrid Genetic Algorithm to cluster the villages and a density-based approach to improve the supply chain network. It found that policymakers have to focus on establishing procurement centres in adequate numbers in surplus states. The study focused on developing an analytical model that will enable food grains procurement companies to make informed decisions. It considered various environmental and economic dimensions of the procurement process. It also considered carbon emissions and freight transportation costs. The study tested the proposed model using various food grain supply chain cases. It concluded that policymakers should focus on establishing procurement centres before the beginning of the marketing session , in surplus states to provide maximum benefit to the farmers. The FCI can then cluster various villages into clusters based on the proposed algorithm. This method can help minimise the overall cost of the procurement process. The study will also help the farmers in making the best use of the MSP by selling their produce to the nearby procurement centers. This will help boost their economic and welfare growth.

4. RESULTS AND DISCUSSION

4.1 Transportation

Transportation in a supply chain is the process of moving products from one point in the supply chain to another. Transportation costs are a significant chunk of the total cost of a company's supply chain. Although the exact contribution might vary, the number can go as high as 60 percent. Warehouse managers should consider the transportation of their products as part of their overall supply chain strategy to lower their costs. This can help them achieve a lower total cost.

The CO2 emissions from transport are 9000 billion tons. The emissions are expected to grow despite the significant developments in energy efficiency; therefore, there is a growing need for finding efficient and greener alternatives.

Transport connects all the parts of the supply chain together. For wheat, transportation distances and modes of transport vary depending on the field location and the products' path to market. Also, the backhaul and the modal contribution assumptions vary by field location.[30]

India's agriculture supply chain transport network consists of two parallel systems: Government procurement and distribution and private procurement and distribution.

The government implemented procurement and distribution consists of a transport network consisting of procurement, inter-state transportation, intra-state distribution, and finally, from district level warehouses to end delivery points, the Fair Price Shops.

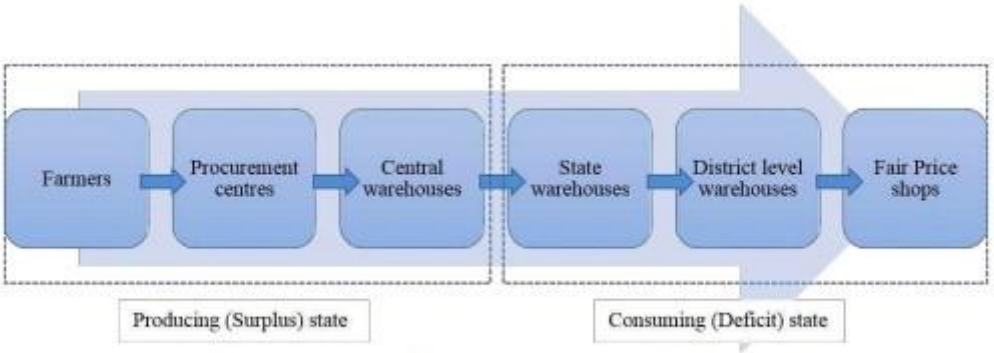
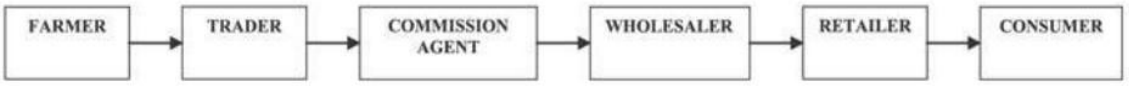


Figure 1 Operations involved in food grain supply chain in India

The privately implemented procurement and distribution consists of farmers, traders, commission agents, wholesalers, and retailers.



Electric trucks have not been a viable alternative to replace heavy-duty trucks because the batteries have low energy density and high energy requirements. However, with the latest research progress in battery technology, the manufacturing of heavy-duty electric trucks, which are viable technically and commercially, has been made possible.

Life Cycle analysis performed by Sen et al. with different trucks in the United States showed that electric trucks outperform conventional trucks in costs and emissions.

With the latest research and development, battery prices are expected to decrease further. The life cycle costs of electric trucks can become lower than the costs of conventional heavy-duty trucks, making electric trucks a viable alternative.

Kurien et al. found out that even after considering the indirect carbon emissions from electricity generation, electric vehicles still have much lower carbon emissions than internal combustion engine vehicles.[31]

Zhou et al. performed the life cycle GHG emissions and the lifetime costs of battery-electric trucks and medium-duty diesel trucks in Toronto. They concluded that the lifetime cost of Electric Trucks could be lower when compared to the lifetime cost of diesel trucks under driving conditions that involve frequent stops/starts and include low payloads, low charging stations costs, and low battery costs.[29]

Trucks used today produce significant amounts of emissions including CO2(70288.92), CO(491.15), NOx(859.51), CH4(12.28),

SO2 (193.73), PM and HC (38.20). Which accounts for 28.8% of the total CO2, 39% of the total NOx, 27.3% of SO2, 25% PM

(0.03 Tg), and contributes 25% of the total vehicular emission of India. Electric trucks provide a greener alternative to diesel-powered trucks, reducing the supply chain's greenhouse impact.[28]

For calculating the CO2 produced for a ton of payload to travel a kilometer of distance for diesel trucks, we considered the CO2 emissions per km of trucks of different payloads and then divided that by the respective payload of the truck to obtain the amount of CO2 produced for a ton of payload to travel a kilometer.

For calculating the CO2 produced for a ton of payload to travel a kilometer of distance for electric trucks, the energy(kWh) required per kilometer for a few of the most popular electric trucks was taken and divided by their capacity(tonnes) [27] to find out their energy per kilometer for carrying a ton of payload (kWh/tkm) and their average were taken. This value was multiplied by the average emission produced to generate a kW of electricity to get the amount of CO2 produced for a ton of payload to travel a kilometer.

Payload (tonnes)	Average CO_2 (g/tkm)
7.4	102.9
10.3	84.0
13.8	56.5
6.3	110.9
13.4	64.7
10.3	84.0
13.8	58.6
Average:	80.17

CO2 emissions for different capacity diesel trucks [26]

Payload (tonnes)	Energy Consumption(kWh/km)	Energy Consumption(Kwh/tkm)	Average CO_2 (g/tkm)
7.5	0.69	0.092	87.4
11	0.88	0.08	76
12	0.88	0.0733	69
16	1.00	0.0625	59
16	1.00	0.0625	59
18	1.00	0.055	52.2
Average			67.1

CO2 emissions for different capacity electric trucks

On comparing the averages produced by the methods it was found that the electric trucks produce 16% less CO2 emissions as compared to their diesel alternatives.

The calculation should not be generalized to all-electric trucks and all driving and terrain situations. Even though the Battery-Electric Truck has lower life cycle greenhouse emissions, this is not valid for all conditions.

The analysis also shows that (as expected) the average CO2 emissions per vehicle subgroup vary significantly as a result of the very different mission profiles, average payloads, and annual mileage.

4.2 Fertilizer

For thousands of years, humans have been using organic and mineral fertilizers to improve the soil fertility. In the last century, these fertilizers have evolved from being natural to being synthesized chemically. The use of these fertilizers has greatly increased crop production.Unfortunately, this increased use of fertilizer has resulted in greenhouse gas emissions. As a result, agriculture has become the second-biggest source of global climate change pollution.

Since plants can't absorb nitrogen from the air, they rely on the soil for their nutrients. During the 1900s, scientists discovered a way to mass-produce ammonia, which can be used as a fertilizer.The development of this technique allowed farmers to double the amount of land they could feed. However, making ammonia at high temperatures requires a lot of energy to generate. This contributes to the greenhouse gas' main cause.Aside from causing pollution, the use of fertilizers also produces greenhouse gasses. When the nitrogen from the fertilizer runs off into the atmosphere, it releases a potent

greenhouse gas known as nitrous oxide. This gas, which warms the planet 300 times more than carbon dioxide, accounts for a small portion of global greenhouse gas emissions.

A study was conducted to understand the environmental impacts of different types of fertilizers using four fertilizers strategies.These strategies included conventional chemical fertilizer(CF),manure compost (MC), and two biochar-amended manure compost strategies [37].Two different types biochar-amended MC fertilizers were used namely MCB5 and MCB10 where 5 and 10 are the percentage of biochar in the fertilizer.

CF strategy is a fertilizing strategy where only chemical fertilizers are used to cultivate crops. During the application of CF strategy it was found that the chemical fertilizers are responsible for high environmental damage.It was observed that during the life cycle of wheat production, the use of chemical fertilizers had the major contribution in the depletion of the stratospheric ozone layer. The effect of the amount of chemical fertilizer used and soil emission of N_2O on the depletion of the stratospheric ozone layer was 56.5% and 41.3% respectively [37].

While analyzing the global warming potential (GWP) of various components in the wheat supply chain it was found that chemical fertilizer products and energy input required to synthesize these fertilizers had the maximum GWP. They were found to be the major source for greenhouse gas emissions(GHG), releasing 51.4% and 29.5% of the total GHG emissions in the wheat supply chain respectively [32][33].

In Manure compost (MC) strategy 50% of the quantity of chemical fertilizer required in CF strategy was substituted by manure compost. While using the manure compost as fertilizer, the major Stratospheric ozone depletion state (SOD) was found to be the stage where the compost is produced. The production of compost contributed 45.6% to the life cycle Stratospheric ozone depletion [35]. GWP value in MC strategy was 9.33% higher than that of CF strategy.[37]

While using the biochar-amended manure compost strategy two types of manures were used i.e MCB5 and MCB10 (5 and 10 denote the percentage of biochar addition in the manure) [38]. Biochar is a Carbon rich additive which is added in the manure compost to reduce harmful methane (CH4) and nitrogen emissions and enhance the nutrient retention capacity of the manure.Biochar posses properties such as large surface area, rich pore structure, and high sorption capacity, which makes the biochar-amended manure compost superior to the regular manure.

It was found that the biochar amended manure compost caused the lowest life cycle Stratospheric ozone depletion(SOD) as the addition of bichar reduced the biogenic N_2O from the composting stage [34][36].

Using MC or biochar-amended MC in place of CF and reducing the input of chemical N can significantly impact the GWP positively.The biochar-amended manure composts minimized fossil-fueled heat generation which resulted in the MCB5 and MCB10 possessing higher reduction potentials compared to the manure composts.The contribution to life cycle greenhouse gas(GHG) emissions of the production stage of compost was found to be 41.6%, 22.3%, and 21.6% for MC, MCB5, and MCB10 strategies respectively [38]. This shows that the compost production stage is a major contributor to the GWP life cycle.The results of the comparison between the different strategies indicate that the use of MCB5,MC and MCB10 can reduce the life cycle GWP of wheat production. Additionally, increased use of biochar can further reduce the life cycle GWP.When compared to the GWP of CF strategy, the GWP of MCB strategy was found to be reduced to 36.9% for MCB5 and 48.2% for MCB10 [38].

Compared to the grain yield rate in the CF strategy,the mean increase rate of grain yield for the MC strategy was 18.7%, while that for the MCB5 and the MCB10 strategies was 17.7% [37][40].

The water consumption of wheat production during the application of compost strategies had decreased. This suggested that the reduction of water consumption has a positive effect on the production of wheat.

MC and MCB strategies displayed lower values in all 3 damage categories (namely human health, ecosystems and resources) , although MCB10 displayed exceptionally higher values in human health and resources. It was also observed that damage to human health decreased from 39.9% to 22.2% if fresh liquid or solid manure was used in place of half of CF [42]. When it comes to reducing the environmental impact, the best results were obtained with MCB5.

4.3 Harvest

Tractors play an essential part on the farm to haul machinery used in agriculture for plowing, planting, harvesting & cultivating crops. Besides this they are also used for landscape maintenance, clearing bushed, lawn care and spreading

fertilizers. They are even used for transportation of produce from the farm to local warehouses. Most of the tractors used today run on diesel powered combustion engines which produce GHG(s) and further contribute to the total carbon footprint of the harvest. However electric tractors provide a cleaner and greener alternative to their diesel powered counterparts as they directly do not emit exhaust gasses. However generation of electricity does produce GHG(s) but these are way less when compared to those produced by diesel engines. Studies such as those conducted in Nantan city, Kyoto in 2008 indicate that use of electric tractors can lead to a reduction in upto 70% of CO2 from 9.7 kg for an engine tractor to 2.9 kg for the electric tractor for tilling an area of 13 acres for 1 h at 0.33 m/s.[34][41]

5. CONCLUSIONS

The above study showcased that replacing existing tools and vehicles with their greener alternatives significantly reduces the environmental impact of the wheat supply chain. It was found that while ploughing the same land, for the same time, under equal loads, electric tractors produced approximately 70% less carbon dioxide when compared to the conventional diesel tractors. Similarly, average CO_2 produced by electric trucks is 16% less than that of diesel trucks for carrying the same payload while covering the same distance. It was found that the use of chemical fertilizers possessed the majority environmental impact in the wheat supply chain. Application of chemical fertilizers contributed 51.4% of the total greenhouse gases emitted in the wheat supply chain. It was found that the use of chemically fabricated fertilizers accounted for 56.5% of all stratospheric ozone depletion caused by the supply chain of wheat. In manure compost(MC) strategy, compost production stage is the major contributor to Stratospheric ozone depletion(45.6%). MC strategy also displayed 9.33% more GWP when compared to CF strategy.Biochar amended manure showed the lowest life cycle Stratospheric ozone depletion because the biogenic N_2O from the composting stage was reduced drastically.MCB5 and MCB10 have the greater potential to reduce greenhouse emissions , as compared to manure composts, due to minimal use of fossil-fueled heat generation. Compared to CF strategy, MCB5 and MCB10 reduced GWP by 36.9% and 48.2%. MC and MCB strategies also showed an increased grain yield along with reduced water consumption , when compared to CF strategy. MC and MCB strategies showed increased grain yields of 18.7% and 17.7% respectively.MC and MCB strategies displayed lower values in all 3 damage categories (namely human health, ecosystems and resources) , although MCB10 displayed exceptionally higher values in human health and resources.

6. FUTURE SCOPE

Silos used for storage need to be of optimum size so as to store large amounts of wheat for long durations of time and avoid wastage. Silos also need to be set up at strategic locations to optimize transportation of wheat from farms to silos for multiple villages. Optimization of transportation of wheat from silos to mills also needs to be considered while deciding the location for silo setups.Machine learning should be incorporated to a greater extent while optimizing silos size and deciding the best location for them.Conventional tools and machinery such as harvester, combine etc, used for the cultivation of wheat can be replaced by their electric alternatives. Moreover, all the fossil-fuel and electric powered vehicles used in the wheat supply chain can be replaced by biofuel (such as H2, Bio-ethanol) powered vehicles .

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