An Overview of Sustainable Practices in Food Processing Supply Chain Environments

O. O. Ojo[1], S. Shah[1], A. D. Coutroubis[1]
[1]Department of Applied Engineering and Management, University of Greenwich, United Kingdom
(olumideolajide.ojo@gre.ac.uk; s.shah@gre.ac.uk; a.d.coutroubis@gre.ac.uk)

Abstract – **Climate change has been a great challenge that the world is facing, it is a menace to the society and it is causing more damage than expected. The researchers are working tirelessly to reduce its impact on the planet in order to save the future. Mitigation of greenhouse gas emission and other sustainable practices is encouraged every day to make the world a better place to live Sustainable practice has been identified as one of the major tools to control this greenhouse gas emission especially in the emergent nations where industrialization is now growing rapidly. This paper discusses and analyzes the food security and food processing industry in the emergent nations. It also reviews literature on food processing, supply chain environments, sustainability and sustainable practices in relation to how these could help in promoting the sustainable development and environmental protection goals in the emergent nations.**

Keywords - **Climate change, emergent nations, emissions, food processing, supply chain, sustainability.**

I. INTRODUCTION

Globalization has brought major increase in manufacturing competition; performance improvement have become increasingly important to companies and organizations in the race to stay ahead of competitors or stay active in business. Sustainable supply chain management is now of paramount importance to manufacturing industries; it is gradually becoming an irresistible option to manage production effectively and with high efficiency in manufacturing sector. Supply chain can said to be a network of organizations responsible for production and distribution of products from conception to final consumer, i.e. improved coordination within and between various supply chain members. Increased coordination can lead to reduction in lead time and cost, alignment of interdependent decision-making process and improvement in the overall performance of each member as well as the supply chain [1]. When planning an expansion and urbanization of any community through industrialization, the incorporation of environmental sustainability, sustainable supply chain management, mitigation of secondary pollution and greenhouse gas (GHG) emissions are crucial design considerations. Industrialization process in such plan must be sustainable and also satisfy evolving global emission standards crucial to ensure air quality and environmental protection. As concluded by [2], the major cause of the present day climate change has been the activities of the industrialized countries, it is however predicted that more greenhouse gas emission will now be from the emergent nations which are presently experiencing rapid industrialization. Increase is GHG emission is associated to the conventional supply chain management process adopted. The use of this old process of supply chain management in the face of rapid urbanization and commercialization in emergent nations can only suggest a potential increase in annual GHG emission rates if current situation remains the same.

Meanwhile, fast moving consumer goods (FMCG) industry is rapidly growing in the emergent nations and it is encouraged in order to combat the food insecurity that is infiltrating these nations. This industry remains one of the fastest growing in most emergent nations due to the rapid population growth and present industrial revolution. Food and beverage industry of any country is always very important and it contributes immensely to the economy of the country. Sustainable supply chain management in food industry has been identified as one of the main tools to tackle the food insecurity in the emergent nations of the world. Several researches have shown that agriculture remains the giant contributor to the economy of most of the emergent nations especially in Sub Saharan Africa [3]. Hence the agro-food production, processing and the integrated supply chain will need to be looked into to make sure that sustainable practices are incorporated at every level in the supply chain environment. Evolving global emission standards suggests the development of innovative strategies that could mitigate the challenges of GHG especially in countries characterized by extreme population increase and rapid industrialization growth.

II. LITERATURE REVIEW

An in-depth and extensive study of current literature will be carried out, this aims to give more knowledge of the planned research. Initial systematic review of relevant literatures will also be done to enhance better understanding of the research principles and concepts. These current and relevant literatures will give insights and better understanding of the research problems and gaps. The review of the past similar researches with the keywords that include sustainability, food processing industry, supply chain management, supply chain environments, sustainable practices etc. will be done to give the idea and concept of incorporating the sustainable practices in the general supply chain management within manufacturing.

A. Food Processing Industry

A processed food can be defined as food that has undergone some changes in form or value addition [4]. Food processing could be in different levels, these levels are determined by the extent of value addition or change. As analyzed by [4], food processing could be in three different levels; the first level of food processing could involve sorting, cleaning, chopping and packaging of vegetables and fruits with brand names for marketing purpose. The second level has a higher level of addition, the form of the farm produce is altered, and it could be conversion of vegetables and fruits to paste, pulp, and flakes. This could also involve frozen foods e.g., frozen meat, fish, seafood, fruits, vegetables etc. The third level of food processing has to do with the conversion of the farm produce to another form entirely as finished product for the purpose of preservation, ease of transportation and having varieties. This could be in form of ketchup, juice, milkshake, ice cream, yoghurt, pasteurized milk, noodles, pasta, biscuits, flakes, snacks, ready to drink coffee, teabags, ready-to-eat meals etc.

It is evident that food insecurity is one of the associated problems contributing to poverty in the emergent nations of the world, it is therefore essential to strengthen and encourage the agricultural post-harvest and agro-processing industries in these regions. Food processing is not only to prolong the shelf life of food but it is also an avenue to come up with different forms and varieties of food from the same agricultural product in order to avoid monotonous consumption that might not always appeal. The role and importance of science, technology and engineering in food and beverage processing conserve the supply of raw foods, protect against further loss, and guarantee the food cultural relevance, nutritional value and the safety [5]. Food quality can said to be a combination of physical and chemical characteristics or attributes of a product that is important as a determinant or that determines the degree of acceptability of the said product to a consumer [6]. Food processing and storage existed to tackle food insecurity which is still dominant in emergent nations due to wastage attributed to factors like poor distribution process and channels, poor infrastructure, poor handling and consumer practices which have adverse effect on the environment, economy and food security in these nations [7].

B. Methods of Food Processing and Preservation

The method of food processing is broadly divided into two categories which include the old method and the new method. Food Processing and preservative technique that still applies in most of the emergent nations of the world is traditional also known as old methods. These kinds of rudimentary methods do not encourage large scale production which is needed to meet up with the increase in demand for food due to population growth [3]. These methods are also not effective enough to keep the shelf life of the preserved food till the next harvesting season of the farm product and the out of season agricultural product cannot be get almost fresh compared to the modern methods of food preservation and processing. Some of this traditional/old methods such as drying, pickling, smoking, roasting, salting, cellaring, and fermentation [3]. Modern method of food processing and preservation has taken over the industry; technological advancement and industrial revolutions keeps the nutritional value, taste and quality of food longer and better than the earlier years' methods. Some of the most promising processes that can accommodate the present day food demand as analyzed by [8] are: Pulse Electric Fields (PEF), High Hydrostatic Pressure (HHP), others are; Irradiation which involves exposure of food product to ionizing radiations or electron beams or rays to kill bacteria, it is also used to delay fruits ripening and vegetables sprouting [9], **C**anning and Bottling which involves products packed and sealed in the container under controlled temperatures and Refrigeration Systems.

C. Supply Chain Environments

Supply chain deals with all the activities that have to do with the flow of goods from its raw state down the production line to the consumers with response flow back of information from the consumer as feedback. "It comprises of business activities that has to do with customers' satisfaction request directly or indirectly" [10]. As defined by [11], "supply chain is the flow and transformation of information and goods from the raw material stage through to the consumers". It can be described as the network consisting of the suppliers, manufacturers, distributors, retailers and consumers. The incorporation of certain skills and features into the supply chain to ensure the smooth running is what brings about the term "Supply Chain Management".

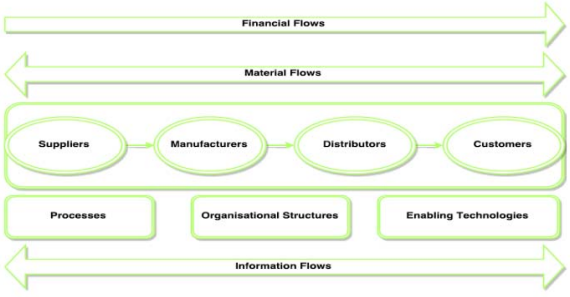

Fig. 1. Typical supply chain management

As defined by [12], "Supply chain management is "the integrated planning, implementation, coordination and control of all business processes and activities necessary to produce and deliver, as efficiently as possible, products that satisfy market requirements". It could also mean management of upstream and downstream relationships in activities within suppliers and customers to deliver superior customer value in form of products and services at the best cost within the supply chain [13]. Supply chain

management could best be described as the efficient integration of suppliers, factories, warehouses and stores so that merchandise (i.e. goods and services) is produced and distributed in the right quantity to the right location at the right time and right cost to satisfy the customers. Supply chain management in manufacturing and every industry generally is put in place to effectively and efficiently coordinate the whole product manufacturing process from the state of raw materials till the products get to the final consumer. This process needs continuity and interrelationship within the members of the supply chain members for the best and appropriate circulation of the necessary elements within the chain which include materials, money and information to be successful. The "most advanced level of coordination in supply chain management takes place in the efficient management of materials, money and information in order to improve and maximize value creation in the supply chain" [14]. This is shown in (Fig 1) which highlights the supply chain management and the flows associated within the process.

D. Food Supply Chain Management (FSCM) ME65sl

Food supply chain management is of paramount importance in everyday life, it is a tool that can be used to combat food insecurity and poverty especially in the emerging nations of the world. "Food poverty is common in these emergent nations of the world and it has led to so many anti-social acts relating to food crime and food frauds" [15]. Supply chain in agro-industrial and agribusiness sector is a bit complex and complicated considering the perishability and food safety factors in agro product processing. It therefore requires stages and a better plan especially during processing to manage the risk involved in the entire supply chain.

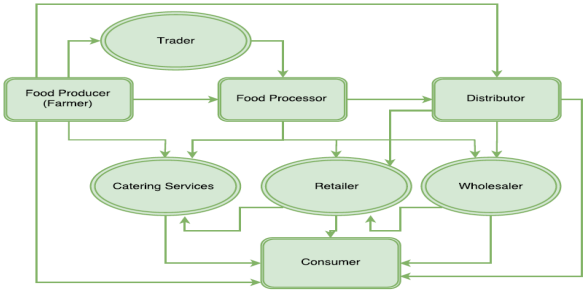

Fig. 2. A typical food supply chain

The supply chain risk can be defined as the risks encountered during production in material, product and information flow within a supply chain environment from the original supplier till the product is delivered to the final consumers [16]. One of the risks associated with the agro-food supply chain include product recall especially when the product does not meet the required quality standard. This is often seen as external failure and it dents companies' reputation and image, but good integrated supply chain can be used as a good tool to avert the risks. Food supply chain is defined as "the round of operations and processes involved in taking food from the state of raw materials to the consumers' table for consumption [15]. The agro-food or agro-industry supply chain can said to be described as the activities carried out on agricultural products from production state to distribution for consumption. Fig. 2 shows typical food supply chain chart with key partners involved in getting food from raw material state to the table. Research studies identified the key characteristics of food SC as long production lead times, variable quality and quantity of the farm base output, variability in process yield, shelf-life constraints, transportation requirement, storage facilities requirements and variable season production [16]. This agro-industrial and agribusiness sector is very important and promotes economy [17]. Despite the relevance of this sector, the food supply chain management has always been taken with levity and had never received the due attention especially in the emergent nations. The progression of the food product within these supply chain players requires monitoring, logistics and better transportation planning; this is what is referred to as the food supply chain management (FSCM). Food supply chain networks can generally be divided into two types [15] in terms of how the food moves from the farm to the table which include; (1) Consumer-driven value food chains: direct movement of harvested agriproducts to the consumer without any alteration to its features, shapes, forms or value. (2) Commodity and producers-focused food chains: movement of agriproducts from the farm into manufacturing industry as raw materials for processing before it gets to the customer's table for consumption.

E. Sustainability and Sustainable Practices

Recent research suggests sustainability has become common word and seen as what could save human existence from being extinguished. It is now seen as an important topic of discussion in the modern day manufacturing and production. It is basically made popular in order to control industrial impacts on the socio-cultural and ecological living. Sustainability has various definitions that identifies the major points surrounding it. Sustainability could be described as the ability to make economical decision whereas ecological balance is maintained putting the future into consideration [18]. The most acceptable definition of sustainability as described by the United States Environmental Protection Agency states "*a process of developing and balancing human technological and economic needs in productive harmony with nature, giving fulfilment to cultural, economic, social and environmental requirement to the present with future generations in consideration"* [19]. Sustainable practices can said to be act of doing things at the same time work on balancing the environmental, social and economic goal. Companies now incorporate this into their mission statement and make it one of the main keys and agenda to enhance their effective growth and improved productivity. Sustainability and sustainable practices concept has inspired many industries to come up with several sustainable supply chain models basically for public acceptance and cost reduction [18].

Many companies work on daily basis in cutting cost on production of goods and services to maximize profit; this can be achieved by working on company's supply chain management. General industrialization growth globally has given great popularity to supply chain recently and the supply chain management is what is being used by all industrial sectors globally in lieu of the conventional economic plans. Most today's environmental and socio-cultural problems in the business and environment are traced to the unsustainable practices used in economic and industrial development [20]. Meanwhile, the three key pillars to sustainability in supply chain in any business include economic, social and environmental [21]. The main goal targeted in the introduction of sustainability in the supply chain management of companies is for them to consider their environmental and social impact while planning their economic growth [21]. A company is said to be successful and responsible if the company is able to run a sustainable supply chain management. However, it is evident that a company that is environmentally friendly but unable to organize its supply chain to achieve good economic outputs would struggle in the market place [22].

III. METHODOLOGY

A. Research Problems and Questions

This research identifies ways to address key challenges associated with incorporating sustainability and sustainable practices into supply chain management within food processing and manufacturing environments. New product development (NPD) and improvement providing better competitive advantage is now a common priority within manufacturing and service companies. This always prompts the companies to work towards supply chain management for cost minimization without regarding environmental and social impacts. Many of these companies now work on improving their products' quality with fair price in satisfying customers' needs while meeting their expectations but they fail to see that integration of sustainable practices could be of great help. Meanwhile, incorporation of sustainability in food processing and manufacturing definitely helps both the companies and the society in terms of cost, business management, maintaining competitive advantage and environmental protection. This research addresses these challenges through these research questions/hypothesis:

1) Does sustainability and sustainable practices have impact within supply chain management?
2) Does supply chain management play an important role in food processing and manufacturing?
3) Can food processing and manufacturing be improved through modification of supply chain process?
4) What are the drivers needed to achieve a sustainable supply chain management?
5) Which part of food manufacturing supply chain is the most important to work on for sustainability?
6) What could be the best strategy to be used for successful integration of sustainability into supply chain management within food processing and manufacturing environments?

B. Proposed Research Framework

Sustainable supply chain management is of paramount importance to manufacturing industries; it is gradually becoming an irresistible option to manage production effectively and also with higher efficiency. Hence, this research aims to develop a framework that will promote a sustainable and suitable food and beverage supply chain management system, featuring higher efficiency and improved techno-economic performance for environmental control using proposed methodology: (1) Background study and in-depth literature review to identify the research gap and the challenges facing the SCM systems within food and beverage manufacturing industry. (2) Critically evaluate and conduct comparative process of the existing approaches to supply chain management in food and beverage manufacturing within developed and emergent nations.

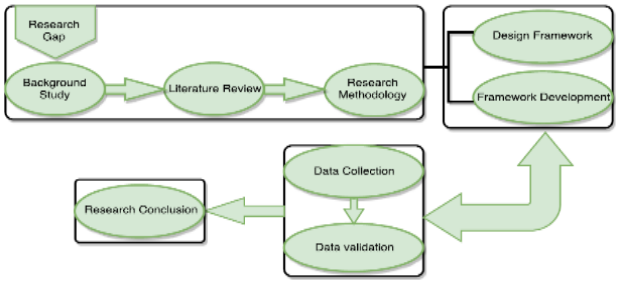

Fig. 4. A proposed research framework

The evaluation identifies the lean aspects and energy savings and consumption within the supply chain process in manufacturing industries. (3) Design and development of novel framework to address the research gaps of sustainable for food and beverage manufacturing in emergent nations. (4) Validation of the research framework towards design solidification and confirmation from survey and data analysis. Fig. 4 summarizes the proposed research plan for the research. A sustainability improvement framework to be proposed improves sustainability performance in food manufacturing SCM especially within emergent nations. This will be developed based on the result of case studies carried out in future. The proposed framework includes (1) Comparative sustainability performance measures within the food industry supply chain, (2) improvement of sustainable performance in SCM practices through optimization, (3) improvement of sustainable performance in the emergent nations food industry supply chain system by restructuring and re-engineering the existing system to meet up with the conditions of these nations.

IV. CONCLUSION

This research presents the proposed novel approach to the integration of sustainable practices in food and beverage manufacturing within the emergent nations. This will be able to address the identified research problems and gaps through proposed research methodology approach. It is evident that improved coordination within various supply chain members can lead to reduction in cost and improvement in overall performance of each member and the entire supply chain systems. However, lack of research on sustainable supply chain in food processing especially within the emerging nations has increase the risk and challenges of climate change. Food processing and manufacturing is paramount and if its supply chain system is well managed, it allows economic growth and support the environment. Hence, the adoption of proposed methods to enhance food production and processing for developed and emerging nations to reduce poverty levels, CO_2 and other greenhouse gas emissions; a process that contributes to global energy target and environmental protection goal. The research fulfils the existing gap of sustainable supply chain management within food manufacturing in emergent nations while promoting the global emission target through green supply chain management. Future research aims to focus on case studies to identify, develop and verify best ways sustainable practices could be incorporated in supply chain management within food industry. This will be applicable for developed and the emergent nations with emphasis on the emergent nations' food manufacturing due to the use of standard traditional methods.

REFERENCES

[1] J. David, Guide to Supply Chain Management; How Getting it Right Boosts Corporate Performance (The Economist Books), 1 ed., New York: Bloomberg Press, 2009.

[2] Z. A. Elum and A. S. Momodu, "Climate change mitigation and renewable energy for sustainable development in Nigeria: A discourse approach," *Renewable and Sustainable Energy Reviews,* vol. 76, pp. 72-80, 2017.

[3] S. A. O. Adeyeye, "The role of food processing and appropriate storage technologies in ensuring food security and availability in Africa," *Nutrition & Food Science,* vol. 47, no. 1, pp. 122-139, 2017.

[4] R. Mahajan, S. Garg and P. B. Sharma, "Processed food supply chain: a framework for literature review," *Journal of Advances in Management Research,* vol. 14, no. 1, pp. 91-109, 2017.

[5] A. O. Olaoye, O. A. Idowu and G. I. Lawrence, "Certain roles of the food scientist in ameliorating," *ISABB Journal of Food and Agricultural Sciences,* vol. 4, no. 1, pp. 13-19, 2014.

[6] D. Tanner, "Food Quality, storage and Transport," Elsevier, New Zealand, 2016.

[7] S. Sharma and S. S. Pai, "Analysis of operating effectiveness of a cold chain model using Bayesian networks," *Business Process Management Journal,* vol. 21, no. 4, pp. 722-742, 2015.

[8] D. Rodrigo, F. Sampedro, A. Silva, A. Palop and A. Martínez, "New food processing technologies as a paradigm of safety and quality," *British Food Journal,* vol. 112, no. 5, pp. 467-475, 2010.

[9] FDA, "Food Facts: Food Irradiation," http://www.fda.gov/educationresourcelibrary, 2016.

[10] A. Ramish and H. Aslam, "Measuring supply chain knowledge management (SCKM) performance based on double/triple loop learning principle," *International Journal of Productivity and Performance Management,* vol. 65, no. 5, pp. 704-722, 2016.

[11] S. Seuring and M. Müller, "From a literature review to a conceptual framework for sustainable supply chain management," *Journal of Cleaner Production,* vol. 16, no. 15, pp. 1699-1710, 2008.

[12] M. Christopher and U. Jüttner, "Supply Chain relationships: Making the Transition to Closer Integration," *International Journal of Logistics; Research and Applications,* vol. 3, no. 1, pp. 5-23, 2000a.

[13] H. Stadtler and C. Kilger, Supply chain management and advanced planning, 1 ed., Berlin: Springer, 2010.

[14] M. Christopher and U. Jüttner, "Developing strategic partnerships in the supply chain: a practioner perspective," *European Journal of Purchasing & Supply Management,* vol. 6, pp. 117-127, 2000b.

[15] H. Lou, M. Zhu, S. Ye, H. Hou, Y. Chen and L. Bulysheva, "An intelligent tracking system based on internet of things for the cold chain," *Internet Research,* vol. 26, no. 2, pp. 435-445, 2016.

[16] A. Chaudhuri, S. K. Srivastava, R. K. Srivastava and Z. Parveen, "Risk propagation and its impact on performance in food processing supply chain," *Journal of Modelling in Management,* vol. 11, no. 2, pp. 660-693, 2016.

[17] I. B. Suryaningrat, "Raw Material Procurement on Agroindustrial Supply Chain Management: A Case Survey of Fruit Processing Industries in Indonesia," *Agriculture and Agricultural Science Procedia,* vol. 9, pp. 253-257, 2016.

[18] Q. Zhang, N. Shah, J. Wassick, R. Helling and P. van Egerschot, "Sustainable supply chain optimisation: An industrial case study," *Computers & Industrial Engineering,* vol. 74, pp. 68-83, 2014.

[19] U.S. EPA, "Learn About Sustainability | Sustainability | U.S. EPA, Epa.gov," United State Environmental Protection Agency, 2017. [Online]. Available: https://www.epa.gov/sustainability/learn-about-sustainability#what. [Accessed 09 May 2017].

[20] M. Formentini and P. Taticchi, "Corporate sustainability approaches and governance mechanisms in sustainable supply chain management," *Journal of Cleaner Production,* vol. 112, pp. 1920-1933, 2016.

[21] S. Chopra and P. Meindl, Supply Chain Management: Strategy, Planning, and Operation, 6 ed., Essex: Pearson, 2016.

[22] E. Ortas, J. M. Moneva and I. Álvarez, "Sustainable supply chain and company performance," *Supply Chain Management: An International Journal,* vol. 19, no. 3, pp. 332-350, 2014.