

Advanced Technology Integration in Food Manufacturing Supply Chain Environment: Pathway to Sustainability and Companies' Prosperity

Olumide Olajide Ojo
Dept. of Applied Engineering and Management, Faculty of Engineering Science
University of Greenwich
 London, United Kingdom
 olumideolajide.ojo@gre.ac.uk

Stefan Zigan
Dept. of Applied Engineering and Management, Faculty of Engineering Science
University of Greenwich
 London, United Kingdom
 s.zigan@gre.ac.uk

John Orchard
Postgraduate Research Studies
Natural Resources Institute
University of Greenwich
 London, United Kingdom
 j.e.orchard@gre.ac.uk

Satya Shah
Off-Campus/Institute of Management
University of Bolton
 Bolton, United Kingdom
 s.shah@bolton.ac.uk

Abstract— The applicability of trends in industries' production, logistics and supply chain management has increased productivity, efficiency and less adverse environmental impact. Sustainability is one of the trends identified and percept by various researches as what every industry could consider ensuring a better future for the environment and prosperity in most sectors. Meanwhile, the application of different new technologies and the current digitalization is helping in achieving the said sustainability trends within the manufacturing industry. This study, therefore, aims to investigate through literatures and a case study how well integration of advanced technology has impacted sustainability and growth within food manufacturing environment. Integration of advanced technology to aid sustainability within food manufacturing and supply chain environment will be investigated through a case study in an agricultural-livestock cooperative company in Andalusia, Spain. Meanwhile, with the combination of the literature review carried out and the explorative research through case study where specialists and experts in sustainability, food manufacturing and supply chain management were interviewed. The research was able to highlight the impacts of the innovations and integration of advanced technology within food manufacturing and supply chain environment with a brief sustainability evaluation using the analysis of the company's KPI.

Keywords—Sustainability, Innovation, New Technology, Supply Chain Management, Food Manufacturing

I. INTRODUCTION

Prosperity in most businesses and enterprises these days especially in manufacturing depends on the understanding of trends of which sustainability or sustainable practices is vital. However, the applicability of new technology could be complementary to this trend for improved efficiency and prosperity in any business or enterprise. Urbanization and climate change could be predicted to increase in the next few decades especially in the emergent nations of the world as a result of infrastructure and technology development needed to meet up with the present population growth. It is evident that human activity and generation of greenhouse gas emissions is affecting the world today in the form of global warming and climate change. Therefore, sustainability and sustainable

practices have been identified by various researches as one of the solutions to threat of environmental degradation [1]. Sustainable food manufacturing and supply chain management could be one of the relevant and desirable actions in the food industry in order to meet the "Sustainable Development Goals". Most industry is working hard to contribute to the achievement of these set goals. "Food manufacturing and supply chain management have always been a global challenge that needs to be addressed [1], this is because food demand will always increase daily as a result of the population growth. Food demand has tripled in the past 55 years (1950-2015) following the world population growth" [2]. This demand will, result in a continual increase in the demand for natural resources used in production and through the entire supply chain system within the food industry. In addition, challenges such as food security, health and safety, food waste, fair trade, climate change, etc. in the food industry create concern daily about environmental sustainability in the sector [1].

There have been questions like how best can food manufacturing supply chain environment be made sustainable with these existing and developing challenges? How can the triple bottom line (TBL) of sustainability (i.e. Social, Environmental and Economic) be met with the problems in the industry? Meanwhile, as suggested by Reg. 1305/15 of European Parliament, "short supply chain in the food industry could help in sustainable agriculture through the reduction of transportation, thereby cutting down on CO2 emissions" [3]. This strategic regulation will help but could only cover a little part of the food manufacturing and its supply chain, but more strategies would still be needed to achieve better sustainability and prosperity. Meanwhile, such approaches could be applied in several ways with the integration of innovations and new technology to meet the triple bottom line (TBL) of sustainability, and this could go a long way to improve food manufacturing and supply chain management. This paper looks into innovation and advanced technology in food industry, sustainability trends, transformation of food supply chain and sustainable food production. It goes further to analyze sustainability in food manufacturing supply chain environment using information from a case study company.

II. LITERATURE REVIEW

A. Innovation and Advanced Technology in Food Industry

Innovation is an idea identified or perceived as new by an individual or group of persons as a solution or improvement to social or technological problems or changes [4]. Innovation can be said to be the implementation of new ideas after combining resources and productive forces perceived through creative thinking to solve a specific problem or improve on the existing situation [5]. Innovation within the food industry has become a thing of interest because of its importance [4]. This innovation is an essential process in the food industry that could bring improvement to food safety, food security as well as improve the triple bottom line (TBL) of sustainability, the, i.e. social, economic and environmental situation within the industry's supply chain. Innovation strategy should be considered throughout the entire supply chain in the food industry for improvement; it should all start from the point of harvest or raw material sourcing, processing or manufacturing and throughout the entire distribution network till it gets to the final consumer. Some researchers have concluded that "Innovation in food industry combines technological innovation with social and cultural innovation to further improve consumer products and services" [6]. However, food industry innovations and strategy should be emphasized for sustainability especially at this period of planned Sustainable Development Goal (SDG) for environmental and human protection. There should be a proper assessment of the environmental aspect of food manufacturing and this will, in turn, strengthen the social and economic point of the industry. Food industry innovation and strategy should not only be directed entirely at technology changes in the food industry, but the social and environmental changes also need to be considered to ensure production of food that satisfies the nutritional, personal and social needs of the consumers [6].

In any food business and the food industry in general, studies had identified innovation as one of the primary drivers for growth and the main aim of this is to make sure that good and healthy foods are produced in an efficient, effective and sustainable way [7]. Application of new technology in food manufacturing supply chain could support sustainable practices, and this could go a long way to help in achieving the needed sustainability within the food industry. Implementation of the latest technology (industry 4.0) within food manufacturing will be of high benefit to the food industry especially for sustainability purpose [7], and this will undoubtedly support the sustainable production which every enterprise is striving to achieve. The application of this advanced technology could go a long way to address a lot of the identified issues like food safety, food security control, perishability, competitive pressure, difficulty in demand predictions etc. within the food manufacturing settings. The digital technology imbibed in the latest industry 4.0 technology in addressing these problems. For instance, Internet of Things (IoT) is applicable in tracking of orders and other Transportation Management Systems (TMS) which ensures food safety, promotes new product development through consumer's feedback, bridge communication gap to help the Just-In-Sequence (JIS) and Just-In-Time (JIT) process needed to meet customer's immediate needs [8, 9]. Big data is useful in

demand and supply predictions and thereby assist in better production plans which controls food wastes [9]. Automation, intelligent robotics and additive manufacturing promote better productivity and reduce the risk of both food safety and incidents associated with health and safety [10]. Tracking and real-time monitoring of products using some advanced technology like sensors, Radio Frequency Identification (RFID) tags, barcodes etc. will be reasonably good in addressing most of the associated problems within food manufacturing and supply chain environment [8]. These technologies and many more could reduce wastes and unnecessary movement of products with better means of communication and thereby reducing GHG emission and carbon footprint [7].

B. Sustainability Trend

The revolution for sustainable development started in the year 1987 during the conference of the "World Commission on Environment and Development" as shown in the 1987 Brundtland report [11]. This decision came up as a result of concerns of fulfilling the current needs of the society without adverse effect or decrease in the needed resources for future generations. The word sustainability has now recently become a common word especially within manufacturing and research environment, and it is perceived to be one of the basic things that could be used to save continuous human existence [12]. It is one of the major topics trending and appears to be an important topic of discussion in this modern-day manufacturing, production and services. Sustainability was made popular and trend to regulate the negative impact of industries on the environment, socio-cultural and ecological living [13]. Various authors and researches defined sustainability in the past with the consideration of the important bottom lines surrounding the creation of the word. Sustainability can be said to be ways by which economic decisions could be made considering the future while ensuring ecological balance is maintained as much as possible [14]. Meanwhile, the United States Environmental Protection Agency (U.S. EPA) came up with a definition of "sustainability as a process of developing and balancing human technological and economic needs in productive harmony with nature, giving fulfilment to cultural, economic, social and environmental requirements to the present generations while putting the future generations in consideration [15].

Sustainability as a trend looks into working out the fulfilment of current needs of the society with balance in the social, economic and environmental goals. It is now evident that every business and industrial sector are adopting sustainability and sustainable practices as a tool for development as they now integrate sustainability into their operations as a strategy to effectively grow and improve their productivity [13]. This trend has further inspired firms to develop a series of sustainable supply chain models presented for public acceptance and cost reduction in products and services [14]. However, different motivations have been propelling organizations and businesses to improve their corporate social responsibility (CSR) and corporate sustainability performance, thereby contributing to global sustainable development [13]. Apart from the fact that this is a

right approach on product improvement and profit maximization, organizations now respond to the call of sustainability and sustainable practices due to retail requirements and other regulatory policies put in place for ethical responsibility [16]. Several kinds of literature after an extensive review including the Brundtland report have been able to conclude that the main pillars of sustainability are environmental protection, socio-cultural development and economic development [14]. Meanwhile, some of the identified primary goals of sustainability and sustainable practices include; Reduction or total eradication of poverty and hunger especially in the emergent nations of the world. Development and promotion of sustainable economic growth, reduction of greenhouse gas emission to control climate change and global warming, promoting a better standard of living, and protecting the environment from further degradation and depletion [17].

C. Transformation of Sustainable Food Supply Chain and Production

Different innovations and technological advancements generally influence digital transformation, this has made most firms to revolutionize their operations and supply chain management through digitalization [14]. This decision is effective in general supply chain management as it properly harmonizes every part of the supply chain i.e. the local, regional, national and international supply chain and operations [18]. This transformation within industries is believed to help attain the needed sustainability within production, operations and supply chain management. Meanwhile, achieving sustainability within any firm is paramount as it enables them to meet up with the environmental standards and regulations, improve efficiency, improve productivity, improve organizational quality, meet up with Corporate Social Responsibility (CRS), improve customer satisfaction, improve on their competitive advantage etc. [14, 16]. The food industry is not left out in this transformation process and therefore use this in ensuring sustainable food production and supply chain management. Several innovations and integration of advanced green technology are used as tools within the food industry to achieve the needed sustainability; for instance, the introduction of renewables, sustainable raw materials, waste management, and energy efficient practices/equipment within operations and supply chain management in the food industry [7, 19].

D. Sustainable Food Production

The daily increase in the demand for food due to the present and predicted population explosion needs an approach for food manufacturers to meet up with the market. However, this approach needs to put future generation and environment into consideration; i.e. sustainability needs to be the key in any proposed plan. Sustainable practice within food production is critical especially with the latest development of global warming and unfavorable climate change and some other socio-economic issues [20]. Meanwhile, Sustainable practices within food production environment have not been taken seriously like most sectors, and just little of this has been researched into lately [21]. Sustainable manufacturing is the new practice in most industry, and it helps in adverse

environmental impact reduction, conservation of energy and other natural resources [22]. The food industry at this point needs to take sustainable production seriously to meet up with sustainability trends and also the set Sustainable Development Goals (SDGs) [23]. Sustainable food production can be described as "technical process involving the reduction in use of raw materials, energy and water consumption as well as allowing smooth recycling of by-products while ensuring high quality and food safety" [23]. This sustainable food production could only be effective if the sustainable practice is applied at every stage of the supply chain i.e. from the raw material stage until it gets to the consumer. This sustainable food production through the entire supply chain is important because it was recently stated that "agricultural production is estimated to contribute about 50% emission greenhouse gas emission within the food supply chain networks" [24]; this is why every part of the food supply chain environment is essential in terms of sustainable practices. Hence, sustainability in the food supply chain environment could mean balancing food demand, calorific and nutritional supply with the efficient use of resources while economic, environment and social factors are put into consideration [25]. The associated environmental impacts could include greenhouse gas emissions, energy use, water use, food waste and packaging waste while the social implications could be ethical trade, nutrition value and food safety [24]. Although sustainable production within the food industry could be difficult, but adoption of some sustainability approaches will still be useful in achieving the best sustainable food production [26]. These sustainability approaches could help in reducing the environmental and socio-economic issues within the food industry, and they include; energy conservation/use of renewable energy, use of renewable materials for production, water conservation, reduced transportation, waste reduction, recycling and proper waste management etc. [27].

III. METHODOLOGY

A. Research Approach

This paper has been able to look into the strategic approach and integration of the advanced technology in food manufacturing and supply chain environment to achieve the new sustainability trend. This was achievable with an analyzed case study that was carried out within a big food manufacturing company. The importance of case study in hypotheses' verification, research clarifications and framework development cannot be overestimated in academics and research environments. It can say to be one of the best methods that have been in constant use within a research environment in terms of the qualitative research approach [28, 29]. This research paper has therefore engaged the application of both primary and secondary research approaches. The secondary aspect of the research reviewed and explored some existing and recent literature on the sustainability trends and sustainable practices, Sustainable food production and supply chain, transformation of food supply chain, innovations and new technology within food manufacturing environments amongst other. However, this study fulfilled the primary aspect of the research by engaging a case study which strictly relied on in-depth semi-structured interview within a food manufacturing

supply chain environment. This case study was carried out to explore the approaches that the food industries are using to meet up with the sustainability trend and how this is affecting the company's performance in terms of productivity, efficiency and profitability.

B. Case Selection

The case study selection is important and gives a good insight into any subject matter [29]. This research therefore critically examines the best environment and firm that could give good insight into the approach of achieving sustainability within a food manufacturing environment. The google search and other research and analysis of food production in Europe identified Spain as one of the leading and key food-producing area in Europe. This industry has been identified as a key player in the Spanish economy with full potentials of future contribution to Spanish and Europe economy at large [7]. The Instituto Nacional de Estadística (INE) industrial survey of December 2014 was able to conclude that Spanish food and beverage industry is the fourth largest in Europe and eighth in the world [30]. This industry remains the first industrial branch in Spain with about 20.5% of net product sales (€93,396million) average per annum, 17.8% of investments in tangible assets and 18.3% of employed people with a total of 353,965 people [30]. The Spanish food and beverage industry have various sectors and fig. 1 analyzed in numbers of companies according to their sectors within the industry.

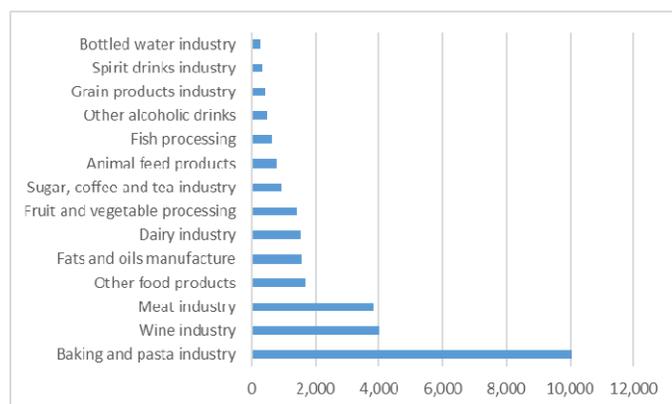


Fig. 1. No. of companies in the Spanish food and beverage industry by sector
Source: INE, Ministry of Agriculture, Food and Environment, 2016

The food industry is crucial and remain one of the most important industrial sectors in Andalusia as it represents the high number of food production turnover in Spain [7]. Andalusia is a Spanish region known for agricultural production with different arable crops, fresh fruits and vegetables and dairy products all year round [31]. This has strengthened the food and beverage manufacturing in this region with more than 5,000 companies which generate over €13 billion annual revenue, employing well over 50,000 people and with the most significant ecological production that accounts for about 54% of Spain's production and the food industry has a 4.5% share of the GDP [32]. Moreover, ecological production is expected to double by 2020; major industry players in Andalusia include well-known companies such as Cargill, Danone, COVAP, Heineken, Kraft Foods or

Sovena [32]. Meanwhile, after research has been able to identify Andalusia as a region that is most suitable for this research, the research selection process further considered some factors in company's selection to ensure better representation of food manufacturing supply chain within the selected Andalusia region. The final selection of the case study firm was made considering factors like the size of the supply chain, information access, sustainability consciousness, honest responses and cooperative approach.

C. Data Collection

The research used explorative methods combining both primary and secondary research. The methods of use in getting data from the case study firm were questionnaires, semi-structured interviews and direct observations through on-site visits to the firm's factories and other production facilities within the value chain. The research questionnaires were sent to the firm some weeks before the management of the company was able to arrange a series of meetings and interviews with the experts and professionals in various departments. These professionals were selected based on their knowledge, experience and involvement in the innovative strategies within the firm's operations and value chain. The firm believed these people were the best to give accurate, unbiased and all necessary information on the research. The semi-structured interviewed which gave open-ended questions featured five key professionals and experts in supply chain and operations management within the firm which include; Head of Quality Control, Head of Supply Chain and Operations Management, Operations Manager (Animal feed mill plant), Production Manager/Contractor in Meat production and the Procurement Manager. The on-site/physical observations gave a better understanding of earlier scheduled interviews. Finally, the research also acquired some additional data and information from various documents of the firm like annual reports, corporate website etc.

IV. DISCUSSION AND ANALYSIS

A. Company's Background

The research finally selected the firm CP for the case study is a cooperative group of companies which combines three sectors of food manufacturing in one company. This firm is into animal feed products, varieties of dairy products and meat production. The firm CP which is believed to be farmers' company has the interest of coming up with minimum production cost profitably and sustainably. The firm has, therefore, come up with different innovative and strategic approach of which one is the integration of advanced technology in its operations to manage its entire food manufacturing and supply chain environment effectively. The firm is one of the strongest cooperatives in Spain and confirmed leading cooperative company in Andalusia with over 600 employees, about 16,000 livestock partners with a turnover of approximately €400 million. CP has three complementary productions which share include; Livestock feeds (30%), Dairy Products (50%) and the Meat Products (20%). The firm can boast of a compound feed factory for its entire hut and has the world modern beef and dairy cattle and milk, goat and Iberian Pig.

B. Animal Feed Production

The animal feeds production section of the business focus on producing highly safe and quality animal feed products. This section starts the complementary operations within the three sectors by providing the feed for the producers of other raw materials (meat and dairy) which is to complement and ensure sustainability within the firm's three production sectors. This section operates on 25,000 m² surface area of land with annual production of 530 million kilograms of livestock feed that feeds more than 140,000 animals yearly and ensures that the needs of its cooperative farmers are met at all times. The raw materials used in the production of the animal feeds are sourced sustainably both locally and internationally. This sector employs about 15 different suppliers for its raw materials sourcing where these suppliers are obliged to follow the directives and policy of the firm which is designed to support sustainable material sourcing. The production of the animal feeds through its supply chain and operations management has fully integrated the use of various advanced technology such as Internet of Things (IoT), Cloud Computing, Cyber-Physical Systems etc. from the raw materials state until they get to the farmers for consumption to ensure sustainability. High-tech silos are used in the storage and monitoring of the raw materials to ensure they retain the needed nutrients that nourish the animals. The manufacturing process within the factories and the warehouses employ the use of advanced technology like the Internet of Things (IoT), Big Data and cloud computing like IoT sensors and real-time analytics to track, monitor and predict the demand which helps in raw materials supply planning and the general production planning process. The Cyber-Physical Systems with automation and robotics systems like advanced information analytics and networked machines are very useful in factory production and warehouse operations. Meanwhile, to ensure sustainability, the operations use recyclable sachets, paper bags and cartoons to package the finished products.

C. Meat Production

The meat production of CP started in the year 2005 with a modern meat processing center (CTC) that operates on 14,000m² area with more than 150 direct employees working in both sections of the processing center which includes the slaughterhouse and the cutting room. This part of the business is divided into two lines where one of the lines is dedicated to the exclusive production of Iberico pork while the other line accommodates production of lamb, goat and beef. Meanwhile, one of the most paramount things taken into consideration during production is sustainable practices that support and control products quality from the source and throughout the process of feeding, breeding, production and distribution. The use of various advanced technology and equipment like IoT sensors, real-time analytics, advanced information analytics and networked machines has helped in products traceability, pH level and temperature control throughout the supply chain. The organic wastes generated are effectively managed and outsourced for fertilizer and energy production using advanced technology.

D. Dairy Products

CP dairy production is the fifth largest milk producer in Spain using one of the most technologically advanced dairy plants. It operates a surface area of about 20,000m² and produces approximately 350 million liters of milk and 7 million liters of cheeses per year. The section sources its raw material from more than 300 suppliers who are members of cooperative of veterinary and ranchers of not more than 3 miles radius to the factory. This short distance for raw material sourcing and the use of advanced technology low emission trucks reduce the amount of greenhouse gas emissions released to the environment. The factory engaged the use of "Advance Program to program Communication" (APPC) which is an advanced technology of high-level protocol designed by IBM that allows interaction of programs across different networks which is needed to maintain the appropriate temperature ranging required for best quality within the dairy cold supply chain. The factory uses an advanced technological process like UHT (Ultra-High-Temperature) to process some waste from milk production into buttermilk and milkshakes. The water consumption in the factory could raise concerns as it uses about 2 million liters of water daily but has been able to use the opportunity of advanced technology water treatment plant to recycle wastewater which can further be used in production equipment clean-ups and other domestic uses. Meanwhile, the factory has been able to complement its electricity supply for the entire company with the use of advanced technology to self-generate electricity through the steam and heat generated from plants during production.

E. Impact of Innovation and New Technology's integration within Food Manufacturing Supply Chain Environment

Innovation within any industry could involve the use of the new business model, development of new processes, and an improvement on the existing methods, products or services. Meanwhile, all these are mostly supported and rely on the integration of advanced technology; technology advancement is widely useful in most business innovations to improve sustainability. This could also help in refined products, efficient process, reduced production time, reduced raw materials usage and in all give a better competitive advantage. Innovations and integration of new technology within food manufacturing and supply chain environment of the case study company has been able to improve its prosperity level and also positively impact the three bottom line (TBL) of the sustainability. This has gone a long way to improve the overall performance of the company in terms of supply chain and general operations optimization and therefore giving room for prosperity as the sustainability improves. These favorable impacts and implications of advanced technology integration on sustainability as determined from the analysis of the data and information acquired during the semi-structured interview carried out within the company during this research include;

a) New Product Development and Product Modifications: The use of new technology that provides for Big Data, cloud computing, Internet of Things etc. used in the market distribution of the company's finished product has given opportunities for identification of best product

specifications from consumers' point of view through feedback over the internet. This has given room for the identification of new products, flavours and packaging that are suitable for the customers. It has improved the customers' retention and loyalty level which strengthens the competitive advantage of the company which in turn improves the economic sustainability of the company.

b) Automation and Smart Manufacturing: The use of new technology that includes Artificial Intelligence, Big Data, Cyber-physical systems, cloud computing, Internet of Things etc. for the coordination of the company's entire supply chain has brought a lot of improvement in the case study company. This has improved productivity and efficiency in operations as a result of interconnected data gathering systems that gives fast connections and interactions between everybody involved in the manufacturing and supply chain environment. This has resulted in a better working environment, better resource control in terms of both human and natural resources, waste reduction, better waste management etc. This had enormous implications for the environmental, social and economic sustainability.

c) Sustainable Supply Chain Integration: The use of these new technology gives room to good supply chain integration, and this has been effective in production as it impacts high food quality control. A well-integrated supply chain system affects production control and ensuring high quality at every stage of the supply chain is secure until the products get to the consumers' tables. This has also been very helpful in accurate customers demand predictions and thereby helping the company to control the quality and quantity of raw materials to ensure food safety and improved the shelf life of the products.

d) Traceability and Easy Food Recall: The use of new technology has given an opportunity for easy and effective communication in food manufacturing and supply chain environment. Therefore, the traceability and easy recall of any contaminated food are now achievable. This has also influenced the early detection of contaminated food and quick recovery of such before getting to consumers' table. This has over time have social implications and has one way improved the Corporate Social Responsibility (CSR) of the company.

F. Sustainability Evaluation

Sustainability can be summarized to be a better process of meeting both present and future needs of humanity with minimal or no impact on the environment [12]. Meanwhile, considering different innovations and advanced technology that is being integrated into production and manufacturing, sustainability evaluation is needed to understand better how this could be well managed to support and promote the achievement of the Sustainable Development Goals (SDGs). Evaluation as defined by Cambridge dictionary is a process of determining values, quality or importance of something [33]. This in any form could be a tool of informed decision making in terms of accountability, development and monitoring which are basics to achieving prosperity in any organization.

However, sustainability in food manufacturing considering our case study could be evaluated using different evaluands and Key Performance Indicator (KPI) of the case study company. The case study company have an excellent Key Performance Indicator (KPI) in place and the representative of the company claimed this is in constant use to evaluate the company's sustainability and progress on yearly basis and is always incorporated into the company's sustainability report. There had been tremendous improvement in terms of progress and sustainability at every integration of new or advanced technology in production and supply chain systems. These improvements could best be summarized under the main sustainability dimensions i.e. Environmental, Economic and Social where the company's drafted KPIs were applied. Meanwhile, social KPIs were designed and considered around employees, community and supplier; the economic KPIs were categorized under quality, cost, delivery and flexibility while the environmental KPIs were considered under pollution, resource utilization and waste. Table I summarizes the sustainability evaluation outcomes through the social, economic and environmental sustainability of the case study company in relation to its prosperity and how it supports the Sustainable Development Goals (SDGs).

TABLE I: SUSTAINABILITY EVALUATION

Sustainability Evaluands	Outcomes
Social	Improved food security, excellent food quality, accessibility, guaranteed health and safety, improved standard of living, direct and indirect employment generation, human empowerment and development, cleaner community, Corporate Social Responsibility (CSR), community development, city population/congestion control.
Economic	Improved energy savings, self-power generation, water conservation, low-cost production, improved customer's purchasing power, better production control, better raw materials control, improved productivity, improved efficiency, cheap products tum out.
Environmental	Good management of Natural resources, Energy conservation, renewable energy usage, good water conservation, Responsible Waste Management, Controlled sanitation, mitigation of Greenhouse Gas emissions, waste reduction, water reduction and recycle, Smart and sustainable communities etc.

V. CONCLUSION AND FUTURE RESEARCH

This study has discussed the significance of advance technology in food manufacturing supply chain environment towards achieving the needed sustainability and business success. The discussion and analysis from the case study pointed out various implications of strategic integration of advanced technology in food manufacturing supply chain environment in terms of sustainable manufacturing and prosperity of the industry. The study also evaluated sustainability within this company's production using Key Performance Indicators (KPIs) around the Three Bottom Line (TBL), i.e. Social, economic and Environmental evaluands and the outcomes as highlighted in Table I. This study has suggested that strategic integration of advanced technology in

food manufacturing and supply chain could be a suitable means to achieve the desire sustainable food manufacturing and to build a prosperous business.

This study is limited to the Livestock/Dairy industry, but it could be applicable in other food manufacturing supply chain environment like poultry, grains, fruits and vegetable etc. where different and compatible KPIs could be drawn to improve their sustainability. Further research could, therefore, look into the same analysis in other areas to come up with comparative studies with which a good framework could be developed to support sustainable production within the entire food industry. This research is a preliminary case study of an ongoing research on sustainable food production within the developing nations of the world. The future research will further investigate the level of advanced technology involvement in food manufacturing and supply chain environment within the emergent nations to support sustainable production and logistics.

REFERENCES

- [1] D. Li, X. Wang, H. K. Chan and R. Manzini, "Editorial: Sustainable Food Supply Chain Management," *International Journal of Production Economics*, vol. 152, pp. 1-8, 2014.
- [2] K. Govindan, "Sustainable consumption and production in the food supply chain: A conceptual framework," *International Journal of Production Economics*, 2017.
- [3] I. Canfora, "Is the Short Food Supply Chain an Efficient Solution for Sustainability in Food Market?," *Agriculture and Agricultural Science Procedia*, vol. 8, pp. 402-407, 2016.
- [4] S. Mohezar and M. N. M. Nor, "Could supply chain technology improve food operators' innovativeness? A developing country's perspective," *Trends in Food Science & Technology*, vol. 38, no. 1, pp. 75-82, 2014.
- [5] D. Jelonek, "The Role of Open Innovations in the Development of e-Entrepreneurship," *Procedia Computer Science*, vol. 65, pp. 1013-1022, 2015.
- [6] M. D. Earle, "Innovation in the Food Industry; Review," *Trends in Food Science & Technology*, vol. 8, pp. 166-175, 1997.
- [7] A. Luque, M. E. Peralta, A. de las Heras and A. Córdoba, "State of the Industry 4.0 in the Andalusian food sector," *Procedia Manufacturing*, vol. 13, pp. 1199-1205, 2017.
- [8] L. Barreto, A. Amaral and T. Pereira, "Industry 4.0 implications in logistics: an overview," *Procedia Manufacturing*, vol. 13, pp. 1245-1252, 2017.
- [9] K. Witkowski, "Internet of Things, Big Data, Industry 4.0 – Innovative Solutions in Logistics and Supply Chains Management," *Procedia Engineering*, vol. 182, pp. 763-769, 2017
- [10] M. A. Kamarul Bahrin, M. F. Othman, N. H. Nor Azli and M. F. Talib, "Industry 4.0: A Review on Industrial Automation and Robotic", *Journal Teknologi*, vol. 78, pp. 6-13, 2016.
- [11] WCED, "World Commission on Environment and Development: Our Common Future," Oxford University Press, Oxford and New York, 1987.
- [12] O. O. Ojo, S. Shah and A. Coutroubis, "An Overview of Sustainable Practices in Food Processing Supply Chain Environments," in *IEEE International Conference on Industrial Engineering and Engineering Management*, Singapore, 2017.
- [13] S. N. Morioka, I. Bolis, S. Evans and M. M. Carvalho, "Transforming sustainability challenges into competitive advantage: Multiple case studies kaleidoscope converging into sustainable business models," *Journal of Cleaner Production*, vol. 167, pp. 723-738, 2017.
- [14] 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.
- [15] U.S. EPA, "Learn About Sustainability | Sustainability | U.S. EPA, Epa.gov," United States Environmental Protection Agency, 2017. [Online]. Available: <https://www.epa.gov/sustainability/learn-about-sustainability#what>. [Accessed 10 November 2018].
- [16] C. Wijethilake, "Proactive sustainability strategy and corporate sustainability performance: The mediating effect of sustainability control systems," *Journal of Environmental Management*, vol. 196, pp. 569-582, 2017.
- [17] K. Sullivan, S. Thomas and M. Rosano, "Using industrial ecology and strategic management concepts to pursue the Sustainable Development Goals," *Journal of Cleaner Production*, vol. 174, no. 20, pp. 237-246, January 2018.
- [18] D. Kumar and Z. Rahman, "Sustainability adoption through buyer supplier relationship across supply chain: A literature review and conceptual framework," *International Strategic Management Review*, vol. 3, no. 1, pp. 110-127, 2015.
- [19] J. A. Watson, A. F. Wysocki and R. A. Bucklin, "The Role and Impact of Technology on Supply-Chain Management in the Food Industry," UF/IFAS Extension Service, University of Florida, Florida, 2015.
- [20] J. G. v. d. Vorst, C. A. Da Silva and J. H. Trienekens, *Agro-industry supply chain management: concepts and applications*, 1 ed., Rome: FAO, 2007.
- [21] M. H. Ali and N. Suleiman, "Sustainable food production: Insights of Malaysian halal small and medium sized enterprises," *International Journal of Production Economics*, vol. 181, pp. 303-314, 2016.
- [22] I. Abdullah, W. H. Wan Mahmood, H. F. Md Fauadi, M. N. Ab Rahman and S. B. Mohamed, "Sustainable manufacturing practices in Malaysian palm oil mills," *Journal of Manufacturing Technology Management*, vol. 28, no. 3, pp. 278-298, 2017.
- [23] F. Chemat, N. Rombaut, A. Meullemiestre, M. Turk, S. Perino, A.-S. Fabiano-Tixier and M. Abert-Vian, "Review of Green Food Processing techniques. Preservation, transformation, and extraction," *Innovative Food Science & Emerging Technologies*, vol. 41, pp. 357-377, 2017.
- [24] E. F. Beitzten-Heineke, N. Balta-Ozkan and H. Reefke, "The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain," *Journal of Cleaner Production*, vol. 140, no. 3, pp. 1528-1541, 2017.
- [25] L. Manning and J. M. Soon, "Development of sustainability indicator scoring (SIS) for the food supply chain," *British Food Journal*, vol. 118, no. 9, pp. 2097-2125, 2016.
- [26] X. Rueda, R. D. Garrett and E. F. Lambin, "Corporate investments in supply chain sustainability: Selecting instruments in the agri-food industry," *Journal of Cleaner Production*, vol. 142, pp. 2480-2492, 2017.
- [27] J. Nunes, P. D. Silva, L. P. Andrade and P. D. Gaspar, "Key points on the energy sustainable development of the food industry – Case study of the Portuguese sausages industry," *Renewable and Sustainable Energy Reviews*, vol. 57, pp. 393-411, 2016.
- [28] M. Holweg and P. Helo, "Defining value chain architectures: Linking strategic value creation to operational supply chain design," *International Journal of Production Economics*, vol. 147, pp. 230-238, 2014.
- [29] F. Sgarbossa and I. Russo, "A proactive model in sustainable food supply chain: Insight from a case study," *International Journal of Production Economics*, vol. 183, pp. 596-606, 2017.
- [30] ICEX, "Incentive grants and state aid: Agro-food industry sector in Spain," Ministerio de Economía, Industria y competitividad, 2017.
- [31] T. Marsden, J. Banks and G. Bristow, "Food Supply Chain Approaches: Exploring their Role in Rural Development," *Sociologia Ruralis*, vol. 40, no. 4, pp. 424-438, 2000.
- [32] Invest in Andalusia, "Investinandalucia.es," 2012. [Online]. Available: <http://www.investinandalucia.es/documents/downloads/descarga-en-6.pdf>. [Accessed 15 November 2018].
- [33] "EVALUATION | meaning in the Cambridge English Dictionary", Dictionary.cambridge.org, 2019. [Online]. Available: <https://dictionary.cambridge.org/dictionary/english/evaluation>. [Accessed: 17- Apr- 2019].