Impact of Business Analytics in the Reduction of Food Loss and Waste in Indian Agri Fresh Produce Supply Chain: A Case Study

Varnika Sagi, Amity Global Business School, Hyderabad, India. varnikasagi@gmail.com Samir Gokarn, Department of Management Studies, Netaji Subhas University of Technology (NSUT), New Delhi, India. samirgokarn@gmail.com

Abstract: Food loss and waste are the most important issues that the Agri Fresh Produce Supply Chains always encounter. As much as 30% to 40% of the produce gets wasted at various levels throughout the supply chain in India. This wastage sums up to Rs. 2,00,000 crores every year and causes a loss of revenue to farmers. It is vital to reduce food loss and waste to fulfill the hunger needs of the growing population, to reduce costs, and inefficiencies in the supply chain. This study explains the factors responsible for food loss and waste in the agri-fresh produce supply chain, especially fruits and vegetables. The influencing factors are mainly harvesting, logistics, intermediaries, information, and communication. Moreover, the case study explores the extent to which business analytics impacts the reduction of food loss or waste caused by these factors.

Keywords — Agri Fresh Produce Supply Chain, Business Analytics, Food loss and waste, India, Influencing factors.

I. INTRODUCTION

A supply chain, an integral part of any business, consists of all parties who are involved in coordinating the flow of materials, information, and capital to fulfill customers' requests directly or indirectly [1], [2]. In this modern era, all the firms are interconnected to each other and the success of a single firm will depend upon its ability to manage the inter-firm relationships [3]. The core concept of SCM is grounded on the economic and behavioral approach [4]. The main focus of the economic approach is to minimize costs and to increase profits. On the other side, the behavioral approach focuses on the sociological and psychological aspects [5].

A food supply chain or food system refers to the processes that describe how food moves from farm to fork. The processes include production, processing, distribution, consumption, and disposal. The continuous growth in demand for food which is a basic necessity is always prevalent. There are a lot of inefficiencies in the supply chain due to which a considerable amount of food gets wasted even before consumption [6]. Additionally, due to poor communication between partners, there are many hurdles caused including delays in the movement of products. There are chances for the increase of bacteria growth, food poisoning, or spoilage which lead to food loss and waste. The reduction of food loss or waste in the Indian food supply chain becomes even more important firstly because India is the second-largest populated country and the number is increasing gradually. Everyone needs food to survive. Secondly, the Indian food supply chain is fragmented in terms of demographics [7].

India is primarily an agrarian country. Agricultural produce such as fruits and vegetables which are perishable and are easily prone to get wasted is focused less upon. However, more attention has to be given to fresh produce like these because they are perishable and have a very short shelf life. An effective supply chain management will help in the timely delivery of quality fresh produce by reducing food loss and waste. Effective Supply chain management includes proper management of all processes right from the production of Agri fresh produce to the consumption of produce. It also involves coordination between several players involved in the supply chain such as farmers, local traders. intermediaries, transporters, processors, wholesalers, and retailers. Ultimately, this entails meeting the requirements of consumers in terms of price, quality, and quantity [8].

Effective supply chain management has become a very valuable way of not only having a competitive edge and better organizational performance but also plays a crucial role in reducing food loss and waste. Business Analytics has been identified as an important tool for effective supply chain management. It helps in predicting and forecasting and helps in the timely fulfillment of customers' demands. A correct relevant business decision based on bundles of very large volumes of both internal and external data is only



possible with Business Analytics [9]. Thus, to reduce food loss and waste we need to attain an effective AFSC. An effective AFSC has to have proper communication, storage, transportation, and information to offer food in a fresh state to the consumer. The adoption of business analytics by AFSC firms becomes very necessary to fulfill the customers' demand and to reduce food loss and waste.

Scenario of food loss and waste in Indian Agri Fresh Produce Industry

The food industry in India accounts for 32% of the world's total food market and it is considered one of the largest industries in India. India is the second-largest producer of fresh food such as fruits and vegetables and produces a sum of 259 million MT [10]. It is also the world's largest producer of fruits such as bananas, papaya, mangoes, and guavas and is the second-largest producer of vegetables such as cauliflower, cabbage, tomato, green peas, and potatoes. Not only is that but, India is one of the fastestgrowing economies in the world. The major producers of fruits in India are Uttar Pradesh, Andhra Pradesh, Maharashtra, Gujarat, and Karnataka. They have a combined share of 51% in the total fruit production. For vegetables, the major producers are Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar, and Gujarat. They account for 55% of the total vegetable production in the country [10]. Besides the fact that it is the largest producer of several Agri commodities, it also has the second-largest consumer market [11]. India has made significant investments in world-class ports, logistics, and supply chains. However, this investment has not contributed to a reduction in food loss and waste on a significant level.

Though the production in India is very high, customers are not getting quality products at the right time for a specific price. This is because of losses and wastage caused due to inefficiencies in the supply chain of fruits and vegetables. A lot of the produce goes into waste every year making India one of the top countries in food wastage. India accounts for nearly 30% of wastage in fruits and vegetables annually and a total loss of 212552 crore rupees was incurred in year 2013 [10]. Negi & Anand, 2014 also explain that there are a lot of inefficiencies in the supply chain of fruits and vegetables in India which leads to loss and wastage of food and in turn earns less income to the various stakeholders. Additionally, it increases costs in the supply chain leading to high prices for the consumer to pay [12], [13]. The amount of food that gets wasted in postharvest losses in India is equal to the consumption of food in the UK [14]. Rs. 2.13 lakh crores losses are incurred by farmers due to the inefficiencies in the supply chain of fruits and vegetables in India [10]. The reasons for this are inadequate cold chain infrastructure, lack of proper information, and transportation issues. Though investment has been made to build e-commerce sites for the food trade,

this has not helped in reducing inefficiencies in the Indian Agri fresh produce supply chain. So, there is a need for a better way to reduce food loss and waste in India.

This paper attempts to highlight the main factors contributing to food loss and waste in the Agri fresh produce supply chain in India and through a case, this study explores the extent to which the adoption of business analytics can help in reducing food loss and waste.

II Influencing Factors

Several factors influence the reduction of food loss and waste in the agri-fresh produce supply chain in the postharvest stage. For better understanding, they are grouped under five major factors. The gist of it is depicted in Figure1. They are Operations and logistics, intermediaries, scientific harvesting, communication and coordination, and information system. Each of these is explained below in detail.

Operations and Logistics

The fresh produce supply chain is dependent on various factors such as cold chain storage, transportation, and road connectivity. As India is still a developing country it has very poor infrastructural facilities. This is one of the primary reasons for food loss and waste in the country. Insufficient infrastructural support to the supply chain leads to 40% of loss in fresh produce such as fruits and vegetables. Post-harvest losses are mainly incurred because of lack of proper cold storage facilities such as storage capacity, poor transportation and the proximity of storage from the farm is also very long [15]. In many places in India, for instance, in Uttarakhand, the farms and markets are not well connected. Farmers in some means have to get their produce to any main road for transportation to the market. This increased a lot of wastage of their produce [16]. Poor infrastructure and lack of meeting facilities caused almost 50% of food waste in developing countries [17]. The supply chain of perishable food items will need the proper temperature to maintain the quality and to improve the shelf life of the product. However, there are losses in the food sector owing to poor cold chain infrastructure [14]. Poor and inadequate transportation facilities also lead to food loss and waste [18]. In Allahabad, Uttar Pradesh the guava supply chain faces food loss and waste due to careless driving and rough roads [19]. The operational cause of waste in the supply chain is due to poor handling and storage services. Food losses in fresh produce are caused mainly by bruising, splitting, and skin breaks of the fresh produce [20].

Intermediaries

In the supply chain of fresh produce, there are a large number of intermediaries. It includes farmers, agents, preharvest contractors, wholesalers, commission agents,



auctioneers, retailers, and consumers. When the food gets transferred from one stakeholder to another, some loss occurs at various stages [21]. Food loss and waste at the wholesale level depend on the number of stakeholders in the marketing channel and the length of the channel [17]. With a large number of intermediaries, the supply chain of fresh produce becomes inefficient as the fresh produce is perishable. Indian supply chains are traditionally very long and fragmented. [15]

Scientific Harvesting

Unscientific means of harvesting are one of the major reasons for post-harvest losses. The post-harvest losses in fresh produce are mainly caused by improper ways and techniques for harvesting the crop [17]. Wrong and faulty methods of harvesting fresh produce lead to food loss [15]. It is also found that losses occur due to improper techniques employed while picking the crop [22]. Harvesting is a very important process and this is the primary stage where food wastage occurs. It is very important to use proper tools and machines and harvest fresh produce carefully at the right time with the appropriate technique to avoid food wastage. As mentioned in the case study of mango, the harvesting must be done properly to reduce food loss and waste.

Communication and coordination

Poor communication and coordination between various stakeholders and between different levels in the supply chain might lead to serious problems. Globalization imposed a need for higher standards for communication networks in a supply chain. With this many organizations have started using the internet for supply chain management (SCM) [23]. Another study by Badiru, 1998 suggested that communication is necessary to establish proper coordination [24]. The Internet is very effective for communicating and can connect all stakeholders at any corner of the country or globe and can enable them to communicate with each other [25], [26]. Knowledge of farmers in using smart technology to communicate and access information must be taken care of. This knowledge is important to them even to learn proper harvesting techniques so that they do not contribute a huge amount to food loss and waste [18].

Information system

Information flow is very essential in any supply chain and it becomes more important in the case of perishable goods because they have a very short shelf life. Knowing the demand is very important to make the fresh produce reach the end consumer. Due to a lack of information on market demand, there is a huge sum of fresh food that is wasted [27]. Lack of information on demand is regarded as the main reason for food loss and waste [28], [29]. The availability of timely information on market demand will enable the farmers to plan their farming and harvesting activities accordingly to fulfill the market demand by also reducing loss and waste in the fresh food supply chain [30], [31].



Figure1 Factors influencing the reduction of food loss and waste in the post-harvest stage

III. RESEARCH METHODOLOGY

Case study method

This study is exploratory in nature and used a case study method to explores the extent to which business analytics impacts the reduction of food loss or waste caused by these factors. Implementing business analytics aids in the reduction of food loss and waste in the agri fresh produce supply chain. However, there is little evidence as to why and how the firms are implementing it. For this purpose, a case study approach was employed in this study. Interviews, reports of the company and websites were also used to gain more insights into the topic. This approach of data collection helps to acquire rich knowledge on the areas where little empirical research is done [32]. In this study, inductive case study was employed to understanding the various aspects of business analytics in reducing food loss and waste in the agri-fresh produce supply chain. Collection of primary data was done through in-depth interviews and through participant and non-participant observation. The name of the company has been concealed as to facilitate unbiased responses.

About the Firm: ABC Enterprises is situated in the mango market in Vijayawada. This is one of the famous shops in the mango market. They are mango wholesalers in Vijayawada and they were in this field since 1916. The nature of their business is wholesale. They have up to 25 employees in their firm. They have a good network of suppliers (farmers) and retailers. ABC Enterprises has also ventured into the sales of fruits like apples, grapes, kiwis, and cherries in bulk in recent years.

The King of Fruits: Mango, scientifically known as Mangifera indica L. is one of the most nutritive and healthy seasonal fruits grown in the country. The fruit is known for its nutritive values and for being a rich and natural source of carbohydrates, vitamins, minerals, and also roughage. India is the largest mango producer in the world with a production



of 19.57 MT cultivated in 2.2 million hectares. More than 75% of the mango producers in India are mainly small and marginal farmers deriving nearly 30-40% of their incomes from the production of this fruit. However, the prevalent inefficiencies in the supply chain lead to food loss and waste and thus incur less profit.

Mango supply chain- ABC Enterprises

Small and marginal farmers either grow the crop on their farms or lease the land for agricultural practices. once the trees start bearing fruits in the summer season, farmers start sorting the fruits according to various parameters such as variety, size, etc. Consequently, they start packing them in crates or cartons to sell them. Some farmers sell the produce directly in market yards to wholesalers or assemblers. Otherwise, from the collection centers, the mangoes are either transported to the wholesale fruit markets or the processing plants or the packing house from where they get exported. The retailers purchase from wholesalers and the consumers finally get the produce from retailers. The retailers and the consumers are at the end of the supply chain bearing the losses of inefficiencies by paying higher amounts. Precisely, for ABC, the farmers sell the produce to collection centers from there the ABC receives the produce and then sells that to the retailers ultimately from whom the consumers buy. The entire supply chain of mango and associated food loss has been summarized in Figure 2.



Figure 2 A detailed mango supply chain with food loss at each stage

Loss points in the supply chain

For both fresh and processed mango supply chains the loss points are similar except for the ripening process in case of processing. However, ABC only deals with fresh fruits. According to FAO, 2018, the quantitative food loss of 20% happens during harvesting and sorting in the case of fresh fruits. This loss happens mainly in the form of cracked fruit due to wrong harvesting practices. Qualitative loss is a loss point in the fresh mango supply chain and amounts to 15% quantitative loss and 20% qualitative loss. A Ripening of the fruit is not a loss point in the mango supply chain whereas retailing is. It is so because at this stage all the inefficiencies in the supply chain become very noticeable in the form of loss due to decay, damage caused by harvesting procedures, and shriveling of the fruit due to moisture loss [11].

IV. DISCUSSION

Implementation of Business Analytics

Food loss and waste most prominently occur in the initial stage of production and during the final stage of consumption. Post-harvesting losses are very much prominent in developing countries because of poor infrastructure and logistics. Researches done by the BCG (Boston Consultancy Group) say that the food loss and waste caused due to the inefficiencies in the supply chain will rise by 1.9% by 2030. In 2019, 1.6 billion tons of food got wasted and this number is to rise to 30.4 million tons by 2030. [33]. However, food loss and waste can be reduced by implementing the use of Business Analytics. Business Analytics often refers to the technologies and practices that help in unraveling and exploring the business performance in the past and to gain insights from that to do better planning for the business at present. Business Analytics has a positive impact on the performance of the Agri fresh produce supply chain. It helps in various processes throughout the supply chain such as coordinating money, material, and information flow. All of this is done with the primary motive of fulfilling customer demands. For a better understanding of the performance of the supply chain, an approach must be employed [34].

The Supply Chain Operations Reference model (SCOR) can be used precisely to analyze the impact that Business Analytics has on efficient and effective supply chain management. The SCOR approach is a very systematic and organized way of monitoring, identifying, and evaluating the performance of the supply chain. This is done through a measurement system encompassing four major processes in supply chain management such as planning, sourcing, making, and delivering. The return was also added to this later on. However, in the case of the Agri fresh produce supply chain, there will not be any return of goods as they are highly perishable and have a very short shelf life. By implementing these processes a rational decision can be taken.

Business Analytics can be used at various stages to improve the performance of agri- fresh produce supply chain-

Planning: Business Analytics can be used in planning to analyze the data and to predict market trends. It also helps in forecasting market demand, weather conditions, labor availability, and various other potential obstacles. This can be done by taking into basis the production and consumption reports of each type of fresh produce year by year.

Sourcing: Sourcing deals with the procurement of seeds or the necessary tools and fertilizers for the crops. Additionally, it also involves searching for suppliers, negotiation, selection of the supplier, price negotiation, etc. Business Analytics is useful in this process as well.



Making: Business Analytics gives an idea of how much produce can be harvested. It also helps in deciding how much produce has to be consumed first and what can be consumed later or can be stored.

Delivering: Various applications of Business Analytics help in delivering the product at the right time. Especially in the case of Agri fresh produce supply chain, it helps in giving timely information and can also aid in effective communication when the produce gets transported from one stakeholder to another before it reaches the final consumer [35].

In this way, Business Analytics enables the stakeholders to make data-driven decisions in analyzing market demand, communicating, coordinating, and timely delivery of the product, thus reducing food loss and waste in the Agri fresh produce supply chain.

Recommendation

Food losses can occur due to technical reasons such as wrong harvesting techniques, improper packaging, and poor ripening conditions. However, these technical issues can be monitored and controlled by various applications of technology and Business Analytics. On the other hand, lack of infrastructure and lack of information or knowledge of stakeholders can be minimized with the intervention of the government.

Capacity-building among stakeholders can be done and they can be educated on effectively managing post-harvest produce. This can be done by conducting on-the-job training for farmers in the farmland. Training can also be done in using various technologies to enhance their farming techniques and to gain more knowledge. Development in infrastructures such as cold chain, better sorting and packing facilities, better road connectivity, and Information and Communication Technology is very much needed. The government should take an initiative in providing such training programs and developing necessary infrastructure.

V. CONCLUSION

The Agri Fresh Produce sector including fruits and vegetables is seen as a very fast-growing economic sector. However, due to inefficiencies in supply chain management, there is an increase in costs and also leads to food loss and waste as seen in the case of ABC Enterprises. Food loss and waste happen at every stage in the agri-fresh produce supply chains. However, food loss and waste at the post-harvest stage are mainly contributed by factors such as poor logistics, a large no. of intermediaries, lack of information on market demand, wrong harvesting techniques, and improper communication. Considering the current concerns of food loss and waste, we must ensure food security. This can be done by the implementation of business analytics to reduce food loss and waste and also for the effective and

efficient management of the agri fresh produce supply chain. Business analytics aids in planning, sourcing, making and delivering fresh produce with effective forecasting thereby reducing food loss and waste.

ACKNOWLEDGMENT

The authors acknowledge the support of ABC Enterprises for the completion of the study "Business Analytics in the reduction of food loss and waste in Indian Agri Fresh Produce Supply Chain". We thank all the authors and academicians who have helped us in researching the topic and for providing constructive inputs. We extend our regards to our peers who have aided towards the completion of the study in its presently.

REFERENCES

[1] V. A. Mabert and M. A. Venkataraman, "Special Research Focus on Supply Chain Linkages: Challenges for Design and Management in the 21st Century," *Decision Sciences*, 29 (3), 537-553, 1998.

[2] S. Lazzarini, F. Chaddad and M. Cook, "Integrating supply chain and network analyses: the study of netchains," *Journal on chain and network science*, 1(1), 7-22, 2001.

[3] D. M. Lambert, M. C. Cooper and J. D. Pagh, "Supply chain management: implementation issues and research opportunities," *The international journal of logistics management*, 9(2), 1-20, 1998.

[4] A. Sachan and S. Datta, "Review of supply chain management and logistics research," *International Journal of Physical Distribution & Logistics Management*, 35(9), 664-705, 2005.

[5] J. T. Mentzer and K. B.Kahn, "A framework of logistics research," *Journal of Business Logistics*, 16(1), 231, 1995.

[6] J. Parfitt, M. Barthel and S. Macnaughton, "Food waste within food supply chains: quantification and potential for change to 2050," *Philosophical transactions of the royal society B: biological sciences*, 365(1554), 3065-3081, 2010.

[7] J. Clay, "World Agriculture and the Environment: A Commodity-by Commodity Guide to Impacts and Practices", *World Economic Forum*, Island Press, 2014.

[8] N. Rao and M. S. Swaminathan, "A farmer-led approach to achieving a malnutrition-free India," *Agricultural Research*, 6(1), 1-7, 2017.

[9] P. Trkman, K. McCormack, M. P. V. De Oliveira and M. B. Ladeira, "The impact of business analytics on supply chain performance," *Decision Support Systems*, 49(3), 318-327, 2010.

[10] ASSOCHAM, "Horticulture Sector in India- State level experience", New Delhi: The Associated Chamber of Commerce and Industry of India, 2013.

[11] Fao.org. 2019. India at a glance | FAO in India | Food and Agriculture Organization of the United Nations. [online] Available at: http://www.fao.org/india/fao-in-india/india-at-a-glance/en/> [Accessed 10 October 2021].

[12] S. Negi and N. Anand, "Supply Chain Efficiency: An Insight from Fruits and Vegetables Sector in India," *Journal of Operations and Supply Chain Management*, December, 2014.

[13] S. Negi and N. Anand, "Supply Chain of Fruits & Vegetables' Agribusiness in Uttarakhand (India): Major Issues and Challenges", *Journal of Supply Chain Management Systems*, 2015.

[14] J. Rathore, A. Sharma and K. Saxena, "Cold Chain Infrastructure for Frozen Food: A Weak Link in Indian Retail Sector," *The IUP Journal of Supply Chain Management*, 2010.

[15] R. Singh, R. Kushwaha and S. K. Verma, "An economic appraisal of post-harvest losses in vegetable in Uttar Pradesh," *Indian Journal of Agricultural Economics*, 2008.

[16] P. Modi, D. Mishra, H. Gulati and K. Murugesan, "Uttarakhand state cooperative federation: can it help the horticulture farmers? *vision—The Journal of Business Perspective*, 13(2), 53-61", 2009.

[17] A. Verma and K. Singh, An economic analysis of Post harvest losses in Fresh Vegetables. *Indian Journal of Agricultural Marketing*, 18(1), 134-139, 2004.

[18] G. Sharma and S. Singh, "Economic Analysis of Postharvest Losses in Marketing of Vegetables in Uttarakhand,"*Agricultural Economics Research Review*, 24, 309-315, 2011.

[19] K. M. Mathi, "A Study on the Supply Chain Management of Guava in Allahabad District of Uttar Pradesh," International Conference on Agribusiness and Food Industry in Developing Countries : Opportunities and Challenges, 2007.

[20] IB. Adeoye, OMO. Babalola and SO. Afolayan, "Economic Analysis of tomato losses in Ibadan metropolis," Oyo State, Nigeria. Afr. J. of Basic & Appl. Sci., 2009.

[21] A. Gauraha and B. Thakur, "Comparative economic analysis of post-harvest losses in vegetables and foodgrains crops in Chhattisgarh," *Indian Journal of Agricultural Economics*, 63(3), 376, 2008.

[22] M. U. Rehan, N. Khan and I. Jan, "Post harvest losses in in Engineering tomato crop (A Case of Peshawar Valley)," Sarhad Journal of Agriculture, 2007.

[23] R. A. Lancioni, M. F. Smith and H. J. Schau, "Strategic internet application trends in supply chain management," *Industrial Marketing Management*, 32, 211–217, 2003.

[24] A. B. Badiru, "Successful initiation of expert systems projects," *IEEE Transactions on Engineering Management*, 35,186–190, 1998.

[25] T. J. Strader, F. R. LIN and M. J. SHAW, "Information infrastructure for electronic virtual organization management," *Decision Support Systems*, 23, 75–94, 1998.

[26] R. MCIVOR, P. HUMPHREYS and L. MCCURRY, "Electronic commerce: supporting collaboration in the supply-chain?," *Journal of Materials Processing Technology*, 139, 147–152, 2003.

[27] N. Viswanadham, "Can India be the food basket for the world?," Working Paper series IBS, Hyderabad, 2007. Retrieved

from

http://www.cccindia.co/corecentre/Database/Docs/DocFiles/Can_I ndia_be.pdf

[28] E. Buyukbay, M. Uzunoz and H. Bal, "Post-harvest losses in tomato and fresh bean production in Tokat province of Turkey," Scientific Research and Essays, 2011.

[29] M. Shukla and S. Jhakharia, "Agri-fresh produce supply chain management: a state-of-the-art literature review," *International Journal of Operations & Production Management*, 33(2), 114-158, 2013.

[30] S. Gokarn and T. S. Kuthambalayan. "Creating sustainable fresh produce supply chains by managing uncertainties." *Journal of Cleaner Production*, 207 908-919, (2019).

[31] S. Gokarn and A. Chaudhary, "Modeling the key factors influencing the reduction of food loss and waste in fresh produce supply chains," *Journal of Environmental Management*, 294, 113063, 2021.

[32] R. K. Yin, "Designing case studies," Qualitative Research Methods 5, 359-386, 2003.

[33] B. Yan, Z. Chen and H. Li, "Evaluation of agri-product supply chain competitiveness based on extension theory," *Operational Research*, 19(2), 543-570, 2019.

[34] N. Carr, "IT doesn't matter," *Harvard Business Review* 81(5) 41–49, 2003.

[35] T. Davenport, "Competing on analytics," *Harvard Business Review* 84 (5) 150–151, 2006.