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Evaluating critical causal factors for post-harvest losses (PHL) in the fruit and vegetables supply chain in India using the DEMATEL approach

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ABSTRACT

The post-harvest and marketing system is a chain of interlinked activities starting after the harvest time and continuing until the delivery of the food product to the consumers. An efficient post-harvest system ensures that the harvested product reaches the customer in the shortest possible time interval without compromising the volume, quality, and safety of the product. The objective of this paper is to identify and model the critical causal factors of post-harvest losses (PHL) in the fruit and vegetable (F&V) supply chain in India, with the help of a detailed literature review and expert opinions. Fifteen causal factors were identified using the decision making and trial evaluation laboratory (DEMATEL) method, which is a multi-criteria decision making (MCDM) tool. This was applied for determining the cause-effect relationships among the identified factors. The results highlighted that the most critical factors that should be tackled to ensure progressive PHL reduction are: lack of proper packaging facilities (PHL3), lack of proper storage facilities (PHL1), insufficient infrastructure (PHL4), improved handling of the products at the farm and marketplace (PHL2), lack of processing facilities (PHL5), lack of linkage between the farmers and processing units (PHL6), lack of linkages in the marketing channel (PHL9), and large number of intermediaries (PHL15). The findings of this study are intended to guide various supply chain members and decision-makers for reducing PHL and improving the overall performance of the F&V supply chain.

1. Introduction

In the recent decades, the proportion of the global population engaged in agriculture has decreased considerably, and now 50% of us live in urban areas. It is estimated that by 2050, this population will be around 70%. Due to rapid urbanization, there is a tremendous need for food security and extended food supply chains. Climate change and increased production of bio-fuels, which has increased more than three times from 2000 to 2008, are potential risks to long-term food security (FAO, 2009). It may be noted that growth in the income of a family switches the dietary needs of the members from starchy foods to shorter shelf-life products such as dairy, fresh fruits and vegetables, fish, and meat. Also, cereals are needed for feeding cattle, which puts tremendous pressure on the crops and reduces the availability of the same for human consumption (Lundqvist et al., 2007).

In today's scenario, the biggest challenge for the agricultural sector is to feed a population of over 9.1 billion by 2050 (FAO, 2009; Parfitt et al., 2010). There would be a tremendous demand from this rapidly increasing population, to meet which, cereal production has to increase from 2.1 billion tons to 3 billion tons annually, and the production of meat must increase to 470 million tons per annum. It is predicted that by 2050, net imports of cereals in developing economies would be about 135 million tons to 300 million tons. Earlier research has aimed to increase agricultural production (50–70% approx.), to bridge the gap between demand and supply of food. In contrast, less attention is given to reducing food wastage and post-harvest loss (FAO, 2009; Hodges et al., 2011). Around 33% of the world food production is wasted or lost, which is approximately 1.3 billion tons/year, costing the global economy around 750

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billion US dollars (FAO, 2010; Prusky, 2011; Chauhan, 2013). It may be noted that 1 ton of grains requires 1000 tons of fresh water (Goswami, 2013). It has been reported that 230 km^3 of fresh water, which can fulfil the drinking water needs of 10 crore people per year, and 300 million barrels of oil, which is used for producing food products, ultimately gets wasted.

The agricultural produce in India is worth INR 50, 000 crores; of this, a massive 40% of the total production is wasted every year. In the context of overall wastage of agricultural produce, milk and poultry, India stands at an unenviable seventh position, whereas Russia tops the list. Among food items, fruits and vegetables have short shelf-lives and form 70% of the wasted food, amounting to 40% of the financial loss (Biswas, 2014; Chauhan, 2013; CSR Journal, 2015). India is finding it somewhat difficult to feed its vast population, and food crisis may worsen considerably in the coming decades (Abass et al., 2014; The World Bank, 2011). A conventional PHL model is shown in Fig. 1.

This research article proposes a review on PHL in the fruit and vegetable supply chain, focusing on the critical causal factors of the same in the Indian context, and develops a model to identify the most significant factors and their cause-effect relationships by employing the decision making and trial evaluation laboratory (DEMATEL) methodology. This investigation intends to guide the policy and decision-makers in understanding the cause-effect relationship of one factor over another, which would help in the elimination of the same for reducing PHL and achieving food security and sustainability in the case supply chain.

This article is arranged in the following sequence-literature review is covered in section 2, followed by research methodology in section 3. Results of the study are detailed in section 4, and discussion and implications are detailed in section 5. Finally, the conclusion of the study is covered in section 6.

2. Literature review

The term post-harvest loss refers to qualitative and quantitative, measurable food losses in the post-harvest system (PHS) (de Lucia and Assennato, 1994). PHS includes the interconnecting activities from the harvesting time to the final decision of the customer to discard or eat the food. These losses can occur at any stage of the supply chain, and financial losses may also be incurred if the products are constructed to lower value markets (Hodges et al., 2011; The World Bank, 2011). This section of the paper focuses on the papers published in the area of PHL, the applications of MCDM approaches in the agricultural supply chains, some of the applications of DEMATEL methodology, and explanation of the identified causal factors. The hierarchy of literature review is shown in Fig. 2.

2.1. Published literature in the area of PHL

This segment of the paper highlights some of the latest papers published in the area of PHL across various countries. Affognon et al. (2015) established the magnitudes of PHL and explored their assessment gaps, going on to identify the measures that reduced the same using meta-analysis. Kasso and Bekele (2016) assessed the PHL causes and factors causing quality deterioration among horticultural crops. Descriptive statistics were employed for analyzing the data. Hodges et al. (2011) compared the PHL in developing economies with that in less developed countries. The PHL governing critical factors and drivers for the reduction of the same were discussed for both the groups of countries. De Steur et al. (2016) identified and analyzed the PHL causal factors using value stream mapping; also, the links with nutrition retention were established in supply chains. Parfitt et al. (2010) found the research gap in understanding the implications of food wastage in BRIC

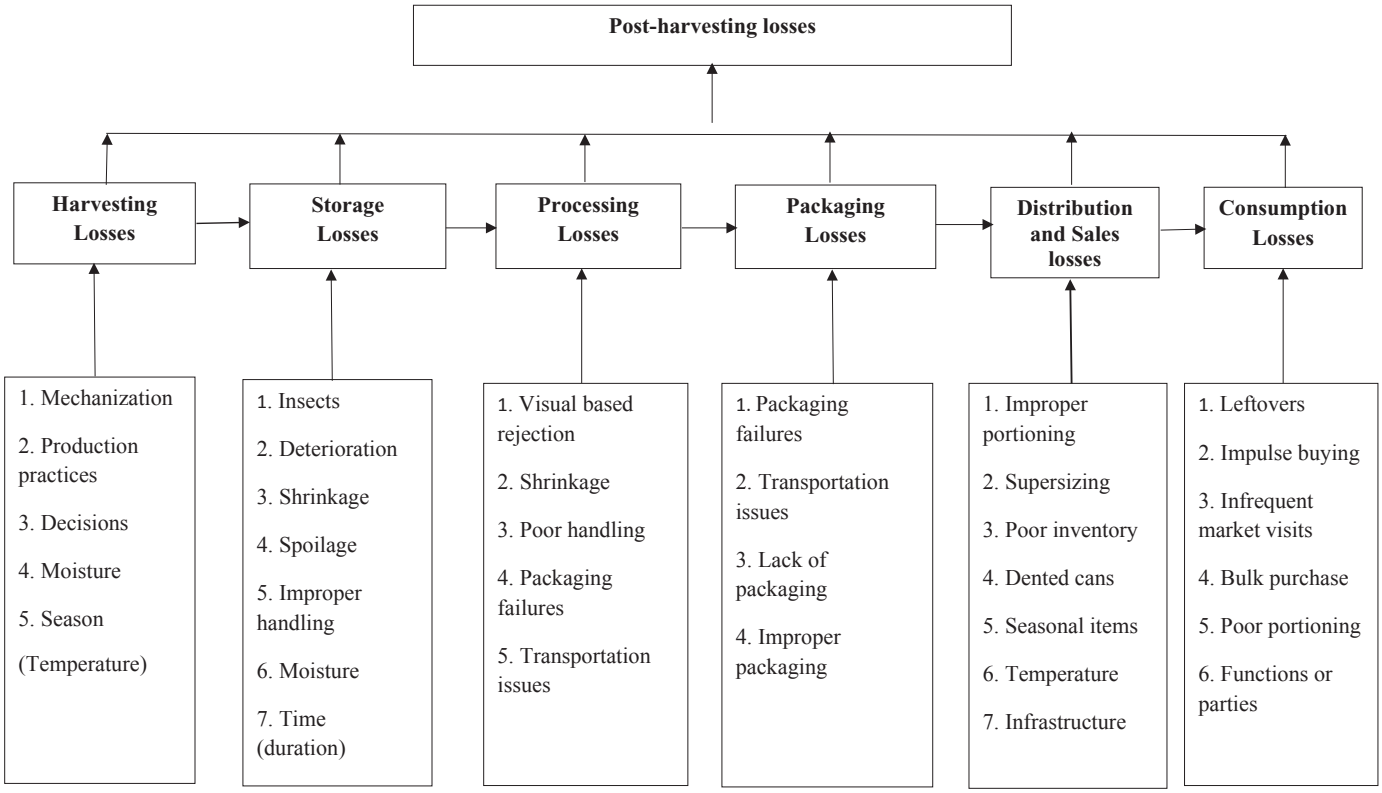

Fig. 1. Post-harvesting losses conceptual model (modified from Accorsi et al., 2014; Aulakh and Regmi, 2013; Gardas et al., 2017a; Papargyropoulou et al., 2014).