Reduction of Post-Harvest Losses in the Maize Value Chain: A Review of Warehousing Literature

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Abstract

This paper comprehensively discussed the existing warehousing literature with regards to the elimination or reduction of grain post-harvest losses and highlights concerned research issues. Most previous reviews on warehousing literature broadly focused on warehouse design and operational issues without a lot of emphasis on how warehousing can boost agricultural productivity through the elimination or reduction of post-harvest losses. Therefore, this paper tried to explore the warehousing of grains and its role in the reduction of post-harvest losses in the overall food supply chain. The proposed gaps from this review would provide a future road map for research in existing and other unexplored directions in the warehousing of agricultural products.

Keywords: Warehousing, Post-harvest losses, Supply chain, Value chain, Materials handling equipment

Introduction

The objective of a warehouse is to deliver the right product, at the right place and at the right time in good condition to satisfy customers with effective resource utilisation (Frazelle, 2002). According to Heragu et al. (2005), a warehouse is a means of providing functions of temporary storage, protection of goods, fulfillment of individual customer orders, packaging of goods, after sales services, repairs, testing, inspection, Just in Time (JIT) sequencing and assembly. Major warehouse operations are classified into receiving, picking, storage and shipping, (Gu et al. 2007). Post-harvest losses can be experienced at any part of these warehouse operations. The review process followed is discussed below along with the framework and derived taxonomy

Literature Review

The significance of warehousing in value chains

According to Sharma (2013), one of the major segments, contributing to a rapid growth in the Logistics industry is warehousing. The growth of international trade, coupled with the rise in containerisation levels has led to a high demand in warehouses. Sainathuli et al. (2014) argue that warehouses play a vital role in mitigating variations in supply and demand, and in providing value-added services in a supply chain. Modern supply chains rely heavily on warehouses for rapidly fulfilling customer demand through retail, web-based, and catalogue channels. Warehouses, often referred to as distribution centers, have emerged from their traditional passive role of serving as buffers to mitigate supply-demand variations to a more active role of providing value-added services such as consolidation/deconsolidation, assembling, and kitting. Sayeed (2013) also points out that careful warehouse management is important in modern supply chains.

Warehouses are divided into four classes, which are agricultural warehouses, container terminals, air cargo complexes and industrial warehouses (Sharma, 2013). Most of the agricultural goods such as maize and wheat are produced only in a certain season but the consumption of these takes place all year round hence the importance of agricultural warehousing.

According to Charlotra (2013), a warehouse is an area in which all kinds of materials for production, distribution, maintenance and packaging are received, stored and issued. In the view of Komarova (2016), inventory is any material and supply that either a business or institution carries for sale or to provide inputs or supplies to the production process. According to Henz (2017), because of increasing need in demand for goods by both internal and external customers, it will not augur well for any business or organisation to place an order for each material or item that may be urgently needed for production or meeting customer needs. Warehouses therefore, play a vital role of ensuring that any material required for production or satisfying customer needs are just available to meet the exact need. In a similar vein, Sissinto et al. (2018) argue that warehousing is necessary because of several reasons. These are seasonal production, large-scale production, need for quick supply, to ensure continuous supply, and price stabilisation.

Seasonal production implies that agricultural commodities are harvested during certain seasons, but their consumption or use takes place throughout the year. Therefore, there is a need for proper storage or warehousing for these commodities, from where they can be supplied as and when required (Henz, 2017). Large-scale production means that, in case of manufactured goods, these days production takes place to meet the existing as well as future demand of the products. Manufacturers produce goods in huge quantity to enjoy the benefits of large-scale production, which is more economical. Therefore, the finished products, which are produced on a large-scale, need to be stored properly until they are cleared by sales (Kumar and Kalita, 2017).

Warehousing is necessary to ensure a quick supply of commodities. Both industrial as well as agricultural goods are produced at some specific places but consumed throughout the country. Therefore, it is essential to stock these goods near the place of consumption, so that without making any delay these goods are made available to the consumers at the time of their need (Kiaya, 2014). The need for continuous production is another factor that justifies the need for warehousing. Continuous production of goods in factories requires adequate supply of raw materials. There is a need to keep sufficient quantity of stock of raw material in the warehouse to ensure continuous production (Edelman et al., 2015). More so, warehouses play a price stabilisation function. To maintain a reasonable level of the price of the goods in the market there is a need to keep sufficient stock in the warehouses. Scarcity in supply of goods may increase their price in the market. Again, excess production and supply may also lead to fall in prices of the product (Richards, 2014).

Effective warehousing is regarded as a competitive weapon as the wider market demands continuous supply of goods in authentic condition (Webber and Labaste, 2014). This genuine nature of a good is protected by warehousing/storage methods and techniques used by firms. Managers can augment the profitability of business by adopting proper warehousing management control devices and competitive strategies thereby enhancing supply chain efficiency. Warehouses are the final point in the supply chain for order assembly, value added services and despatch to the customer and it represents approximately 20-24% of total logistics costs (Charlotra, 2013). Warehouses are critical to the achievement of customer service levels (Henz, 2017). They act as the nodes in the supply chain where customer orders are assembled and dispatched. Warehousing management in supply chain leads to sales growth reduced space requirements, increased volume capacity, control of inventory and increased customer service (Charlotra, 2013).

General warehousing strategies

Warehousing and its management cannot be appreciated differently from the general functions of management. According to Sayeed (2013), the four functions or types of activities of warehouse management are planning, organising, leading, and controlling. More so, from a warehousing perspective, the key functions are (i) receiving, quality control, and put-away/storage and (ii) picking, sorting, packing, and shipping (Sainathuli et al., 2014). Effectively making decisions around warehouse design and operations is vital to accomplish these functions. Some of these decisions include aisle layout, material-handling selection, workforce planning and scheduling, and information technology infrastructure. These decisions have a significant bearing on the warehouse's throughput and cost, and influence other supply chain decisions such as inventory and transportation (Kiaya, 2014). For example, a new picking technology such as pick-to-light or robotic picking (for example, Kiva robots) that alters (actually, improves) worker productivity may mean that inbound and outbound shipment schedules, and inventory requirements at the warehouse, would be modified due to this change in the warehouse's throughput (Henz, 2017).

A modern large warehouse is a complex technical structure, which consists of many interrelated elements, has a definite structure, and performs a number of functions to transform the material flow as well as the generation, processing and distribution of goods among consumers (Komarova, 2016). In this case, because of the variety of parameters, technological solutions, equipment design, and characteristics of different nomenclature, handled cargo warehouses are complex systems (Kumar and Kalita, 2017). At the same time the warehouse itself is only part of the system of higher level, the logistics chain, which forms the basic and technical requirements for the storage system sets goals and criteria for its optimal functioning, dictates the terms of processing load (Kondratjev, 2015).

Consequently, warehouse management is subdivided into tactical and operational decisions. Tactical decisions primarily address how to efficiently plan materials and resources for the short-term period (a week to a few months), within the constraints of the long-term decisions. According to Shephard (2014), tactical plans assess the expected overall demand, which the warehouse must meet in an aggregated manner; in other words, the expected order quantities are checked against total capacity of space, labour, and equipment, and are then translated into output and required processes. Tactical warehouse plans include inventory replenishment, storage location assignment, workload planning, and transport planning (Richards, 2014). Inventory replenishment and storage location assignment plans determine which products should arrive and where these should be stored (Webber and Labaste, 2014). In addition, Daninger et al. (2017) argue that workload and transport planning balance the expected workload over the available resources (labour, equipment, and transport).

Second, at the operational level, actual demand is assessed on a disaggregated basis (Edelman et al., 2015). In this regard, resources such as space, equipment (for example, storage systems, retrieval systems, and internal transport equipment), storage units (like the pallets or boxes), labour, and instructions and procedures are allocated among the warehouse working orders (Sissinto et al., 2018). Operational decisions are narrow in scope and short-term focused (a few hours to a few days). At the operational level, many of the resources are given and it is difficult to make large-scale changes in resourcing. The goal of operational decisions is to optimise shop floor activities by avoiding any inefficiency in movement, storage, and information transfer, so that operational costs are minimised while customer orders are delivered in accordance with the expectations of the recipient (Kumar and Kalita, 2017). Overall, warehouse management decisions are the outcomes of the planning and control, and shop floor optimisation processes which link operational resources (space, equipment, and labour) with customer demand. Planning is paramount and it means taking the best decisions possible, in accordance with the predetermined objectives (Richards, 2014). Control means measuring the results,

and possibly taking corrective actions when results are not in line with objectives (Sayeed, 2013). Shop floor optimisation concentrates on the actual loading, sequencing, scheduling, and routing problems in a warehouse. It includes three distinct, though integrated, activities, loading resources, and sequencing and scheduling work orders (Sissinto et al., 2018).

Consequently, warehouses have been going through various challenges. For example, supply chains are becoming more integrated and shorter, operate globally, customers are more demanding, and technology changes are occurring rapidly (Komarova, 2016). In order to cope with these challenges organisations are adopting innovative approaches such as warehouse management system (Henz, 2017). A warehouse Management System (WMS) primarily aims to control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, put-away and picking. A WMS provides the information necessary to manage and control the flow of products in a warehouse, from receiving to shipping (Richards, 2014). Since a warehouse is a node in the flow of products serving or steered by other business functions, such as purchasing and sales, a WMS must communicate with other management information systems about issues including order acceptance, procurement, production control, finance, and transportation (Kiaya, 2014).

A WMS is a database driven computer application, to improve the efficiency of the warehouse by directing cutaways and to maintain accurate inventory by recording warehouse transactions (Henz, 2017). The systems also direct and optimize stock based on real-time information about the status of bin utilisation. It often utilizes Auto ID Data Capture (AIDC) technology, such as barcode scanners, mobile computers, wireless LANs (Local Area Network) and potentially Radio-frequency identification (RFID) to efficiently monitor the flow of products (Sissinto et al., 2018). Once data has been collected, there is either batch synchronization with, or a real-time wireless transmission to a central database. The database can then provide useful reports about the status of goods in the warehouse. The primary function of a warehouse control system is to receive information from the upper level host system, most often being the warehouse management system, and translate it for the daily operations. A common goal is to ensure a situation where warehouse employees never have to retype information because it already lies in one system or is collected automatically. Warehouse control system is usually the interface that is used to manage processes, people and equipment on the operational level. Based on warehouse control system, literature distinguishes three types of warehouse management systems, which are basic, advanced, and complex (Webber and Labaste, 2014).

Basic WMS is apt to support stock and location control only. It is mainly used to register information. Storing and picking instructions may be generated by the system and possibly displayed on RFID terminals. The warehouse management information is simple and focuses on throughput mainly (Komarova, 2016). The advanced WMS, in addition to the functionality offered by a basic WMS, is able to plan resources and activities to synchronize the flow of goods in the warehouse. The WMS focuses on throughput, stock, and capacity analysis (Webber and Labaste, 2014). Finally, in complex WMS the warehouse or group of warehouses can be optimised. Information is available about each product in terms of where it is located (tracking and tracing), what is its destination and why (planning, execution and control). Further, a complex system offers additional functionality like transportation, dock door, and value added logistics planning which help to optimise the warehouse operations as a whole (Komarova, 2016).

Warehouse management systems can be standalone systems or modules of an Enterprise Resource Planning (ERP) system or supply chain execution suite (Sissinto et al., 2018). The primary purpose of a WMS is to control the movement and storage of materials within a warehouse. The WMS can be deployed as a paper-based, RFID wireless based or combination of both (Komarova, 2016).

Warehousing and post-harvest losses: The nexus

According to Chebanga et al. (2018), the population explosion is a major concern and is expected to reach 10.5 billion by 2050,globally. This explosion in population demands the increase in the agriculture and food resources. The supply of the food should increase at least by 60% in order to meet the food demand in 2050. Currently, Zimbabwe's economy is improving systematically after an economic decline from 2000 to 2008. The main contributor to the economy is agriculture sector, with about 70% of the population depending on agriculture. Apart from this increase in economic growth through agriculture, the losses due to poor post-harvest practices remain a concern for most of the farmers. According to Kikulwe et al. (2018), the reduction of post-harvest losses has become a central pillar of sustainable global food systems. In essence, post-harvest losses reflect a missed opportunity in the fight against global food insecurity.

Post-harvest losses are classified into three main categories, that is, quantitative loss, qualitative loss, and economic or commercial loss. The losses due to post-harvest practices are both qualitative and quantitative food loss along the supply chain, since the beginning of harvest until consumption (Chebanga et al., 2018). Others classified as direct and indirect losses. A qualitative loss is contamination of grain by moulds and includes loss in nutritional quality, edibility, consumer acceptability of the products and the caloric value (Suleiman and Rosentrater, 2015). Qualitative losses result in the reduction in the quality and, consequently, the value of the food item. Quantitative losses results in a reduction in weight and consequent loss in total value. Quantitative loss also indicates the reduction in physical weight, and can be readily quantified and valued, example a portion of grain damage by pests or lost during transportation. Losses in quantity have been found to be more common in developing countries. Economic loss is the reduction in monetary value of the product due to a reduction in quality and or/ quantity of food (Tefera, 2012). According to FAO (2013), at a global level, volumes of lost and wasted food in high-income regions are higher in downstream phases of the food chain, but just the opposite in low-income regions where more food is lost and wasted in upstream phases. These losses need to be reduced so that traders may realise reasonable profits and contribute immensely to economic growth and poverty reduction in the country.

One of the options for reducing post-harvest losses is sound warehousing. According to Chebanga et al. (2018), improper storage is one of the reasons for the high level of post harvest losses. Storage is a component within a farming system, a trading enterprise, or a government policy, and may be undertaken because of its contribution to other activities or objectives within these broader contexts. Much of the post-harvest losses usually occur during storage and marketing (Chebanga et al., 2018). On this note, there is need for farmers and traders to learn to apply effective methods of storage, grading and sorting of their commodities as well use of proper packing materials to reduce losses. The mode of transport and transport distance play an important role in influencing the magnitude of postharvest losses. Poor transportation method, larger distance from the market, and outdated use of storage containers lead to higher postharvest harvest losses.

Proper and adequate storage or warehousing is essential in order to reduce post-harvest losses (Kiaya, 2014). Storage plays a vital role in the food supply chain, and several studies reported that maximum losses happen during this operation. Storage is the art of keeping the quality of agricultural materials and preventing them from deterioration for specific period of time, beyond their normal shelf life. Different crops are harvested and stored by various means depending on the end utilisation. Whether the seed will be used for new plantings the following year, for forage being processed into livestock feed, or even for crops to be developed for a special use, the grower must be aware of harvesting and storage requirements toward a quality product. After determining the prescribed use for the crop,

timing for harvest and storage is of important consideration. Along with an assessment of when to harvest, the farmer needs to determine the method of harvesting (Affognon et al., 2015).

There are a wide range of storage structures used throughout the world to successfully store agricultural produce. Some of the agricultural produce like fresh fruit and vegetables require specialised structures that needs to be kept cool (refrigerated, or at least ventilated and shaded) and the produce put into storage must be of high initial quality (Kikulwe, 2018). Irrespective of the type of produce, appropriate storage is essential for a number of reasons, including the perishable nature of agricultural and biodegradable materials, and the need provide food materials all year round. Warehousing is also essential for the purposes of pilling/ provision for large-scale processing, preservation of nutritional quality, price control, and regulation, optimisation of farmers' gain/financial empowerment of farmers, and creating opportunities for export market (Henz, 2017).

Marketing boards as warehouses and role in reducing post-harvest losses

The introduction of marketing boards in Africa can be traced back to colonial times when colonial masters developed these marketing boards to facilitate the export of agricultural commodities from Africa to the international markets (Ayo et al., 2017). With the advent of independence many African governments perpetuated the functioning of these marketing boards to facilitate the marketing of African agricultural products to international markets and promote food security through maintaining national strategic reserves after food security had became topical during the World Food Summit of 1996 (FAO, 2013).

European colonial powers formed marketing boards to facilitate the export of agricultural commodities to Europe and to stabilise prices faced by colonial elites (for food crops) and metropolitan buyers (for export crops) by making them to access international markets (Kiaya, 2014). Post- independence governments generally maintained marketing boards because these were considered more efficient in conducting organised trade as they were used to market strategic agricultural commodities to international markets than the traditional, decentralized private sector. More compelling, marketing boards provided a convenient way for the governments to maintain control over the marketing of strategic commodities, such as the food staples and important export crops. The marketing boards system was most prevalent in the Anglophone African and South Asian countries, but widespread as well in Francophone and Lusophone African countries and in Asia and Latin America (Morris and Kamarulzamna, 2017).

The rationale for the intervention in marketing boards is multidimensional and some of the principal reasons have faded into the past or were never openly expressed (Kikulwe, 2018). The basis for governmental monopoly control of foreign trade was one of the prime reasons for the establishment of these state-controlled boards. Exports of farm crops were in the hands of a very few European and American concerns. The control of market behaviour and taxation of long-distance trade were also well-established perquisites of traditional authorities long before European occupation (Henz, 2017). The first marketing boards in Africa were authorised partly in response to widespread belief that they would raise prices, farm incomes, and export proceeds. British West Africa did, in fact, supply the lion's share of world cocoa shipments, while Nigeria and the Congo produced most of the marketed palm oil. It was believed that governmental control would reduce marketing costs to the benefit of producers in the sense that producers will not incur transportation costs to international markets, rather they would sell their products to marketing boards, and these same boards will market these agricultural products at the international markets. More so, because marketing board boast large-scale and state of the art storage facilities, they are essential for the prevention of post-harvest losses (Mahmoud, 2013).

However, as argued by Kikulwe (2018), the marketing boards seem to be failing to effectively perform their mandate. About three decades after liberalisation, agricultural markets in Africa remain largely inefficient (Africa Union Commission, 2018). These marketing boards are typically characterised by high distribution margins and seasonal price variability. Poor rural transport infrastructure is one of the contributory factors as, quite often, food-surplus areas lack good road and rail networks, leading to under- investment in haulage transport facilities in rural communities and consequent high transit losses, the cost of which is passed onto consumers (Henz, 2017). A lack of efficient storage infrastructure is another factor. It is a major reason for the very high levels of post-harvest losses found in Africa (Africa Union Commission, 2018).

Warehousing challenges in relation to containing post-harvest losses

There are a number of challenges in warehousing. The main warehouse and storage problems include the poor transport networks. Grain takes long to be delivered. There is also the challenge of the poor quality of warehouses in terms services/ facilities availability. According to Kiaya (2014), where there is condensation or moisture due to high humidity, there is always the presence of biological growths such moulds or fungi, insects and rodents causing infestation. Biological agents attack paper and other organic materials when both temperature and humidity are uncontrolled. Mould spores remain suspended in the air until they find suitable conditions for their growth. If mould is observed in the warehouse yet environmental conditions are not altered to halt its proliferation, the mould will digest the material on which it has begun to grow. This results in the staining and deterioration of materials attacked and in rapid loss of strength of organic materials (Affognon et al., 2015). The growth of fungi is revealed by the formation of whitish patches on book covers and documents, which later may become brownish or greenish in colour. It is a common experience to note that this mould growth occurs more readily on items made of organic materials that are tightly packed, and this is because a thin, stagnant pocket of moist air is formed which favours mould growth (Ayo et al., 2017).

Moreover, according to Chebanga et al. (2018), high temperature, humidity, and negligence favour the growth and proliferation of insects. There are a myriad of examples of negligence, which include the accumulations of dirt and dust from poor or careless housekeeping practices, and the introduction of foodstuffs to storage areas. Other examples are the entry of insect-infested items into the warehouse, open windows, air vents or poorly sealed windows and doors, unattended roof leaks and cracks in a deteriorated warehouse building, and poor ventilation (Henz, 2017). When it comes to grain storage, rodents, and insects are the worst enemies of grains and other organic materials that are cellulose in nature. The materials contain proteins and carbohydrates in the form of sizing, paste or starches, and other organic substances attractive to insects (Affognon et al., 2015). The nature and extent of the damage depend not only on the insect and material, but also on how promptly the infestation is discovered and controlled. Damage may vary from a few holes to complete destruction (Kikulwe, 2018).

Options for enhancing warehousing operations to contain post-harvest losses

A myriad of options could be in use to enhance warehousing and contain post-harvest losses. These include adequate resource allocation for storage facilities and sound management (Kiaya, 2014). It is necessary to allocate warehouse resources efficiently and effectively to enhance the productivity and reduce the operation costs of the warehouse. One vital area determining the efficiency of warehouse is the determination of the proper storage locations for potentially thousands of products in a warehouse. Various factors affecting the storage assignment like order picking method, size and layout of the storage system, material handling system, product characteristics, demand trends, turnover rates

and space requirements are been extensively studied. It has been suggested that selecting appropriate storage assignment policies (random, dedicated, or class-based) and routing methods (transversal, return, or combined) with regards to above factors is a possible solution to improve the efficiency (Henz, 2017). Various decision support models and solution algorithms have also been established to solve warehouse operation planning problems (Hansen, 2013).

The use of information systems in warehouse management is necessary. According to Richards (2014), the complexity of warehouse management is indicated among others by amount and heterogeneity of handled products, the extent of overlap between them, amount and type of technology as well as characteristics of associated processes. As the complexity increases it becomes necessary to use warehouse management systems for handling warehouse resources and to monitor warehouse operations (Sissinto et al., 2018). The warehouses with a high amount of processed order lines and amount of stock keeping units are best supported by customized software. It is difficult to update daily operations of inventory level, locations of forklifts and stock keeping units (SKUs) in real-time by using the barcode-based or manual-based warehouse management systems (Kumar and Kalita, 2017). RFID technology could also be adopted to facilitate the collection and sharing of data in a warehouse. Tests are performed for evaluating the reading performance of both the active and passive RFID apparatus. Implementing RFID technologies requires a thorough cost and benefit analysis of implementation. The costs of RFID implementation include tag reader costs, communication costs and other infrastructure costs. RFID can improve the automatic checkout process at a retail store, so it can reduce inventory costs as a result of more efficient shelf replenishment. RFID technologies can support the redesign of business processes; improve data quality; real-time data collection; synchronization and information sharing between the players of supply chain (Henz, 2017). RFID implementation can also bring about additional benefits such as reduction losses due to shop lifting and increased use of point of sale applications (Komarova, 2016).

The implementation of Warehouse Management Systems (WMS) necessarily provides an increase in accuracy reduction in labour costs if the labour employed to maintain the system is less than the labour saved on the warehouse floor and a greater ability to service the customer by reducing cycle times (Sayeed, 2013). WMS does not only lead in inventory reduction but also to greater storage capacity. An increase in accuracy and efficiency of the receiving process might lead to reduction in level of safety stock required. Nevertheless, the consequence of this reduction will hardly be visible to the overall inventory levels (Edelman et al., 2015). WMS might just not affect the factors (lot sizing, lead times and demand variability) controlling the inventory levels. However, WMS is instrumental in more efficient and organized that leads to increased storage capacity (Sissinto et al., 2018).

The implementation of WMS for a company demands significant investment and time (several months) which has to be justified with the benefits obtained after implementation. The justification involves the excellent analysis of the current situation of the warehouse and warehouse operation for a specific period of time tuning the WMS (Shephard, 2014). The organisation should be prepared to change the entire process and system storage. Only WMS implementations without changing processes show that does not lead to cost savings or efficiency improvements, it will only reduce errors due to human factors (Kiaya, 2014).

Another option for enhancing warehousing and reducing post-harvest losses is to ensure that quality produce goes into the storage facilities (Mutambara, 2014). Enhancing grain quality during production stage is paramount. Only crops with high initial quality can be stored successfully; it is therefore essential to ensure that only crops of the highest quality (mature, undamaged) are stored. Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity, and environmental conditions (Webber and Labaste, 2014). There could also be a need for the training of

farmers on gaps is essential so that they produce grain of acceptable quality. The farmers could be organised into groups to compete in an increasingly demanding marketplace (Kumar and Kalita, 2017). The joining of a farmer organisation is a necessary step for small-scale farmers who want to increase their income and capture more value in the value chain, like becoming a crop specialist. Unlike individual farmers, farmer organisations have the resources to attract and build relationships with different links in the value chain, both locally and further afield. The farmer organisations help individual farmers by combining the harvests of a number of producers, buying bulk inputs at lower prices on farmers' behalf, and giving farmers access to farm support services. By their sheer size, cooperatives have enough market power to raise the prices received by individual farmers and ensure that farmers receive a steadier, more secure income. Many farmer groups include savings and loan schemes for their members. These schemes help farmers work with money, keep records, and learn financial skills that are essential to improve their businesses (Henriksen et al., 2014).

Efficient transport systems are necessary for sound warehousing and the reduction of post-harvest losses (Richards, 2014). The concept of integrating warehousing with efficient transport systems (rail and road) tends to bring about significant cost savings while adding automation (which automatically means bulk storage) to grain warehouses will help to reduce the labour cost (Sayeed, 2013).

Moreover, the marketing boards could provide Warehouse Receipt System (WRS) facilities. WRS can help reduce post-harvest losses (Affognon et al., 2015). High post-harvest losses that occur in Africa and this is not only due to lack of suitable storage facilities but also to limited access to inventory credit that hampers intra and inter-seasonal stockholding. A viable WRS encourage storage of agricultural commodities in well-run storage facilities and can therefore help to significantly reduce post-harvest losses (FAO, 2013). Warehouse receipt systems have the potential to address a variety of challenges faced by farmers in developing countries. The challenges include a high degree of storage losses due to substandard crop storage facilities, lack of access to formal, collateralised credit at reasonable interest rates among both grain traders and smallholder farmers, and the inability of traders or farmers to exploit temporal arbitrage opportunities (Edelman et al., 2015).

WRS, through its potential to increase demand for storage, could address high price seasonality driven by high transport costs and thin markets (Kikulwe, 2018). This lower price seasonality stands to the benefit those that tend to sell low or buy high, with obvious food security benefits via both income and consumption channels. However, the ability of WRS to stimulate demand for storage will be hampered if prices do not follow predictable seasonal patterns. Prices tend to be more unpredictable when markets are thin, or when government involvement through trade policy, international trade, or domestic stock releases is done in an ad hoc manner. WRS guarantees the quantity and quality of the commodity stored and could reduce post-harvest losses and improve food security (Edelman et al., 2015).

However, there are challenges associated with WRS, which have led to the slow or limited progress in establishing WRS in Africa, appear to be quite common (Wilson et al, 2011). They include lack of suitable storage infrastructure, legal and regulatory issues, lack of requisite skills, missing or weak complementary market institutions, difficulty in attracting key stakeholders especially bankers, problems encountered in ensuring smallholder participation and disabling elements in the policy environment. Kikulwe (2018) acknowledges that well-equipped warehouses will serve not only as a safe and hygienic place for food grain reserves but also provide a first line of defence in the event of a food emergency. However, the question of food grain warehousing goes beyond the facility itself to include the policy options and the need to maintain stocks of grain in years of good harvests to guard against widespread hunger in those years when production falls short of needs (Henz, 2017).

Finally, to work with other links in the value chain, the marketing boards, farmers, and other stakeholders in agriculture should develop a 'chain vision' (Kikulwe, 2018). This means that they see how their value chains work, as a network of specialised companies that need each other to make money (Kikulwe, 2018). Farmers should acknowledge the presence of other links in the chain, and respect that their interests are also legitimate. Different links in the chain should understand the need for cooperation rather than fighting against each other. They should understand that, though sellers and buyers will always have opposed interests, a high price and a low price, respectively, they have a shared interest in satisfying the consumer. When the consumer is satisfied, the businesses of both the seller and the buyer will grow. For a value chain to be successful, everyone in the chain must benefit and must feel that they are being treated fairly (Sissinto et al., 2018).

Lessons from literature review

One of the key lessons from literature review is that warehousing and the reduction of post-harvest losses entail that humans or the stakeholders involved in this processes exhibit certain behaviours. In the maize production and marketing system, the behaviour of value chain players ought to lead towards sound warehousing and reduction of post-harvest losses. The threat of food insecurity, amid an increase in the global population, seems to provide the motivation for investing in effective and efficient warehouses and reducing post-harvest losses. There is also a need for all the stakeholders in the grain value chain to develop positive attitudes because post-harvest losses seem to be a complex problem eluding solutions. Post-harvest maize losses can be described in triplicate, that is, quantitative, qualitative, and economic losses.

Another lesson from literature review is that post-harvest losses occur along the whole food value chain, from production to consumption. Therefore, prevention of food losses ought to be done in all the stages of the grain value chain. However, most of the losses occur after harvest and in the storage facilities. There is seasonal production of maize; therefore, sound warehousing is paramount. This also stems from the fact that effective warehousing is regarded as competitive weapon as the wider market demands continuous supply of goods in authentic condition. This genuine nature of goods is protected by warehousing/storage methods and techniques used by the organisations. Warehousing is also part of the general management functions of planning, organising, leading, and controlling. Moreover, there are tactical and operational decisions in warehousing.

A review of literature showed that supply chains have become more complex and integrated. Therefore, there is a need for innovations like the Warehouse Management System, which is computer-based. The Marketing Board, like GMB, ought to take a leading role in warehouse innovations. The state-controlled entities, which were inherited from the colonial administrations, are essential in helping the governments to maintain control over the supply of staple foods. While the Marketing Board are essential, they face challenges in their warehousing operations, which include poor transport networks that negatively affect the delivery of grain (losses can happen during transportation), and improper storage facilities. Literature suggested several options, including an allocation of adequate resources and sound management of warehouses, the use of ICTs in warehouse management, improvement of grain quality throughout the production process, providing grain drying services to farmers who deliver their grain, use of super grain storage bags, metal silos and using the warehouse receipt system.

Conclusion and Future Direction

A review of related literature in the warehousing of grains and reduction of post-harvest losses was extensively explored; nevertheless, this is a paper as it highlights important conclusions derived from

various sources. Post harvest grain losses in storage can be reduced by making use of a warehouse management system, super grain bags, metal silos, hermetically sealed storage bags and regular fumigation of storage facilities. However, some gaps have been identified in this literature review. These gaps are going to provide a future direction for research in existing and other unexplored areas of the warehousing of grains and reduction of post-harvest losses.

- There is a need to explore the handling and management of grains within the storage facilities as this is where higher percentages of post-harvest losses are recorded.
- Proper grain storage methods require more exploration, particularly on how they can help to reduce post-harvest losses.
- The effectiveness of Grain Marketing Boards in reducing post-harvest losses also needs to be explored.
- The grain transportation methods and their impacts on the quantity and quality of grains also need further study.
- The grain dispatch systems used in the grain warehouses are an unexplored area.
- Since 2000, the trend of using IT systems is enhancing overall productivity in warehouse (Gunasekaran et al. 1999), but the review trend shows that research papers integrating warehouse operations with GIS, GPS, SAP, RFID and other computer applications are still not up to a satisfactory level as compared to e-commerce adoption in customer ordering. This gap is overlooked by researchers and must be addressed in future which can improve decision making abilities of managers enhancing operations and reducing post-harvest losses.

References

Affognon, H., Mutungia C. Sangingac, P. and Borgemeister, C. 2015. Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta-Analysis, *World Development,* 66, 49-68.

African Union Commission. 2018. *Post-Harvest Loss Management Strategy*, Addis Ababa.

Ajzen, I. 1991. The Theory of Planned Behaviour, *Organisational Behaviour, and Human Decision Processes,* 50, 179-211

Anseeuw, W. Kapunya, T. and Saruchera, D. 2012. *Zimbabwe's Agricultural Reconstruction: Present State, Ongoing Projects, and Prospects for Reinvestment,* Pretoria; Development Bank of Southern Africa.

Ayo, J.A. Oboh, S., Ayo, V.A. and Popoola, C. 2017. Estimating Post-Harvest Loss: A Challenge of Developing Nations, *FUW Trends in Science and Technology Journal*, 2(2), 806-813.

Chebanga, F., Mukumbi, K., Mutetwa, M., and Mtaita, T. 2018. Post-Harvest Losses to Agricultural Product Traders in Mutare, Zimbabwe, *Journal of Scientific Agriculture*, 2, 26-38.

Creswell, J.W. 2014. *Research Design, Quantitative, Qualitative, and Mixed Methods Approaches, Fourth Edition*, Thousand Oaks, California; Sage.

Daninger, a. Datta, S. and Guichon, D. 2017. *Reducing Post-Harvest Losses: A Behavioural Approach,* New York; The Rockefeller Foundation, Ideas42.

Department for International Development, 2009. *Road to Market, Field Record of Interviews of Beneficiaries of Market Development Projects in Africa Produced for the Crop*, London; Post-Harvest Research Project.

Edelman, B., Lee, L.H., Mabiso, A., and Pauw, K. 2015. *Strengthening Storage, Credit, and Food Security Linkages: The Role and Potential Impact of Warehouse Receipt Systems in Malawi,* Washington D.C.; International Food Policy Research Institute.

Food and Agriculture Organisation, 2010. *Missing Food: The Case of Post-Harvest Grain Losses in Sub-Saharan Africa,* Washington D.C.; World Bank.

Food and Agriculture Organisation. 2013. Food Wastage Footprint: Impacts on Natural Resources, Rome; Publications Office.

Hansan, S.N.M.S., Harun, R, and Hock, L.K. 2015. Application of Planned Behaviour in Measuring the Behaviour to Reduce Plastic Consumption among Students at Univesiti Putra, Malaysia, Malaysia, *Procedia Environmental Sciences,* 30(2015), 195-200.

Hansen H.O. 2013. *Food Economics: Industry and Market,* New York; Routledge.

Hartwich, F. 2012. *Engaging Smallholders in Value Chains: Who Benefits under Which Circumstances?* Vienna, United Nations Industrial Development Organisation, Agribusiness Development Branch.

Henz, GP. 2017. Post-Harvest Losses of Perishables in Brazil: What do we know so far? *Horticultura Brasileira,* 35, 006-013.

Henriksen, L., L. Riisgaard, S., Ponte, F., Hartwich, G. and Kormawa, P. 2014. *Agro-Food Value Chain Interventions in Asia: A Review and Analysis of Case Studies,* Vienna; United Nations Industrial Development Organisation.

Kaminski, J. and L. Christiaensen. 2014. *Post-Harvest Loss in Sub-Saharan Africa: What do Farmers Say?* Policy Research Working Paper 6831. Washington, DC; World Bank.

Kapuya, T., Saruchera, D., Jongwe, A., Mucheri, T., Mujeyi, K., Truab, L.N. and Meyer, F. 2010. *The Grain Value Chain in Zimbabwe,* Rome; Food and Agriculture Organisation.

Kiaya, V. 2014. *Post-Harvest Losses and Strategies to Reduce Them,* Rome; Action Contre la Faim (ACF), Scientific and Technical Department.

Kikulwe, E.M., Okurut, S., Ajambo, S., Nowakunda, K., Stoian, D., and Naziri, D. 2018. Post-Harvest Losses and their Determinants: A Challenge to Creating a Sustainable Cooking Banana Value Chain in Uganda, *Sustainability,* 2018, 10, 2381, 1-19.

Komarova, J. 2016. *Improvement of Warehousing Operations Case: CKBM Limited, Russia,* JAMK University of Applied Sciences; School of Technology, Communication, and Transport.

Kondratjev, J. 2015. *Logistics: Transportation and Warehouse in Supply Chain,* Centria University of Applied Sciences.

Kumar, D. and Kalita, P. 2017. Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing Countries, *Foods 2017,* 6(8), 1-22.

Leedy, P.D. and Ormrod, J.E. 2010. *Practical Research: Planning and Design, Ninth Edition,* New York; Merril.

Maiyaki, A.M. 2010. *Zimbabwe's Agricultural Industry,* Kano; Banyoro University.

Mahmoud, A.B., 2013. Syrian Consumers: Beliefs, Attitudes, and Behavioural Responses to Internet Advertising', *Business: Theory and Practice*, 14(4), 297–307.

Mancini, M.C. 2013. Geographical Indications in Latin America Value Chains: A Branding from Below; Strategy or a Mechanism Excluding the Poorest?, *Journal of Rural Studies 32,* 295-306.

Mapira, J. and Mazambara, P. 2013. Indigenous Knowledge Systems and Their Implication for Sustainable Development in Zimbabwe, *Journal of Sustainable Development in Africa*, 15(5), 101-123.

Minh, T. 2017. *Agricultural Value Chains in Developing Countries: Concepts and Analysis: Synthesis of Reading Materials*, www.researchgate.net/publication/314952732 [Accessed 27 March 2019].

Morris, K.J.K., and Kamarulzaman, N.H. 2017. Conceptual Framework for Estimating Post-Harvest Losses in Food Supply Chains: The Case of Plantain Fruits in Nigeria, *International Journal of Business and Economics Research,* 3(6-1), 31-37.

Mutambara, J. 2014. *Policy and Institutional Arrangements for Managing Risk for Crop Production and Post-Harvest Handling in Disaster-Prone Areas of Zimbabwe*, Pretoria; Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN), Regional Secretariat.

Mutambara, J., Mwakiwa, E., and Makotose, W. 2013. *Assessment of the Maize Situation, Outlook, and Investment Opportunities in Zimbabwe*, Harare; University of Zimbabwe.

Negi. S. and Anand, N. 2014. Supply Chain Efficiency: An insight from Fruits and Vegetables Sector in India, *Journal of Operations, and Supply Chain Management*, 7(1), 154-167.

Nyoni, E. 2012. *Restructuring Procedures Manual*, Harare; Printflow.

Ponte, S. and Sturgeon, T. 2014. Explaining Governance in Global Value Chains: A Modular Theory-Building Effort, *Review of International Political Economy*, 21(1), 195-223.

Ramaa, A., Subramanya, K.N. and Rangaswamy, T.M. 2012. Impact of Warehousing Management System in a Supply Chain, *International Journal of Computer Applications*, 54(1), 14-30.

Rawnsley, A.C. 2012. *Teeside University Research Governance, Policy, Procedures, and Guidelines for Research Ethics*, Teeside University.

Rembold, F., Hodges, R., Bernard, M., Knipschild, H., and Léo, O. 2011. *The African Post-Harvest Losses Information System (APHLIS): An Innovative Framework to Analyse and Compute Quantitative Post-Harvest Losses for Cereals under Different Farming and Environmental Conditions in East and Southern Africa*, Rome; European Commission, Joint Research Centre, Institute for Environment and Sustainability.

Richards, G. 2014. *Warehouse Management*, London; Kogan Page.

Sainathuli, B., Parikh, P. J., Zhang, X., and Kong, N. 2014. The Warehouse-Inventory-Transportation Problem for Supply Chains, *European Journal of Operational Research*, 237(2), 690-700.

Samuel, A., Saburi, A., Usanga, O.E., Ikotun, I., and Isong, I.U. 2011. Post-Harvest Food Losses Reduction in Maize Production in Nigeria, *African Journal of Agricultural Research*, 6(21), 4833-4839

Saunders, M., Lewis, P., and Thornhill, A. 2015. *Research Methods for Business Students, Seventh Edition*, London; Prentice-Hall.

Sayeed, S.I. 2013. *A Study on Warehouse Management of REB: A Case Study of Central Warehouse, Dhaka*, Dhaka, Bangladesh; Eastern University, Institute of Governance Studies.

Sharma, V.P. 2013. *India's Agrarian Crisis and Smallholder Producers' Participation in New Farm Supply Chain Initiative*, Ahmedabad; Indian Institute of Management.

Shepherd, A. 2014. *Approaches to Linking Producers to Markets*, Rome; FAO.

Simon, M.K. 2011. *Dissertation and Scholarly Research: Recipes for Success*, Washington D.C., Seattle.

Sissinto, E.G., Adegbola, Y.P., Biaou, G., and Zossou, R.C. 2018. Farmers' Willingness to Pay for New Storage Technologies for Maize in Northern and Central Benin, *Sustainability*, 2018, 10, 2925, 1-21.

Suleiman, R.A. and Rosentrater, K.A. 2015. *Current Maize Production, Post-Harvest Losses and the Risk of Mycotoxins Contamination in Tanzania*, Presentation at the 2015 ASABE Annual International Meeting Sponsored by ASABE, New Orleans, Louisiana, July 26-29, 2015.

Taylor, S.J., Bogdan, R, and DeVault, M.L. 2016. *Introduction to Qualitative Research Methods, a Guidebook and Resource*, Hoboken, New Jersey; Wiley.

Tefera, T. 2012. Post-Harvest Losses in African Maize in the Face of Increasing Food Shortage, *Food Security*, 4(2), 267-277.

Trienekens, J.H. 2011. Agricultural Value Chains in Developing Countries: A Framework for Analysis, *International Food, and Agribusiness Management Review*, 14: 51-82.

Truong, Y., 2009. An Evaluation of the Theory of Planned Behaviour in Consumer Acceptance of Online Video and Television Services, *The Electronic Journal Information Systems Evaluation*, 12(2), 177–186.

United Nations. 2018. *The Sustainable Development Goals Report 2018*, New York.

Vheremu, W. Munyaradzi, B. and Jiyame, J. 2007. *Mechanisation: Panancea to Zimbabwe's Agricultural Productivity*, Chinhoyi; Chinhoyi University of Technology.

Webber, C.M and Labaste, P. 2014. *Building Competitiveness in Africa's Agriculture: A Guide to Value Chain Concepts and Applications*, Washington D.C.; World Bank.
Wilson, D., Wilson, K. and Harvey, C. 2011. *Small Farmers, Big Change, Scaling up Impact in Smallholder Agriculture,* Oxford; Practical Action Publishing and Oxfam Great Britain.